CURRICULUM

FOR

CIVIL ENGINEERING

SEMESTER - VII (CIVIL ENGINEERING)

S.No	Paper Code	Paper Title	L	T	P	Credits
1	100705	Graduate Employability Skills and Competitive Courses (GATE, IES, etc.)	3	0	0	0
2	-	Open Elective- I	3	0	0	3
3	101701	Professional Practice, Law & Ethics	2	0	0	2
4	-	Program Elective - III	3	0	0	3
5	-	Program Elective- II	3	0	0	3
6	100709	Project-I	0	0	12	6
7	100707	Summer Entrepreneurship - III	0	0	16	8

PAPER CODE - 101 701

101701	Professional Practice, Law & Ethics	L:2	T:0	P:0	CREDIT:2

Basic elements of civil engineering professional practice are introduced in this course. Roles of all participants in the process- owners, developers, designers, consultants, architects, contractors, and suppliers - are described. Basic concepts in professional practice, business management, public policy, leadership, and professional licensure are introduced. The course covers professional relations, civic responsibilities, and ethical obligations for engineering practice. The course
also describes contracts management, and various legal aspects related to engineering. Further, the course familiarizes students with elementary knowledge of laws that would be of utility in their profession, including several new areas of law such as IPR, ADR.

The course is designed to address the following:

- ➔ To make the students understand the types of roles they are expected to play in the society as practitioners of the civil engineering profession
- ➔ To develop some ideas of the legal and practical aspects of their profession

Detailed contents:

Professional practice covering the respective roles of the various stakeholders in the profession of civil engineering and the factors governing the same; Professional ethics relating to civil engineering; Various aspects of contracts relating to construction and management of contracts; types of contractual and other disputes in the profession and methods of dispute resolution; legal aspects relating to employment and service conditions of labour; intellectual property rights and their legal framework.

Module 1A

Professional Practice: Respective roles of various stakeholders: Government (constituting regulatory bodies and standardization organizations, prescribing norms to ensure safety of the citizens); Standardization Bodies (ex. BIS, IRC)(formulating standards of practice); professional bodies (ex. Institution of Engineers(India), Indian Roads Congress, IIA/ COA, ECI, Local Bodies/ Planning Authorities) (certifying professionals and offering platforms for interaction); Clients/ owners (role governed by contracts); Developers (role governed by regulations such as RERA); Consultants (role governed by bodies such as CEAI); Contractors (role governed by contracts and regulatory Acts and Standards); Manufacturers/ Vendors/ Service agencies (role governed by contracts and regulatory Acts and Standards).

Module 1B

Professional Ethics: Definition of Ethics, Professional Ethics, Business Ethics, Corporate Ethics, Engineering Ethics, Personal Ethics; Code of Ethics as defined in the website of Institution of Engineers (India); Profession, Professionalism, Professional Responsibility, Professional Ethics; Conflict of Interest, Gift Vs Bribery, Environmental breaches, Negligence, Deficiencies in state-of-the-art; Vigil Mechanism, Whistleblowing, protected disclosures.

Module 2

General Principles of Contracts Management: Indian Contract Act, 1972 and amendments covering General principles of contracting; Contract Formation & Law;
Privacy of contract; Various types of contract and their features; Valid & Voidable
Contracts; Prime and sub-contracts; Joint Ventures & Consortium; Complex contract terminology; Tenders, Request For Proposals, Bids & Proposals; Bid Evaluation;
Contract Conditions & Specifications; Critical /"Red Flag" conditions; Contract award
& Notice To Proceed; Variations & Changes in Contracts; Differing site conditions;
Cost escalation; Delays, Suspensions & Terminations; Time extensions & Force Majeure;
Delay Analysis; Liquidated damages & Penalties; Insurance & Taxation; Performance and
Excusable Non-performance; Contract documentation; Contract Notices; Wrong practices in contracting (Bid shopping, Bid fixing, Cartels); Reverse auction; Case Studies;
Build-Own-Operate & variations; Public- Private Partnerships; International Commercial Terms;

