

List of PhD Courses approved in the Department of Civil Engineering

Sr.	Course Code.	Structural Engineering Course Title	Credit Hrs	Course contents
1	CE-611	Advanced Mechanics of Materials	3	Three-dimensional stress analysis; strain energy; Elastic anisotropy ; energy methods; Introduction to composite mechanics; finite element method; fracture mechanics; fatigue; Damage mechanics Plasticity; Concrete Plasticity; Elastic perfectly plastic fracture models; Elastic-hardening plastic fracture models; Viscoplasticity/creep
2	CE-612	Nonlinear Finite Element Methods	3	Overview of Nonlinear Problems; Sources of nonlinearities in structural problems; General features of nonlinear response; Formulation of Geometrically Nonlinear Finite Elements; Residual and incremental forms; Finite element Total Lagrangian and corotational formulations; FEM nonlinear equilibrium equations; Solution of Nonlinear Equations; Classification of solution methods; Increment control techniques; Augmented equation methods; Incremental and pseudo-force methods; Newton methods; Secant (quasi-Newton) methods; Acceleration and line search; Dynamic relaxation; Computer Implementation of Nonlinear Analysis; Applications to Structural Stability
3	CE-613	Strengthening and Retrofitting of Concrete Structures with Bonded Composites	3	Need for strengthening and retrofitting, review of member-level and structure-level retrofit, properties of fibre reinforced polymers (frp), adhesives and cement-based composites, strengthening techniques, basis of design, strengthening and retrofitting strategies, behaviour, mechanics and dimensioning of members strengthened and retrofitted in flexure, shear and through-confinement, detailing and practical execution, strengthening of masonry with composites, design models for frp-strengthened masonry, durability, case studies and design examples.
4	CE-614	Concrete Durability	3	Review of the fresh and hardened properties of concrete Introduction to the durability problems in concrete structures, Mechanisms of concrete deterioration, Microstructure of damaged concrete, Durability tests, Factors affecting durability, concept of durable concrete design considering national and international code specifications, Principles governing durability, Overview of the mathematical Model(s) for the durability of Concrete
5	CE-615	Recycled Aggregate Concrete	3	Review of the physical and chemical properties of aggregates as constituent of concrete Background / history of the use of recycled aggregates in concrete, physical and mechanical properties of recycled aggregate, difference of the properties of natural and recycled aggregates as a constituent of concrete, Importance of the selective demolition for the production of recycled aggregates, Recycled aggregates classification, contaminants in recycled aggregates, chemical composition of recycled aggregate, properties and composition of recycled aggregates from construction and demolition waste suitable for

				concrete production, size and shape, density, water absorption Recycled aggregate concrete (RAC) – Fresh and hardened properties, microstructure of recycled aggregate concrete, techniques for improving properties of recycled aggregate concrete, durability properties, techniques for improving durability properties
	CE-616	IMPACT ANALYSIS FOR STRUCTURAL MEMBERS	3	Strain-Rate-Sensitive Behaviour of Materials (with emphasis on the concrete and steel) under various simple dynamic loads; Quasi-Static Behaviour, Quasi-Static Method of Analysis, Impact of a Mass on a Fully Clamped Beam, Quasi-Static Method of Analysis with Finite-Deflection Effects, Influence of Finite-Deflections in a Fully Clamped Beam Subjected to an Impact Loading; Static Plastic Behaviour of Beams, Basic Equations for Beams, Plastic Collapse Theorems for Beams; Dynamic Plastic Behaviour of Beams, Governing Equations for Beams, Simply Supported Beam Loaded Impulsively, Impact of a Mass on a Fully Clamped Beam, Impact of a Cantilever Beam
	CE-617	ADVANCED CEMENT-BASED MATERIALS	3	Properties of cement-based materials as Micromechanics and transport properties, fresh and hardened properties including durability. Microstructure, Interfacial effects on cement-based materials. Mix design methods. Specifications, design guidelines and standards. Influence of different types of pozzolans including but not limited to fly ash, silica fume, ground granulated blast furnace slag, metakaolin, bagasse ash and rice husk ash etc. along with practical aspects. Strength enrichment using chemical admixtures, fillers and or fibers. Hydration of cement with emphasis on chemistry. Structural mechanics and applications of cement- based composites such as self-consolidating concrete, high performance concrete, self-healing concrete, shotcrete, fiber reinforced concrete, roller-compacted concrete and rubberized concrete. Cellular concrete; Foamed concrete and Slurry infiltrated concrete (SIFCON)
	CE-518	ADVANCED CHARACTERIZATION TECHNIQUES FOR CEMENTITIOUS MATERIALS	3	Physical, Chemical, and thermal characterization techniques such as Laser diffraction particle size analyzer (LDP), Energy dispersive X-Ray (EDX), X-Ray fluorescence (XRF), X-Ray diffraction (XRD), Thermal gravimetric analysis (TGA), Transient plane source (TPS), calorimetry. Working mechanism, Result analysis. Measurement of different parameters along with chemical shrinkage. Any other related technique. Macro and microstructural techniques such as Scanning electron microscopy (SEM), X-ray tomography (CT Scan). Working mechanism. Result analysis with image visualization and analysis software. Short introduction to thermodynamic modelling. Non-Destructive techniques such as: Nuclear density, Rebar inspection in hardened concrete, and radiography inspection.
	Geotechnical Engineering			
	Course No.	Course Title	Credit Hrs	Course contents

