NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF CIVIL ENGINEERING

Revised Curriculum and Syllabi

Program Name
Master of Technology in Structural Engineering
Effective from the Academic Year: 2021-2022

Recommended by DPAC	: 12.07.2021
Recommended in PGAC	: 16.08.2021
Approved by the Senate	: 22.08.2021

CURRICULUM

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 1001	Advanced Analysis of Structures	4-0-0	4
2	CE 1002	Advanced RC Structure	4-0-0	4
3	CE 1003	Introduction to Finite Element Method in Structural Engineering	4-0-0	4
4	CE 9011-30	Elective I	3-0-0	3
5		Elective II	3-0-0	3
6	CE 1051	Laboratory I: Structural Lab-I	0-0-4	2
7	CE 1052	Laboratory II: Computational Lab	0-0-4	2
TOTAL			**18-0-8**	**22**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 2001	Advanced Steel Structure	4-0-0	4
2	CE 9031-50	Elective III	3-0-0	3
3		Elective IV	3-0-0	3
4		Elective V	3-0-0	3
5	CE 9051-60	Elective VI	3-0-0	3
6	CE 2051	Laboratory III: Structural Lab-II	0-0-4	2
7	CE 2052	Mini Project with Seminar	0-0-8	4
TOTAL			**16-0-12**	**22**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	XX907X	Audit Lectures /Workshop	0-0-2	0
2	CE 3051	Dissertation -I	0-0-24	12
3	CE 3052	Non-Project Seminar / Evaluation of Summer Training	0-0-4	2
TOTAL			0-0-30	**14**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CE 4051	Dissertation –II /Industrial Project	0-0-24	12
2	CE 4052	Project Seminar	0-0-4	2
TOTAL			0-0-28	**14**

CREDIT UNIT OF THE PROGRAM:

Semester	I	II	III	IV	TOTAL
Credit Unit	22	21	14	14	**72**
Contact Hours	26	28	30	28	**112**

Sub Discipline: DEPTH ELECTIVES

FIRST SEMESTER : Specialization Elective-I & II

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
CE 9011	Advanced Concrete Technology	3-0-0	3
CE 9012	Design of Pre-stressed Concrete Structure	3-0-0	3
CE9013	Advanced Structural Mechanics	3-0-0	3
CE 9014	Reliability Methods in Structural Engineering	3-0-0	3
CE 9015	Space Structures and Suspended Structures	3-0-0	3
CE 9016	Applied Probability and Statistics in Civil Engineering	3-0-0	3
CE 9017	Offshore Structural Engineering	3-0-0	3
CE 9018	Wind Analysis and Design of Structures	3-0-0	3
CE 9019	Foundation Engineering	3-0-0	3

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SECOND SEMESTER : Specialization Elective-III to V

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
CE9031	Plate and Shell Structures	3-0-0	3
CE9032	Theory of Elastic Stability	3-0-0	3
CE9033	Advanced Bridge Engineering	3-0-0	3
CE9034	Structural Dynamics	3-0-0	3
CE9035	Soil Structure Interaction	3-0-0	3
CE9036	Advanced Theory of Vibration	3-0-0	3
CE9037	Mechanics of Composite and Smart Structures	3-0-0	3
CE9038	Analysis and Design of Tall Structures	3-0-0	3
CE9039	Soil Dynamics & Machine Foundation	3-0-0	3
CE9040	Repair and Rehabilitation of Structures	3-0-0	3
CE9041	Engineering Elasticity and Plasticity	3-0-0	3
CE9042	Retrofitting and Strengthening of Structures	3-0-0	3

Specialization Elective-VI

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
CE9051	Advanced Finite Element Method in Structural Engineering	3-0-0	3
CE9052	Applied Numerical Methods	3-0-0	3
CE9053	Machine Learning in Civil Engineering	3-0-0	3
CE9054	Structural Optimization	3-0-0	3

Specialization specific faculty and their specializations

S. No.	Name	Qualification	Area of Specialization	(Reg / Temp. / Adjunct)
1	Dr. D. K. Singha Roy	BE, M. Tech, Ph.D.	Structural Engg. (Concrete Technology)	Regular
2	Dr. P. Ray	BE, M. Tech, Ph.D.	Structural Engg. (S. & F. Mechanics, CFD)	Regular
3	Dr. S. Saha	BE, M. Tech, Ph.D	Structural Engg. (Concrete Structure)	Regular
4	Dr. A. K. Banik	BE, M. Tech, Ph.D.	Structural Engg. (Offshore Structure)	Regular
5	Dr. A. K. Samanta	BCE, MCE, Ph.D.	Structural Engg. (Concrete & Steel Structure)	Regular
6	Dr. A. K. Datta	BE, M. Tech, Ph.D.	Structural Engg. (FEM, SHM)	Regular
7	Dr. R. P. Nanda	BE, M. Tech, Ph.D	Structural Engg. (Eq. Engg.)	Regular
8	Dr. D. Das	BE, M. Tech., Ph.D.	Structural Engg. (St. Dynamics)	Regular
9	Dr. P. Topdar	BCE, ME, Ph.D.	Structural Engg. (FEM, SHM)	Regular
10	Dr. P. Roy	BE, M. Tech., Ph.D	Structural Engg. (Reliability Engg.)	Regular
11	Dr. S. Karmakar	DCE, B.Tech, M.Tech, PhD	Structural Engg. (CFD, Bridge Engg.)	Regular

DETAILED SYLLABI OF COURSES

1. Sessional /Practical /Laboratory (Group)

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-1051	**Laboratory -I**: Structural Lab-I	0-0-4	2	

Structural Lab (Determination of properties of fine aggregate, coarse aggregate, cement, green concrete and hardened concrete, concrete mix design, casting and testing of RC beam & slab, NDT application & comparison)	[42]

TEXT BOOKS:

1. Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), IS 456: 2000, BIS, New Delhi.
2. Design Aids for Reinforced Concrete to IS: 456 – 1978, BIS, New Delhi

REFERENCE BOOKS:

1. Concrete Technology by A. M. Neville & J. J. Brooks (Pearson Edu.)
2. Concrete Technology by M. S. Shetty (S. Chand)
3. Indian Standard Concrete Mix Proportioning – Guidelines, IS 10262: 2009, BIS, New Delhi.

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-1052	**Laboratory -II**: Computational Lab	0-0-4	2	

Introduction to advanced computing environment. Introduction to high-level scientific languages, Solution of structural Engineering problems using high level languages. Development of software for analysis of different types structures. Introduction to commercial Finite Element software for solving Structural Engineering problems.	[8] [24] [12] [8]

TEXT BOOKS:

1. Relevant books as per faculty members.

REFERENCE BOOKS:

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-2051	**Laboratory -III**: Structural Lab-II	0-0-4	2	

Design Project (Design and detailing of various structural connections -RC, Structural Steel & Composite)	

TEXT BOOKS:

1. Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), IS 456: 2000, BIS, New Delhi.
2. Design Aids for Reinforced Concrete to IS: 456 – 1978, BIS, New Delhi

REFERENCE BOOKS:

1. Concrete Mix Proportioning-Guidelines, IS 10262: 2019.
2. Coarse and Fine Aggregate for Concrete – Specification, IS 383: 2016.

