Course Curriculum for Master of Technology

In

Structural Engineering

(Civil Engineering)

SCHEME OF INSTRUCTION AND SYLLABI
(Effective from 2025-26)

National Institute of Technology Arunachal Pradesh

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NATIONAL INSTITUTE OF TECHNOLOGY ARUNACHAL PRADESH

Vision

To transform into an acclaimed institution of higher learning with creation of an impact on the north eastern region in terms of innovation and entrepreneurship

Mission

- To generate new knowledge through state-of-the-art academic program and research in multidisciplinary field
- To identify regional, Indian and global need to serve the society better.
- To create an ambience to flourish new ideas, research and academic excellence to produce new leaders and innovators
- To collaborate with other academic, research institutes and industries for wholistic growth of the students
- Utilization of available big resources to encourage entrepreneurship through formation of startups

DEPARTMENT OF CIVIL ENGINEERING

Vision

Committed to produce outstanding professional engineers to serve the society having leadership and entrepreneurship skills with focus on interdisciplinary and innovative ideas and high-end research to compete at the global level with special emphasis commensurate to North Eastern region.

Mission

1. To impart skill development courses that add values to student competencies
2. To advocate quality education in a congenial environment, research with the aim to establish centers of excellence and consultancies for industrial and social needs.
3. To inculcate moral and ethical values among the students.
4. To promote the innovative utilization of the natural resources of the northeastern region.
5. To create a platform for the students to collaborate with other academic, research institutes and industries for their all-round development

Department of Civil Engineering

Brief about the Department:

The Department of Civil Engineering at the National Institute of Technology Arunachal Pradesh (NITAP) was established in 2013 with an initial intake of 30 students. As one of the oldest engineering disciplines, Civil Engineering encompasses the design, construction, and maintenance of the physical and naturally built environment, including infrastructure such as roads, bridges, canals, dams, and buildings.

The Department of Civil Engineering at NIT Arunachal Pradesh is headed by Dr. Mainak Mallik, who serves as the Head of the Department and an Associate Professor. His research interests include Bio-Concrete, Structural Health Monitoring, Sustainable Materials, and Self-Compacting Concrete.

The Department boasts a team of six faculty members with diverse research interests, including:

- **Dr. Mainak Mallik**, Associate Professor: Focuses on bio-concrete, structural health monitoring, sustainable materials, and self-compacting concrete.
- **Dr. M. Berlin**, Associate Professor: Specializes in Environmental and Water Resources Engineering.
- **Dr. Jumrik Taipodia**, Assistant Professor: Researches Subsurface Exploration, Seismic Microzonation, Slope Stability Analysis, Foundation Engineering, and Soil Mechanics.
- **Dr. Nabam Rich**, Assistant Professor: Specializes in Environmental, Water and Waste Treatment, and Municipal Solid Waste Management.
- **Dr. Haridharan M K**, Assistant Professor: Expertise in Structural Engineering and Forensic Engineering.
- **Dr. Jayakesh K**, Assistant Professor: Specializes in Transportation Engineering, focusing on the Characterization of Pavement Materials, Pavement Design, Traffic Management, and Road Safety.

The department is committed to advancing the field of civil engineering through quality education and research, contributing to the development and maintenance of essential infrastructure.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech	Civil Engineering
M.Tech	Structural Engineering (July, 2025)
PhD	Structural Engineering
	Geotechnical Engineering
	Transportation Engineering
	Environmental Engineering
	Water Resource Engineering

Note: Refer to the following weblink for Rules and Regulations of Civil Engineering Courses:
https://www.nitap.ac.in/department/department?name=Civil Engineering&dept=8345cde791

M. Tech. – Structural Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the Programme M.Tech Structural Engineering will

1. **PEO1:** Gain Knowledge and skills to identify, analyze the contemporary issues and contribute to the development of structural engineering systems.
2. **PEO2:** Analyze and design structural components and systems in compliance with relevant standards and codes.
3. **PEO3:** Identify and apply sustainable, alternative, and cost-effective construction materials while adopting quality control practices.
4. **PEO4:** Engage in lifelong learning for career enhancement and adapt to changing societal and technological needs.

PROGRAM OUTCOMES (POs)

At the end of the program, the student will be able to:

1. **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems
2. **PO2:** An ability to write and present a substantial technical report/document
3. **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Advanced Structural Analysis and Design: Postgraduates will excel in analyzing and designing complex structural systems using modern tools, methodologies, and codes of practice.
2. Sustainability and Regional Development: Postgraduates will develop sustainable and innovative engineering solutions that cater to the unique infrastructural needs of the northeastern region and beyond.
3. Research and Innovation: Postgraduates will engage in high-quality research, exploring experimental and computational methods to contribute to advancements in structural engineering.

Mapping program outcomes with Program Educational Objectives

Program Outcomes	PEO1	PEO2	PEO3	PEO4
PO1	3	3	1	3
PO2	3	3	1	2
PO3	2	3	2	3

Legend:

- **3: Strong Contribution, 2: Moderate Contribution, 1: Low Contribution &**
- **- No Contribution**

SCHEME OF INSTRUCTION

M. Tech. (Structural Engineering) Course Structure

1. Semester wise Credit point distribution

Sl. No.	Semester	Credit Point
1	First	17
2	Second	17
3	Third	16
4	Fourth	15
Total Credit Points		**65**

2. Subject Category wise Credit point Distribution

Course Category	Sem-I	Sem- II	Sem-III	Sem-IV	Total Credit Point
Core (Basic Science)	3	--	--	--	3
Core (Professional)	6	6	--		12
Elective (Professional)	3	3	--	--	6
Elective (online course)	3	6	--	--	9
Lab (Professional)	2	2	--	--	4
Internship/ Industrial Training/ Academic Attachment (I/A)	--	--	1	--	1
Academic Project	--	--	15	15	30
Total Credit Point	17	17	16	15	65

M. Tech. 1st Year, Semester I

Sl. No	Course Code	Course Title	L	T	P	C
1.	MA-511	Applied Mathematics for Structural Engineering	3	0	0	3
2.	CE-511	Advanced Reinforced Concrete Structure Design	3	0	0	3
3.	CE-512	Matrix Method of Structural Analysis	3	0	0	3
4.	CE-513X	Programme Elective I	3	0	0	3
5.	CE-514X	Programme Elective II / Online (NPTEL)	3	0	0	3
6	CE-516	Structural Engineering Laboratory	0	0	4	2
Total Credits			**17**	**0**	**4**	**17**

M. Tech. 1st Year, Semester II

Sl. No	Course Code	Course Title	L	T	P	C
1.	CE-521	Structural Dynamics	3	0	0	3
2.	CE-522	Prestressed Concrete Design	3	0	0	3
3.	CE-523X	Programme Elective III	3	0	0	3
4.	CE-524X	Programme Elective IV /Online (NPTEL	3	0	0	3
5.	CE-525X	Programme Elective V / Online (NPTEL)	3	0	0	3
6.	CE-526	Design Studio Laboratory	0	0	4	2
Total Credits			15	0	0	17

Summer Term (Evaluation in the III Semester)

Sl. No	Course Code	Course Title	L	T	P	C
1.	CE-527	Internship / Industrial Training / Academic Attachment (I/A) (8 weeks)	0	0	0	1
Total Credits			**0**	**0**	**0**	**1**

M. Tech. 2nd Year, Semester III

Sl. No	Course Code	Course Title	L	T	P	C
1.	CE-611	Dissertation I	0	0	15	15
Total Credits			**0**	**0**	**15**	**15**

M. Tech. 2nd Year, Semester IV

Sl. No	Course Code	Course Title	L	T	P	C
1.	CE-621	Dissertation II	0	0	15	15
Total Credits			**0**	**0**	**15**	**15**

List of Electives

- Theory of Elasticity
- Advanced Design of Metal Structures
- Failure Analysis of Structures
- Advanced steel and concrete Composites
- Forensic Engineering and Rehabilitation of Structures
- Fracture Mechanics
- Finite Element Analysis of Structural Members
- Desing of Off-shore Structures
- Seismic Design of Structures
- Wind Effect on Structures
- Advanced Concrete Technology
- Prefabricated Structures
- Structures in Disaster Prone Areas
- Analysis and Design of Tall Buildings
- Design of Industrial Structures
- Earthquake Analysis and Design of Structures
- Design of Bridges
- Stability of Structures
- Theory of Plates and Shells
- Foundation Analysis and design
- Analysis of Deep and Machine Foundation
- Soil Structure Interaction

Subject Code: MA-511
Subject Name: Applied Mathematics for Structural Engineering
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To develop students with knowledge in Laplace and Fourier transform.
2. To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.
3. To expose the students to calculus of variation, conformal mappings and tensor analysis.
4. To familiarize students in the field of bilinear transformations.
5. To expose students to the concept of vector analysis.

B. Course Content

1. Vector spaces and subspaces, solution of linear systems, Linear independence, basis, and dimension, The four fundamental subspaces, Linear transformations, Orthogonal vectors and subspaces, Cosines and projections onto lines, Projections and least squares The fast Fourier transform, Eigenvalues and eigenvectors, Diagonalization of a matrix, Difference equations and powers of matrices, Similarity transformations

2. Laplace transform: Definitions, properties - Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave Equation

3. Fourier transform: Definitions, properties – Transform of elementary functions, Dirac Delta function – Convolution theorem – Parseval's identity – Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poisson's equations

4. Concept of variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functionals dependent on functions of several independent variables – Variational problems with moving boundaries –Problems with constraints – Direct methods – Ritz and Kantorovich methods – Computer implementation of Simple cases – Applications of Artificial Intelligence -Machine learning and Deep learning to Simple Structural engineering problems.