1	CE-621	Advanced Experimental Techniques in Geomechanics	3	Isotropic consolidation testing techniques, Advanced Triaxial Testing of soil and rocks, Measurement of elastic parameters, X-rays for Geomechanics, 2D and 3D Digital Image Correlation, Scanning Electron Microscopy (SEM) Analysis, Ultrasonic measurement (ultrasonic tomography) in experimental Geomechanics, Elastic Wave Propagation in Soils, Electromagnetic Wave Propagation in Soils, Geo-microbial -investigation techniques, Geo-chemical investigations, Geothermal properties and testing of soil and rocks, Introduction to centrifuge testing of soils.
2	CE-622	Computational Geomechanics	3	Introduction to Finite Element Methods, Use of Finite Element Methods in Geomechanics, Constitutive laws for geotechnical materials: linear elastic, nonlinear elastic, linear elastic-perfectly plastic and nonlinear elasto-plastic Elastic-perfectly plastic properties of soil, Constitutive soil models: elastic properties, yield criterion, flow rule, elastic-plastic stiffness matrix, selection of soil parameters, Stress paths: foundation loading, slope stability, stress path, 2D and 3D stress spaces, examples of stress paths, pore pressure changes, application of stress paths, The critical state framework for modelling soil behaviour.
3	CE-623	Advanced Soil Stabilization	3	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 equipment's, Use of geotextile fabrics for stability of soft & compressible soils, Analysis of geotechnical problems: affecting site use including weak, compressible soil; high shrink-swell potential; and liquefiable soils, Components of stabilization: lime, cement, fly ash, natural fibres (wheat straw, rice husk, etc.), artificial fibres (Geosynthetics), organic matters, chemicals, bitumen, The selection of the type and determination of the percentage of stabilizing agents, Methods of stabilization: Vibro-compaction technique, vacuum consolidation, Soil nailing, using natural/artificial fibre, Using bio-enzymes.
4	CE-624	Submarine Landslides and Tsunami	3	Submarine slope systems, Submarine Landslides, Tsunami generation, Occurrence, Distribution and Scale of Submarine Landslides, Energy Transfer from landslide motion to water motion, Weak geological layers, Over-pressuring, Earth quick, Storm Wave Loading, Gas

				Hydrates, Ground water seepage, Glacial loading, volcanic island growth, Over-Steepening, Hazard Estimation, Modelling Tsunami by submarine landslides prediction and simulation methods, Potential impact assessment, Case Studies,
5	CE-625	ADVANCED SOIL DYNAMICS	3	
		Water Resources Engineering		
	Course No.	Course Title	Credit Hrs	Course contents
1	CE-601	Advanced Open Channel	3	Introduction to open channels. Open channel. properties. Energy and Momentum principles in open channel flow. Specific energy in non-prismatic channel. Specific force and Momentum Principle applied to non-prismatic channels. Critical flow and control section. Gradually varied flow. Practical problems in Gradually varied flow. Gradually Varied flow - Dynamic equations. Rapidly Varied flow and Hydraulic jump. Spatially Varied flow. Flow through culverts bridges and under the gates. Method.' of characteristics and its application to unsteady flow problem. Computation of water surface profile by using HEC-RAS software. Case study of Soan River water surface profile.
2	CE-602	Hydraulics of Sediment Transport	3	Hydro dynamic of fluid particle systems. Settling velocity of particles and effect of particles on the viscosity. Theoretical and experimental considerations, Bed and suspended loads. Total loads. Scour criteria and Related problems. The Regime concept. Bed form mechanics. Sediment measuring devices. Sediment transport in unlined channels. Model laws.
3	CE-603	Applied Probability and statistics	3	Statistics. Introduction. Type of data and variable. Presentation to data. Densification tabulation. Frequency distribution. Graphical representation. Simple and multiple bar diagram pie diagram. Histogram. Frequency polygon. Frequency curve and their types. Probability distribution & Transformation of variables: Uniform Binomial. Hyper geometric, Poison, Normal, Exponential, Chi-square, F, & T distributions; Random sampling; Sampling distribution of mean; Central limit theorem, Statistical inference & Hypothesis testing: confidence & significance level; Sample size determination; Point & interval estimates; Interval estimates for population mean, population standard deviation, & population proportion. Type I, & type II errors; one tail & two tail tests; tests concerning means & variances, Linear & Multiple linear regression & correlation:

				Simple linear regression; properties of least square estimates; confidence limits & tests of significance; choice of a regression model; correlation. Estimation the coefficients; adequacy of the model, Analyses of variance: one way classification; tests for the equality of several variances; Single degree of freedom comparisons; Multiple range test; Comparing treatment with a control; Comparing a set of treatments in block; Randomized complete block design; Random effects model, Factorial experiments: two-factor experiments; Interaction in two- factor experiments; Two-factor analysis of variance; Three-factor analysis; Choice of sample size. 2k factorial experiments: yate's technique for computing contrasts; factorial experiments in incomplete blocks; fractional factorial experiments; analysis of fractional factorial experiments.
4	CE-604	Similitude and Hydraulic Models	3	Dimensional Analysis. Hydraulic similitude. Dimensionless numbers. Fixed bed river and structural models. Movable bed river models. Distorted scale models and interpretation of results. Regain theory in models. Model. materials and construction. Case studies of hydraulic models of major river/ canal projects completed in recent past in Pakistan.
4	CE-605	Alluvial Channel Design	3	Introduction to alluvial channels. Properties of alluvial soil. Problems of design of unlined channel. Rational Approach. Duboys bed load function. Einstein's bed load formula. Suspended load function. Maximum permissible velocity. Design based on above approaches. Tractive force method. Kennedy's silt theory and modification. Lacey's regime concept. Lacey's equation and diagram. Further development in Lacey's theory. Blench method. Simons Albertson method. Examples based on above methods and their comparison. Recent methods. Hydraulic design criteria. Munir Quraishi method causes of failure of lining. Case studies of Rohri canal.
5	CE-606	Earthen Structures	3	Failure Mechanisms in natural and artificial slops. 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. Relevant case studies to be incorporated.
		Construction Management		
	Course No.	Course Title	Credit Hrs	Course contents
1	CE-631	BIM Implementation and Management	3	BIM Process: History, Concepts, Terminologies, Benefits, Status Quo of Implementation; BIM as a Tool for Value generation, Integration, Communication and Collaboration.

				<p>BIM Contract Negotiation and Risk Allocation: Contract liability and standards of care related to BIM, BIM contract negotiation, Intellectual property rights and licensing issues related to BIM, BIM coverage in insurance and bond products, Risk allocation and management responsibility provisions on BIM projects;</p> <p>BIM Technology and Application: Software Skills, Model creation, Model simulation, Applications of BIM Technology for Delivering Better Value, Constructability, Quality, Safety, Energy Efficiency, Security of Infrastructure, etc.;</p> <p>BIM Adoption and Integration: Operational/Administrative Issues; Strategic issues; Technical issues;</p> <p>BIM Synthesis: BIM Standards, Lean and Sustainable Design and Construction through BIM</p>
2	CE-632	Artificial Intelligence Theory and Applications in Construction	3	<p><i>Theory</i>: Overview, Agents and Rationality, Problem Solving, Search, Genetic Algorithms, Knowledge Representation and Reasoning, Logical Agents, Propositional Logic and Inference, First-Order Logic, Planning, Uncertainty, Bayesian Networks and Inference, Decision Making Under Uncertainty;</p> <p>Decision Support System and Expert System: DSS, Business Intelligence, Knowledge Management in Construction, Expert Systems in Construction, Knowledge Acquisition, Representation and Reasoning, Advanced Intelligent Systems in Construction;</p> <p>Fuzzy Logic: Classical Sets and Fuzzy Sets, Membership Functions, Fuzzification and Defuzzification, Logical Operations, Fuzzy Inference System (FIS), Fuzzy transactions, Decision Making with Fuzzy Information, Application Examples in Construction;</p> <p>Artificial Neural Networks: Concept, Work Architecture, Multiple Layers of Neurons, Transfer Functions, Neuron model and Network Architecture, Supervised and Unsupervised Neural Networks, Application Examples in Construction;</p> <p>Particle Swarm Optimization: Theory, Algorithms and application of optimization, Parameter selection, Convergence, Multiple Objective optimization, Application Examples in Construction;</p> <p>Nonparametric Methods and Support Vector Machines (SVMs), Computer Vision, Robotics in Construction;</p> <p>Artificial Intelligence Applications in Construction Management domain;</p> <p>Working with MATLAB integrated environment.</p>
3	CE-633	Innovative and Agile Construction Project Management	3	<p>Managing Complex Construction Project Environment: Managing project politics, Workload management – multiple projects, recovering failing construction projects, The Project Management Office, Delivering Best Value, Managing Stakeholders, Managing Virtual/Remote Project Teams, Building High-Performance Teams, Human Resource Management in Construction Business, Design-Construction integration management in construction, Constructability Analysis and Value Engineering</p> <p>Improving Personal Effectiveness as a Construction Project Manager: Setting SMART goals, Using New Innovations, Human Aspects, Delegation, Time Management, Motivation, Decision Making, Meetings, Communications, Negotiations, Presentations,</p>

