Master of Technology

In

Civil Engineering (Structures)

Course Structure & Syllabus

Department of Civil Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1.	CE-651	Advanced Structural Design	4	0	0	4	4
2.	CE-652	Structural Dynamics	4	0	0	4	4
3.	CE-653	Advanced Concrete Technology	4	0	0	4	4
4.	CE-7MN	Programme Elective-I	4	0	0	4	4
5.	CE-7MN	Programme Elective-II	4	0	0	4	4
6.	CE-654	Computing in Structures Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective - I & II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1.	CE-661	Reliability based Structural Design	4	0	0	4	4
2.	CE-662	Earthquake Engineering	4	0	0	4	4
3.	CE-663	Bridge Engineering	4	0	0	4	4
4.	CE-7MN	Programme Elective-III	4	0	0	4	4
5.	CE-70N	Institute Elective	4	0	0	4	4
6.	CE-664	Concrete Technology Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective –III: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No	Course No.	Course Name	Hours/week	Credit
1	CE-798	M Tech Dissertation	--	18
	Total			**18**

SEMESTER-IV

Sr. No	Course No.	Course Name	Hours/week	Credit
1	CE-799	M Tech Dissertation	--	18
	Total		**--**	**18**

Total Credit of the Programme: 80

Annexure I: List of Programme Electives

	Course No	Course Title
Program Electives	CE-726	Retrofitting of concrete and Masonry Structures
	CE-727	Continuum Mechanics
	CE-728	Pre-stressed Concrete structures
	CE-729	Prefabricated structures
	CE-730	Advanced Structural Analysis
	CE-731	Design of Plates and Shells
	CE-732	Advanced Composite Materials in Structures
	CE-733	Disputes and Arbitration in Engineering Projects
	CE-734	Building Services and Maintenance
	CE-735	Advanced foundation design
	CE-736	Disaster Management
	CE-737	Finite Element Method
	CE-738	Fracture Mechanics of Concrete
	CE-739	High Rise Buildings
	CE-740	Optimization Methods
	CE-741	Construction Management
	CE-742	Advanced Steel Structures

Annexure II: List of Institute Elective Courses

	Course No	Course Title
Institute Electives	CE-701	Project Management
	CE-702	Disaster Management
	CE-703	Environmental Impact Assessment
	CE-704	Remote Sensing & GIS
	CE-705	Engineering Seismology

Course Name: **Advanced Structural Design**
Course Code: **CE-651**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To make students to learn principles and philosophy of Structural Design
- To design and detail special types of RCC structures.
- Ductile detailing structures as per codal provision.

Course Content

Basic philosophy of Design of Concrete Structures; Design of Single and Multi-Bay Structures in concrete, Ductile detailing for Members and Joints, Analysis and design of Deep Beams, Curved Beams, Silos and Bunkers, Chimneys, Overhead Water Tanks and Supporting Structures, Analysis and Design of Shear Walls, Design of RC members for Fire resistance.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the principles of structural design.

CO2: Understand the principles of detailing and develop analytical skills.

CO3: Able to design special types of reinforced concrete structures silo, bunker, flat slab, water tank.

Books and References

1. N. Krishna Raju, Advanced Reinforced Concrete Design, C.B.S. Publishers and Distributors, Delhi.
2. Pillai, S.U. and Menon, D., "Design of RCC Structures", McGraw-Hill Education.
3. P.C. Varghese, Advanced Reinforced Concrete Design, Prentice - Hall of India, Pvt. Ltd., New Delhi.
4. A.K. Jain, Reinforced Concrete (Limit State Design)
5. Indian Standard Code 456 2000, "Code of Practice for plan & reinforced concrete".
6. Special Publications -16, "Design Aids for Reinforced Concrete", to IS: 456.

Course Name: **Structural Dynamics**
Course Code: **CE-652**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge to model discrete single-degree and multiple-degree vibratory systems and calculate the free and forced response of these systems.
- To introduce the fundamental concepts to Calculate the mode shapes and frequencies for the free response of vibratory systems
- To enable the students to calculate responses under random vibrations

Course Content

Introduction to Fundamentals of Vibrations, Undamped Free Vibrations of SDOF Systems, Damped Free Vibrations of SDOF systems, Forced vibrations of SDOF systems, MDOF Systems: Numerical methods in dynamics: Mode Superposition Method, Direct Integration Scheme: Continuous systems: Equations of motion, Hamilton's principle, Lagrangian formulation, Introduction to Random vibration.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Develop the equations of motion for vibratory systems and solving them for the free and forced response

CO2: Develop the skill to solve an Engineering problem under dynamic loading for industrial use.

CO3: Develop the skill to understand the effect of damping in the calculation of response

Books and References

1. Dynamics of Structures by R.W. Clough and J. Penzien, McGraw Hill international edition.
2. Structural dynamics by Mario Paz, CBS Publishers.
3. Dynamics of structures: Theory and applications to Earthquake Engg. by Anil K. Chopra, PHI Ltd.
4. Vibration analysis and foundation dynamics by K. Rao, Wheeler.
5. Wind effects on structures: fundamentals and applications to design by E. Siniu and R. H. Scanlan, John wiley and sons.