Module 3

Arbitration, Conciliation and ADR (Alternative Dispute Resolution) system:
Arbitration – meaning, scope and types – distinction between laws of 1940 and 1996;
UNCITRAL model law – Arbitration and expert determination; Extent of judicial intervention; International commercial arbitration;
Arbitration agreements – essential and kinds, validity, reference and interim measures by court; Arbitration tribunal – appointment, challenge, jurisdiction of arbitral tribunal, powers, grounds of challenge, procedure and court assistance; Award including Form and content,
Grounds for setting aside an award, Enforcement, Appeal and Revision;
Enforcement of foreign awards – New York and Geneva Convention Awards;
Distinction between conciliation, negotiation, mediation and arbitration, confidentiality, resort to judicial proceedings, costs;
Dispute Resolution Boards; Lok Adalats.

Module 4

Engagement of Labour and Labour & other construction-related Laws: Role of

Labour in Civil Engineering; Methods of engaging labour- on rolls, labour sub-contract, piece rate work; Industrial Disputes Act, 1947; Collective bargaining; Industrial Employment (Standing Orders) Act, 1946; Workmen's Compensation Act, 1923;
Building & Other Construction Workers (regulation of employment and conditions of service) Act (1996) and Rules (1998); RERA Act 2017, NBC 2017.

Module 5

Law relating to Intellectual property: Introduction – meaning of intellectual property, main forms of IP, Copyright, Trademarks, Patents and Designs, Secrets; Law relating to Copyright in India including Historical evolution of Copy Rights Act, 1957, Meaning of copyright – computer programs, Ownership of copyrights and assignment, Criteria of infringement, Piracy in Internet – Remedies and procedures in India; Law relating to Patents under Patents Act, 1970 including Concept and historical perspective of patents law in India, Patentable inventions with special reference to biotechnology products, Patent protection for computer programs, Process of obtaining patent – application, examination, opposition and sealing of patents, Patent cooperation treaty and grounds for opposition, Rights and obligations of patentee, Duration of patents – law and policy considerations, Infringement and related remedies;

ORGANISATION OF COURSE (2-0-0)

S.No	Module	No of Lectures
1A	Professional Practice	2
1B	Professional Ethics	2
2	Contracts Management	18
3	Dispute Resolution Mechanisms	5
4	Labour; Labour & other Laws	2
5	Intellectual Property Management	1

Text/Reference Books:

- B.S. Patil, Legal Aspects of Building and Engineering Contracts, 1974.
- The National Building Code, BIS, 2017
- RERA Act, 2017
- Meena Rao (2006), Fundamental concepts in Law of Contract, 3rd Edn. Professional Offset
- Neelima Chandiramani (2000), The Law of Contract: An Outline, 2nd Edn. Avinash Publications Mumbai
- Avtar Singh (2002), Law of Contract, Eastern Book Co.
- Dutt (1994), Indian Contract Act, Eastern Law House
- Anson W.R. (1979), Law of Contract, Oxford University Press
- Kwatra G.K. (2005), The Arbitration & Conciliation of Law in India with case law on UNCITRAL Model Law on Arbitration, Indian Council of Arbitration
- Wadhera (2004), Intellectual Property Rights, Universal Law Publishing Co.
- T. Ramappa (2010), Intellectual Property Rights Law in India, Asia Law House
- Bare text (2005), Right to Information Act
- O.P. Malhotra, Law of Industrial Disputes, N.M. Tripathi Publishers
- K.M. Desai(1946), The Industrial Employment (Standing Orders) Act
- Rustamji R.F., Introduction to the Law of Industrial Disputes, Asia Publishing House
- Vee, Charles & Skitmore, Martin (2003) Professional Ethics in the Construction
  Industry, Engineering Construction and Architectural management, Vol.10, Iss2,pp 117-127, MCB UP Ltd
- American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application
- Ethics in Engineering- M.W.Martin& R.Schinzinger, McGraw-Hill
- Engineering Ethics, National Institute for Engineering Ethics, USA
- www.ieindia.org
- Engineering ethics: concepts and cases – C. E. Harris, M.S. Pritchard, M.J.Rabins
- CONSTRUCTION CONTRACTS, http://www.jnormanstark.com/contract.htm
- Internet and Business Handbook, Chap 4, CONTRACTS LAW, http://www.laderapress.com/laderapress/contractslaw1.html
- Contract&Agreements
  http://www.tco.ac.ir/law/English/agreements/General/Contract%20Law/C.htm
- Contracts, http://206.127.69.152/jgretch/crj/211/ch7.ppt