			<p>Writing Technical Reports and Letters, Technical Leadership Skills and Styles, Stress Management.</p> <p>Recent Advances in Construction Project Management: Relational, Lean and other recent forms of contracting/ project delivery strategies, Advancements in Procurement, Advancements in Contract Law, Strategic Project Management, Recent techniques in Project Decision and Risk Analysis, Project Portfolio Management, Six Sigma and other Recent Strategies in Project Quality Management, Zero Accident and other Recent Strategies in Construction Safety, Technopreneurship in Construction, Lean Construction, Sustainability and LEED/ Green Construction, High Performance/ Smart Buildings, Crime Prevention through Environmental Design, Cultural Intelligence, Agile Project Management, Rolling-wave Planning, Advanced Planning and Scheduling Techniques, Recent Advancements in Supply Chain Management in Construction, Recent trends in use of ICT & Mobile Apps in Project Management, RFID Applications in construction, New software/ packages in construction project management, Construction Failure Analysis.</p>
5	CE-634	ADVANCED CONSTRUCTION RISK MANAGEMENT AND DECISION MODELLIN	<p>Review of Risk Management and Decision Modelling; Multi attribute Utility Theory; Advanced and modified versions of Analytical Hierarchy Process (AHP); Prioritization and optimization frameworks; Markov Chains and Markov Decision Process; Dynamic Programming; Game Theory; Multivariate analysis using Structural Equation Modeling (SEM); Bayesian Analysis; Modelling Management's Value System; Performance based analysis; Portfolio Analysis; Life Cycle Risk Management; Decision Support Systems; Case based application of the techniques.</p>
6	CE-635	LEGAL AFFAIRS AND DISPUTE RESOLUTION IN CONSTRUCTION	<p>Legal issues and litigation pertaining to construction, including contract law and interpretation; professional liability and negligence; public bidding law and regulation; insurance law; workers' compensation; environmental law and compliance; acts and statutes governing design and construction of public or private projects, public-private partnership.</p> <p>Various laws and regulations in Pakistan such as, real estate development and construction law; labor and employment law; government contracts; corporate and bankruptcy law and regulation; land-use law; intellectual property law and code of ethics.</p> <p>Dispute resolution mechanisms including, negotiation, mediation, local and international arbitration, and alternative dispute-resolution systems; project case studies related to dispute resolution</p>
7	CE-636	INFRASTRUCTURE ASSET MANAGEMENT	<p>Challenges of infrastructure management, frameworks for infrastructure asset management; planning needs assessment and performance indicators; asset information management; data inventory; monitoring and evaluation data; performance modeling and failure analysis; infrastructure service life; construction; maintenance; repair; rehabilitation; and reconstruction of infrastructure; integrated infrastructure asset management systems: available systems; system application; and benefits; future directions in infrastructure asset management.</p>
4	CE-637	LASER SCANNING AND DIGITAL PHOTOGRAMMETRY FOR CIVIL	<p>Laser Scanning: Principles of Photogrammetric Mapping; Photogrammetric and LiDAR Georeferencing; LiDAR Mapping Principles; Quality Assurance and Quality Control of LiDAR Mapping; LiDAR Data Classification, processing of LiDAR data; Automatic Detection and Reconstruction of scanned structure</p>

