CURRICULUM

MASTER IN CIVIL ENGINEERING

WITH
SPECIALISATION IN
IN

STRUCTURAL ENGINEERING

Structural Engineering Courses

Compulsory Courses					
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
CE-501 / CE-5101	Advanced Structural Analysis	3	CE-504 / CE-5104	Advanced Engineering Mathematics	3
CE-502 / CE-5102	Mechanics of Solids	3	CE-511 / CE-5105	Structural Dynamics	3
CE-503 / CE-5103	Advanced Reinforced Concrete	3			
Elective Courses					
CE 505 / CE-5106	Prestressed Concrete Design	3	EQ 521 / EQ-5121*	Displacement Based Seismic	3
CE 506 / CE-5107	Finite Element Method *(Prerequisite: CE 502 or Consent of*	3	EQ 522 / EQ-5122*	Performance Based Seismic	3
CE 507 / CE-5108	Advanced Concrete Technology	3	EQ 523 / EQ-5123*	Seismic Design of Steel and Composite Structures	3
CE 508 / CE-5109	Computer Methods in Structural Analysis	3	EQ 524 / EQ-5124*	Seismic Design and Assessment of Masonry Structures	3
CE 509 / CE-5110	Theory of Plates and Shells (*Prerequisite: CE 502 Mechanics of Solids*)	3	EQ 525 / EQ-5125*	Loss Estimation and Hazard	3
CE 510 / CE-5111	Structural Stability *(Prerequisite: CE 501 Advanced Structural Analysis)*	3	EQ 526 / EQ-5126*	Fundamentals of Fire Dynamics	3
CE 512 / CE-5112	Bridge Analysis and Design *(Prerequisite: CE 511 Structural Dynamics)*	3	EQ 527 / EQ-5127*	Seismic Vulnerability Assessment of Bridges	3
CE 513 / CE-5113	Seismic Analysis and Design *(Prerequisite: CE 511 Structural Dynamics)*	3	EQ 528 / EQ-5128*	Finite Element Method	3
CE 514 / CE-5114	Design of Tall Structures	3	EQ 529 / EQ-5129*	FRP Reinforced	3
CE 515 / CE-5115	Design of Steel Structures	3	EQ 530 / EQ-5130*	Fracture Mechanics of Concrete	3
CE 516 / CE-5116	Repair Maintenance And Strengthening of Reinforced Concrete Structures *(Pre requisite: CE 507 Advanced Concrete Technology)*	3	EQ 531 / EQ-5131*	Structural Fire Engineering	3
CE 517 / CE-5117	Performance-Based Design	3	CE 532 / EQ-5132*	Fire Safety and Management	3
CE-519 / CE-5118	Advanced Cementitious	3	CE 5022 / CE-5512	Forensic Engineering	3
CE-5002	Thesis	6			

COMPULSORY COURSES

CE 501/ CE-5101 Advanced Structural Analysis 3 Credit Hours

Matrix algebra, solution of equations, review of energy principles, virtual work; degree of redundancy, choice of redundants, flexibility method, kinematic indeterminacy, development of element stiffness matrices, stiffness method of analysis of structures, computer applications and software development, axial force effects and eigenvalue analysis, introduction to finite element method, introduction to structural stability.

CE 502 / CE-5102 Mechanics of Solids 3 Credit Hours

Introduction to Cartesian tensors; stress tensor and tensorial transformation of stress; Mohr's circle for 3-D stress transformation; dyadic and indicial symbols; finite and infinitesimal strain tensors; Mohr's circle for 3-D strain; constitutive equations for anisotropic material; composite laminates; two dimensional theories of yield; Airy's stress function in plane elasticity; generalized Fourier series solution to biharmonic equation; elasticity in polar coordinates; thermoelasticity; numerical methods in elasticity.

CE 503 / CE-5103 Advanced Reinforced Concrete 3 Credit Hours

Constituent materials and their properties. Material behaviour and common models in various loading regimes and application for concrete, steel and reinforced cement concrete. Analysis in flexure; known methods and theories, pre-cracking, post cracking and behaviour at ultimate load, analysis at discrete point on M-ø curve, moment-curvature relationships and ductility, non-linear analysis in flexure, effect of tension in concrete and tension stiffening load-deflection diagram, plastic rotation capacity and curvature ductility, deflection and crack control mechanism, recent researches in cracking and crack width, idealization and idealized models for analysis in flexure, analysis of prismatic non-prismatic sections in flexure. Shear in reinforced concrete; theories regarding diagonal tension problem, shear-flexure interaction, idealization, assumptions, assumptions, prevailing methods, their limitations and scope, ACI adaptation, Torsion as applied to concrete sections, strength of section in torsion for plain and reinforced concrete; review of theories, adaptation by code committee strength of section in combined shear and torsion.

CE 504 / CE-5104 Advanced Engineering Mathematics 3 Credit Hours

Numerical solutions of linear algebraic equations. Solutions of non-linear using first and second order iterative methods. Numerical differentiation and integration. Partial differential equations and finite difference methods. Eigen Value problems such as plates. Laplace equations. Applications of Legendre., Chebyshev, Hankal and Bessel Functions to Structural Problems. Application of Taylor Series, Runge Kutta Method. Calculus of Variation, Euler-Lagrange equations, Raleigh-Ritz & Galerkin techniques.

CE 511 / CE-5105 Structural Dynamics 3 Credit Hours

Single Degree of Freedom Systems: Formulation of the equation of motion and its methods of formulation, Free vibration response; undamped free vibration and damped free vibration; Response to different types of dynamic loadings and different methods of analysis of nonlinear structural response.

Multi Degree of Freedom Systems: Formulation of equation of motion and evaluation of structural property matrix, undamped free vibration, Vibration frequencies; mode shapes, orthogonality conditions, methods of practical vibration analysis and analysis of nonlinear systems, introduction to random vibration, Application of structural dynamics to earthquake engineering and methods of determinstic analysis, soil frame interaction.

ELECTIVE COURSES

CE 505 / CE-5106 Prestressed Concrete Design 3 Credit Hours

Basic concepts of prestressed concrete, Systems of prestressing, materials. Partial prestressing, prestress losses. Use of high strength concrete. Structural behaviour of Beams for Elastic and Ultimate ranges for Bending and Shear. Moment curvature relationship, Camber and deflections. Detailed design of simple and continuous beams for Service and Ultimate loads. Design of End Anchorages. Determination of Cable layout. Construction techniques. Precast and in-situ pre-stressed concrete members. Applications to special structures.