Course Name: **Advanced Concrete Technology**
Course Code: **CE-653**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the concrete at micro level.
- To introduce the fundamental concepts of properties in fresh and hardened state of concrete.
- To enable the students to understand the preparation of different types of concrete and the evaluation of properties using destructive, semi destructive and non-destructive tests.

Course Content

Constituents of Concrete, Cement chemistry; Aggregates for concrete, Tests and standards; Admixtures for concrete; Concrete mixture proportioning for admixture-based concretes. Concrete behavior: Properties of fresh concrete; Mechanical behavior of concrete; Microstructure of Concrete, Durability of concrete. Special topics: Special cement and concrete; Use of Recycled/ Waste Materials in concrete, Advances in concrete construction; Nondestructive evaluation of concrete structures; Cement based composites, Shrinkage and Creep.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the chemistry of concrete and basic terminology

CO2: Describe the basic understanding of the design requirements for advanced concrete.

CO3: Apply the principles of non-destructive testing for understanding of the construction and inspection requirements the buildings

CO4: Assess the safety of concrete structures

Books and References

1. Concrete Technology by Neville, A.M. and Brooks, J.J., ELBS, Prentice Hall.
2. Properties Of Concrete by Neville, A.M., Pitman, Pitman Publishers.
3. Concrete Structure, Material and Properties by Mehta, P.K., Prantice Hall Inc.
4. Advanced Concrete Technology - Constituent Materials by Newman, John & Choo, Ban Sang. Elsevier, Butterworth-Heinemann.
5. Advanced Concrete Technology - Concrete Properties by Newman, John & Choo, Ban Sang. Elsevier, Butterworth-Heinemann.
6. Advanced Concrete Technology - Testing and Quality Newman, John & Choo, Ban Sang. Elsevier, Butterworth- Heinemann.
7. Fly Ash In Concrete by Malhotra, V.M. and Ramezaniaanpour, A.A., CANMET, Natural Resources Canada.
8. High Performance Concrete And Applications by Shah, S.P., and Ahmad, S.H., Edward Arnold.

Course Name: **Computing in Structures Lab**
Course Code: **CE-654**

Contact Hours/Week: **4P** Course Credits: **02**

Course Objectives

- To provide skills for Drafting, modeling, analyzing and designing
- To provide skills for developing programs using Computational Tools
- To enable the students to handle large scale problems using general purpose softwares

List of Experiments

Familiarize the students with softwares: STAAD.Pro (Structural Work suite), ANSYS, ETABS, MATLAB, AutoCAD, MIDAS, ABAQUS, and any other available software.

1. To carry out Linear Static Analysis of Continuous Beams, Portal Frames, Truss (2D and 3D) and Multistoried Building using STAAD.Pro and ETABS.
2. To carryout detailing of reinforcement in Beams, Slabs, Columns, Individual and combined footings and Staircases using AutoCAD
3. To carry out static Linear and Non-Linear and dynamic analysis of any large structure using ANSYS/ ABAQUS
4. To write programme in MATLAB for analysis of beam with different support conditions and generate SFD and BMD.
5. To carry out analysis and design of Bridge superstructure and substructure using MIDAS

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on the above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Model the complex engineering problems.

CO2: Analyse the results obtained from software and design the structures accordingly.

CO3: Use these computational tools effectively.

Course Name: **Reliability Based Structural Design**
Course Code: **CE-661**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about accurate and efficient approaches to assess uncertainties in loads, geometry, material properties, manufacturing processes and operational environments
- To introduce the fundamental concepts relevant to Reliability approach, LRFD (Load and Resistance Factor Design) design method.
- To enable the students to understand reliability assessment techniques to develop initial guidance for robust designs.

Course Content

General introduction: Introduction to statistics and Probability, Probability Distribution Function, Modeling of D.L., L.L, W. L. and earthquake effects, Modeling of material properties and modelling of failure function, code calibration and Partial Factor of safety, Reliability of structural systems. Design formats: Reliability approach, LRFD (Load and Resistance Factor Design) design method, Monte-Carlo simulation, Latin Hypercube, FORM and SORM, Application of Reliability method.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the uses Reliability assessment techniques in civil engineering
CO2: Describe different techniques and procedure of Reliability techniques in civil engineering.
CO3: Apply principles of different Reliability assessment techniques
CO4: Use Reliability assessment techniques to identify where significant contributors of uncertainty occur in structural systems or where further research, testing and quality control could increase the safety and efficiency of the structure.

References Texts Book

1. Reliability analysis by R. Ranganathan, Jaico Publishing house.
2. Reliability of Structures by A S Nowak, K Collins, McGraw-Hill
3. Probability, Reliability and Statistical Methods in Engineering Design by Achintya Haldar and Sankaran Mahadevan, John Wiley & Sons, Inc.
4. ReIiabiIity Engineering and Risk Analysis by Mohammad Modarres, Mark Kaminskiy and Vasiliy Krivtsov,
   Marcel Dekker, Inc.

