VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme Leading to

Master of Technology (M.Tech.) Degree in

Civil Engineering with Specialization in Structural Engineering

Implemented from the batch admitted in Academic Year 2014-15

Head of Department
Structural Engg.
V.J.T.I.
Mumbai - 400 019.

Dean-Academics
VJTI MUMBAI

M.Tech. Civil Engineering with Specialization in Structural Engineering

(This page will list the M.Tech. program's Program Educational Objectives (PEOs) and Program Outcomes (POs). Please carefully see NBA's Graduate Attributes for Masters programs in engineering / technology. POs of the M.Tech. program should incorporate all these graduate attributes)

Program Educational Objectives (PEOs)

1. To excel in professional career and/or higher education by acquiring knowledge in engineering and mathematical principles along with state of art computing skills.
2. To analyze real life problems and design technically sound, economically feasible and socially acceptable structural systems.
3. To exhibit professionalism, ethical attitude, effective communication, teamwork in their profession and adapt to latest trends and technology by engaging in lifelong learning.

Program Outcomes (POs)

1. An ability to apply principles of mathematics and engineering fundamentals appropriate to the structural engineering discipline.
2. An ability to identify, formulate, analyze and solve a structural engineering problem.
3. An ability to design and conduct experiments and to analyze and interpret the results.
4. An ability to use current techniques, skills, and modern tools necessary for solving complex field problems.
5. An ability to analyze the local and global impact of latest trends in structural engineering on society.
6. An understanding of professional, ethical, legal, security and social responsibilities.
7. An ability to function effectively in individual capacity as well as in diverse and multidisciplinary teams to accomplish a common goal.
8. An ability to communicate effectively with a wide range of audiences.
9. To develop the enthusiasm for continuing professional development.
10. An ability to apply engineering and management principles in a project management team, both as a team member and as a leader.

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Scheme of Instruction and evaluation

SEMESTER I

Scheme of Instruction				Scheme of Evaluation				
S. No	**Course code**	**Course Title**	**L-T-P (Hours / week)**	**Credits**	**TA**	**IST**	**ESE**	**ESE hours**
1.	CE5001S	Computational Methods	3-1-0 = 4	4	20	20	60	3
2.	SE5001S	Continuum solid Mechanics	3-0-0=3	3	20	20	60	3
3.	SE5002S	Experimental Methods in Structural Engineering	3-0-0=3	3	20	20	60	3
4.	SE5003S	Advance Geotechnical Engineering	3-0-0=3	3	20	20	60	3
5.	Prog. Elective	Program Elective course 1	3-1-0=4	4	20	20	60	3
6.	Prog. Elective	Program Elective course 2	3-1-0=4	4	20	20	60	3
7.	SE5004L	Experimental Methods Lab	0-0-3 =3	1.5	100 % CIE			-
8.	SE5005L	Numerical methods lab	0-0-3 =3	1.5	100 % CIE			-
		Total	27	24				

bbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, **IST**: In Semester Tests (comprise of average of two In semester tests), **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

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SEMESTER II

Scheme of Instruction				Scheme of Evaluation				
S. No	**Course code**	**Course Title**	**L-T-P (Hours / week)**	**Credits**	**TA**	**IST**	**ESE**	**ESE hours**
1.	CE5006S	Research Methodology	3-1-0 = 4	4	20	20	60	3
2.	SE5006S	Finite Element Method	3-0-0 = 3	3	20	20	60	3
3.	SE5007S	Design of Pre-stressed concrete structures	3-0-0=3	3	20	20	60	3
4.	SE5008S	Design of Concrete infrastructural and industrial structures	3-0-0=3	3	20	20	60	3
5.	Prog. Elective	Program Elective Course 3	3-1-0=4	4	20	20	60	3
6.	Prog. Elective	Program Elective Course 4	3-0-0=3	3	20	20	60	3
7.	SE5009L	Advanced Computer Aided Analysis Laboratory	0-0-3 =3	1.5	100 % CIE			-
8.	SE5010L	Advanced Computer Aided Design Laboratory	0-0-3 =3	1.5	100 % CIE			-
9.	SE5801D	Technical Seminar	0-0-4 =4	2	100 % CIE			
		Total	30	25				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, **IST**: In Semester Tests (comprise of average of two In semester tests), **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

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List of Elective 1:

S. No	Course code	Course Title (Times new roman 12 bold)
1.	SE5101S	Nonlinear Analysis
2.	SE5102S	Mechanics of Composite Materials
3.	SE5103S	Repairs and Rehabilitation of Structures

List of Elective 2:

S. No	Course code	Course Title (Times new roman 12 bold)
1.	SE5104S	Advanced Structural Mechanics
2.	SE5105S	Design of Offshore Structures

List of Elective 3:

S. No	Course code	Course Title (Times new roman 12 bold)
1.	SE5106S	Structural Dynamics and Earthquake Engineering
2.	SE5107S	Bridge Engineering

List of Elective 4:

S. No	Course code	Course Title (Times new roman 12 bold)
1.	SE5108S	Mechanics of Plates and Shells
2.	SE5109S	Earth Pressure and Retaining Structures
3.	SE5110S	Design of Tall Structure

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SEMESTER III and SEMESTER IV – Project work

S. No	Course code	Course Title	Credits	Evaluation pattern	Semester
1.	SE6901D	Stage –I Presentation	4	Graded evaluation by a committee of atleast two examiners including supervisor (guide)	III
2.	SE6902D	Stage –II Presentation	4	Graded evaluation by a committee of atleast two examiners including supervisor (guide)	III
3	SE6903D	Stage –III Presentation	4	Graded evaluation by a committee of atleast two examiners including supervisor (guide)	IV
4.	SE6904D	Final Presentation and Viva Voce	12	Graded evaluation by a committee of atleast two examiners including supervisor (guide) and an external examiner	IV

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	CE5001S
Course Title	Computational Methods

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: identify the attributes and use them to model any phenomenon or situation in the field of civil engineering into a set of mathematical equations.

CO2: identify the optimum methods and obtain the solution of various types of mathematical equations

CO3: perform curve fitting into a data set and perform extrapolation and interpolation of data from a given data set.

CO4: apply the principles of optimization to get optimal solutions to problems in civil engineering.

Mathematical Model

Purpose of modeling, types of model, steps in modeling process - problem definition, purpose definition, conceptualization, selection computer code, model design, calibration, validation, errors in engineering calculations (sources of errors, significant digits, rounding off, propagation of maximum error, propagation of variance, bias & precision)

Interpolation and Extrapolation

Newton's Interpolation-forward and backward, Lagrange's Interpolation, , Hermite Interpolation, Spline Interpolation- Cubic, Inverse Interpolation, Extrapolation, Civil Engineering Application- Elevation Contour Map, Isohyetal Map, Noise Map, etc.

Roots of an Equation, Numerical Differentiation, Numerical Integration and Solution of Ordinary Differential Equations

Roots of an Equation: Newton Raphson method, Modified Newton Raphson method and successive approximation method. Numerical Integration: Trapezoidal rule, Simpson's rule (⅓ rd, ⅜ th), Gauss quadrature method 2-point, 3-point, Double integration: Trapezoidal rule, Simpson's rule (⅓ rd), Numerical solutions of ordinary differential equations: method of Euler, Taylor and Runge-Kutta procedures. Civil Engineering Application- Earthwork volume estimation, Estimation of pile capacity, etc.

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Curve Fitting and Errors

Curve fitting (Interpolation, function that fits given values - approximate and exact, find function where reaches min/max or a specific value, linear regression, higher order polynomial, Gaussian, quantifying errors in curve fitting). Civil Engineering Application-population Forecasting Methods, Reduction Rate Parameters for design of Treatment Units, atmospheric dispersion of pollutant (Gaussian Dispersion Model) , Dispersion at sea outfall, etc.