2. Project /Seminar/ (Individual)

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-2052	**Mini Project** with Seminar	0-0-8	4	Individual
Study of Special Topic related or not related to Project				[28]
TEXT BOOKS: 1. Relevant books as per Supervisor /Guide				
REFERENCE BOOKS:				

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-3051	Dissertation -I	0-0-24	12	Individual
Attempt for solution (Numerical /Experimental) & Progress				
TEXT BOOKS: 1. Relevant books as per Supervisor /Guide				
REFERENCE BOOKS:				

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-3052	Non-Project Seminar /Summer Training	0-0-4	2	Individual
Presentation of Special Topic which is not related to Project or Summer Training as applicable				
TEXT BOOKS: 1. Relevant books as per Supervisor /Guide				
REFERENCE BOOKS:				

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-4051	Dissertation -II /Industrial Project	0-0-24	12	Individual
Final reporting & Thesis submission				
TEXT BOOKS: 1. Relevant books as per Supervisor /Guide				
REFERENCE BOOKS:				

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
CE-4052	Project Seminar	0-0-4	2	Individual
Presentation of various/ Special Topic(s) related to Project				
TEXT BOOKS: 1. Relevant books as per Supervisor /Guide				
REFERENCE BOOKS:				

Program Outcomes (POs):

1. PO1: An ability to independently carry out research, investigation and development work to solve practical problems.

Independent Investigation Capability

2. PO2: An ability to write and present a substantial technical report/document.

Technical report writing

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 program.

Mastery on specialization

4. PO4: An ability to apply advanced level knowledge, techniques and modern tools in analyzing and designing for various structural engineering applications.

Advanced knowledge/design solutions

5. PO5: An ability to apply advanced engineering knowledge for carrying out assignments & projects in multidisciplinary environments.

Team work in Multidisciplinary project

NB.: COs (preferably 4 to 5 nos) will be as per the Faculty concerned… and the Correlation Level of Co vs PO as below

"1" – Slight (Low) Correlation
"2" – Moderate (Medium) Correlation
"3" – Substantial (High) Correlation

3. DEPARTMENTAL CORE

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			L	T	P	H	
CE 1001	**Advanced Analysis of Structures**	**PER**	**4**	**0**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Engineering Mechanics, Solids Mechanics, Structural Analysis	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Model and analyze different structural systems by matrix method of analysis using displacement/ stiffness method • CO2: Model and analyze different structural systems by matrix method of analysis using force/ flexibility method • CO3: Develop basic understanding of elastic instability, second-order effects and nonlinearity on structures and introductory dynamic analysis.
Topics Covered (Hrs)	***Part-I :*** **Recapitulation** of basic theories/ theorems, fundamental concepts of analysis of Truss /Frames /structures, basic concepts of force and displacement methods, statical and kinematic indeterminacies, Consistent Deformation method, Slope-Deflection method. [6] **Stiffness / Displacement Method**: Element stiffness matrix, load vector, transformation matrices, assembling, global stiffness matrix, solution. [10] **Flexibility/ Force Method**: Element flexibility matrix, load vector, transformation matrix, assembling, global flexibility matrix, solution. [6] ***Part-II*** : **Introduction to Elastic instability and second-order effects** on simple structure **[10]** **Introduction to nonlinear analysis**: Geometric and material nonlinearity [4] **Introduction to Structural Dynamics:** Vibration and Oscillation, Degree of freedom, Free body diagram, D'Alembert's principle, Free and forced vibration, Damping, Dynamic loading, Free and forced vibration of undamped and viscously damped SDOF & MDOF system [8]
Text Books, and/or reference material(s)	**Text Books**: 1. Intermediate Structural Analysis by C.K. Wang, McGraw-Hill Education 2. Structural Analysis by L.S. Negi & R.S. Jangid, Tata McGraw-Hill Publishing Company Limited 3. Structural Analysis: A Unified Classical and Matrix Approach, Amin Ghali, Adam M. Neville by E & FN SPON 4th Ed. 4. Stability Analysis and Design of Structure by M. L. Gambhir, Springer 2004 edition 5. Structural Dynamics: Theory and Computation by Mario Paz, Kluwer Academic Publishers **Reference Books:** **1.** Structural Analysis: A Matrix Approach by G.S. Pandit & S.P. Gupta, Tata McGraw-Hill Publishing Company Limited **2.** Dynamics of Structures by Ray Clough (Author), Joseph Penzien, McGraw-Hill Education; 2nd edition (31 May 1993)

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	-
CO2	3	2	3	3	-
CO3	-	-	3	2	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE1002	**Advanced RC Structure**	**PCR**	**3**	**1**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Design of Concrete Structures	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)

- CO1: Acquire knowledge of engineering design of different Member
- CO2: Ability to analyze the special /utility Structures: Bunker, Silo, Water Tank, Shell etc
- CO3: Ability for understanding the need of future studies

Topics Covered (Hrs)

1. **Brief Introduction :** Concrete as a construction material, Recapitulation of basic concepts WSM & LSM, Serviceability calculation, deflection and cracking **(4)**

The following design will be taught using different IS codes along with major /latest international codes like ACI-318, EC-2, AS-3600, and etc.

2. **Moment Redistribution:** Examples of single and multi-span beams **(4)**
3. **Combined footing: D**esign of combined, strip and raft footing, pilecap **(6)**
4. **Multistoried building:** Design and detailing of multistoried building frames, Wind & earthquake load, Crack & deflection, earthquake resistance design & detailing **(8)**
5. **Flat Slab:** Design of flat slab and associated Column **(4)**
6. **Yield Line:** Analysis and design by yield line theory **(6)**
7. **Deep and curve Beam:** Design of deep & curve beam **(4)**
8. **Tension member:** Brief introduction to tension members **(2)**
9. **Water Tanks:** Different types of tank **(6)**
10. **Bunkers & silo:** Analysis & Design of bunker & silo **(6)**
11. **Shell and folded plate:** Design of shell and folded plate **(4)**

Text Books, and/or reference material (s)

Text Books:

1. Adv. R. C. C Design Vol-II, by S.S. Bhavikatti, New Age International (P) Limited, New Delhi
2. Adv. R. C. C Design, by N.K. Raju, CBS Publishers & Distributor, New Delhi
3. IS 456: 2000, Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi.
4. IS 3370 (I, II, IV): 2009 & 1965, Concrete structures for storage of Liquids- Code of practice (1stRevision), BIS, New Delhi.
5. IS 1893 (I): 2016, Criteria for earthquake resistance design of Structures-General provisions and building (6th Revision), BIS, New Delhi.
6. IS 13920: 2016, Ductile design & detailing of R. C. structures subjected to seismic forces- code of practice (1st Revision), BIS, New Delhi
7. ACI-318-19, Building Code Requirements for Structural Concrete and Commentary
8. EC-2: 1992, Design of concrete structures
9. AS-3600: 2018, Standards for Concrete Structures.
10. www.nptel.ac.in

