

Approved Program structure and syllabus of M Tech. in Dam Safety and Rehabilitation

(Programme structure approved by the Senate in its 100th meeting held on March 6, 2024, and syllabus approved by the Academic programme committee in its meeting held on July 12, 2024)

COURSE OBJECTIVES, STRUCTURE AND THE SYLLABUS

Course Objectives

The course objective is to train the sponsored officers and gate-qualified fresh engineers to deal with the complete life cycle of the dam and take up the challenges of safety and rehabilitation of the older dams and the design of new dams. To develop analytical, operational, and sectoral understanding, M. Tech. students will be exposed to a plethora of courses related to dam safety, which would enhance the qualitative and quantitative research methodology, policy aspects, and skills to devise appropriate solutions.

**INTERNATIONAL CENTRE OF EXCELLENCE FOR DAMS
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

Program Code: **XXX M.Tech. (Dam Safety and Rehabilitation)**
 Department: **International Centre of Excellence for Dams**
 Year: **I**
 Model: **2**

Teaching Scheme					Contact Hours/Week			Exam Duration	
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical
Semester-I (Autumn)									
1.	DSC-501	Hydrologic Safety Evaluation of Dams	PCC	3	2	1	0	-	-
2.	DSC-503	Reservoir Sedimentation and Silt Management	PCC	3	2	0	2	-	-
3.	DSC-505	Seepage through Dams	PCC	3	2	0	2	-	-
4.	DSC-507	Geotechnical safety evaluation of Dams	PCC	3	2	0	2	-	-
5.	DSC-509	Seismic Hazard Assessment for dams	PCC	3	2	0	2	-	-
6.		Social Science Course	SSC	2	-	-	-	-	-
		Total		17					
Semester-II (Spring)									
1.		Program Elective-I	PEC	3	-	-	-	-	-
2.		Program Elective-II	PEC	3	-	-	-	-	-
3.		Program Elective-III	PEC	3	-	-	-	-	-
4.		Program Elective-IV	PEC	3	-	-	-	-	-
5.		Program Elective-V	PEC	3	-	-	-	-	-
6.		Science, Technology, and Advanced Research-tools	STAR	3	-	-	-	-	-
7.	DSC-700	Seminar	SEM	2	-	-	-	-	-
		Total		20					

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**INTERNATIONAL CENTRE OF EXCELLENCE FOR DAMS
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

Program Code: **XXX M.Tech. (Dam Safety and Rehabilitation)**
 Department: **International Centre of Excellence for Dams**
 Year: **II**
 Model: **2**

Teaching Scheme					Contact Hours/Week			Exam Duration	
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical
Semester-I (Autumn)									
1	DSC-691	Internship Social Activity	ISA	5	-	-	-	-	-
2	DSC-701A	Thesis Stage-I	THESIS	10	-	-	-	-	-
		Total		15					
Semester-II (Spring)									
1	DSC-701B	Thesis Stage-II	THESIS	14	-	-	-	-	-
		Total		14					

Summary				
Semester	1	2	3	4
Semester-wise Total Credits	17	20	15	14
Total Credits	66			

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M.Tech. (Dam Safety and Rehabilitation)

Program Elective Courses

Teaching Scheme					Contact Hours/Week			Exam Duration	
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical
1	DSL-501	Assessing and Managing Risks Associated with Dams	PEC	3	2	1	0	3	0
2	DSL-502	Disaster Management and EAPs for dams	PEC	3	2	0	2	3	0
3	DSL-503	Dam Safety Surveillance, Instrumentation and Monitoring	PEC	3	2	1	0	3	0
4	DSL-504	Environmental Monitoring and Impact Assessment of Dams	PEC	3	2	0	2	3	0
5	DSL-505	Earthquake Geotechnical Engineering	PEC	3	2	0	2	3	0
6	DSL-506	Geospatial Techniques for Monitoring of Dams	PEC	3	2	0	2	3	0
7	DSL-507	Hydraulic design of spillways and energy dissipators	PEC	3	2	0	2	3	0
8	DSL-508	Contract and Financial Management	PEC	3	2	1	0	3	0
9	DSL-509	Seismic Safety Evaluation of Dams	PEC	3	2	0	2	3	0
10	DSL-510	Planning and Design of Hydro-Mechanical Components in Dams	PEC	3	2	1	0	3	0
11	DSL-511	Ground Improvement and Geo-synthetics	PEC	3	2	0	2	3	0

