CURRICULUM

M. TECH.

in

STRUCTURAL AND CONSTRUCTION ENGINEERING

(July 2023 admission onwards)

DEPARTMENT OF CIVIL ENGINEERING

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
Jalandhar

PO - Programme Outcomes

- PO1: An ability to independently carry out research /investigation and development work to solve practical problems.
- PO2: An ability to write and present a substantial technical report/document.
- PO3: Students should be able to demonstrate a degree of mastery over structures and construction engineering area. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Program Specific Outcomes (PSOs)

- PSO1: Ability to design and conduct experiments, as well as analyze and interpret data related to structures and construction engineering problems.
- PSO2: Ability to apply principles of structures and construction engineering to solve real-world problems and make informed decisions based on technical, economic, and environmental considerations.
- PSO3: Ability to use modern tools and technologies for structures and construction engineering, analysis, design, and management.

Program Educational Outcomes (PEOs):

- PEO1: Graduates will have the ability to independently carry out research, investigation, and development work to solve practical problems related to structures and construction engineering.
- PEO2: Graduates will be able to write and present technical reports and documents related to structures and construction engineering, using appropriate skills and tools.
- PEO3: Graduates will be able to demonstrate a mastery of structures and construction engineering at a level higher than the requirements in the appropriate bachelor program, and will be able to apply this knowledge to identify and solve complex problems in the field.
- PEO4: Graduates will be able to design, analyze, and evaluate structures and construction engineering projects, taking into account technical, environmental, economic, and social factors, and will be able to make informed decisions based on sound engineering principles and ethical considerations.

TEACHING SCHEME

Semester – I*

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - I	3	0	0	3
CE	Course - II	3	0	0	3
CE	Course - III	3	0	0	3
CE	Course - IV	3	0	0	3
CE	Course - V	3	0	0	3
CE	Course - VI	3	0	0	3
CE	Lab-I	0	0	3	2
CE	Lab-II	0	0	3	2
Total					**22**

Semester - II

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - VII	3	0	0	3
CE	Course - VIII	3	0	0	3
CE	Course - IX	3	0	0	3
CE	Course - X	3	0	0	3
CE	Course - XI	3	0	0	3
CE	Course - XII	3	0	0	3
CE	Lab-III	0	0	3	2
CE	Lab-IV	0	0	3	2
Total					**22**

Semester – III*

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Independent Study	0	0	6	3
CE	Dissertation Part I	0	0	12	6*
Total					**09**

Semester – IV[@]

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Dissertation Part II	0	0	24	12*
Total		0	0	24	**12**

[@]*The result of Dissertation Part I & II shall be forwarded cumulatively after evaluation of dissertation*

Grand Total of Credits = 65

LIST OF CORE COURSES FOR M. TECH.

(STRUCTURAL AND CONSTRUCTION ENGINEERING)

S. No.	Course No.	Course Title	Periods			Credits
			L	T	P/D	
1.	CE-501	Advanced Solid Mechanics	3	0	0	3
2.	CE-502	Advanced Reinforced Concrete Design	3	0	0	3
3.	CE-503	Structural Dynamics	3	0	0	3
4.	CE-504	Analysis and Design of Foundations	3	0	0	3
5.	CE-506	Earthquake Resistant Design of Structures	3	0	0	3
6.	CE-507	Advanced Structural Analysis	3	0	0	3
7.	CE-508	Advanced Construction Practices	3	0	0	3
8.	CE-509	Quantitative Methods in Construction Management	3	0	0	3
9.	CE-601	Independent Study	0	0	6	3
10.	CE-600	Dissertation Part-I Dissertation Part-II	0	0	30	6+12

LIST OF LABORATORY COURSES FOR M. TECH.

(STRUCTURAL AND CONSTRUCTION ENGINEERING)

S. No.	Course No.	Course Title	Periods			Credits
			L	T	P/D	
1.	CE-520	Foundation Engineering Laboratory	0	0	3	2
2.	CE-521	CAD Laboratory	0	0	3	2
3.	CE-522	Concrete Structures Laboratory	0	0	3	2
4.	CE-523	Material Testing Laboratory	0	0	3	2

LIST OF ELECTIVES FOR M. TECH.

(STRUCTURAL AND CONSTRUCTION ENGINEERING)

S. No.	Course No.	Course Title	Periods			Credits
			L	T	P/D	
1.	CE-505	Finite Elements Analysis	3	0	0	3
2.	CE-510	Quality and Safety Management in Construction	3	0	0	3
3.	CE-511	Construction Economics and Finance	3	0	0	3
4.	CE-512	Repair and Retrofitting of Structures	3	0	0	3

5.	CE-513	Advanced Numerical Methods	3	0	0	3
6.	CE-514	Highway Construction and Maintenance	3	0	0	3
7.	CE-515	Theory of plates And Shells	3	0	0	3
8.	CE-516	Geospatial Technologies	3	0	0	3
9.	CE-517	Pre-stressed Concrete Design	3	0	0	3
10.	CE-518	Infrastructures Development Projects	3	0	0	3
11.	CE-519	Analysis and Design of Tall Buildings	3	0	0	3
12.	CE-526	Construction Methods and Equipment	3	0	0	3
13.	CE-527	Design of Industrial Structures	3	0	0	3
14.	CE- 528	Advanced Steel Design	3	0	0	3
15.	CE- 529	Soil Dynamics and Machine Foundations	3	0	0	3
16.	CE-530	Construction and Contract Management	3	0	0	3
17.	CE-531	Geoenvironmental Engineering	3	0	0	3
18.	CE-532	Landfill and Ash ponds	3	0	0	3
19.	CE-533	Solid and Hazardous Waste Management	3	0	0	3
20.	CE-534	Concrete Mechanics	3	0	0	3
21.	CE-535	Recent Advances in Construction Materials	3	0	0	3
22.	CE-536	Composite Materials	3	0	0	3
23.	CE-537	Simulation & Modelling	3	0	0	3
24.	CE-538	Site Investigations and Ground Improvement	3	0	0	3
25.	CE-539	Engineering Behaviour of Soils	3	0	0	3
26.	CE-540	Geosynthetics	3	0	0	3
27.	CE-541	Pavement Design	3	0	0	3
28.	CE-565	Ground Improvement Techniques	3	0	0	3
29.	CE-575	Fundamentals of Soil Behaviour	3	0	0	3
30.	CE-576	Soil Structure Interaction	3	0	0	3
31.	CE-577	Earth Retaining Structures	3	0	0	3
32	CE-578	Advanced Structural Mechanics	3	0	0	3
33.	ID-601	Research Methodology	3	0	0	3
34.	CE-590	Modelling and Research Methodology	3	0	0	3

CE 501 Advanced Solid Mechanics [3-0-0-3]

Course Objectives:

- Apply the principles of elasticity theory to solve engineering problems related to stress and strain in structures and components using appropriate tensor notations and differential equations of equilibrium.
- Analyze and design structures and components under elastic and plastic behavior using appropriate yield criteria such as Tresca and Von Mises criteria.
- Evaluate the fundamental concepts of visco-elasticity and its application in engineering, including the behavior of materials under varying loading conditions.
- Communicate effectively about elasticity theory and its applications in technical reports and presentations, using appropriate terminology and mathematical notations.

Course Syllabus:

State of stress in a body. Tensor notations, Differential equations of equilibrium, Invariants of the stress tensor, Theory of strain, Displacement components, strain components and relation between them, Generalised Hooke's law, Solution of the elasticity problem in terms of displacements, Basic equations of the theory of elasticity, Lame's equations, Plane problem in cartesian co-ordinates, Plane problem in polar co-ordinates, Shrink fits, Rotating disks with uniform thickness, Plate with hole, Torsion in prismatic bars, Saint Venant's method, Solution of torsion problem in terms of stresses Strain energy, Elastic plastic behavior, Design philosophy, Linear elastic and plastic behavior, Tresca and Von Mises yield criteria, Visco-elastic behavior.

Course Outcomes:

- To develop the ability to apply the principles of elasticity theory to solve engineering problems related to stress and strain in structures and components. (PO1)
- To develop the ability to analyze and design structures and components under elastic and plastic behavior using appropriate yield criteria. (PO2)
- To develop an understanding of the fundamental concepts of visco-elasticity and its application in engineering. (PO3)
- To develop the ability to communicate effectively about elasticity theory and its applications in technical reports and presentations. (PO2)

Text and Reference Books:

- Timoshenko S P and Goodier J N "Theory of Elasticity" McGraw Hill, New York,2002.
- Housner G W and Vreeland J R "The Analysis of Stress and Deformation" Mcmillan London, 1998.
- Srinath L S "Advanced Mechanics of Solids" Tata Mcgraw Hill, New Delhi, 2000.
- Westergaard H M "Theory of Elasticity and Plasticity" Harvard University Press, Cambridge, 1998.
- Kazimi S M A "Solid Mechanics" Tata McGraw Hill, New Delhi, 1999.

CE-502 Advanced Reinforced Concrete Design [3-0-0-3]

Course Objective:

- To make students understand about the various elements of different types of industrial and non-industrial RCC structures.
- To make students understand regarding design provisions as per Indian standards
- To make students understand regarding the design of basic elements like beams and slabs
- To make students able to analyze and design of chimneys, shear walls, virendeel girders, concrete trusses.

Course Syllabus:

Deflections of Reinforced Concrete Beams and Slabs; Estimation of Crack Widths in Reinforced Concrete Beams; Inelastic Analysis of Reinforced Concrete Beams and Frames; Design of Shear Walls, Cast-in-Situ Beam-Column Joints, Deep Beams, Chimneys, Ribbed Slabs; Design of Reinforced Concrete Members for Fire Resistance; Software Applications, Virendeel Girders, Concrete Trusses.

Course Outcome:

- Understand the various elements of industrial and non-industrial RCC structures. (PO1)
- Understand the design provisions as per Indian standards code(s)(PO1, PO2)
- Understand the design procedure of the basic elements like, beams, slabs. (PO2, PO3)
- Understand the design of chimneys, shear walls, virendeel girders, concrete trusses (PO2, PO3)

Text and Reference Books:

- Varghese P C "Advanced Reinforced Concrete Design" Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
- Krishna Raju N "Advanced Reinforced Concrete Design" CBS Publishers and Distributors, New Delhi, 1988.
- Park R and Paulay T "Reinforced Concrete Structures" John Wiley and Sons, New York, 1975.
- SP 208 "Examples for the Design of Structural Concrete with Strut – and – Tie Models" Editor: Karl – Heinz Reineck, American Concrete Institute, Michigan, 2003.
- Leet, Kenneth M and Bernal D "Reinforced Concrete Design" McGraw Hill, London, 1998.

CE 503 Structural Dynamics [3-0-0-3]

Course Objective:

- To understand the concept of degrees of freedom and constraints, and apply them to solve problems related to the motion of single and multiple degree of freedom systems.
- To analyze the response of single degree of freedom systems to different types of excitations such as harmonic, non-harmonic, impulse, and blast loading.
- To develop an understanding of the theory of vibration pick-ups and estimation of dynamic characteristics through conventional solutions.
- To use mode superposition method for seismic analysis of multi degree of freedom systems.

Course Syllabus:

Concept of degrees of freedom and constraints, Equations of motion, Newton's Law and De Alembert's Principle, Response of single degree of freedom systems to initial conditions, Response to harmonic excitation, Dynamic amplification factor, Transmissibility, Base Isolation, Response to non-harmonic excitations such as impulse, step loading and blast loading, Duhamel's Integral, Earthquake response analysis, Response spectrum, Theory of vibration pick – ups, Estimation of dynamic characteristics through experimental investigations, Multi degree of freedom systems, Orthogonality of mode shapes, Mode superposition method for seismic analysis.

Course Outcome:

- Able to analyze the motion of single and multiple degree of freedom systems using equations of motion, Newton's Law and De Alembert's Principle, and evaluate the response to different types of excitations. (PO3)

- Able to evaluate the dynamic amplification factor, transmissibility, and base isolation of structures subjected to harmonic and non-harmonic excitations. (PO1)
- Able to design vibration pick-ups and estimate dynamic characteristics through experimental investigations. (PO2)
- Able to use mode superposition method to analyze the seismic response of multi degree of freedom systems. (PO3)

Text and Reference Books:

- Clough R W, Penzien J, "Dynamics of Structures", McGraw-Hill, Inc, New York, 1991.
- Chopra A K "Dynamics of Structures: Theory and Applications to Earthquake Engineering" Prentice Hall (India) Private Ltd, New Delhi, 2000.
- Roy Creig Jr. "Structural Dynamics: An Introduction to Computer Methods", John Wiley & Sons, New York, 1981.
- James M L, Smith G M, Wolford J C and Whaley P W "Vibration of Mechanical and Structural Systems: With Microcomputer Applications", Happer & Row, Publishers, New York, 1989.
- Rao S S, "Mechanical Vibrations", Pearson Education, New Delhi, 2004.

CE-504 Analysis and Design of Foundation Structures [3-0-0-3]

Course Objective:

- To understand the fundamental concepts and principles of different types of footings and their design criteria.
- To develop the knowledge and skills required to analyze and design shallow, deep, pile, and combined footings under different loading conditions.
- To analyze and design different components of well foundations, considering soil-structure interaction.
- To develop an understanding of soil liquefaction and its mitigation techniques.

Course Syllabus:

Course Syllabus: Introduction to shallow and deep footings, Depth, spacing of footings, water table effects, allowable bearing capacity of footings. Design of Isolated, strap, combined and Raft footings. Footings subjected to eccentric loading, uplift and overturning.

Deep foundation: Types of piles, Negative skin-friction, Ultimate carrying capacity of pile and pile group. Design of pile footings, caps for piles, settlements, Geotechnical design considerations. Lateral stability of well foundations, design of different components of well foundations.