- Business & Personal Law. Chapter 7. "How Contracts Arise", http://yucaipahigh.com/schristensen/lawweb/lawch7.ppt
- Types of Contracts, http://cmsu2.cmsu.edu/public/classes/rahm/meiners.con.ppt
- IV. TYPES OF CONTRACTS AND IMPORTANT PROVISIONS, http://www.worldbank.org/html/opr/consult/guidetxt/types.html
  Contract Types/Pricing Arrangements Guideline- 1.4.G (11/04/02), http://www.sandia.gov/policy/14g.pdf

ELECTIVE PAPERS

Pavement Design

Introduction: Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements. Stresses and Deflections in Flexible Pavements: Stresses and deflections in homogeneous masses. Burmister's two layer theory, three layer and multi-layer theories; wheel load stresses, various factors in traffic wheel loads; ESWL of multiple wheels. Repeated loads and EWL factors; sustained loads. Pavement behaviour under transient traffic loads. Flexible
Pavement Design Methods For Highways and Airports: Empirical, semi-empirical and theoretical approaches, development, principle, design steps, advantages; design of flexible pavements as per IRC; Stresses in Rigid Pavements: Types of stresses and causes, factors influencing the stresses; general considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses. Rigid Pavement Design: Types of joints in cement concrete pavements and their functions, joint spacings; design of CC pavement for roads and runways as per
IRC, design of joint details for longitudinal joints, contraction joints and expansion joints. IRC method of design by stress ratio method. Design of continuously reinforced concrete pavements; Maintenance, repair and rehabilitation of pavements including design of bituminous and concrete overlays as per IRC

Building Construction Practice

Specifications, details and sequence of activities and construction coordination – Site Clearance – Marking – Earthwork - masonry – stone masonry – Bond in masonry - concrete hollow block masonry – flooring – damp proof courses – construction joints – movement and expansion joints – precast pavements – Building foundations – basements – temporary shed – centering and shuttering – slip forms – scaffoldings – de-shuttering forms – Fabrication and

erection of steel trusses – frames – braced domes – laying brick -- weather and water proof – roof finishes – acoustic and fire protection; Sub Structure Construction- Techniques of Box jacking – Pipe Jacking - under water construction of diaphragm walls and basement-Tunnelling techniques – Piling techniques - well and caisson - sinking cofferdam - cable anchoring and grouting-driving diaphragm walls, sheet piles - shoring for deep cutting - well points - Dewatering and stand by Plant equipment for underground open excavation; Super Structure Construction- Launching girders, bridge decks, offshore platforms – special forms for shells - techniques for heavy decks – in-situ prestressing in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy Equipment and conveyors
Erection of articulated structures, braced domes and space decks

Transport of water and wastewater

The objective of the course is to make students gain insight into how the water and wastewater gets transported through conduits and open channels, and use the same for the design, operation and maintenance of these systems. Water Supply Systems: Storage requirements, impounding reservoirs, intake structures, pipe hydraulics, design of distribution systems, distribution and balancing reservoirs, pipe materials, appurtenances, design for external loads, maintenance and operation. Sanitary Sewerage Systems: Flow estimation, sewer materials, hydraulics of flow in sewers, sewer layout, sewer transitions, materials for sewers, appurtenances, manholes, sewer design, conventional and model based design, sewage pumps and pumping stations, corrosion prevention, operation and maintenance, safety. Storm water
Drainage Systems: Drainage layouts, storm runoff estimation, hydraulics of flow in storm water drains, materials, cross sections, design of storm water drainage systems, inlets, storm water pumping, operation and maintenance

