

Annexure –VIII
Master of Construction Engineering
Curriculum

Structural Repair and Retrofit Engineering

FIRST SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
	Departmental / Specialization Basket	Subject Code	Subject Name	Lecture (Theoretical + Tutorial)	Sessional	Examination	
Paper-I	PG / CT / T / 111	Advanced Structural Analysis	3 + 1		100		4
Paper-II	PG / CT / T / 112	Repair Materials for Masonry and Concrete Structures	3 + 1		100		4
Paper-III	PG/CT/T/113	Elective - I	3 + 1		100		4
Sessional Courses	Subject Code	Subject Name					
Sessional - I	PG/CT/S/111	Computer Aided Structural Analysis Laboratory		3		100	3
			12	3	300	100	15
Elective - IA	PG/CT/T/113A	Theory of Elasticity, Plasticity & Elastic Stability					
Elective - IB	PG/CT/T/113B	Construction Management & Estimation of Repair					
Elective - IC	PG/CT/T/113C	Fabrication Technology for Steel Structures					

Total Periods/Week = 15

Total Marks = 400

Master of Construction Engineering
SECOND SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
	Departmental / Specialization Basket	Subject Code	Subject Name	Lecture (Theoretical + Tutorial)	Sessional	Examination	
Paper-IV	PG / CT / T / 121	Condition Assessment and Health Monitoring of Structures-I	3 + 1		100		4
Paper-V	PG / CT / T / 122	Elective - II	3 + 1		100		4
Sessional Courses	Subject Code	Subject Name					
Sessional - II	PG/CT/S/121	Repair Materials Laboratory		3		100	3
			12		300		12
Elective – 2A	PG / CT / T / 122A	Structural Dynamics and Earthquake Engineering					
Elective – 2B	PG / CT / T / 122B	Soil Dynamics & advanced foundation Engineering					
Elective – 2C	PG / CT / T / 122C	Disaster Mitigation Engineering					

Total Periods/Week = 12

Total Marks = 300

Master of Construction Engineering
THIRD SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
	Departmental / Specialization Basket	Subject Code	Subject Name	Lecture (Theoretical + Tutorial)	Sessional	Examination	
Paper-VI	PG / CT / T/ 211	Repair and Retrofitting Technique-I	3 + 1		100		4
Paper-VII	PG / CT / T/ 212	Condition Assessment and Health Monitoring of Structures-II	3 + 1		100		4
Paper-VIII	PG / CT / T/ 213	Elective - III	3 + 1		100		4
Sessional Courses							
Sessional III	PG / CT / S / 211	Condition Assessment and Structural health monitoring Laboratory		3		100	3
			12	3	300	100	15

Elective - IIIA PG /CT /T/213A Structural Safety, Reliability and Maintenance Management
 Elective - IIIB PG /CT /T/213B Design of structure with special emphasis for Repair & Retrofitting
 Elective - IIIC PG /CT /T/213C Retrofitting of Historical & Heritage Structures

Total Periods/Week = 15

Total Marks = 400

Master of Construction Engineering
FOURTH SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
	Departmental / Specialization Basket	Subject Code	Subject Name	Lecture (Theoretical + Tutorial)	Sessional	Examination	
Paper-IX	PG / CT / T / 221	Repair and Retrofitting Technique-II	3 + 1		100		4
Sessional Courses							
Sessional IV	PG / CT / S / 221	Repair and Retrofitting laboratory		3		100	3
Sessional V	PG / CT / S / 222	Term Paper Leading to Thesis		3		100	3
			4	6	100	200	10

Total Periods/Week = 10

Total Marks = 300

FIFTH and SIXTH SEMESTER

Sessional Courses						
Sessional VI	Thesis Work		16		300	12
Sessional VII	Viva-Voce				100	4
			16		400	16

Total Periods/Week =16

Total Marks = 400

SYLLABUS OF MASTER OF CONSTRUCTION ENGINEERING

Structural Repair and Retrofit Engineering

FIRST SEMESTER

Theoretical Courses

PG / CT / T / 111 - Advanced Structural Analysis

Introduction, Matrix method of analysis, stiffness and flexibility matrices of structural elements, various coordinate system and their transformation and synthesis. **Assembly of global matrix and application of boundary condition. Derivation of member forces. Load vector. Solution of truss problems.** Finite element method (FEM). **Pascal triangle.** Element properties. Shape functions **and formulation of elemental stiffness matrices of truss members, beam member and frame element.** Plane stress and plane strain problems, **Triangular and rectangular elements in FEM. Finite Difference method (FDM), Application to plate bending problems.** Introduction to non-linear analysis.