Course Name: **Earthquake Engineering**
Course Code: **CE-662**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about Earthquake Engineering
- To introduce the fundamental concepts relevant to application of structural dynamics in Earthquake Engineering
- To enable the students, understand the factors that make the structures Earthquake Resistant

Course Content

Earthquakes: Causes, Magnitude and Intensity, Ground Motions, Sensors; Linear Earthquake analysis: Idealization of structures, Modal, Response spectrum analysis, Capacity based design, Time History Analysis; Nonlinear Earthquake analysis: Force-deformation relationships, Equation of motion, Ductility, Pushover Analysis; Identification of seismic damages in Reinforced concrete building, Structural irregularity effect on the performance of RC buildings, Seismic resistant Building Architecture; Ductility considerations in Earthquake Resistant Design of Reinforced Concrete Building; Earthquake resistance design: Reinforced Concrete frame, Shear wall, Codal and Detailing Provisions w.r.t IS:1893-2016, IS:13920-2016

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different method of earthquake analysis

CO2: Describe problems related to siesmo resistant Building Architecture

CO3: Apply principles of structural dynamics

CO4: Assess and generated the earthquake resistant features in the buildings

Books and References

1. Earthquake resistant design of structures by Pankaj Agarwal, Manish Shrikhande, Prentice-Hall, New Delhi.
2. Earthquake Resistant Design of Structures by S K Duggal, Oxford University Press.
3. Earthquake resistant design: for engineers and architects, by D. J. Dowrick, John Wiley and sons.
4. IS: 1893 (Pt1) 2016, Criteria for earthquake resistant design of structures, Bureau of Indian Standards, New Delhi.
5. IS 13920 2016- Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice. Bureau of Indian Standards, New Delhi.

Course Name: **Bridge Engineering**
Course Code: **CE-663**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart concepts and skills of Bridge Engineering
- To introduce the fundamental concepts of analysis and design of different type of bridges.
- To enable the students to understand the skills and concepts of bridge engineering

Course Content

A review of Historical Developments, Loads and stresses, choice of bridge types, IRC Loading and other bridges loads and impact factor. Types, Type selection components of Bridges, Arcs, Abutments, Pile foundations, cofferdams and other foundations suitable for bridges economical span, preliminary design of bridges. Design of bridges: RCC Slab culvert, RCC T-Beam and Slab Bridge, Box Girder Bridge, PSC girder bridge. Design of substructure: piers, abutments.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the conceptualize the fundamentals of bridge engineering

CO2: Analyse and design of different component of bridges

CO3: Apply principles and algorithms for analysis and design of different components of bridges.

CO4: Assess the results obtained by solving problems of different component of bridges

Books and References

1. Bridge Engineering by Ponnuswamy R., Tata McGraw Hill Publication New Delhi.
2. Essentials of Bridge Engineering by Johnson Victor D.,Oxford and IBH publication Co.
3. Design of Bridges by Krishna Raju N., Oxford and IBH publication Co.
4. National Building Code of India (ISI).
5. Bridge Superstructure by N. Rajagopalan, Narosa.
6. A Text Book of Bridge Engineering by Jagadeesh and Jairam, Prentice Hall, New Delhi.
7. Rainas concrete bridge practice, Analysis, design and economics by V K Raina, Shroff Publishers.

Course Name: **Concrete Technology Lab**
Course Code: **CE-664**

Contact Hours/Week: **4P** Course Credits: **02**

Course Objectives

- To provide skills for designing high strength concrete
- To provide skills for carrying out nondestructive tests of concrete/steel specimen
- To enable the students to understand the loading and response measuring systems

List of Experiments

1. To carry out Mix design for normal strength concrete Grade M30, using of admixture/plasticizer.
2. To carry out Mix design for high strength concrete Grade M65, using of admixture/plasticizer.
3. To determine flexural tensile strength of concrete using flexure test.
4. To determine Split tensile strength of concrete using cylinder test.
5. To determine failure pattern of beam in Shear experimentally on large scale beam.
6. To determine failure pattern of beam in flexure experimentally on large scale beam.
7. To carry out rebound hammer test on concrete cubes of known strength and compare the predicted values of compressive strength.
8. To carry out ultrasonic Pulse velocity test on a given sample of concrete.
9. To determine the cover thickness and bar diameter and spacing on a slab using cover meter.
10. To determine potential of corrosion using half-cell potentiometer in field.
11. To determine Dynamic modulus of Elasticity of a sample beam.
12. To carry out Rapid Chloride Penetration Test on concrete sample.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Carryout nondestructive test to understand the condition of the steel/concrete specimen

CO2: Design high strength concrete for industrial use

CO3: Identify behavior of beams under shear and flexure

Course Name: **Advanced Steel Structures**
Course Code: **CE-742**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the design of industrial structures based on the latest standards
- To introduce the design concepts of transmission tower, gantry girders and cranes column
- To introduce the design concept of structures using cold formed steel

Course Content

Design of industrial stacks - Self-supporting and guyed stacks lined and unlined; Analysis and design of transmission line tower; Analysis and design of Gantry girders and crane columns. Cold formed Steel Sections - Types of cross sections - Local buckling and post buckling - Design of compression and Tension members - Beams - Deflection of beams - Combined stresses and connections.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Design the industrial stakes for industry use
CO2: Design the gantry girders, crane columns and transmission tower
CO3: Design the structures using cold formed steel

Books and References

1. Design of Steel Structures by Subramanian N, Oxford University Press, New Delhi.
2. Design of Steel Structures, Bhavikatti by S.S., I.K. International Publishing House Pvt. Ltd., New Delhi.
3. Comprehensive design of steel structures by Punmia B.C., Lakshmi Publications, New Delhi.
4. IS 800-2007, Code of practice for general construction in steel, Bureau of Indian Standards, New Delhi.
5. IS 801-2001, Code of practice for use of Cold formed light gauge Steel Structural Members in general Building construction, Bureau of Indian Standards, New Delhi.