Soil liquefaction, evaluating the liquefaction potential by Standard Penetration Tests and Cone Penetration Tests, Liquefaction of clayey soil, Mitigation of Liquefaction Hazard by site modification methods

Course Outcome:

- Analyze and design different types of footings, including shallow, deep, pile, and combined footings, and evaluate their performance under different loading conditions, such as eccentric loading, uplift, and overturning, using appropriate design criteria and methods. (PO2)
  Evaluate and design caps for piles, considering their interaction with the soil and other structural components. (PO3)
- Design different components of well foundations, such as well cap, well curb, well steining, and well apron, using appropriate design criteria and methods, considering soil-structure interaction. (PO3)
- Evaluate the liquefaction potential of soil using different methods, such as Standard Penetration Tests, Cone Penetration Tests, and Shear Wave Velocity, and propose appropriate mitigation techniques to reduce the risk of soil liquefaction. (PO1)

Text and Reference Books:

- Saran S "Analysis and Design of Sub-Structures" Oxford and IBH, New Delhi, 1996.
- Bowls J E "Foundation Analysis and Design" Mc Graw Hill, New York, 1988.
- Peck R B, Henson W E and Thorn burn W T "Foundation Engineering" John Willey and Sons, New York, 1984.
- Teng W C "Foundation Design" Prentice Hall, New Delhi, 1992.
- Naeim F "The Seismic Design Hand Book", Kluwer Academic Publishers, London, 2001.
- Krammer S "Geotechnical Earthquake Engineering" Pearson Education Pvt. Ltd. New Delhi, 2003.

CE-506 Earthquake Resistant Design of Structures [3-0-0-3]

Course Objective:

- To study the multimodal and multidirectional response spectrum analysis.
- To make students familiar regarding understanding the earthquake resistance design philosophy.

- To carry out lateral load analysis with reference to Indian standard code.
- To make students able to do seismic design and detailing of structures with reference to IS code.

Course Syllabus:

Introduction to Engineering Seismology, Introduction to Earthquake Resistant Design, Behaviour of buildings and structures during past earthquakes and lessons learnt, goals of earthquake resistant design. Linear static and dynamic procedure for seismic load calculation – IS 1893, 2016 Earthquake resistant measures at planning stage: Geotechnical and architectural considerations, irregularities, earthquake resistant measures in structures as per IS : 4326 –1993, principals of earthquake resistant design – behaviour of concrete and steel, confined concrete, the capacity design method; Study of IS 13920 –2016 behaviour of masonry structures during earthquakes, analysis and behaviour of masonry infilled RC frames, earthquake resistant measures in masonry buildings.

Course Outcome:

- Study the multimodal and multidirectional response spectrum analysis (PSO1, PEO4).
- Understanding the earthquake resistance design philosophy (PSO2, PEO4).
- To carry out lateral load analysis with reference to Indian standard code (PSO2, PEO4).
- Able to do seismic design and detailing of structures with reference to IS code (PSO2, PEO4).

Text and References Book:

- Dowrick D J "Earthquake Resistant Design for Engineers and Architects" John Wiley and Sons, New York, 1987.
- Dowrick D J "Earthquake Risk Reduction" John Wiley and Sons, New York, 2003.
- Englekirk R E "Seismic Design of Reinforced and Pre-cast Concrete Buildings" John Wiley and Sons, New York, 2003.
- Pauley T and Priestley M J N "Seismic Design of Reinforced Concrete and Masonry Buildings" John Wiley and Sons, New York, 1992.
- Key D "Earthquake Design Practices for Buildings" Telford Publishers, London, 1990.

CE-507 Advanced Structural Analysis [3-0-0-3]

Course Objective:

- To develop an understanding of the concepts of static and kinematic indeterminacy and apply matrix algebra to solve simultaneous equations for structural analysis.
- To apply the stiffness method to analyze continuous beams, trusses, and frames under different loading conditions and temperature effects.
- To develop an understanding of element approach for structural analysis and apply it to analyze beams, trusses, and frames using 2D truss and beam elements.
- To understand the application of virtual work and energy principles for solving practical structural problems.

Course Syllabus:

Basic concepts, Degree of static and kinematic indeterminacy, Matrix algebra, Solution of simultaneous equations by Gaussian Elimination, Flexibility and Stiffness Matrices, System Approach: Development of stiffness matrix, Applications of stiffness method to continuous beams, trusses and frames. Effect of temperature, and pre strain. Element Approach: Element stiffness, 2D truss element and beam element, Transformation matrix, Assembly of global stiffness matrix, Storage requirement of stiffness matrix i.e. full storage, banded storage and skyline storage, Effect of node and element numbering, Boundary conditions, Application of stiffness method to beams, trusses and frames. Computer applications, Material and geometrical non-linearity, Application of Virtual work and energy principles.

Course Outcome:

- Able to analyze the degree of static and kinematic indeterminacy of structures and solve simultaneous equations using Gaussian elimination. (PO1)
- Able to develop stiffness matrices using the system approach and analyze continuous beams, trusses, and frames under different loading conditions and temperature effects. (PO2)
- Able to apply the element approach to analyze beams, trusses, and frames using 2D truss and beam elements, and assemble global stiffness matrices. (PO3)
- Able to use virtual work and energy principles to solve practical structural problems. (PO1, PO3)

Text and Reference Book:

- Pandit G S and Gupta S P “Matrix Analysis of Structures” Tata McGraw Hill, New Delhi, 2003.
- Gere W and Weaver J M “Matrix Analysis of Structures” CBS Publishers, New Delhi, 2002.

- Rajasekaran S and Sankarasubramanian G "Computational Structural Mechanics" Prentice Hall India, New Delhi, 2001.
- Vazirani V N and Ratwani M M "Advanced Theory OF structures and Matrix Method" Khanna Publishers, New Delhi, 1995.

CE-508 Advanced Construction Practices [3-0-0-3]

Course Objective:

- To make students understand regarding implementation of new technologies/concepts as applied in the field of advanced construction
- To make students understand regarding different technologies of mass concreting, industrialized construction and special methods of construction
- To make students understand and analyze the problems associated with construction in extreme weathers and difficult conditions
- To make students understand and analyze the design and application of basic element bridge construction including segmental construction

Course Syllabus:

Concrete Construction Methods, Formwork Design and Scaffolding; Slip Forms and other moving forms; Pumping of Concrete; Grouting and Mass Concreting Operations (roller compacted concrete); Ready-Mix Concrete; Various Methods of Handling and Placing Concrete, accelerated curing, Hot and cold weather concreting, Under water concreting, Prestressing. Steel and Composite Construction Methods**,** Fabrication and erection of structures including heavy structures, Prefab construction, Industrialized construction and Modular coordination. Special Construction Methods, Construction in Marine Environments, High Rise Construction, Bridge Construction including Segmental Construction, Incremental Construction and Push Launching Techniques; Geosynthetics; Safety, Quality Measures and Reliability.

Course Outcome:

- Understand the latest construction techniques applied to engineering construction (PO1)
- Get knowledge of design analyze, compare and evaluate the technology of mass concreting, industrialized construction and special construction methods (PO1, PO2)
- Understand and analyze the challenges associated with construction in extreme weathers conditions and onsite construction issues (PO1, PO2)
- Understand the concepts of special construction methods, bridge construction techniques, quality assurance and quality control and geosynthetics (PO1, PO2, PO3)

Text and Reference Book:

- Neville A M and Brooks J J "Concrete Technology", Pearson Education Asia, Singapore, 1994.
- Neville A M "Properties of Concrete", Pearson Education, New Delhi, 2004.
- Peurifoy R L "Construction Planning, Equipment and Methods" McGraw Hill Ltd., New York, 2002.

CE-509 Quantitative Methods in Construction Management [3-0-0-3]

Course Objective:

- To introduce the fundamental concepts of probability and statistics and their applications in construction engineering.
- To develop an understanding of linear programming and optimization techniques used in construction engineering.
- To introduce queuing theory and decision theory and their applications in construction engineering.
- To develop an understanding of simulation models and their applications in construction engineering.

Course Syllabus:

Introduction and concepts of probability and statistics, Optimization through Linear programming- Need for linear programming, Linear programming model, dual problem, dynamic programming. Transportation model, solution of Transportation model, Assignment problems, solution of assignment problem. Queuing theory- waiting line models, deterministic model, probabilistic model, Decision theory- decision analysis, decision under uncertainty, Nature of Games, Games model, solution of Games model, simulations as applied to construction- simulation models, steps in simulation, Monte carlo simulation. Modifications and improvement on CPM/PERT techniques.

Course Outcome:

- Apply probability and statistics concepts and techniques to analyze and interpret data related to construction engineering problems. (PO3)
- Formulate and solve linear programming models to optimize resource allocation and scheduling in construction projects. (PO2, PO3)
- Apply queuing theory and decision theory to analyze and optimize waiting line models and decision-making processes in construction projects. (PO3)

- Develop and apply simulation models to evaluate and improve the performance of construction projects under uncertain conditions. (PO1)

Text and Reference Books:

- Verma M "Construction Planning and Management Through System Techniques" Metropolitan Book Company, New Delhi, 1985.
- Chitkara K K "Construction Project Management – Planning, Scheduling and Controlling" Tata McGraw Hill, New Delhi, 2000.
- O'Brien J "CPM in Construction Management" McGraw Hill, New York, 1999.
- Harris R B "Precedence and Arrow Networking Techniques for Construction" John Wiley & sons, New York, 1999.
- Levy S "Project Management in Construction" McGraw hill, New York, 2000.

CE 601 Independent Study [0-0-6-3]

Course Objective:

- To develop students into self-directed learners and independent researchers.
- To provide more scope and depth in the Graduate Kinesiology curriculum by encouraging students to Investigate areas of interest not currently included in any approved course.
- To study areas and develop projects that cut across existing course boundaries.
- To understand more deeply into specific parts of an existing course offering.
- To provide the student with sufficient circumstances to assess personal aptitude for the sport management, fitness management, or sports studies field.
- To develop a critical understanding of and the ability to apply theoretical knowledge from the student's chosen concentration, sport management, fitness management, or sports studies, in a research or self-directed learning environment.

Guidelines:

This is a seminar oriented subject in which the student is required to select a topic of his interest related to recent developments and the state-of-the art in the field under study in consultation with a designated faculty advisor. The student shall be required to carry out a comprehensive literature survey on the selected topic and compile a detailed report and present a minimum of two seminars comprising of one mid-term seminar and one end semester seminar. A continuous evaluation of the student performance in terms of seminar presentation and final report shall be carried out.

Course Outcome:

- Students will be required to identify, describe, and document at least three personal learning outcomes specific to their independent study to help ensure their independent study experience is congruent with their personal, professional goals (PO1, PO2, PEO1, PEO2)
- These outcomes must be included on the student's independent study report and approved by their faculty advisor.

CE 600	**Dissertation Part-I**	**[0-0-6-6]**
	and	
	Dissertation Part-II	**[0-0-24-12]**

Guidelines:

- Candidate should carry out the preliminary literature survey and subsequently, identify the problem in broad terms for Dissertation and finalize/ settle it in consultation with Guide/ Supervisor.
- Pursuant to this, the candidate shall refer multiple literatures pertaining to the theme of the problem and understand the problem and define the problem in the precise terms.
- Candidate should attempt solution to the problem by analytical/simulation/experimental methods. The solution shall be validated with proper justification. The learner shall compile the report in standard format.
- Candidates are advised to publish in reputed International/National Conference and reputed International/National journal.
- The work to be pursued as a part of the dissertation shall be divided broadly in two parts, namely Dissertation I and Dissertation II.
- The topic of the Dissertation should be such that it is a value addition for the existing knowledge in the field and has some worthwhile research input.

CE-520	**Foundation Engineering Laboratory**	**[0-0-3-2]**

Course Objective:

- To develop practical skills in testing and analyzing soil and geotechnical materials.
- To gain an understanding of the behavior of soil and geotechnical materials under different loading conditions.

- To apply theoretical knowledge of geotechnical engineering to practical laboratory experiments.
- To develop an ability to interpret and analyze laboratory test results to inform geotechnical design.

Course Syllabus:

Plate load test, Standard penetration test, Static cone penetration test, Dynamic cone penetration test, Triaxial shear test, large shear box test and testing of Geotextiles and geofibres.

Course Outcome:

- Demonstrate practical skills in performing laboratory tests on soil and geotechnical materials. (PO1, PO3)
- Analyze and interpret laboratory test results to characterize soil and geotechnical material. (PO1, PO3)
- Apply theoretical knowledge of geotechnical engineering to design and execute laboratory experiments. (PO1, PO3)
- Synthesize laboratory test results with theoretical knowledge to inform geotechnical design decisions. (PO1, PO2, PO3)

CE 521 CAD Laboratory [0-0-3-2]

Course Objective:

- To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design, analysis of building and Computer Aided Engineering Analysis.
- To create congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations.
- To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

Course Syllabus:

- Introduction to various research and design software's and their applications
- Comparison of Numerical and theoretical deflection of single and multi-span beam with pinned and fixed supports
- Analysis and design of G+4 building against Dead and Live load using STAAD Pro.
- Analysis and design of multistory framed building against Earthquake & wind loading using STAAD Pro.
- Analysis and design of steel truss against seismic loading using STAAD Pro.
- Analysis and design of suspension Cable Bridge using STAAD Pro.

- Determine the stress and deformation of one way and two-way slab using ABAQUS/CAE.
- Determine the stress and deformation of singly and doubly reinforced concrete beam using ABAQUS/CAE.
- Determine the stress and deformation of axially loaded reinforced concrete column using ABAQUS/CAE.
- Determine the stress and deformation of steel truss bridges using ABAQUS/CAE.