CE 506 / CE-5107 Finite Element Method 3 Credit Hours

(Prerequisite: CE 502 or Consent of Instructor)

Basic equations of elasticity; virtual work; stiffness properties of structural elements; variational and weighted residual methods, applications to trusses, beams, plane frames, two-dimensional, axi-symmetric and three-dimensional solids; higher order and isoparametric elements; field and time-dependent problems of fluid and heat flow; computational modelling.

CE 507 / CE-5108 Advanced Concrete Technology 3 Credit Hours

Raw materials, manufacturing, composition physical properties of Ordinary Portland Cement. Effect and implication of variation in composition and various blends of cement. Hydration process and product of hydration, volume changes upon hydration. Structure of the hardened cement paste, its deformational characteristic and mechanisms, strength of hardened cement paste and factors affecting the strength of hardened cement paste. Properties of rock and mineral aggregates used in concrete and its influence on strength and durability of concrete. Properties of fresh and hardened concrete, factors affecting the properties and its correlation with performance, and test and measurement of these properties. Hot and cold weather concrete, fiber concrete, mass concrete, recycled concrete and Ferrocment. Deterioration, causes and mechanism of deterioration of concrete with emphasis on some well known causes.

CE 508 / CE-5109 Computer Methods in Structural Analysis 3 Credit Hours

Introduction to finite difference calculus; applications in computing bending moments, shear force and deflection of beams, critical loads for columns and analysis of beams on elastic foundations; plate bending by finite difference; finite difference software development; introduction to finite element method; application to problems of Timoshenko beam and Mindlin plate bending with emphasis on software development.

CE 509 / CE-5110 Theory of Plates and Shells 3 Credit Hours
(*Prerequisite: CE 502 Mechanics of Solids*)

Equation of equilibrium and deformation. Cylindrical bending of Plates of Rectangular, Circular and other non-standard shapes. Classical methods of solutions. Navier, Levy Galerkin and Raleigh-Ritz methods. Strain Energy methods. Grillage and Orthotropic Plate theory. Applications of Finite difference and Finite Element methods. Large deflection of Plates. Geometric and material non-linearity.

Theory of Shells. Membrane and bending theories. Shells of revolution, Symmetric and non-symmetric loads applied to Cylindrical, Spherical and Conical Shells.

Study of existing experimental results for Shells with complex boundary conditions. Simplified design of Cylindrical shells. Domes and Folded Plates.

CE 510 / CE-5111 Structural Stability 3 Credit Hours
(Prerequisite: CE 501 Advanced Structural Analysis)

Introduction to common areas of stability problems in structures, conservative and non-conservative loads, elastic and inelastic buckling of columns; stability of members under combined bending and axial loads; buckling of frames; torsional buckling of open sections; lateral stability of beams and buckling of thin plates and shells; design considerations for stability.

CE 512 / CE-5112 Bridge Analysis and Design 3 Credit Hours
(Prerequisite: CE 511 Structural Dynamics)

Bridge loadings and bridge systems; types of deck structures and idealization; orthotropic plate theory and its application to multi-girder deck systems; use of finite difference and finite strip methods; composite steel girder-slab bridges, pseudo slab, girder-slab and multi- beam type prestressed concrete bridges, design consideration for substructures; analysis of horizontally curved bridge decks.

CE 513 / CE-5113 Seismic Analysis and Design 3 Credit Hours
(Prerequisite: CE 511 Structural Dynamics)

Introduction to wave propagation in solid media, body and surface waves, reflection and refraction. Causes of earthquake,review of the seismicity of earth with special reference to Pakistan; computation of response to lateral forces. Review of structural vibration theory and response spectrum. Methods for analysis of multi-storeyed buildings and others subjected to earthquake motions. Design of reinforced concrete structures to resist earthquake forces,

concepts of ductility and energy absorption. Reliability Analysis.

CE 514 / CE-5114 Design of Tall Structures 3 Credit Hours

Wind loads, Gust factors & Karman Vortices. Design for strength and stability, thermal loads, fatigue and corrosion. Behaviour of tall structures under static and dynamic loads. Design for buckling. Criteria for design of Chimneys, TV towers, Transmission towers and Tubular Scaffolding.

CE 515 / CE-5115 Design of Steel Structures 3 Credit Hours

Review of elastic-plastic concepts of structural behaviour; plastic design of beams and frames; design of plate girders, compression member with large width-thickness ratio, stiffened plate, composite design and behaviour, behaviour of rigid and semi-rigid connections; design considerations for fracture and fatigue; design of rigid frames; behaviour of multistory frames and second-order analysis.

CE 516 / CE-5116 Repair Maintenance And Strengthening of Reinforced Concrete Structures 3 Credit Hours

(Pre requisite: CE 507 Advanced Concrete Technology)

Review of engineering properties of conventional and prestressed reinforced concrete materials. Review of design theories and its implications. Review of deterioration and causes of deterioration of concrete structures and its implication on structures. Implication of debonding of reinforcing steel and analytical modelling of sections with unbounded reinforcement. Need of strengthening are re-strengthening. Prevailing strengthening techniques and their comparison. Recent researches in strengthening in flexure and shear, methodologies, analysis, design and execution. Strengthening techniques related to columns and foundations. Case studies of strengthened and re-strengthened structures.

CE 517 / CE-5117 Performance Based Design 3 Credit Hours

Mechanics of earthquakes and strong ground motion characteristics, response spectra and seismic response of elastic and inelastic systems, mechanical behaviour of structural members under earthquake excitations, seismic design philosophies, philosophy of seismic design for reinforced concrete structures, building code procedures for seismic design, advantages of performance-based seismic design, seismic performance levels, measures of seismic performance, seismic hazard, performance objectives, general approaches for estimating deformation capacity of the structures, response spectra, fundamental consideration of direct displacement-based design, analysis tools for direct displacement-based design, framed buildings, dual wall-frame buildings, masonry buildings, structures with isolation and added damping, pushover analysis.

CE-519 / CE-5118 Advanced Cementitious Composites 3 Credit Hours

Overview of the structure of cementitious materials, Physical, Chemical Composition and Microstructure of advanced cementitious materials. Characterisation techniques such as Scanning Electron Microscopy (SEM), X-Ray fluorescence (XRF), X-Ray diffraction (XRD). The properties to be studied include Fresh properties: Workability, Consistency, Rheology. Hardened properties: Physical, Mechanical, Thermal. Durability.