Course Name: **Retrofitting of concrete and Masonry Structures**
Course Code: **CE-726**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about Maintenance and Retrofitting of Structures
- To introduce the fundamental concepts procedure and methodology for maintenance and retrofitting
- To enable the students to understand the repair materials

Course Content

Maintenance – Importance, Principles, quality assurance, Preventive; Importance of repair, rehabilitation and retrofitting, causes of distress, evaluation methods for condition assessment, Dealing with cracks; Repair materials – Characteristic, repair techniques, quality control methods for repair of concrete. Corrosion damage - Reinforced concrete and its repair, prevention measures; Retrofit techniques for concrete and Masonry as per codal provision.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different methodologies of maintenance and retrofitting in structures

CO2: Describe problems related to maintenance and retrofitting of structures

CO3: Apply principles of compatibility of materials

CO4: Assess the requirement of maintenance and retrofitting in structures

Books and References

1. IS 13935 - 2009, Seismic Evaluation, Repair and Strengthening of Masonry Buildings
2. IS 15988: 2013 Seismic Evaluation and Strengthening of Existing Reinforced Concrete Buildings - Guidelines
3. Practical Handbook on Building Maintenance by M K Gupta, Nabhi Publication, New Delhi
4. Practical Problems and Solutions in Civil Engineering Works by S C Basu Roy, Nabhi Publication, New Delhi
5. Concrete and Concrete Materials by Vinod K Mehrotra, Standard Publishers Distributors, New Delhi
6. Building Repair and Maintenance Management by P S Gahlot & Sanjay Sharma, CBS Publishers & Distributors Pvt. Ltd., New Delhi

Course Name: **Continuum Mechanics**
Course Code: **CE-727**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the tensor
- To impart knowledge about the static analysis of a component to find the internal actions (forces and moments).
- To introduce the advanced concepts to determine stresses, strains and deformation due to internal actions.

Course Content

Basic concepts of the theory of continuous media, Introduction To Tensor Algebra, Stress at a point, Equality of Shear, Mohr's circle, Octahedral Stress, Pure shear, Strain at a point, Strain-Displacement Relationships, Compatibility, Stress-Strain Relationships, Boundary Value Problem in elasticity, Plane Stress And Plane Strain Case, Axis symmetry case, Stress Function Approaches, Elements Of Plasticity: Yield Criteria, Flow Rule And Hardening. Plastic stress-strain relationships, Variational methods.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: work with tensors, both in indicial and in direct notation

CO2: identify stresses and strain at a point of a body

CO3: solve advanced stress analysis problems

CO4: formulate and solve 3D stress analysis problems

Books and References

1. Continuum mechanics by D.S. Chandrasekharaiah and L. Debnath, Prism Books Pvt. Ltd., Bangalore.
2. Theory of elasticity by S. Timoshenko and J.N. Goodier, McGraw Hill Book Company, Int. edt.
3. Elastic and Inelastic stess analysis by I. H. Shames and F. A. Cozzarellie, prentice Hall New Jersey.
4. Mechanics OF Solids by A K Singh, PHI.
5. Advanced Mechanics of Solids by L S. Srinath, McGraw Hill.

Course Name: **Prestressed Concrete Structures**
Course Code: **CE-728**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To design a prestressed concrete beam accounting for losses.
- To design the anchorage zone for post tensioned members.
- To design composite members

Course Content

Principles of prestressing: Materials of prestressing, Pre and post tensioning methods; losses in pre-stressing, Deflection of prestressed concrete members; **Pre-tensioned and post-tensioned beams**: Design of prestressed concrete sections for flexure, shear, bond, and anchorage forces; **Analysis and design:** Analysis and design of indeterminate prestressed structures, Choice of cable profiles, concordancy and linear transformation of cable profile, effect of creep and shrinkage on prestressed concrete structures, Design of end block, Partial prestressing, Definition- principles and design approach, Composite structure.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Able to learn the principles, materials, methods, and systems of prestressing.

CO2: Able to know the different types of losses and deflection of prestressed members.

CO3: Able to learn the design of prestressed concrete beams for flexural, shear and tension and to calculate ultimate flexural strength of beam.

CO4: Able to learn the design of anchorage zones, composite beams, analysis and design of continuous beam.

Books and References

1. N. Krishna Raju, Pre-stressed concrete, Tata-McGraw Hill, New Delhi.
2. Nawy E.G, "Prestressed Concrete: A fundamental approach", Prentice Hall
3. Mallick S.K. and Gupta A.P, "Prestressed Concrete", Oxford & IBH
4. T. Y. Lin and N. H. Burns, Design of pre-stressed concrete structures, John Wiley and Sons, New York.

Course Name: **Prefabricated Structures**
Course Code: **CE-729**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits:**04**

Course Objectives

- To understand the principle and techniques of precast Prefabricated construction.
- To understand the behaviour of the precast Prefabricated structures.
- To understand the manufacturing and jointing of prefabricated structures.
- To visit the related Codal provisions.