Course Outcome:

- Apply solutions or to do research in the areas of Design and simulation in the field of civil Engineering (PEO1)
- Have abilities and capabilities in developing and applying computer software and hardware to mechanical design and manufacturing fields.
- Formulate relevant research problems; conduct analytical study and analyzing results with modern mathematical methods and use of software tools (PEO2).
- Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work (PSO2).

CE-522 Concrete Structures Laboratory [0 0 3 2]

Course Objectives:

- To make students understand about the design of Plain Cement Concrete (PCC) and Steel Fiber Reinforced Concrete (SFRC).
- To make students understand about testing of PCC and SFRC samples under compression and tension.
- To make students understand of flexural testing of PCC and SFRC samples under static loading.
- To make students understand of flexural testing of PCC and SFRC samples under fatigue loading.

Course Syllabus:

Testing of PCC and SFRC samples under compression and flexural testing under static and fatigue loading.

Course outcomes

- Design of Plain Cement Concrete (PCC) and Steel Fiber Reinforced Concrete (SFRC) (PO1, PO2)
- Perform the tests on PCC and SFRC samples under compression and tension (PO2, PO3)

- Perform the flexural testing of PCC and SFRC samples under static loading (PO2, PO3)
- Perform the flexural testing of PCC and SFRC samples under fatigue loading. (PO2, PO3)

CE-523 Material Testing Laboratory [0 0 3 2]

Course Objectives:

- To make students understand about various materials used for manufacturing of concrete.
- To make students understand regarding various materials to be used for manufacturing of concrete.
- To make students understand about design of concrete mixes for normal, standard and high-grades using standard codes.
- To make students understand about design of concrete mixes for high strength and high performance fly ash based concrete.

Course Curriculum:

Design of concrete mixes for high strength and high performance of fly ash concrete.

Course outcomes

- Identify the conventional and non-conventional materials used for manufacturing of concrete (PO1)
- Perform basic tests on materials used for manufacturing of concrete (PO1, PO2)
- Analyze normal, standard and high-grade concretes as per standards (PO2, PO3)
- Analyze the concrete mixes for high strength and high performance with fly ash (PO2, PO3)

Syllabus of Electives

CE 505 Finite Elements Analysis [3-0-3]

Course Objectives:

- To introduce the basic concepts of finite element analysis and its various applications.
- To provide students with the necessary knowledge to develop finite element models and perform finite element analysis.
- To train students to evaluate the results of finite element analysis and interpret them.
- To enable students to design and optimize structures using finite element analysis.

Course Syllabus:

Introduction: Structural stiffness analysis, Introduction, Matrix Algebra and Gaussian Elimination, The structural element, One, two and three Dimensional Problems, Truss elements, Assembly and analysis of a structure; Transformation of co-ordinates. Element characteristics, Two Dimensional Problems, Plane stress and plane strain.

Interpolation Functions: Shape functions using cartesian coordinates, Natural coordinates, one, two and three dimensional element, Method of Zeros. Modelling Considerations, Element characteristics, Two Dimensional Isoparametric Elements, Assessment of accuracy, Some practical applications. Axi-Symmetric stress analysis, Some improved elements in two dimensional problems

Stress and Strain on One, two and three dimensional element (C0 Element): Gradient operator [B] Matrix, stiffness matrix, force vector due to the self weight, point force and hydrostatic force, thermal load, stress tensor and strain tensor, Area coordinate systems of triangular element, CST, LST and QST Element, Degenerated element.

Validity of the elements: Introduction, application of chain rule, Jacobian, validity of two-dimensional element, area of the cartesian space element,

Numerical Integration: Introduction, Gaussian Quadrature rule, Accuracy, application of numerical integration on one, two and three dimensional problems, find out the body force using numerical integration.

Beams and Frames (C1 Element): Introduction, Shear force, bending moment on beams and frames against point force, uniformly distributed load and uniformly varying loads.

Bending of plates and shells: Introduction, nodes, Thin plates and thick plates theory, Kirchoff's plate theory, Mindlins plate theory, Reduced integration and full integration,

Techniques for Nonlinear Analysis: Introduction, Mass matrix for one and two dimensional element, non-linear analysis.

Course Outcomes:

- Able to define and explain the basic concepts of finite element analysis and its various applications. (PO1, PO3)
- Able to interpret the results of finite element analysis and explain their significance. (PO2, PO3)
- Able to develop finite element models, perform finite element analysis using FEM software, and optimize structures using finite element analysis. (PO1, PO3)
- Able to evaluate the results of finite element analysis, identify potential design problems, and suggest solutions. (PO1, PO2, PO3)

Text and Reference Books:

- Desai C S and Abel J F, "Introduction to the finite element method" CBS Publishers and Distributions, Delhi, 2004.
- Buchanan G R, "Schaum's Outline Series, Theory and Problems of Finite Element Analysis" McGraw Hill International Edition/Tata McGraw Hill, New Delhi, 2004.
- Chandrupta T R and Belegundu A D, "Introduction to Finite Elements in Engineering" PHI, New Delhi,1997.
- Krishnamoorthy C S, "Finite Element Analysis – Theory and Programming" TMH Publishing Co. Ltd. New Delhi, 2002.
- Bathe K J, "Finite Element Procedures" Prentice Hall of India, New Delhi, 1997.

CE-510 Quality and Safety Management in Construction [3-0-0-3]

Course Objective:

- Analyze and apply quality control techniques during design and construction of structures using quantitative tools.
- Develop quality assurance systems and prepare quality manuals, checklists, and inspection reports.
- Evaluate and implement safety measures during construction, demolition, and use of equipment.
- Synthesize and compare quality and safety standards/codes in design and construction through case studies.

Course Syllabus:

Introduction to quality: Planning and control of quality during design of structures. Quantitative techniques in quality control. Quality assurance during construction. Inspection of materials and machinery. In process inspection and test. Preparation of quality manuals, check-list and inspection report. Establishing quality assurance system. Quality standards/codes in design and construction. Concept and philosophy of total quality management (TQM). Training in quality and quality management systems (ISO-9000). Concept of safety. Factors affecting safety; physiological, Psychological and Technological. Planning for safety provisions. Structural safety. Safety consideration during construction, demolition and during use of equipment. Management of accidents/injuries and provision of first aid. Provisional aspect of safety. Site management with regard to safety recommendations. Training for safety awareness and implementation. Formulation of safety manuals. Safety legislation, standards/codes with regard to construction. Quality vs Safety. Case Studies.

Course Outcome:

- Independently conduct research and apply quantitative techniques for quality control during design and construction of structures (PO1).
- Produce technical reports and documentation related to quality control and safety measures (PO2).
- Demonstrate mastery of quality control and safety standards and codes in design and construction (PO3).
- Apply critical thinking to evaluate and compare quality and safety standards/codes through case studies (PO3).

Text and Reference Books:

- Fox A J and Cornell H A "Quality in the Construction Projects" American Society of Civil Engineers, New York, 1992.
- Hellard R B "Total Quality in Construction Projects: Achieving Profitability with Customer Satisfaction" Thomas Telford, London, 1993.
- Davies V J and Thomasin K "Construction Safety Handbook" Thomas Telford, London, 1997.
- Thorpe B "Quality Assurance in Construction" Gower, Aldershort, 1996.
- NICMAR "Safety Management in Construction Industry – A Manual for Project Managers" NICMAR, Mumbai, 1998.
- NICMAR "Handbooks of Safety in Construction" Vol. 1 to 6. NICMAR, Mumbai, 1998.

CE-511 Construction Economics and Finance [3-0-0-3]

Course Objective:

- Evaluate and analyze financial data and apply engineering economics principles to make informed capital budgeting decisions.
- Understand and apply accounting principles to construction industry-specific situations.
- Develop and implement project financial plans and budgets, including managing working capital and multiple sources of finance.
- Evaluate and manage financial risks and uncertainties in construction projects.

Course Syllabus:

Construction accounting, Income statement, Depreciation and amortization, Engineering economics, Time value of money, discounted cash flow, NPV, ROR, Pl, Bases of comparison, Incremental rate of return, Benefit-cost analysis, Replacement analysis, Break even analysis, Risks and uncertainties and management decision in capital budgeting. Taxation and inflation. Work pricing, cost elements of contract, bidding and award, revision due to unforeseen causes, escalation. Turnkey activities, Project appraisal and project yield. Working capital management, financial plan and multiple source of finance. International finance, Budgeting and budgetary control, Performance budgeting, appraisal through financial statements, Practical problems and case studies.

Course Outcome:

- Independently conduct financial analysis and develop financial plans for construction projects. (PO1, PO2, PO3)
- Demonstrate mastery of accounting principles and their application to the construction industry. (PO3)
- Evaluate and compare different capital budgeting techniques and make informed decisions. (PO3)
- Develop and implement financial strategies to manage risks and uncertainties in construction projects. (PO3)

Text and Reference Book:

- Palmer W J "Construction Accounting and Finance" McGraw hill, New Delhi, 1994.
- Kuehal S C "Corporate Finance" Tata McGraw Hill, New Delhi, 1995.
- Block S B and Geoffery A H "Foundations of Financial Management" McGraw Hill, London, 2001.
- Singh H "Construction Management and Accounts" Tata McGraw Hill, New Delhi, 1993.

CE-512 Repair and Retrofitting of Structures [3 0 0 3]

Course Objectives:

- To make students understand regarding principles, criterion, materials and techniques used for repair and retrofitting.
- To make students understand regarding the concepts related to seismic vulnerability, their evaluation, assessment and design considerations.
- To make students understand regarding design and implementation techniques of retrofitting of masonry buildings along with concept of structural integrity.
- To make student understand about the standard codes of practices used for repair and retrofitting of RC buildings, bridges, dams and heritage structures.

Course Curriculum:

Principles of retrofitting, objective and principles of intervention, design steps for intervention, criteria for repair and retrofitting, repair materials and techniques, seismic vulnerability evaluation of buildings, feasibility assessment, design considerations, analytical and experimental techniques, retrofit design and implementation, techniques of retrofitting and improving structural integrity of masonry buildings, codes of practices for repair and retrofitting, techniques of retrofitting of RC

buildings and structural elements, retrofitting of bridges and dams and heritage structures, retrofitting of structures by seismic base isolation, case studies of retrofitting of structures.

Course outcomes:

- Understand the principles, criterion, materials and techniques used for repair and retrofitting (PO1).
- Understand the concepts related to seismic vulnerability, their evaluation, assessment and design considerations (PO1, PO3).
- Understand retrofit design and implementation, techniques of retrofitting and improving structural integrity of masonry buildings (PO1, PO2).
- Understand the codes of practices, retrofitting techniques for RC buildings, bridges, dams and heritage structures (PO1, PO2, PO3).

Text and Reference Books:

- Bungey J H "Testing of Concrete in Structures" Surrey University Press London, 1989.
- Paulay T & Preistley "Seismic Design of Reinforced Concrete Structures and Masonry Buildings" John Wiley and Sons London, 1992.
- ATC-40 (Vol. 1 & 2) "Seismic Evaluation and Retrofitting of Concrete Buildings" Applied Technology Council California, 1996.
- FEMA – 273 "NEHRP Guidelines for Seismic Rehabilitation of Buildings" Building Seismic Safety Council Washington, 1997.
- FEMA – 310 "Handbook for Seismic Evaluation of Buildings – a pre standard" Building Seismic Safety Council Washington, 1998.
- Krammer S "Geotechnical Earthquake Engineering" Pearson Education pvt. Ltd. New Delhi, 2003.

CE 513 Advanced Numerical Methods [3-0-0-3]

Course Objectives:

- Analyze and solve linear equations and systems using both direct and iterative methods, and apply these techniques to engineering problems.
- Demonstrate an understanding of matrix properties, Eigenvalues and Eigenvectors, and their applications in engineering.
- Apply numerical techniques to solve non-linear equations, including Newton Raphson, secant, and Aitken methods, and analyze their convergence.
- Apply numerical differentiation and integration techniques to solve ordinary and partial differential equations, and assess the impact of truncation errors.

Course Syllabus:

Introduction Solutions to linear equations, properties of matrices, Eigen values and Eigen vectors, solutions of linear systems; direct methods and iterative methods, Computation of Eigen values, solutions to the problems using programming languages (C, C++, FORTRAN, MATLAB). Solutions of nonlinear equations, importance of nonlinear equations, different numerical techniques to solve nonlinear equations (Newton Raphson method, secant method, Aitken method). Approximation of functions. Introduction, Taylor series, least squares, legendre polynomials, regression analysis.
Numerical differentiation and integration, ODE and PDE, truncation errors.

Course Outcomes:

- Independently investigate and solve complex linear and non-linear engineering problems using numerical techniques. (PO1, PO3)
- Produce technical reports and presentations that communicate their numerical solutions effectively. (PO2)
- Demonstrate a mastery of numerical methods and their application in solving engineering problems, beyond the requirements of the bachelor's program. (PO3)
- Apply programming languages such as C, C++, FORTRAN, and MATLAB to implement numerical methods and analyze their performance. (PO1)

Text and Reference Books:

- Chapra, S. C. and Canale R. P., 2003. Numerical Methods for Engineers. Tata McGraw Hill.
- Carnahan, B., Luther, H. A. and Wilkes, J. O., 1969. Applied Numerical Methods", John Wiley.
- Heath, M. T., 1997. Scientific Computing: An Introductory Survey. McGraw Hill.

- Rajasekaran, S., 1999. Numerical Methods in Science and Engineering. S. Chand.

