CURRICULUM

M. TECH.
in
STRUCTURAL AND CONSTRUCTION ENGINEERING

(July 2019 admission onwards)

APPROVED BY

BOARD OF STUDIES (BOS)

12th MEETING, February 20, 2019

DEPARTMENT OF CIVIL ENGINEERING

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY,

Jalandhar

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	Lab-I	0	0	3	2
CE	Lab-II	0	0	3	2

Semester - II

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - VI	3	0	0	3
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	Lab-III	0	0	3	2
CE	Lab-IV	0	0	3	2
Total					19

Semester – III*

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - XI	3	0	0	3
CE	Course - XII	3	0	0	3
CE	Independent Study	0	0	6	3
CE	Dissertation Part I	0	0	12	6*
Total					**15**

Note: 8 Core courses excluding Independent Study and Dissertations and 4 Elective courses need to be completed for the degree. ***Only Elective Courses will be offered in the 3rd Semester.***

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 Analysis, Design and Construction	3	0	0	3
28.	ID-601	Research Methodology	3	0	0	3
29.	CE-590	Modelling and Research Methodology	3	0	0	3

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

Course Objectives

- To understand solving Methods of three-dimensional stress and strain analysis and extended to allow the student and to obtain solutions using analytical as well as numerical methods.
- This subject will include the analyses of principal stresses and strains, state of stress and strain, true stress-true strain and generalized Hooke's law and failure criteria.
- In addition, this subject will focus on plastic deformation of solids, including the analysis of residual stresses and the collapse load of structures subjected temperature and mechanical loading.
- To understand the responses of materials to fatigue and fracture, as well as their creep and viscoelastic behavior.

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 behaviour, Design philosophy, Linear elastic and plastic behaviour, Tresca and Von Mises yield criteria, Visco-elastic behaviour.

Course Outcomes

- This subject helps to understand the theory of elasticity including strain/displacement and Hooke's law relationships;
- As outcome, subject helps to analyze solid mechanics problems using classical methods and energy methods;
- To solve for stresses and deflections of beams under unsymmetrical loading;
- To locate the shear center of thin wall beams; and to obtain stresses and deflections of beams on elastic foundations;

- To obtain solutions to column buckling and plate problems; as well as to apply various failure criteria for general stress states at points.

Text and Reference Books:

1. Timoshenko S P and Goodier J N "Theory of Elasticity" McGraw Hill, New York,2002.
2. Housner G W and Vreeland J R "The Analysis of Stress and Deformation" Mcmillan London, 1998.
3. Srinath L S "Advanced Mechanics of Solids" Tata Mcgraw Hill, New Delhi, 2000.
4. Westergaard H M "Theory of Elasticity and Plasticity" Harvard University Press, Cambridge, 1998.
5. 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 Understandable about the various elements of different types of industrial and non-industrial RCC structures.
- To make students' Knowledgeable of design provisions given in Indian standard code.
- To make students able to design the basic elements like, beams, slab.
- To make students able to analyze and design the 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 different types of industrial and non-industrial RCC structures.
- Knowledge of design provisions given in Indian standard code.

- Able to design the basic elements like, beams, slab.
- Able to analyze and design the chimneys, shear walls, virendeel girders, concrete trusses.

Books Recommended:

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

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

Course Objective:

- To analyze structures subjected to any kind of dynamic excitation and computing quantities like displacements, forces, stresses, etc.
- Understanding the analytical methods and procedures in a way that emphasize physical insight.
- Ability to apply the structural dynamics theory to real-world problems like seismic analysis and design of structures.
- To study the mode shapes and frequencies of single and multi degree of freedom of structures.

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:

- Apply knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
- Create simple computer models for engineering structures using knowledge of structural dynamics interpret dynamic analysis results for design, analysis and research purposes apply structural dynamics theory to earthquake analysis, response, and design of structures

Books Recommended:

1. Clough R W, Penzien J, "Dynamics of Structures", McGraw-Hill, Inc, New York, 1991.
2. Chopra A K "Dynamics of Structures: Theory and Applications to Earthquake Engineering" Prentice Hall (India) Private Ltd, New Delhi, 2000.
3. Roy Creig Jr. "Structural Dynamics: An Introduction to Computer Methods", John Wiley & Sons, New York, 1981.
4. 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.
5. 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 be able to develop deeper understanding of shallow and deep foundations.
- To be able to develop understanding of different design parameters.
- To be able to design foundations and reinforced retaining walls.

Course Syllabus:

Introduction to shallow and deep footings, Design of strap, Raft and combined footings, Design of pile footings, Caps for piles, design of different components of well foundations, Footings subjected to eccentric loading, uplift and overturning, Soil-Structure interaction, Sub grade reaction method, Geotechnical design considerations, Site and soil conditions, Soil liquefaction, Evaluating the liquefaction potential by Standard Penetration Tests, by Cone Penetration Tests, by

Shear Wave Velocity, Liquefaction of clayey soil, Mitigation of Liquefaction Hazard by site modification, Mitigation of Liquefaction Hazard by Structural Design, Seismic Settlement, Subsidence and Differential Compaction, Fault Rupture, Lateral Seismic Earth Pressures.