Course Content

Introduction: Introduction, Need for prefabrication, Principles, Materials, Modular coordination, Standardization Systems, Production, Transportation, and Erection.

Prefabricated Components: Behavior of structural components, large panel constructions, Construction of roof and floor slabs, Wall panels, Columns, Shear walls

Design Principles: Disuniting of structures, Design of cross section based on efficiency of material used, Problems in design because of joint flexibility, Allowance for joint deformation.

Joint in Structural Members: Joints for different structural connections, Dimensions and detailing, Design of expansion joints.

Design for Abnormal Loads: Progressive collapse, Code provisions, Equivalent design loads for considering abnormal effects such as earthquakes, cyclones etc., Importance of avoidance of progressive collapse.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO 1: Design the prefabricated structural elements.

CO2: Design the joints and connections.

CO3: Design the structures using codal provisions.

Books and References

1. Koncz T., Manual of precast concrete construction, Vols. I, II and III, Bauverlag, GMBH.
2. Structural design manual, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag.

Course Name: **Advanced Structural Analysis**
Course Code: **CE-730**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the analysis of the statically and kinematically indeterminate structures
- To enable the students to understand the factors that cause such behaviour of the indeterminate structure by matrix method.
- To analyze trusses, beams and frames using matrix flexibility method and matrix stiffness method.

Course Content

Degree of Static and Kinematic indeterminacy, Released and restrained structure; Matrix method using system approach – flexibility and stiffness method for analysis of continuous beams, rigid – jointed plane frame and pin-jointed plane frame.
Introduction to Direct Stiffness method; Formation of member stiffness matrix; Transformation of load vector and displacement vector Assembly of global stiffness matrix and load vectors; Boundary condition and solutions; Application to planer structures –beam and plane truss.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Acquire knowledge about different types of indeterminate structures.

CO2: Analyse different types of indeterminate structures by traditional methods.

CO3: Analyse different types of indeterminate structures by advanced computational methods.

Books and References

1. Pandit, G.S. and Gupta, S.P., “Structural Analysis- A Matrix Approach (2/e)”, McGraw Hill Education.
2. Weaver, W. Jr., and Gere, G.M., “Matrix Analysis of Framed Structures (2/e)”, CBS Publishers.
3. Menon, D., “Advanced Structural Analysis”, Narosa Publishing House.
4. Hibbeler, R.C., “Structural Analysis (10/e)”, Pearson Education India.

Course Name: **Design of plate and shells**
Course Code: **CE-731**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about plates and shells.
- To introduce the fundamental concepts of analysis and design of plate and shells
- To enable the students to understand the factors that differentiate the design of plate and shell w.r.t frame structures

Course Content

Historical development of modern shell roofs- Brick domes, Reinforced concrete shells, Folded plates for roofing. Types of shell roofs and design -Classification of shells, Structure analysis and design. spherical domes and conical roofs- Analysis, design and detailing. Circular cylindrical shells- Classification, analysis and design, beam theory. Folded plates- Preliminary analysis, Slab-beam analysis of folded plate, transverse moment steel design, design of longitudinal steel, diaphragm design and detailing.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different types of plate and shell

CO2: Describe problems related to plate and shell analysis

CO3: Apply principles of membrane and bending analysis

CO4: Assess the analysis of structure in curvature

Books and References

1. Design of reinforced concrete shells and folded plates by P.C. Varghese, PHI Learning Pvt. Ltd.
2. Design and construction of concrete shell roofs by Ramaswamy,G.S., Delhi: CBS Publishers and Distributors.
3. Fundamentals of the analysis and design of shell structures by Kelkar, Vasant S., Prentice Hall, New Jersey:

Course Name: **Advanced Composite Materials for RC Structures**
Course Code: **CE-732**
Course Type: **Programme elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the use of composites in RC structures.
- To design FRP reinforced concrete structures.
- To design FRP strengthened structural components in RC structures.

Course Content

Introduction and History of FRP, Overview of Composite materials, Physical and Mechanical Properties and Test methods, Design of RC Structures reinforced with FRP Bars, Flexural Strengthening of RC Beams, Shear Strengthening of Beams, Flexural Strengthening of Slabs, Strengthening of Axially and Eccentrically Loaded Columns, Confinement models, Seismic Retrofit of Columns.

Course Outcomes

Upon successful completion of the course, the students will be able
to CO1: Understand the design of FRP reinforced concrete structures.
CO2: Understand the application of FRP as a potential material for strengthening of RC structural components.
CO3: Understand the application of FRP as a potential material for retrofitting of RC structural components

Books and References

1. ACI 440.1R-15, "Guide for the design and construction of structural concrete reinforced with Fiber-reinforced Polymer (FRP) bars.
2. S.B. Singh, "Analysis and Design of FRP Reinforced Concrete Structures," McGraw-Hill Education Pvt. Ltd., New York, USA

Course Name: **Disputes and Arbitration in Engineering Projects**
Course Code: **CE-733**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about avoidance of disputes and conflicts and wastage of time and Resources
- To enable students to be involved in the process of Conflict avoidance, management and Dispute resolution in construction projects.
- To understand range of dispute resolution techniques including Adjudication and Arbitration proceedings.
- To enable the student to understand conflict management and dispute resolution procedures including negotiation, mediation and conciliation, adjudication, arbitration and litigation.