Reference Books:

1. Reinforced Concrete, 6th Edition, by S.K. Mallick and A.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, 1996.
2. Reinforced Concrete Design, 2nd Edition, by S. Unnikrishna Pillai and DevdasMenon, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	1	-	-	-	1
CO2	2	3	-	3	2
CO3	3	-	3	-	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE1003	**Introduction to Finite Element Method in Structural Engineering**	**PCR**	**3**	**1**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Knowledge of Solid Mechanics, Structural Analysis and Advanced Mathematics.	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Realising the limitation of classical methods in solution of real life Structural Engineering problems and understanding how FEM addresses such limitations through appropriate modelling and analysis • CO2: Skill to simulate simple engineering structures through FE modelling followed by analysis and interpretation of resulting data to ascertain their reliability and applicability in light of physical constraints of the system and common engineering sense. • CO3: Skill to use computational tools for solving Structural Engineering problems. • CO4: Ability of using FE software packages and development of FE codes for modelling, analysis and investigation of engineering problems relevant to industry and research.
Topics Covered (Hrs)	**Review** of principles of virtual work and minimum potential energy, Introduction to F.E.M. Basic concept, General applicability, Solid bar under axial load, Engineering applications, Elementary theory of elasticity (6) **Use of Matrix Algebra in implementation of FEM**: Importance, Matrix Manipulation Techniques, Solution of Simultaneous Linear Equations, Inverse of Matrix, Eigen Values and Eigen Vectors, Computer Implementation (4) **Spring Element:** General, Implementation in FEM, Applications, Problems (4) **Bar Elements**: Definition, Property Matrix using Direct and Energy Approach, Shape functions, Problems and Validation (4) **Structural Engineering Problems:** Analysis of Trusses, Beams, Frames etc. by FEM. Validation against solution by classical methods (16) **Real life Structures:** Modelling of real life structural Engineering problems, element selection, convergence studies, error analysis (6) **Computer Programs**/ SOFTWARES: Exposure to structural engineering problems and their solution in Industry and Research (4)
Text Books, and/or reference material(s)	1. Fundamentals Of Finite Element Analysis by David V. Hutton Publisher: Tata Mcgraw Hill Education Private Limited (2005) 2. Finite Element Procedures by Klaus-Jsrgen Bathe Publisher: Prentice-Hall (2009) 3. Finite Element Analysis Theory and Application with ANSYS by Moaveni Publisher: Pearson (2008) 4. Finite element analysis: theory and programming by C Krishnamoorthy (2001) Tata McGraw Hill Education 5. Concept and Applications of Finite Element Analysis by Robert D. Cook, David S. Malkur: Wiley.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	-	-	2	2	-
CO2	3	-	2	-	-
CO3	2	-	-	3	2
CO4	-	1	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE2001	**Advanced Steel Structure**	**PER**	**4**	**0**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Understand the design aspects, principles of few steel structures as a whole.
- CO2: Apply basic knowledge of steel design of components for design solutions of whole structure.
- CO3: Understand various methods /principles to evaluate horizontal effect /wind load on steel structures.
- CO4: Formulate, analyse, and design of various Civil Engineering Steel structures with reference to the IS code of practice.

Topics Covered (Hrs)

1. **Recapitulation** :Properties of structural steel, I.S. rolled sections, exposure to I.S. Codal provisions, Design philosophy of Limit State method for Steel Structures.(4)

The following design will be taught using different IS codes along with major international latest codes like AISC-360, EC-3, AS-4100, and etc.

2. ***Part-I :*** **Design of Industrial Shed**: Description of Different components, Loads Calculation, Analysis and Design of Truss members, Purlin, Top Chord and Bottom Chord Diagonals, Shoe Plate and Bolts design, Columns Design, Base Plate and Anchor Bolts Design. (10)
3. ***Part-II:*** **Design of water tank**: Staging, Columns braced type staging. (10)
4. ***Part-III :*** **Design of Castellated beams** and open web structures.(4)
5. ***Part-IV :*** **Bridges :** Design loads for highway / railway bridges, Design of truss bridges for highway and railway. (10)
6. ***Part-V :*** **Introduction to Plastic Design**:. Plastic hinge, Plastic-Collapse method, Plastic Analysis of Frames (8)

Text Books, and/or reference material(s)

Text Books:

1. Design of steel Structures : N. Subrhamanium (Oxford publications)
2. IS 800-2007 : General Construction in Steel-Code of Practice
3. IS 808-1989 : Dimensions of Hot Rolled Steel beam, column, channel and angle sections
4. IS 3370-1965 code for concrete structures for he storage of liquids
5. IS 805: 1968 Code of Practice for Use of Steel in Gravity Water Tanks
6. IRC:6-2017 Standard Specifications and Code of Practice for Road Bridges
7. AISC-360: 2011, American Institute of Steel Construction
8. EC-3: 1993, Design of steel structures
9. AS-4100: 1998, Standards for Steel Structures

Reference Books:

1. Limit State Design of Steel Structures : S.K. Duggal (Mc Graw Hill publications)
2. Design of steel Structures : S. S. Bhavikatti (IK Intl Publishing House, N Delhi)

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	2	2	-	-
CO3	-	-	-	3	1
CO4	-	2	-	-	-

4. DEPARTMENTAL /DEPTH ELECTIVES

ODD SEMESTER (Elective-I & II): CE 9011-30

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9011	**Advanced Concrete Technology**	**PEL**	**4**	**0**	**0**	**4**	**4**