M.Tech. (Dam Safety and Rehabilitation)

Science, Technology, and Advanced Research-tools basket

Teaching Scheme					Contact Hours/Week			Exam Duration	
S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical
1	DST-501	Analysis of Dam Instrumentation Data	STAR	3	2	1	0	3	0

Social Sciences Course Basket

S.No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical
1	DSS-501	Sustainable Tourism around Dams	SSC	2	1	0	2	-	-

* 2 **DSS-502 Stakeholders Management of Dams and Large Infrastructure Projects, Credits (2), (1-1-0)**

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SYLLABUS (PROGRAMME COMPULSORY COURSES)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSC-501

Course Title: Hydrologic Safety Evaluation of Dams

L-T-P: 2-1-0

Credits: 3

Subject Area: PCC

Course Outlines:

Basic concepts of hydrological safety evaluation, Design flood estimation for gauged and ungauged catchments using hydro-meteorological approach; Design storm analysis; Design flood estimation for gauged and ungauged catchments using statistical analysis, Reservoir routing and spillway capacity determination, hydrologic and hydraulic channel routing; Dam breach modelling; preparation and revision of reservoir rule curves, Hydrological safety under changing climate, Comprehensive risk assessment and management, Gate operations and safety of gates.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSC-503

Course Title: Reservoir Sedimentation and Silt Management

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outlines:

Need of Silt Management in the Reservoir; Erosion and Sedimentation in Drainage Basins; Catchment area Development; Sediment Delivery Ratio; Reservoir Sedimentation Process; Incipient Condition and Sediment Transport; Sediment Yield; Trap Efficiency; Distribution of Sediment in a Reservoir; Sediment Measurement and Monitoring; Mathematical and Physical Modelling; Mitigation of Reservoir Siltation; Structural and Non-Structural Adaptive Measures; National and International Practices of Reservoir Sediment Management.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSC-505

Course Title: Seepage through Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outlines:

Importance of seepage in dam safety and rehabilitation, Flow through porous media, Darcy's law, seepage velocity, Dupuit's theory, Phreatic lines, free surface and seepage discharge. Flow nets, Boundary conditions, Numerical techniques; Measurement of seepage, seepage control, Seepage detection, control and monitoring; Selection of core materials, Dam filters and Design criteria; use of geo-textiles, stability conditions, Drainage of embankments, Dam Grouting, Design and installation of grout curtains.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSC-507

Course Title: Geotechnical Safety Evaluation of Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outlines:

Basics of Soil Mechanics; Basics of Rock Mechanics; Strength Behaviour of Intact and Jointed Rocks: Mohr envelopes, Linear and Non-Linear Strength Criteria; Geo-mechanical Modelling and Geological Hazards: Geological discontinuities, Classification Systems; Bearing capacity; Reservoir rim slopes; Retaining structures: Earth pressure theories; Design principles of gravity and embankment dams; Probabilistic methods in Geotechnical Engineering: Probabilistic analysis of slopes, foundations and retaining structures; Hazard, Vulnerability and Risk; Software analysis: Different software and their applications in designs

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSC-509

Course Title: Seismic Hazard Assessment of Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outlines:

Introduction to seismology; Causes of earthquakes, their classifications & their effects on Dam & structures; Plate tectonics; Internal structure of earth; Body & surface waves; Seismic phases; Intensity & magnitude, Principles of seismograph; networks; Probabilistic & deterministic Seismic Hazard Assessment; Earthquake occurrence models; maximum credible earthquake; design basis earthquake; Frequency magnitude relationship; Poissonian & Non-Poissonian models; GMP equations; Return periods; Geophysical Methods: Seismic; Well logging; SASW & MASW methods; GPR; bedrock profiling; Site Effects.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSS-501