Finite Difference and Finite Element Method

Finite Difference Method, Boundary value problems of exact differential equations limited to second order only, PDE's-Parabolic-explicit. Crank Nicholson method, Hyperbolic equations, Elliptic equations. Finite Element Method (limited to 1D elements).: Basic understanding of finite element method including elements types and their formulation. Civil Engineering Application- Groundwater modeling, Flood routing, Self Purification of Streams (Streeter Phelps Equation), Finite element methods for simple beam and truss problem, 1 D consolidation problem, etc.

Optimization

Concept of optimization, linear programming, civil engineering application, environmental engineering, water resources engineering, structural engineering.

Recommended Reading

1. Hamming R. W., Numerical Methods for Scientist and Engineers, McGraw Hill, 1998.
2. Scarborough J. B., Numerical Mathematical Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., 2000.
3. Jain K. K., Iyengar S. R. K and Jain R. K., Numerical Methods - Problem and Solutions, Wiley India Pvt. Ltd, 2001.
4. Hayter A. J., Probability and Statistics, Duxbury, 2002.
5. Mathews J. H. and Fink K. D., Numerical Methods using MATLAB, Pearson Education, 2004.
6. Capri S. C. and Canale R. P., Numerical Methods for Engineers, 6th Edition, McGraw Hill, 2010.
7. Hildebrand F. B., Introduction to Numerical Analysis, Dover Publications, 1987.
8. Rajasekaran S., Numerical Methods in Science and Engineering, A Practical Approach. S. Chand & Company Ltd., New Delhi 2003.
9. Sastry S. S., Introductory Methods for Numerical Analysis, 5th Edition, Prentice Hall of India Private Ltd., New Delhi, 2012.
10. Akai T. J., Applied Numerical Methods for Engineers, John Wiley & Sons, 1994.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5001S
Course Title	Continuum Solid Mechanics

COURSE OUTCOME:

After completion of this course students shall be able to

CO1: define basic definitions of modern continuum mechanics, such as deformations, strains, stress, constitutive equations of linear and non-linear materials.

CO2: apply basic elasticity formulation in 2-D and 3-D domains for rectangular and polar coordinate systems.

CO3: apply energy theorems for the elasticity solutions.

Introduction

Stress transformation and strain transformation at a point in an elastic body, 3D problems, rigid body translation and rotation of an element in space, formulation of generalized Hooke's law, derivation of displacement for a general displacement field u, v, w, evaluation of principal stresses and strains at a point, tensor notations for stresses and strains at a point.

2-D Problems in Continuum Mechanics

Study of plane stress and plain strain idealizations of problems. Application of equilibrium and compatibility conditions to solve a problem of continuum mechanics. Application of boundary conditions and stress functions approach for solution of problems. 2-D problem formulation in rectangular coordinates, polynomial solutions and cantilever loaded at the end, simply supported beam under uniformly distributed load and linear loading. 2-D problem in polar coordinates, stress distribution about an axis, pure bending of curved bars, displacement for symmetrically loaded cases, bending of a curved bar by forces at end. Stress analysis of plates with circular hole due to in plane loading. Stress analysis in structures due to a concentrated load at a point of a straight boundary. Stress analysis of circular disks and wedges. 2-D formulation for stress analysis of prismatic bars of elliptical, rectangular, triangular and other sections subjected to torsion by Membrane Analogy.

3-D Problems in Continuum Mechanics

Application of equilibrium and compatibility conditions to 3-D problems in continuum mechanics. Problems of rods under axial stress, bar under its own weight and pure bending of prismatic rods. Bending of prismatic bars as a problem of continuum mechanics in 3-D. Bending of a cantilever, stress function for circular and rectangular sections of bars.

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Energy Theorems

Applications of complementary energy theorems to the problems of continuum mechanics

Recommended Reading

1. Wang C. T., Applied Elasticity, McGraw Hill Book Co., 1953.
2. Timoshenko S. P. and Krieger S. W., Theory of Plates and Shells, McGraw Hill International Ed., 1959.
3. Timoshenko S. P. and Goodier J. N., Theory of Elasticity, McGraw Hill Book Company, International Ed., 1970.
4. Shames H. and Cozzarellie F. A., Elastic and Inelastic Stress Analysis, Prentice Hall New Jersey, 1992.
5. Chandrasekharaiah D. S. and Debnath L., Continuum Mechanics, Prism Books Pvt. Ltd., Bangalore, 1994.
6. Srinath L. S., Advanced Mechanics of Solids, Tata McGraw-Hill Education, 2009.
7. Boresi Arthur P., Chong K., Lee J. D., Elasticity in Engineering Mechanics, Wiley and Sons, 2011.
8. Budynas R. G., Advanced Strength and Applied Stress Analysis, WCB/McGraw-Hill, 1999.
9. Sadd M. H., Elasticity- Theory, Applications and Numerics, Academic Press, 2009.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5002S
Course Title	Experimental Methods in Structural Engineering

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: illustrate significance and relevance of experimental stress analysis in structural engineering.

CO2: measure stresses-strains using strain gauges and photo-elasticity techniques.

CO3: apply principles of model analysis and its application to forecast behavior of prototypes.

CO4: interpret various non-destructive and load testing techniques to assess the health of structures.

Introduction to General Experimentation

Role and limitations, properties of engineering materials, failure due to excessive stresses, buckling, fatigue, creep, impact, testing machines for standard tests.

Force and Strain Measurement

Strain measurements, types of strain gauges, electrical resistance strain gauges, cross sensitivity factor, gauge indicators, analysis of strains at a point, measurement of dynamic strains, galvanometer and oscilloscope, basic concept of model analysis, model materials and their properties, dimensional analysis, means of application of forces, means of measurement of forces and displacements, calculation of displacement in prototypes.

Photo Elasticity

Basic concepts, stress optic laws, Isoclinic's, Isochromatics, Material fringe value, application to determination of stress in beams, rings and discs.

Non-Destructive Methods of Testing of Concrete

Basic concepts in Ultrasonic Testing, Schmidt Hammer, Magnetometer. Determination of strength and quality of concrete using above mentioned method. Determination of corrosion/ carbonation in R.C member, reviews of various other Non-destructive techniques for determining quality of concrete, concept of condition survey of a structure, load testing of structures, codal provisions for load testing and Non-destructive testing of concrete structures.

Recommended Reading

1. Frocht M. M., Photoelasticity, John Wiley, 1941.
2. Dally J. W. and Riley W. F., Experimental Stress Analysis, McGraw Hill Book Co. 1977.

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3. Srinath L., Raghavan. M., Ingaiah K., Gargesha G, Pant B. and Ramachandra K., Experimental Stress Analysis, Tata McGraw Hill Company, New Delhi, 1984.
4. Singh S., Experimental Stress Analysis, Khanna Publishers, New Delhi, 1996.
5. Bungy J. H. and Millard S. G., Testing of Concrete in Structures, Blackie Academic and Professional Glasglow 2010.
6. Ramesh K., Digital Photoelasticity- Advanced Techniques and Applications, Springer-Verlag, Heidelberg, New York, 2000.
7. Ramesh K., Experimental Stress Analysis, IIT Madras, India, 2009.
8. Ganesan T. P., Model Analysis of Structures, Universities Press (India) Ltd., Hyderabad, 2000.
9. Ramesh, K., Digital Photoelasticity: advanced techniques and applications, Volume 1, Springer-Verlag, 2000.
10. Ramarutham, Experimental Stress Analysis, Dhanpatrai and Publishers.
11. Malhotra V. M., and Carin Nicholas J., Handbook on Nondestructive Testing of Concrete, Second Edition, CRC Press, New York, 2006.
12. Guideline for Structural Condition Assessment of Existing Buildings: An ASCE Standard: SEI/ASCE 11-19, By American Society of Civil Engineers, Structural Engineering Institute. New York, 2000.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5003S
Course Title	Advanced Geotechnical Engineering

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: interpret appropriate method of soil investigation to classify and characterize soils for foundation design.