The cementitious composites to be covered include: High Performance Concrete, Self- Self-Consolidating Concrete, Self-Healing Concrete, Shotcrete, Fibre Reinforced Concrete, Cellular Concrete, Foamed Concrete AND Slurry-infiltrated Concrete (SIFCON). Pozzolan and Supplementary (waste) Materials: Silica Fume, Fly ash, Metakaolin, Rice Husk, Bagasse Ash

EQ 521 / EQ-5121* Displacement Based Seismic Design 3 Credit Hours

Philosophy and need for displacement based design (DBD), review of conventional force based design (FBD) methods with particular reference to seismic design codes, review for DBD methods, advantages of DBD over FBD with illustrative examples, seismic input for DBD method such as displacement spectrum; concept of hysteretic damping and displacement ductility; influence of displacement and ductility on spectral displacement response; attenuation model for displacement spectrum, fundamental considerations of DBD, design limit states and performance levels, single degree of freedom (SDF) structures, multi-degree of freedom (MDF) structures, p-delta effects, combination of seismic and gravity loadings, considerations for torsional response, capacity design of members, nonlinear analysis tools, force-displacement response for reinforced concrete members, force-displacement response for steel members, analysis related to capacity design philosophy, application of DBD in buildings, bridges and structures with base isolation and added damping.

EQ 522 / EQ-5122* Performance Based Seismic Design 3 Credit Hours

Mechanics of earthquakes and strong ground motion characteristics, response spectra and seismic response of elastic and inelastic systems, mechanical behaviour of structural members under earthquake excitations, seismic design philosophies, philosophy of seismic design for reinforced concrete structures, building code procedures for seismic design, advantages of performance-based seismic design, seismic performance levels, measures of seismic performance, seismic hazard, performance objectives, general approaches for estimating deformation capacity of the structures, response spectra, fundamental consideration of direct displacement-based design, analysis tools for direct displacement-based design, framed buildings, dual wall-frame buildings, masonry buildings, structures with isolation and added damping, pushover analysis.

EQ 523 / EQ-5123* Seismic Design of Steel and Composite Structures 3 Credit Hours

Elastic and inelastic behaviour of steel subjected to static and dynamic loading, mechanical behaviour of steel beams, types of connection, behaviour of connections, methods of global analysis, seismic design of steel structures using seismic design provisions, concepts of ductility, inter-storey drift; behaviour factors/force reduction factors and damage, capacity design

principles, typology of steel structures, effect of global instability, effects of diaphragms, semi-rigid connections and axial forces, seismic design of moment resisting steel frames; braced steel frames and composite structures, introduction to performance and displacement based design, hybrid force and displacement based design and use of advanced methods of analysis.

EQ 524 / EQ-5124*	Seismic Design and Assessment of Masonry Structures	3 Credit Hours

An introduction to masonry and non-engineered construction, mechanical properties of clay brick, cellular concrete block, autoclave aerated concrete (AAC) block, adobe and stone masonry units, categories of masonry walls for seismic resistance, in-plane and out-of-plane behaviour of masonry assemblages and walls, analytical methods for masonry walls, seismic design of masonry moment resisting wall frames and masonry-infilled frames, assessment of unreinforced masonry structures, design principles and code specifications for masonry construction, repair and strengthening techniques for damaged masonry buildings after earthquakes, displacement based design of masonry structures.

EQ 525 / EQ-5125*	Loss Estimation and Hazard Mitigation	3 Credit Hours

Modelling parameters, geometric nonlinearity and material inelasticity, concentrated vs. distributed plasticity modelling approach, nonlinear dynamic analysis, selection, scaling and matching of accelerograms, nonlinear static analysis, conventional pushover analysis, multi-modal pushover analysis and adaptive pushover analysis, nonlinear static procedures, capacity spectrum method (CSM), adaptive capacity spectrum method (ACSM), N2 method, modal pushover analysis (MPA) method and displacement based earthquake loss assessment (DBELA) method, seismic vulnerability assessment of single structures using nonlinear static and dynamic procedures with special reference to (FEMA) and Applied Technology Council (ATC) provisions, seismic vulnerability assessment of groups of structures (empirical and analytical methods), hazard, exposure, human/economic losses, remote sensing and global earthquake model (GEM) initiative.

EQ 526 / EQ-5126*	Fundamentals of Fire Dynamics	3 Credit Hours

Fire and its ingredients, chemistry and physics of fires, smouldering, fuels and materials, combustion process, fire combustion products and toxicity, forms of heat transfer, heat flux as an indication of damage, radiation form fires, piloted and auto-ignition, ignition time, diffusion and premixed flames, flame spread, flame spread rate, burning rate, fire development, fire growth rate, fully developed fires, fire plumes, compartment fires, fire spread, smoke movement, smoke spread, smoke hazard management

EQ 527/ EQ-5127*	Seismic Vulnerability Assessment of Bridges	3 Credit Hours

Bridge Typologies and Bridge components; Classification of Road Bridges; functional and operational requirements; Bridge planning and selection of Bridge site; Collection of bridge design data; Standard loading for bridge design and design process for highway bridges; Bridge management systems (process, characteristics and practice); Bridge management cycle; Bridge inventory data; Bridge inspection methods; Collection of bridge condition information; Bridge condition assessment (historical & recent perspective); Bridge assessment models and assessing

a bridge in terms of damage and defects; Aging and deterioration processes; Performance problems and threats; Identifying functional deficiencies; Recognizing reduced redundancy; Bridge condition ratings; Bridge condition index; Challenges associated with various bridge component rating methods; Seismic vulnerability and assessment of damage; Systematic evaluations of bridges based on failure modes; Fragility curves; Repair and retrofitting, Priorization; Optimization of retrofit methods

EQ 528/ EQ-5128*	Finite Element Method	3 Credit Hours

Basic equations of elasticity; virtual work; stiffness; properties of structural elements; variational and weighted residual methods; application to trusses, beams, plane frames, two- dimensional, axi-symmetric and three-dimensional solids; higher order and isoparametric elements; field and time-dependent problems of fluid and heat flow; computational modelling

EQ 529 / EQ-5129*	FRP Reinforced Concrete	3 Credit Hours

Basic equations of elasticity; virtual work; stiffness; properties of structural elements; variational and weighted Overview of FRP reinforcement; constituent materials for FRP; properties of FRP composites; design issues such as cover delamination, FRP debonding; design basis for FRP reinforcement and strengthening; flexure and shear design; serviceability design of FRP RC beams; FRP reinforcement detailing; flexure strengthening of beams and slabs; shear strengthening of RC members; FRP confining for columns; fire resistance and endurance of FRP reinforced structures

EQ 530 / EQ-5130*	Fracture Mechanics of Concrete	3 Credit Hours

Introduction to fracture mechanics; applications of fracture mechanics to concrete; principles of linear-elastic fracture mechanics; principles of nonlinear fracture mechanics; dynamic fracture mechanics; nonlinear fracture models; structure and fracture process of concrete; nonlinear fracture mechanics for mode I quasi-brittle fracture; test methods to determine mode I fracture properties for concrete; fracture resistance curves (R-curves) for quasi-brittle materials; tension softening response of concrete; applications of fracture mechanics to plain and reinforced concrete structures under static and temperature load