Course Title: Sustainable Tourism Around Dams

L-T-P: 1-1-0

Credits: 2

Subject Area: SSC

Course Outlines:

Concept of sustainability and sustainable development. Concept of Sustainable Tourism around dams, issues, challenges and limitations. The current state of tourism around dams in India, UNWTO. The Framework Convention on Tourism Ethics, SF-MST, India's and different state's tourism policy, Socio-cultural problems and understanding feasibility assessment for dam tourism and its key components. Highlight best case studies and effective strategies for implementing agencies to enhance tourism around dams.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSS-502

Course Title: Stakeholder Management of Dams &
Large Infrastructure Projects

L-T-P: 1-1-0

Credits: 2

Subject Area: SSC

Course Outlines:

Relevance of stakeholder management in dam projects; Variety, variability & complexity of issues; Project impediments: social, environmental, legal, and associated issues of financing, contracts, resource management; Identification and classification; Networked effect; Stakeholder model for dam projects; Two-way process of stakeholder relationship; Level of relationship, Measurement of stakeholder value; Social & environmental safeguards; Stakeholder oriented organizations.

Note: The students are required to take at least one course from the social sciences basket. In addition to the above two courses which are offered by the ICED, students can be allowed to take a social sciences basket course floated by the other Departments.

SYLLABUS (PROGRAMME ELECTIVE COURSES)*

(* Subject to the approval of IAPC, which might take place in the month of October; The syllabus will indicate the broad topics only; Details are for the guidance of the teachers)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-501

Course Title: Assessing and Managing Risks Associated with Dams

L-T-P: 2-1-0

Credits: 3

Subject Area: PEC

Course Outlines:

Overview of Dams Risk Assessment and Management: Smart Governance and risk management, Risk analysis Formal Framework, Risk-informed decision-making and its importance in an integral Dam Safety Management Program, Dam Safety Program Fundamentals in USA, Spain, Argentina, Brazil etc.

Basis for a Risk-Informed Dam Safety Management Program for India: Dam failure risks worldwide, Dam failure risks in India, Lessons learnt from Risk Assessment and Management worldwide.

Initial Risk-Based Screening: Purpose of a risk-based screening tool, elements of the risk-based screening tool, brief reference to the Hazard Classification in India, dam safety inspections reports and DHARMA. Practical workshop or hands-on exercise.

Identification of Failure Modes: PFMA (Potential Failure Mode Analysis), types of failure modes and loading scenarios, the purpose of the failure mode identification, Identification and classification of Failure Modes, Identification of investigation and surveillance needs, Proposal of risk reduction actions. Practical workshop or hands-on exercise.

Semi-Quantitative Risk Analysis: Introduction, scope, and limitations of a semi-quantitative risk analysis (Failure probability categories Vs. Consequences categories), Prioritization of new studies or instrumentation. Practical workshop or hands-on exercise.

Quantitative Risk Assessment: Introduction, scope and limitations. Incremental Risk Concept, Failure modes structure, Risk model input data, Levels of Detail in Risk Calculation input data,

Event tree concept and calculation examples, Common Cause Adjustment, Risk Calculation in dam systems, Risk Representation (FN and FD Graphs). Uncertainty analysis in risk calculations. Practical workshop or hands-on exercise.

Risk Evaluation (Quantitative Risk Assessment): Introduction, scope and limitations on Risk Evaluation process. Tolerability Guidelines Worldwide (ANCOLD, USBR, USACE, other countries/agencies), Proposal and justification of Tolerability Guidelines for India, Definition and prioritization of risk reduction actions, Risk reduction principles, Relation between quantitative risk models and DRIP Guidelines. Practical workshop or hands-on exercise.

Portfolio Risk Management: Introduction, Risk-informed decision-making inputs, risk-informed decision-making process (conditioning aspects). Structure of Reports on Dam Safety Risk Assessment. Practical workshop or hands-on exercise.