Pre-requisite(s)	Course Assessment methods
Concrete Materials & Technology	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Understand the concrete and its ingredients influence in gaining strength. • CO2: Design the concrete mixes of various types and grades as per IS codes. • CO3: Summarise the concepts of conventional concrete and its variation with other special concretes. • CO4: Describe the application and use special purpose concrete.
Topics Covered (Hrs)	**Brief Introduction to Concrete:** Classification of concrete, Properties of concrete, Grades of concrete, Advantage and disadvantages of concrete as a construction material. 3 **Brief Introduction to Concrete Making Materials:** Cement, Aggregates, Water, Admixture : Brief review of types, properties and application, Codal provisions. 5 **Concrete Mix Design :** Factors influencing design of mix, IS methods of design of mixes for ordinary, high strength concrete, self-compacted concrete, mass concrete. 8 **Fresh Concrete:** Rheology of concentrated suspensions, pastes, mortars and concretes; workability, segregation and bleeding. Theory and principles governing the correct placing and compaction of concrete. 5 **Properties of Hardened Concrete:** Strength; deformation under load; elasticity; creep; drying shrinkage and other volume changes. Thermal properties, Destructive and non-destructive tests. 5 **Special Concretes:** Lightweight concrete: autoclaved aerated concrete, Ready–mix concrete, no-fines concrete, lightweight aggregate concrete and foamed concrete, high strength concrete; refractory concrete; high density and radiation-shielding concrete; polymer concrete; fibre-reinforced concrete; recycled concrete. 7 **Special Purpose Concrete:** Sprayed concrete, underwater concrete, grouts and grouted concrete, mass concrete, pumped concrete, concrete for liquid retaining structures**.** 6
Text Books, and/or reference material(s)	*Text Books:* 1. Concrete Technology by M. S. Shetty, S. Chand & Co. Ltd., 2005. 2. Concrete Technology by A. M. Neville & J. J. Brooks, Pearson Education, 2008 3. Concrete Mix Proportioning-Guidelines, IS 10262: 2019. 4. Coarse and Fine Aggregate for Concrete – Specification, IS 383: 2016. 5. Plain and Reinforced Concrete – Code of Practice, IS 456: 2000. *Reference Books:* 1. Advance Concrete Technology by John Newman & Ban Seng Cho, Elsevier, 2003. 2. Concrete Technology by M. L. Gambhir, Tata McGraw Hill, 2007.

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	3
CO2	-	-	-	3	-
CO3	-	-	3	-	-
CO4	-	3	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9012	**Design of Prestressed Concrete Structure**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Analysis and design of structures	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)	• CO1: Apply knowledge of solid mechanics & concrete structures for design solutions. • CO2: Understand basic design philosophies applicable to pre-stressed concrete structures. • CO3: Formulate, analyse, and design basic components of Civil Engineering Pre-stressed Concrete structures.
Topics Covered (Hrs)	**Introduction:** Basic principles, advantage, Comparison with RC, Types of pre-stressing and Stress analysis **(4)** **Materials:** Specifications and characteristics of concrete and high tensile steel **(2)** **Loss of Prestressed**: Different type of loss with derivation and numerical problems **(4)** **Flexural Analysis:** Derivation of moment of resistance, Pre-stressing force and eccentricity with numerical problems **(4)** **Shear and torsion:** Design of beam for shear and torsion **(4)** **Deflection and Cracking:** Cause and requirement along with numerical problems **(4)** **Design of end zone:** Transmission length, design of bearing plate and burst reinforcement **(4)** **Member Design:** One-way slab, beam, Axial members, Poles, Sleepers, Pipes, Tanks & etc., Two-way pre-stressing, Circular pre-stressing, Partial pre-stressing, Composite construction and Statically indeterminate structures. **(14)**
Text Books, and/or reference material(s)	*Text Books:* 1. Prestressed Concrete, 5thEdition by N. Krishna Raju, Tata McGraw-Hill Publishing Company Limited, New Delhi. 2. Prestressed Concrete, 5thEdition, by S. Ramamrutham, Dhanpat Rai Publishing Co. Pvt. Ltd. New Delhi. 3. IS 1343: 2012, Prestressed Concrete – Code of Practice (2ndRevision), BIS, New Delhi. 4. www.nptel.ac.in *Reference Books:* 1. Fundamentals of Prestressed Concrete by N. C. Sinha & S. K. Roy, S. Chand & Company Ltd, New Delhi 2. Lin T.Y. Design of prestressed concrete structures, Asia Publishing House, Bomba y 1995

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	1	3	-	-	1
CO2	2	-	-	-	2
CO3	3	-	3	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9013	**Advanced Structural Mechanics**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Solid Mechanics		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs):	• CO1: To develop basic understanding of the fundamental concepts of the advanced topics. • CO2: To define the stress and strain tensors for structural members and to write the stress-strain relationships. • CO3: To evaluate the state of stress or state of strain with respect to the different theories of failure and compare. • CO4: To apply the principles of structural mechanics to special structures.
Topics Covered (Hrs)	**Analysis of stress:** Definition of stresses; stress matrix; state of stress; Cauchy's stress relations; stress transformation, principal stresses; equations of equilibrium; different types of stresses; polar coordinates; three-dimensional Mohr's circle. **(7)** **Analysis of strain:** Definition of strains; deformation vector; strain-displacement relations; strain matrix; principal strains; total distortion and rigid body rotation; strain compatibility conditions; volumetric strain; polar coordinates. **(6)** **Stress-strain constitutive relations:** (4) **Theories of failure:** (3) **Analysis of non-prismatic member**s: General Euler-Bernoulli Law; linear Euler-Bernoulli equation; effect of bending of non-prismatic members. **(2)** **Thin Walled Pressure Vessels**: Stresses, strains in cylindrical and spherical vessels; change in volume, strengthening of thin cylinders, solution of numerical problems to implement the above concepts. **(4)** **Thick Walled Pressure Vessels:** Cylinders and Spheres: stresses; compatibility; Lame's equation; special case of solid shaft; thick spherical shells. **(4)** **Curved Beams**: Introduction; stresses in curved beams; eccentricity; rings under loads; distribution of stresses and bending moments in rings. **(4)** **Unsymmetrical Beam Bending**: Introduction; beams with doubly symmetric cross-sections; beams with arbitrary cross sections. **(4)** **Introduction To Plates** (4)
Text Books, and/or reference material(s)	***Text Books:*** 1. Solid Mechanics by S.M.A. Kazimi, Tata McGraw-Hill Publishing Company Limited 2. Advanced Mechanics of Solids by L.S. Srinath, Tata McGraw-Hill Publishing ***Reference Books:*** 1. Mechanics of Solids by Abdul Mubeen

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reporting	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	2	-	3	-	-
CO2	3	-	3	2	-
CO3	3	-	3	2	-
CO4	-	1	-	2	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE 9014	Reliability Methods in Structural Engineering	PEL	3	0	0	3	3

Pre-requisite(s)	Course Assessment methods
Structural Analysis and Engineering Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: Understand of reliability theory based on knowledge of fundamentals of probability and statistics.
- CO2: Apply Monte carlo and other simulation techniques to solve different civil/structural engineering problems.
- CO3: Evaluate reliability index using different reliability methods.
- CO4: Calibrate partial safety factors of variables of different performance functions for Level I code

Topics Covered (Hrs)

Introduction: Introduction to structural safety and reliability, Concepts of uncertainty in reliability-based analysis and design. (2)
Basic statistics and probability: Definition of random variables, Axioms of probability, probability functions, conditional probability, Discrete and continuous random variables, probability distribution of random variables, random vectors and functions of random variables. (8)
Simulation techniques: Monte Carlo method, Latin Hypercube simulations, Variation reduction techniques. (8)
Basic reliability methods: Basic definition of Reliability Index, First order reliability method, Hasofer-Lind reliability index, Rackwitz-Fiessler reliability method. (10)
Reliability-based design: Reliability-based design code and its development, Load and resistance factor design format, Calibration of partial safety factors for a Level I code, Uncertainty models for load and resistance parameters. (10)
Advanced reliability methods: Second order reliability method. (2)
Structural system reliability: Introduction to structural system reliability. (2)

Text Books, and/or reference material(s)

TEXT BOOKS:

1. Ang and Tang, 'Probability concepts in engineering planning and design'Vol I and II, John Wiley.
2. R. Ranganathan, 'Structural Reliability Analysis and Design', Jaico Publishing House *Reference Books:*

REFERENCE BOOKS:

1. Halder, A., and Mahadevan, S. 'Probability, reliability and statistical methods in engineering design'. John Wiley and Sons. New York.
2. Papoulis, A. 1991, 'Probability, random variables and stochastic processes' McGraw Hill New York.
3. Melchers, R.E. 1987. Structural Reliability Analysis and Prediction. Chichester, England: Ellis Horwood.