EQ 531 / EQ-5131*	Structural Fire Engineering	3 Credit Hours

Fire safety in buildings; fundamentals of fire behaviour in buildings; room fires and post-flashover fires; estimating the temperatures in building compartments and individual structural members; fire severity and the concept of equivalent fire severity; standard test results and calculation methods for fire resistance; fundamentals of the behaviour of common construction materials under fire; application of structural analysis principles to the fire problem; design of structures exposed to fire; fire resistance design of steel structures; fire resistance design of concrete structures; fire resistance design of lightweight frame structures

CE 532 / EQ-5132* **Fire Safety and Management** **3 Credit Hours**

Fire safety concepts; design fires; flame spread, modelling of flame spread and fire growth; external fire spread and heat radiation; smoke movement; buoyancy; principles of smoke hazard management; smoke spread; smoke hazard management subsystems; fire safety measures; fire safety system design principles, occupant evacuation; fire department response; qualitative and quantitative risk assessment; fire safety risk management; logic trees

CE 5022 / CE-5512 **Forensic Engineering** **3 Credit Hours**

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.

CURRICULUM

MASTER IN CIVIL ENGINEERING

WITH
SPECIALISATION IN
IN

GEOTECHNICAL ENGINEERING

Geotechnical Engineering Courses

Compulsory Courses					
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
CE 531/CE-5201	Advanced Soil Mechanics	3	CE 534/ CE-5204	Soil Investigation and	3
CE 532/ CE-5202	Foundation Engineering	3	CE 540/ CE-5205	Earth Retaining	3
CE 533/ CE-5203	Soil-Foundation Dynamics *(Prerequisite: CE 532 Foundation Engineering)*	3			
Elective Courses					
CE 535 / CE-5206	Earth Structures	3	CE 541 / CE-5211	Computer Applications in Geotechnical Engineering	3
CE 536 / CE-5207	Soil Stabilization	3	CE 542 / CE-5212	Geoenvironmental Engineering	3
CE 537 / CE-5208	Rock Mechanics	3	CE 543 / CE-5213	Transportation	3
CE 538 / CE-5209	Groundwater & Seepage	3	CE 5022 / CE-5214	Forensic Engineering	3
CE 539 / CE-5210	Subsurface Hydrology	3	CE 5002	Thesis	6

COMPULSORY COURSES

CE 531 / CE-5201 Advanced Soil Mechanics 3 Credit Hours

Physical characteristic of soils and their identification, clay mineralogy, clay-water relations. Numerical, mathematical and sketching solutions for simple steady-state flow problems. Stress in soil mass under applied stresses for two and three dimensional problems, equilibrium equations, stress invariants and octahedral stresses. One dimensional consolidation equation and its mathematical analysis, immediate and consolidation settlement analysis for thin and thick soil layers, plasticity or creep effetcs (Deconday consolidation).

Shearing strength of cohesionless and cohesive soils using Mohr-columb failure criteria. Critical state theory; representation of stress path on the Rendulic Plot, critical state live and equation, Roscor and Hvorseleve surfaces and their equations.

CE 532 / CE-5202 Foundation Engineering 3 Credit Hours

Properties of sub-surface materials for classification, Bore logs information for foundation selection. Selection criteria of foundation resting on various types of soils, foundation on non- uniform soils and rocks. Case studies of actual foundation problems. Development of theoretical bearing capacity equations for shallow and deep foundations under drained and undrained conditions. Design procedures and behaviour of different types of foundation. Introduction to seismic behaviour of subsoil and building foundations. Foundation problems solution by Finite Difference method, Reinforced earth, Beam on elastic foundation and Lateral thrust due to compaction of soil by rollers.

CE 533 / CE-5203 Soil-Foundation Dynamics 3 Credit Hours

(Prerequisite: CE 532 Foundation Engineering)

Vibration of elementary systems, foundation vibratory theory, foundation design for vibratory loads, foundation isolation, wave propagation theory, response of soils to dynamic loading, dynamic soil properties, field and laboratory methods for evaluation of dynamic soil properties, liquefaction of sands, vibratory compaction of granular materials.

CE 534 / CE-5204 Soil Investigation and Testing 3 Credit Hours

Purpose, planning of Subsurface exploration, Sub-soil investigation by conventional and geophysical methods. Sampling techniques: Standard static and dynamic laboratory tests for measurement of Soil Properties, In-situ groundwater conditions. Lab work related to the tests covered, report preparation.

CE 540 / CE-5205 Earth Retaining Structures 3 Credit Hours

Pressure on Retaining Walls. Basic Concepts and Earth Pressure Theories. Design criteria and Pressure Analysis of Rigid Walls with and without surcharge Loads. Effect of seepage and Drainage on Walls. Pile-supported Retaining Wall. Behaviour of Flexible Earth-Retaining

structures. Design Criteria and Pressure Analysis of Anchored Bulk Heads, Braced Out and Tie-Back Bracing system, Design criteria for cellular cofferdams. Behaviour of Retaining Walls during earthquakes.

ELECTIVE COURSES

CE 535 / CE-5206	Earth Structures	3 Credit Hours

Failure Mechanisms in Natural and Artificial Slopes. Stability Analysis for slopes in Cohesive, Non-Cohesive and C-phi soils. Use of stability charts. Steady state seepage problems in Earth Structures. Influence of surcharge, submergence and tension crack on Stability. Numerical Integration Analysis by Fellenius Method and Bishop's Simplified Method. Principles of Design and Stability Analysis of Earth and Rock Fill Dams under Drained and Un-drained conditions: stress Distribution and Deformation within the Dam and Foundation Strata. Effect of earthquakes on slope stability.

CE 536/ CE-5207	Soil Stabilization	3 Credit Hours

Principles and methods of altering engineering properties of soils. Mechanisms of soil stabilization. Mechanical, electrical and thermal stabilization. Specifications, construction and control methods. Types of compaction equipment. Optimum utilization of compaction equipments. Use of geo-textile fabrics for stability of soft & compressible soils.

CE 537 / CE-5208	Rock Mechanics	3 Credit Hours

Rock as Material, Rock Formation and Structure, Folding, Faulting and Joints. Analysis of Stress and Infinitesimal strain. Friction, Linear Elasticity. Strength of Rock and Cemented granular materials. Crack Phenomena and the Mechanism of Fracture. Fluid Pressure and Flow in Rocks. Brittle and Creep Behaviour, Determination of Static and Dynamic Mechanical properties of Rock in laboratory and field, Mining and other Civil Engineering Applications. Rock Slope Engineering.