C. Text Books

1. David C. Lay, ***Linear Algebra and Its Applications***, Addison Wesley, 2002.
2. Gilbert Strang, ***Introduction to Linear Algebra***, Wellesley-Cambridge Press, 1993.
3. Sheldon Axler, ***Linear Algebra Done Right***, Springer-Verlag, 1995.
4. Roger A. Horn and Charles R. Johnson, ***Matrix Analysis***, Cambridge University Press, 1990.
5. Erwin Kreyszig, ***Advanced Engineering Mathematics***, Wiley, 1999.
6. M. J. Lighthill, ***Introduction to Fourier Analysis and Generalized Functions***, Cambridge University Press, 1958.
7. J. R. P. P. Chhabra, ***Introduction to Variational Methods in Physics***, Taylor & Francis, 1970.
8. James Brown and Ruel Churchill, ***Complex Variables and Applications***, McGraw-Hill, 1984.
9. J. N. Reddy, Introduction to Finite Element Method, McGraw Hills, 4th Edition

D. Reference Books

1. Sankara Rao K., ***Introduction to Partial Differential Equations***, Prentice Hall of India Pvt. Ltd., New Delhi, 1997
2. Gupta A.S., ***Calculus of Variations with Applications***, Prentice Hall of India Pvt. Ltd., New Delhi, 1997
3. Spiegel M.R., ***Theory and Problems of Complex Variables and its Application*** (Schaum's Outline Series), McGraw Hill Book Co., Singapore,1981
4. James. G, ***Advanced Modern Engineering Mathematics***, Pearson Education, Third Edition, 2004
5. Lev. D. Elsgolc, ***Calculus of Variations, Dover Publications***, New York, 2012.
6. James Stewart, Single variable calculus early transcedentals, Cengage Publishers, 2016 (Or it's Series)
7. Veerarajan, T., **Engineering Mathematics**, Tata McGraw Hills, Fifth Edition
8. https://www.ncsea.com/foundation/innovation/artificial-intelligence-in-structural engineering/
9. Hadi Salehi, Rigoberto Burgueño, **Emerging artificial intelligence methods in Structural Engineering**, Engineering Structures, 171, 15 September 2018, Pages 170-189

E. Course Outcomes

At the end of the Course students will be able

1. To solve boundary value problems using Laplace and Fourier transform techniques.
2. To solve fluid flow and heat flow problems using conformal mapping.
3. To develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.
4. To apply vector calculus in linear approximations, optimization, physics and engineering.
5. To solve physical problems such as elasticity, fluid mechanics and general relativity.

Subject Code: CE-511
Subject Name: Advanced Reinforced Concrete Structure Design
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To understand the design concept of various special concrete structures and detailing.
2. To understand the design of underground and elevated liquid retaining structures.
3. To study the design of material storage structures.
4. To know the use of IS code for Wind and Seismic Force
5. To familiarize with analytical tools such as Yield line theory

B. Course Content

1. Basic overview of several RC retaining structures – retaining wall, water tank, storage bins etc.
2. Design of earth retaining structures- Introduction, Forces on retaining walls, types of retaining walls, Design of Cantilever, design of counterfort retaining walls.
3. Design of water retaining structures – Introduction, General considerations, design criteria, tanks resting on ground, underground tank, elevated tank
4. Design of material retaining structures- silo and bunker – Difference between bunker and silo, design of square bunker, design of circular bunker, design of silo
5. Yield line theory of slabs- Hillerberg method of design of slabs-Design of Flat slabs and flat Plates_ Shear in Flat slabs and Flat plates. Approximate analysis and design of Grid floors.
6. Multistorey building frames -Calculation of forces due to Wind and seismic force based on IS CODE.

C. Text Books:

1. Arthur. H. Nilson, David Darwin and Charles W Dolan, ***Design of Concrete Structures***, Tata McGraw Hill, 2004.
2. Park and Pauley T, ***Reinforced concrete Structures***, John Wiley and Sons, New York, 2009.
3. James G MacGregor, James K Wight, ***Reinforced Concrete- Mechanics and Design***, Prentice Hall, Pearson Education South Asia Pte Ltd, 2006.
4. Bhavikatti S. S., ***Advance RCC Design***, 3rd Edition, New Age International Private Limited, 2008.
5. Krishnam Raju, N., ***Design of Reinforced Concrete Structures***, 2nd Edition, CBS Publishers and Distributors, New Delhi, 2007.

D. Reference Books

1. IS 456: 2000, ***Indian Standard Plain and Reinforced Concrete*** – Code of Practice (4th Revision), BIS, New Delhi.
2. IS 3370 (I, II, IV): 2009 & 1965, ***Concrete structures for storage of Liquids***- Code of practice (1st Revision), BIS, New Delhi.
3. IS 1893 (I): 2016, ***Criteria for earthquake resistance design of Structures***-General provisions and building (6th Revision), BIS, New Delhi.
4. IS 13920: 2016, ***Ductile design & detailing of R. C. structures subjected to seismic forces***-code of practice (1st Revision), BIS, New Delhi
5. ACI-318-19, ***Building Code Requirements for Structural Concrete and Commentary***
6. EC-2: 1992, ***Design of concrete structures***
7. AS-3600: 2018, ***Standards for Concrete Structures***.
8. Varghese P.C., ***Advanced Reinforced Concrete***, Prentice Hall of India, New Delhi, 2009
9. Unnikrishnan Pillai S and Menon D., ***Reinforced concrete Design***, Tata McGraw Hill Book Co., New Delhi, 2003.

E. Couse Outcomes

At the end of the Course students will be able to

1. Design of earth retaining structures- cantilever and counterfort retaining walls.
2. Design of water retaining structures- underground, on-ground and elevated water tanks.
3. Design of material retaining structures- bunkers and silos.
4. Multistorey building frames – use of IS code for Wind and Earthquake force.
5. Design of flat slab

Subject Code: CE-512
Subject Name: Matrix Methods of Structural Analysis
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the classical, matrix and finite element methods of structural analysis.
2. To make students understand structural behavior.
3. To enable students to analyse determinate and indeterminate structures.
4. To familiarize students with displacement method.
5. To expose students to analysis of substructures.

B. Course Content

1. Generalized measurements - Degrees of freedom - Constrained measurements - Behavior of structures - Principle of superposition - Stiffness and flexibility matrices in single, two and n-co-ordinates - structures with constrained measurements.

2. Stiffness and flexibility matrices from strain energy - Betti's law and its applications- Determinate and indeterminate structures - Transformation of element matrices to system matrices - Transformation of system vectors to element vectors.
3. Flexibility method applied to statically determinate and indeterminate structures – Choice of redundant - Transformation of redundant - Internal forces due to thermal expansion and lack of fit.

4. Stiffness method - Internal forces due to thermal expansion and lack of fit - Application to symmetrical structures - Comparison between stiffness and flexibility methods.

5. Analysis of substructures using the stiffness method and flexibility method with tridiagonalization - Analysis by Iteration method - frames with prismatic members – non-prismatic members.

C. Text Books

1. Hibbeler R. C., ***Structural Analysis***, Pearson College Div., 2005.
2. Kassimali A., ***Matrix Analysis of Structures***, Cengage Learning, 2021.
3. Meriam J. L. and Kraige L. G., ***Structural Analysis: In Theory and Practice***, John Wiley & Sons, 2011.
4. Hibbeler R. C., ***Structural Analysis: A Matrix Approach***, Prentice Hall, 1998.
5. Dawe R. L., ***Introduction to Structural Analysis and Design***, Elsevier, 1984.
6. Callister C. R. and Hull M. R., ***Structural Analysis: Using Classical and Matrix Methods***, HarperCollins, 1990.
7. Gere J. M., ***Advanced Structural Analysis***, Van Nostrand Reinhold, 1990.

D. Reference Books

1. Natarajan, C., Revathi, P., ***Matrix Methods of Structural Analysis***-Theory and Problems, PHI Learning Private Limited, Delhi, 2014
2. Moshe, F., Rubenstein, ***Matrix Computer Analysis of Structures***, Prentice Hall, New York, 1966
3. Rajasekaran S, Computational Structural Mechanics, Prentice Hall of India, New Delhi, 2001.
4. McGuire, W., and Gallagher, R.H., ***Matrix Structural Analysis***, John Wiley and Sons, 1979.
5. John L. Meek., ***Matrix Structural Analysis***, McGraw Hill Book Company, 1971.

E. Couse Outcomes

At the end of the Course students will be able to

1. Understand energy concepts in structures, characteristics of structures, transformation of information in structures.
2. Perform analysis by iteration method and determine deflection of structures using Maxwell-Betti Law of Reciprocal Deflections.
3. Understand generalized and constrained measurements.
4. Apply principle of superposition in practical problems.
5. Understand fundamental relationships for structural analysis and develop analytical models.

Subject Code: CE- 516
Subject Name: Structural Engineering laboratory
Credit Point: 2 (L=0, T=0, P=4)

A. Course Objective

1. To study the properties of concrete.
2. To learn the method of concrete mix design as per ACI and IS code and to get exposure to special concrete.

3. To carry out strength tests and non-destructive tests on concrete.
4. To investigate the structural behaviour of RC beams and measure strain.
5. To assess the dynamic behaviour of structural components.
6. To get exposure to usage of popular software such as ABAQUS

B. Course Content

1. Properties of concrete ingredients – concrete mix design ACI/ IS method for M45 to M60 grade (IS), up to M80 grade (ACI), Design of Special Concrete like FRC, SCC, HPC - strength tests on concrete – Non-destructive tests on concrete. Use of various types of strain gauges - Mechanical and Electrical strain gauges – Specimen preparation and testing of R.C. beams and study of their behaviour.

2. Experiments on dynamic analysis - Assessment of the mode shapes and frequencies of Demo MDOF system - Assessment of the behaviour of structure under non-harmonic load - Assessment of the mode shape of cantilever beam - Assessment of the mode shape of simply supported beam.

C. Text Books

1. Bhavikatti S. S., ***High Performance Concrete***, New Age International Publishers, New Delhi, 2008.
2. Malhotra V. M. and Dhir R. K., ***Fiber-Reinforced Concrete: From Design to Structural Applications***, Taylor & Francis, London, 1990.
3. Dhir R. K., Thomas M. M. J. P., and S. M. M. J. I., ***Self-Compacting Concrete: Materials, Properties and Applications***, Woodhead Publishing, Cambridge, 2019.
4. Priestley M. J. N., ***Experimental Techniques in Concrete Mechanics***, Springer-Verlag, Berlin, 1985.

D. Reference Books

1. Kukreja C. B., Kishore K., and Chawla R., ***Material Testing Laboratory Manual***, Standard Publishers Distributors, New Delhi, 2008.
2. Srinath L. S., ***Experimental Stress Analysis***, Tata McGraw-Hill Publishing Company Limited, 1984.
3. Johnston C. D., ***Fibre Reinforced Cements and Concrete***, Taylor and Francis Publishers.
4. De Schutter G., Bartos P. J. M., Domone P., and Gibbs J., ***Self-Compacting Concrete***, Whittles Publishing, 2008.
5. Chopra A. K., ***Dynamics of Structures: Theory and Application to Earthquake Engineering***, Pearson Education, 2001.

