

**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
<b>Sessional Courses</b>	Subject Code	Subject Name					
Sessional - I	PG/CT/S/111	Computer Aided Structural Analysis Laboratory		3		100	3
			<b>12</b>	<b>3</b>	<b>300</b>	<b>100</b>	<b>15</b>
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
<b>Sessional Courses</b>	Subject Code	Subject Name					
Sessional - II	PG/CT/S/121	Repair Materials Laboratory		3		100	3
			<b>12</b>		<b>300</b>		<b>12</b>
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
<b>Sessional Courses</b>							
Sessional III	PG / CT / S / 211	Condition Assessment and Structural health monitoring Laboratory		3		100	3
			<b>12</b>	<b>3</b>	<b>300</b>	<b>100</b>	<b>15</b>

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
<b>Sessional Courses</b>							
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
			<b>4</b>	<b>6</b>	<b>100</b>	<b>200</b>	<b>10</b>

**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
			<b>16</b>		<b>400</b>	<b>16</b>

**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 co-ordinate system and their transformation and synthesis-matrix formulation of force and displacement methods – member approach. Finite element concept in Engineering Analysis –Element properties; shape functions; plane stress & plane strain problems, Introduction to non-linear analysis.

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

Repair material properties, load carrying capacity, service/exposure properties, constructability and appearance, volume change and shrinkage; Different types of Cementitious repair materials, criteria for material selection, strength of hardened concrete, bond strength; Elasticity, Creep and shrinkage; admixtures; Microstructure of concrete and mechanism of deterioration; Durability of concrete; Concrete composites with admixtures; Pumped concrete; Self compacting concrete; Fiber-reinforced concrete; Mix design; 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

#### **Elective – I**

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

Equations of equilibrium and compatibility, plane stress and plane strain problems, stress functions, constitutive relationship. bending of beams, torsion of shafts. Basic concepts and yield criteria, equations of plasticity, elastoplastic analysis, strain hardening. Introduction to fundamental principles and model for elastic stability of column. Stability of frames

##### **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 form 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, Bill of quantities, Analysis of rate, Overhead and profit, Determination of unit rate, Specification of 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, methods 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 drilling, Ultrasonic pulse velocity test, Rebar locators, Half cell potentiometers, Concrete resistivity, Carbonation test, Chemical tests like pH, Sulphates and Chlorides, chloride profiles, Pile Integrity Test, Impact echo test, Pull off test, Petrography, other advanced methods etc; Condition assessment of pavements.

#### **Elective – II**

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

Introduction – Dynamic system with single degree of freedom, Damped and undamped system ; Natural frequency, Free and forced vibrations, resonance and dynamic load factor, multiple-degree of freedom systems. Eigen value problems, mode shapes; Modal analysis; Introduction to earthquake Engineering, Earthquake magnitude and intensity; Wind and earthquake forces, seismic design- Response Spectrum method, Dynamic Analysis. Time domain and frequency domain analysis, application to buildings and bridges.

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

Strength and deformation of soil under dynamic loads; Determination of dynamic coefficients, shear modulus and elastic constants of soil; Transient/shock loading on cohesionless soil; Damping in soil – geometrical and internal damping; Elastic wave propagation theory. Vibration theory related to machine foundations; design of foundation for reciprocating and rotary machines, foundation for impact type loading; vibration isolation technique. Seismic loading; Soil properties for seismic design; Earth pressure under seismic condition; Liquefaction of soil; determination of ground acceleration; Damping of soil; Foundation design under earthquake loading.

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

Natural and Man made disaster, History of disaster and lesson learned, Hazard and Risk, Earthquake, Flood, Wind & Storms Blast & explosion, – effect on structural safety, Loss computation, Mitigation approaches - Preparedness, Management and Rehabilitation, Vulnerability analysis, Structural aspect to reduce vulnerability, Structural performance enhancement. Holistic approach for multi-faced disaster mitigation, Design issues, Seismic retrofitting. Cyclone shelter, Flood control etc.

### **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

## **THIRD SEMESTER**

### **Theoretical Courses**

#### **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, 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.

#### **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**

Historical constructions, Masonry and heritage structures, special consideration - inspection, advanced testing and modelling, assessment, advanced experimental and numerical techniques, 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, Load testing. Introduction to Dynamic Testing of structural members.

## **FOURTH SEMESTER**

### **Theoretical Courses**

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

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 Retrofitting, Ductile Detailing of Structures; Different types of lateral bracings, Introduction to active and passive control of structures, Tuned mass damper, Base isolation technique.

### **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. Yield Line Testing of Slab

#### **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**