Pipeline Engineering

The course should cover key issues for designing and operating pipelines for transmission and distribution of water; Analysis of flow in water transmission and water distribution systems (pump & gravity); optimal design and operation of systems for achieving different goals (including latest tools available for optimization); Extended period simulations, Software for WDN analysis and design, Rehabilitation of pipeline systems; Water auditing, online monitoring and control, leak and burst detection; transient analysis and surge protection; Appurtenances (valves / flow meters etc.); Selection of pipe material; Jointing details; Pipe laying and testing; Structural design for buried and surface mounted pipes

Prerequisite: Basic course in Hydraulic Engineering

Surface Hydrology

Study of descriptive and quantitative hydrology dealing with the distribution, circulation, and storage of water on the earth's surface; discusses principles of hydrologic processes and presents methods of analysis and their applications to engineering and environmental problems.

Masonry Structures

Introduction to analysis, design and construction of masonry structures. Mechanical properties of clay and concrete masonry units, mortar, and grout. Compressive, tensile, flexural, and shear behavior of masonry structural components.
Strength and behavior of unreinforced bearing walls. Detailed design of reinforced masonry beams, columns, structural walls with and without openings, and complete lateral-force resisting building systems.

Wood Structures

Mechanical properties of wood, stress grades and working stresses; effects of strength- reducing characteristics, moisture content, and duration of loading and causes of wood deterioration; glued- laminated timber and plywood; behavior and design of connections, beams, and beam-columns; design of buildings and bridges; other structural applications: trusses, rigid frames, arches, and pole-type buildings; and prismatic plates and hyperbolic paraboloids.

Concrete Technology

Concrete; Properties of ingredients, tests, Production of concrete, mixing, compaction curing, Properties of fresh concrete; Defects in Concrete, Concrete additives.; Behavior of concrete in tension and compression, shear and bond,
Influence of various factors on test results, Time dependent behavior of concrete
-creep, shrinkage and fatigue; Concrete mix design; Proportioning of concrete mixes, basic considerations, cost specifications, factors in the choice of mix proportion, different method of mix design. Quality control, Behavior of concrete in extreme environment; temperature problem in concreting, hot weather, cold weather and under water conditions, Resistance to freezing, sulphate and acid attack, efflorescence, fire resistance; Inspection and testing of concrete-

Concrete cracking, types of cracks, causes and remedies Non-destructive tests on concrete; Chemical tests on cement and aggregates; Special concrete; types and specifications, Fibre reinforced and steel Fibre reinforced concrete, Polymer concrete, Use of admixtures; Deterioration of concrete and its prevention Repair and rehabilitation.

Advanced Structural Analysis

Elasticity: Introduction, Components of strain and strain, Hooke's law, Plane stress and plane strain, Equations of equilibrium and compatibility, Boundary conditions, Two dimensional problems in rectangular and polar coordinates, Bending of simple and cantilever beams; Model Analysis: Structural similitude, Direct and indirect model analysis, Model material and model making, Measurement for forces and deformations; Introduction to Finite element method for structural analysis; Review of principle of virtual work, Ritz method, Discretization of domain, Basic element shape, Discretization process; Application of finite element method to one and two dimensional plane stress strain elements.

Soil Mechanics-II

Application of soil mechanics to determine earth pressures, analysis of retaining walls, cuts & excavations and sheet piles, stability of slopes, instrumentation. **Reference books:**

- ➔ Soil Mechanics by Craig R.F., Chapman & Hall
- ➔ Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning

On successful completion of this course, the students:

- ➔ Should be able design retaining walls subjected to various loads with the knowledge of earth pressure theories.
- ➔ Should be able to design sheet pile walls with different methods.
- ➔ Should get familiarized with different construction practices for excavation with advantages and disadvantages of each method.
- ➔ Should be able to determine the safety analysis for slopes with different methods proposed in the syllabus.
- ➔ Should get introduced with the commercial softwares for analyzing the stability of slopes and retaining walls.