E. Couse Outcomes

At the end of the Course students will be able to

1. Arrive at concrete mix design for various types of concrete as per codal provisions
2. Be familiar with the properties of concrete and perform non-destruction testing on concrete
3. Cast and test structural RC elements for strength and deformation behaviour
4. Carry out dynamic testing on structural components
5. Assess the behaviour of structures subjected to cyclic load testing
6. Use ABAQUS for specialised structural designs

Subject Code: CE-521
Subject Name: Structural Dynamics
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the concepts of dynamic loading and to study the dynamic response of SDOF, MDOF and continuous systems subjected to different types of dynamic loads.
2. To learn free and forced vibration response of structural systems.
3. To familiarize students with mathematical models representing real time problems of discrete and continuous vibratory systems.
4. To make students understand the principle of virtual displacements.
5. To expose students to the concept of resonance.

B. Course Content

1. Introduction to Dynamic analysis - Elements of vibratory systems and simple Harmonic Motion - Mathematical models of SDOF systems - Principle of Virtual displacements - Evaluation of damping resonance.
2. Fourier series expression for loading - (blast or earthquake) - Duhamel's integral - Numerical methods - Expression for generalized system properties - vibration analysis - Rayleigh's method - Rayleigh-Ritz method.
3. Evaluation of structural property matrices - Natural vibration - Solution of the Eigen value problem - Iteration due to Holzer and Stodola.
4. Idealization of multistoried frames - analysis to blast loading - Deterministic analysis of earthquake response - lumped SDOF system.
5. Differential equation of motion - Beam flexure including shear deformation and rotatory inertia - Vibration analysis using finite element method for beams and frames.

C. Text Books

1. Mario Paz, and William Leigh, ***Structural Dynamics***, CBS, Publishers, 1987.
2. A.K. Chpora "***Dynamics of Structures Theory and Application to Earthquake Engineering***" Pcarson Education, 2001.
3. J. L. Humar, ***Dynamics of Structures***, CRC Pres, 2012.

D. Reference Books

1. Bureau of Indian Standards (BIS), *IS 1893 (Part 1): 2016* - ***Criteria for Earthquake Resistant Design of Structures: General Provisions and Buildings*****,** BIS, New Delhi, 2016.
2. Paz, M., ***Structural Dynamics****: Theory and Computation*, Kluwer Academic Publishers, Dordrecht, 1997.
3. Craig, R. R., Jr.**,** ***Structural Dynamics: An Introduction to Computer Methods***, John Wiley & Sons, New York, 1981.
4. Clough, R. W., and Penzien, J., ***Dynamics of Structures***, McGraw-Hill, New York, 1975.
5. Biggs, J. M., ***Introduction to Structural Dynamics***, McGraw-Hill Book Co., New York, 1964.

E. Couse Outcomes

At the end of the Course students will be able to

1. Mathematically model a structural system for dynamic analysis.
2. analyse structures using various methods of vibration analysis
3. use structural property matrices to study structural behaviour.
4. Arrive at solution to Eigen value problem and idealize multi storied frames.
5. Perform deterministic analysis for earthquake response. System.

Subject Code: CE-522
Subject Name: Prestressed Concrete Design
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To develop an understanding of the philosophy of pre-stressing design.
2. To study the design of indeterminate pre-stressed concrete structures.
3. To have a better understanding about the connections for pre-stressed concrete elements.
4. To design pre-stressed concrete bridges.
5. To study the design of pre-stressed concrete pipes and tanks.

B. Course Content

1. Introduction – Important concepts of pre-stressing – Systems for Pre-stressing – The philosophy of design - Time dependent deformation of concrete and losses of pre- stress.

2. Flexural design of pre-stressed concrete elements – Shear, torsion and bond – Indeterminate pre-stressed concrete structures – Camber, deflection and crack control.

3. Pre-stressed concrete compression and tension members – Two-way pre-stressed concrete floor systems – Connections for pre-stressed concrete elements.

4. Design of pre-stressed concrete bridges incorporating with long-term effects like creep, shrinkage, relaxation and temperature effects. Circular prestressing- Design of Prestressed Concrete Pipes and water

C. Text Books

1. Krishna Raju, N., ***Prestressed Concrete***, Tata McGraw Hill, 2018, 6th Edition.
2. Lin, T. Y., ***Design of Prestressed Concrete Structures***, Wiley India Pvt. Ltd., 2010, 3rd Edition.
3. Rajagopalan, ***Prestressed Concrete***, Narosa Publishing House, 2010.

D. References

1. Antonnie. E. Naaman, ***Prestressed Concrete Analysis and Design***, Technopress, 3rd Edition, 2012.
2. J.P. Annie, P. Easwary and Y.R.M. Rao, ***Prestressed concrete analysis and design***, 2018.
3. Edward. G. Nawy, ***Prestressed Concrete***, Prentice Hall, 5th Edition, 2010.
4. Arthur. H. Nilson, ***Design of Prestressed Concrete***, John Wiley and sons, 2nd Edition,1987.
5. P Dayaratnam and P sarah, Medtech, ***Prestressed Concrete Structures***, 2017, 7th Edition., 2005.

E. Course outcomes
At the end of the course students will be able to

1. Ensure the design philosophy of prestressing
2. Design the flexural members due to shear, torsion, bond by incorporating the prestress losses.
3. Design the connections for compression and tension prestressing elements and floor systems.
4. Design the prestressed concrete girder bridges by incorporating the long-term effects.
5. Design the prestressed concrete pipes and tanks.

Subject Code: CE-526
Subject Name: Design Studio Laboratory
Credit Point: 2 (L=0, T=0, P=4)

A. Course Objective

1. Learn design and detailing of RCC buildings.
2. Understand design of steel industrial pre-engineered buildings.
3. To familiarize with conceptual design and design basis report.
4. Learn design of bridges and special structures.
5. To get exposure to usage of popular software such as STAAD. Pro, ETABS, MIDAS and SAP2000.

B. Course Content

1. Reinforced concrete buildings, Structural steel industrial sheds, Bridges for each of the structures, the following are covered in the form of a mini-project: conceptual design, design basis report, numerical model and analysis, structural design, structural drawings, bill of quantities, Special structures: tall structures, industrial structures, large span roof structures.
2. The conceptual design and methods of construction are covered, Special topics: Thumb rule design, integrated approach for design, process and stages of design, building information modelling.

C. Text Books

1. N. Krishna Raju, ***Design of Reinforced Concrete Structures***, CBS Publishers & Distributors Pvt Ltd., New Delhi, 2016, 4th Edition.
2. S. K. Duggal, ***Design of Steel Structures***, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2000.
3. James K. Wight and James G. MacGregor, ***Reinforced Concrete: Mechanics and Design***, Pearson Education, 2011, 6th Edition.
4. Bungale S. Taranath, ***Design of Tall Buildings: Steel, Concrete, and Composite Systems***, CRC Press, 2016, 2nd Edition.
5. W. J. O. K. Kluin and E. van der Rijt, ***Large-Span Roof Structures***, Taylor & Francis, 1986.
6. R. C. Hibbeler, ***Structural Analysis***, Pearson Education, 2017, 10th Edition.
7. S. P. Timoshenko and D. H. Young, ***Theory of Structures***, McGraw-Hill Book Company, 1965.

D. Reference book

1. K. Raju, ***Structural Design & Drawing***, Universities Press, 2009.
2. D. J. Victor, ***Essentials of Bridge Engineering***, Oxford & IBH Publishing, 2019.
3. N. Subramanian, ***Design of Steel Structures: Limit State Method***, Oxford University Press, 2017.
4. Bureau of Indian Standards, *SP:34,* ***Handbook on Concrete Reinforcement and Detailing***, Bureau of Indian Standards, 1987.
5. Indian Roads Congress, *IRC 6,* ***Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations***, Indian Roads Congress, 2017.
6. Bureau of Indian Standards, ***IS 800, General Construction in Steel - Code of Practice***, Bureau of Indian Standards, 2007.
7. STAAD.Pro Documentation https://www.bentley.com/software/staad
8. SAP2000 Documentation. https://wiki.csiamerica.com/display/doc/SAP2000
9. ETABS Documentation. https://wiki.csiamerica.com/display/doc/ETABS
10. https://www.midasoft.com/bridge-library/civil/products/midascivil

E. Course Outcomes

At the end of the Course students will be able to

1. Analyse, design and create structural drawings of RCC buildings.
2. Analyse, design and create structural drawings of steel industrial buildings.
3. Create conceptual designs and design basis reports.
4. Analyse and design of bridges and special structures.
5. Use STAAD.Pro, ETABS, MIDAS and SAP2000 for specialised structural designs.

List of Electives

- Theory of Elasticity
- Advanced Design of Metal Structures
- Failure Analysis of Structures
- Forensic Engineering and Rehabilitation of Structures
- Advanced steel and concrete Composites
- Fracture Mechanics
- Finite Element Analysis of Structures
- Designing of Off-shore Structures
- Seismic Design of Structures
- Wind Effect on Structures
- Advanced Concrete Technology
- Prefabricated Structures
- Structures in Disaster Prone Areas
- Analysis and Design of Tall Buildings
- Design of Industrial Structures
- Earthquake Analysis and Design of Structures
- Design of Bridges
- Stability of Structures
- Theory of Plates and Shells
- Foundation Analysis and design
- Analysis of Deep and Machine foundation
- Soil Structure Interaction

Subject Code: CE-XXX
Subject Name: Theory of Elasticity
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To make students understand the principles of elasticity and plasticity
2. To familiarize students with basic equations of elasticity
3. To expose students to two dimensional problems in Cartesian and polar coordinates
4. To make students understand the principle of torsion of prismatic bars
5. To familiarize students with the concepts of plasticity and yield criteria

B. Course Content

1. Basic concepts of deformation of bodies – deformation gradient- Tensor notations of stress and strain in 3D field - Traction - Engineering and Cauchy stress and Green- Lagrange Strains- Cauchy form of equilibrium equation - Transformation of stress and strain in a 3D field Equilibrium equation in 2D and 3D Cartesian coordinates

2. Compatibility equations - Stresses: Principal, Octahedral, Hydrostatic and deviatoric - Derivation of Constitutive law - reduction to isotropic and uniaxial case

3. Plane stress and plane strain problems - 2D problems in Cartesian coordinates as applied to beam bending using Airy's stress function - Problems in 2D - Polar coordinate

4. Equations of equilibrium and compatibility - stress concentration in holes - Circular disc subjected to diametral compressive loading - semi-infinite solid subjected to different types of loads. Thin and thick cylinders under internal pressure.