CE 538 / CE-5209	Groundwater & Seepage	3 Credit Hours

Hydromechanics of confined and unconfined flow of water through soils, potential theory, conformal mapping transient flow. Applications to design of earth dams.

CE 539 / CE-5210	Subsurface Hydrology	3 Credit Hours

Introduction: Groundwater and hydrologic cycle, Groundwater as a Resource, Groundwater as geotechnical problem

Physical Properties and Principles: Basic principles of fluid flow in saturated and unsaturated materials Hydraulic Head and Fluid Potential, Darcy's Law, Hydraulic Conductivity and Permeability, Transmissivity and storativity, Aquifers and Aquitards, Steady State and Transient

Flow Equations of Groundwater Flow; Infiltration and Groundwater Recharge.
Groundwater Resource Evaluation: Development of Groundwater Resources, Exploration, Evaluation and exploitation, Well, Aquifer and Basin Yields, Exploration for Aquifers; Geological and Geophysical Methods, Drilling, Installation of Wells and Piezometers, Pumping Tests, Groundwater Quality, Well head Protection. Groundwater monitoring, Groundwater models—analytical and numerical models
Groundwater and Geotechnical Problems/Applications: Artificial Recharge, Seawater Intrusion, Drainage and Dewatering, Pore Pressure, Land Subsidence, Landslides and Slope Stability.

CE 541 / CE-5211 Computer Applications in Geotechnical Engineering 3 Credit Hours

Numerical solutions of partial differential equations, Finite difference Approximation solutions to two-dimensional flow field and one-dimensional consolidation Soil Layer. Finite Element Method application to stress analysis of Linearly elastic systems of Geotechnical Engineering problems. Soil-foundation Dynamics Interaction problems.

CE 542 / CE-5212 Geoenvironmental Engineering 3 Credit Hours

Introduction: Emergence of Geoenvironmental Engineering, Types of Geoenvironmental Problems.Chemical Background And Geochemistry: Toxic Chemicals, Inorganic Chemistry, Organic Chemistry, Nuclear Chemistry,Chemical Analysis Methods. Contaminant Transport Mechanism: Introduction, Sources of Contamination, Types of Contaminants, Transport Processes, Chemical Mass Transfer Processes , Biological Process (Biodegradation), Contaminant Transport and Fate Modeling, Applications. Contaminated Site Characterization And Risk Assessment: Preliminary Site Assessment, Exploratory Site Investigation, Detailed Site Investigation, Risk Assessment Procedures, Remedial Strategy. Waste Management And Landfill Design: Sources of Wastes, Classification of Wastes, Waste Characterization, Environmental Concerns with Wastes, Waste Management Strategies, Landfill Configurations, Waste containment liner systems, Containment System Liner Design, Leachate collection and removal system, Final cover systems, Gas generation and management, End uses of closed landfills..

CE 543 / CE-5213 **Transportation Geotechnics 3 Credit Hours**

Properties of geomaterials for design and construction of highways, airfield and port pavements. Embankments for highways and high-speed trains, Behavior of compacted geomaterials using stabilization technique. Geosynthetics and reinforcement of constructed layers and interlayers. Compaction technology, compaction management, maintenance technology. Underwater geotechnics for construction of breakwater, jetties, wharves and other coastal infrastructure purposes. Modeling of multi-layered structures and supporting ground under dynamic and repeated loads. Case studies.

CE 5022/ CE-5214 Forensic Engineering 3 Credit Hours

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert

testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.

CURRICULUM

MASTER OF ENGINEERING MANAGEMENT (MEM)

IN

WATER RESOURCES MANAGEMENT

WATER RESOURCES MANAGEMENT COURSES

Compulsory and Common Elective Courses					
Compulsory Courses			**Common Elective Course**		
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
EM-501	Organizational Systems	3	EM-511	Total Quality Management	3
EM-502	Accounting and Financial Management	3	EM-512	Project Evaluation and Feasibility Analysis	3
EM-503	Strategic Planning and Decision Making	3	EM-513	Research Methods in Engineering Management	3
EM-504	Project Management Framework and Tools	3			
EM-505	Operations Research	3			
Elective Courses					
CE-544	Quantitative Tools for Engineering Management	3	CE-591	Cost Engineering and Control	3
CE-545	Construction Claim Management	3	CE-592	Decision Making and Risk Management in Construction	3
CE-546	Vulnerability Analysis and Hazard Mitigation	3	CE-593	Construction Operations and Development of Technologies	3
CE-547	Housing for Developing Countries	3	CE-594	Bidding Strategy and the Legal Construction Environment	3
CE-548	Occupational Health and Safety in Construction Project Management	3	CE-595	Technical Entrepreneurship and the Management and Marketing of Construction Services	3
CE-549	Value Engineering in Construction	3	CE-596	Public Infrastructure Management	3
CE-550	Construction Productivity Management	3	CE-597	Real Estate Management	3
CE-587	Human Resource Management in Construction Industry	3	CE-598	Construction Failure Analysis	3
CE-588	Leadership in Construction Management	3	EQ-532	Fire Safety and Management	3
CE-589	Supply Chain Management in Construction	3	CE-5022	Forensic Engineering	3
CE-590	Advanced Topics in Project Management	3	CE-5002	Thesis	6
CE-5023	Building Information Modelling (BIM) for Construction Industry	3			

COMPULSORY COURSES

EM-501 Organizational Systems 3 Credit Hours

Definitions of management; Evolution of management thought, classical, quantitative and behavioural schools; Interactions between organizations and their environments. The planning process; Strategic and tactical planning, developing planning premises, nature of managerial decision making, quantitative aids, management by objectives. Organizational structures; Behaviour of the individual, work group, and organization; Coordination and spans of control, the informal organization; authority delegation and decentralization, groups and committees, managing organizational change and conflict. Motivation, performance and satisfaction; Building a high-performance team; Leadership, interpersonal and organizational communication, staffing and personal function. The control process; Budgetery and non-budgetery methods of control; Team performance measurement and improvement strategies. Use of management information systems.

EM-502 Accounting and Financial Management 3 Credit Hours

Foundations of finance with applications in corporate finance and investment management. Major financial decisions made by corporate managers and investors with focus on process valuation. Criteria for investment decisions, valuation of financial assets and liabilities, relationships between risks and return, market efficiency, and the valuation of derivative securities. Major corporate financial instruments including debt, equity and convertible securities. Analysis and projection of financial statements, cost elements in pricing, cost control and design of accounting systems.