Environmental impact assessment and life cycle analyses

Evolution of EIA: Concepts of EIA methodologies, Screening and scoping; Rapid EIA and Comprehensive EIA; General Framework for Environmental Impact Assessment, Characterization and site assessment. Environmental Risk Analysis, Definition of Risk, Matrix Method. Checklist method, Fault tree analysis, Consequence Analysis; Socioeconomic aspects, measures of effectiveness of pollution control activities; Environmental Legislation; Introduction to Environmental Management Systems; Environmental Statement - procedures; Environmental Audit: Cost Benefit Analysis; Life Cycle Assessment; Resource Balance, Energy Balance & Management Review; Operational Control; Case Studies on EIA.

Groundwater Engineering

The main objective is to provide sufficient knowledge to the students about the groundwater hydrology, well hydraulics and well construction, geophysical explorations, groundwater quality and management of groundwater resources; Problems and perspectives regarding groundwater in India; Hydrogeology: Darcy's Equation; flow characteristics; general flow equations; unsaturated flow; Well Hydraulics: Steady and unsteady radial flows in aquifers; partially penetrating wells; multiple well systems; characteristic well losses; specific capacity, Surface and Subsurface investigations (Geologic methods; remote sensing; geophysical explorations; electrical resistivity and seismic refraction), Water Wells: Construction; completion, development, protection and rehabilitation of wells; Groundwater quality; Groundwater Management: Basin management, investigations, conjunctive use, modeling, artificial recharge; Saline water intrusion

Structural Dynamics

Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multidegree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; and introduction to systems with distributed mass and flexibility.

Geographic Information Systems and Science

Investigation of geographic information systems (GIS) and science (GIScience) including theory and applications areas. A major portion of the course will be based on use of a current widely-used GIS computer software system. Aspects of geographic data entry and editing, spatial analysis, and map development and display will be considered. Relationship of GIS to the Global Positioning System (GPS) and satellite generated data will be addressed.

Civil Engineering Design-II

Innovation and creativity in conceptual design; sustainability; health and safety; investigative procedures. The use of analysis, synthesis and optimization in design; project planning, networks and graphs. Design of embankments, dams; drainage design; route location and alignment design of roads; assessment of natural hazard impacts and environmental impacts.

Public Transportation Systems

Public Transport: Definitions, modes of public transport and comparison, public transport travel characteristics, trip chaining, technology of bus, rail, rapid transit systems, basic operating elements; Transit Network Planning: Planning Objectives, principles, considerations, transit lines – types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, evaluation of network, accessibility considerations; Transit Scheduling: Components of scheduling process, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling;Transit Agency and Economics: Organizational structure of transit agency, management and personnel, transit system statistics, performance and economic measures, operations, fare structure; Design of Facilities: Design of bus stops, design of terminals – principles of good layout, types of layout, depot location, twin depot concept, crew facilities and amenities.

Traffic Engineering and Management

Traffic Forecast: General travel forecasting principles, different methods of traffic forecast - Mechanical and analytical methods, Demand relationships, methods for future projection; Design Hourly Volume For Varying Demand Conditions: Concept of Design vehicle units and determination of PCU under mixed traffic conditions,

Price-volume relationships, demand functions. Determination of design hourly volume; critical hour concept;Highway Capacity: Factors affecting capacity, level of service;
Capacity studies - Capacity of different highway facilities including unsignalised and signalised intersections. Problems in Mixed Traffic flow; Case studies; Accident
Analysis: Analysis of individual accidents and statistical data; Methods of representing accident rate; Factors in traffic accidents; influence of roadway and traffic conditions on traffic safety; accident coefficients; Driver strains due to roadway and traffic conditions; Traffic Flow Theory: Fundamental flow relationship and their applications, Traffic flow theories and applications; Shock waves; Queuing theory and applications; Probabilistic Aspects Of Traffic Flow: Vehicle arrivals, distribution models, gaps and headway distribution models; gap acceptance merging parameters, delay models, applications; Simulation: Fundamental principle, application of simulation techniques in traffic engineering - formulation of simulation models, Case studies. Formulation of system models.