CE 514 Highway Construction and Maintenance [3-0-0-3]

Course Objectives:

- To provide an understanding of the physical and chemical properties of materials used in road construction, including bitumen, aggregates, and stabilizers.
- To develop knowledge and skills in the construction of low volume roads, flexible pavements, and rigid pavements.
- To introduce students to the different layers of flexible and rigid pavements and their requirements, as well as the materials needed for each layer.
- To enable students to identify common pavement failures, evaluate pavements, and apply appropriate maintenance methods.

Course Syllabus:

- **Materials for road construction**: material properties (physical and chemical) of bitumen, cutback, emulsions, stabilizers, polymeric bitumen, elastomeric and plastomeric compounds, aggregates, coarse sand, stone dust, slags, river bed material.
- **Soil Construction of low volume roads:** Construction of Earth road, Construction of Gravel road, Construction of WBM roads.
- **Flexible Pavement Construction:** various layers and their advantages and requirements, standard materials' requirements, possible types of materials in different layers.
- **Construction of rigid pavements:** various layers and their advantages and requirements, standard materials' requirements, possible types of materials in different layers.
- **Pavement maintenance and retrofitting:** Pavement Failures, Pavement maintenance methods, Evaluation of pavement, Strengthening of existing pavements by overlaying, retrofitting of rigid pavements.

Course Outcome:

- Students will be able to identify the physical and chemical properties of materials commonly used in road construction. (PO3)
- Students will be able to construct different types of low volume roads, including earth roads, gravel roads, and WBM roads. (PO3)
- Students will be able to construct flexible and rigid pavements, including knowledge of the layers required and standard material requirements for each layer. (PO3)
- Students will be able to evaluate pavement failures and apply appropriate maintenance methods, as well as strengthen existing pavements through overlaying and retrofitting of rigid pavements. (PO1, PO2, PO3)

Text and Reference Book:

- Khanna, S. K and Justo, C.E.G. 1991. Highway engineering, Khanna Publishers.
- Sharma and Sharma, 1980. Principles and practice of highway engg., Asia Publishing House.
- Teng, 1980. Functional designing of pavements, Mc Graw - Hill.

CE-515 Theory of plates and Shells [3-0-0-3]

Course Objectives:

- To understand the fundamental concepts and governing equations of plates and shells.
- To analyze thin rectangular plates under different types of loads using Navier's and Levy's solutions.
- To design and analyze grid flat thin slab systems.
- To analyze and design different types of shells including spherical, conical, and cylindrical shells.

Course Syllabus:

Plates: Introduction, Classification of pates, Governing equation of thin rectangular plate, Navier's Method of solution for Rectangular Plates subjected to point load, uniformly distributed load, patch load and linear hydro-static load, Levy's Solution, Bending of Orthotropic plates and Governing equation of thin rectangular plate, Analysis and Design of Grid flat thin slab system, Governing equation of Circular plate, Triangular plate and Elliptical plate, Structural behavior of Folded plate roofs, Slab-beam analysis of folded plates, The vibration of plates.

Shells: Introduction, Type of shells, Equation of equilibrium of Spherical Shells, Design of Spherical shells with/without circular ring beam, Equation of Equilibrium of Conical Shells, Umbrella Shells, Conical water tank, Design of conical roof including edge beam, Equation of Equilibrium of cylindrical shells, Semi-circular shells, Circular cylindrical shells under axisymmetric loading, Analysis of doubly curved shells, Hipped roof.

Course Outcome:

- Able to derive and apply the governing equations of plates and shells to solve practical problems. (PO1, PO3)
- Able to analyze thin rectangular plates under point loads, uniformly distributed loads, patch loads, and linear hydro-static loads using Navier's and Levy's solutions. (PO1, PO3)
- Able to design and analyze grid flat thin slab systems for practical applications. (PO2, PO3)

- Able to analyze and design different types of shells including spherical, conical, and cylindrical shells. (PO1, PO2, PO3)

Text and Reference Book:

- S. P. Timoshenko, and S. W. Krieger "Theory of Plates and Shells," McGraw-Hill, 1959.
- B.K. Chatterjee, Theory and Design of Concrete Shells" Spon Press; Revised edition, 1988.
- E.H. Mansfield "The Bending and Stretching of Plates," 2nd edition, Cambridge University Press, 1989.
- H. Kruas, Thin Elastic Shells, John Wiley & Sons Ltd, 1968.
- G.S. Ramaswamy, Design and Construction of Shell Structures, CBS Publishers, New Delhi, 1996.
- E. Ventsel, and T. Krauthammer, Thin Plates and Shells: Theory, Analysis, and Applications, 1st Edition, CRC Press, 2001
- K. Chandrasekhara, Analysis of Thin Concrete Shells, Oxford and IBH, Kolkata, 1971.
- J.N. Bandopadhyay Thin Shell Structures, New Age International Publishers, New Delhi, 1986.
- IS 2210-1988, Criteria for design of reinforced concrete shell structures and folded plates, Bureau of Indian Standards, New Delhi.

CE 516 Geospatial Technologies [3-0-0-3]

Course Objectives:

- Understand the fundamental concepts and principles of geospatial technology.
- Analyze and interpret maps and satellite images using cartographic and remote sensing techniques.
- Develop skills in using GIS software and conducting spatial data analysis.
- Apply geospatial technology to solve practical problems in various fields such as urban planning, environmental studies, and defense studies.

Course Syllabus:

Chapter–1: Geospatial Overview: Introduction to Geospatial Technology, Why to study, Geospatial Technology, Importance of Geospatial Technology.

Chapter–2: Mapping & Cartography: What is Map & its Importance, Map Scale and Types, Elements of Map and Indexing, Map Coordinate System, Interpretation of Satellite Images.

Chapter–3: Remote Sensing: Introduction, Spectral Reflectance Signature, Digital Image Processing, Visual Interpretation of Satellite data, Aerial Photo and Its Interpretation, Advanced Remote Sensing Technologies, Advantages and Benefits of RS, Overview on Remote Sensing Technology, Fundamentals of Remote Sensing, Physics of Electro Magnetic Energy, Remote

Sensing Platforms, Sensors and Data Products, Remote Sensing Applications, Indian Remote Sensing Systems.

Chapter–4: Geographic Information System (GPS): Introduction, Digital Cartography, Advantages and Benefits of GIS, GPS Accuracy and Accuracy factors, Types of GPS, List of Global Navigation System, GPS Today & Limitations of GPS, Uses of GPS Technology. GIS Data Element and Data Structure, Fundamentals of Database Concept, Data Input to GIS System, GIS Data Editing, Attribute Data Linking, Spatial and Non Spatial data Analysis, Map Projection and Coordinate System, Applications of GPS.

Chapter–5: Geographical Information System (GIS), Fundamentals of GIS, Components of GIS. GIS Acquisition of GIS, Data Types of GIS, Application of GIS.

Chapter-6: Trends in Geospatial Technology: Introduction, Remote Sensing Trends & Technology, GIS Trends & Technology, Web Based GIS, Enterprise GIS, Mobile GIS, 3-D Visualization and Fly through, Open GIS, GPS Trends & Technology.

Chapter–7: Applications of Geospatial Technology: Water shed Studies, Flood Studies, Ground water Studies, Health Issues, Utility Studies, Security and Defense Studies, Urban and infrastructure Studies

Course Outcomes:

- Create technical reports and presentations demonstrating mastery of geospatial technology concepts and principles (PO2).
- Independently conduct research and investigation to solve practical problems using geospatial technology (PO1).
- Apply geospatial technology to structures and construction engineering area at a higher level than the requirements in the appropriate bachelor program (PO3).
- Demonstrate proficiency in using geospatial technology to analyze and solve problems in various fields, such as environmental and defense studies (PO2, PO3).

Text and Reference Book:

- Ahmed, El-Rabbany 2012. Introduction to GPS: the global positioning system, Second Edition; published by Artech House.
- David, L., Verbyla 1995. Satellite remote sensing of natural resources, CRC Press.

CE-517 Prestressed Concrete Design [3-0-0-3]

Course Objective:

- Apply the principles of prestressing to design and analyze prestressed concrete structures using appropriate methods, techniques, and codes.

- Present technical reports that communicate the design process, assumptions, and conclusions related to prestressed concrete structures.
- Demonstrate mastery over the design and analysis of prestressed concrete structures by applying critical thinking and problem-solving skills.
- Apply numerical methods and computer programming languages to solve problems related to prestressed concrete structures and critically evaluate the results.

Course Syllabus:

Definition, Basic Principles, Types of prestressing, Systems of prestressing, Loss of prestress, materials used, Advantages and disadvantages. Critical load condition, Permissible stresses, Various suggested methods of design, Dimensionless Design variables, Solution of equations, Design Procedure based on flexure, Minimum weight design, Cable layout and profile of tendons, Design by load balancing method, Code provisions. Allowable stress considerations, non-depersonalized allowable stress equations and their solution, Shrinkage Stresses. Two span continuous beams and their analysis, Application of moment distribution method, Design of continuous beams, Continuous beams with variable section. One way and two-way slabs, Beam and slab construction, Principal Stresses, failure due to shear, combined bending and shear, Bond, Prestressing cable at the centroidal axis, Symmetric multiple cable, cable with eccentricity, Inclined cables, Spalling and bursting stresses. Compression members, Tension members, Prestressed Concrete Pavements, Folded plates and Shells, Arches, Dams, Rigid frames, cylindrical tanks.

Course Outcome:

- To understand the principles and design of prestressed concrete structures for solving practical problems independently. (PO1)
- To develop the ability to write technical reports and present the design of prestressed concrete structures. (PO2)
- To demonstrate mastery over the design and analysis of prestressed concrete structures at a higher level than the undergraduate program. (PO3)
- To apply numerical methods and computer programming languages for solving problems related to prestressed concrete structures. (PO1)

Text and Reference Book:

- Raju N K “Prestressed Concrete” Tata McGraw Hill, New Delhi, 2001.
- Rajagopalan N “Prestressed Concrete” Narosa, New Delhi, 2002.
- Dayaratnam P “Prestressed Concrete” Oxford & IBH, New Delhi, 2001.
- Lin T Y “Prestressed Concrete” John Wiley and Sons, New York, 2002.

- Nawy E G "Prestressed Concrete: A Fundamental Approach" Prentice Hall, New Delhi, 1995.
- I.S.: 1343 – 1980 Code, BIS New Delhi.

CE-518 Infrastructure Development Projects [3-0-0-3]

Course Objective:

- Analyze the impact of infrastructure development on economic growth, standard of living and the environment.
- Evaluate the need for reforms in infrastructure operations, maintenance, financing and technology.
- Compare and contrast different mechanisms for private sector participation in infrastructure development.
- Apply innovative technologies, methodologies and management in the construction of infrastructure projects.

Course Syllabus:

Introduction: Meaning and Scope. Impact on economic development, standard of living and environment. Reasons for rise of public sector and government in infrastructural activities. Changed socio-economic scenario and current problems and related issues. Emerging trends in project contracting, from labor contracting to EPF turnkey jobs. Policies on infrastructure Development: A historical review of the Government policies on infrastructure. Current public policies on transportations, power and telecom sectors. Plans for infrastructure development. Reforming infrastructure: Reasons for and need of reforms: operations, maintenance and financial, technological and methodological considerations, Role of World Bank and other multilateral funding agencies in reform movement. Private Sector Participation: Options in infrastructure development and management. Commercial principles options and mechanisms of involvement. Joint Sector, corporatization, privatization and other means of financing. Experience of other countries.

Mechanisms: BOT, BOOT, BOO and other mechanisms. Experience of other countries and in India thus far. General guidelines on making Joint Ventures and private sector participation. Construction and Infrastructure: Construction component of various infrastructure sectors. Highway, ports and aviation, power, telecom, railways, irrigation. Current scenario, future needs, investment needed, regulatory framework, government policies and future plans. Technological and methodological demands and innovations on in constructors, construction

Management: construction Management in infrastructure development projects. Training of construction managers. New trends in management and construction projects. Construction materials and machinery required for various types of infrastructure development projects.

Innovations in technologies, methodologies and management in construction of infrastructure projects. International designs and specifications and techniques of project execution.

Course Outcome:

- Conduct independent research to propose solutions for practical problems related to infrastructure development. (PO1)
- Prepare technical reports and presentations on infrastructure projects. (PO2)
- Demonstrate a mastery of knowledge and skills in infrastructure development beyond what is required in the undergraduate program. (PO3)
- Design and implement innovative solutions for infrastructure development projects. (PO3)

Text and Reference Book:

- Vaid K "Construction and Infrastructure Development – Issues and Challenges" NICMAR, 2003.
- India Infrasturcture Report 2001 & 2002, Oxford University Press, New Delhi, 2001/02
- NICMAR, Construction Business Opportunities in Infrastructure Development in India, NICMAR, Mumbai, 2001.
- Parikh K S "India Development Report 1999-2000" Oxford University Press, New Delhi, 1999.
- Rakesh Mohan Committee "The India Infrastructure Report" National Council of Applied Economic Research, New Delhi, 1996.

CE-519 Analysis and Design of Tall Buildings [3-0-0-3]

Course Objective:

- To make students understand regarding various structural elements and types of tall buildings.
- To make students understand regarding various structural systems for tall buildings, shear walls and their arrangement.
- To make students understand regarding structural system of tall buildings made with and without shear walls along with 3-dimensional analysis of core buildings and tube-in-tube construction.
- To make students understand regarding design of tall buildings, procedure of elastic design, ultimate strength design and limit state design of super structures including structural connections.

Course Syllabus:

Principles of Planning, Technological Planning, Mechanical systems, Fire rating, local consideration, structures elements, types of structural systems for tall buildings, Shear Walls and their arrangement. Loads on Tall Buildings, Gravity loads, live loads, wind loads and seismic loading, Code Provisions. Discussion of relevant codes of practices and loading standards. Analysis off Tall Buildings with and without Shear Walls, Approximate analysis for gravity loads, lateral loads. Analysis of tube-in-tube constructional and 3-Dimensional analysis of shear core buildings, stability, stiffness and fatigue, factor of safety and load factor, Design of Tall Buildings Procedures of elastic design, ultimate strength design and limit state design of super structures including structural connections.