PG / CT / T/ 112 – Repair Materials for Masonry & Concrete Structures

Durability of concrete; service/exposure **conditions,** Concrete composites with **chemical and mineral admixtures.** Microstructure of concrete and mechanism of deterioration. Strength of hardened concrete, bond strength; Elasticity, Creep and shrinkage. Mix design of concrete; Pumped concrete; Self compacting concrete; Fiber-reinforced concrete; Repair material properties, Different types of Cementitious repair materials, criteria for material selection, cold joints, different types of cracks in concrete structures, shrinkage compensating concrete, polymer materials- polymer impregnated concrete, polymer modified concrete; Chemical and physical characteristics of epoxy resins, use of epoxy resins, application, hardening, handling precautions, test methods, geo-polymers, Carbon and steel fibers. Joint Sealants and chemicals, Different types of metals as repair material. Compatibility criterion of older & newer materials, Different standards. **Lime as a repair material. Classification of repair mortars, Lime concrete, Lime cement mortar for repair of old masonry structures. Use of cold mix in road repair. Grouting of soil for strengthening of weak soil.**

Elective – I

PG / CT / T / 113A - Theory of Elasticity, Plasticity and Elastic Stability

Equations of equilibrium and compatibility, plane stress, plane strain **and axi-symmetric problems,** stress functions, **Cartesian tensors and indices notation, tensor calculus, tensorial treatment of stress and strain.** constitutive relationship. bending of beams, torsion of shafts. Basic concepts and yield criteria, equations of plasticity, elasto-plastic analysis, strain hardening. Introduction to fundamental principles and model for elastic stability of column.

PG / CT / T / 113B - Construction Management & Estimation of Repair

Planning and Scheduling CPM and PERT Squared networks, Monitoring and updating. control on material consumption. Use of computer packages, Material procurement storage and accountancy. Contracts objective of contracting parties: Reconciliation of aims. Conflicts and problems, Standard from contracts, Type of contracts, their peculiarities and applications to repair job; Tendering process; Storing of materials

with identifiable batch lot, documentation of incoming certificates, in-house checking and documentation of input materials, semi processed materials, finished materials. Quality assurance plan, Items of work. Method of measurement and documentation, Pricing rules of taking off, Principles of abstracting,

Specification and item of works for Repair and Retrofit, Analysis of rate, Overhead and profit, Determination of unit rate and preparation of Bill of quantities, Preparation of tender documents, Quality control measures for Repair and Retrofit work.

PG / CT / T / 113C – Fabrication Technology for Steel Structures

Importance of fabrication technology, Fabrication procedures, Shop and site fabrication, sequence of activities -surface cleaning, cutting & machining, punching & drilling, straightening, fitting & reaming, fastening, riveting, bolting, welding, Non-destructive testing of steel structures, radiographic and ultrasonic testing of welds, quality control, erection planning, surface treatment against corrosion.

Sessional Courses

PG / CT / S / 111 – Computer Aided Structural Analysis Laboratory

Computer application of matrix and finite element method, use of structural engineering software packages

SECOND SEMESTER

Theoretical Courses

PG / CT / T / 121 Condition Assessment and Health Monitoring of Structures-I

Cause of deterioration; Service and exposure conditions, visual investigation, Embedded metal corrosion, Corrosion Mechanism, Assessment of Corrosion, exposure to aggressive chemicals, Freeze thaw disintegration, Alkali- aggregate reaction, Sulphate attack, Erosion, shrinkage, thermal cracking of freshly placed concrete, Fire damage, causes and control of cracking, evaluation of cracking, active and inactive cracks, settlement cracks, honey combs. Assessment of depth, size and condition of existing foundations; Introduction to Monitoring techniques of ground movements during construction and restoration of structures.

Different Non-destructive and partial destructive methods of investigation for concrete, Masonry and Timber structures- Schmidt Hammer test, Concrete core test, Ultrasonic pulse velocity test, Rebar locators, Half cell potentiometer test, Concrete resistivity, Carbonation test, Chemical tests on concrete like pH, Sulphates and Chlorides, chloride profiles, Pile Integrity Test, Impact echo test, Cross hole sonic logging, Pull off test, Petrography, other advanced methods etc.; Condition assessment of pavements.