EM-503 Strategic Planning and Decision Making 3 Credit Hours

Critical issues in shaping the competitive strategy for engineering-driven companies in a turbulent business environment; Corporate mission; Key Result Areas and situational analysis including strengths, weaknesses, opportunities and threats; Identifying planning assumptions, critical issues, setting objectives, formulating strategy. Managing technology as a strategic resource of the firm; Understanding of the process, roles and rewards of technological innovation; Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering and manufacturing; Government, societal and international issues; Issues pertaining to cultural diversity and ethical concerns. Subjective, judgmental and expert decisions; Conflict resolution in strategic decisions involving technological alternatives; Hierarchical decision modeling; Individual and aggregate decisions; Decision discrepancies and evaluation of group disagreements.

EM-504 Project Management Framework and Tools 3 Credit Hours

Role of projects in organization's competitive strategy; Standard methodologies for managing projects; Project life cycle; Design-implementation interface; Estimating: preliminary and detailed; Contractual risk allocation; Scheduling: PBS; WBS; Integration of scope, time, resource and cost dimensions of a project; Evaluation of labor, material, equipment, and subcontract resources; Scheduling techniques including CPM/ PERT, GERT, critical chain;

Solving real-world project schedules; Monte Carlo simulation; Cost budgeting; Cost baseline; Cash flow analysis; Earned value analysis; Cost control; Proposal presentation; Application of software for project management (MS Project, P3).

EM-505 Operations Research 3 Credit Hours

Deterministic modeling: Linear programming; The simplex method; Multiple objective linear optimization; Duality and sensitivity analysis; Post optimality analysis from the viewpoint of technology management; Transportation, transshipment, and assignment problems; Problem. formulation; Goal programming; Network analysis; Dynamic programming; Integer programming and nonlinear programming. Probabilistic modeling: Markov chains; Queuing theory and applications; Inventory theory; Forecasting; Design analysis and simulation; Pareto optimality and tradeoff curves.

COMMON ELECTIVE COURSES

EM-511 Total Quality Management 3 Credit Hours

Critical principles and procedures of quality management in a competitive global environment; contemporary definitions of quality; construction quality; Product quality; Process quality; Quality economics; Quality philosophies; Planning, organizing and controlling for quality; Human resource strategies; QA and QC tools.

EM-512 Project Evaluation and Feasibility Analysis 3 Credit Hours

Evaluation of engineering projects from the engineering management perspective; Techniques for capital investment for decision-making; Time value of money and the concept of equivalence; Present worth, annual and rate of return analysis; Multiple alternatives; Replacement criteria; Tax considerations; Breakeven sensitivity analysis; Project evaluations under uncertainty; Risk sharing; Capital budgeting; Cost of capital depreciation; Multicriteria decisions. Project feasibility analysis; Organizational impacts; Societal impacts; Environmental impacts.

EM-513 Research Methods in Engineering Management 3 Credit Hours

Research methods in engineering and technology management; Statistical techniques including proper selection; Use and interpretation of parametric and non-parametric tests along with factor and discriminate analysis; Design of experiments and model misspecification; Simulation in engineering and management research and practice.

ELECTIVE COURSES

CURRICULUM

MASTER IN CIVIL ENGINEERING

WITH
SPECIALISATION IN
IN

TRANSPORTATION ENGINEERING

Transportation Engineering Courses

Compulsory Courses					
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
CE-561/ CE-5301	Urban Transportation Planning	3	CE-564/ CE-5304	Probability & Statistics	3
CE-562/ CE-5302	Geometric Design of Highways	3	CE-569/ CE-5305	Pavement Analysis & Design	3
CE-563/ CE-5303	Advanced Traffic Engineering & Management	3			
Elective Courses					
CE-565/ CE-5306	Traffic Flow Theory *(Prerequisite: CE-564 Advanced Probability & Statistics)*	3	CE-571/ CE-5311	Waterway Transportation	3
CE-566/ CE-5307	Highway Materials & Construction	3	CE-572/ CE-5312	Transportation Systems Evaluation	3
CE-567/ CE-5308	Public Mass Transportation	3	CE-573/ CE-5313	Road Maintenance Management System	3
CE-568/ CE-5309	Airport Planning & Design		CE-5314	Railway Track Engineering	3
CE-570/ CE-5310	Transportation Economics	3	CE-5022/ CE-5512	Forensic Engineering	3
		3	CE-5002	Thesis	6

COMPULSORY COURSES

CE-56 1/ CE-5301 Urban Transportation Planning 3 Credit Hours

Coordination of City Planning and Transportation Planning. Trip generation, trip distribution, modal split, trip assignment models. Preparing landuse cum transport plans. Economic evaluation. Urban travel Characteristics and trends in travel demand. Basic urban transportation studies i/c origin destination surveys, Inventory use studies, Parking studies and transit surveys. Pedestrian facilities. Light rail and Mass Rapid Transit.

CE-562 / CE-5302 Geometric Design of Highways 3 Credit Hours

Design philosophy and present trends, Design controls and criteria. Design Speed, Safe Stopping & Passing Sight Distances, Road gradients, Superelevation. Capacity as Design control. Horizontal & Vertical alignments. Types of cross section, Speed Change Lanes, Medians, Design of at grade & grade separated intersections. Road-rail crossings, Road planning. Highway drainage, Roadside development. Design automation concepts and introduction to highway design software.

CE-563 / CE-5303 Advanced Traffic Engineering & Management 3 Credit Hours

Road inventory, Traffic measurements, flow, speed, road structures, driver, vehicle & pedestrian characteristic. Controlled & uncontrolled intersections. Signals, traffic light, road markings, traffic signs. One way and Tidal Flow System, Parking Controls, Environmental Management. Capacity Analysis of signalised and un-signalised intersections. Accident study and road safety. Intelligent Transport System

CE-564 / CE-5304 Probability & Statistics 3 Credit Hours

Probability: Concepts of Probability and their relevance to statistical analysis, Probability distributions relevant to transportation data analysis. Data Collection: Survey planning and design, traffic survey practice, inventory surveys, transport usage surveys, travel time and congestion surveys, matrix surveys, questionnaires and interviews, sources and use of secondary data, Statistics: Summary measures. Statistical distributions, confidence intervals, hypothesis testing, contingency tables, correlation and linear regression, ANOVA; Multivariate analysis

CE-569 / CE-5305 Pavement Analysis & Design 3 Credit Hours

Pavement type, stress distribution in pavements; theoretical and actual subgrade conditions & traffic loading, design principles, methods & criteria for flexible pavements, rigid & semi-rigid pavements. Design of special duty & temporary pavements. Environmental influences & effects, pavement overlays, Mechanistic Design of Pavements. Pavement Subdrainage.

ELECTIVE COURSES

CE-565 / CE-5306 Traffic Flow Theory 3 Credit Hours

(Prerequisite: CE-564 Advanced Probability & Statistics)

Traffic variables & parameters, ranges of traffic intensity, capacity of a roadway, bottle necks. Approaches to traffic flow theory, Traffic flow relationships, time-sequence diagram, Distribution of traffic variables, Head-way, speed distributions, traffic flow & different Queuing theory as applied to traffic flow, Traffic dynamics, Microscopic & Macroscopic models.