Course Outcome:

- Understand various structural elements and types of tall buildings (PO1)
- Understand the concept of structural system of tall building and shear walls (PO1)
- Understand and analyze the structural system of tall buildings made with and without shear walls along with 3-dimensional analysis of core buildings and tube-in-tube construction (PO2, PO3)
- Understand and analyze design of tall buildings, procedure of elastic design, ultimate strength design and limit state design of super structures including structural connections (PO2, PO3)

Text and Reference Book:

- Schumelles W “High rise Building Structures” John Wiley and Sons, New York, 1977.
- Ghali A “Structural Analysis: A Unified Classical and Matrix Approach” E & F Spon, London, 1999.
- Taranath B S “Structural Analysis & Design of Tall Buildings” McGraw – Hill International, New York, 1988.
- Brester B and Lin T Y “Steel Structures” John Wiley and Sons, New York, 1981.
- Coull and Stafford S “Tall Buildings with Particular Reference to Shear Wall Structures” Pergamon Press, New York, 1967.

CE – 521 CAD LABORATORY [0-0-3-2]

Course Objectives:

- To introduce the fundamental concepts and tools of commercial software's for civil engineering applications.
- To learn how to create, edit, and annotate 2D and 3D building models using academic software.
- To familiarize students with the use of software, IS Codal provisions, and standards in in the Civil Engineering field.
- To create professional-quality design and develops engineering designs using academic design softwares.

Course Syllabus:

- Comparison of Numerical and theoretical deflection of single and multispan beam with pinned and fixed supports.
- Analysis and design of G+4 building against Dead and Live load using STAAD Pro.
- Analysis and design of G+4 building against earthquake & wind loading using STAAD Pro.
- Analysis and design of tall buildings against earthquake & wind loading using STAAD Pro.
- Analysis and design of steel truss against seismic loading using STAAD Pro.
- Analysis and design of suspension Cable Bridge using STAAD Pro.

Course Outcomes:

- Able to apply the fundamental concepts of engineering to solve engineering problems using Commercial softwares such as STAAD Pro, ETAB, SAP, ABAQUS etc. (PO1, PO2, PO3)
- Able to analyze, design and interpret data, and compare the predicted deflection with the limiting deflation as per IS Codal recommendations. (PO1,PO3)
- Able to communicate effectively by producing technical design reports and annotations that can be easily understood by other engineering professionals. (PO2)
- Able to operate effectively in a professional environment by demonstrating technical communication skills, interacting effectively with construction professionals, and creating professional-quality AutoCAD drawings. (PO1, PO2, PO3)

CE-526 Construction Methods and Equipment [3-0-0-3]

Course Objective:

- Analyze and select appropriate equipment for various construction activities based on technical and economic factors.
- Evaluate production outputs and costs associated with construction equipment, and use the analysis to improve project efficiency.
- Demonstrate an understanding of the characteristics and performances of various types of construction equipment and their applications in different construction activities.
- Apply construction engineering fundamentals to identify problems and develop solutions related to construction equipment and activities.

Course Syllabus:

Factors affecting selection of equipment technical and economic, construction engineering fundamentals, Analysis of production outputs and costs, characteristics and performances of equipment for Earth moving, Erection, Material transport, Pile driving, Dewatering, Concrete construction (including batching, mixing, transport and placement) and tunneling.

Course Outcome:

- Develop skills to independently carry out research/investigation and development work to solve practical problems related to structural and construction engineering. (PO1)
- Improve technical writing and presentation skills in preparing substantial technical reports/documents related to equipment selection and construction engineering fundamentals. (PO2)
- Achieve a degree of mastery over the area of construction engineering fundamentals and equipment selection that exceeds the requirements of an appropriate bachelor's program. (PO3)
- Apply knowledge of technical and economic factors to evaluate the characteristics and performances of equipment used for earth moving, erection, material transport, pile driving, dewatering, concrete construction, and tunneling. (PO1)

Text and Reference Book:

- Purifoy R L and Clifford J S “Construction Planning, Equipment and Methods: McGraw Hill, New York, 2002.
- Verma M “Construction Equipment and its Planning and Application” Metropolitan Book company, New Delhi, 1994.
- Singh J “Heavy Construction Planning, Equipment and Methods” Oxford and IBH, New Delhi, 1992.

- NICMAR 'Millennium Directory of Construction Equipment and Machinery Manufactured in India" CIRC, NICMAR, 2001.

CE-527 Design of Industrial Structures [3-0-0-3]

Course Objective:

- To develop an understanding of the planning and design principles for industrial structures.
- To learn the design principles of braced and unbraced industrial portals in steel, gantry girder, single and multi-bay industrial sheds in steel and concrete.
- To understand the design principles of chimneys, masts, cooling towers, storage structures, large span roof structures, suspension roof structures, and machine foundations.
- To develop skills in the analysis and design of Virendeel Girders.

Course Syllabus:

Planning of industrial structures, Design of braced and unbraced industrial portals in steel, Design of gantry girder, Design of single and multi-bay industrial sheds in steel and concrete. Design of tie rods, sag rods, grit angles and purlins under action of dead, live and wind loads. Design of chimneys under combination of dead load, wind load and temperature stresses, Design of masts and cooling towers, Design of storage structures like bunkers and silos using Airy's and Jensen's theories. Design of large span roof structures and suspension roof structures, Machine foundations, Design of foundations for impact and rotary and reciprocating type machines. Analysis and design of Virendeel Girders.

Course Outcome:

- Able to plan and design industrial structures using appropriate design principles. (PO1, PO2, PO3)
- Able to design braced and unbraced industrial portals, gantry girders, and single/multi bay industrial sheds in steel and concrete under various loads. (PO1, PO2, PO3)
- Able to design chimneys, masts, cooling towers, storage structures, large span roof structures, suspension roof structures, and machine foundations under different loading conditions. (PO1, PO2, PO3)
- Able to analyze and design Virendeel Girders using appropriate design methods and principles. (PO1, PO2, PO3)

Text and Reference Book:

- Krishna Raju N "Advanced Reinforced Concrete Design" CBS Publishers, New Delhi, 2001.
- Chandra R "Design of Steel Structures" Vol. II, Standard Publishers, Delhi, 1991.
- Dayaratnam. P, "Design of Steel Structures" Wheeler Publishers, Allahabad, 1996.

CE-528 Advanced Steel Design [3-0-0-3]

Course Objective:

- Analyze the behavior of structures under plastic conditions and determine the plastic collapse load.
- Evaluate the wind loads on industrial buildings and design braced and unbraced industrial frames.
- Compare and contrast different configurations and components of elevated steel tanks and stacks.
- Apply design principles for light gauge steel and aluminum structures, including consideration of residual stresses.

Course Syllabus:

Plastic Design, Plastic Hinge, Plastic Collapse Load, Plastic Analysis of Frames; Wind Loads on Industrial Buildings, Braced and Unbraced Industrial Frames; Transmission Line Towers, Analysis by Tension Coefficients, Member Selection; Steel Tanks and Stacks, Different Configurations and components of Elevated Circular Tanks; Steel Stacks, Design Considerations; Design in Light Gauge Steel; Aluminum Structures; Residual Stresses.

Course Outcome:

- Conduct independent research and investigation to develop solutions for practical problems related to the design of structures under plastic conditions. (PO1)
- Write and present substantial technical reports and documents on the design of industrial buildings, transmission line towers, and steel tanks and stacks. (PO2)
- Demonstrate a mastery of knowledge and skills in the design of steel and aluminum structures beyond what is required in the undergraduate program. (PO3)
- Apply design principles for light gauge steel and aluminum structures, including consideration of residual stresses, to develop innovative solutions for practical problems. (PO3)

Text and Reference Book:

- Dayaratnam P "Design of Steel Structures" Wheeler Publishers, Allahabad, 1996.
- Arya A S and Ajmani J L "Design of Steel Structures" Nem Chand & Bros., Roorkee, 1996.
- Raz S A "Structural Design in Steel", New Age International Publishers, New Delhi, 2002.
- Neal B G "Plastic Analysis of Structures" Chapman Hall, London, 1977

CE-529 Soil Dynamics and Machine Foundations [3-0-0-3]

Course Objective:

- To understand the nature of dynamic loads and stress conditions on soil elements under earthquake loading.
- To comprehend the theory of vibrations and its application to soil and foundation structures.
- To study the behavior of retaining walls during earthquakes and the modification of Coulomb's theory.
- To analyze the liquefaction potential of soil and evaluate the effectiveness of various techniques for vibration isolation and screening of waves.

Course Syllabus:

Nature of dynamic loads, stress conditions on Soil elements under E.Q. loading, Theory of vibrations, Behavior of retaining walls during earthquakes, modification of Coulomb's theory, Modified Culmann's construction, Analytic solution for C- Code of Practice, General, Failure Zones & ult. B.C. criteria for satisfactory action of a footing, Earthquakes loads on footings. Dynamic analysis for vertical loads, Theory, criterion of liquefaction, factor affecting, Laboratory studies on liquefaction in Triaxial shear and Oscillatory simple shear, Evaluation of Liquefaction Potential, Vibration table studies, Liquefaction behavior of Dense sands, Introduction, Criteria for a satisfactory M/C foundation, Methods of analysis, Degrees of freedom of a Block foundation, soil spring stiffness, vibrations of a block I.S. for design of reciprocation M/c design procedure for Block Foundation, Vibration Isolation & Screening of Waves.

Course Outcome:

- Understand the dynamic behavior of soil and foundation structures under earthquake loading conditions and identify the factors affecting their stability. (PO1)
- Apply the theory of vibrations to analyze the response of soil and foundation structures to dynamic loads. (PO2)

- Analyze the behavior of retaining walls during earthquakes. (PO3)
- Evaluate the liquefaction potential of soil using laboratory studies and vibration table tests and design vibration isolation and screening techniques for soil and foundation structures. (PO1)

Text and Reference Book:

- Barken D D "Dynamics of Bases and Foundations" McGraw Hill, New York, 1962.
- Saran S "Soil Dynamics and Machine Foundations", Galogotia Publications Pvt. Ltd,New Delhi, 1999.
- Rao N D V K "Vibration Analysis and Foundation Dynamics" Wheeler Publishing Div. of A. H. Wheeler & Co. Ltd. New Delhi, 1998.
- Prakash S "Soil Dynamics" McGraw Hill Book Company, New York, 1981.
- Richart F E, Hall J R and Woods R D, "Vibrations of Soils and Foundations", Prentice Hall International, N Jersey, 1970.
- Krammer S "Geotechnical Earthquake Engineering" Pearson Education Pvt. Ltd. New Delhi, 2003.

CE-530 Construction and Contract Management [3-0-0-3]

Course Objective:

- Analyze project costs and develop accurate cost estimates through rate analysis, overhead charges, and value engineering.
- Evaluate bidding models and strategies to qualify bidders and develop tendering and contractual procedures.
- Apply legal and ethical considerations to contract administration, claims, compensation, and dispute resolution techniques
- Develop management information systems to assess risk analysis and ensure compliance with professional ethics, duties, and responsibilities of parties.

Course Syllabus:

Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies, Qualification of bidders, Tendering and contractual procedures, Indian Contract Act 1872, Definition of Contract and its applicability, Types of contracts, international contracts, Conditions and specifications of contract. Contract administration, Claims, compensation and

disputes, Dispute resolution techniques, Arbitration and Cancellation Act 1996, Arbitration case studies, Professional ethics, Duties and responsibilities of parties, Management Information systems, Risk analysis, Value engineering.

Course Outcome:

- Independently conduct research and investigation to develop accurate project cost estimates, using value engineering techniques and management information systems to solve practical problems. (PO1)
- Write and present substantial technical reports and documents on project cost estimation, bidding models and strategies, and contract administration and dispute resolution techniques. (PO2)
- Demonstrate mastery of knowledge and skills in project cost estimation, bidding models and strategies, and contract administration and dispute resolution techniques beyond what is required in the undergraduate program. (PO3)
- Apply legal and ethical considerations to develop and implement effective contractual procedures, claims, compensation, and dispute resolution techniques, while ensuring compliance with professional ethics, duties, and responsibilities of parties. (PO3)

Text and Reference Book:

- Prakash V A "Contract Management in Civil Works Projects" NICMAR, 1997.
- Richard C "Construction Contracting" John Wiley & sons, New York, 1986.
- Ashworth A "Civil engineering Contractual Procedures" Longman, Harlow, 1998.
- McCaffer R and Baldwin A N: Estimating and Tendering for Civil engineering works" Thomas Telford, London, 1991.
- Thomas R "Construction Contract Claims" Macmillan, London, 1993.

CE 531 Geo-environmental Engineering [3-0-0-3]

Course Objectives:

- Analyze the physical, chemical, and biological characteristics of solid waste and their impact on subsurface contamination.
- Evaluate the permeability of soil and waste and determine the factors affecting it.
- Design waste disposal facilities such as landfills and ash ponds based on their sitting criteria, waste containment principles, and barrier materials.
- Assess the environmental impact of waste disposal facilities and the detection, control, and remediation of subsurface contamination.

Course Syllabus:

Sources and effects of subsurface contamination; Physical, Chemical and biological characteristics of solid wastes; Soil-waste interaction; Contaminant transport; Laboratory and field evaluation of permeability; Factors affecting permeability; Waste disposal on land. Types of landfills: Sitting criteria; waste containment principles; Types of barrier materials; Planning and design aspects relating to waste disposal in landfills, in ash ponds and tailing ponds, and in rocks. Environmental monitoring around landfills; Detection, control and remediation of subsurface contamination; Engineering properties and geotechnical reuse of waste, demolition waste dumps; Regulations; Case studies.