5. Torsion of sections - St. Venant's theory – Torsion of elliptical sections - Torsion of triangular sections - Prandtl's membrane analogy– Warping Torsion of rolled profiles - Torsion of thin- walled tubes.

6. Plasticity – Introduction - Reasons of plasticity - slip lines - Plastic stress-strain relations.

7. Flow rules (associated and non-associated) - Different hardening rules - Yield criteria for metals - Graphical representation of yield criteria.

C. Text Books

1. S. P. Timoshenko and J. N. Goodier, ***Theory of Elasticity***, McGraw-Hill, 3rd Edition, 1970.
2. M. H. Sadd, ***Elasticity: Theory, Applications, and Numerics***, Academic Press, 2005.
3. A. C. Ugural and S. K. Fenster, ***Advanced Strength and Applied Elasticity***, Prentice Hall, 4th Edition, 2003.

D. Reference Books

1. A. E. Green and W. Zerna, ***Theoretical Elasticity***, Dover Publications, 2nd Edition, 2012.
2. L. D. Landau and E. M. Lifshitz, ***Theory of Elasticity***, Pergamon Press, 2nd Edition, 1970.

E. Course Outcomes

At the end of the Course students will be able to

1. Apply elastic analysis to study the fracture mechanics
2. Apply linear elasticity in the design and analysis of structures such as beams, plates, shells and sandwich composites
3. Apply hyper-elasticity to determine the response of elastomer-based objects

4. Analyse the structural sections subjected to torsion
5. Understand various theories of failure and concept of plasticity

Subject Code: CE-XXX
Subject Name: Advanced Design of Metal Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To compute wind load on structures and deflection of beams.
2. To understand design of stacks.
3. To get familiarized with cold formed steel sections and different types of connections.
4. To get exposed to design of compression and tension members.
5. To design members subjected to torsion and understand plastic analysis of Structure

B. Course Content

1. Steel metallurgy – mechanical properties – section classification - limit state method of design for structural steel – plastic analysis and design

2. Estimation of loads – structural systems for multi-story and industrial buildings - moment resisting frame, concentrically and eccentrically braced frame – pre-engineered building systems – moment resisting connections – base plate connections

3. Composite construction – shear connector – behaviour and design of steel concrete composite slabs, beams and columns

4. Fatigue behaviour and design – S-N curve approach – design category classification – design for variable repeated loading - fatigue assessment

5. Cold formed steel design – buckling and post-buckling behaviour of members – effective width method and direct strength method for design of cold-formed steel beams, columns, beam-columns

Note: *Site visits shall be encouraged during the course for experiential learning*

C. Textbooks

1. N. Subramanian, ***Design of Steel Structures***, Oxford University Press, 2008.
2. L. S. Negi, ***Design of Steel Structures***, Tata McGraw-Hill Publishing Company Limited, 1997, 2nd Edition.
3. S. K. Duggal, ***Design of Steel Structures***, McGraw Hill Education, 2017.

D. Reference Books

1. Bureau of Indian Standards**,** ***IS 800:2007 – General Construction in Steel – Code of Practice***, Bureau of Indian Standards, 2007**.**
2. S. K. Duggal, ***Design of Steel Structures***, McGraw Hill Education, 2017.

E. Course Outcomes

At the end of the Course students will be able to

1. Analyze and design steel structural components.
2. Design and evaluate connections under different loading conditions.
3. Apply advanced concepts such as fatigue and fracture mechanics in steel design.
4. Perform stability and performance-based design for complex steel structures.

Subject Code: CE-XXX
Subject Name: Failure Analysis of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To understand the causes of failure, failure modes and mechanism.
2. To know how engineering materials and components fail.
3. To understand the concept of design and manufacturing integrity.
4. To understand material selection procedure based on requirement.
5. To get exposed to legal problems in failure of structures.

B. Course Content

1. Causes of failure – Types of failure – why, what, how – durability of materials – Landmark case – Performance and shape inadequacy – statistics and reliability – life cycle assessment.

2. Structural failure – material and load effects – environment effect - Non-structural and structural repairs – Biocidal treatment and use of preservatives – deterioration of wood.

3. Macro micro level failures – component and sub-system failures - failure theories –analytical models – cases and type of problem in components – safety evaluation.

4. Structural systems – case studies – pin-jointed steel systems – rigid jointed frames – concrete walls - arches – reinforced concrete beams and frames – shells – repair of concrete bridge and water retaining structures.

5. Bridge maintenance techniques – The refurbishment of buildings, legal responsibilities – Case studies – Definition of smartness – sensors – automatic and adaptive systems – smart components.

C. Test Book

1. Rasnom, W. H., ***Building Failures***, E&F N. SPON Ltd., 1980.
2. Moskvin, V., ***Concrete and Reinforced Structures – Deterioration and Protection***, Mir Publishers, Moscow, 1980.
3. Kenneth, L., and Carper, ***Forensic Engineering***, 2nd Edition, CRC Press, 2001.

D. References

1. V. K. Raina, ***Concrete Bridge Practice: Construction, Maintenance and Rehabilitation***, 2nd Edition, Shroff Publishers and Distributors, August 2010.
2. Srinivasan Chandrasekaran, Luciano Nunziante, Giorgio Serino, Federico Carannante, ***Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures***, CRC Press, Florida, 2009.

E. Course Outcomes

At the end of the course student will be able to

1. Identify the objective of study of fracture mechanics.
2. Model linear elastic fracture mechanics.
3. Simulate actual failure analysis problems in site.
4. Understand repair and maintenance of structures and product liability issues.
5. Analyse and design structures for failure prevention.

Subject Code: CE-XXX
Subject Name: Forensic Engineering and Rehabilitation of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objectives (CO)

1. To understand the causes of failure of structures.
2. To enable students to diagnose distress of structures.
3. To make students understand various environmental problems and natural hazards.
4. To expose students to modern techniques of retrofitting.
5. To familiarize students with case studies.

B. Course Content

1. Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading.

2. Diagnosis and Assessment of Distress: Visual inspection – non-destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multistorey buildings – Fibre optic method for prediction of structural weakness.

3. Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and flood - strengthening of buildings – provisions of BIS 1893 and 4326.

4. Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting - jacketing– use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – rust eliminators and polymer coating for rebars - foamed concrete-mortar repair for cracks - shoring and underpinning strengthening by pre-stressing.

5. Case studies – buildings - heritage buildings - high rise buildings - water tanks – bridges and other structures.

C. Text Books

1. Raikar, R. N., ***Learning from Failures: Deficiencies in Design, Construction and Service***, R&D Centre (SDCPL), Raikar Bhavan, 1987.
2. Kaminetzky, Dov, ***Design and Construction Failures: Lessons from Forensic Investigations***, Galgotia Publications, New Delhi, 2001.
3. Ratay, Robert T. (Ed.), ***Forensic Structural Engineering Handbook***, 2nd Edition, McGraw-Hill Professional, 2010.
4. Gaylord, Edwin H. Jr., Gaylord, Charles N., and Stallmeyer, James E. (Eds.), ***Structural Engineering Handbook***, 4th Edition, McGraw-Hill Professional, 1997.
5. Ho, Sook-Ying, and Irving, P. E., ***Structural Failure Analysis and Prediction Methods for Aerospace Vehicles and Structures*****,** Woodhead Publishing, 2010.

D. References

1. Natarajan, C., Janardhanam, R., Chen, S.-E., and Schmidt, R., ***Indo-U.S. Forensic Practices: Investigation Techniques and Technology,*** Proceedings of the First Indo-U.S. Forensic Engineering Workshop, National Institute of Technology, Tiruchirappalli, India, December 15–17, 2010.
2. Lewis, G. L. (Ed.), ***Guidelines for Forensic Engineering Practice***, American Society of Civil Engineers (ASCE), Reston, VA, USA, 2003.

3. Chen, S.-E., Janardhanam, R., Natarajan, C., and Schmidt, R., ***Indo-U.S. Forensic Practices: Investigation Techniques and Technology***, American Society of Civil Engineers (ASCE), Reston, VA, USA, 2010.

E. Course Outcomes

At the end of the course student will be able to

1. Understand the causes of failure of structures.
2. Diagnose distress of structures.
3. Understand various environmental problems and natural hazards.
4. Be exposed to modern techniques of retrofitting.
5. Be familiar with case studies.

Subject Code: CE-XXX
Subject Name: Fracture Mechanics
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To understand the concept of fracture mechanics.
2. To get exposed to method of stress analysis.
3. To understand failure mechanisms.
4. To understand design methods.
5. To understand stress intensity factor.

B. Course Content

1. Failure theories, Fracture, Definition of stress intensity factor, Fracture toughness - Energy release rate, Critical Energy release rate - Crack mouth opening displacement, R- Curve and J integral - Basic reasons for fracture mechanics approach for concrete, Limitations of linear elastic fracture mechanics for concrete and steel. Non- linear fracture method - Fracture energy and size effect. Shrinkage and creep, shear transfer, Failure modes, Test Methods for fracture analysis, Case studies and discussions.

C. Text Books

1. Broek, D., ***Elementary Engineering Fracture Mechanics***, Sijthoff & Noordhoff International Publishers, Alphen aan den Rijn, The Netherlands, 1978.
2. Elfgren, L., and Shah, S. P. (Eds.)**,** ***Analysis of Concrete Structures by Fracture Mechanics***, Proceedings of the RILEM Workshop, Chapman and Hall, London, 1991.
3. Sih, G. C., and Di Tommaso, A.**,** ***Fracture Mechanics of Concrete: Structural Application and Numerical Calculation***, Martinus Nijhoff Publishers, Dordrecht, 1985.
4. Shah, S. P., Swartz, S. E., and Ouyang, C.**,** ***Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock, and Other Quasi-Brittle Materials***, Wiley-Interscience, New York, 1995.

D. References

1. Prashant Kumar, ***Elements of Fracture Mechanics***, Tata McGraw Hill, New Delhi, India, 2009.
2. K. Ramesh, ***e-Book on Engineering Fracture Mechanics***, IIT Madras, 2007.
3. Richard W. Hertzberg, Richard P. Vinci, and Jason L. Hertzberg, ***Deformation and Fracture Mechanics of Engineering Materials*****,** 5th Edition, Wiley, India, 2014.