Mapping of Course Outcomes Cos→POs

	Independent investigation capability	Technical Reporting	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	-	-		3	-
CO2	-	-	3	-	-
CO3	-	-	3	-	-
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9015	**Space Structures and Suspended Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: understand the concept of space structures and suspended structures & loading on it. • CO2: understand the basis and methods of various load calculation, IS codal provisions • CO3: Formulate, analyse, and design of various space structures and suspended structures.
Topics Covered (Hrs)	***Part-I :*** Determinate and indeterminate space structures, Methods of analysis, Design of pin-jointed and rigid space frames, wind, earthquake loading, and load combination [14] ***Part-II :*** Different types of suspended structural systems, Methods of static and dynamic analysis. [14] ***Part-III :*** Linear and non-linear analysis of Suspended structures, Suspension Bridges, analysis & design of suspension cable. [8] ***Part-IV :*** Lateral load resisting /interacting system for Suspended Structures.[6]
Text Books, and/or reference material(s)	*Text Books:* 1. Bryan Stafford Smith, Alex Coull, Tall Building Structures- Analysis and Design, John wiley & sons, 2006. 2. Woltang Schuller, High- rise building Structures, John wiley and Sons, New York 1976 3. Moore F. (1999), Understanding Structures, McGrew-Hill. *Reference Books:* 1. Troitsky M. S. (1994), Planning and Design of Bridges, John Wiley & Sons Inc. 2. Walther R. etc. (1988), Cable-Stayed Bridges, 2nd Edition, Thomas Telford Ltd. 3. Troitsky M. S. (1988), Cable-Stayed Bridges, 2nd Edition, BSP Professional Books 4. Handbook Concrete Engineering, Mark Fintel, CBS Publisher

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	2	3	-	-
CO3	-	-	-	3	2
CO4	-	2	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total of contact hours				Credit
			L	T	P	H	
CE 9016	**Applied Probability and Statistics in Civil Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods
Engineering Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	• CO1: understand the basic of probability and statistics • CO2: understand the random variables, different distributions of random variables, functions of random variable, joint distribution, sampling distributions, estimation theory, testing of hypothesis and goodness of fit tests. • CO3: solve different engineering problems applying the theory of probability and statistics. • CO4: apply the theories of probability and statistics to analyse data which is important for design of civil engineering structures and foundations.
Topics Covered	**Probability:** Axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, CE problems. (5) **Random Variables:** Discrete, continuous random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, probability and moment generating function, Markov inequality, Chebyshev's inequality problems. (6) **Special Distributions:** Discrete uniform, binomial, geometric, negative binomial, hypergeometric, Poisson, continuous uniform, exponential, gamma, Weibull, beta, normal, lognormal, civil engineering problems. (8) **Function of a random variable:** Different functions of a random variable. (2) **Joint Distributions:** Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, bivariate normal distribution. (4) **Sampling Distributions:** The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problem (3) **Estimation:** Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions. (6) **Testing of Hypotheses:** Null and alternative hypotheses, the critical and acceptance regions, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportion. (8) **Goodness of fit tests:** Chisquare goodness of fit test and its applications, civil engineering problems. (2)
Text Books, and/or reference material	**TEXT BOOKS:** 1. Ang, A. H. S. and Tang, W. H. 1975. Probability Concepts in Engineering Planning and Design: Volume 1, Basic Principles, Wiley. 2. Ang, A. H.-S. and Tang, W. H. 1984. Probability Concepts in Engineering Planning and Design: Volume 2 Decision, Risk and Reliability, Wiley, New York. 3. Ross, S, 1998. A First Course in Probability, Prentice Hall, NJ. 4. Montgomery, D.C. and Runger, G.C. 1998. Applied Statistics and Probability for Engineers, Wiley, New York. **REFERENCE BOOKS:** 1. Speiegel M. R., Schiller, J.J. and Srinivasan, R. A. 2010. Probability and Statistics, Tata- Mcgraw-Hill, New Delhi. 1. Papoulis, A. 1991. Probability. Random variable and Stochastic process, McGraw-Hill, New York.

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	-	-	-
CO2	2	-	-	-	-
CO3	-	-	3	-	-
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE 9017	**Offshore Structural Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites Structural Analysis and Structural dynamics		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Identify the types of offshore structures, parameters governing solid-fluid interaction and environmental forces acting on offshore structures. • • CO2: Apply static methods of analysis for stresses in Offshore structures • CO3: Solve for response analysis of offshore structures – single and multi-degree of freedom problems, frequency and time domain analyses						
Topics Covered	**Topic 1: Introduction:** Loads and structural forms of different types of offshore structures; (4) **Topic 2: Fundamental of offshore structural dynamics:** Elements of single d.o.f. system subjected to free and forced vibrations; Analysis for transient and steady state force; Equivalent damping for nonlinear systems; Dynamics of multi d.o.f. systems; Eigen values and vectors; Iterative and transformation methods; Mode superposition. Fourier series and spectral method for response of single d.o.f. systems; Vibrations of bars, beams and cones with reference to soil as half space; Behaviour of concrete gravity platform as a rigid body on soil as a continuum; (14) **Topic 3: Environmental loadings:** Short and long term statistics of wind; Static wind load; Effect of size, shape and frequency; Aerodynamic admittance function and gust factor, spectral response due to wind for various types of structures; Wave loads by Morison's equation; (4) **Topic 4: Statics and Dynamics of offshore structures:** Static and dynamic analysis of fixed structures; Use of approximate methods. Design of offshore platforms: Introduction, fixed and floating platforms. Steel, concrete and hybrid platforms. Design criteria. Environmental loading. Wind, wave and current loads after installation.. Behaviour under dynamic loading. Static and dynamic analysis of platforms and components. (14)						
Text Books, and/or reference material	**Text Books:** 1. Offshore Structural Engineering, Thomas H Dawson, Prentice Hall, 1983 2. Dynamic Analysis and Design of Ocean Structures. Srinivasan Chandrasekaran, Springer, 2015. 3. Dynamics of Offshore Structures, Wilson, J. F., John Wiley, 2002. **Reference Books:** 1. Offshore Mechanics, Madjid Karimirad, Constantine Michailides and Ali Nematbakhsh, Wiley, 1 edition 2. Offshore structures – Vol. 1 & 2, Clauss, G, Lehmann, E & Ostergaard, C., SpringerVerlag, 1992						