CE-566 / CE-5307 Highway Materials & Construction 3 Credit Hours

Properties & Usage of soil, sand & rock as highway materials. Modification & evaluation of their properties, Criteria for use & acceptance, testing, variability & Quality Control, requirements of crushed rock for surfacing, use of non standard material, material resources, in-service conditions & their effect on material performance.

Properties & use of bitumens, asphalts, tars & concrete as pavement materials, Rheology of bitumens, bituminous coating of aggregates, optimization of bituminous mixtures, Asphalt concrete mix design. Quality Control & performance of bituminous & concrete pavement materials.

CE-567 / CE-5308 Public Mass Transportation 3 Credit Hours

The development of public transportation, Urban passenger modes, Comparative analysis and selection of transport modes, perspective of transport & highway planning, managing and operating public transportation system, policy considerations, Unconventional systems. Mass and Rapid Transit Systems.

CE-568 / CE-5309 Airport Planning & Design 3 Credit Hours

Air Transportation, classification & size of airports, Air craft characteristics, Airport Planning i/c necessary surveys, Ground transportation facilities, Airport capacity & delays, Air traffic control, layout & design of runways, taxiways & aprons, layout & design of terminals & service facilities, Passenger, Baggage & Cargo handling systems, lighting, visual aids, Maintenance equipment & operations, Airport drainage.

CE-570 / CE-5310 Transportation Economics 3 Credit Hours

Economic function of Transportation; Economic Significance of Improved Transportation; Freight Rates and Locations of Industries and Markets; Technical and economic characteristics of different modes of transport; Development of transportation system in Pakistan including pricing, and regulation, railroads, highways, pipeline, water and air transportation; and the roles that these modes of transportation play in economic development; Economic efficiency of

various modes of Transport; Explanation of travel or shipping behaviour within the paradigm of microeconomic demand and supply theory. Transport project appraisal.

CE-571 / CE-5311 Waterway Transportation 3 Credit Hours

Ocean transportation: Planning, ship characteristics, Location & design of Ports & harbours, environmental factors, general layout, effect of wind, wave and tides. General & bulk cargo berths & their installations, Transit sheds, Warehouses & cold storage. Design & construction of Breakwaters and docks. Channel Regulation and demarcation of harbour.

CE-572 / CE-5312 Transportation Systems Evaluation 3 Credit Hours

Concepts and principles of transportation economic analysis, transportation costs and benefits, user and nonuser consequences, needs studies, finance and taxation, methods of evaluation of plans and projects, cost-effectiveness, environmental impact assessment.

CE-573 / CE-5313 Road Maintenance Management System 3 Credit Hours

Introduction to Road Maintenance management System; Need for adoption of Road, Maintenance Management System, Types of Road Maintenance-Routine, Periodic Preventive/Proactive, Road Referencing System, Road Database and its Management, Road Data Collection in the form of Road Inventory, Feature Condition Survey, Accident Data Collection, etc and introduction to state-of the art equipments, Works Programming i.e. Prioritization of Roads for Maintenance, Type of Distress and their treatment, Road Asset Management System (RAMS), Preparation of Road Business Plans, Procurement of funding for maintenance, Road Fund, Toll collection, Bridge Management System, Organization for Maintenance Management, Road Disaster Prevention System.

CE-575 / CE-5314 Railway Track Engineering 3 Credit Hours

Evolution and Structure of the Railway Track, Coning of Wheels and Canting of Rails, Functions and Types of Rails; Rails Joints, Design of Fish-plated Joints, Modern Development in Insulated Rail Joints; Historic Development and Requirements of Sleepers, Types and Design of Sleepers; Classification of Railway Curves, Degree and Radius of Curves, Realignment of Curves; Ballast and Formation, Formation Treatment Methods; Track Maintenance Practices: Manual and Mechanised, Track Management System; Track Construction and Track Rehabilitation; Derailment Investigation Methods.

CE-5022 / CE-5512 Forensic Engineering 3 Credit Hours

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample

removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.

CURRICULUM

MASTER IN CIVIL ENGINEERING

WITH
SPECIALISATION IN
IN

CONSTRUCTION ENGINEERING LAW

Construction Engineering Law Courses

Compulsory Courses					
Course Code	**Course Title**	**Credit Hrs**	**Course Code**	**Course Title**	**Credit Hrs**
CE-5011 / CE-5501	Fundamentals of Law and Legal Structures	3	CE-5014/ CE-5504	Construction Claims Preparation and	3
CE-5012 / CE-5502	Intellectual Property (IP) Protection and Professional Ethics	3	CE-5015/ CE-5505	Construction Disputes	3
CE-5013 / CE-5503	Construction Contracts and Procurement Law	3			
Elective Courses					
CE-5016/CE-5506	Fundamentals of Environmental Laws of Construction Industry	3	CE-5021/ CE-5511	International Perspective of Construction Law	3
CE-5017/ CE-5507	Construction Specifications Writing and Documentation	3	CE-5022/CE-5512	Forensic Engineering	3
CE-5018/ CE-5508	Construction Law Case Studies	3	CE-5024/CE-5513	Tort in Engineering	3
CE-5019/ CE-5509	Building Codes and Regulations	3	CE-5022/ CE-5514	Forensic Engineering	3
CE-5020/ CE-5510	Construction Law and Risk Management	3	CE-5002	Thesis	6

COMPULSORY COURSES

CE-5011 / CE-5501 Fundamentals of Law and Legal Structures 3 Credit Hours

The legal systems: Sources of law and court system; Basic Principles of Contract law; Sale of Goods Laws; Business Organizations; Money and Banking Laws; Health and Safety at Work; Agency; Property Law; Taxation Law; Contracts, Negligence, and Malpractice; Complaints, Motions, Trials, and Appeals; Partnership, Corporations, and Liability for the Acts of Others; Employment Law; Bankruptcy; Act of 1976 to make provision for the regulation of the engineering profession; Other pertinent laws.

CE-5012/ CE-5502 Intellectual Property (IP) Protection and Professional Ethics 3 Credit Hours

Overview of Intellectual Property Law; The Use of Intellectual Property in Business; Introduction to Patents; Obtaining Information from a Patent; Patentable Subject Matter and Utility; Requirement of Non-Obviousness for Patentability; The Patenting Process and Patent Application; Design Patents; Protection of information and communication related patents; Business method protection; Trademark; Ethical Reasoning and ethics for engineer ethics, norms and codes of professional conduct; Workplace rights and responsibilities; Ethics and research misconduct, authorship credits etc.