Elective – II

PG / CT / T / 122A - Structural Dynamics and Earthquake Engineering

Introduction to Structural Dynamics, Dynamic Load, Degree of Freedom, Dynamic system with single degree of freedom (SDOF), Wind and Earthquake forces, D'Alembert Principle, Free and forced vibration, Damping, Damped and undamped SDOF system, Natural frequency, Forced vibration of SDOF system, Resonance and Dynamic load Factor, Multiple Degrees of freedom system (MDOF), Concept of shear building model, Eigen value problems, Mode shapes.

Introduction to Earthquake Engineering, Characteristics of Earthquake, Measures of earthquake – magnitude and intensity. Objective of Earthquake Resistant design, Earthquake disaster mitigation principle, Calculation of earthquake forces as per IS 1893 (Part I), 2016 or latest revision, Equivalent static method, Dynamic analysis, Introduction to Time domain and Frequency Domain analysis, Response Spectrum method and its application to multistoried building, calculation of story shears, Introduction to Time History analysis.

PG / CT / T / 122B - Soil Dynamics and Advanced Foundation Engineering

Vibration of elementary systems, Degrees of freedom, analysis of systems with several degrees of freedom, natural frequencies of continuous systems, Strength and deformation of soil under dynamic loads; Determination of dynamic coefficients, shear modulus and elastic constants of soil; Damping in soil – geometrical and internal damping; Elastic wave propagation theory. Vibration theory related to machine foundations; Design of foundation for reciprocating machines, foundation for impact type loading; vibration isolation technique. Seismic loading; Soil properties for seismic design; Earth pressure under seismic condition for design of retaining walls; Liquefaction of soil; case studies of failure of structures due to liquefaction, determination of ground acceleration; Determination of bearing capacity of soil under dynamic loading. Foundation design under earthquake loading.

SECOND SEMESTER

Theoretical Courses

PG / CT / T / 122C - Disaster Mitigation Engineering

Disasters, Hazards and Risks, Various types of natural and man made hazards and disasters, Earthquake, Cyclone, Flood, Blast etc. and their effect on structures, Loss computation, History of various disasters and lesson learnt.

Mitigation Engineering, Various approaches, Feasible preparedness, Prediction and preventive measures, Disaster Management and rehabilitation, Vulnerability analysis, Mitigation approaches to reduce structural vulnerability, Structural performance enhancement, Zones subjected to multiple hazards, Holistic approach for multiple hazard mitigation, Design issues for optimal mitigation, Seismic retrofitting, Cyclone resistant structures and cyclone shelter, Flood control etc. Case studies of different application of disaster mitigation engineering.

Sessional Courses

PG / CT / S / 121 – Repair Materials Laboratory

Different tests on repair materials, Test of different Fiber, Mix design with and without admixtures, design mix and tests on self compacting concrete. Physical testing of structural & reinforcing steel

PG / CT / T / 211 - Repair and Retrofitting Technique-I

Definitions, repair methodology, Methods of crack repair in masonry and concrete structures, routing and sealing of cracks, removal and surface preparation in masonry and concrete structures, cleaning of reinforcement steel, reinforcement repair, **Addition of supplemental reinforcement**, anchorage, bonding repair materials to existing concrete, material placement methods; Shot-creting and guniting, Grouting- Portland cement grouting, chemical grouting, Dry packing, polymer impregnation, Strengthening of structures: Techniques, design consideration, flexural strengthening, Shear Strengthening, strengthening of columns-jacketing of Columns, strengthening by interior and external reinforcing, External Pre-stressing, Fiber wrapping, Corrosion Protection: surface treatment, joint sealants, cathodic protection, removal and replacement techniques of Structural members. **Shoring and Underpinning**

PG / CT / T / 212 - Condition Assessment and Health Monitoring of Structures-II

Testing of structural steel, lamination, Dynamic Loading and Fatigue, welding technology, weldability, Inspection of riveted, welded and bolted connections, Quality control aspect of welded joints, Different non-destructive methods of testing for steel structures – DP test, ultrasonic and radiography test etc. Fire damaged steel structures, Structural health monitoring, active and passive health monitoring techniques, Load testing of structures, Dynamic testing of Structures; Introduction to system identification techniques; Sensors, Exciters, Data acquisition and data processing, filtering technique, Sampling rate, Application of Digital Signal Processing in structural health monitoring, Introduction to probabilistic structural health monitoring.