Course Outcome:

- Students will be able to design shallow and deep foundations.
- Students will be able to determine different design parameters.
- Students will be able to design reinforced retaining wall.

Books Recommended:

1. Saran S "Analysis and Design of Sub-Structures" Oxford and IBH, New Delhi, 1996.
2. Bowls J E "Foundation Analysis and Design" Mc Graw Hill, New York, 1988.
3. Peck R B, Henson W E and Thorn burn W T "Foundation Engineering" John Willey and Sons, New York, 1984.
4. Teng W C "Foundation Design" Prentice Hall, New Delhi, 1992.
5. Naeim F "The Seismic Design Hand Book", Kluwer Academic Publishers, London, 2001.
6. 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:

Behaviour of buildings and structures during past earthquakes and lessons learnt, goals of earthquake resistant design. Linear static procedure for seismic load calculation – IS 1893 – 2002,

2016 combination of gravity and seismic action. Multimodal and Multidirectional response spectrum analysis. Earthquake resistant measures at planning stage: Geotechnical and architectural considerations, irregularities, earthquake resistant measures in sloping roofs, staircase, foundations and general construction details IS : 4326 –1993, principals of earthquake resistant design – behaviour of concrete and steel, confined concrete, the capacity design method; Study of IS 13920 – 1993, 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.
- Understanding the earthquake resistance design philosophy.
- To carry out lateral load analysis with reference to Indian standard code.
- Able to do seismic design and detailing of structures with reference to is code.

Books Recommended:

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

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

Course Objective:

- To make students able to determine the various properties of cement experimentally
- To determine the specific gravity and water absorption of fine and coarse aggregates.
- To perform various test of fresh and harden concrete.
- To make students able to carry out the test procedure of compressive test and flexure test.

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 prestrain. 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:

- Determination of various properties of cement experimentally.
- Determination of specific gravity and water absorption of fine and coarse aggregates.
- Various test of fresh and harden concrete.
- Carry out the test procedure of compressive test and flexure test.

Books Recommended:

1. Pandit G S and Gupta S P "Matrix Analysis of Structures" Tata McGraw Hill, New Delhi, 2003.
2. Gere W and Weaver J M "Matrix Analysis of Structures" CBS Publishers, New Delhi, 2002.
3. Rajasekaran S and Sankarasubramanian G "Computational Structural Mechanics" Prentice Hall India, New Delhi, 2001.
4. 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 give an experience in the implementation of new technology concepts which are applied in field of advanced construction.

- To enable students to describe, analyze, compare and evaluate the technology of mass concreting, industrialised construction and special construction methods.
- To aware the students of some of the problems that can be associated with construction in extreme weathers and difficult conditions.

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, Industrialised 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:

- Students shall understand the latest construction techniques applied to Engineering Construction.
- Students will attain an overall picture of special construction methods with a good understanding of the onsite construction issues and gain an insight in constructing civil, industrial, bridges and building type projects in extreme conditions.

Books Recommended:

1. Neville A M and Brooks J J "Concrete Technology",Pearson Education Asia, Singapore, 1994.
2. Neville A M "Properties of Concrete", Pearson Education, New Delhi, 2004.
3. 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:

- Review the basic concepts of probability and statistics.

- To apply linear programming for optimization of various problems.
- To get familiar with queuing theory, decision theory and game theory.
- To get overview of modifications and improvement on CPM/PERT techniques.

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 uncertainity, 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:

- Students will learn the basics of probability and statistics, linear programming for optimization, queuing theory, game theory and CPM/PERT tecniques.

Books Recommended:

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

- The objective is to learn to perform tests on soil and determine the properties of various soils

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:

- Students will be able to perform different tests on soils

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 softwares and their applications

- 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 Multistorey 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.
- 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.
- Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.

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

Course Objective:

- To perform the testing of PCC and SFRC samples under compression and flexural testing under static and fatigue loading.

Course Syllabus:

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

Course Outcome:

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

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

Course Objective:

- To make students aware about the design of concrete mixes for high strength and high performance of fly ash concrete.

Course Syllabus:

- Design of concrete mixes for high strength and high performance of flyash concrete.

Course Outcome:

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

Syllabus of Electives

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

Course Objective:

- To implement the basics of FEM to relate stresses and strains.
- To solve one, two and three dimensional and dynamic problems using Finite Element Analysis.
- To develop the ability to generate the governing FE equations for systems governed by partial differential equations;
- To understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements;
- To develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to realistic engineering problems through the use of a major commercial general-purpose finite element code.