Risk Governance: Introduction, Capacity building, Risk Communication, Overall Regulatory Framework, Review and quality assurance, Other Factors Affecting Decision Making- Climate Change, Inter-State Issues etc.

Institutional Framework in Dam Safety: Perspective of Institutional framework in Switzerland, USA, Australia; Existing Dam Safety Monitoring Mechanism in India-Dam Safety Organization (DSO), National Committee on Dam Safety (NCDS), National Committee on Seismic Design Parameters (NCSDP); Dam Safety Legislation in India-Historical Development, Important Provisions of the Dam Safety Bill 2019.

Overview of Dams Risk Assessment and Management; Basis for a Risk-Informed Dam Safety Management Program for India; Initial Risk-Based Screening; Identification of Failure Modes; Semi-Quantitative Risk Analysis; Quantitative Risk Assessment; Risk Evaluation (Quantitative Risk Assessment); Portfolio Risk Management; Risk Governance; Institutional Framework in Dam Safety.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-502

Course Title: Disaster Management and EAPs for Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Overview of Disaster Management and Flood Mapping: Disaster management cycle, Disaster Management Policies in India. Potential Uses of Flood Mapping in brief, Tiered Flood Modelling and Mapping Approach in India.

Flood Risk Associated with Dams: Types of Dams, Dam Failure concept, Estimation of consequences.

Disaster Mitigation: Warning and evacuation, do's and don'ts about disaster, damage survey for designing aid package, detailed survey for reconstruction, repair and retrofitting, post disaster survey, long term measures, codal practices.

Remote Sensing and Geographic Information Systems (GIS) applied to Emergency Preparedness and flood Mapping: Techniques, uses, importance, Planning the Mapping Process, Geographical Information System (GIS), GIS Software, Practical workshop or hands-on exercises

Dam Hazard Classification Framework in India: CWC Guidelines; Assessment of the Area Affected by Dam break; Failure Scenarios, Classification of the Dams in India Based on Hazard Potential; Potential Consequences Index Definition and Calculation Process (Additive-weighting scheme), Potential Implications of Hazard Potential Classification; Requirement for Emergency Action Plans (EAP) and their revision. Practical workshop or hands-on exercises.

Emergency Action Plans Preparation: Emergency management Organisation (Stakeholders), Relationship of the EAP document and the O&M manual. Establishment of emergency response protocols/procedures, Notification Flowcharts, levels of alerts and associated thresholds, preparedness actions/protocols, local evacuation plan [shelters, evacuation routes, warning time], communications networks, emergency resources and equipment. Practical workshop or hands-on exercises.

Emergency Action Plans Implementation: Stakeholder's Consultation Meeting (discussion-based exercise), mock-drill or tabletop exercise for EAP testing and improvement. Design of an incident management system, types, and design process of a warning system network in the flood plain. Integration of the Dam EAP with the District/State Disaster Management Plan. Practical workshop or hands-on exercises.

Environmental Management: Introduction; Existing Policies and Legal Framework; Procedure for Environment, Forest and Wildlife Clearances; EIA Procedure; Environmental Management and Control; External Funding Agency's Policy and Requirements on Environmental and Social Safeguards

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-503 **Course Title:** Dam Safety Surveillance,
Instrumentation and Monitoring

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PEC

Course Outlines:

Dam Safety Inspection Program: Types, preparing for an Inspection, Inspecting Embankment Dams, Concrete and Masonry Dams, Spillways, Outlets and Mechanical Equipment, Inspecting General Areas, Visual Inspection using remotely Operated Vehicles (ROVs), Use of Remotely Operated Underwater Vehicles (ROVs), Use of Unmanned Aerial Vehicles (UAVs)

Documenting an Inspection: Method, Checklist, Field Sketches, Photographs, Monitoring Data, Global Positioning Sensors (GPS), Inspection Notes, Visual Inspection Documentation, Writing an Inspection Report, Comprehensive Inspection Report.