CO2: summarize the basic and advanced physical properties of soil.

CO3: To evaluate the safe allowable bearing capacity of shallow foundation and load carrying capacity of deep foundation by shear and settlement criteria under different loading and soil conditions.

CO4: Illustrate the methods of ground improvement technique for improvement of weak soil.

Introduction

Review of fundamentals of soil mechanics. Relationship between physical properties effective stress principle, subsurface ground geotechnical investigation, direct method of exploration, lateral extent and depth of explorations, bore log details, indirect methods and practical applications.

Consolidation

One dimensional consolidation, Terzaghi's theory, differential equation and solution, determination of compressibility parameters from laboratory tests, field consolidation curve, secondary consolidation, quasi-pre consolidation, three dimensional consolidation.

Shear Strength

Mohr's Coulomb's criteria of failure, shear strength of clayey soils under different drainage conditions, pore pressure parameters, shear strength of sand, critical void ratio, dilatancy.

Estimation of Stresses in Soils

Boussinesq and Westergard theories, Newmark chart, practical applications.

Bearing Capacity of Soils

Shallow foundations, ultimate bearing capacity, safe bearing capacity and allowable bearing pressure, modes of failure, Terzaghi theory: detailed derivation, Vesic and Indian Standard IS (6403) methods to determine net ultimate bearing capacity, factors affecting ultimate bearing capacity: shape, GWL, eccentricity and compressibility of clay (including critical rigidity Index criteria), settlement analysis for clay and sand, elastic settlement use of Steinbrenner and Fox Theory, Schmertmman's method. Bearing capacity of foundation on compact and weathered rock. Raft foundation.

Pile Foundation

Piles: necessity and types of piles (Axially loaded). Static and dynamic formulation for load carrying capacity of single and group piles in sand and clay. Pile load test as per 2911 (Part I & Part II) method, settlement of single pile and group piles in sand and clay, weathered rock. Introduction to pile raft.

Ground Improvement

Sand drains and stone columns. Reinforced Earth Wall: Materials and general considerations, Design and Stability, Grouting, applications and functions of Geotextiles, Geocell Caissons: Types and stability analysis, Cofferdams.

Soil Dynamics

Introduction – Fundamentals of soil dynamics - Types of machine foundations – General criteria for design of machine foundation - Vibration analysis of machine foundation - Design of foundation for Reciprocating machines and Impact machines – Vibration isolation – Construction aspects of machine foundations – Study experiment – Block vibration test.

Recommended Reading

1. Terzaghi K. and Peck R. B., Soil Mechanics in Engineering Practice, Wiley and Sons, 1996.
2. Alamsingh, Soil Mechanics and Foundation Engineering, Vol I & Vol II, Standard book House, 2013.
3. Holtz, R.D. & Kovacs, W.D., "An introduction to geotechnical engineering", Prentice Hall, 1981.
4. Taylor D.W., Fundamentals of soil mechanics, Asia publications Bombay, 1967.
5. Das B. M., Shallow Foundation- Bearing Capacity & Settlement" Taylor & Francis, 2009Das B. M., Principles of Foundation engineering, PWS Publishing Company, 2012.
6. Winterkorn H. and Fang F. Y., Foundation Engineering Handbook, CBS Publishers & Distributors, New Delhi, 1990.
7. Bowles J. E., Foundation Analysis and Design, McGraw-Hill Book Co, 2001.
8. Shamsher P. and Sharma H., Pile Foundations in Engineering Practice, Wiley and Sons, 1990.
9. Purushothama R., Ground Improvement Techniques (HB), Laxmi Publication Pvt Ltd., New Delhi, 2005.
10. Ranjan, Gopal & Rao, A.S.R., "Basic and applied soil mechanics", New Age International Pvt. Ltd., 2004
11. Krammer S. L. Geotechnical Earthquake Engineering, Prentice Hall, 1996
12. Swami Saran, Soil Dynamics and Machine Foundation (2nd Ed,), Galgotia Publication Pvt Ltd.

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13. Das B. M. Advanced Soil Mechanics, 4th Ed. C.R.C. Press, 2013.
14. Murthy V.N.S., Advanced Foundation Engineering, CBD Publishers and Distributors, New Delhi, 2010.
15. Hausmann M. R., Engineering Principles of Ground Modification McGraw-Hill Inc., US, 1990.

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Programme Name	M. Tech. (Civil Engineering with specialization in Structural Engineering), SEMESTER II
Course Code	CE5006S
Course Title	Research Methodology

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: critically evaluate current research

CO2: develop hypothesis and a research proposal

CO3: design methods of data collection and to select appropriate tools for analysis

CO4: illustrate method of communication of scientific results for peer review

Introduction

Meaning and purpose of research, objectives of research, types of research, significance of research, research approaches, research methods v/s methodology, research process, criteria of good research. Research and scientific methods.

Research Problem

Steps in research: identification, selection and formulation of research problem- research questions-research design- formulation of hypothesis- review of literature. Definition, necessity and techniques of defining research problem; formulation of research problem; objectives of research problem.

Research Design

Need and features of good research design. Types of research designs, basic principles of experimental designs; design of experiments.

Data Collection

Primary and secondary data. Collection methods - observation – interview – questionnaire – schedule - pretest - pilot study - experimental and case studies, secondary data - relevance, limitations and cautions.

Sampling Design

Sampling theory - types of sampling - steps in sampling - sampling and non-sampling error - sample size - advantages and limitations of sampling. Census and sample surveys, different types of sample designs, characteristics of good sample design. Techniques of selecting a random sample.

Hypothesis Testing

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Fundamentals and procedure of hypothesis testing, flow diagram for hypothesis testing. Measurement in research: measurement scales - tests of good measurement construction of likert and semantic differential scales-source of errors in measurement - scale validation. Parametric and non-parametric tests of hypothesis testing, non-parametric tests like sign, run, Kruskal-Wallis test and Mann - Whitney test. testing of significance of mean, proportion, variance and correlation- testing for significance of difference between means, proportions, variances and correlation coefficients. Limitations of tests of hypothesis, one-way and two-way Anova - Latin square tests for association and goodness of fit.

Technical Paper and Report Writing

Basic concepts of paper writing and report writing, review of literature, concepts of bibliography and references, significance of report writing, steps of report writing, types of research reports, methods of presentation of report.

Structuring the Report

Types of reports, contents, styles of reporting, steps in drafting reports, chapter format, pagination, identification, using quotations, presenting footnotes- abbreviations, presentation of tables and figures, referencing, documentation, use and format of appendices- indexing editing and evaluating the final draft.

Research Ethics

Ethical issues, ethical principles that govern research, ethically valid information sources, regulatory compliance. Introduction to IPR and Patent registration.

Recommended Reading

1. Fisher R. A., Statistical Methods for Research Workers, Macmillan Pub Co., 1970.
2. Montgomery D. C., Design and Analysis of Experiments, John Wiley, 2001.
3. Kothari C. R., Research Methodology: Methods and Techniques, Second Edition, New Age International Publishing, 2004.
4. Panneerselvam R., Research Methodology, Prentice Hall Publication, 2004.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5006S
Course Title	Finite Element Method

COURSE OUTCOME:

After completion of this course students shall be able to

CO1: apply different techniques for solution of boundary value problems.

CO2: formulate 1D and 2D finite elements and their applications to linear static and dynamic field problems.

CO3: formulate material and geometric nonlinear finite elements and their applications to structural stability problems.

CO4: model and analyze different types of problems in structural engineering using finite element software packages.

Introduction

Concept of an element, various element shapes displacement models, foundation of finite element method using principle of virtual displacements, derivation of element stiffness and loads for pin-jointed bar element, beam element, triangular plate element (in-plane forces), rectangular plate element (in-plane forces), quadrilateral plate element (in-plane forces), triangular and rectangular plate elements in bending.

