Syllabus

Civil Engineering

1. Water Resources Engineering

Water resources systems: components of the system, objectives of water resources development, development, planning, and design, construction, and operation of water resources systems.

Introduction to drainage problems in different climates: Urbanisation, its effects, and consequences for drainage-interaction between urban and peri-urban areas.

The Hydrological Cycle: Global Water and Energy Budgets, Philosophy of Mathematical Models of Watershed Hydrology. Precipitation: Climate impacts of irrigation, Climate change and water resource sustainability, Human-water-climate interactions, formation and processes, Data availability, Spatial-temporal scale issues. Relationship between hydrology, meteorology, and climatology, Hydrometeorology, Importance of the study of hydrometeorology, Hydrometeorological extreme events, Characteristics of extreme events, Climate change impacts on hydrometeorology.

Dams: Different kinds of dams and the choice criteria, Environmental considerations
Gravity Dams: various forces acting and their analysis and representation, stability requirements, two-dimensional analysis, distribution of normal and shear stress, principal stresses, joints and their treatment.

Canals: Basic concepts of various canal design theories and their limitations. Design of weirs and canal structures on permeable foundations, Khosla's theory and applications. Design of canal falls

Fundamentals of Groundwater Flow: Occurrence of Ground Water, Vertical Distribution of G.W. Darcy's Law, Permeability, Porosity, Anisotropic Aquifers, Differential equations of G.W. flow. Potential Flow: Flownets, Boundary conditions, and Flow-net construction for confined & unconfined flow systems. Irrigation water system and management.

Concept of the watershed, introduction to watershed management, different stakeholders and their relative importance, watershed management policies and decision-making,

2. Environmental Engineering

- Physical,chemicalandbiologicalparameters,standards(drinkingwaterandwastewatereffluent),Gastransferprocesses,sedimentation,coagulationflocculation,disinfection,filtrationinwatertreatmentsystem.
- Water treatment system technologies to purify water.
- Fundamentalsofwastewatertreatmentssystem,detailsofdifferentaerobicprocessesandanaerobicprocesses
- Solidwaste(E-waste/C&D/biomedical/plastic)managementandtreatmenttechnologies
- Measurementandcontrolofprincipalairpollutants,globalchallengesofairpollution,measurementandcontrolofnoisepollution
- Concept and application of EIA
- LEED rating and Green Buildings
- Instrumentation for measurement of water/water water/air/noise

3. Disaster Assessment and Mitigation (DAM)

Hazard, Vulnerability and Risk Assessment

Introduction to Hazard: Definition ofhazard, Hazard estimation, Effect of hazard on structures.

*Vulnerability:*Definition of vulnerability, Methodologies of vulnerability assessment, Evaluation, Building Types, Micro & Macro methods, Intensity Scales, Damage probability matrix, Vulnerability functions.

Risk: Definition and components of risk, Fundamentals of risk analysis, Element at risk and their attributes, Seismic risk evaluation, Assessment for different disasters, Extreme event analysis.

Disaster: Direct and indirect damages, Ground failures in the past earthquake, Damage to structures, Associated damage due to fire, flooding and tsunami, Failure of embankments, dams and bridges.

*Disaster Mitigation:*The collection of data and information, Quantified risk assessment for industrial accidents; Release of toxics products, Dispersion analysis.

Natural and Manmade Disasters

Introduction to natural resources, Distribution of natural resources, Challenges, Natural disasters and their classification, Scales of disasters, Disaster Management Act and Policy, Institutional framework and mechanism, History and status of disaster management in India, Terminology and concepts in disaster risk management.