E. Course outcomes

At the end of the course student will be able to

1. Understand fracture toughness and fracture energy.
2. Be familiar with energy release rate.
3. Get exposed to the concept of crack mouth opening displacement.
4. Understand fracture mechanics of concrete.
5. Be familiar with linear and nonlinear fracture mechanics.

Subject Code: CE-XXX
Subject Name: Advanced steel and Concrete Composites
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce students to steel-concrete composite structures and types of shear connectors.
2. To make students understand analysis and design of composite beams and deflection of composite beams.
3. To make students be familiar with composite slabs, analysis and design of composite floor systems.
4. To get students exposed to types of composite columns.
5. To make students learn vibration of composite beams and cyclic behaviour of composite sections.

B. Course Content

1. Introduction – limit states of composite sections - shear connectors – types of shear connectors – degree of shear connection – partial and complete shear connections – strength of shear connectors – Analysis and design of composite beams without profile sheet.

2. Design of composite beam – propped condition – un-propped condition – deflection of composite beams – beam with profile sheeted deck slab – design of partial shear connection.

3. Introduction – Composite slabs – profiled sheeting – sheeting parallel to span – sheeting perpendicular to span – analysis and design of composite floor system.

4. Type of Composite columns – design of encased columns – design of in-filled columns –
5. axial, uni-axial and bi-axially loaded columns.

6. Temperature – shrinkage and creep – vibration of composite beams – Cyclic behavior of composite section – case studies.

C. Text Books

1. Johnson, R. P., ***Composite Structures of Steel and Concrete: Beams, Slabs, Columns, and Frames for Buildings*****,** 3rd Edition, Blackwell Publishing Ltd., Oxford, UK, 2004.
2. Institute for Steel Development and Growth (INSDAG)**,** ***Teaching Resources for Structural Steel Design***, Vol. 2 of 3, INSDAG, Kolkata, India, 2000.
3. Narayanan, R. (Ed.), ***Composite Steel Structures: Advances, Design, and Construction***, 1st Edition, Elsevier Applied Science Publishers, London, UK, 1987.

D. References

1. Owens, G. W., and Knowles, P. R. (Eds.)**,** ***Steel Designers' Manual***, 5th Edition, Blackwell Scientific Publications, Oxford, UK, 1992.

2. Oehlers, D. J., and Bradford, M. A., ***Composite Steel and Concrete Structural Members: Fundamental Behaviour***, Pergamon Press, Oxford, UK, 1995.

E. Course Outcomes

At the end of the course students will be able to

1. Understand steel-concrete composite structures and types of shear connectors.
2. Understand analysis and design of composite beams and deflection of composite beams using IS:11384 and EC4.
3. Be familiar with composite slabs, analysis and design of composite floor systems.
4. Get exposed to types of composite columns.
5. Learn vibration of composite beams and cyclic behaviour of composite sections.

Subject Code: CE-XXX
Subject Name: Finite Element Analysis of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To study the energy principles, finite element concept, stress analysis, meshing, nonlinear problems and applications.
2. To arrive at approximate solutions to finite element problems.
3. To perform finite element analysis on one dimensional and two dimensional problems.
4. To familiarize students with isoperimetric element components.
5. To apply equilibrium equations, strain displacement relation, linear constitutive
6. relation in practical problems.

B. Course Content

1. Direct stiffness method - Special characteristics of stiffness matrix - Assemblage of elements
2. –Boundary condition and reaction - Analysis of framed Structures - 2D truss element - 2D beam element - Gauss elimination and LDLT decomposition - Basic steps in finite element analysis.
3. Differential equilibrium equations - strain displacement relation - linear constitutive relation - special cases - Principle of stationary potential energy - application to finite element methods. Some numerical techniques in finite element analysis.

4. Displacement models - convergence requirements. Natural coordinate systems - Shape function. Interpolation function - Linear and quadratic elements - Lagrange and Serendipity elements - Strain displacement matrix - element stiffness matrix and nodal load vector.

5. Two dimensional isoparametric elements - Four noded quadrilateral elements - triangular elements - Computation of stiffness matrix for isoparametric elements numerical integration (Gauss quadrature)- Convergence criteria for isoparametric elements.

6. Analysis of plate bending: Basic theory of plate bending - displacement functions - plate bending Elements. Plane stress and plane strain analysis: Triangular elements - Rectangular elements
   Note: *Assignments shall include modelling, analysis and visualization in general purpose finite element software such as ABAQUS*

C. Text Books

1. Krishnamoorthy, C. S., *Finite Element Analysis: Theory and Programming*, 2nd Edition, Tata McGraw-Hill Education, New Delhi, India, 2011.

2. Rao, Singiresu S., *The Finite Element Method in Engineering*, 5th Edition, Butterworth-Heinemann, an Imprint of Elsevier, 2010.
3. Liu, G. R., and Quek, S. S., *The Finite Element Method: A Practical Course*, 1st Edition, Butterworth-Heinemann, 2003.

D. References

1. Chennakesava R. Alavala, ***Finite Element Methods: Basic Concepts and Applications***, Prentice Hall India Learning Private Limited, New Delhi, India, 2008.
2. J. N. Reddy, ***An Introduction to the Finite Element Method***, 3rd Edition, McGraw-Hill Education, New Delhi, India, 2005.
3. P. Seshu, ***Textbook of Finite Element Analysis***, PHI Learning Private Limited, New Delhi, India, 2003.

E. Course Outcomes

At the end of the course student will be able

1. To use displacement models to solve practical problems in structural engineering.
2. To apply numerical techniques of finite element analysis to solve real time problems.
3. To make use of shape function and interpolation function to study structural behaviour.
4. To apply linear and quadratic elements in the finite element analysis of various types of structures.
5. To predict structural behaviour using strain displacement matrix and element stiffness matrix.

Subject Code: CE-XXX
Subject Name: Seismic Design of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the basics of earthquake engineering and how they influence the structural design.
2. To aim at introducing engineering seismology and building characteristics.
3. To make students understand structural irregularities, dos and don'ts in earthquake engineering design, code provision on different types of structures.
4. To make students be familiar with structural modelling and lateral load resisting design.
5. To make students get exposed to strength, stiffness and ductility requirements and energy dissipation devices.

B. Course Content

1. Engineering seismology – rebound theory plate tectonics - Seismic design concepts EQ load on simple buildings – load path floor and roof diaphragms – seismic resistant building architecture – plan configuration – vertical configuration – pounding effects – mass and stiffness irregularities – torsion in structural system.

2. Provision of seismic code (IS1893, IS 13920)- Ductile Detailing – Building systems – frames – shear wall – braced frames – layout design of Moment Resisting Frames (MRF)– Design of Masonry structures.

3. Cyclic loading behaviour of RCC and Steel elements (Damage Models) - base isolation – Energy dissipating devices – case studies.

4. Performance Based Seismic Design - Seismic performance evaluation of structural and non-structural components and systems.

C. Text Books

1. Pankaj Agarwal and Manish Shrikhande, ***Earthquake Resistant Design of Structures***, Prentice-Hall of India, New Delhi, 2006.
2. K. E. Bullen and Bruce A. Bolt, ***An Introduction to the Theory of Seismology***, 4th Edition, Cambridge University Press, Cambridge, 1985.
3. T. K. Datta, ***Seismic Analysis of Structures***, John Wiley & Sons, 2010.

D. References

1. S. K. Duggal, ***Earthquake-resistant Design of Structures***, Oxford University Press, New Delhi, 2007.
2. T. Paulay and M. J. N. Priestley, ***Seismic Design of Reinforced Concrete and Masonry Buildings***, John Wiley & Sons, 1992.
3. Srinivasan Chandrasekaran, Luciano Nunziante, Giorgio Serino, and Federico Carannante**,** ***Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures***, CRC Press, Florida, 2009.

E. Course Outcomes

At the end of the course students will be able to

1. Understand the basics of earthquake engineering and how they influence the structural design.
2. Understand engineering seismology and building characteristics.
3. Learn structural irregularities, do's and don'ts in earthquake engineering design, code provision on different types of structures.
4. Be familiar with structural modelling and lateral load resisting design.
5. Get exposed to strength, stiffness and ductility requirements and energy dissipation devices.

Subject Code: CE-XXX
Subject Name: Wind Effect on Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. Understand the fundamental principles of wind engineering.
2. Analyze wind load effects on various types of structures.
3. Basic concept of bluff-body aerodynamics and various aeroelastic phenomenon.
4. Design structures to withstand wind loads.
5. Understanding the principle behind the provision in relevant codes and their application

B. Course Content

1. Introduction to wind engineering; Importance of studying wind effects on structures; Structure and characteristics of the atmospheric boundary layer; Wind profiles and turbulence; Wind speed, direction, and frequency

2. Basic fluid dynamics principles related to wind flow; Bluff body aerodynamics; Pressure distribution around structures; Overview of relevant codes and standards

3. Basic concepts of structural dynamics; Dynamic response of structures to wind loads; Aeroelasticity; Vortex shedding and galloping; Flutter analysis; Suspended-span bridges

4. Wind-resistant design of building; Equivalent static wind loads; Along and across wind response; Wind-induced discomfort in and around duildings; Mitigation of building motions

C. Text Books

1. Emil Simiu and Robert H. Scanlan, ***Wind Effects on Structures: Fundamentals and Applications to Design***, 3rd Edition, Wiley-Interscience, 1996.
2. Alan G. Davenport, ***Wind Structure Interaction***, Wiley, publication year not specified.
3. Giovanni Solari (Ed.), ***Wind Science and Engineering: Origins, Developments, Fundamentals and Advancements*****,** Springer, 2019.
4. Henry Liu, ***Wind Engineering: A Handbook for Structural Engineering***, Prentice Hall, 2008.
5. Emil Simiu and Robert H. Scanlan, ***Wind Effects on Structures: An Introduction to Wind Engineering***, 2nd Edition, Wiley-Interscience, 1986.

D. Reference Books

1. IS 875 (Part 3):2015, ***Code of Practice for Wind Loads on Buildings and Structures***.
2. Holmes J.D., ***Wind Loading of Structures***, CRC Press.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the basics of wind engineering and how they influence structural design.
2. Analyze wind load effects on various types of structures.
3. Learn bluff-body aerodynamics and various aeroelastic phenomenon
4. Design structures to withstand wind loads.
5. Use relevant codes and apply them for wind design of structures

Subject Code: CE-XXX
Subject Name: Advanced Concrete Technology
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To understand the properties of concrete materials and their influence on concrete performance.
2. To study advanced concrete mix design techniques for enhanced durability and strength.
3. To analyze the effects of chemical and mineral admixtures on concrete properties.
4. To explore special concretes and their applications in modern construction.
5. To examine the latest advancements in concrete technology, including self-healing concrete and 3D printing.