Variational Formulation of Finite Element Method (FEM)

Isoparametric elements: local vs. natural co-ordinate system, line, triangular quadrilateral and tetrahedral elements, interpolation displacement models. Formulation of isoparametric finite element matrices in local and global coordinate system.

Implementation of FEM

Discretization of the structure, calculation of element stiffness, mass and equivalent nodal loads. Assemblage of structure matrices. Boundary conditions, solutions of the overall problem. Calculations of element stresses and computer program organization.

Non-linear Analysis

Geometric non-linearity, geometric stiffness of an axial element. Stability of bar, spring system. General formulation of geometrically nonlinear problem. Geometric stiffness of beam - column and triangular elements. Introduction to non-linear material behavior, non-linear spring, introduction to elasto-plastic analysis, elasto-plastic analysis of a truss. 2-D element formulations, general formulation of a physically non-linear problem.

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Dynamic Analysis

Formulation of inertial properties. Lumped mass vs. Consistent mass matrices, condensation and assembly of mass matrices. Formulation of damping properties – free vibration, steady – state and transient response analysis for simple problems. Formulation and solution of problems in structural mechanics using the above mentioned methods.

Programming and Organization of FEM Programs

Static-linear analysis, non-linear and dynamic analysis, mesh generation aspects, equation solving techniques, input/output plotting.

Recommended Reading

1. Desai C. and Abel J., Introduction to the Finite Element Method, East West Press Pvt. Ltd., 1972.
2. Shames I. H. and Dym C. J., Energy and Finite Element Methods in Structural Mechanics, McGraw Hill, New York, 1985.
3. Cook R. D., Malkan D. S. and Plesta M. E., Concepts and Application of Finite Element Analysis - Third Edition, John Wiley and Sons Inc., 1989.
4. Rajasekaran. S., Finite Element Analysis in Engineering Design, Wheeler Publishing, 1993.
5. Bathe K. J., Finite Element Procedures in Engineering Analysis, Prentice Hall, 1996.
6. Reddy J. N., Introduction to Finite Element, McGraw Hill Book Co., 2006.
7. ZienkiWiez O. C., The Finite Element Method in Engineering Science, McGraw Hill Book Co., 2006.
8. Krishnamoorthy C. S., Finite Element Analysis: Theory and Programming, McGraw Hill Book Co., 2007.
9. Desai Y. M., Eldho T. I. and Shah A. H., Finite Element Method with Applications in Engineering, Dorling Kindersely Pvt. Ltd., Licensees of Pearson Education in South Asia. 2011.
10. Logan D. L., A First Course in the Finite Element Method, Third Edition, Thomson Asia Pte Ltd, 2002.
11. Desai C. S., Kundu T., Introductory Finite Element Method, CRC Press, 2001.
12. Chandrupatla T. R. and Belegundu A. D., Introduction to Finite Elements in Engineering, Method, Third Edition Prentice-Hall India Private Ltd., 2002.
13. Gupta O. P., Finite and Boundary Element Methods in Engineering, Oxford & IBH Publishing Co. Pvt. Ltd, 2000.
14. Buchanan G. R., Theory and Problems of Finite Element Analysis. Schaum's Outline Series, McGraw Hill International Edition, 1995.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5007S
Course Title	Design of Pre-Stressed Concrete Structures

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: explain the principles of pre-stressed concrete.

CO2: analyze and design pre-stressed concrete sections.

CO3: analyze and design determinate and in-determinate structural members.

Introduction to Pre-stressed Concrete

Basic concept and general principles of prestressed concrete, materials used and their properties, methods, technique of prestressing and system of prestressing, loss of prestress, historical perspective on prestressed concrete, basics of bridge design

Analysis of Prestressed Concrete Section for Flexure

Loading stages and computation of section properties, critical sections under working loads for pretensioned and post-tensioned members, load balancing method of analysis of prestressed concrete beams.

Design of Pre-Stressed Concrete Section for Flexure

General philosophy of design, design approaches in working stress method and limit state method, critical conditions for design, limit state of collapse in flexure, permissible stresses in concrete and steel.

Analysis and Design of Pre-Stressed Concrete Members for Shear and Torsion

Calculation of principal tension under working load, permissible principal tension, shear strength calculation under limit state of collapse for both cracked and uncracked in flexure End zone stresses in pre-stressed concrete members:

i. Transfer of pre-stress in pre-tensioned members: Pretension transfer bond, transmission length, end zone reinforcement.

ii. Anchor zone stresses in post-tensioned members: stress distribution in end block, anchor zone reinforcement.

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Design of Prestressed Concrete Members

Design of simply supported pretensioned and posttensioned slabs and beams. introduction to application of prestressing to continuous beams and portal frames, linear transformation and concordancy of cables.

Deflections of Prestressed Concrete Members

Importance of control of deflection, factors influencing deflection, short term and long term deflection. Deflection of simply supported beam.

Innovative Trends in Prestressed Concrete Construction

Introduction to external prestressing, concept of extradosing in PC bridges, prestressed concrete earthquake resistance structure.

Recommended Reading

1. Evans R. H. and Bennett E. W., Prestressed Concrete, Champman and Hall, London, 1958.
2. Lin T. Y., Design of Prestressed Concrete Structures, John Wiley and Sons Inc., 1981.
3. Sinha N. C. and Roy S. K., Fundamentals of Prestressed Concrete, S. Chand and Co., 1998.
4. Krishna Raju, Prestressed Concrete, Tata McGraw Hill Publishing Co., 2000.
5. Rajagopalan N., Prestressed Concrete, Narosa Publications, New Delhi, 2008.
6. IS: 1343- 1980: Code of Practice for Prestressed Concrete.
7. IRC 112- 2011 Code of Practice for Concrete Road Bridges.
8. FIB Bulletin 51: Structural Concrete – Textbook on behaviour, design and performance, Volume I, November 2009.
9. FIB Bulletin 52: Structural Concrete – Textbook on behaviour, design and performance, Volume II, January 2010.
10. FIB Bulletin 53: Structural Concrete – Textbook on behaviour, design and performance, Volume III, December 2009.

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Programme Name	**M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II**
Course Code	**SE5008S**
Course Title	**Design of Concrete Infrastructural and Industrial Structures**

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: identify different types of reinforced concrete structures and predict their behavior under working and ultimate loads.

CO2: apply the principles, procedures and current codes of practice for the design of various reinforced and pre-stressed concrete structures.

CO3: evaluate the adequacy of a given structural design for loads not envisaged at design stage.

CO4: conceptualize, plan and design some infrastructural construction enabling structural systems.

Introduction

Stress strain characteristics of concrete and reinforcing steel review of elastic theory, ultimate strength theory and limit state approach for design of structures. Review of resolution of structures into structural members. Review of load transfer mechanisms, redundancies and alternate load paths in structures.

Design Methods

Introduction to the concept of limit design of structural components and yield line analysis of slabs and its application to the prevailing codes of practice. Study of limit states of collapse and serviceability. Application of these concepts to design of structural components.

Design of High Rise Buildings

Criteria for design of high rise structures with or without basements. Input parameters for the structure and its foundation. Analysis, design and detailing of High Rise Buildings and their raft foundations using latest software tools available.

Design of PT Slabs

Study of the behavior of flat slabs. Criteria for design of one/two way PT Slabs. Analysis, design and detailing of PT Slabs using software tools available.

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Design of Retaining Structures

Review of Retaining Wall and Water Tank Design principles. Design of Silos and Bunkers. Design and detailing of Retaining Walls of Basements of High Rise Structures.

Design of Superstructure of Segmental Bridges

Principles of analysis, design and detailing of segmental bridges. Study of prevailing code provisions and their application. Analysis and design of the superstructure using software tools available.