Elective – III

PG / CT / T/ 213A - Structural Safety, Reliability and Maintenance Management

Constructional Hazards, Structural safety, Proof test, Introduction to Probability and Statistics: Conditional probability; Bayes' Theorem, Independence, Discrete and Continuous distributions, Regression Analysis, Analysis of variance. Reliability index, First and second order of reliability; Geometrical interpretation of Reliability index; Probability of Failure; Introduction to maintenance management, appraisal procedure, Introduction to decision analysis, Maintenance of buildings, bridges, pavements and Industrial structures, continuous monitoring system Life Cycle cost, Introduction to life estimation of structures.

PG / CT / T/ 213B - Design of Structure with special emphasis for Repair & Retrofitting

Working stress and Limit state method of design, Design of retrofitted reinforced slab, flanged beams and column, Beam-Column problem, Design of retrofitted footing - Isolated, Combined footing, Design of retaining structures, Design of retrofitted steel structures.

PG / CT / T/ 213C - Retrofitting of Historical & Heritage Structures

Illustration and classifications of Historical constructions, Masonry and heritage structures, different case studies related with features of masonry/heritage structures, special consideration - inspection, advanced

testing and modelling for evaluation of performance of structures, assessment, advanced experimental and numerical techniques for estimation of structural response for performance prediction, innovative strengthening techniques.

Sessional Courses

PG / CT / S / 211 - Condition Assessment and Structural Health Monitoring Laboratory

Non destructive / partial destructive tests on concrete and steel structures.

Laboratory report has to be prepared with major emphasis to relate real life structural performance. Group discussion.

FOURTH SEMESTER

Theoretical Courses

PC / CT / T / 221- Repair and Retrofitting Technique-II

Condition monitoring of pavements by NDT using FWD, GPR etc. for estimation of pavement strength and design of overlay for pavement repair. Evaluation of joint efficiency in concrete pavement, design of white topping for repair of damaged bituminous/concrete road pavements, monitoring of pavement response by skid resistance, roughness index, design of flexible overlay based on rebound deflection.

Cleaning and surface Preparation of Corroded Structural Steel, replacement and addition of new members, different Types of Steel and Composite Joints, Shoring; underpinning of foundation; Different techniques for pavement Repair and strengthening.

Introduction to Seismic Evaluation and seismic retrofit. Basic safety objectives, Hazard level and limit states of seismic performance levels, Retrofit goals and strategy, Global and local Retrofit objectives and different techniques, objectives and different techniques

Introduction to nonlinear static pushover analysis, capacity and demand spectrum, Performance point. Ductile detailing of structures, Different types of lateral bracing, Introduction to active and passive control of structures, Tuned mass damper, Base isolation technique-its objective, applicability, advantage and limitation.

Sessional Courses

PG / CT / S / 221 - Repair and Retrofitting Technique- Laboratory

Methods of crack repair, Grouting- Portland cement grouting, chemical grouting, Dry packing, polymer impregnation, shear capacity strengthening, flexural strengthening, Exterior post tensioning, Jacketing, FRP wrapping. Repair and retrofit work site visit, Presentation of lab results with reference to case studies in seminar, group discussion and viva voce.

PG / CT / S / 222 – Term Paper Leading to Thesis

Each student will be given a thesis/project problem preferably on a case study of repair & retrofitting at the beginning of fourth Semester. He/She will work on the literature survey, scope of work, equipment development etc. and submit a report/dissertation. The main Thesis / Project work will however, be done in the fifth and sixth semesters.

FIFTH AND SIXTH SEMESTER

PG / CT / TH / 31- Thesis

Each student will devote full time in the fifth and sixth semester on a Thesis/Project on an assigned research problem of Design/Development work under the supervision of a faculty member. He/She will present a Thesis/Project Report at the end of the sixth Semester which will be evaluated by a Board of Examiners consisting of the Supervision and External Examiner. The evaluation of the thesis will be followed by a viva-voce in front of faculty members and other post-graduate students.

PG / CT / VV/ 32- Viva-Voce