Foundation Engineering

Analysis and design of foundations, types of foundations, bearing capacity and settlement of foundations; ground movements due to construction; analysis and design of excavations, retaining walls, cuts & excavations and sheet piles, slopes and underground structures.

Reference books:

- A. Singh, Modern Geotechnical Engineering, 3rd Ed., CBS Publishers, New Delhi, 1999.
- B.M. Das, Principles of Foundation Engineering, 5th Ed., Thomson Asia, Singapore, 2003.
- N. Som, Theory and Practice of Foundation Design, Prentice Hall, New Delhi, 2003.

After successful completion of this course, the students would:

- Learn about types and purposes of different foundation systems and structures. ➔ Have an exposure to the systematic methods for designing foundations.
- Be able evaluate the feasibility of foundation solutions to different types of soil conditions considering the time effect on soil behaviour.
- Have necessary theoretical background for design and construction of foundation systems.

Structural Analysis by Matrix Methods

Analysis of truss and frame structures using flexibility and stiffness methods of matrix analysis; computer applications.

Structural Mechanics

Beams under lateral load and thrust; beams on elastic foundations; virtual work and energy principles; principles of solid mechanics, stress and strain in three dimensions; static stability theory; torsion; computational methods.

Reinforced Concrete

Study of the strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces; extensive discussion of the influence of the material properties on behavior.

Structural Analysis-II

Analysis of building frames; Kani's, moment distribution and other methods and Approximate methods; Stiffness matrix method; Application to simple problems of beams and frames; Flexibility matrix method; Application to simple problems of beams and frames; Moving loads for determinate beams; Different load cases, Influence lines for forces for determinate beams; Influence lines for pin-jointed trusses; Influence lines for indeterminate beams using Muller Breslau principle. Influence lines for Arches and stiffening girders.

Decision and Risk Analysis

Development of modern statistical decision theory and risk analysis, and application of these concepts in civil engineering design and decision making;
Bayesian statistical decision theory, decision tree, utility concepts, and multi-objective decision problems; modeling and analysis of uncertainties, practical risk evaluation, and formulation of risk-based design criteria, risk benefit trade-offs, and optimal decisions.

Design of Concrete Structures-I

Study of the strength, behavior, and design of indeterminate reinforced concrete structures, Load and stresses, load combinations, Working stress and limit state approach. Analysis and design of sections in bending – working stress and limit state method,

Rectangular and T-sections, Beams with reinforcement in compression, One-way slab. Design for shear and bond, Mechanism of shear and bond failure, Design of shear using limit state concept, Development length of bars; Design of sections in torsion. Design of two-way slabs; Design of flat slab – direct method; Circular slab;
Slab type staircase, Placement of reinforcement in slabs; Voided slab. Design of compression members, Short column, Columns with uniaxial and bi-axial bending; Long columns, use of design charts. Design of foundation; Wall footing, Isolated and combined footing for columns. All designs to be as per the most recent BIS standards as applicable

Environmental Fluid Mechanics

Incompressible fluid mechanics with particular emphasis on topics in analysis and applications in civil engineering areas; primary topics include principles of continuity, momentum and energy, kinematics of flow and stream functions, potential flow, laminar motion, turbulence, and boundary-layer theory.