Recommended Reading

1. Park R. and Paulay T., Reinforced Concrete Structures, John Wiley & Sons, 1975.
2. Purushothaman P., Reinforced Concrete Structural Elements, Tata McGraw-Hill, 1984.
3. Kong and Evans, Reinforce and Prestressed Concrete Structures, ELBS, 1995.
4. Nilson A. H., Design of Concrete Structures, McGraw-Hill, 1997.
5. Pillai S. U. and Menon D., Reinforced Concrete Design, Tata McGraw-Hill, 2003.
6. Varghese P. C., Advanced Reinforced Concrete Design, Prentice-Hall of India, 2005.
7. IS: 456-2000, Plain and Reinforced Concrete Code of Practice.
8. IRC: 6-2000 Standard Specifications and Code of Practice for Road Bridges, The Road Congress.
9. IS: 875(Part3)- 2007: Wind Loads on Buildings and Structures.
10. ACI 318:2008 – Building Code Requirements for Structural Concrete, American Concrete Institute, 2008.
11. Specification for Structural Steel Buildings, American Institute of Steel Construction, 2005.
12. Eurocode EN 1990:2002+A1 – Basis of structural design, 2002.
13. Eurocode 2 Part 1-1, BS EN 1992-1-1 Common Rules for Buildings and Civil Engineering Structures, The Institution of Structural Engineers, 2004.
14. Eurocode 3 Part 1-1, BS EN 1993-1-1 Design of Steel Structures General Rules and Rules for Buildings, The Institution of Structural Engineers, 2004.

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Elective courses

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5101S
Course Title	Nonlinear Structural Analysis

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: apply nonlinear behavior in structural stability analysis.

CO2: apply stability principals for simple and complex buckling analysis of structures.

CO3: apply plastic analysis techniques to simple and complex structures.

CO4: design simple and complex structures using plastic design methods.

Elastic Stability

Geometric non linearity: basic concept. Analysis of beam column with various end conditions, use of trigonometric series. Elastic buckling of bars, Euler's formula; buckling of continuous beams, buckling of non-prismatic members, effect of shear force on buckling of bars, use of energy method and finite difference method. Buckling of single span portal frames.

Torsional Buckling

Pure torsion of thin walled beams of open cross section warping and warping rigidity, Torsional buckling of columns, combined buckling by torsion and flexure. Lateral torsional buckling of beams, Lateral buckling of beams in pure bending lateral torsional buckling of cantilever and simply supported beams. Indian codal provisions regarding buckling of steel members (columns and beams).

Plastic Analysis

Concepts of plastic analysis of steel structures, stress strain relations. Shape factors, plastic modulus, plastic hinge, fully plastic moment, moment curvature relations. Determination of collapse loads – single and multiple span beams, carrying various types of loads. Collapse load analysis of pin jointed frames, single/multiple span rigid jointed portal frames and single bay gabble frames. Use of plastic mechanism methods for calculation of collapse load, lower and upper bound theorems, various types of failure mechanisms. Effect of axial force and shear force on the fully plastic moment of a section. Design of beams and single span rigid jointed frames subjected to a system of proportionate loading as per Indian code provisions. Introduction to yield line theory.

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Recommended Reading

1. Sathyamoorthy M., Nonlinear Analysis of Structures, CRC Press, Boca Raton, Florida, 1997.
2. Fertis D. G., Nonlinear Mechanics, CRC Press, Boca Raton, Florida, 1998.
3. Reddy J. N., Nonlinear Finite Element Analysis, Oxford University Press, 2008.
4. Chandrasekaran S., Nunziante L., Serino G. and Carannante F., Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures, Taylor and Francis, 2010.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5102S
Course Title	Mechanics of Composite Materials

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: explain constituents of composites and their structural applications.

CO2: apply constitutive relationship for composite materials.

CO3: explain classical formulation of composite beams and plates subjected to static and dynamic loadings.

Introduction

Definition of fiber reinforced composites, applications and various reinforcement and matrix materials.

Mechanics of a Lamina

Linear elastic stress-strain relations, elastic constants based on micromechanics, plane stress constitutive relations, transformation of stresses and strains transformation of material coefficients, thermal stresses and strains.

Laminated Composites

Types of laminated composites, displacement field approximations for classical laminate theory, laminate strains, stress resultants, stiffness matrices, stresses and strains due to applied loads, introduction to first order shear deformation theory.

Failure Theories of a Lamina

Maximum stress failure theory, maximum strain failure theory, Tsai-Hill failure theory, Tsai-Wu failure theory.

Mechanical Properties Determination

Tensile properties, compressive properties, flexure properties, in-plane shear properties, inter-laminar shear strength.

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Recommended Reading

1. Jones R. M., Mechanics of Composite Materials, McGraw-Hill, Kogakusha Ltd., Tokyo, 1975.
2. Agarwal B. D. and Broutman L. J., Analysis and Performance of Fiber Composites, John-Wiley and Sons, 1980.
3. Kaw A. K., Mechanics of Composite Materials, CRC Press, Florida, 1997.
4. Hyer M. W., Stress Analysis of Fiber-Reinforced Composite Materials, McGraw Hill, 1999.
5. Mukhopadhyay M., Mechanics of Composite Materials and Structures, University Press, India, 2004.
6. Daniel and Ishai, Engineering Mechanics of Composite Materials, Oxford University Press, 2005.
7. Christensen R. M., Mechanics of Composite Materials, Dover Publications, New York, 2005.
8. Mota Soares C. A., Mota Soares C. M., and Freitas Manuel J.M., Mechanics of Composite Materials and Structures (Proceedings), Springer Science & Business Media, 1999.

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Programme Name	**M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I**
Course Code	**SE5103S**
Course Title	**Repairs and Rehabilitation of Structures**

COURSE OUTCOME:

After completion of this course students shall be able to

CO1: determine physical properties and characteristics of cement and reinforced concrete.

CO2: assess why concrete structures crack and deteriorate.

CO3: explain different rehabilitation and repair systems and materials that are currently in use, how they work, their limitations and why some are more effective than others

Maintenance and Repair Strategies

Maintenance, repair and rehabilitation, facets of maintenance, importance of maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.

Serviceability and Durability of Concrete

Quality assurance for concrete construction concrete properties- strength, permeability, thermal properties and cracking. - effects due to climate, temperature, chemicals, corrosion - design and construction errors - effects of cover thickness and cracking.

Materials and Techniques for Repair

Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, expansive cement, polymer concrete, sulphur infiltrated concrete, ferro cement and polymers coating for rebars loadings from concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels and cathodic protection.

Repairs to Structures

Repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure using FRP.

Recommended Reading

1. Allen R. T. and Edwards S. C., Repair of Concrete Structures, Blakie and Sons, UK, 1987.

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2. Raikar R. N., Learning from Failures Deficiencies in Design, Construction and Service - R&D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
3. Campbell D., Allen and Roper H., Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK, 1991.
4. Palaniappan N., Estate Management, Anna Institute of Management, Chennai, 1992.
5. Shetty M. S., Concrete Technology Theory and Practice, S. Chand and Company, New Delhi, 1992.
6. Santhakumar A. R., Training Course notes on Damage Assessment and Repair in Low Cost Housing , RHDC-NBO, Anna University, July 1992.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5104S
Course Title	Advanced Structural Mechanics

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: apply stiffness method of analysis for beams, frames and grids structural elements.

CO2: apply structural mechanics principles to unsymmetrical and open-thin walled cross sections.

CO3: apply structural mechanics principals to beams curved in plan and beams curved in elevation and for deep beams.

CO4: apply structural mechanics principles to beams resting on elastic foundations.

CO5: use different theories of failure for structural analysis and design.

Revision of Matrix Methods of Structural Analysis

Stiffness approach for solution of beams, truss, plane frame and grids.

Symmetrical and Unsymmetrical Section

Unsymmetrical bending, flexural stresses due to bending in two planes, shear center, bending of unsymmetrical section. Bending of beams with large initial curvature loaded in there plane of curvature. Application of analysis of hooks, chain links etc. Beams curved in plan loaded perpendicular to their plane, fixed and continuous curved beams.