Course Content

Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Owner's and contractor's estimate. Pre-qualification of bidders and enlistment of contractors. Tendering and contractual procedures, Indian Contract Act 1872, Definition of Contract and its applicability, Types of contracts, international contracts, FIDIC, Conditions and specifications of contract. Contract administration, Duties and responsibilities of parties Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conciliation Act 1996, Arbitration case studies, Negotiation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the underlying causes of most conflicts and disputes and demonstrate knowledge and understanding the techniques used to avoid Conflicts and manage them.

CO2: Apply the basic principles of Dispute Resolution expeditiously.

CO3: Be involved in range of dispute resolution techniques including Adjudication and arbitration proceedings.

CO4: Display knowledge about conflict management and dispute resolution procedures including negotiation, mediation and conciliation, adjudication, arbitration and litigation.

Books and References

1. A Guide to Quantity Surveyors, Engineers Architects and Builders (Vol I: Taking off quantities, Abstracting & Billing; Vol II: Analysis of Prices) by Kharb, K.S., Sushila Publications.
2. Construction Contracts by Keith Collier, Reston Publishing Company, Inc, Reston,Verginia.
3. Construction Contracts - Law and Management by John Murdoch & Will Hughes, Spon Press, Taylor & Francis Group.
4. Gajerai, G.T., "Law relating to Building and Engineering Contracts in India" Butterworths.
5. Govt of India, Central Public Works Department, "CPWD Works Manual 2003."
6. Govt of India, Central Public Works Department, "Analysis of Rates for Delhi (Vol 1 & 2)." and "Delhi Schedule of Rates."
7. Govt of India, Central Public Works Department, "CPWD 7/8: General Conditions of Contracts."
8. Govt of India, Military Engineer Services, "IAFW 2249: General Conditions of Contracts.

Course Name: **Building Services and Maintenance**
Course Code: **CE-734**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To develop the understanding of students about light, electrical services and sound theory and their application to building design
- To impart knowledge about various aspects of water-supply, drainage, sewerage system and solid waste disposal from the buildings
- To enable students to understand multifunctional complex problem of design with emphasis on circulation, socio-cultural factor, behavioral aspect with application of building services (water supply and sanitation)
- To expose the students to services in commercial complex, stadiums, 5-star hotel, multistoried Apartments and Hospitals, Civic Buildings, Terminal Buildings, Housing Layout and University Buildings on an intermediate scale, with emphasis on the building bye-laws , cost effectiveness and innovative structural considerations.

Course Content

Building Fabric, Heating, Ventilation and Air-Conditioning Systems; Vertical Transportation Systems; Electrical Distribution Systems; Indoor And Outdoor Lighting Systems; Fire Protection Systems; Security Systems; Communication Systems; Building Automation Systems; Public Addressing Systems, Plumbing And Drainage, Daily Maintenance, Conditioned Based Maintenance, Preventive Maintenance, Use Of New Surveying Technologies such as Ultrasound, X- Ray, Imaging, Sherography, Infrared and other Non-Destructive Testing methods.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the underlying principles of heating, ventilation and air-conditioning systems.

CO2: Apply the basic principles of indoor and outdoor lighting.

CO3: Describe and apply the building automation systems effectively

CO4: Display knowledge about use of newer technologies and application of basic principles for science for testing.

Books and References

1. Herbert W. Stanford III. Effective building maintenance: protection of capital assets by Lilburn, Ga.: Fairmont Press; Boca Raton, FL: Distributed by Taylor & Francis.
2. Brian Wood. Building maintenance by Chichester, U.K.; Ames, Iowa: Wiley-Blackwell.
3. Building maintenance guidebook / Buildings Department by HKSAR. Hong Kong: Building Dept.
4. Building maintenance management. London: Collins by Reginald Lee., HarperCollins Distribution Services, London.
5. Building services: performance, diagnosis, maintenance, repair and the avoidance of defects by H.W. Harrison, P.M. Trotman., London: CRC.
6. Building services maintenance / Building Services Research and Information Association by Bracknell, BSRIA.
7. Heating Ventilating and Air Conditioning Analysis and Design by Faye C. McQuiston and Jerald D. Parker, Wiley.
8. Bureau of Indian Standards, "HAND BOOK OF FUNCTIONAL REQUIREMENTS OF BUILDINGS, (SP-41 & SP-32)", BIS.

Course Name: **Advanced Foundation Design**
Course Code: **CE-735**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the foundation and the effect of foundation on the behavior of structures.
- To introduce the fundamental concepts relevant to foundation design
- To enable the students to understand the factors that cause the design of foundation for static and dynamic design of foundation

Course Content

General principles, Bearing Capacity, settlement and lateral pressure, Design of Shallow foundations, spread, strip and combined footings (Conventional and elastic line methods), Raft footings (conventional, finite difference and elastic half space methods), Design of deep foundations: piles and pile groups, pile caps, Design of retaining walls and sheet piles, principles of design of coffer dams and diaphragm walls, design of machine foundation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different type of shallow and deep foundation systems and problems

CO2: Describe the various parameters for the design of foundations and how does it affect them.

CO3: Apply principles and algorithms for the design of foundation for static and dynamic conditions.