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	-	-	3	-	-
CO3	-	1	-	-	3
CO4	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9018	**Wind Analysis and Design of Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: understand the basis and methods of wind load calculation, IS codal provisions • CO2: understand various elements/principles of design philosophy to be used in the design of structures to cater wind load /effect. • CO3: Formulate, analyse, and design of various Civil Engineering Concrete /Steel structures.
Topics Covered (Hrs)	***Part-I :*** Introduction : Concept of wind, Causes and types of wind, Along wind and across wind, Gust, Reference to different codes of practices related to wind [12] ***Part-II :*** Wind pressure effect on tall structures & slender structures ; Buildings, Sheds, chimneys; Towers etc. [12] ***Part-III :*** Wind pressure effect on cable supported bridges, steel bridges [8] Wind pressure, effect on cooling towers, silo, Microwave towers, Transmission line towers [6] ***Part-IV :*** Wind tunnel testing & simulations, Statistical analysis of wind. [4]
Text Books, and/or reference material(s)	*Text Books:* 1. Wind and Earthquake Resistant Buildings: Structural Analysis and Design by Bungale S. Taranath, CRC Press Book 2. Wind Loading on Structures by JD Holmes : 2001, Spon Press, New York 3. IS 875:2015 Part III : Design Loads (Other than Earthquake) for Buildings and Structures- Code of Practice 4. An Explanatory Handbook to IS 875 Part III Wind load on Buildings and Structures by NM Bhandari, Prem Krishna *Reference Books:* 1. IS 456: 2000,Indian Standard Plain and Reinforced Concrete – Code of Practice (4th Revision), BIS, New Delhi. 2. IS 14732 : 2000 Guidelines for evaluation of response of structures… under low frequency horizontal motion. 3. IS 16700 : 2017 Criteria for structural safety of tall concrete buildings. 4. Handbook Concrete Engineering, Mark Fintel, CBS Publisher 5. Advanced Reinforced Concrete Design N Krishna Raju, CBS Publishers

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	2	3	-	-
CO3	-	-	-	3	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE 9019	**Foundation Engineering**	**PCR**	**3**	**1**	**0**	**4**	**3**
Pre-requisites		Soil Mechanics					
		CT+EA					

Course Outcomes	At the end of the course, the student will be able to: • CO1: Interpret field and laboratory data and prepare soil investigation report. • CO2: Analyze bearing capacity and settlement of foundations. • CO3: Design shallow and deep foundations. • CO4: Analyze and suggest remedial measures against foundation failures.
Topics Covered	**Soil Exploration:** Exploration Methods; Planning the Exploration Program; Boring and Sampling; In Situ Tests: Standard Penetration Tests, Field Vane & Borehole shear tests, Rock Sampling, Core Recovery, RQD; Geophysical Exploration; Plate Load Test, Static Cone Panetration Test. Preparation of Soil Report. (8) **Shallow Foundations:** Bearing Capacity:- Bearing capacity of foundation based on in-situ tests. Bearing capacity for foundation on slope, design of mat foundations including floating raft, Effect of Water Table; Footings with Eccentric or Inclined Loads, on Layered Soils. (10) **Deep Foundations:** Mechanics of load transfer in piles, load carrying capacity, pile load test, Vertically loaded piles, Static capacity, Bearing Resistance of Piles on Rock; Uplift Resistance; Laterally Loaded Piles –Ultimate Lateral Resistance; Negative Skin Friction; Under Reamed Piles; Ultimate Capacity of Pile Groups in Compression, Pullout & Lateral Load; Efficiency; Settlements of Pile Groups. (10) **Sheet piles:** Design of anchored sheet piles: Free Earth Support Method, Fixed Earth Support Method, Problems. (6) **Coffer Dams:** Cellular cofferdams- Circular and Diaphragm type, Merits and demerits, Deign of circular type cofferdams, practice problems. (6) **Braced Cuts:** Pressure envelope for Braced – Cut design, Pressure envelope for cuts in layered soil, Design of various components of a braced cut, Bottom heave of cut in clay, Stability of the bottom of cut in sand.(4)
Text Books, and/or reference material	**TEXT BOOKS:** 1. Design Aids in Soil Mechanics and Foundation Engineering S.R. Kaniraj 2. Foundation Engineering by V.N.S Murthy **REFERENCE BOOKS:** 3. Foundation Engineering by B.M.Das 4. Foundation Engineering By J.E. Bowles 5. Design of Pile Foundation By Tomlinsion.

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

Course Outcome	PO1	PO2	PO3	PO4
CO1	2	3	--	1
CO2	3	1	2	--
CO3	3	2	3	--
CO4	2	--	3	--

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EVEN SEMESTER (Elective-III - V) : CE 9031-50

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE9031	**Theory of Plates and Shells**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Solid Mechanics, Structural Analysis	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Derive the expressions of the curvature and displacement relationships of plates subjected to bending moments, twisting moments and shear force. • CO2: Analyse the simply supported plates and solve them by using Navier's and Levy's Methods. • CO3: Analyse the thin shell structures using membrane theory. • CO4: Design the cylinder shell and review the IS codal provisions of it.
Topics Covered (Hrs)	**Basic curvature and displacement relationships**. Expressions for bending, moment, twisting moments, shear forces. (4) **Plate equation**, Edge conditions. Solution of simply supported plates by Navier's and Levy's methods. Introduction to anisotropic plates. (12) **Plate subjected to in plane forces**, Buckling of plates. Numerical analysis of plates. Design of plates. (6) **Shell structure**: Classification, Differential geometry, Curvature, Strain, Displacement relations. (4) **Membrane theory of thin shells** and design of cylindrical shells of double curvature (synclastic and anticlastic), Shells of revolution, North light shell. (10) **Design of shell** and review of IS code provisions, Introduction to bending theories: Application to cylindrical shells and design. (6)
Text Books, and/or reference material(s)	**Text Book(s) :** 1. Theory of Plates and Shells: Timoshenko and Krieger, McGraw Hill 2. Theory and Analysis of Plates: Classic and Numerical Methods, Rudolph Szilard, Prentice Hall Inc. New Jersey **Reference Book(s):** 3. Design and Construction of Concrete Shell Roofs : G.S. Ramaswamy, CBS Publisher & Distributors (2005)

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	-	-	3	-	-
CO3	-	-	3	-	-
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9032	**Theory of Elastic Stability**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Analyze and determine the critical loads for different beam-column structural members. • CO2: Evaluate the structural stability and determine the critical loads by applying approximate methods. • CO3: Model and analyze continuous beams and frames from the stability criteria. • CO4: Solve problems on stability using numerical techniques • CO5: Differentiate between elastic and inelastic buckling and evaluate critical load for inelastic buckling
Topics Covered (Hrs)	1. Introduction, fundamental principle and models for elastic stability of column. (2) 2. Stability as an Eigen value problem, Approximate methods for buckling of bars and frames, Energy methods, Rayleigh-Ritz's method, Galerkin's method. (10) 3. Beam columns under concentrated and continuous lateral loads, Beam columns with continuity and restrained ends. (10) 4. Stability of continuous beams and frames, Stiffness matrices and stability functions for members with and without lateral restraints. (10) 5. Numerical integration for stability problems by Newmark's method. (5) 6. Inelastic buckling of structures. (5)
Text Books, and/or reference material(s)	***Text Books:*** 1. Stability Analysis and Design of Structures - M.L. Gambhir; Publisher - Springer-Verlag Berlin Heidelberg 2. Theory of Elastic Stability - Stephen P. Timoshenko & James M. Gere; Publisher - McGraw-Hill Book Co., Inc. ***Reference Books:*** 3.