B. Course Content

1. The fundamental properties of cement, aggregates, and water in concrete are discussed. The role of hydration in strength development is analyzed. The effects of different types of cement, including high-performance and blended cements, on concrete properties are studied.

2. Various methods of mix design, including ACI, IS 10262, and DOE methods, are explored. The significance of water-cement ratio, aggregate gradation, and admixtures in optimizing concrete mix performance is studied. The influence of supplementary cementitious materials like fly ash, silica fume, and ground granulated blast-furnace slag (GGBS) is analyzed.
3. High-performance concrete (HPC), self-compacting concrete (SCC), fiber-reinforced concrete (FRC), and geopolymer concrete are discussed. The applications of lightweight and heavyweight concrete in specialized construction projects are examined.

4. The mechanisms of concrete deterioration, including corrosion, sulfate attack, alkali-aggregate reaction, and freeze-thaw effects, are explained. Strategies for improving durability, such as the use of corrosion inhibitors, surface coatings, and high-performance curing techniques, are discussed. The concept of sustainable concrete, including the use of recycled aggregates and eco-friendly binders, is introduced.

5. Recent advancements in concrete technology, including self-healing concrete, ultra-high-performance concrete (UHPC), and 3D printed concrete structures, are studied. The role of nanotechnology in enhancing concrete performance is explored. Case studies of modern concrete innovations in large-scale infrastructure projects are analyzed.

C. Text Books

1. A. M. Neville, ***Properties of Concrete***, Pearson Education,1963.
2. M. S. Shetty, ***Concrete Technology: Theory and Practice (Revised Edition)***, S. Chand, 2006.
3. A. M. Neville & J. J. Brooks, ***Concrete Technology (2nd Edition)***, Pearson Education, 2010.
4. Zdeněk P. Bažant & Jaime Planas, ***Fracture and Size Effect in Concrete and Other Quasibrittle Materials (1st Edition)***, CRC Press, 1998.

D. Reference Books

1. IS 10262:2019, ***Concrete Mix Proportioning – Guidelines***.
2. P. K. Mehta & P. J. M. Monteiro**,** ***Concrete: Microstructure, Properties, and Materials***, McGraw-Hill, 2026.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the role of various concrete constituents and their influence on strength and durability.
2. Design advanced concrete mixes to optimize workability, strength, and sustainability.
3. Apply knowledge of special concretes in modern construction applications.
4. Analyze the durability aspects of concrete and implement strategies to enhance performance.

Subject Code: CE-XXX
Subject Name: Prefabricated Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the fundamentals of prefabrication in construction.
2. To study different types of prefabricated components and their production methods.
3. To analyze the structural behavior of precast elements and their connections.
4. To explore the benefits and challenges of prefabrication in modern construction.
5. To understand the role of automation and modular construction in prefabricated structures.

B. Course Content

1. Types of prefabrication, prefabrication systems and structural schemes - Disuniting of structures - Structural behavior of precast structures.

2. Handling and erection stresses - Application of pre-stressing of roof members; floor systems, two way load bearing slabs, Wall panels, hipped plate and shell structures.

3. Dimensioning and detailing of joints for different structural connections; construction and expansion joints.

4. Production, Transportation and erection - Shuttering and mould design - Dimensional tolerances - Erection of R.C. Structures, Total prefabricated buildings.

5. Designing and detailing prefabricated units for 1) industrial structures 2) Multistorey buildings and 3) Water tanks, silos bunkers etc., 4) Application of pre-stressed concrete in prefabrication

C. Text Books

1. K. Elliott, ***Precast Concrete Structures***, Butterworth-Heinemann, publication year not specified.
2. C. G. Preece, ***Modular Construction and Prefabrication***, CRC Press, publication year not specified.
3. Ryan E. Smith, ***Prefab Architecture: A Guide to Modular Design and Construction (1st Edition),*** Wiley, 2010.
4. Hubert Bachmann & Alfred Steinle, ***Precast Concrete Structures (1st Edition)***, Ernst & Sohn, 2011

D. Reference Books

1. IS 15916:2010, ***Building Design and Erection Using Prefabricated Concrete Elements – Code of Practice.***
2. Bock & J.L. Boehm, ***Advanced Prefabrication Techniques***, Springer.

E. Course Outcomes

At the end of the Course students will be able to

1. Get introduced to prefabrication and its types.
2. Know the different types of prefabrication systems.
3. Learn different structural connections.
4. Be exposed to erection of RC structures.
5. Be familiar with designing and detailing of prefabricated units.

Subject Code: CE-XXX
Subject Name: Structures in Disaster-Prone Areas
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To understand the impact of natural disasters on structures.
2. To study the design principles for disaster-resistant structures.
3. To analyze the behavior of buildings and infrastructure under extreme loading conditions.
4. To explore retrofitting and strengthening techniques for existing structures.
5. To examine case studies of disaster-resistant construction worldwide.

B. Course Content

1. The different types of natural disasters, including earthquakes, cyclones, floods, and landslides, are introduced. The impact of these disasters on structures and infrastructure is analyzed. The significance of hazard zoning and disaster risk assessment in structural engineering is discussed.

2. The principles of earthquake-resistant design, including base isolation and energy dissipation techniques, are introduced. The behavior of different structural systems under seismic loading is analyzed. The seismic design provisions in IS 1893 and IS 13920 are discussed with examples.

3. The effects of high winds and cyclones on buildings and bridges are studied. The aerodynamic modifications and design strategies for wind-resistant structures are examined. The impact of floods and storm surges on foundations and structures is analyzed, along with design techniques for flood-resistant construction.

4. The causes and effects of landslides on buildings and retaining walls are discussed. The role of geotechnical engineering in landslide mitigation is explored. Fire-resistant design principles, including the selection of fireproof materials and structural fire protection methods, are studied.

5. The necessity and methods of retrofitting existing structures for disaster resistance are discussed. The use of fiber-reinforced polymers (FRP), jacketing, and dampers in strengthening structures is analyzed. Case studies of retrofitting techniques applied to historical and modern buildings are examined.

C. Text Books

1. A. K. Chopra, ***Dynamics of Structures***, Pearson Education, 2007.
2. Clough & Penzien, ***Dynamics of Structures***, McGraw-Hill, 1995.
3. Bungale S. Taranath, ***Wind and Earthquake Resistant Buildings: Structural Analysis and Design*****,** CRC Press, 2005.
4. Federal Emergency Management Agency (FEMA 454), ***Designing for Earthquakes: A Manual for Architects***, 2006.
5. David Godschalk (Ed.), ***Natural Hazard Mitigation: Recasting Disaster Policy and Planning***, Island Press, 1999.

D. Reference Books

1. IS 1893:2016, ***Criteria for Earthquake Resistant Design of Structures***.
2. IS 13920:2016, ***Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces*****.**

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the effects of natural disasters on structural integrity.
2. Design structures to withstand earthquakes, wind, floods, and landslides.
3. Analyze retrofitting and strengthening techniques for disaster-prone buildings.
4. Implement disaster-resistant construction techniques in real-world projects.

Subject Code: CE-XXX
Subject Name: Analysis and Design of Tall Buildings
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce design philosophy, loading, different types of frames, types of shear walls.
2. To study the effects of lateral loads such as wind and earthquakes on high-rise structures.
3. To make students understand approximate analysis, accurate analysis and reduction techniques.
4. To familiarize students with design of structural elements, buckling analysis, pdelta analysis.
5. To make students understand translational – torsional instability.

B. Course Content

1. Design philosophy – Loading - Sequential loading, materials.

2. High risk behavior, rigid frames, braced frames, in filled frames; shear walls, coupled shear walls, wall – frames, tubulars, cores, outrigger - braced and hybrid mega system.

3. Approximate Analysis, Accurate Analysis and Reduction Techniques - Analysis of building for member forces - drift and twist - Computerized general three-dimensional analysis.

4. Structural elements - design, deflection, cracking, pre-stressing, shear flow - Design for differential movements, creep and shrinkage effects, temperature effects and fire.

5. Overall buckling analysis of frames, wall – frames – second order effects of gravity loading – simultaneous first order and P-delta analysis, Translational - torsional instability, out of plumb effects.

C. Text Books

1. Bungale S. Taranath, ***Structural Analysis and Design of Tall Buildings***, McGraw-Hill
2. Bryan Stafford Smith & Alex Coull, ***Tall Building Structures: Analysis and Design***, Wiley,
3. Feng Fu, ***Design and Analysis of Tall and Complex Structures***, Elsevier, 2018.
4. Bungale S. Taranath, ***Structural Analysis and Design of Tall Buildings: Steel and Composite Construction***, CRC Press, 2011.
5. Dr. Raja Rizwan Hussain, ***Structural Design of High-Rise Buildings: Detailed Background, Evolution, Analysis, and Design of High-Rise Multi-Storey Reinforced Concrete and Structural Steel Buildings*****,** LAP Lambert Academic Publishing, 2010.

D. Reference Books

1. IS 16700:2017, ***Criteria for Structural Safety of Tall Concrete Buildings***.
2. A. Ghosh, ***Tall Buildings: Design and Technology***, CRC Press, 2017.

E. Course Outcomes

At the end of the Course students will be able to

1. To understand the design philosophy, loading, different types of frames, types of shear walls.
2. To be exposed to different lateral load resisting systems.
3. To understand approximate analysis, accurate analysis and reduction techniques.
4. To be familiar with design of structural elements, buckling analysis, p-delta analysis.
5. To understand translational – torsional instability.

Subject Code: CE-XXX
Subject Name: Design of Industrial Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To study the design and analysis of industrial buildings and structures.
2. To understand load considerations for different types of industrial structures.
3. To explore the behavior of steel and reinforced concrete industrial buildings.
4. To design specialized structures such as silos, chimneys, and transmission towers.
5. To analyze seismic and wind effects on industrial structures.

B. Course Content

1. The classification of industrial structures, including warehouses, factories, and processing plants, is introduced. The design considerations, such as functional requirements, loading conditions, and durability aspects, are discussed.