Course Syllabus

Structural stiffness analysis, Introduction, Matrix Algebra and Gaussian Elimination, The structural element, One Dimensional Problems, Trusses, Assembly and analysis of a structure; Transformation of co-ordinates. Finite elements of a column, Element characteristics, Two Dimensional Problems, Plane stress and plane strain, Interpolation Functions, Numerical Integration and 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, Beams and Frames, Bending of plates, Techniques for Nonlinear Analysis, Three Dimensional Problems in Stress Analysis, Heat Conduction and Seepage Problems

Course Outcome:

- Implement numerical methods to solve mechanics of solids problems.
- Formulate and Solve axially loaded bar Problems.
- Formulate and analyze truss and beam problems.
- Implement the formulation techniques to solve two-dimensional problems using triangle and quadrilateral elements.
- Formulate and solve Axi-symmetric and heat transfer problems.

Books Recommended:

1. Zienkiewiez O. C., "The Finite Element Method" Mcgraw Hill, London, 1991.
2. Abel J F and Desai C A "Finite Element Method" Van Nostrand Reinhold, New York., 2004.
3. Reddy, J.N., "An Introduction to the Finite Element Method", Tata McGraw Hill, New Delhi, 2003.
4. Bathe K J "Finite Element Procedures" prentice Hall of India Private Limited, New Delhi, 1997.
5. Chandrupatla T R and belegundu A D "Introduction to Finite Elements in Engineering" Prentice Hall of India Private Limited, New Delhi, 1997.

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

Course Objective:

- To introduce the students about quality and safety related challenges in construction industry.
- To make students aware about the globally recognized guidelines/theories for quality and safety in construction.
- To understand the importance of safety management in construction and the reduction of accidents on construction sites.

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:

- Students will understand the concept of QC (quality control), quality assurance (QA) and TQM (Total Quality Management) in construction projects.
- Students will be able to recognize and evaluate occupational safety and health hazards onsite, and to determine appropriate hazard controls following the hierarchy of controls. Students will furthermore be able to analyze the effects of onsite exposures, injuries and illnesses, fatalities and the methods to prevent incidents at construction site.

Books Recommended:

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

- To evaluate construction project economics, cost-benefit analysis, breakeven analysis and to analyze construction risks and uncertainties.
- Understand the importance of working capital management, budgeting and control.
- To study the need for financial management and means of achieving the same.
- Provide students with an economic perspective of the real estate and construction sectors, and an understanding of their roles on the general economy.

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:

- On completion of this course the students will be able to know Life cycle costing, Financial Planning and Management for the construction project and Economical analysis of construction projects.
- Students will be able to carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives
- Students will understand the economic principles that underpin construction activities and will be able to use and apply cost planning and control techniques.

Books Recommended:

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

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

Course Objective:

- To make students familiar about the understanding of the structure of earth.
- To understand the importance of geology applied to civil engineering practice.
- To make students Knowledgeable of different types of rocks and minerals and their physical properties.

- To make students Knowledgeable of in situ determination of engineering properties of rock masses.
- To make students understandable regarding the concepts of folds and faults, their classification and relation to engineering purposes.

Course Syllabus:

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 Outcome:

- Understand the structure of earth.
- To understand the importance of geology applied to civil engineering practice.
- Knowledge of different types of rocks and minerals and their physical properties.
- Knowledge of in situ determination of engineering properties of rock masses.
- Understand the concepts of folds and faults, their classification and relation to engineering purposes.

Books Recommended:

1. Bungey J H "Testing of Concrete in Structures" Surrey University Press London, 1989.
2. Paulay T & Preistley "Seismic Design of Reinforced Concrete Structures and Masonry Buildings" John Wiley and Sons London, 1992.
3. ATC-40 (Vol. 1 & 2) "Seismic Evaluation and Retrofitting of Concrete Buildings" Applied Technology Council California, 1996.
4. FEMA – 273 "NEHRP Guidelines for Seismic Rehabilitation of Buildings" Building Seismic Safety Council Washington, 1997.

5. FEMA – 310 "Handbook for Seismic Evaluation of Buildings – a pre standard" Building Seismic Safety Council Washington, 1998.
6. Krammer S "Geotechnical Earthquake Engineering" Pearson Education pvt. Ltd. New Delhi, 2003.

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

Course Objectives:

- To understand the different numerical methods and presently available methods
- To be able to use different numerical methods for solving various geotechnical problems

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 non linear equations, importance of non linear equations, different numerical techniques to solve non linear 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:

- Student should be able to use different numerical methods for solving various geotechnical problems.

Text and Reference Books:

1. Chapra, S. C. and Canale R. P., 2003. Numerical Methods for Engineers. Tata McGraw Hill.
2. Carnahan, B., Luther, H. A. and Wilkes, J. O., 1969. Applied Numerical Methods", John Wiley.
3. Heath, M. T., 1997. Scientific Computing : An Introductory Survey. McGraw Hill.
4. Rajasekaran, S., 1999. Numerical Methods in Science and Engineering. S. Chand.