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	2	-	2	3	-
CO2	3	-	3	-	-
CO3	3	-	3	3	-
CO4	3	-	3	-	-
CO5	3	-	3	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9033	**Advanced Bridge Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Analysis and design of structures	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)	• CO1: Acquire knowledge to select different type bridges by assessing their material, capacity, quality & suitability • CO2: Ability to make a bridge plan and design following requisite criteria • CO3: Supervise the construction procedure of different components of a bridge • CO4: Assess the quality and roles of various components of bridge
Topics Covered (Hrs)	**Hydraulic design:** Survey, Catchment, Site selection, Hydraulic geometry, Linear waterways, Economic span, Afflux and Scour. **(4)** **Loads on bridge:** Different types of load acting on bridge along with numerical **(6)** **Slab and box culvert:** Analysis of deck slab - effective width & length method and numerical example with different type of live load. **(4)** **R.C. beam-slab and steel composite bridges:** R.C. T-beam bridge and steel composite bridge design using Pigeaud's method and Courbon's method **(4)** **Dynamic response of bridge deck:** General features, factor affecting vibration, practical approach for vibration analysis and numerical examples. **(2)** **Prestressed concrete bridge:** General features, advantage of P.S.C. Bridge, design details of pre-tensioned and post–tensioned bridge and numerical (**4**) **Bridge bearing:** Introduction, types of bearing, design principles of different bearing and numerical examples **(2)** **Substructure:** Introduction, type of piers, forces acting on piers, stability analysis of abutment, types of wing wall and numerical examples of Pier and Abutment. **(4)** **Bridge foundation:** General aspect, types of foundations, design aspect of pile and well foundations and numerical examples of pile and well foundations. **(4)** **R.E. Wall:** Brief introduction to R.E. wall, methodology, analysis and design. **(2)** **Special Topics:** Brief idea on Pipe culvert, Masonry arch, Skew bridges, Rigid frame bridge, Plate girder bridge, Steel trussed bridge, Balanced cantilever bridge, Continuous bridge and Cable stayed bridges. **(4)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Bridge Engineering by S. Ponnuswamy, Tata McGraw-Hill Publishing Company Limited, New Delhi. 2. IRC: 6-2017 Standard Specifications and Code of Practice for Road Bridges 3. www.nptel.ac.in ***Reference Books:*** 1. Design and construction of Highway Bridges by K. S. Rakshit, New Central Book Agency (P) Ltd

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	-	1	3	-	-
CO2	-	2		3	1
CO3	3	3	-	-	3
CO4	3	3	-	-	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9034	Structural Dynamics	PEL	3	0	0	3	3

Pre-requisite(s)	Course Assessment methods
Solid Mechanics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Develop & analyze damped & un-damped SDOF systems for free & forced vibration. • CO2: Develop and analyze the MDOF systems for free & forced vibration. • CO3: Model civil engineering structures & derive the dynamic properties of structures, natural frequencies, mode shapes & structural responses numerically • CO4: Apply the concepts & principles of structural dynamics for earthquake analysis of civil engineering structures & evaluate their seismic performance
Topics Covered (Hrs)	**Introduction:** D'Alembert's principle, dynamic loads, definition of degrees of freedom **(1)** **SDOF system:** Equations of motion, undamped and damped SDOF systems, viscous damping, critically damped, over-damped and under-damped system, damping coefficient determination, dynamic magnification factor and transmissibility. **(7)** **Forced vibration of SDOF systems:** Vibration under sinusoidal loads, response to general dynamic loading - Duhamel's integral: impulse, rectangular, triangular loading problems. **(5)** **Fourier analysis and response in the frequency domain** theory, problems **(2)** **MDOF system:** Development and solution of equations of motion, problems **(2)** **Free vibration of MDOF systems:** Eigen values and vectors, natural frequencies and modes, orthogonality of modes, normalization of modes, modal expansion, concept of normal/generalized coordinates, problems **(5)** **Free vibration response**: Free vibration of un-damped systems, modal analysis. **(3)** **Forced vibration of MDOF systems:** Modal expansion of excitation vector, modal analysis, modal contribution factors. **(3)** **Forced vibration response:** Modal analysis, forced vibration for un-damped systems subjected to sinusoidal loading and arbitrary loading**. (5)** **Damping in structures:** Classical, non-classical damping, mass proportional, stiffness proportional, Rayleigh, Caughey damping, Modal analysis for classically damped free and forced vibration systems **(4)** **Earthquake analysis of structures:** Equations of motion for un-damped and classically damped systems single and multiple degree of freedom systems, modal participation factors, modal analysis, response spectrum analysis, modal combination rules **(4)**
Text Books, and/or reference material(s)	***Text Books:*** 1. Dynamics of Structures by Anil K. Chopra, PHI 2. Earthquake Resistant Design of structure by Pankaj Agarwal and Manish Shrikhande. 3. Structural Dynamics: Theory and Computation by Mario Paz, Kluwer Academic Publishers ***Reference Books:*** 4. Elements of Earthquake Engineering, Jai Krishna, A.R. Chandrasekaran, B. Chandra. South Asian Publishers. 5. Theory of Vibration with Applications, W.T. Thomson, PHI

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	2	-	3	2	-
CO2	-	-	-	-	-
CO3	3	1	3	2	2
CO4	3	2	2	3	3