Unsteady Open Channel Flow

This course should discuss how to analyze for unsteady flows in open channels;
Derivation of 1-D and 2-D shallow water flow equations; Consideration for non-hydrostatic pressure distribution; Basics of numerical methods: FiniteDifference and Finite Element Methods; Latest shock capturing Finite Volume methods for solving 1-D and 2-D shallow water flow equations; Dam Break flow; Flood routing in large channel networks, Flood routing in compound channels; Flood routing in channels with flood plains, Surface irrigation flow modeling

Prerequisite: Basic course in Hydraulic Engineering

Environmental Laws and Policy

Overview of environment, nature and ecosystem, Concept of laws and policies,
Origin of environmental law, Introduction to environmental laws and policies,
Environment and Governance, sustainable development and environment, understanding climate change, carbon crediting, carbon footprint etc., Introduction to trade and environment. International environmental laws, Right to Environment as Human Right, International Humanitarian Law and Environment, environment and conflicts management, Famous international protocols like Kyoto.

Rock Mechanics

Determination of physical properties of rocks, failure criterion, rock mass classification, stress around mine openings, strain and displacement of the rock mass, rock reinforcement and support, subsidence.

Reference books:

- Engineering Rock Mechanics: An Introduction to the Principles by J. A. Hudson and J. P. Harrison
- Rock Mechanics: For Underground Mining by Barry H.G. Brady
- Fundamentals of Rock Mechanics, 4th Edition, John Conrad Jaeger, Neville G. W.
  Cook, Robert Zimmerman

On successful completion of this course the students will be able to:

- Define the properties (viz., physical, mechanical) of rocks and failure criterion of rock mass.
- Use engineering rock mass classification (RMR, Q-system, RQD)
- Analyse the stress distribution in situ and around an opening in underground structures (viz., mine openings, tunnels).
- Determine the relation between strain and displacement components of rock mass.
- Perform field Instrumentation techniques and laboratory studies. Understand the fundamentals of ground subsidence.

Earthquake Engineering

Theory of Vibrations; Concept of inertia and damping - Types of Damping -
Difference between static forces and dynamic excitation - Degrees of freedom - SDOF idealization - Equations of motion of SDOF system for mass as well as base excitation - Free vibration of SDOF system - Response to harmonic excitation - Impulse and response to unit impulse - Duhamel integral; Multiple Degree of Freedom System; Two degree of freedom system - Normal modes of vibration - Natural frequencies - Mode shapes - Introduction to MDOF systems - Decoupling of equations of motion - Concept of mode superposition (No derivations); Elements of Seismology; Causes of Earthquake - Geological faults - Tectonic plate theory - Elastic rebound – Epicentre; Hypocentre
- Primary, shear and Rayleigh waves - Seismogram - Magnitude and intensity of earthquakes - Magnitude and Intensity scales - Spectral Acceleration - Information on some disastrous earthquakes; Response of Structures to Earthquake; Response and design spectra - Design

earthquake - concept of peak acceleration - Site specific response spectrum - Effect of soil properties and damping - Liquefaction of soils Importance of ductility - Methods of introducing ductility into RC structures Design
Methodology IS 1893, IS 13920 and IS 4326 - Codal provisions - Design as per the codes - Base isolation techniques - Vibration control measures - Important points in mitigating effects of earthquake on structures

Transients in Closed Conduits

This course should cover key issues for understanding the unsteady flow in pipes (water hammer) and designing for surge protection; Differential equations for unsteady pipe flow; Characteristic method for solution; Formulation of boundary conditions; transients in pumping mains (power failure; pump start up); transients in penstocks of hydro-electric schemes; analysis for transient control using surge tanks; air chambers; air valves; pressure regulating valves etc.; Emphasis should be on development of computer programs for transient analysis; awareness about commercially available software for transient analysis

Prerequisite: Basic course in Hydraulic Engineering

Urban Hydrology and Hydraulics

Hydraulic analysis and design of urban, highway, airport, and small rural watershed drainage problems; discussion of overland and drainage channel flows; hydraulics of storm-drain systems and culverts; determination of design flow; runoff for highways, airports, and urban areas; design of drainage gutters, channels, sewer networks, and culverts.

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