CO4: Assess the results obtained by solving above problems

Books and References

1. Foundation analysis and Design by J.E. Bowles McGraw Hill New York
2. Design of foundation Systems: Principles and practice by P.N. Kurien New Delhi, Narosa.
3. Foundation design and construction by M.J. Tomlinson, Addison Wesley.
4. Design of RCC Foundations by P C Varghese, PHI.

Course Name: **Disaster Management**
Course Code: **CE-736**
Course Type: **Programme Elective**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the disaster Management
- To introduce the fundamental concepts relevant to various aspect of disaster
- To enable the students to understand the factors that cause the disaster.
- To be able to assess risk and vulnerability for natural and man-made hazard

Course Content

Introduction to Natural & Man-made Disasters: Understanding Disasters, Geological and Mountain Area Disasters, Wind and Water Related Natural Disaster, Man Made Disasters Technologies for Disaster Management Role of IT in Disaster Preparedness, Remote Sensing, GIS and GPS, Use and Application of Emerging Technologies, Application of Modern Technologies for the Emergency communication, Application and use of ICST for different disasters. Rehabilitation, Reconstruction and Recovery: Introduction and basic concept; Disaster Response And Management: Introduction to Response Essential Components, Stakeholders Co-ordination in Disaster Response, Human Behavior and Response Management and Relief Measures; Behavior and Response Management and Relief Measures; Disaster Mitigation: meaning and concept, Disaster Mitigation Strategies, Emerging Trends in Disaster Mitigation, Mitigation management, Role of Team and Coordination.

Course Outcomes

After learning the course, the students should be able to:

1. Understand disasters, disaster preparedness, role of IT, remote sensing, GIS and GPS,
2. Understand Rehabilitation, Reconstruction and Recovery,
3. Apply knowledge Disaster Response and Management, Risk Assessment and Vulnerability Analysis,
4. Understand Disaster Mitigation.

Books and References

1. Natural Hazards by Bryant Edwards, Cambridge University Press, U.K.
2. Disaster Management by Carter, W. Nick, Asian Development Bank, Manila.
3. Disaster Mitigation Experiences and Reflections by Sahni, Pardeep et.al., Prentice Hall of India, New Delhi.
4. Space Technology for Disaster management: A Remote Sensing & GIS Perspective by Roy, P.S. IIRS (NRSA) Dehradun.
5. Natural Disaster by Sharma, R.K. & Sharma, G. APH Publishing Corporation, New Delhi.
6. Disaster Management in the Hills by Singh Satendra, Concept Publishing Company, New Delhi.
7. Disaster Management through Panchayati Raj by Taori, K, Concept Publishing Company, New Delhi.

Course Name: **Finite Element Method**
Course Code: **CE-737**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To learn basic principles of finite element analysis procedure.
- To learn the theory and characteristics of finite elements that represent engineering structures
- Learn to model complex geometry problems and solution techniques
- To learn and apply finite element solutions to Structural Engineering problem

Course Content

Approximate methods of Analysis, Introduction, Steps in finite element, Different approaches in FEM- Direct, Variational, Energy, Weighted residual,1-D FE Analysis- bar element, truss element, Beam element and Frame element, 2-D FE Analysis-CST element for plane stress and plane strain, Axis symmetry case,4-node rectangular element, Langrangian interpolation function, 3-D FE Analysis- brick element, Assembling, iso-parametric formulations, Use of Symmetric and anti-symmetric condition.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the concepts various approaches in FEM.
CO2: Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element
CO3: Apply FEM in different fields like, seepage proble, heat transfer etc.
CO4: Develop element level equation and generate global stiffness equation for the engineering problem

Books and References

1. Finite Element Analysis: Theory and Programming by C.S. Krishnamoorty, Tata McGraw-Hill Education
2. Introduction to Finite Elements in Engineering by T. R. Chandrupatla, A. D. Belegundu, Pearson Education Limited
3. Fundamentals Of Finite Element Analysis by D. V.Hutton, Tata McGraw-Hill Education
4. Finite element methods by Vol I & Vol II, O.C. Zienkiewicz and R.L. Taylor, McGraw Hill.
5. Finite element procedures by K. J. Bathe, PHI Ltd.
6. Concepts and applications of finite element analysis by R.D. Cook, D.S. Malkus and M.E. Plesha, John Wiley and Sons.

Course Name: **Fracture mechanics of concrete**
Course Code: **CE-738**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the fracture mechanics of concrete.
- To introduce the fundamental concepts relevant to fracture mechanics
- To enable the students to understand the factors that cause the design of concrete structures based on fracture mechanics concepts

Course Content

Linear elastic fracture mechanics: Overview of fracture mechanics, Fracture at atomic level, Stress concentration factor, Griffith's Energy Theory, Energy release rate, SIF, Effect of finite size, Instability and R curve, Crack tip plasticity, CTOD, Integral. Fracture mechanics of concrete: fracture mechanics of concrete, Nonlinear fracture models, RILEM fracture energy, Softening of concrete, Fracture process
zone, size effect, Interface fracture, Fracture behavior of HSC and HPC.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Linear and nonlinear fracture mechanics models applicable for civil structures

CO2: Describe the various parameters for the design of concrete structures

CO3: Apply principles and algorithms for the design of structures based on concepts of fracture mechanics

CO4: Assess the results obtained by solving above problems

Books and References

1. Elementary Engineering Fracture Mechanics by David Broek, Sijthoff and Noordhaff, Alphen Aan Den Rijn, The Netherlands.
2. Analysis of Concrete Structure by Fracture Mechanics by L. Elfgren and S.P. Shah, Proc of Rilem Workshop, Chapman and Hall, London.
3. Elements of Fracture Mechanics by Prashant Kumar, Tata McGraw Hill, New Delhi, India.