Comprehensive Dam Safety Review: Procedures, Details to be provided to DSRP before inspection, Composition of DSRP, Reports of Comprehensive Safety Evaluation, Roles and the Responsibilities of Dam Safety Review Panel, Empanelment of Members of DSRP

Instrumentation and Monitoring: Monitoring Frequency, Measurement of Seepage and Leakage, Movement, Types of Movement, Reservoir / Tail water Elevations, Staff Gauge, Precipitation, Local Seismic Activity, Stress and Strain, Types of Pressure (Stress) Measuring Devices, Temperature, Critical Physical Data to be monitored, Data Evaluation.

Instrumentation System Planning: Embankment Dams: Instrumenting Existing Embankment Dams, Monitoring Seepage and Water Pressure, Monitoring Soil Stresses, Indian Standards Instrumentation System Planning, Instrumentation System Planning: Seismic Monitoring, Instrumentation of Existing Dam

Hydro-Meteorological Instrumentation: Measurement, Recording, Installation, Data validation, Errors in measurement of rainfall, temperature, relative humidity, wind speed, evaporation, snowfall, water level, suspended load etc.

Instrumentation Data Collection and Management: Introduction, Data Collection, Manual Data Collection, Stand Alone Data loggers, Real time Monitoring Networks, Advantages and

Disadvantages, Data Management and Presentation, Database software, Data Processing, Data Maintenance, Data Presentation, Critical Data Analysis.

Monitoring Data Organization and Analysis: Introduction, Design Aspects, Numerical Modelling, Back Analysis for Calibration, Dynamic Loading, Dynamic Analysis, Monitoring Data Analysis, The Purposes of Monitoring Data Analysis, Automatic Data Acquisition, Evaluation of Measurement Data, Data analysis and Evaluation Summary

Automation of Instrumentation: Power for remote equipment, Vandalism, Lightning protection, Notification protocols, Data Acquisition and Management

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-504

Course Title: Environmental Monitoring and Impact Assessment of Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Water quality issues: Impact of reservoir on water flow; Impacts on thermal regime; Water chemistry; Sedimentation; Nutrient enrichment; Water pollution; Emission of greenhouse gases; Climate change; Hydrological and water quality impacts; Soil and landscape changes; Agro-economic issues; Human health impacts,

Ecosystem resilience issues: Concept of an Ecosystem; importance of biological diversity; Destruction in ecosystem; Impacts on organisms and biodiversity; Influence in primary production; Effects on aquatic ecosystems; Value of ecosystem goods and services; Social and cultural impacts

Assessment of carbon footprints in dams

Guidelines and Standard Codes: Introduction; National and international legislative frameworks, codes; Future challenges

EIA methods and Tools: Introduction; basic principles of EIA for reservoir; Development of scope; Mandate and study design; Base line survey; Methodology for EIA; Economic approaches; Environmental Impact Statement (EIS) preparation; temporal and spatial scales; socio-environmental factors; Planning and reservoir management; case studies

Environmental Clearances: Introduction; Requirement for environmental clearances; Procedure for environmental clearances; Analysis of alternatives

Legal Issues: Introduction; Policy, legal and regulatory compliance; Statutory clearance approval and permissions

Societal considerations in dams: Societal considerations, Gender-related issues in Dam safety and rehabilitation

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-505

Course Title: Earthquake Geotechnical Engineering

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Introduction: Earthquakes, characteristics and distribution, tectonic features of the earth, geo-tectonic divisions of the Indian continent, geologic hazards perception. Background and lessons learnt from damages in past earthquakes.

Earthquakes in Different Geological Set-Ups: Geological structures and deformation pattern, inter and intra – continent set up, convergent zones, divergent margins, trenches, thrusts and faults. Earthquake implication of structural discontinuities, the impact of the neo-tectonic activity.

Mapping: Coordinate and coordinate systems; geographical and map projection system, 2D and 3D data transformation, types of maps, scales, map sheet numbering systems and uses, types of maps, introduction to topographical and geological maps, thematical maps, geological sections, data processing, analysis and presentation techniques.

Wave Propagation: Waves in semi-infinite media – one-, two- and three-dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium.

Dynamic Soil Properties: Stress & strain conditions, the concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross borehole; Evaluation of damping and elastic coefficients; Stress-strain behaviour of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils.