2. The different framing systems used in industrial buildings, including steel portal frames, trusses, and precast concrete frames, are studied. The selection of materials and construction techniques for industrial structures is explored.

3. The impact of dead loads, live loads, wind loads, seismic loads, and temperature effects on industrial buildings is analyzed. The design of industrial structures based on IS 875 and IS 1893 provisions is discussed.

4. The analysis and design of silos, bunkers, chimneys, cooling towers, and storage tanks are covered. The role of seismic and wind loads in the stability of these structures is examined. The impact of dynamic loading on vibrating equipment foundations is analyzed.

5. The influence of seismic forces on industrial buildings, including base isolation techniques, is studied. The aerodynamic considerations for industrial towers, chimneys, and large-span roofs under wind loads are explored. Retrofitting and strengthening strategies for existing industrial structures are examined.

C. Text Books

1. L.S. Negi, ***Design of Steel Structures***, Tata McGraw-Hill, 1997.
2. N. Subramanian, ***Design of Steel Structures***, Oxford University Press, 2008.
3. Ashoke Kumar Dasgupta, ***Design of Industrial Structures: Reinforced Cement Concrete and Steel***, 1st Edition, 2022.
4. Devdas Menon, ***Advanced Structural Analysis***, Tata McGraw-Hill, 2009.

D. Reference Books

1. IS 800:2007, ***General Construction in Steel*** – *Code of Practice*.
2. IS 4995:1974, ***Criteria for Design of Bins and Silos***.

E. Course Outcomes

At the end of the Course students will be able to

1. Design industrial buildings and steel structures.
2. Analyze different load effects on industrial buildings.
3. Apply seismic and wind-resistant design principles.
4. Design specialized industrial structures such as chimneys and silos.

Subject Code: CE-XXX
Subject Name: Earthquake Analysis and Design of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the fundamentals of earthquake engineering and seismic analysis.
2. To study the dynamic behavior of structures under earthquake loads.
3. To understand seismic design provisions in IS codes and performance-based design.
4. To analyze the seismic response of different structural systems.
5. To explore seismic retrofitting and strengthening techniques for structures.

B. Course Content

1. The causes and characteristics of earthquakes are introduced, including plate tectonics and seismic waves. The classification of earthquakes, seismic hazards, and their effects on structures are discussed. The importance of earthquake-resistant design in mitigating structural damage is emphasized.

2. The behavior of single-degree-of-freedom (SDOF) and multi-degree-of-freedom (MDOF) systems under dynamic loads is analyzed. The concept of response spectrum analysis, modal analysis, and time-history analysis is introduced. The importance of damping, resonance, and energy dissipation in earthquake engineering is discussed.

3. The principles of seismic design, including ductility, overstrength, and redundancy, are covered. The seismic design provisions of IS 1893 and IS 13920 for reinforced concrete and steel structures are explored. The design of earthquake-resistant frames, shear walls, and braced structures is discussed.

4. The concept of performance-based seismic design and non-linear analysis is introduced. The design and evaluation of buildings for different performance levels, such as immediate occupancy and collapse prevention, are discussed. The techniques for seismic retrofitting, including base isolation, energy dissipation devices, and fiber-reinforced polymer (FRP) strengthening, are explored.

5. Case studies of major earthquakes and their impact on structures are analyzed. The causes of seismic failures, including soft-story collapse, liquefaction, and resonance effects, are examined. The lessons learned from past earthquake disasters and their influence on modern seismic design practices are discussed.

C. Text Books

1. A.K. Chopra, ***Dynamics of Structures***, Pearson Education, 2007.
2. Clough & Penzien, ***Dynamics of Structures***, McGraw Hill, 1993.
3. Amr S. Elnashai and Luigi Di Sarno, ***Fundamentals of Earthquake Engineering***, Wiley, 2008.
4. Edmund Booth (Ed.), ***Earthquake-Resistant Design, Protection, and Performance***, CRC Press, 2023.

D. Reference Books

1. IS 1893:2016, ***Criteria for Earthquake Resistant Design of Structures***.
2. Paulay and Priestley, ***Seismic Design of Reinforced Concrete and Masonry Buildings***, John Wiley & Sons, 1992.
3. Clough & Penzien, ***Dynamics of Structures***, McGraw Hill, 1993.
4. Amr S. Elnashai and Luigi Di Sarno, ***Fundamentals of Earthquake Engineering***, Wiley, 2008.
5. Edmund Booth (Ed.), ***Earthquake-Resistant Design, Protection, and Performance***, CRC Press, 2023.

E. Course Outcomes

At the end of the Course students will be able to

1. Analyze the seismic behavior of structures using dynamic analysis techniques.
2. Design reinforced concrete and steel structures for earthquake resistance.
3. Apply performance-based design principles in seismic engineering.
4. Implement retrofitting and strengthening strategies for earthquake-prone structures.

Subject Code: CE-XXX
Subject Name: Design of Bridges
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To learn the components of bridges, classification of bridges, importance of bridges.
2. To understand the investigation for bridges, subsoil exploration, choice of bridge type.
3. To study the specification of road bridges, loads to be considered.
4. To familiarize students with various types of bridges such as slab-bridge, T beam bridge, pre-stressed concrete bridge, continuous bridge, arch bridge, box girder bridge decks.
5. To get exposure to evaluation of sub structures, type of foundations, importance of bearings, lessons from bridge failures.

B. Course Content

1. Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type.

2. Specification of road bridges – width of carriageway – loads to be considered - dead load - IRC standard live load – Impact effect.
3. General design considerations – Slab Bridge – Design of T-beam bridge – Prestressed concrete bridge – continuous bridge – Arch Bridge – Box girder bridge decks.

4. Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations.

5. Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Electrometric bearing – Joints – Expansion joints. Construction and Maintenance of bridges- Lessons from bridge failures.

C. Text Books

1. S. Ponnuswamy, ***Bridge Engineering***, Tata McGraw-Hill, 3rd Edition, 2017.
2. D.J. Victor, ***Essentials of Bridge Engineering***, Oxford & IBH Publishing Co. Pvt. Ltd., 6th Edition, 2017.
3. Weiwei Lin and Teruhiko Yoda, ***Bridge Engineering***, Springer, 2017.
4. Jim J. Zhao and Demetrios E. Tonias, ***Bridge Engineering: Design, Rehabilitation, and Maintenance of Modern Highway Bridges***, McGraw-Hill Education, 3rd Edition, 2012.

D. Reference Books

1. IRC Codes: ***Specifications and Design Standards for Road Bridges***.
2. Ponnuswamy, S. ***Bridge Engineering***. Tata McGraw Hill, 2008.
3. Victor, D.J. ***Essentials of Bridge Engineering***. Oxford IBH, 2001.
4. Lin, Weiwei, and Yoda, Teruhiko. ***Bridge Engineering***. Butterworth-Heinemann, 2017.
5. Zhao, Jim J., and Tonias, Demetrios E. ***Bridge Engineering: Design, Rehabilitation, and Maintenance of Modern Highway Bridges***. 3rd Edition, McGraw-Hill Education, 2012.
6. Wang, C.K. ***Design of Highway Bridges***. John Wiley & Sons, 1978.
7. Chen, Wai-Fah, and Duan, Lian (Editors). ***Bridge Engineering Handbook***. 2nd Edition, CRC Press, 2014.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the classification and design principles of bridges.
2. Analyze different loads acting on bridges and their effects.
3. Design bridge superstructures and substructures for various loading conditions.
4. Implement construction, maintenance, and rehabilitation strategies for bridges.

Subject Code: CE-XXX
Subject Name: Stability of Structures
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the principles of structural stability and buckling analysis.
2. To study the stability of beams, columns, and frames under different loading conditions.
3. To analyze nonlinear stability problems and post-buckling behavior.
4. To explore the stability of plates, shells, and complex structures.
5. To apply energy methods and numerical techniques in stability analysis.

B. Course Content

1. Stability concept –bifurcation buckling – methods of stability analysis – energy method – initial imperfection – large displacement analysis

2. Buckling of columns –Euler column –second order and fourth order equation method – Rayleigh-Ritz and numerical methods – Axially loaded column – Eccentrically loaded column– inelastic buckling

3. Buckling of frames – braced and unbraced frames – slope deflection equations, matrix method – effective length – alignment charts

4. Torsional and flexural-torsional buckling – torsion of thin walled open cross-section – flexural-torsional buckling of columns – lateral-torsional buckling of beams and beam-columns

5. Buckling of plates – Differential equation of plate buckling – critical load on plates for various boundary conditions – Energy method – Finite difference method

C. Text Books

1. S.P. Timoshenko and J.M. Gere, ***Theory of Elastic Stability***, 2nd Edition, McGraw-Hill, 1961.
2. M.A. Crisfield, ***Non-Linear Finite Element Analysis of Solids and Structures***, Wiley, 1991.
3. Sukhvarsh Jerath, ***Structural Stability Theory and Practice: Buckling of Columns, Beams, Plates, and Shells***, CRC Press, 2020.
4. S.P. Timoshenko and J.M. Gere, ***Theory of Elastic Stability***, 2nd Edition, McGraw-Hill, 1961.

D. Reference Books

1. Chajes, Alexander. *Principles of Structural Stability Theory*. Prentice Hall, 1974.
2. Bureau of Indian Standards. *IS 800:2007 – General Construction in Steel – Code of Practice*. 2007.
3. Simitses, George J., and Dewey H. Hodges. *Fundamentals of Structural Stability*. Butterworth-Heinemann, 2006.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the fundamental principles of structural stability.
2. Analyze the buckling behavior of columns, frames, plates, and shells.
3. Apply energy methods and numerical techniques in stability analysis.
4. Evaluate real-world structural failures and implement stability solutions.

Subject Code: CE-XXX
Subject Name: Theory of Plates and Shells
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the fundamental theories of plates and shells.
2. To analyze bending and buckling behavior of thin plates.
3. To study the procedure for rectangular plates and circular plates subjected to lateral loads.
4. To study the classification and behavior of shells.
5. To study the membrane analysis of shells.

B. Course Content

1. Thin plates with small deflection; assumptions - Long plates in cylindrical bending, strain energy in rectangular plates - governing differential equations (Kirchhoff Plate) and various boundary conditions.