Course Outcomes:

- Develop a technical report on the physical, chemical, and biological characteristics of solid waste and their impact on subsurface contamination. (PO2)
- Analyze the permeability of soil and waste, and evaluate the factors affecting it, to design effective waste disposal facilities. (PO1)
- Apply the principles of waste disposal facility design to select appropriate barrier materials and evaluate the environmental impact of these facilities. (PO3)
- Develop remediation strategies to mitigate subsurface contamination and evaluate their effectiveness. (PO1)

Text and Reference Books:

- Sharma, H. and Reddy, K.R., 2004. Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies. Wiley.
- Daniel, D.E., 1993. Geotechnical Practice for waste disposal. Chapman and Hall, London
- Koerner, R.M., 2005. Designing with Geosynthetics. Prentice Hall, New Jersey
- Reddi, L.N. and Inyang H.I., 2000. Geoenvironmental Engineering: Principles and Applications, Marcel Dekker Inc Publication

CE - 532 Landfills and Ash ponds [3-0-0-3]

Course Objectives:

- Evaluate the different types of solid waste, hazardous waste, coal ash, and other wastes, and their respective landfilling practices.
- Design, plan, and construct a landfill system for different types of solid wastes, hazardous waste, and coal ash.

- Develop strategies for managing leachate and gas in municipal solid waste landfills.
- Assess the environmental impacts of landfill systems and implement closure and reclamation plans.

Course Syllabus:

Integrated solid waste management of municipal solid waste, hazardous waste, coal ash and other wastes; Landfilling practice for different types of solid wastes; Municipal solid waste landfills: acceptability of waste; planning, design, construction, operation and closure including management of leachate and gas. Hazardous waste landfills: waste compatibility and acceptability; planning, design, construction, operation, closure and environmental monitoring. Ash ponds: Slurry disposal versus dry disposal; Engineering properties of bottom ash, fly ash and pond ash; planning and design; incremental raising of height by upstream and downstream methods; closure and reclamation.

Course outcomes:

- Analyze the characteristics and properties of different types of solid wastes, hazardous waste, coal ash, and other wastes, and identify appropriate landfilling practices for each type. (PO1)
- Create a comprehensive landfill design, construction, and operation plan that meets regulatory requirements and considers factors such as waste compatibility, environmental impacts, and leachate and gas management. (PO2, PO3)
- Evaluate the effectiveness of leachate and gas management strategies for municipal solid waste landfills, and propose recommendations for improvement. (PO3)
- Evaluate the environmental impacts of landfill systems, and develop closure and reclamation plans that consider engineering properties of ash and pond materials. (PO1, PO3)

Text and Reference Books:

- Datta, M., 1998. Waste disposal in Engineered landfills, Narosa Publishers.
- Reddy, L.N. and Inyang. H. I., 2000. Geoenvironmental Engineering –Principles and Applications, Marcel Dekker, Inc., New York
- Powell, J., Jain, P., Xu, Q., Tolaymat, T., and Townsend, T. G., 2015. Sustainable Practices for Landfill Design and Operation. Springer.

CE – 533 Solid and Hazardous Waste Management [3-0-0-3]

Course Objectives

- Evaluate the different characteristics of municipal solid waste and their impact on the environment using analysis and synthesis
- Formulate and compare waste management options for solid waste reduction, materials recovery, and disposal using critical thinking and analysis
- Develop and apply effective techniques for the collection, transport, and treatment of municipal solid waste using creativity and problem-solving
- Analyze and apply relevant norms, rules, and regulations to solid waste management using knowledge and comprehension

Course Syllabus:

Municipal Solid Waste: Generation, Rate Variation, characteristics (Physical, Biological and Chemical); Management Options for Solid Waste, Waste Reduction at the Source, Collection techniques, Materials and Resources Recovery / Recycling. Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations and Disposal Techniques (Composting, Vermi Composting, Incineration, Refuse Derived fuels, Landfilling). Norms, Rules and Regulations. Economics of the on-site v/s off site waste management options. Integrated waste management.

Course outcomes:

- Conduct independent research and analysis on the characteristics and management of municipal solid waste, resulting in a technical report/document (PO1)
- Present effective waste management options, including waste reduction, materials recovery, and disposal, demonstrating mastery of the structures and construction engineering area (PO2)
- Design and implement collection, transport, and treatment strategies for municipal solid waste, demonstrating a high level of problem-solving ability (PO3)
- Comply with relevant norms, rules, and regulations in solid waste management, demonstrating an understanding of the legal and regulatory framework (PO2)

Text and Reference Books:

- Tchobanoglous, G., Vigil, S.A. and Theisen, H.,1993. Integrated Solid Waste Management: Engineering Principles and Management Issues, Mc-Graw Hill.
- Pichtel, J., 2005. Waste Management Practices – Municipal, Hazardous and Industrial, CRC Press.
- Vesilind, P.A., 2008. Solid Waste Engineering, Thomson Learning Inc.

- Vesilind, P.A., Worrell, P.A., Reinhart, D., 2001. Solid Waste Engineering, Nelson Engineering.
- Peavy, H.S., Rowe, D.R., Tchobanoglous, G., Environmental Engg, McGraw Hill, International Edition.

CE-534 Concrete Mechanics [3-0-0-3]

Course Objective:

- To make students aware regarding the theological modeling of fresh concrete, constitutive equations: nonlinear elasticity, plasticity, visco-elasticity understand the properties of composite materials.
- To share the concepts of Shear and torsion Bond-slip and phenomenon of cracking in reinforced concrete.
- To share the concepts of Statical and dynamical analysis of R. C. structures, trends.

Course Syllabus:

Introduction to concrete mechanics, Rheology of fresh concrete, and its measurements as per EFNARC specifications, Viscoelasticity and its rheological models, Microstructure of concrete (Microstructure of aggregate and cement phase, interfacial transition zone), Durability of concrete Moisture diffusion: Permeability of Concrete, Drying creep and shrinkage cracking, solid and structural mechanics of reinforced concrete, introduction to fracture mechanics of hardened concrete

Course Outcome:

- Introduction, theological modeling of fresh concrete, constitutive equations: nonlinear elasticity, plasticity, visco-elasticity understand the properties of composite materials (PEO3).
- Shear and torsion Bond-slip and phenomenon of cracking in reinforced concrete (PSO1).
- Statical and dynamical analysis of R. C. structures, trends (PSO2).

Text and Reference Book:

- Jan G. M. van Mier “Fracture Processes of Concrete”, CRC Press; 1 edition, 1997.
- Carpinteri A. and Ingraffea A. R. “Fracture mechanics of concrete: material characterization and testing”, Martinus Nijhoff Publishers, 1984.

CE-535 Recent Advances in Construction Materials [3-0-0-3]

Course Objective:

- To make students understand regarding various construction materials required in specific places and situations
- To make students understand regarding concepts of concreting in different environments, Ferro cement, polymers and its science
- To make students understand regarding concepts of sandwich panels, adhesives, sealants and structural bearings
- To make students understand regarding concepts polymer foams, polymer concrete composites and moisture barriers

Course Syllabus:

Foams and lightweight materials, fibre reinforced concrete. Types of fibres, workability, mechanical and physical properties of fibre reinforced concrete, Industrial waste materials in concrete, their influence on physical and mechanical properties and durability of concrete, Concrete at high temperature, High strength concrete, changes in concrete with time, corrosion of concrete in various environments, corrosion of reinforcing steel, electro chemical process, measures of protection, Ferro-cement, materials and properties polymers Civil Engineering Polymers, fibres and composites, fibre reinforced plastic in sandwich panicles, modeling. Architectural use and aesthetics of composites. Adhesives and sealants. Structural elastomeric bearings and resilient seating. Moisture barriers, polymer foams and polymers in building Physics, Polymer concrete composites.

Course Outcome:

- Understand various construction materials required in specific places and situations (PO1)
- Understand and analyze the concepts of concreting in different environments, Ferro cement, polymers and its science (PO1, PO2, PO3)
- Understand regarding concepts of sandwich panels, adhesives, sealants and structural bearings (PO1, PO2)
- Understand regarding concepts polymer foams, polymer concrete composites and moisture barriers (PO1, PO2)

Text and Reference Books:

- Marios, S. and Peter, D. 2017. Construction Materials: their nature and behavior, CRC Press.
- David, D., and Cather, B. 2013. Construction materials reference book, Routledge.

- Zhang, H. 2011. Building materials in civil engineering, Woodhead Publishing Series in Civil and Structural Engineering.
- Hornbostel, C. 1991. Construction materials: types, uses and applications, John Wiley & Sons.
- Duggal, S.,K. 1998. Building materials, New age international.
- Grosse, Christian U., 2007. Advances in construction materials, Grosse, Christian U. (Ed.), Springer.

CE-536 Composite Materials [3-0-0-3]

Course Objective:

- To make students aware about the definition of composite materials, classification of composite materials, role of matrix in composite materials, polymer matrices, classification of polymer.
- To make students knowledgeable regarding the role of fibers in composites, comparison of fibres, role of interface in the fibre matrix composite.
- To make analysis of an orthotropic lamina and laminated composites, elastic properties of unidirectional laminate.

Course Syllabus:

Definition of Composite Materials, Classification of Composite Materials, Role of matrix in a composite material, Polymer matrices, Classification of Polymer, Metal Matrices, Ceramic matrices, Comparison of polymer matrix, Metal matrix and ceramic Matrix, Role of fibres in composites, Comparison of Fibres, Role of interface in the fibre matrix composite. Characterization of composites, Analysis of an Orthotropic Lamina and laminated Composites, Elastic properties of Unidirectional Laminate, cross ply laminate, Angle ply laminates, short fibre composite materials, Experimental Characterization of Composites.

Course Outcome:

- Definition of composite materials, classification of composite materials, role of matrix in composite materials, polymer matrices, classification of polymer (PSO2,PEO4).
- Role of fibres in composites, comparison of fibres, role of interface in the fibre matrix composite (PSO2, PSO3, PEO4).
- Analysis of an orthotropic lamina and laminated composites, elastic properties of unidirectional laminate (PSO1, PSO2, PSO3, PEO3).

Text and Reference Book:

- Chawla, Krishan K. "Composite Materials: Science and Engineering (Materials Research and Engineering)", Springer; 3rd edition, 2013.
- Brandt A. M. "Cement-based Composites: Materials, Mechanical Properties and Performance", CRC Press, 1994.
- Yang Y., Yu J., Xu H. and Sun B. "Porous lightweight composites reinforced with fibrous structures", Springer; 1st edition, 2017.

CE-537 Simulation & Modelling [3-0-0-3]

Course Objective:

- To introduce the concept of mathematical models, numerical models, and physical models.
- To provide an understanding of deterministic and stochastic models and their applications.
- To introduce the concepts of optimization and its different types including single and multiple objectives optimizations.
- To provide an understanding of probability distributions, random number generation, and queuing theory.

Course Syllabus:

Introduction: Mathematical models, numerical models and Physical models. Deterministic and stochastic models. Concepts of simulation.
Competitive situations: Optimization, Single and multiple objectives optimizations, Pareto optimal solutions. Introduction to linear and geometric programmings. Zero degree and single degree of difficulty.
Growth and Decay processes: Discrete and continuous systems. Differential and Integral equation approach, Fibonacci growth.
Probability Distributions: Binomial and Poisson distributions, Normal, Lognormal and pareto distributions.
Generation of random numbers: Uniform variable, normal and lognormal variables.
Queing theory: Montecarlo methods, solutions of Laplace equations in two dimensions.

Course Outcome:

- Able to analyze practical problems and choose appropriate modeling techniques to solve them. (PO1, PO3)
- Able to apply optimization techniques to civil engineering problems. (PO1, PO2, PO3)
- Able to analyze growth and decay processes and use them to make predictions. (PO1, PO3)

- Able to apply probability distributions and generate random numbers to solve engineering problems. (PO1, PO3)

Text and Reference Book:

- Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event System Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
- Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.
- Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
- Narsingh Deo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN: 0-87692-028-8.

CE-538 Site Investigations and Ground Improvement [3-0-0-3]

Course Objective:

- Plan and design site investigation programs using appropriate geophysical, direct, semi-direct, and indirect methods.
- Evaluate the geotechnical properties of soils and rocks using field tests, laboratory tests, and sampling techniques.
- Design and control compaction and stabilization processes for soil improvement.
- Develop dewatering systems and techniques for construction in water-bearing soils.

Course Syllabus:

Site Investigations: Planning of investigation programmes, Information required for planning different stages of investigations. Geophysical methods: electrical resistivity, and seismic refraction methods. Methods of site investigations: Direct methods, semi-direct methods and indirect methods, Drilling methods. Boring in soils and rocks, methods of stabilizing the bore holes, measurement of water table, field record. Field tests: In-situ shear test, in-situ permeability test, SPT, DCPT, SCPT, in-situ vane shear test, pressure meter test, plate load test. Codal provisions. Sampling techniques, Sampling disturbances, storage, labeling and transportation of samples, sampler design, influence on properties. Report writing. Safety measures.

Geotechnical Processes: Principles of compaction, Laboratory compaction, Engineering behavior of compacted clays, field compaction techniques- static, vibratory, impact, Earth

moving machinery, Compaction control. Shallow Stabilization with additives: Lime, fly ash, cement and other chemicals and bitumen.

Deep Stabilization: sand column, stone column, sand drains, prefabricated drains, electro osmosis, lime column. soil-lime column. Grouting: permeation, compaction and jet. Vibro floatation, dynamic compaction, thermal, freezing. Dewatering systems.