Ground Response Analysis: Introduction-, one-, two- and three-dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction.

Liquefaction: Introduction, pore pressure, liquefaction related phenomena – flow liquefaction and cyclic mobility; Factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS;

Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction.

Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations.

Seismic Slope Stability: Types of earthquake-induced landslides; Evaluation of slope stability – stability analysis with dynamic loading, friction circle method, effective and total stress methods of analysis, factor of safety, yield acceleration, damage potential, displacement analysis, effect of saturated and submerged conditions, FEM analysis of slope stability.

Remote Sensing in Earthquake Geology: Basic concepts of satellite imaging of ground, types of satellite data in identifying the tectonic features, recognising characteristics of earthquake deformation features, SAR interferometry for earthquake deformation studies; Application of GPS for mapping;

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-506

Course Title: Geospatial Techniques for Monitoring of Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Overview of Geospatial Technologies

Introduction to optical remote sensing and its applications to surface water changes; Fundamentals of Digital Image Processing

Introduction to microwave (SAR) remote sensing; InSAR processing and its application to dam monitoring and associated tools/software; Structural Monitoring of Dam Structures using SAR

Introduction to UAV sensing; various components of UAV; autonomous UAVs; UAV data collection and processing methods; Indian Regulatory Systems for UAV sensing

Introduction to LiDAR; LiDAR data collection methods; Application of LiDAR technology to dam monitoring

Introduction to GPS Systems; GPS data collection techniques; Application of GPS to dam monitoring

Monitoring of Catchment Characteristics using geospatial technologies: Snow covered areas and rain-fed areas

Monitoring of landslide zones using geospatial technologies and their representation in GIS

Application of geospatial technologies for land use/cover change monitoring in flood-prone downstream areas of dams and risk assessment

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-507

Course Title: Hydraulic Design of Spillways and Energy Dissipators

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Introduction to hydraulic structures and their necessity.

Embankment Dams: Types, design considerations, seepage analysis and control, stability analysis, construction techniques

Gravity Dams: Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam

Spillways: Types and their design, Ogee spillway, Chute and side spillway, Shaft spillway, Labyrinth and Piano Key Weirs, spillway gates, cavitation, aerators, inflatable rubber weirs, stepped spillway, nappe and skimming flow

Energy dissipators: Necessity, Types and their selection, design of hydraulic jump type stilling basins, Bucket and Flip type energy dissipators, Impact and pipe outlet

Supercritical flow, oblique jump, supercritical transition

Hydraulic modelling of spillways and energy dissipators, dimensional analysis, modelling of turbulence, friction, air entrainment etc., scale effects,

Life time assessment of dam and associated works

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-508

Course Title: Contract and Financial Management

L-T-P: 2-1-0

Credits: 3

Subject Area: PEC

Course Outlines:

Contract Management: Formation, Standard bid documents, tender and award of tenders, Online contracts, mistake and auctions, Breach and termination of contract, Impossibility of performance (force majeure clause), Forfeitures, loss and damages, Delays and liquidated damages, Risk, loss and indemnities, Condition, warranty, merchantability and quality of goods, Transportation, delivery, and Incoterms, Letters of credit, bank guarantee, and performance guarantee, Jurisdiction of courts, arbitration and dispute resolution, Confidentiality clauses and exemption/exclusion clauses, Contracts and taxation.

Financial Management, Financial Analysis: Introduction, uses, M&A, Private Equity, Equity Research, Career Opportunities, Skills Required

Financial Statement Preparation: Balance Sheet, Profit and Loss and Cash Flow, Revenues and Expenses, Consolidated Accounts, Tangible Assets, Goodwill, Depreciation

MS Excel: Spreadsheet Vocabulary, Logical & Statistical Functions, Data Validation, Custom List, Goal Seek, Scenarios, Data Manipulation, Pivot Tables and Macros

Accounting Basics: The Accounting Process, Accounting & Book-Keeping, Financial Terminologies, Accounting Concepts, the Accounting Cycle, Hindalco: Walk Through of Financial Statements