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

Course Objectives:

- To understand the requirement of materials and their role in pavements
- To gain knowledge of various types of failures in pavements and their specific remedy

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: their advantages and requirements, standard materials' requirements, possible types of materials in different layers.

Construction of rigid pavements: various layers: 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:

- The students will be able to evaluate the condition of pavement and specify requisite measure in terms of either pavement strengthening or maintenance.
- The course will enable students to make use of different materials in the specific layer of pavements.

Recommended Books:

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

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

Course Objectives:

- To achieve fundamental understanding of the classical theory of plates and shells, address importance of plate and shell structures, introduce analytical solutions and numerical techniques and present detailed design of plate as well as shell structures.

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 behaviour 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:

- To enable students to apply the theory of plates and shells to problems, involving various geometries, loading and boundary conditions, to diverse problems in civil engineering and other related fields such as aerospace and mechanical engineering.

Recommended Books:

1. S. P. Timoshenko, and S. W. Krieger "Theory of Plates and Shells," McGraw-Hill, 1959.
2. B.K. Chatterjee, Theory and Design of Concrete Shells" Spon Press; Revised edition, 1988.
3. E.H. Mansfield "The Bending and Stretching of Plates," 2nd edition, Cambridge University Press, 1989.
4. H. Kruas, Thin Elastic Shells, John Wiley & Sons Ltd, 1968.
5. G.S. Ramaswamy, Design and Construction of Shell Structures, CBS Publishers, New Delhi, 1996.

6. E. Ventsel, and T. Krauthammer, Thin Plates and Shells: Theory, Analysis, and Applications, 1st Edition, CRC Press, 2001
7. K. Chandrasekhara, Analysis of Thin Concrete Shells, Oxford and IBH, Kolkata, 1971.
8. J.N. Bandopadhyay Thin Shell Structures, New Age International Publishers, New Delhi, 1986.
9. 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:

The goals of this course are to:

- Provide knowledge about the fundamentals of remote sensing, sensor systems and image characteristics
- Provide knowledge about the GPS system and its components, the GPS signal structure, the types of GPS measurements and their errors and biases.
- Provide an introduction to LIDAR data and discusses how to integrate and manage LIDAR data in GIS
- Enhance student understanding of characteristics of spatial data that come from different sources
- Enhance student understanding of data quality issues when integrating different data sources in GIS.

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:

Upon successful completion of the class, students should be able to:

- Critically evaluate and analyze data quality for their GIS project
- Design a geo-database and defend the data type selection
- Appraise the degree to which remote sensing data can be used efficiently and effectively
- Interpret the GPS signal and the factors that affect signal quality
- Interpret the significance of Dilution of Precision and its effect on position accuracies and evaluate correction techniques
- Decide and defend the use of raster versus terrain when performing analysis with LIDAR data
- Combine LIDAR data with multiple data sources to create more complex three-dimensional surfaces

Recommended Books:

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

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

Course Objective:

- To understand the general mechanical behavior of prestressed concrete.
- To analyze and design prestressed concrete flexural members.
- To analyze and design for vertical and horizontal shear in prestressed concrete.
- To analyze transfer and development length as well as prestress losses.
- To analyze and design for deflection and crack control of prestressed concrete member.

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-dimensionalised 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.

Books Recommended:

1. Raju N K “Prestressed Concrete” Tata McGraw Hill, New Delhi, 2001.
2. Rajagopalan N “Prestressed Concrete” Narosa, New Delhi, 2002.
3. Dayaratnam P “Prestressed Concrete” Oxford & IBH, New Delhi, 2001.

4. Lin T Y "Prestressed Concrete" John Wiley and Sons, New York, 2002.
5. Nawy E G "Prestressed Concrete : A Fundamental Approach" Prentice Hall, New Delhi, 1995.
6. I.S. : 1343 – 1980 CODE, BIS New Delhi.

Course Outcome:

- Students will be able to identify and apply the applicable industry design codes relevant to the design of prestressed concrete members.
- Student will be familiar with professional and ethical issues and the importance of lifelong learning in structural engineering.
- Students will become familiar with the prestressed concrete fabrication and construction process.
- Students will be able to perform an industry relevant design project in a team setting.

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

Course Objective:

- To understand various concepts of infrastructure planning and management and know stages of an Infrastructure Project Lifecycle.
- To understand the role of Private sector and World Bank in infrastructure growth.
- To familiarize with the latest trends in Construction management, Construction materials and Construction machinery required for various types of infrastructure development project.

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 labour 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, corporatiozation, 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.

Books Recommended:

1. Vaid K "Construction and Infrastructure Development – Issues and Challenges" NICMAR, 2003.

2. India Infrasturcture Report 2001 & 2002, Oxford University Press, New Delhi, 2001/02

3. NICMAR, Construction Business Opportunities in Infrastructure Development in India, NICMAR, Mumbai, 2001.

4. Parikh K S "India Development Report 1999-2000" Oxford University Press, New Delhi, 1999.

5. Rakesh Mohan Committee "The India Infrastructure Report" National Council of Applied Economic Research, New Delhi, 1996.