2. Simply supported rectangular plates - Navier solution with various types of loads, rectangular plates with various boundary conditions - Naviers method for patch/point loads - Levy's method, Axi- symmetric circular plates
3. Demonstration of numerical methods such as Rayleigh, Galerkin and Kantorovich methods. Approximate analysis of Grids (Rankine-Grashoff) – Analysis of Folded Plates by Winter-Pei distribution

4. Overview on Orthotropic plates – Overview on Large deflection of plates and mid-plane stretching (Foppl- von Karman plate) – Overview on Mindlin Reissner Theory

5. Stability of rectangular plates fundamentals - some edge conditions- design applications such as section classification and simple postcritical method

6. Shells: structural behavior, classification, translational and rotational shells- hyperbolic paraboloid- elliptic paraboloid- Gaussian curvature - Overviews on Shell theories such as Higher order theories, Marguerre theory, DKJ Theory etc Membrane theory of shells- cylindrical shells- shells of revolution including design

C. Text Books

1. S.P. Timoshenko & S. Woinowsky-Krieger, ***Theory of Plates and Shells***, McGraw-Hill, 1959.
2. J.N. Reddy, ***Theory and Analysis of Elastic Plates and Shells***, CRC Press, 2007.

D. Reference Books

1. K. Chandrashekhara, ***Theory of Plates***, Universities Press, 2001.
2. IS 2210:1988, ***Criteria for Design of Reinforced Concrete Shell Structures***, Bureau of Indian Standards, 1988.
3. Ansel C. Ugural, ***Plates and Shells: Theory and Analysis***, McGraw-Hill, 1999.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the principles and classifications of plates and shells.
2. Analyze bending, buckling, and stability problems in plates and shells.
3. Analyse circular plates under axi-symmetric deflection.
4. Classify different types of shells and study their behavior.
5. To analyze shells using membrane theory.

Subject Code: CE-XXX
Subject Name: Foundation Analysis and Design
Credit Point: 3 (L=3, T=0, P=0)**

A. Course Objective

1. To introduce the fundamental concepts of foundation engineering.
2. To study soil exploration techniques and site investigation for foundation design.
3. To analyze bearing capacity and settlement of shallow and deep foundations.
4. To design different types of foundations, including isolated, raft, and pile foundations.
5. To explore ground improvement techniques for enhancing foundation performance.

B. Course Content

1. The classification and functions of foundations, including shallow and deep foundations, are introduced. The principles of soil mechanics and their relevance in foundation design are discussed. The role of site investigation and soil exploration techniques in selecting suitable foundations is analyzed.

2. The theories of bearing capacity, including Terzaghi's and Meyerhof's methods, are studied. The impact of groundwater on bearing capacity and soil stability is analyzed. The different types of settlement—immediate, primary, and secondary—are discussed along with allowable settlement criteria.

3. The design principles for different types of shallow foundations, including isolated footings, combined footings, strip footings, and raft foundations, are explored. The effect of load distribution and stress concentration on foundation performance is discussed. The foundation design process as per IS 6403 is introduced.

4. The classification and applications of deep foundations, including pile and well foundations, are discussed. The load-carrying capacity of single and group piles is analyzed using static and dynamic methods. The lateral load analysis of piles and pile group efficiency is introduced. The design and construction of well foundations for bridges and offshore structures are explored.

5. The different ground improvement techniques, including soil stabilization, vibro-compaction, grouting, and geosynthetics, are studied. The causes of foundation failures due to poor soil conditions, improper design, and construction defects are analyzed. Case studies of foundation failures and their remedial measures are discussed.

C. Text Books

1. J.E. Bowles, ***Foundation Analysis and Design***, McGraw-Hill, 1996.
2. Braja M. Das, ***Principles of Foundation Engineering***, Cengage Learning, 2010.
3. Braja M. Das & Nagaratnam Sivakugan, ***Principles of Foundation Engineering*** (9th Edition), Cengage Learning, 2017.

4. Richard L. Handy & Merlin G. Spangler, ***Foundation Engineering: Geotechnical Principles and Practical Applications***, McGraw-Hill, 2007.

D. Reference Books

1. IS 6403:1981, ***Determination of Bearing Capacity of Shallow Foundations***.
2. IS 2911:2010, ***Design and Construction of Pile Foundations*** – *Code of Practice*.
3. ***Foundation Engineering Handbook: Design and Construction with the 2009 International Building Code*** edited by Robert W. Day (2nd Edition, 2010).

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the principles of foundation engineering and site investigation.
2. Analyze the bearing capacity and settlement of different types of foundations.
3. Design shallow and deep foundations for various soil conditions.
4. Evaluate foundation failures and apply ground improvement techniques.

Subject Code: CE-XXX
Subject Name: Analysis of Deep and Machine Foundations
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the behavior and design principles of deep foundations.
2. To analyze axial and lateral load-bearing capacity of piles.
3. To study the dynamic response of machine foundations.
4. To design machine foundations for different types of machinery and loading conditions.
5. To explore vibration isolation techniques for minimizing structural effects.

B. Course Content

1. The need for deep foundations in weak soil conditions is introduced. The different types of deep foundations, including piles, drilled shafts, and caissons, are discussed. The choice of foundation type based on site conditions and structural requirements is analyzed.

2. The behavior of piles under vertical and horizontal loads is studied. The static and dynamic analysis of pile groups using load transfer mechanisms is discussed. The use of p-y curves for lateral load analysis of piles is introduced. The application of finite element methods in deep foundation analysis is explored.

3. The principles of vibration analysis in foundation design are introduced. The classification of machine foundations based on dynamic loads and operating conditions is discussed. The importance of resonance, natural frequency, and damping in machine foundation design is explored.

4. The design principles for block foundations, frame foundations, and pile-supported foundations for reciprocating and rotary machines are studied. The methods for analyzing dynamic soil-structure interaction effects are discussed. The design of foundation reinforcement for vibration control is introduced.

5. The different vibration isolation techniques, including elastomeric pads, floating foundations, and tuned mass dampers, are explored. The effect of vibration on adjacent structures and methods for mitigating harmful vibrations are discussed. Case studies of industrial machine foundation failures and corrective measures are analyzed.

C. Text Books

1. P. Srinivasulu & C. Vaidyanathan, ***Handbook of Machine Foundations***, Tata McGraw-Hill, 1976.
2. D.D. Barkan, ***Dynamics of Bases and Foundations***, McGraw-Hill, 1962.
3. Alvar M. Kabe & Brian Moaveni, ***Vibration Analysis and Structural Dynamics for Civil Engineers*****,** CRC Press, 2014.
4. Joseph E. Bowles, ***Foundation Analysis and Design*** (5th Edition), McGraw-Hill, 1996.

D. Reference Books

1. IS 2974:1982, ***Code of Practice for Design and Construction of Machine Foundations***, Bureau of Indian Standards, 1982.
2. Kameswara Rao, ***Vibration Analysis and Foundation Dynamics***, CRC Press, 1998.
3. P. Srinivasulu & C. V. Vaidyanathan, ***Handbook of Machine Foundations*** (2nd Edition), Tata McGraw-Hill, 2017.
4. Braja M. Das & Nagaratnam Sivakugan, ***Principles of Foundation Engineering*** (9th Edition), Cengage Learning, 2017.
5. Anil K. Chopra, ***Dynamics of Structures*** (5th Edition), Pearson Education, 2016.

E. Course Outcomes

At the end of the Course students will be able to

1. Analyze the behavior of deep foundations under axial and lateral loads.
2. Design machine foundations for different machinery types.
3. Evaluate dynamic soil-structure interaction effects.
4. Apply vibration isolation techniques for minimizing structural damage.

Subject Code: CE-XXX
Subject Name: Soil-Structure Interaction
Credit Point: 3 (L=3, T=0, P=0)

A. Course Objective

1. To introduce the principles of soil-structure interaction (SSI).
2. To analyze the effects of soil flexibility on foundation performance.
3. To study numerical modeling techniques for SSI analysis.
4. To explore the dynamic behavior of soil-structure systems under seismic loads.
5. To understand the influence of soil-foundation interactions on structural response.

B. Course Content

Module 1: Introduction to Soil-Structure Interaction (SSI)

The concept of soil-structure interaction and its significance in geotechnical engineering is introduced. The difference between rigid and flexible foundations in structural response is discussed. The importance of SSI in high-rise buildings, bridges, and buried structures is analyzed.

Module 2: Elastic and Inelastic Interaction Models

The development of Winkler's foundation model and its applications in SSI analysis is studied. The elastic continuum approach and the effect of soil nonlinearity on foundation response are analyzed. The behavior of layered soil foundations and multi-layered soil interaction models are discussed.

Module 3: Numerical Methods in SSI Analysis

The application of finite element and boundary element methods in soil-structure interaction problems is introduced. The role of soil stiffness in structural deformation and load

redistribution is examined. The numerical modeling of soil-foundation interaction in real-world case studies is analyzed.

Module 4: Dynamic Soil-Structure Interaction

The impact of earthquake loads on soil-foundation interaction is explored. The role of SSI in modifying seismic response spectra is discussed. The analysis of soil liquefaction and its effects on foundation stability is introduced. The role of base isolators in reducing SSI effects is explored.

Module 5: Case Studies and Practical Applications

The effect of SSI on bridges, offshore platforms, retaining walls, and underground structures is studied. The influence of pile-soil interaction on bridge foundation response is analyzed. Case studies of failures due to inadequate SSI considerations are discussed.

C. Text Books

1. Poulos & Davis, ***Soil-Structure Interaction***, Wiley, 1974.
2. B.M. Das, ***Principles of Foundation Engineering***, Cengage Learning, 1983.
3. P. Gu & Y. Zhou, ***Soil-Structure Interaction: Theoretical Advances***, Springer, 2020.
4. A.S. Bhattacharya & K.K. Sarma, ***Soil-Structure Interaction: Numerical Analysis and Modelling*** (1st Edition), CRC Press, 2008.

D. Reference Books

1. IS 2950:1981, ***Code of Practice for Design and Construction of Raft Foundations***.
2. J.E. Bowles, ***Foundation Analysis and Design***, McGraw-Hill, 1996.
3. D.P. Coduto, ***Foundations on Rock: Engineering Practice*** (2nd Edition), Prentice Hall, 2001.
4. A.S. Cakmak, ***Soil-Structure Interaction*** (1st Edition), Elsevier, 1989.

E. Course Outcomes

At the end of the Course students will be able to

1. Understand the fundamental concepts of soil-structure interaction.
2. Apply numerical modelling techniques for SSI analysis.
3. Evaluate the effects of seismic loads on soil-foundation systems.
4. Design foundations considering soil-structure interaction effects.