Ratio Analysis: Introduction to Ratio Analysis, Objectives of Ratio Analysis, Dupont Analysis, Types of Ratios, Simple Consolidation, Preparing Consolidated Statements

Financial Modelling: Create a Basic IB Financial Model, Types of Data & Variables, Growth Rates and Proportions, BEDMAS Principle

Forecasting and Modelling

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-509

Course Title: Seismic Safety Evaluation of Dams

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Introduction to Dams: Introduction to dams; Characteristics of embankment dams; Differences between embankment dam and other types of dams; Components of an embankment dam, functions and suitable materials; Zones of an embankment dam; Types of embankment dams: Homogeneous, Zoned and Diaphragm type dams; Influence of inclined and vertical core; Composite dams; Site selection for an embankment dam: Geology and seismicity of the dam site, Reservoir rim and basin, Construction materials, Suitable spillway location, Submergence aspects, and Construction infrastructure;

Case Studies Related to Dam Failures: Performance of embankment dams in past earthquakes; Causes of dam failure: Non-Earthquake conditions and Earthquake conditions; Different modes of dam failures; Inferences from various case studies: Teton dam, Machchhu dam failure, Hebgen dam, Los Angeles dam, San Fernando dam, and Sheffield Dam.

Stability Analysis of Dams: Effective and total stress methods of analysis; Analysis by Fellinius, Spencer, Bishop, Spencer method, Morgenstern price methods; Seismic slope stability methods: Inertial slope stability methods, Pseudostatic analysis, Displacement analysis; Pseudo-static analysis by Friction-circle, Fellinius and Bishop's methods; Factor of safety, yield accelerations and damage potential under saturated and submerged conditions; Displacement analysis by Newmark and Makdisi-Seed methods; Different loading cases for dam stability analysis: End of the construction, Partial submergence, Sudden drawdown, Steady state seepage, Sustained rainfall, and Earthquake; Slope protection measures

FEM for Dam Analysis: Application of FEM, Dam-foundation interaction; Identification of zones of hydraulic fractures and cracks; Nonlinear analysis, Tangent stiffness, Secant stiffness methods and No-tension analysis; Inertial and Weakening slope stability analysis; Modelling aspects: Element size, Domain size, Boundary conditions. Computer applications: Software to compute static & dynamic stresses induced, Deformations & displacements resulted, and Zones of liquefaction within the dam; Dynamic analysis of dams with examples;

Seismic Performance Criteria for Large Embankment Dams: Background; Integral dam safety concept; Seismic hazard a multi-hazard; Primary factors to consider in seismic design: Regional factors, Local factors; Selection of earthquakes for analysis; Seismic evaluation requirements; Seismic input parameters for analysis; The conceptual and constructional criteria for seismic-resistant fill dams

Design Response Spectra – Generation of Time History: Introduction, Standard code of practices; Synthesis of uncorrelated accelerograms: Modification of recorded accelerograms in time-domain, Modulated sum of harmon, Superposition of narrow-band time histories, Parametric time series modelling, Modification of recorded time history in frequency domain, Ground motion

synthesis in frequency-domain; Spatially correlated accelerograms: Modelling of spatial variation, Method of spectral factorization, Method of principal components.

Reservoir Rim and Basin Stability: Causes and effects of rim stability, methods for assessing rim and basin stability; Earthquake-induced landslide activity, Different types of earthquake-induced landslides and their assessment methods.

Assessment of Seepage Pressures: Seepage in earth and rockfill dams and their foundations, Different methods of seepage assessment; Standard analytical solutions for seepage problems, Piping and Liquefaction; Estimation of pore pressure by flow net and its construction: Confined flow and Unconfined flow; FEM analysis for the estimation of seepage pressures.

Guidelines for the Seismic Design and Construction of Embankment Dams: Different codal provisions: Core, Shell, Cut-off wall, Cut-off Barrier, Transition Zones and Transition Filters; Internal drainage system; Protective layers for erosion control; Free board; Parapet wall; Riprap;

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-510

Course Title: Planning and Design of Hydro-Mechanical Components in Dams

L-T-P: 2-1-0

Credits: 3

Subject Area: PEC

Course Outlines:

Introduction & Types of Gates: Brief history of development, Gates components, main applications, types and classification.