Earthquake Physics: Wave propagation, Wave types (compression, shear, surface), Attenuation; Causes: Tectonic plate motions, Magma movement, Isostatic rebound, subsurface fluid changes; Effects: No damage or massive damage, Tsunamis, Subsidence, Detection, Seismic network, Warning, Recovery; Updated building codes, Man mitigate damage. *Tsunamis Physics*: Pressure, Wave propagation, Causes: Earthquakes, Underwater landslides; Effects: Sudden rise and fall in sea level, Coastal damage, Loss-of-life; Detection: Seismic networks, Pressure gauges, Wave-height buoys, Warning, Siren, Recovery: Hampered by loss of infrastructure; Rebuild with knowledge that it can happen again, Upgrade facilities and infrastructure. *Volcanic Eruptions Physics*: Pressure, Density, Causes: Tectonic plate interactions, Hot spots; Effects: Lahars (hot mud flows), Nue Ardente (firey clouds), Lava flows over roads and buildings, Ash flows, Earthquakes, Detection: Small seismic network, Tilt meters, Laser ranging. *Landslides Physics*: Friction, Causes: Saturated soil, Unstable snow; Effects, Detection: Geologic profiles identify candidate areas, Snow depth, cohesion, etc. *Floods Physics*: Response time, Fluid flow, Causes, Excessive rain upstream, Channelizing Effects: Property loss, Life loss, Sedimentation, Change in course of river, Detection: Stream gauges, Forecast models of stream flow; Recovery: Move people & buildings, Build dykes, Flood control. *Nuclear accidents (TMI and Chernoble) Physics*: Nuclear energy, Half-life, Causes: Operational mistakes, Poor construction, Poor design; Effects: Radioactive fallout, Radiation sickness, Increased cancer rate, Detection: Radiation monitors, Radionuclide observations; Recovery: Clean-up & disposal of contaminated material, Iodine tablets. *Droughts*: Classification of droughts, Causes of droughts, Effects of droughts, Preventive measures of droughts, Drought management strategies.

Spatial Data Collection and Analysis

Basics of map reading, Types and sources of map, Cartographic representation of data, Map coordinate system, Projections and their types, Guidelines for preparing a base map, Thematic mapping.

Aerial photographs, Mosaic, Image interpretation - Elements and methods, Stereo-model.

Physics of remote sensing: Electromagnetic spectrum and spectral signatures, Types of remote sensing, Platforms and sensors, Active and passive sensors, Aerial photographs, Satellite images, Radars, Sensor characteristics, Resolution - spatial, spectral, radiometric and temporal, Image interpretation - Elements and methods, Image correction - Geometric, Digital image enhancement techniques (stretching, filtering), Classification: supervised and unsupervised, Application of remote sensing techniques in resource and environment mapping, Monitoring case studies.

Introduction to Microwave Remote Sensing.

Global Positioning Systems (GPS): Introduction to the GPS functions, Field operation of GPS and data collection using GPS, Basic concepts and components of GIS.

Climate Variability and Adaptation

Climate Change Policy Framework: Climate change as a problem, Impacts of climate change, Climate variability and natural resources, United Nations Framework Convention on Climate Change (UNFCCC), Background to the Convention and its aims, Kyoto Protocol and the Flexibility Mechanisms, Emission trading.

Mitigation: Mitigation and policy evaluation, Strategies and technology options, Climate change case studies.

Adaptation: Adaptation and policy evaluation, Strategies and technology options, Case studies of adaptation, Evaluation of the effectiveness of approaches in managing climate change risk, Effectiveness of policy approaches in reducing climate change and variability risk.

Geoinformatics and Its Applications

Geographical Information System: Components of GIS; Feature types, Spatial data models (raster & vector) - their advantages and disadvantages; Spatial data creation and management- methods, topology creation, editing and manipulation, attaching attribute data.

Spatial analysis: Single and multiple layer spatial analysis, Spatial querying; arithmetic and logical operations, 3D analysis, Spatial data visualization - map design and layout for thematic layers and display of tables and graphs using GIS software, Application of GIS in natural resources assessment and inventory, Change detection, Applications of GIS for assessment of disasters, Preparation of vulnerability maps for different type of disasters, Prioritization analysis for mitigation of different types of disasters.

Rehabilitation, Reconstruction and Recovery

Recovery and reconstruction: Introduction, Medium and long term recovery aspects, Community participation in defining objectives and their priorities, Disaster risk communication.

Rehabilitation: Physical and social infrastructure, Relocation and reconstruction of housing, public buildings, bridges, dams, archives and monuments, services such as water supply, electricity, waste

management, communication, capacity building for self-help construction, Numerical condition surveys for foundation, Structural and functional deterioration, Design criteria, Materials and techniques. Predictive performance models, Repair and retrofitting: Earthquake damages of buildings, their retrofitting and restoration, Superficial repair, Structural repair, Structural strengthening of habitable spaces, public buildings, roads, bridges, dams, culverts etc.

Disaster Resilient Structures and Retrofitting

Earthquake effects on the structures, Classification of loads, Seismic methods of analysis, Seismic design methods, Seismic damages during past earthquakes and effect of irregularities and building architecture on the performance of structures, Basic design considerations for multistoried RC and steel structure with foundation as per latest IS:1893, Capacity based design of building, Types of ductility, Factors affecting ductility, Ductile detailing as per latest IS:13920, Seismic design considerations for masonry buildings.