Course Outcome:

- Develop a technical report on the site investigation program, including geophysical, direct, semi-direct, and indirect methods used to evaluate the site's geotechnical properties. (PO2)
- Evaluate and interpret the results of field and laboratory tests, and sampling techniques, to determine the geotechnical properties of soils and rocks. (PO1)
- Design and control compaction and stabilization processes using additives, grouting, vibro floatation, dynamic compaction, and thermal methods. (PO3)
- Develop dewatering systems and techniques for construction in water-bearing soils and assess their effectiveness. (PO1)

Text and Reference Books:

- Peck R B, Hanson W B and Thorn Burn T H “Foundation Engineering” John Wiley and Sons Inc, New York, 1974.
- Teng W C “Foundation Design” Prentice Hall of India Pvt. Ltd., New Delhi, 1977.
- Bowles J E “Foundation Analysis and Design” McGraw Hill, New York, 1982.
- Saran S “Analysis and Design of Substructures”, Oxford & IBH Publishing Co. (P) Ltd., New Delhi, 1996.
- Coduto, Donald P“Foundation Design”, Pearson Education International, New Jersy, 2001

CE-539 Engineering Behaviour of Soils [3-0-0-3]

Course Objectives

- Analyze the origin, nature, and distribution of soils and describe individual particles.
- Evaluate the behavior of soils under different stresses and strains, including consolidation, shear, and creep.
- Apply principles of effective stress and steady-state flow to determine the coefficient of permeability of soils.
- Synthesize information from various tests to determine the engineering behavior of different types of soils found in India.

Course Syllabus:

Origin, nature and distribution of soils. Description of individual particle. Clay mineralogy, clay-water-electrolytes. Soil fabric and structure. Effective stress principle. Steady state flow in soils. Effect of flow on effective stress. Determination of coefficient of permeability. Consolidation, one, two, three and radial consolidation. Variation of effective stress during consolidation. Various consolidation tests and determination of parameters. Stress-path. Triaxial and direct shear tests. Shear behavior of granular soils. Factors affecting shear behavior. Determination of parameters. Shear behavior of fine grained soils. Pore pressure parameters. UU, CU, CD tests. Total and effective stress-strength parameters. Total and effective stress-paths. Water content contours. Factors affecting strength: stress history, rate of testing, structure and temperature.
Anisotropy of strength, thixotropy, creep. Determination of in-situ undrained strength. Stress-strain characteristics of soils. Determination modulus values. Critical state model. Engineering Behavior of soils of India: Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soils, aeolin deposits.

Course outcomes

- Recall and explain the origin, nature, and distribution of soils, and describe individual particle characteristics. (PO3)
- Evaluate and analyze the effective stress principle, steady-state flow in soils, and the effect of flow on effective stress. (PO1)
- Apply consolidation, stress paths, and shear behavior of granular and fine-grained soils. (PO1, PO3)
- Analyze and evaluate the engineering behavior of soils of India using critical state models. (PO1, PO2)

Text and Reference Books:

- Mitchell, James K., (1993), "Fundamentals of soil Behaviour", 2nd Edition, John Wiley and sons.
- Das, B.M., (1997), "Advanced soil Mechanics", Taylor and Francis.
- Lambe, T.W., and Whitman, R.V., (1987), "Soil Mechanics", John Wiley and Sons.
- Gulhati, Shashi K., and Datta Manoj (2008), "Geotechnical Engineering, Tata Mcgraw-Hill Company Ltd.
- Coduto, Donald P (2002), "Geotechnical Engineering, Principles and Practices", Pearson Education International, New Jersy.

CE-540 Geosynthetics [3-0-0-3]

Course Objective:

- To identify and explain the various types and functions of geosynthetics and reinforced soil structures.
- To analyze the manufacturing processes, testing and evaluations of geosynthetics and reinforced soil structures.
- To evaluate and apply the principles of soil reinforcement in designing and constructing geosynthetic reinforced soil retaining structure.
- To assess the Indian experiences and codal provisions for geosynthetics in pavement and environmental control.

Course Syllabus:

Geosynthetics and Reinforced Soil Structures: Types and functions; Materials and manufacturing processes; Testing and evaluations; Principles of soil reinforcement; Design and construction of geosynthetic reinforced soil retaining structures walls and slopes; Codal provisions; Bearing capacity improvement; embankments on soft soils; Indian experiences. Geosynthetics in Pavements: Geosynthetics in roads and railways; separations, drainage and filtering in road pavements and railway tracks; overlay design and construction; AASHTO and other relevant guidelines; trench drains. Geosynthetics in Environmental Control: Liners for ponds and canals; covers and liners for landfills - material aspects and stability considerations; Landslides - occurrences and methods of mitigation; Erosion - causes and techniques for control.

Course Outcome:

- Develop a technical report on the design and construction of geosynthetic reinforced soil retaining structures with an ability to independently carry out research/investigation to solve practical problems (PO1, PO2).
- Demonstrate mastery over the area of geosynthetics and reinforced soil structures by presenting a substantial technical report/document (PO3).

- Apply the knowledge and understanding of geosynthetics in pavements and railways to analyze and design separations, drainage, filtering in road pavements and railway tracks (PO3).
- Evaluate the techniques for controlling landslides and erosion by considering the material aspects, stability considerations, and AASHTO guidelines for covers and liners for landfills and ponds/canals (PO3).

Text and Reference Books:

- Rao G V and Raju S "Engineering with Geosynthetics" Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1990.
- Ranjan G and Rao A S R "Basic and Applied Soil Mechanics" International Publishers, New Delhi, 2000.
- Koerner R M "Designing with Geosynthetics" Prentice-Hall, N. J., U.S.A., 1986.
- Saran, S., (2006), "Reinforced soil and its Engineering Applications", I.K. International Pvt. Ltd.
- Jones, C.J.F.P. (1985), "Earth Reinforcement and soil structures", Butterworth and co. (Publishers) Ltd., London, England.

CE-541 Pavement Design [3-0-0-3]

Course Objectives:

- To develop an understanding of the factors that affect pavement design, including traffic loads, environmental conditions, and material properties.
- To learn about the different types of pavement structures and functional attributes for highways and airports.
- To analyze the stresses in flexible and rigid pavements using single layer, two layer, and three layer theories and wheel load, temperature, and combined stresses.
- To explore the various approaches for designing and constructing pavements, including empirical, semi-empirical, and mechanistic-empirical methods.

Course Syllabus:

Introduction: Pavement structure and functional attributes, factors affecting pavement design, types of wheel loads for highway and airports, development of design methods for highways and airport pavements.

Analysis of Pavements: Stresses in flexible pavements- Single layer, Two layer and Three layer theories , ESWL, EWLF, etc.; Stresses in rigid pavements- Wheel load, temperature and combined stresses.

Flexible Pavement Design: Various approaches for designing the highway and airport pavements (empirical, semi-empirical, mechanistic empirical, etc.), methods falling under each of these methods, overview of the revision of specifications pertaining to these methods, design of pavements using these methods.

Rigid Pavement Design: Various approaches for designing the pavements (highways and airports) and methods falling under each of these methods, overview of the revision of specifications pertaining to these methods, design of pavements using these methods, design of joints

Design of Low Volume Roads: Design of low volume roads (flexible and rigid) as per IRC Specifications.

Course Outcomes

- Students will be able to identify and evaluate the factors that affect pavement design, and select appropriate design methods for specific projects. (PO1)
- Students will be able to analyze the stresses in flexible and rigid pavements and apply appropriate design methods for different pavement types. (PO3)
- Students will be able to design pavements using empirical, semi-empirical, and mechanistic-empirical methods, and evaluate the quality control and quality assurance during pavement constructions. (PO2, PO3)
- Students will be able to design and construct low-cost roads, including stabilization of subgrade, sub-base, and base, and selection of appropriate low-cost materials and methods for construction. (PO1, PO3)

Text and Reference Books:

- Sharma, S.K., 2014. Principles, Practice and Design of Highway Engineering (Including Airport Engineering); S. Chand and Company Pvt. Ltd., New Delhi.
- Srinivasakumar, R., 2015. Pavement Design; University Press, Hyderabad (First Published 2013; Preprinted in 2015).
- Kadiyali, L.R.and Lall, N.B., 2005. Principles and Practice of Highway Engineering; Khanna Publishers, Delhi
- Yang H. Huang, 2008. Pavement Analysis and Design; Pearson Prentice Hall, USA
- Das, Animesh, 2017. Analysis of Pevement Structures; CRC Group, Taylor and Francis Group
- Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2015. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition).
- Saxena, Subhash Chandra, 2014. A Text Book of Highway and Traffic Engineering; CBS Publishers and Distributors, New Delhi

- Venkatramaiah, C., 2016. Transportation Engineering (Vol.-I)- Highway Engineering.; University Press, Hyderabad.
- Rao, G.V., 2000. Principles of Transportation and Highway Engineering; Tata Mc-Graw Hill Publishing House Pvt. Ltd., New Delhi.
- Chakraborty, P. and Das, A., 2013. Principles of Transportation Engineering, Prentice Hall India Learning Pvt. Ltd., New Delhi (Eighth Printing: January 2013).
- Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2013. Highway Material and Pavement Testing; Nem Chand and Bros., Roorkee, India.
- Yoder E.J. and Witzack M.W., 1991. Principles of Pavement Design; John Wiley and Sons, New York.
- Kandhal, Prithvi Singh, 2014. Bituminous Road Construction in India; PHI Learning Pvt. Ltd., Delhi
- Delattee, Norbert J., 2017. Concrete Pavement: Design, Construction and Performance (Second Edition)
- Mallick, Rajib B. and Korchi, Tahar El, 2017. Pavement Engineering: Principles and Practice, CRC Press, Taylor and Francis Group (Third Edition)
- Nikolaides, A., 2017. Highway Engineering: Pavement Materials and Control of Quality, CRC Press, taylors and Francis Group.

Additional Reading

- Relevant specifications of Bureau of Indian Standards for Highway Material Testing, Indian Roads Congress (IRC) and Ministry of Road Transport and Highways (MoRTH) w.r.t. / Pavement Design and Highway Construction revised time to time shall be referred to, e.g.:
- *IRC: 37-2012*. "Tentative Guidelines for the Design of Flexible Pavements," Indian Road Congress, Delhi. *IRC: 58-2015*. "Tentative Guidelines for the Design of Rigid Pavements," Indian Road Congress, Delhi.
- *IRC: 81-2012*. "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique," Indian Road Congress, Delhi
- *IRC: SP: 76-2008*. "Tentative Guidelines for Conventional, Thin and Ultra-Thin White-topping," Indian Road Congress, Delhi.

Note: Some of the recent specifications may not have been incorporated in few books authored by Indian Authors. For this, titles of multiple books are given in the list of the Recommended Books. The latest editions shall be used. In addition to this, relevant specifications/ codes with the latest revisions thereof shall be referred to.

CE 565 Ground Improvement Techniques (3-0-0)

Course Objectives:

- To understand the need for ground improvement and various methods of ground improvement, including mechanical, hydraulic, physico-chemical, electrical, and thermal methods, and their applications.
- To explain the general principles of compaction, mechanics, and quality control in the field.
- To describe the in-place densification methods in granular soil, including vibrofloatation, compaction pile, vibro compaction piles, dynamic compaction, and blasting.
- To discuss soil stabilization techniques such as lime stabilization, cement stabilization, fly-ash-lime stabilization, and soil-bitumen stabilization.

Course Syllabus:

Introduction: Need of Ground Improvement: Different methods of Ground improvement, Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods, etc. and their applications. General Principal of Compaction: Mechanics and quality control in field

Ground Improvement in Granular Soil: In place densification by (i) Vibrofloatation (ii) Compaction pile (iii) Vibro Compaction Piles (iv) Dynamic Compaction (v) Blasting

Ground Improvement by Hydraulic Modification: Methods of dewatering open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, stone columns and PVD.

Soil Stabilization: Lime stabilization-Base exchange mechanism, Pozzolanic reaction, lime-soil interaction, lime columns. Cement stabilization: Mechanism, amount, age and curing. Fly-ash - Lime Stabilization, Soil Bitumen Stabilization.

Ground Improvement by Grouting: Grouting in soil, types of grout, desirable characteristics, grouting pressure, grouting methods.

Course Outcomes:

- Demonstrate knowledge of the principles and different methods of ground improvement by identifying and explaining the mechanical, hydraulic, physico-chemical, electrical, and thermal methods, and their applications. (Understanding) (PO3)
- Apply the principles of soil compaction to solve practical problems by designing and analyzing the quality control measures in the field. (Application level) (PO3)
- Evaluate and select appropriate ground improvement techniques for granular soils and hydraulic modification methods by comparing and contrasting their advantages and limitations. (Analysis level) (PO3)
- Synthesize the knowledge of grouting techniques and soil stabilization mechanisms to design and present a technical report on a practical problem in the field. (Synthesis level) (PO1, PO2)

Text and Reference Books:

1. Purushothama Raj, P., 1995. Ground Improvement Techniques, Tata McGrawHill, New Delhi.
2. Hausmann, M.R., 1990. Engineering Principles of Ground Modification, McGraw-Hill International Editions,
3. Han, J., 2015. Principles and Practice of Ground Improvement, John Wiley & Sons
4. Chattopadhyay, B.C. and Maity, J., 2011. Ground Control and Improvement Techniques, PEEDOT, Howrah.
5. Bell, F.G., 2006. Engineering Treatment of Soils, E&FN Spon, New York.