Course Outcome:

After the completion of course, students will be able to:

- Gather background information and research and describe its impact on the infrastructure project.
- Understand the concepts of financial, economic, social and environmental impact and describe and explain how these are undertaken in an infrastructure project.

- Students will be able to understand the challenges and strategies for successful Infrastructure Project Implementation.

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

Course Objective:

- To make students aware about the structural elements and types of structural elements for tall buildings.
- To make analysis off Tall Buildings with and without Shear Walls, tube-in-tube constructional and 3-Dimensional analysis of shear core buildings.
- To make students knowledgeable of design of Tall Buildings Procedures 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:

- Structural elements and types of structural elements for tall buildings.
- Analysis off Tall Buildings with and without Shear Walls, tube-in-tube constructional and 3-Dimensional analysis of shear core buildings.
- Design of Tall Buildings Procedures of elastic design, ultimate strength design and limit state design of super structures including structural connections.

Books Recommended:

1 Schumelles W “High rise Building Structures” John Wiley and Sons, New York, 1977.

2. Ghali A "Structural Analysis: A Unified Classical and Matrix Approach" E & F Spon, London, 1999.

3. Taranath B S "Structural Analysis & Design of Tall Buildings" McGraw – Hill International, New York, 1988.

4. Brester B and Lin T Y "Steel Structures" John Wiley and Sons, New York, 1981.

5. Coull and Stafford S "Tall Buildings with Particular Reference to Shear Wall Structures" Pergamon Press, New York, 1967.

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

Course Objective:

- Properly select heavy equipment based on applications, utilization, productivity, and other factors
- Understand the elements of equipment cost and evaluating equipment owning alternatives.
- Have a basic understanding of various aspects of construction and earthwork, including but not limited to: concrete construction, Pile driving, tunneling, construction equipment and dewatering.

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:

- Learn how to best utilize construction equipment on site work and heavy civil projects.
- Become familiar with construction methods, equipment and their capabilities.
- Understand standard designations, sizes, and gradations of equipment.

Books Recommended:

1. Purifoy R L and Clifford J S "Construction Planning, Equipment and Methods: McGraw Hill, New York, 2002.

2. Verma M "Construction Equipment and its Planning and Application" Metropolitan Book company, New Delhi, 1994.

3. Singh J "Heavy Construction Planning, Equipment and Methods" Oxford and IBH, New Delhi, 1992.
4. 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 qualify the students to analyse and design of various types of industrial buildings and to understand the design concept of Cold–formed light gauges steel sections.
- To understand the design concept of chimneys, cooling towers and bunkers
- To understand the design concept of trussed girder bridges and bearing
- To develop clear understanding of the concepts and practical knowledge of modern Civil Engineering techniques for design of steel structures.

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:

- Capable of designing the industrial buildings with and without crane girders and students are capable enough to scrutinise the analysis and design of various industrial structures.
- Capable of designing the elements of steel construction.
- Capable of providing the design of concrete –Steel composite sections.
- Able to understand the analysis and design of trussed girder bridges and bearing.
- Able to analyze and design steel chimney, lattice tower and students able to independently design steel structures using relevant IS codes

Books Recommended:

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

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

Course Objective:

- To make students able to plastic design, plastic hinge, plastic collapse load, plastic analysis of frames.
- To make students knowledgeable about the different configurations and components of elevated circular tanks.
- To make students aware about the design of light gauge steel.

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:

- Able to plastic design, plastic hinge, plastic collapse load, plastic analysis of frames.
- Different configurations and components of elevated circular tanks.
- Design of light gauge steel.

Books Recommended:

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

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

Course Objective:

- Identification of dynamic loads and their characteristic.
- To apply theories of vibrations.
- Able to determine dynamic soil parameters.
- Understand the concept of Vibration isolation and screening.

Course Syllabus:

Nature of dynamic loads, stress conditions on Soil elements under E.Q. loading, Theory of vibrations, Behaviour of retaining walls during earthquakes, modification of Coulomb's theory, Modified Culmann's construction, Analytic solution for C- □□soils, Indian Standard 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 behaviour 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:

- Students will learn the basics of dynamic loads and their characteristics, apply theories of vibrations.
- Students will be able to determine the dynamic soil parameters and understand the concept of vibration isolation.

Books Recommended:

1. Barken D D "Dynamics of Bases and Foundations" McGraw Hill, New York, 1962.

2. Saran S "Soil Dynamics and Machine Foundations", Galogotia Publications Pvt. Ltd,New Delhi, 1999.

3. Rao N D V K “Vibration Analysis and Foundation Dynamics” Wheeler Publishing Div. of A. H. Wheeler & Co. Ltd. New Delhi, 1998.
4. Prakash S “Soil Dynamics” McGraw Hill Book Company, New York, 1981.
5. Richart F E, Hall J R and Woods R D, “Vibrations of Soils and Foundations”, Prentice Hall International, N Jersey, 1970.
6. Krammer S “Geotechnical Earthquake Engineering” Pearson Education Pvt. Ltd. New Delhi, 2003.