Fire safety of buildings, Effect of high temperatures on different types of steel and concrete structural members, Fire resistance by structural detailing, Analytical determination of the ultimate bending moment, Design of RC members for fire resistance, Introduction of IS:1642.

General characteristics of blast and effects on structures, Blast load on above and below ground structures, Response of structural elements to blast force, Dynamic strength of materials and design stresses, Load combinations for design, Introduction of IS:4991.

Sources of weakness in RC and Steel framed buildings, Classification of retrofitting techniques, Conventional and non-conventional methods, IS code provisions for retrofitting of masonry structures.

Disaster Response and Preparedness

Global Disaster: Global and Indian scenario, Science and policy, Institutional framework for disaster preparedness and mitigation, Managing natural and anthropogenic disasters, Principles and practice of disaster response operations and management, Disaster Planning, Public Administration/Policy and Emergency management, Incident command center, Training need analysis and human resource development plan, Corporate/public agency coordination, Human element in preparedness planning, Current trends in disaster preparedness. Hazard monitoring, tracking and modelling, Early warning systems, Warning protocols, Indian disaster resource network, Public health aspects of disaster management and emergency services systems, Urban hazards and disaster planning, Fire services preparedness, Emergency sanitation, Shelter environments, Conceptual and Applied Issues in Emergency Management: Operational decision making, Introduction to emergency management and planning, Organization and structure of emergency management, Emergency management research methods and analysis, Public information for emergency management, Principles and practice of disaster relief and recovery, Logistic support system, Computer applications in emergency management. Principles of natural hazard reduction, Toxicology and biohazards in emergency management, Terrorism Preparedness: Critical infrastructure and emergency management, Emergency preparedness, response, and planning for hazardous materials, Terrorism, WMD and other contemporary issues, Incident management systems and emergency operations center, Contingency planning, Community emergency response team, Community

relations for environmental and emergency managers, Contingency planning for business and industry, International disasters.

Disasters and Special Structures

Introduction to Special Structures and Their Uses: Bridges, Dams, Nuclear power plants, Thermal power plants.

Underground Structures: Tunnels, Subways and Storage Tanks, Pipelines, Railways, Roads, Retaining structures, Liquid storage tanks, Waterways, Reservoirs, Wastewater infrastructure and Offshore structures.

Performance of special structures during past disaster, Vulnerability of special structures, Health monitoring, Operations and maintenance, Potential threats and risk assessments, National and international policies, Environmental impact due to damage of special structures, Case study, Emergency plan and risk reduction, Post-Disaster recovery and reconstruction.

Geohazards and Mitigation Measures

Sudden Geologic Hazards: Earthquakes, Tsunamis, Liquefaction, Volcanic eruptions, Pyroclastic flows and Ash falls, Landslides and Avalanches, Rock falls and Debris flow, Glacial bursts, Flash floods, Geomagnetic storms.

Gradual Geologic Hazards: Geogenic groundwater contamination (arsenic, fluoride, etc.), Stream erosion, Coastal erosion, Alluvial fans, Salt water intrusion, Ground settlement, Ground subsidence and sink holes, Sand dune migration and desertification.

Mitigation Measures: Geosynthetics in hazard prevention and containment, Hazard warning systems, Engineering and construction measures in hazard mitigation, Adaptive urban planning in hazard mitigation.

Hydrometeorological Disasters, Adaptation and Mitigation

Hydrologic cycle, Relationship between hydrology, meteorology and climatology, Hydrometeorology, Importance of study of hydrometeorology, Hydrometeorological extreme events, Characteristics of extreme events, Climate change impacts on hydrometeorology, Hydrometeorological hazards and disasters, Flood, Drought, Storms and Heat & Cold Waves, Causes, effects and their impacts, Hydrometeorological hazard monitoring and forecasting, Early warning systems, Risk assessment and Socioeconomic responses, Resilience of communities to hydrometeorological hazards, Adaptation and Mitigation measures and considerations, Hydrometeorological hazard studies, their mapping and impact assessment.

Introduction to Sustainable Development

Introduction: Definitions of Sustainable development, Pillars, Principles, Evolution and parameters of sustainable development, Issues and challenges to sustainable development, MDGs, SDGs.

Tools for Sustainability: Environment management, Environmental legislations, ISO 14000, Life cycle assessment, Environmental impact assessment case studies,

Sustainable Engineering: Overview of Sustainable Engineering, Case studies in sustainable engineering, Sustainable waste water treatment, Solid waste, Sanitation practices/ methods, Nexus between technology and sustainable development, Financial sustainability.
Innovative Practices: Applications of sustainability, Sustainable development in urban system, Water conservation, Sustainable transport systems, Sustainable habitats.