Selection of Hydraulic Gates: Selection criteria of Hydraulic gates.

Hydraulic Gates Design & Weight Estimation: Hydrostatic, load cases, allowable stresses, design of skin plate, horizontal beams, embedment, gate weight estimation.

Hydro-dynamic Forces: Hydro-dynamic forces (down pull, uplift, cavitation etc.), aeration, modeling, etc.

Gate Operating Systems: Gate operating forces, hoists (Hydraulic & mechanical).

Materials, Fabrication, Erection, Testing & Commissioning etc.: Materials, rubber seals, fabrication, transportation & erection materials, fabrication transportation, erection, testing & commissioning.

Hydraulic Gates for Dam Safety: Operation & maintenance of hydraulic Gates, rehabilitation, inspection, operation & maintenance, automation, etc. Recent trends & developments in Hydraulic gates engineering.

Practical Examples/ Workshops

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSL-511

Course Title: Ground Improvement and Geosynthetics

L-T-P: 2-0-2

Credits: 3

Subject Area: PEC

Course Outlines:

Basics: Principles of ground improvement, Types/Classification of ground improvement techniques. Mechanical modification, Types of compaction techniques, 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,

Methods of stabilizations: – Mechanical – Admixture (Cement/Lime) - Bituminous - Chemical. Types of admixture stabilisation- Grouting (permeation grouting, compaction grouting, jet grouting), Deep Soil Mixing, Mass Soil Stabilisation, Cutter Soil Mixing.

Grouting: - basic functions- permeation-compaction-hydro fracture, classification of grouts- grout ability ratio- properties of grouts - viscosity, stability, fluidity, rigidity, thixotropy, permanence
Grouting applications: - seepage control in soil and rock under dams- seepage control in soil for cut off walls – stabilization grouting for underpinning.

Properties of admixture stabilised soils, Design of hydraulic cut-off walls, grout curtains.

Geosynthetics: Properties of geosynthetics and its testing, 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. improvement of ground using geomembranes, geocells, geonets, geotubes

Reinforced earth: - Mechanism- types of reinforcing elements- reinforcement-soil interaction – applications- reinforced soil structures with vertical faces. Design of reinforced earth retaining walls, reinforced earth embankments structures

Advances in ground improvement technologies- thermal stabilisation, biotechnical stabilization, hydroseeding etc.

Case Studies: Different case studies in India and around the world in the field of Ground Improvement and Geosynthetics.

SYLLABUS (STAR COURSE)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: International Centre of Excellence for Dams (ICED)

Subject Code: DSR-000

Course Title: Analysis of Dam Instrumentation Data

L-T-P: 2-0-2

Credits: 3

Subject Area: STAR

Course Outlines:

Basics of time series analysis: Introduction to time-series data and model in context to dam instrument data; concept of trend, seasonality, cyclicity, and irregularity; data interpolation and forecasting; ARIMA model.

Introduction to programming: Essentials of programming with a focus on time-dependent data, conditional statements, loops. Read, plotting and processing time-dependent data. Understanding of object-oriented programming, data structure, and functions.

Essentials of probability: basics of probability density functions, homogenous and normal distribution, relationship with least-square solutions, covariance matrix.

Frequency domain analysis: Introduction to Fourier series, Fourier transform, Fast-Fourier transform, Wavelet Analysis, spectral analysis, spectrogram.

ANN: Introduction to Artificial Neural Networks, General Properties of ANN, Types of ANN and their Architecture, Activation Functions, Back-propagation Algorithm, Training and Evaluation

Fuzzy Logic Algorithm: Introduction to Fuzzy Logic Algorithm, Basic Concept in Fuzzy Systems, Fuzzy Model Application in Dam Operations

Genetic Algorithms: Introduction, Basic Units of GA, GA Operations, Multi-objective Optimization Applications in Dam Engineering.