Theories of Failure

Maximum stress theory, maximum shear stress theory, maximum strain theory, Von Mises & Tresca's failure theories.

Beams on Elastic Foundation

Beams of unlimited lengths, Semi-infinite lengths and finite lengths on elastic foundation.

Analysis of Deep Beams

Determination of stresses and deflection.

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Recommended Reading

1. Shames I. H., Mechanics of Deformable Solids, Prentice Hall, India, 1980.
2. Boresi A. P. and Schmidt R. J., Advanced Mechanics of Materials, John Wiley & Sons, 2002.
3. Timoshenko S., Strength of Materials, Vol. I and II. CBS Publishers, 2002.
4. Srinath L. S., Advanced Mechanics of Solids, Tata McGraw Hill, 2009.
5. Budynas R. G., Advanced Strength and Applied Stress Analysis, WCB/McGraw-Hill, 1999.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5105S
Course Title	Design of Offshore Structures

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: examine influence of hydrodynamics, probabilities aspects and structural behavior on the offshore structures.

CO2: analyze and design fixed offshore structures using prevailing codes of practice.

CO3: analyze and design floating offshore structures using prevailing codes of practice.

Wave Theories

Wave generation process, small and finite amplitude wave theories.

Forces of Offshore Structures

Wind forces, wave forces on vertical, inclined cylinders, structures - current forces and use of Morison equation.

Offshore Soil and Structure Modelling

Different types of offshore structures, foundation modeling, and structural modeling.

Analysis of Offshore Structures

Static method of analysis, foundation analysis and dynamics of offshore structures.

Design of Offshore Structures

Design of platforms, helipads, jacket tower and mooring cables and pipe lines. .

Recommended Reading

1. Brebia C.A and Walker S., Dynamic Analysis of Offshore Structures, New Butterworths, U.K. 1979.
2. Dawson T. H., Offshore Structural Engineering, Prentice Hall Inc Englewood Cliffs, N.J. 1983.
3. Chakrabarti S. K. Hydrodynamics of Offshore Structures, Computational Mechanics Publications, 1987.
4. Reddy D. V. and Arockiasamy M., Offshore Structures, Vol.1 and Vol.2, Krieger Publishing Company, Florida, 1991.

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5. API, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms, American Petroleum Institute Publication, RP2A, Dalls, Tex, 2000.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5106S
Course Title	Structural Dynamics and Earthquake Engineering

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: perform dynamic analysis of single and multiple degree of freedom systems.

CO2: describe principles of seismology and earthquake hazards.

CO3: illustrate development of linear and non-linear earthquake response spectra.

CO4: apply earthquake response spectra to design seismic resistant structures.

Introduction

Definitions of the problems in dynamics: Static VS Dynamic loads, Different types of dynamic loads. Introduction to soil structure interaction and hydrodynamics.

Single Degree of Freedom (SDOF) Systems

Undamped vibration of SDOF System, natural frequency and period of vibration, damping in structures, viscous damping and Coloumb damping, effect of damping on frequency of vibration and amplitude of vibration, Logarithmic decrement. Forced vibration, response to periodic loading, response to pulsating forces dynamic load factors.

Response of Structure

General dynamic load, Duhamel's Integral, Numerical Evaluation of Dynamic Response of SDOF systems, Response of structure in frequency domain subjected to general periodic and non- periodic impulsive forces of short duration.

Generalized SDOF and MDOF System

Distributed mass system idealized as SDOF system, use of Rayleigh's method. Response of SDOF system subjected to ground motion, lumped mass multi degree of freedom (MDOF) system, coupled and uncoupled systems.

Frequencies of Vibration and Mode Shapes

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Orthogonally principle, Vibration of MDOF systems with initial conditions, approximate methods of determination of natural frequencies of vibration and mode shapes. Energy methods and use of Lagrange's method in writing equations of motions decoupling of equations. Forced vibration of MDOF system, Modal analysis. Application to Multistory rigid frames.

Earthquake and Ground Motion

Seismicity of a region, causes of earthquake. Measurement of Earthquake ground motion, Seismogram. Characterization of ground motion, earthquake response shapes, deformation, pseudo-velocity, pseudo-acceleration response spectra, peak structural spectra, factors influencing response spectra, design response spectra for elastic systems, peak ground acceleration. Response spectrum characteristic.

Earthquake Responses on Structures

Types of earthquake excitation, lumped SDOF elastic systems, translational excitation, lumped MDOF elastic systems, multi-storey buildings with symmetric plans, multi-storey buildings with unsymmetrical plans, torsional response of symmetric plan building, combining maximum model responses using mean square response of a single mode, SRSS and CQCC combination of modal responses. I.S. code provisions for seismic analysis of buildings and water towers, approximate method of earthquake analysis -seismic coefficient method and its limitations, response spectrum method, time history analysis.

Case Studies

Review of damages during past earthquakes and remedial measures, seismic design considerations, allowable ductility demand, ductility capacity, reinforcement detailing for members and joint.

Recommended Reading

1. Biggs J. M., Introduction to Structural Dynamics, McGraw Hill, 1964.
2. Paulay T. and Priestly M. N. J., Aseismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1991.
3. Taranath B. S., Structural Analysis and Design of Tall Buildings, McGraw Hill Book Company, New York, 1999.
4. Chopra A. K., Dynamics of Structures, Pearson Education, 2001.
5. Paz M., Structural Dynamics: Theory and Computation, Kluwer Academic Publication, 2004.
6. Agarwal P. and Shrikhande M., Earthquake Resistant Design of Structures, Prentice Hall of India, 2006.
7. Karmer S. L., Geotechnical Earthquake Engineering, Prentice Hall PTR, 1996.
8. Duggal S. K., Earthquake Resistant Design of Structures, Oxford University Press, 2007.
9. Roy. D. and Rao G., Elements of Structural Dynamics: A New Perspective, John Wiley and Son, 2012.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5107S
Course Title	Bridge Engineering

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: evaluate the design loads and use them for safe and serviceable design of bridges.

CO2: conceive and design different types of reinforced concrete bridges.

CO3 conceive and design steel and pre stressed concrete bridges along with their substructures and foundation.

CO4: conceive and design of continuous and composite bridges.

Introduction and Investigation for Bridges

Components of bridge - classification - need for investigation data collection - design discharge - linear waterway - economical span scour depth - traffic projection - choice of bridge type.

Loads on Bridges

Indian road congress (irc) bridge codes - dimensions - dead and live loads - impact effect - wind and seismic forces - longitudinal and centrifugal forces - hydraulic forces - earth pressure - temperature effect and secondary stresses.

Slab and T - Beam Bridges

Design of slab bridges - skew slab culverts - box culverts. T - pigeaud curves - courbon's theory - hendry jaegar method design of t - beam bridges.

Long Span Bridges

Hollow girder bridges - balanced cantilever bridges - continuous girder bridges - rigid frame bridges - arch bridges - bow string gird prestressed concrete bridges - composite prestressed concrete super structures - erection of precast girders - continuous construction - recent trends.

Bearings and Substructure

Design of bearings for slab, girder, skew bridges - design of piers abutments - trestles, joints-expansion joints.

Recommended Reading

1. Taylor F. W., Thomson S. E. and Smulski E., Reinforced Concrete Bridges, John Wiley & Sons, New York, 1955.
2. Raina V. K., Concrete Bridge Practice, Tata McGraw Hill Publishi Co., New Delhi – 1991.

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3. Conference Proceedings, Advances and Innovations in Bridge Engineering, IIT, Madras and Indian Institute of Bridge Engi Tamilnadu, Allied Publisher, New Delhi, 1999.
4. Johnson V. D., Essentials of Bridge Engineering, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2006.
5. Krishna Raju N., Design of Bridges, Fourth edition, Oxford & IBM Publishing Co., Bombay, 2009.
6. Relevant IRC Codes.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5108S
Course Title	Mechanics of Plates and Shells

COURSE OUTCOMES:

New CO's

After completion of this course students shall be able to

CO1: formulate equations for solution of structural response of plate bending problems by classical theories.