Lifeline Services and Disasters
Water and Sanitation: Availability and supply of water, Water quality, Disinfection of water sources, Rehabilitating water distribution systems, Emergency treatment of drinking-water, Cleaning wells after seawater flooding, Hygiene promotion in emergencies, Measuring chlorine levels in water supplies, Planning for excreta disposal in emergencies, Technical options for excreta disposal in emergencies.
Power Sector: Generation, Transmission and Distribution System, Grid disturbance and disasters, Blackout, Causes of disaster in Power Sector, Major areas prone to disaster, Power system restoration, System Security, Safety of equipment for disasters, Hazardous and toxic materials and their management in power sector, Cyber Threats, Cyber security for Power Grid, Disaster Management in power sector.
Transportation System: Transport Infrastructure Systems, Interdependencies, Vulnerable systems, Potential threats and risks, Transportation disruption, Transportation disaster planning, Risk assessment, Preparedness, Mitigation, Response, Recovery, Transportation Resilience, Monitoring and assessment, Emergency response and risk reduction, Pre-disaster risk assessment and management, Policies, Institutions, and Processes, Technical-planning, operations and maintenance, Post-Disaster recovery and reconstruction.

Socio-Economics of Disasters and Disaster Finance
Disasters and the macro-economy, Public finance and disasters, Funding for Disaster Management – State Disaster Mitigation fund, State Disaster response fund (SDRF), National Disaster Response Fund (NDRF), Prime Minister National Relief Fund (PMNRF), Chief Minister Relief Fund and Role, Financing the cost of future disasters.
Information on Natural Hazards and Disaster Reduction, Financial management of disaster risks, Assessment of disaster risks, Financial vulnerabilities and the impact of disasters.
Insurance Policies for Disaster Management: Evaluation of risk funding and risk transfer policies, Catastrophe insurance pool, Reserve funds and contingent credit policies, Role of Government and market participants, Insurance policy design, Fiscal cost of relief and reconstruction, Grants and low interest loan for reconstruction.
Legal Considerations for Disaster Financial Management.

4. Geotechnical Engineering

Soil Mechanics: Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability – one dimensional flow, Seepage through soils – two – dimensional flow, flow nets, uplift pressure, piping, capillarity, seepage force; Principle of effective stress and quicksand condition; Compaction of soils; One- dimensional consolidation, time rate of consolidation; Shear Strength, Mohr's circle, effective and total shear strength parameters, Stress-Strain characteristics of clays and sand; Stress paths.

Foundation Engineering: Sub-surface investigations – Drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories – Rankine and Coulomb; Stability of slopes –Finite and infinite slopes, Bishop's method; Stress distribution in soils – Boussinesq's theory; Pressure bulbs, Shallow foundations – Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations – dynamic and static formulae, Axial load capacity of piles in sands and clays, pile load test, pile under lateral loading, pile group efficiency, negative skin friction.

5. Transportation Engineering

Highway Materials

Soil: classification, nomenclature, desirable properties, laboratory and field test, IRC/MORT&H standards, materials for low-cost roads, stabilized soil, lime, fly ash, and cement and soil-bitumen stabilization. Aggregate: classification, gradation, physical properties test, soil-aggregate and aggregate bitumen mixes, sub base, base and wearing course materials, quality manufacture of aggregates with respect to IRC/MORT&H specifications (clause 400) BM, soft aggregates, artificial aggregates, industrial waste as road aggregate, blending of aggregate by triangular chart, trial and error proportioning methods. Bitumen: origin, extraction, physical properties test, various terms related to tar and bitumen, uses and application of different bituminous material in highway construction, bitumen chemistry, constituents structure, ageing, rheology of bituminous binders, Adhesion, failures, weathering of bituminous road materials, bituminous mixes, requirements of bituminous mixes, Marshall and other methods of bituminous mix design, IRC/ MORT&H specifications (clause 500), bitumen modification. Cement: constituents, environmental issues concrete, properties of cement in fresh and hardened state, test methods, durability properties, mineral admixtures, material specifications, Concrete Mix Design.