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

Course Objective:

- To make Civil Engineering students able to analyze, evaluate and design construction contract documents.
- Resolve disputes collaboratively and amicably and outline alternative dispute resolution methods.

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:

Students will be able to

- Recognize different types of contracts and the effect of each type on the risk allocation strategy.
- Prepare contract schedules, notice inviting tender and contract documents.
- Apply contract administration tools and techniques to effectively manage the contract and avoid disputes during implementation.

Books Recommended:

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

CE 531 Geoenvironmental Engineering [3-0-0-3]

Course Objectives:

1. To make students aware about subsurface contamination and its sources
2. To make students learn about geotechnical aspects of planning and design of facilities for disposal of different kinds of solid waste
3. To make students learn about detection & monitoring of subsurface contamination and control & remediation of contaminated sites.
4. To make students learn about rehabilitation of waste dumps and geotechnical re-use of waste.

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:

Students will be to

- plan and design the facilities for disposal of different kinds of solid waste
- plan the detection and monitoring of subsurface contamination

Text and Reference Books:

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

CE -532 Landfills And Ashponds [3-0-0-3]

Course Objectives

- To make students learn about design of waste disposal facilities
- To make students learn about the construction and operation of waste disposal facilities

Course Content

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

The student will be able to:

- To design the waste disposal facilities
- To contribute in construction and operation of the waste disposal facilities
- To plan the environmental monitoring around the waste disposal facilities.

Text and Reference Books:

1. Datta, M., 1998. Waste disposal in Engineered landfills, Narosa Publishers.
2. Reddy, L.N. and Inyang. H. I., 2000. Geoenvironmental Engineering –Principles and Applications, Marcel Dekker, Inc., New York

3. 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

- To make students understand the components of solid waste management system
- To make students learn about recycling, reuse and reclamation of solid wastes

Course Content

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

After this course student will be able to:

- To review the components of solid waste management system
- Appreciate the significance of recycling, reuse and reclamation of solid wastes
- develop an insight into the collection, transfer, and transport of municipal solid waste
- understand the importance and operation of a various facilities for resource recovery and waste disposal

Text and Reference Books:

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

4) Vesilind, P.A., Worrell, P.A., Reinhart, D., 2001. Solid Waste Engineering, Nelson Engineering.
5) 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, Theological modeling of fresh concrete, Constitutive Equations: Nonlinear elasticity, plasticity, visco-elasticity and fracture mechanics of hardened concrete, confinement and ductility, Moisture diffusion: Permeability of Concrete, Drying creep and shrinkage cracking, solid and structural mechanics of reinforced concrete, Skew bending, modified compression field and unified theories of R.C. Beams under bending, shear and torsion, Bond-slip and phenomenon of cracking in reinforced concrete: Statical and dynamical analysis of R. C. Structures, Trends.

Course Outcome:

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

Recommended Books:

1. Jan G. M. van Mier “Fracture Processes of Concrete”, CRC Press; 1 edition, 1997.
2. 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 introduce the students with various types of construction materials required in specific places and situations.
- To provide the knowledge regarding construction of infrastructure with the use of these materials that involves designing the constituents, mixes and gradations.
- To gain knowledge regarding use of cheap alternative materials in place of high cost construction materials.

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:

- The students will be able to make use of specific materials required for a given construction work.
- Course will enable them to decide the materials on basis of service life and expected performance on basis of their properties.

Recommended Books:

1. Marios, S. and Peter, D. 2017. Construction Materials: their nature and behavior, CRC Press.
2. David, D., and Cather, B. 2013. Construction materials reference book, Routledge.
3. Zhang, H. 2011. Building materials in civil engineering, Woodhead Publishing Series in Civil and Structural Engineering.

4. Hornbostel, C. 1991. Construction materials: types, uses and applications, John Wiley & Sons.
5. Duggal, S.,K. 1998. Building materials, New age international.
6. **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 materials, 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.
- Role of fibres in composites, comparison of fibres, role of interface in the fibre matrix composite.
- Analysis of an orthotropic lamina and laminated composites, elastic properties of unidirectional laminate.

Recommended Books:

1. Chawla, Krishan K. "Composite Materials: Science and Engineering (Materials Research and
2. Engineering)", Springer; 3rd edition, 2013.
3. Brandt A. M. "Cement-based Composites: Materials, Mechanical Properties and Performance", CRC Press, 1994.
4. 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 impart the fundamental knowledge on using various analytical tools like STAAD Pro, ABAQUS, etc., for Engineering Simulation.
- Engineering problem modelling and solving through the relationship between theoretical, mathematical, and computational modelling for predicting and optimizing performance and objective.
- To impart knowledge on how these tools are ued in Industries by solving some real time problems using these tools.
- Develop solutions and extract results from the information generated in the context of the engineering domain to assist engineering decision making.