CO2: apply Navier's and Levy's solutions for plate bending problems.

CO3: Illustrate plate bending behavior using energy theorem.

CO4: examine shell action and simplified membrane and bending analysis for thin shells of single and double curvatures.

Introduction to Plates Theory

Thin and thick pates, small and large deflection theory of thin plate-assumptions, moment-curvature relations, stress resultants, governing differential equation for bending of rectangular plates, various boundary conditions.

Small Deflection Theory for Laterally Loaded Thin Rectangular Plates

Navier's and Levi's solution for distributed and concentrated loads, use of numerical technique for the solution of plates, concept of influence surface, study of simply supported plate with continuous edge moments.

Symmetrical Bending of Circular Plates

Small deflections under axi-symmetric transverse loads, differential equations of equilibrium, different support conditions, plates with overhangs, plates with coaxial circular opening.

Potential Energy Principle

Solution of thin plates with various boundary conditions and loadings.

Shear Deformation Theory

Introduction to shear deformation theories.

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Introduction to Shells

Introduction to structural behavior of thin shells, membrane and bending actions. Mathematical representation of a shell surface, principal curvatures, Gauss curvature, Classification of shells.

Membrane Theories of Shell

Membrane theories of thin shells stress resultants, application to cylindrical shells under symmetric loads and surfaces of revolution under axi-symmetric loads.

Cylindrical Shells

Bending theory of open circular cylindrical shells with special emphasis on approximate theories of Finsterwalder and Shorer theories: Introduction to DKJ, Flugge and other exact theories: Different boundary conditions for single and multiple shells.

Recommended Reading

1. Timoshenko S. P. and Woinowsky-Krieger S., Theory of Plates and Shells, McGraw-Hill, 1959.
2. Ramaswamy G. S., Design and Construction of Concrete Shell Roofs, CBS Publishers & Distributors, 1986.
3. Kelkar V. S. and Sewell R. T., Fundamentals of the Analysis and Design of Shell Structures, Prentice Hall International, 1987.
4. Ugural A. C., Stresses in Plates and Shells, McGraw-Hill, 1999.
5. Varadan T. K. and Bhaskar K., Analysis of Plates, Narosa Publishing House, 1999.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5109S
Course Title	Earth Pressure and Retaining Structures

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: discuss classical theories of earth pressure.

CO2: evaluate stability of rigid retaining structures.

CO3: evaluate behavior of flexible retaining structures.

CO4: interpret load carrying capacity of piles subjected to lateral loads.

Earth Pressure

Types, Rankine's theory, backfill features - soil type, surface inclination, loads on surface, soil layers, water level, Coulomb's theory, effects due to wall friction and wall inclination, graphical methods, earthquake effects.

Rigid Retaining Structures

Types, empirical methods, stability analysis.

Flexible Retaining Structures

Types, material, cantilever sheet piles, anchored bulkheads - free earth method, fixed earth method, moment reduction factors, anchorage.

Braced Excavation

Types, construction methods, pressure distribution in sands and clays, stability - bottom heave, seepage, ground deformation.

Reinforced Soil Walls

Elements, construction methods, external stability, internal stability.

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Laterally Loaded Piles

Short and long piles, free head and fixed head piles, lateral load capacity of single piles, lateral deflection, elastic analysis, group effect, lateral load test, codal provisions.

Underground Structures in Soils

Pipes, conduits, trenchless technology, tunneling techniques-cut-and-cover method, shield tunneling.

Recommended Reading

1. Poulos H. G. and Davis E. H., Pile Foundation and Design. John Wiley & Sons, 1988.
2. Shamsher P. and Sharma H. D., Pile Foundations in Engineering, Wiley-Interscience, 1990.
3. Bowles J. E., Foundation Analysis and Designs, McGraw-Hill Book Co. 1995.
4. Clayton C. R. I., Woods R. I. and Milititsky J., Earth Pressure and Earth Retaining Structures, Third Edition, Taylor & Francis, 1995.
5. Terzaghi K. and Peck R. B., Soil Mechanics in Engineering Practice, Wiley and Sons, 1996.
6. Chang Y. O., Deep Excavation: Theory and Practice. CRC Press, 2006.
7. Nayak N. V., Foundation Design Manual, Dhanpat Rai Publishing Co., 2002.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5110S
Course Title	Design of Tall Structure

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: differentiate the behavior of a tall structure vis a vis a short one.

CO2: explain behavior of various structural systems used for design of tall structures under gravity and lateral loading along with their advantages and limitations.

CO3: use structural engineering software for analysis and design of high rise structures.

CO4: design and detail tall buildings under various loading and serviceability conditions.

Design Principles and Loading

Design philosophy, loading, sequential loading, materials - high performance, concrete - fibre reinforced concrete - light weight concrete - design mixes. Gravity loading, wind loading, earthquake loading, effect of creep, shrinkage and p – delta, combination of loading-working stress design-limit state design-plastic design.

Behaviour of Various Structural Systems

Factors affecting growth, height and structural form. High rise behaviour, rigid frames, braced frames, infilled frames, shear walls, coupled shear walls, wall-frames, tubulars, cores, futrigger - braced and hybrid mega systems.

Structural Form and Modelling for Analysis

Structural form-braced frame structures-rigid frame structures-in filled frame structures-flat plate and flat slab structures-shear wall structures-wall frame structures-framed tube structures-outrigger braced structures-suspended structures-core structures-space structures-hybrid structures. Floor systems reinforced concrete one way slabs on beams and slabs on beams or walls-one way pan joists and beams one way slabs on beams and girders-two way flat plate-two way flat slab-waffle flat slabs-two way slab and beam. Floor systems-steel framing-one way beam system-two way beam system-three way beam system-composite steel-concrete floor systems.

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Analysis and Design

Modelling for approximate analysis, accurate analysis and reduction techniques, analysis of buildings as total structural system considering overall integrity and major subsystem interaction, analysis for member forces, drift and twist, computerized general three dimensional analysis.

Structural Elements

Sectional shapes, properties and resisting capacity, design, deflection, cracking, prestressing, shear flow, design for differential movement, creep and shrinkage effects, temperature effects and fire resistance.

Stability of Tall Buildings

Overall buckling analysis of frames, wall-frames, approximate methods, second order effects of gravity of loading, p-delta analysis, simultaneous first-order and p-delta analysis, translational, torsional instability, out of plumb effects, stiffness of member in stability, effect of foundation rotation.

Recommended Reading

1. Beedle. L. S., Advances in Tall Buildings, CBS Publishers and Distributors, Delhi, 1986.
2. Lin T.Y. and Stotes B. D., Structural Concepts and Systems for Architects and Engineers, John Wiley, 1988.
3. Smith B. S. and Coul A., Tall Building Structures - Analysis and Design, John Wiley and Sons, Inc., 1991.
4. Gupta Y. P., Proceedings of National Seminar on High Rise Structures- Design and Construction Practices for Middle Level Cities, New Age International Limited, New Delhi,1995.
5. Taranath B. S., Structural Analysis and Design of Tall Buildings: Steel and Composite Construction, CRC Press, 2011.
6. Kheir K. and Ali M., The Future of the City: Tall Buildings and Urban Design, WIT Press, 2013.

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Lab courses

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5004L
Course Title	Experiment Methods Lab

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: use strain measuring techniques and instrumentation.

CO2: operate Equipments of NDT.

CO3: estimate soil and rock parameters.