Pavement Analysis and Design

Components of pavement structure, importance of sub-grade soil properties on Pavement performance. Functions of sub-grade, sub-base, base course and Wearing course. Effects of dual wheels and tandem axles, area of contact, tire pressure, CBR value of different layers, design methods for flexible pavement: sustainable cost-effective options for roads. Elements in design of rigid pavements: Wheel load, stresses, basic properties of concrete elasticity, shrinkage & creep, durability of Concrete, dry lean concrete, rigid pavement design, concrete mix design, admixture. Temperature stresses: Effect of temperature variations on concrete pavements. Combination of stresses due to different causes, Types of distress: structural and functional, serviceability, fatigue cracking, pavement deformation and low temperature shrinkage cracking, factors affecting performance. Pavement overlays: Flexible overlays and Rigid overlays. Micro surfacing, gap grading, cold mixes using emulsion and foam Bitumen etc. recycled material.

Intersection Analysis and Design

Type of intersection, general considerations for the location of various intersection types, principles of intersection design, types of maneuvers, relative speed, conflict points and areas, design surveys for intersection, intersection geometrics for various types including approach and exit details. Capacity and performance analysis of various types of intersections for various types of operation-capacity level of service, intersection delay, uncontrolled priority controlled and roundabout intersection- their capacity and delay analysis, and overall design. Design and operational evaluation of weaving sections. Design of speed change lanes and median lanes. Grade separated intersection and interchanges-types, suitability and economic justifications. Design of intersection controls-signalization design and analysis, turn control, general traffic control by islands, pedestrian control, signs, markings, intersections lighting etc. Road Safety Audit – Introduction, Case studies.

Transportation Planning

Transportation planning methodology, hierarchical levels of planning-statewide, regional, urban passenger and goods transportation. General concept and process of transportation planning. Urbantransportation planning, urban travel characteristics: private and public, travel behavior analysis. Travel demand estimation and

forecasting. Transportation Analysis Zone Design; Travel demand Analysis; Land use – Transportation Modelling; Route Planning; Decision support for Transportation Planning. Trip classification and socio-economic variable in trip making, trip generation; multiple regression analysis, category analysis, comparative study. Modal split analysis- traditional analysis, behavioralapproach to mode choice, two-stage modal split models. Trip distribution: Growth factor method, gravity model. Intervening opportunity and competing opportunity models, comparative study. Traffic assignment network assignment, capacity restrained.Land-use transport planning: Land-use transport intersections, transport related land use models and their use in transportation planning

Highway Construction

Classification of types of highway construction, Suitability of each type under Indian conditions, selection of base course and surface course. Earth work & Soiling: Selection of soils, construction of embankments, excavation and compaction equipment's. Field and laboratory tests for quality control. Stone soiling, brick soiling, current practices. Construction of earth roads, gravel roads, soil stabilized roads; water bound macadam, paved roads, bricks, stones. Bituminous construction: properties, requirements and specifications of materials, equipment's and plants. Detailed construction procedure of each type. Field and laboratory tests for quality control. Choice of binders under different conditions. IRC and MORTH specifications. Recommendations under Indian conditions: Bituminous surface treatments, interface treatments – primecoat and tack-coat, surface dressing and sealcoat, grouted or penetration macadam, bituminous bound macadam, bituminous concrete, mastic asphalt. Cement Concrete Road Construction: Necessity of providing a base course under cement concrete road. Selection of materials, construction methods, Quality control tests (lab. and field), Construction equipment's. Joints in cement concrete pavements: Classification of various types of joints, necessity, method of construction, load transfer devices, dowel bars, tie bars. Joint filler and sealer materials, IRC specifications. Reinforced Cement Concrete Road Construction:

Traffic Engineering

Introduction: definitions and normal scope of study within traffic engineering. Traffic characteristic: Review of road user characteristics and vehicular characteristics. Various traffic studies: i. Spot speed studies - data analysis and interpretations ii. Speed and delay studies- Purpose, course of delay, various methods of speed and delay studies. iii. Traffic volume studies and characteristics iv. Origin and destination studies: Various methods of O and D studies and sampling. v. Traffic capacity studies- Volume and density relationships, critical density, basic, possible and practical capacities. Factors affecting possible and practical capacities. vi. Parking studies and characteristics – Public interest in parking studies, cordon count, space inventory, parking practices. Evaluation of parking controls. vii. Accident studies and characteristics – Course of accidents, accident studies and records, reports, application of accident studies, preventive measures. Traffic controls and operations, a. Traffic regulations and various means of traffic control, traffic islands, rotaries & signals. b. Traffic management-Techniques and applications. c. Roadway Lighting-Design and layout.

6. Structural Engineering

Bending moment and shear force diagram; Analysis of trusses, arches, beams, cables and frames; Stiffness and Flexibility methods; Design of concrete and steel structures; Concrete mix design; Codal provisions; Working stress and Limit state design of beams, slabs and columns; Construction Management; Seismic analysis.