		INFRASTRUCTURE		Digital Photogrammetry: Definition, concepts, and applications of digital photogrammetry; Basic Optics; vertical photography, image coordinate measurements, mathematical models. theory of orientation, photogrammetric geo referencing, digital image matching.
	CE-638	ADVANCED SUSTAINABLE CONSTRUCTION		Principles of sustainability; relationship between sustainable development and sustainable construction; principles and benefits of sustainable construction; UN sustainable development goals w.r.t. sustainable construction; sustainable thinking from an industry perspective; ecological design; sustainable construction materials; closing material loop in sustainable construction; sustainable construction technologies; Assessment for sustainable construction processes; green building assessment; green building rating systems; green building design process; sustainable sites and landscape; building energy issues; indoor environmental quality; green building implementation.
8	CE-639	ENERGY EFFICIENT BUILDINGS		Overview of energy efficiency requirements; energy audit procedures and reporting guidelines; principles of thermal analysis; energy efficiency screening approaches; building envelope retrofit; overview of electrical, heating, cooling and water systems retrofit; passive design strategies; net-zero energy retrofits, methods of estimating energy savings; innovative energy optimization strategies; renewable energy systems; reducing carbon footprint of built environment; case studies.
10	CE-640	BUILDING ENERGY EFFICIENCY ANALYSIS		Overview of building energy modeling; building envelope specifications: building envelope, weather, geometry and spaces, surfaces, constructions, sub-surfaces; defining energy uses and spaces: energy uses and thermal loads, space types, load definitions, occupancy schedules, lighting fixtures and luminaries; water equipment; developing 3D model using BIM; setting-up energy models; material settings: selecting materials, defining materials, setting up thermal properties of materials; energy settings: space definition, power density, lighting density, operating schedule, condition type, space type, occupancy, building type, HVAC systems; geo-graphical settings: location and orientation; generating energy models; simulation and optimization; interpretation of results; basic concepts of life cycle assessment: goal and scope definition, inventory assessment, impact assessment, improvement assessment; ISO standards for LCA; inventory profile creation; performing building energy life cycle assessment for using LCA tool.
	CE-641	SUSTAINABLE CITIES AND SYSTEMS		Elements of the sustainable city; transitioning to a sustainable city; Sustainable Urban Systems: energy, water, solid waste, sewage treatment, open spaces and parks, transportation; Contexts of Sustainable Lifestyle; Sustainability Management: sustainable supply chain, industrial ecology, sustainable finance, sustainability mismanagement; The role of public policy in building sustainable cities: public-private partnerships, public opinion, and values of urban sustainability; Cases in urban sustainability: sustainable urban living, the building of the smart grid, parks and public spaces.
11	CE-642	Advanced Facilities Planning and Management		Facilities Management (FM) in the Built Environment: Overview of FM; FM Organizational Models and Stages of development; Dynamic, Strategic FM; Excellence through Client/User Orientation; Engaging with Stakeholder Needs FM for Buildings: Building Systems; Building Safety and Security; Building Services Management; Space & Relocation Management; Lean Maintenance of Buildings; Disaster Recovery Planning and Disaster Resilience; Facilities Condition Assessment; Sustainable & Green Buildings; LEED and Energy Performance of Buildings; Building Management Systems; Smart and Intelligent Buildings; Case Studies

				<p>Overview of Technology Dimensions in FM: Computerized Facilities Management Systems (CFMS); Current State of Technologies for Facility Manager; Technologies for Facilities Audit and Condition Assessment.</p> <p>Further Aspects in FM: Overview of Financial Management and Contracts in FM; Human Aspects in Facilities Management; Contemporary Research Dimensions in FM with emphasis on current local, regional and global challenges</p>
12	CE-643	Human and Social Dimensions of Energy Use		<p>The expectation of thermal comfort Daylight: Impacts daylight on Productivity and Human Performance, Integrated system design approaches to HVAC systems for low-rise residential structures, Capitalization of Energy Efficiency for Housing Market, Understanding the Household Conservation Motivation & Behavior, Organizations, and Actors in Interventions to Improve Household Fuel Use, Use of Mass Media to Influence Energy Consumption Behavior, Smart Homes and Energy Efficiency Constructive Technology Assessment of ICT Use in Sustainable Buildings, Barriers to Innovative Technology Adoption.</p>
13	CE-644	Advanced Geo-informatics for Facilities Management		<p>Advanced Operations in GIS, Concept and Application of 4 Ms in GIS, Levels of use of GIS, Spatial Layering in GIS, Coordinate System and Map Projection, Geocoding and Survey Data Integration in GIS. Point Pattern Analysis, Lines and Networks, Performing Network Analysis, Area Objects and Spatial Autocorrelation, Spatial Interpolations, Geo-statistical Analysis, Map Overlay Analysis, Multivariate Data, Multidimensional Space and Specialization, GIS Modeling and Related Issues. Application of GIS in Building Facility Management Systems, Efficient routing of services lines, Optimization of supply chain. Relevant case studies.</p>