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:

- The student will be able to appreciate the utility of the tools like STAAD Pro or ABAQUS in solving real time problems and day to day problems.
- Use of these tools for any engineering and real time applications.
- Acquire knowledge on utilizing these tools for a better project in their curriculum as well as they will be prepared to handle industry problems with confidence when it matters to use these tools in their employment.

Recommended Books:

1. 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.

2. Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.

3. Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.

4. 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:

- Understand the basic principles, techniques of soil stabilization.
- Knowledge of different methods of soil stabilization.
- Identify the geosynthetic materials and its applications.
- To get familiar with different techniques of improvement of bearing capacity.

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 behaviour of compacted clays, field compaction techniques- static, vibratory, impact, Earth moving machinery, Compaction control. Shallow Stabilization with additives: Lime, flyash, cement and other chemicals and bitumen.

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

Course Outcome:

- Students will learn the basics of stabilization and different techniques and materials used for stabilization.
- Students will learn about geosynthetics and their properties.
- Students will learn to design the foundations on stabilized soils and will be able to compare the results with not stabilized soils

Recommended Books:

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

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

Course Objective:

- To understand the mechanical stress, strain and strength of soil.

- To understand the critical state soil mechanics.
- Apply fundamental knowledge of the behaviour of soil as an engineering material in Civil Engineering Projects.
- Analyse and solve a range of soil-related problems, especially those involving water flow and soil settlement.

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 behaviour of granular soils. Factors affecting shear beahviour. Determination of parameters.

Shear behaviour of granular soils. Factors affecting shear beahviour. Determination of parameters. Shear behaviour of fine grained soils. Porepressure 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 Behaviour of soils of India: Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soils, aeolin deposits.

Course Outcome:

- Students will be able to determine the stress, strain of soil, critical state of soil.
- Students will have knowledge regarding the behaviour of soil as an engineering material in Civil Engineering Projects.
- Students will learn to analyse and solve a range of soil-related problems, especially those involving water flow and soil settlement.

Books Recommended:

1. Mitchell, James K., (1993), "Fundamentals of soil Behaviour", 2nd Edition, John Wiley and sons.

2. Das, B.M., (1997), "Advanced soil Mechanics", Taylor and Francis.

3. Lambe, T.W., and Whitman, R.V., (1987), "Soil Mechanics", John Wiley and Sons.

4. Gulhati, Shashi K., and Datta Manoj (2008), "Geotechnical Engineering, Tata Mcgraw-Hill Company Ltd.

5. Coduto, Donald P (2002), "Geotechnical Engineering, Principles and Practices",
Pearson Education International, New Jersy.

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

Course Objective:

- Understand different the basics of Geosynthetics
- Identify the geosynthetic materials and its applications.
- To get familiar with using different geosynthetics for improvement of bearing capacity and soil texture.

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:

- Students should be able to distinguish between different geosynthetics.

- Students should be able to determine the properties of geosynthetics.
- Students should be able to determine the bearing capacity of soil after introducing geosynthetics.

Recommended Books:

1. Rao G V and Raju S "Engineering with Geosynthetics" Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1990.

2. Ranjan G and Rao A S R "Basic and Applied Soil Mechanics" International Publishers, New Delhi, 2000.

3. Koerner R M "Designing with Geosynthetics" Prentice-Hall, N. J., U.S.A., 1986.

4. Saran, S., (2006), "Reinforced soil and its Engineering Applications", I.K. International Pvt. Ltd.

5. Jones, C.J.F.P. (1985), "Earth Reinforcement and soil structures", Butterworth and co. (Publishers) Ltd., London, England.

CE-541 Pavement Analysis, Design and Construction [3-0-0-3]

Course Objectives

1. To study the different types of pavements depending upon the mode of transportation using it and further, depending upon the structural behaviour.
2. To understand the concept of consideration of wheel loads, axle loads, wheel –axle configuration and allied aspects as a pre-requisite in the analysis and design of the pavement.
3. To study the various types of structural responses (stresses and deformations) inducing in the pavements due to wheel load and other climatic variations.
4. To introduce the constructions of different types of highway pavements.
5. To study the different types of distresses in the pavement, evaluation of the existing pavements using different methods and rehabilitation of the distressed pavements.
6. To study the design methodology and construction technology w.r.t. low volume roads.

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

Highway Constructions: Construction of water bound macadam, wet mix macadam roads, bituminous concrete Roads, bituminous surfacing and treatment, cement concrete roads, semi-rigid and composite pavements, pavement consruction using Pozzolanic and waste materials, roller compacted concrete pavement, fiber reinforced concrete pavements, quality control and quality assurance during constructions, etc.