Minimum 10 experiments to be conducted

1. Evaluation of material properties (Modulus of elasticity E and Poisson's ratio μ) of metals using strain gauge.
2. Evaluation of material properties (Modulus of elasticity E and Poisson's ratio μ) of concrete using strain gauge.
3. Evaluation of bending moments in a cantilever beam using strain gauge transducer application.
4. Evaluation of torsional moments in a shaft using strain gauge transducer application.
5. Use of Schmitz hammer to estimate in-situ strength of concrete and estimate of depth of carbonation.
6. Use of UPV to estimate, E value, quality / density of concrete.
7. Use of half-cell potentiometer to estimate corrosion potential in RCC element.
8. Load test of RCC flexural elements.
9. Evaluation shear parameters of soil using tri-axial test.
10. Evaluation shear parameters of soil using box-shear test.
11. Evaluation unconfined compressive strength of rock samples.
12. Evaluation compressive strength of rock sample using point load test.
13. Evaluation of compressibility parameters by 1-D consolidation test.
14. Evaluation of bulking load of columns.

Compulsory tutorials on communication skills

Assignment related to written communication.

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Recommended Reading

1. Dally J. W. and Riley W. F., Experimental Stress Analysis, McGraw-Hill, Inc. New York, 1965.
2. Holister G. S., Experimental Stress Analysis, Cambridge University Press, 1967.
3. Rangan C. S., Instrumentation- Devices and Systems, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1983.
4. Srinath L. S., Experimental Stress Analysis, Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi, 1984.
5. Dally J. W. and Riley W. F., Experimental Stress Analysis, McGraw-Hill Inc. New York, 1991.
6. Singh S., Experimental Stress Analysis, Khanna Publishers, New Delhi, 2006.
7. Boweles, J. Engineering Properties of Soils and their Measurement

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER I
Course Code	SE5005L
Course Title	Numerical Methods Lab

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: apply knowledge of different numerical methods to solve the algebraic equations and to solve system of linear and non-linear equations and concept of convergence of numerical results.

CO2: apply knowledge of different numerical methods for interpolation, differentiation, integration and solving set of ordinary differential equations.

CO3: use built in functions in MATLAB, EXCEL, and MATHCAD.

CO4: create MATLAB, EXCEL, and MATHCAD functions for solving engineering problems and validation of the numerical results.

Minimum 6 experiments to be conducted

1. Experiments of sources of errors, significant digits, rounding off, propagation of maximum error, propagation of variance, bias & precision.
2. Experiments on Interpolation, Newton's Interpolation- Forward, Backward, Hermite Interpolation, Spline Interpolation - Cubic, Inverse Interpolation, Extrapolation.
3. Structural engineering application of Interpolation techniques: Stress contours, etc.
4. Experiments on numerical differentiation and integration.
5. Structural engineering application of numerical differentiation and integration, estimation of pile capacity, etc.
6. Experiments on curve fitting and errors.
7. Structural engineering applications of curve fitting and errors.
8. Experiments on Finite difference method.
9. Experiments on Finite element method.
10. Experiments on optimization techniques.
11. Numerical solutions of plane stress problems.
12. Numerical solutions of plane strain problems.
13. Wind engineering, gust factor IS 875 part III

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Using MATHLAB, MATHCAD, SCILAB, FORTRAN, C++.

Compulsory tutorials on communication skills. Assignment related to oral communication.

Recommended Reading

1. Rubinstien, M. F., Matrix Computer Analysis of Structures Hall, 1966.
2. Meek J. L., Matrix Structural Analysis, McGraw Hill Book Company, 1971.
3. Bathe K. J. and Wilson E. L, Numerical Methods in Finite Element Analysis, Prentice Hall, Engle Wood Cliffs, New Jersey, USA, 1976.
4. McGuire W., Gallagher R. H. and Ziemian R. D., Structural Analysis, with MASTAN2, John Wiley, Second Edition, 2000.
5. Jain R. K. and Iyengar S. R. K., Advanced Engineering Mathematics, Narosa, 2001.
6. Rajasekaran S. and Sankarasubramanian G, Computational Structural Mechanics, Prentice Hall of India Pvt Ltd, New Delhi Edition, 2001.
7. Mathews J. H. Numerical Methods for Mathematics Sciences and Engineering second edition, Prentice Hall of India, New Delhi 2003.
8. McCormac J. C., Structural Analysis: Using Classical and Matrix Methods, John Wiley, Fourth Edition, 2007.

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Programme Name	M. Tech. (Civil Engineering with Specialization in Structural Engineering), SEMESTER II
Course Code	SE5009L
Course Title	Advanced Computer Aided Analysis Laboratory

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: analyze structure subjected to mechanical and thermal loads.

CO2: perform dynamic analyses of any structure.

CO3: use different software tools for analysis of structures.

(ANY 10)

1. Analysis beams and frames subjected to mechanical loading.
2. Analysis of beams and frames subjected to thermal loading.
3. Seepage analysis of earthen dams.
4. Analysis of axisymmetric structures subjected to mechanical loading.
5. Analysis of retaining structures.
6. Estimation of load carrying capacity of piles.
7. Analysis of plates subjected to mechanical loading.
8. Analysis of plates subjected to thermal loading.
9. Evaluation of earth slope stability.
10. Dynamic (Free and forced) vibration analysis of beams, plates.
11. Static and dynamic analysis of Dynamic multistory and multi-bay frames with shear walls.
12. Buckling analysis of columns and frames.
13. Analysis of pre-stressed beams.

Using ANSYS, ABAQUS, ETABS, SAFE, STAAD, MIDAS, GEOSLOPE
Compulsory tutorials on communication skills
Assignment related to presentation skills.

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Recommended Reading

1. Fleming J. H., Computer Analysis of Structural Systems, Prentice- Hall, 1973.
2. Krishnamoorthy C. S and Rajeev S., Computer Aided Design, Narosa Publishing House, New Delhi, 1991.
3. ANSYS, ABAQUS, ETABS, SAFE, STAAD, MIDAS, GEOSLOPE User Manuals.

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Programme Name	**M. Tech. (Civil Engineering with specialization in), SEMESTER II**
Course Code	**SE5010L**
Course Title	**Advanced Computer Aided Design Laboratory**

COURSE OUTCOMES:

After completion of this course students shall be able to

CO1: analyze and design various structural elements and structures by developing a software programs.

CO2: apply various codal provisions for design of various structures.

CO3: utilize commercial software tools in analysis and design of various structures.

CO4: prepare design basis reports and working drawings for various structures.

(Any 1 out of 1 to 5 and any one from 6 to 10)

1. Analysis and design of flat slab.
2. Analysis and design of folded plates.
3. Analysis and design of shell roofs.
4. Analysis and design of RCC retaining walls.
5. Analysis and design of shoring system using touch piles / meter piles.
6. Analysis and design of high rise building.
7. Analysis and design of steel bridges.
8. Analysis and design of RCC bridges.
9. Analysis and design of Pre-stressed concrete bridges.
10. Analysis and design of industrial structures.

Design basis report, detailed structural drawings, design calculations

Using ETABS, SAFE, STAAD, MIDAS

Compulsory tutorials on communication skills.

Assignment related to group discussion.

Recommended Reading

1. Richard Forsyth (Ed.), Expert System Principles and Case Studies, Chapman and Hall, 1965.

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2. Hinton and Owen, Finite Element Programming, Academic Press 1977.
3. Billy E. Gillet, Introduction to Operation Research- A Computer Oriented Algorithmic Approach, Tata McGraw 1982.
4. Harrison H. B., Structural Analysis and Design, Vol. I & II, Pergamon Press, 1991.
5. Krishnamoorthy C. S. and Rajeev S., Computer Aided Design, Narosa Publishing House New Delhi, 1991.
6. IS: 1343- 1980: Code of Practice for Prestressed Concrete.
7. IS: 456-2000, Plain and Reinforced Concrete Code of Practice.
8. IRC: 6-2000 Standard Specifications and Code of Practice for Road Bridges, The Road Congress.
9. IS: 875(Part3) - 2007: Wind Loads on Buildings and Structures.

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