CE-5013/ CE-5503 Construction Contracts and Procurement Law 3 Credit Hours

Principles of construction contracts (basics, doctrines, and elements of contract.); Review of types of construction contract (DB, DBB, CMAA, CM@Risk); Overview of Standard forms of Contracts (PEC, AIA, FIDIC etc.); Design liability of engineers and contractors; Finance and management of contracts; Contractual obligations of employer, architect/engineer, and contractors; Concepts and processes in construction law including procurement; Right to payment, time, completion and liquidated damages; Public works procurement and tendering procedures; PPRA regulations, SPPRA regulations; New and emerging options including, integrated project delivery, public private partnerships, concessions and joint ventures, early and collaborative working, frameworks and alliances; Subcontracting and supply contracts; overview of international perspective of contracts and procurement.

CE-5014/ CE-5504 Construction Claims Preparation and Analysis 3 Credit Hours

Contract Administration for Claims and Claims Avoidance; Types of Claims; Construction contact errors; Unforeseen and changed conditions; Delays, disruptions, acceleration, termination, and proving of claims; Extension of time claims; Methods of Delay Analysis (Use of CPM techniques, Forensic Schedule analysis, window analysis, etc.); Claim for Additional Payments and its calculations; Construction claims related documentation; Claims preparation and presentation; Essential Elements of a Successful Claim; International perspective of construction claims.

CE-5015/ CE-5505 Construction Disputes 3 Credit Hours

Introduction to Construction Disputes; Starting point, causes and reasons of arise of disputes; Role of the Engineer in dispute avoidance; Dispute avoidance; Negotiation; Mediation; Arbitration ; Expert determination ; Early neutral evaluation ; Procedures of dispute resolution as per PEC rules, FIDIC, AIA and comparison among the requirements.; Overview of

Arbitration law in Pakistan and Arbitration Act of 1940; Dispute review and resolution boards; Litigation ; Multi-party Dispute Resolution.

ELECTIVE COURSES

CE-5016 / CE-5506 Fundamentals of Environmental Laws of Construction Industry **3 Credit Hours**

An Overview of Environmental Law and its Development; Legal and Administrative; Structures for their Implementation from the International, Regional and National Perspectives; Regulations and laws in Pakistan and the Laws of Selected Countries; Project Planning Applications, Permissions and Other Consents; Planning and Pollution Control; Site Hazards, nuisance and waste management; Environmental Impact Assessment; Environmental Crisis Management ; Application of Policy Issues in Environmental Management ; Political Economy of Environmental Regulations; Case studies.

CE-5017 / CE-5507 Construction Specifications Writing and Documentation **3 Credit Hours**

The role of specifications and construction project documents; Relationship between drawings and specifications; Types of specifications; Organization and formatting of specifications; Specification writing principles. Bidding documents, general conditions, special conditions; Bonds, guarantees and warranties writing; Specification resources and writing procedures; Modifications to bidding and contract documents; Computer Aided; Specifications writing; Specifications and plan interpretation; Case studies.

CE-5018/ CE-5508 Construction Law Case Studies **3 Credit Hours**

Case study and analysis of reported appellate decisions on common construction law issues on topics such as tort or negligence; Quantum merit; privity of contract, flow down clauses; suspension and termination; cases related to funding, penalty clauses; design liability; concurrent delays; insurance and bonding; landmark cases that lead to development of new legal doctrines (eg: Severin; Spearin doctrines); licensing; bid disputes; contract issues; construction lien law; surety problems; and unresolved claims; international construction project related case studies

CE-5019/ CE-5509 Building Codes and Regulations **3**

Study of building codes required at city, provincial, and federal levels and their relation to quality control. These may include (but not limited to): Conduct and Consulting Byelaws; Construction and Operations Engineering Works Byelaws; Code of Ethics and Conduct; Building Code of Pakistan; Building Code of Pakistan-Energy Provisions; Building Code of Pakistan Fire Safety Provisions; Building Control and Town Planning Regulations; Land Regulations; Different Development Authorities and their regulations; Overview of Regional Codes; Overview of International Codes; Comparative assessment of national vs. international codes and regulations.

CE-5020/ CE-5510 Construction Law and Risk Management 3 Credit Hours

Risk Management Essentials; Risk and legal aspects during project inception, feasibility and financing, procurement model selection; Risk identification and mitigation strategies employed during the delivery phase and their role in avoiding unnecessary disputation; Allocation of Risks through Contracts; Philosophies and commercial drivers affecting risk allocation in contracts and consultancy agreements; Security for performance mechanisms and instruments; Risk Insurance mechanisms in Construction; Insurance products available to the construction industry and related laws; International best practices in Risk insurance; Managing sub-contract/suppliers risk; Need for documentation, written procedures and maintenance of risk records; Construction Law & Risk Management Cases Studies

CE-5021/ CE-5511 International Perspective of Construction Law 3 Credit Hours

International Construction Projects; Typical Hazards in International Construction Business; Civil law vs. Common Law; Common delivery methods and international construction; Unification and standardization in International Construction Projects; Aspects of Price, time variations, and claims; FIDIC Contracts; AIA Contracts; Overview of Construction terms in different languages, such as; Chinese, Czech, English, French, German, Hungarian, Polish, Portuguese, Russian, Spanish; The influence of national culture on the preparation, evaluation and negotiation of time and money claims on international construction projects; International Projects Dispute Resolution; Projects funded by International Funding Agencies (World Bank, ADB, AIDB); Case studies

CE-5022/CE-5512 Forensic Engineering 3 Credit Hours

Introduction to Forensic Engineering; Competencies and Qualifications of Forensic Engineers: qualifications, attributes competencies, technical skills, legal knowledge, detective skills, communication skills, personality characteristics etc. The Standard of Care: expert testimony, methods, validity, reliability, Delphi process of expert consensus; Civil Engineering Investigations: activities in investigation, site investigation, sampling and collection of evidence, preliminary findings, equipment and its selection, recording observations, photography, sample removal, eyewitness account, field tests, document collection and review, theoretical analysis, laboratory tests and investigation, office investigations determination of procedural responsibilities, reports; Ethics of Forensic Engineering: code of ethics, solicitation of work, contract process, testimony ethics, damage caused by unethical conduct, ethical standards for publication, interaction with media; The Legal Forum: role of forensic engineer as a witness in mediation and litigation, admissibility of testimony by forensic engineers, rules of evidence and testimony, testimony in courts and at deposition (preparation, demeanor, speech, direct examination, cross examination etc.), codes and guidelines (local and international) for professionals engaged as experts; The Business of Forensic Engineering: readiness, marketing, decisions, liability, insurance individual and group practice; National and International Case Studies.