Evaluation and Strengthening:

Distresses in flexible and rigid pavements, condition and evaluation surveys, present serviceability index, roughness measurement, pavement maintenance, Benkelman beam deflections, different methods of designing the overlays, overview of the revision of specifications pertaining to these methods, design of different overlays, skid resistance and measurement

Low Volume and Low Cost Roads: Classification of low cost roads, stabilization of subgrade, sub-base and base and its advantages, low cost materials and methods used for construction, design of low volume roads.

Course Outcomes

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

1. Understand the structural actions involved in the pavement due to different types of load acting thereon and the various methods of analysis of these pavements.
2. Understand the application of analysis in the design of pavements using various methods of pavement designs along with the design of low volume roads.
3. Understand the various aspects of the construction of different types of roads including that of low volume roads.
4. Know the different types of failures occurring in the existing pavements and carry out the structural and functional evaluation of pavements;
5. To apply the knowledge gained in evaluating the pavements in pre-empting the failure and subsequently, in arriving upon the methodology of the rehabilitation of pavements.

Books Recommended:

1. Sharma, S.K., 2014. Principles, Practice and Design of Highway Engineering (Including Airport Engineering); S. Chand and Company Pvt. Ltd., New Delhi.
2. Srinivasakumar, R., 2015. Pavement Design; University Press, Hyderabad (First Published 2013; Preprinted in 2015).
3. Kadiyali, L.R.and Lall, N.B., 2005. Principles and Practice of Highway Engineering; Khanna Publishers, Delhi
4. Yang H. Huang, 2008. Pavement Analysis and Design; Pearson Prentice Hall, USA
5. Das, Animesh, 2017. Analysis of Pevement Structures; CRC Group, Taylor and Francis Group
6. Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2015. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition).
7. Saxena, Subhash Chandra, 2014. A Text Book of Highway and Traffic Engineering; CBS Publishers and Distributors, New Delhi
8. Venkatramaiah, C., 2016. Transportation Engineering (Vol.-I)- Highway Engineering.; University Press, Hyderabad.
9. Rao, G.V., 2000. Principles of Transportation and Highway Engineering; Tata Mc-Graw Hill Publishing House Pvt. Ltd., New Delhi.
10. Chakraborty, P. and Das, A., 2013. Principles of Transportation Engineering, Prentice Hall India Learning Pvt. Ltd., New Delhi (Eighth Printing: January 2013).

10 Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2013. Highway Material and Pavement Testing; Nem Chand and Bros., Roorkee, India.

Reference Books

11. Yoder E.J. and Witzack M.W., 1991. Principles of Pavement Design; John Wiley and Sons, New York.
12. Kandhal, Prithvi Singh , 2014. Bituminous Road Construction in India; PHI Learning Pvt. Ltd., Delhi
13. Delattee, Norbert J., 2017. Concrete Pavement: Design, Construction and Performance (Second Edition)
14. Mallick, Rajib B. and Korchi, Tahar El, 2017. Pavement Engineering: Principles and Practice, CRC Press, Taylor and Francis Group (Third Edition)
15. 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.

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

Course Objectives:

- To understand research and research process.
- To acquaint students with identifying problems for research and develop research strategies.
- To familiarize students with the techniques of data collection, analysis of data and interpretation.

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:

Learner will be able to…

- Prepare a preliminary research design for projects in their subject matter areas.
- Accurately collect, analyze and report data.
- Present complex data or situations clearly.
- Review and analyze research findings.

Recommended Books:

1. 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.
2. Handbook of Science Communication, compiled by Antony Wilson, Jane Gregory, Steve Miller, Shirley Ear, Overseas Press Indian Pvt. Ltd, New Delhi, first edition 2005.
3. G L Squires, ―Practical physics, Cambridge University Press for all scholars except those from Humanities and Management sciences.

4. Peter B Medeq, ― Advice to a Young Scientist, Pan Books, London 1979.

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

Course Objectives:

- Learn the research types, methodology and formulation.
- Know the sources of literature, survey, review and quality journals.
- Understand the research design for collection of research data.
- Understand the research data analysis, writing of research report and grant proposal.

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 softwares. 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:

- Differentiate the research types and methodology.
- Able to do literature survey using quality journals.
- Able to collect research data.
- Process research data to write research report for grant proposal.

Recommended Books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K. 2002. An introduction to research methodology, RBSA Publishers.
2. Kothari, C.R, 2004. Research methodology, methods & technique, New Age International Publishers, New Delhi.
3. Ganesan, R. 2015. Research methodology for engineers, MJP Publishers, Chennai.
4. Khananabis, Ratan and Saha, Suvasis 2015. Research methodology, Universities Press, Hyderabad.
5. Agarwal,Y.P. 2004. Statistical Methods: concepts, application and computation, Sterling Publishing Pvt. Ltd., New Delhi.
6. Upagade, Vijay and Shende, Aravind 2009. Research methodology, S. Chand & Company Ltd., New Delhi.
7. Nageswara Rao, G. 2012. Research methodology and quantitative methods, BS Publications, Hyderabad.