CE 575 Fundamentals of Soil Behaviour (3-0-0)

Course Objectives

- Understand the physio-chemical behavior of soils and the mechanisms of soil-water interaction. (Comprehension)
- Analyze the volume change behavior of soils and its relation to physical interactions and deformation characteristics. (Analysis)
- Classify clay minerals and evaluate their importance in geotechnical engineering. (Evaluation)
- Explain the basics of unsaturated soil and soil water retention measurement techniques. (Comprehension)

Course Syllabus

Classification of clay minerals and their importance in geotechnical engineering; swelling and collapsing soils; Soil fabric and its measurement using mercury intrusion porosimetry (MIP), Scanning Electron Microscope (SEM), XRD analysis and other methods.
Physio-Chemical Behaviour of Soil: Mechanisms of soil-water interaction; Properties of adsorbed water; Clay-water-electrolyte system: ionic distributions, diffuse double layer theory, and its controlling factors; Cation exchange; Soil-chemical interactions.
Principle of effective stress: force distributions in a particulate system, Water-Air interactions in soils; Measurement of pore pressure, inter-granular stress, effective stress for saturated and unsaturated soils; Volume change behaviour of soils: physical interactions in volume change, osmotic pressure and water adsorption influences on compression and swelling; General characteristics of strength and deformation: fabric and strength, friction and physical interactions among soil particles, strength parameters for sands and clays; Deformation characteristics: linear elastic stiffness, transition from elastic to plastic states, plastic deformation, time-dependent deformation-structure interaction.
Basics of unsaturated soil, soil suction, suction measurement techniques and limitations.

Course Outcomes

- Develop the ability to independently carry out research and investigation in soil physio-chemical behavior and volume change behavior. (PO1)
- Demonstrate the ability to write and present a substantial technical report/document on the

classification and importance of clay minerals and unsaturated soil behavior. (PO2)

- Exhibit mastery over the area of soil behavior and mechanics at a level higher than the requirements in the appropriate bachelor program. (PO3)
- Apply knowledge of soil suction measurement techniques and limitations to practical problems in geotechnical engineering. (Application)

Text and Reference Books:

1. Mitchell, J. K. and Soga, K. Fundamentals of soil behaviour, Wiley, New York, 2005.
2. Yong, R. N. and Warkentin, B. P. Soil properties and behaviour, Elsevier, 2012.
3. Lambe, T.W. and Whitman, R.V. Soil mechanics, John Wiley and Sons, New York, 1979.

CE 576 Soil structure interaction (3 0 0)

Course Objectives

- Analyze and model the behavior of soil-foundation interaction problems using various soil response models and techniques (Apply).
- Evaluate and compare the performance of different models for soil-structure interaction problems in terms of their accuracy and efficiency (Evaluate).
- Design and analyze elastic foundations for beams, plates, and piles based on theoretical and numerical methods (Create).
- Understand the behavior of soil-foundation interaction under dynamic loads and its impact on the design of foundations and structures (Understand).

Course Syllabus

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior

B**eam on Elastic Foundation**- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to t their stiffness.

Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap

Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile- raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.

Course Outcomes

- Develop the ability to independently analyze and solve practical problems related to soil-foundation interaction using appropriate techniques and models (PO1).
- Demonstrate proficiency in technical writing and presentation by producing a substantial report on a soil-foundation interaction problem (PO2).
- Achieve a high level of mastery in the field of soil-foundation interaction and apply this knowledge to solve complex problems (PO3).
- Evaluate and assess the impact of soil-foundation interaction on the design and performance of foundations and structures (PO2, PO3).

Text and Reference Books:

1. N.P. Kurien, Design of Foundation Sytems : Principles & Practices, Narosa, New Delhi 1992
2. E.S. Melerski, Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation, Taylor and Francis, 2006.
3. L.C. Reese, Single piles and pile groups under lateral loading, Taylor & Francis, 2000
4. G. Jones, Analysis of Beams on Elastic foundation, Thomas Telford, 1997

CE 577 EARTH RETAINING STRUCTURES (3-0-0)

Course Objectives:

1. Analyze and evaluate the behavior of earth pressures on retaining structures using Rankine's and Coulomb's theories. (Analyze)
2. Develop design specifications for different types of earth retaining structures and waterfront retaining structures. (Create)
3. Evaluate the stability of braced excavations and design diaphragm walls and cofferdams. (Evaluate)
4. Investigate and analyze the behavior of sheet piles and bulkheads in granular and cohesive soils using free earth and fixed earth support methods. (Analyze)

Course Syllabus:

Introduction to earth pressure – basic concepts – active, passive and at rest earth pressures

Rankine's and Coulomb's earth pressure theories – concepts and drawbacks – earth pressure models – graphical methods and their interpretations

Types of earth retaining structures – types - classifications – specifications

Retaining walls and MSE Walls- types – Design specifications and pressure distribution variations-

Structural Design & Stability- Waterfront Retaining Structures

Sheet Piles and Bulkheads in Granular and Cohesive Soils - Materials Used for Sheet Piles – Free Earth and Fixed earth Support Methods

Braced Excavations: Arching in Soils - Soil Pressures on Braced Walls, Design of Diaphragm Wall, Coffer Dams and Stability of Braced Cuts, Basement Walls

Course Outcomes:

1. Demonstrate the ability to independently carry out research and investigation on earth retaining structures and present findings in a substantial technical report/document. (Create-PO1, PO2)
2. Apply the concepts of earth pressure theories and models to solve practical problems in the design of different types of earth retaining structures. (Analyze-PO3)
3. Evaluate the stability of braced excavations and design diaphragm walls and cofferdams to meet design specifications. (Evaluate-PO3)
4. Analyze the behavior of sheet piles and bulkheads in granular and cohesive soils using free earth and fixed earth support methods and develop recommendations for design. (Analyze, Create-PO3)

Text and Reference Books:

1. Bowels, J. E., "Foundation Analysis and Design", McGraw Hill Company, 1997.
2. Das, B. M., "Foundation engineering", Cengage Learning, 2007.
3. Gulhati, S. K. and Datta, M., "Geotechnical engineering", McGraw Hill company, 2017.
4. Clayton,C. R.I., Woods, R. I., Bond, A. J. and Milititsky, J., "Earth Pressure and Earth-Retaining Structures", 2014.

CE-578 Advanced Structural Mechanics [3-0-0-3]

Course Objectives:

- To understand the basic concepts of bending of unsymmetrical sections
- To understand the fundamentals of bending of curved beams in elevation and in plan.
- To study different theories of failures
- To understand the concepts of beams on elastic foundation and deep beams.

Course Curriculum:

Unsymmetrical bending, flexural stresses due to bending in two planes, shear center, bending of unsymmetrical section

Bending of beams with large initial curvature, application of analysis of hooks, bends and curved links, etc.

Beams curved in plans loaded perpendicular to three plane, fixed and continuous curved beams.

Theories of failure, maximum stress theory, maximum shear stress theory, maximum strain theory, von Mises and Tesca's 'failure theories.

Beams on elastic foundation, beams of unlimited length, semi-infinite lengths and finite lengths on elastic foundation

Analysis of deep beams, determination of stresses and deflection

Course outcomes:

On successful completion of the course, the learner shall be able to:

1. Apply fundamental concepts of mathematics, science and engineering to solve the problems in the field of structural engineering and mechanics.
2. Analyze the sections subjected to unsymmetrical bending and evaluate the stresses developed therein and also to apply the knowledge gained in respect of different theories of failure in solving the problems pertaining to the mechanics of materials.
3. Evaluate the stresses in the beams and similar structures curved in elevation and the beams curved in plan.
4. To analyze the beams on elastic foundations and the deep beams.

Recommended Books:

1. Wang: Applied Elasticity, Mc Graw Hill Books Co.
2. S. Timoshenko: Theory of Elasticity, McGraw Hill
3. J. Chakrabarti: Theory of Plasticity, McGraw Hill Book Co.
4. S. Timoshenko: Strength of Materials, Vol. I and II, CBS Publishers
5. I. H. Shames: Mechanics of Deformable Solids, Prentice Hall India
6. A.P. Boresi: Advanced Mechanics of Material, John Wiley & Sons.
7. L.S. Srinath: Advanced Mechanics of Solids, Tata McGraw Hill

ID 601 **Research Methodology** **[3-0-0-3]**

Course objectives

- Apply problem-solving strategies using logical reasoning and mathematical skills to conduct research and develop solutions.
- Analyze and evaluate various types of models and techniques of numerical simulation in order to make approximations and solve complex problems.
- Demonstrate effective communication skills through oral and written presentations of technical reports and documents.
- Apply professional ethics and stress management techniques to successfully navigate the psychological and interpersonal challenges of the PhD process.

Course Syllabus:

Thinking Process: role of thinking in research, levels and styles of thinking, common sense and scientific thinking, examples.

Problem solving: problem solving strategies- reformulation or rephrasing, techniques of representation, logical thinking, division into sub problems, verbalization, awareness of scale, importance of graphical representation, examples.

Experimental and modelling skills: census and sample survey, sampling procedure, important scaling techniques, methods of data collection, estimation and reduction of random errors, detection and elimination of systematic error, guideline for constructing questionnaire, scientific method role of hypothesis in experiment, hypothesis testing, F test, t-test, chi square test, use of ANOVA.

Types of models, the art of making approximations, problem representation, logical reasoning, mathematical skills, techniques of numerical simulation.

Problem finding and literature survey: information gathering reading searching and documentation, types, attributes and sources of research problem; problem formulation, relative importance of various forms of publication; choice of journal entries using process, difference between publishing and patenting.

Effective communication-oral and written: examples in straightening the importance of effective communication, stages and dimensions of a communication process.

Stress management time management interpersonal skills professional ethics: psychological faces of a PhD process, stress points, managing self, teamwork, sense of humor, plagiarism and research ethics.

Course Outcome:

- Develop effective research strategies and problem-solving techniques to independently solve practical problems related to structural and construction engineering (PO1).

- Produce a substantial technical report and deliver an oral presentation that demonstrates mastery of the subject matter (PO2).
- Demonstrate a high level of mastery over the subject matter of structural and constrution engineering, exceeding the requirements of an appropriate bachelor's program (PO3).
- Exhibit professional ethics and interpersonal skills, manage stress and time, and develop a sense of humor to successfully navigate the PhD process (PO1, PO2, PO3).

Text and Reference Books:

- E.M. Phillips and D S Pugh, ― How to get a PhD – a handbook for PhD student s and their supervisors, Viva books Pvt. Ltd for all scholars irrespective of their disciplines.
- Handbook of Science Communication, compiled by Antony Wilson, Jane Gregory, Steve Miller, Shirley Ear, Overseas Press Indian Pvt. Ltd, New Delhi, first edition 2005.
- G L Squires, ―Practical physics, Cambridge University Press for all scholars except those from Humanities and Management sciences.
- Peter B Medeq, ― Advice to a Young Scientist, Pan Books, London 1979.

CE 590 Modelling and Research Methodology [3-0-0-3]

Course Objectives:

- Develop a deep understanding of research methodology and design, including the ability to develop a comprehensive research plan.
- Conduct effective literature surveys and reviews to identify relevant sources of information and assess the quality of existing research.
- Collect and analyze data using appropriate statistical techniques and software.
- Communicate research findings effectively through written reports, technical papers, and oral presentations.

Course Syllabus:

UNIT –I Research methodology

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

UNIT –II Literature survey

Importance of literature survey -Sources of information -Assessment of quality of journals and articles -Information through internet. Literature review: Need of review -Guidelines for review -Record of research review.

UNIT –III Research design

Meaning of research design -Need of research design -Feature of a good design -Important concepts related to research design -Different research designs -Basic principles of experimental design -Developing a research plan -Design of experimental set-up -Use of standards and codes of Civil Engineering.

UNIT –IV Data collection and analysis:

Collection of primary data and Secondary data of different Civil Engineering fields -Data organization -Methods of data grouping -Diagrammatic representation of data -Graphic representation of data -Sample design -Need for sampling -Some important sampling definitions-Estimation of population -Role of statistics for data analysis -Parametric vs. non parametric methods -Descriptive statistics -Measures of central tendency and dispersion -Hypothesis testing. -Use of statistical software. Data Analysis: Deterministic and random data -Uncertainty Analysis-Tests for significance -Chi-square -Student's t-test -Regression modeling -Direct and interaction effects –ANOVA-F-test -Time series analysis -Autocorrelation and autoregressive modeling.

UNIT –V Research report writing:

Format of the research report –Synopsis –Dissertation -Thesis -Its differentiation –References–Bibliography -Technical paper writing -Journal report writing -Making presentation -Use of visual aids. Research proposal preparation: Writing a research proposal and research Report-Writing research grant proposal.

Course Outcome:

- Demonstrate the ability to independently conduct research and solve practical problems related to structural and construction engineering using a comprehensive research plan (PO1).
- Write and present a substantial technical report or dissertation that meets the requirements of the program and demonstrates mastery of the subject matter (PO2, PO3).
- Analyze and interpret data using appropriate statistical methods and software, and draw valid conclusions from the results (PO1, PO3).
- Effectively communicate research findings through written reports, technical papers, and oral presentations using appropriate visual aids (PO2).

Text and Reference Books:

- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K. 2002. An introduction to research methodology, RBSA Publishers.
- Kothari, C.R, 2004. Research methodology, methods & technique, New Age International Publishers, New Delhi.
- Ganesan, R. 2015. Research methodology for engineers, MJP Publishers, Chennai.

- Khananabis, Ratan and Saha, Suvasis 2015. Research methodology, Universities Press, Hyderabad.
- Agarwal,Y.P. 2004. Statistical Methods: concepts, application and computation, Sterling Publishing Pvt. Ltd., New Delhi.
- Upagade, Vijay and Shende, Aravind 2009. Research methodology, S. Chand & Company Ltd., New Delhi.
- Nageswara Rao, G. 2012. Research methodology and quantitative methods, BS Publications, Hyderabad.