Course Name: **High Rise Buildings**
Course Code: **CE - 739**
Course Type: **Programme Elective**

Contact Hours/Week: 4**L** Course Credits: **04**

Course Objectives

- To impart knowledge of the latest concepts, techniques and design of wind- and seismic-resistant buildings.
- To introduce the fundamental concepts relevant to different approaches of high-rise building design method.
- To enable the students to understand the factors that causes the economy and optimization of the structural design and construction of high-rise building.

Course Content

Design Criteria: Design philosophy, static and dynamic approach, Structural systems and concepts, Effect of openings. Large panel construction. Foundation superstructure interaction. Gravity and lateral load resisting Structural Systems: High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Steel-Concrete Composite Floor Systems Aluminum Facades. Analysis and Design: Modeling for approximate analysis, accurate analysis, subsystem interaction, differential movement, creep and shrinkage effects, temperature effects and fire. Stability of tall Buildings: Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity loading, simultaneous first order and P-Delta analysis, translational, Torsional instability. Foundations: Design of pile foundations.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the uses of wind- and seismic-resistant buildings in civil engineering

CO2: Describe different techniques and procedure of the high-rise building design method in civil engineering.

CO3: Apply principles of different criteria considering the economy and optimization of the structural design and construction of high-rise buildings.

CO4: Assess the Applications of different approach of high-rise building design method in civil engineering.

Books and References

1. Structural Analysis and Design of Tall Buildings by Taranath B.S, McGraw Hill, New York.
2. Designing and installation of services in building complexes and high rise buildings by Jain,V.K. , Khanna Publishers, New Delhi.
3. High rise structures; design and constructions practices for middle level cities by Gupta,Y.P. , New Age International Publishers, new Delhi.
4. Tall building structures Analysis and Design by Bryan Stafford Smith & Alexcoull, John Wiley.

Course Name: **Optimization Methods**
Course Code: **CE-740**
Course Type: **Programme Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the optimization
- To impart knowledge about the multi-objective nature of Engineering Design
- To Apply optimization methods to solve the Engineering Design Problems

Course Content

Basics of engineering analysis and design, need for optimal design, formulation of optimization problem, classical-simplex search, gradient search, Newton Raphson and global Optimization techniques-Introduction to GA, Constrained and Unconstrained optimization problems, convex optimization, Sensitivity analysis, Numerical methods for nonlinear optimization problems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understanding the basic concepts of classical optimization
CO2: Analysis of optimization algorithms
CO3: Applications of optimization in Civil Engineering

Books and References

1. Optimization for engineering design: Algorithms and examples by K. Deb, PHI Pvt Ltd.
2. Introduction to optimum design by J.S. Arora, McGraw Hill International editions.
3. Elements of structural optimization by R.T. Hafta and Z. Gurdal, Kluwer academic publishers.
4. Engineering Optimization theory and Practice by S. S. Rao, New Age International.

Course Name : **Construction Management**
Course Code : **CE-741**
Course Type : **Programme elective**

Contact Hours/Week: **4L** Course Credits: 03

Course Objectives

- Understanding the need of construction planning,
- Understanding planning and scheduling using critical path method,
- Understanding planning and scheduling using PDM, and
- Understanding scheduling of repetitive construction projects.

Course Content

Construction Planning: Owner level planning**,** pre-tender stage planning, contract stage planning,
Construction Contracts: Contract act, types of contracts, tender and condition of contract, tender notice, pre requisites for tendering, tender document, EMD, Receipt and opening of tenders, evaluation of tenders, award of contract, Legal aspect of contract,
Critical Path Method (CPM) for scheduling of simple construction projects: Work breakdown structure, developing networks, AOA and AON representation of network, activity times, activity floats, critical path method.
Precedence Diagram Method (PDM) **for scheduling of complex construction projects**: Precedence networks fundamentals, advantages, logic and precedence networks applications, PDM versus CPM.
Line of Balancing (LOB) for scheduling of repetitive construction projects: Line of balance methods of scheduling repetitive construction, time and space buffers, linear interpretation of precedence relationships.
Selection of Planning Techniques for construction projects: Selection of planning and scheduling techniques, Techniques for different level of management, level of detail needed, project success or failure.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Plan and schedule construction project by Critical path method,
CO2: Plan and schedule construction project by PDM,
CO3: Apply LOB to solving problems of repetitive construction planning

Books and References

1. Chitkara, K. K. “Construction Project Management, planning scheduling and controlling.”
2. Bansal V. K. “Project management:Planning and Scheduling Techniques.”
3. Moder J. J. Philips, C.R. and Davis, E.W. “Project Management with CPM and PERT, and precedence diagramming”
4. Pilcher, R. “Project Cost Control in Construction”. Brien J.J. CPM in “Construction Management”, Mc. Graw Hill.