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9035	**Soil-Structure Interaction**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: understand the basis of soil-structure interaction • CO2: understand various soil models like beams on elastic foundation (Winkler beam model), infinite beam, and finite beam models. • CO3: apply soil-structure interaction models to different type of foundations like pile, sheet pile walls (cantilever and anchored sheet pile walls) by analytically and numerically. • CO4: analyse the foundation of different civil structures with considering soil-structure interaction in static as well as dynamic conditions.
Topics Covered (Hrs)	**Part I:** Introduction, Superstructure-foundation interaction, static soil-structure interaction.(4) Non-uniform contact pressure, Interaction problems of shallow foundation, Combined footing, Rigid method, Flexible method. (6) **Various Soil Models:** Beams on elastic foundation, Infinite beam, Finite beam, Modulus of subgrade reaction and effecting parameters. (10) Sheet pile wall, Cantilever and anchored sheet pile wall, Fixed earth support, Free earth support. (4) Piles under different loading conditions, Analysis under lateral load, Different approaches, Mechanism of failure, Ultimate load, Deflections, Elastic continuum approach, Design, Analysis. (8) **Part-II:** Introduction to dynamic soil- structure interaction (DSSI). (4) Geotechnical consideration of DSSI (2) Dynamic pile-soil interaction (4)
Text Books, and/or reference material(s)	*Text Books:* 1.Advanced GEOTECHNICAL Engineering soil-structure Interaction using Computer and Material Models by C.S.Desai, Musharraf Zaman. 2. Foundation analysis and Design by J.E.Bowles *Reference Books:* 1. Soil-Structure Interaction Numerical Analysis and Modelling by J. W. Bull. 2. Advanced Soil Mechanics B.M. Das, McGraw Hills Publishers. 3. Dynamic Soil-Structure Interaction, John. P. Wolf, Prentice Hall Inc.

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	-	-	-	-
CO3	-	-	3	-	-
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE 9036	**Advanced Theory of Vibration**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites Structural dynamics		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Understand Wave propagation and dynamics of elastic half space • CO2: Analyze dynamic equations by computational methods of analysis • CO3: Apply dynamic Analysis method for different interaction problems						
Topics Covered	Topic 1: Wave Propagation in one and two dimensions, Dynamics of a mass on an elastic half space; (10) Topic 2: Computational structural dynamics solution of dynamic equations by convolution, time step integration, complex modes, frequency domain methods Modal synthesis in frequency domain. Sub-structuring techniques spatially periodic structures Numerical methods for nonlinear hysteretic systems Lanczos method. (18) Topic 3: Dynamic soil-structure interaction, Fluid-structure interaction problems related to liquid storage tanks and offshore structures. (12) Topic 4: Elements of Random vibration, Wind induced vibration of Structures Variational formulation of equations of motion, Non-linear vibration, Design for extreme dynamic loads such as impact, blast and seismic loading. (10)						
Text Books, and/or reference material	**TEXT BOOKS:** 1. Non-linear dynamics and random vibration analysis by J.S. Rao, Wiley Publishers 2. Theory of Vibration by A. A. Shabana, Springer **REFERENCE BOOKS:** 1. Vibrations and stability by J. J. Thomson, Springer						

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	-	-	3	-	-
CO3	-	1	-	3	-
CO4	-	-	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE9037	**Mechanics of Composite and Smart Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisite(s)		Course Assessment methods					
Knowledge of Solid Mechanics, Structural Analysis & Design		Continuous (CT) and end assessment (EA). CT+EA					

Course Outcomes (COs) :	• CO1: Knowledge of composite and smart materials, advantage over their conventional counterparts and their specific use in engineering structures • CO2: Skills for analysis of structural components, made of composite and smart materials, under various loads • CO3: Ability to use numerical techniques for modeling and analysis of simple structures for realistic prediction of their structural behavior. • CO4: Confidence and preparedness for modeling and analysis of real life problems involving composite and smart structures for industry/research
Topics Covered (Hrs)	Introduction, Types of composite materials, Lamina and Laminate, Matrix and Fibre, Fibre-reinforced Composites, Comparison of strengths between bulk material and fibres (6) Co-ordinate systems, Effect of orientation of fibres on the strength and stiffness of composite structures (6) Micromechanics and Macro mechanics, Constitutive relations, Stresses and Strains, Failure criteria of composites (8) Analysis of simple composite structures: beams and plates (8) Introduction to smart materials, Different types of smart materials, their properties and applications (4) Smart structures as a special case of composite structures (4) Finite Element Method in analysis of composite and smart Structures (6)
Text Books, and/or reference material(s)	Text Books: 1. Mechanics Of Composite Materials by Robert M. Jones: Taylor and Francis (2015) 2. Mechanics Of Composite Materials and Structures by Madhujit Mukhopadhyay: University Press (2004) 3. Smart Structures: Analysis and Design by A. V. Srinivisan and D. M. McFarland: Cambridge University Press. Reference Books: 1. Mechanics of Composite Structures by Autar K. Kaw: Taylor and Francis (2006) 2. Mechanics of composite structures by L. P. Kollar and G. S. Springer, Cambridge University Press.

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	-	-	2	-	-
CO2	-	-	1	2	-
CO3	-	-	2	3	-
CO4	3	-	2	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9038	**Analysis and Design of Tall Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: understand the concept of Tall building, loading on Tall building. • CO2: : understand the basis and methods of wind load calculation, IS codal provisions on tall buildings • CO3: understand various methods /principles for the analysis of Tall building mainly to cater horizontal effect /wind load. • CO4 : Formulate, analyse, and design of various Tall Civil Engineering Concrete /Steel structures.
Topics Covered (Hrs)	***Part-I :*** Concept of tall building, factor affecting growth, height and structural form. Tall building structure- design process, strength and stability, stiffness and drift limitation, human comfort criteria, creep, shrinkage and temperature effects. Gravity, wind, earthquake loading, and load combination [12] ***Part-II :*** Braced frame structures, rigid frame structures, in filled frame structure, flat plate and flat- slab structures, shear wall structures, wall- frame structures, framed-tube structures, outrigger -braced structures, suspended structures, core- structures, space and hybrid structures. Floor systems- reinforced concrete and steel framing. [14] ***Part-III :*** Design considerations Nature of wind, Characteristics of wind, provisions of IS codes of practice. [8] ***Part-IV :*** Lateral load resisting /interacting system for Steel Structures, such as Towers [8]
Text Books, and/or reference material(s)	*Text Books:* 1. Bryan Stafford Smith, Alex Coull, Tall Building Structures- Analysis and Design, John wiley & sons, 2006. 2. Woltang Schuller, High- rise building Structures, John wiley and Sons, New York 1976 *Reference Books:* 1. Lynn S. Beedle, Advances in Tall Buildings, CBS Publishers and Distributors Delhi, 1996. 2. B.S. Taranath, Structural Analysis & Design of tall Buildings, McGraw Hill, 1998. 3. IS 14732 : 2000 Guidelines for evaluation of response of structures… under low frequency horizontal motion. 4. IS 16700 : 2017 Criteria for structural safety of tall concrete buildings. 5. Handbook Concrete Engineering, Mark Fintel, CBS Publisher

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	2	3	-	-
CO3	-	-	-	3	2
CO4	-	2	-	-	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE 9039	**Soil Dynamics And Machine Foundation**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Geotechnique					
		CT+EA					

Course Outcomes	At the end of the course, the student will be able to: • CO1: Apply theory of vibrations to solve dynamic soil problems • CO2: Analyze and design behaviour of a machine foundation resting on the surface, embedded foundation and foundations on piles by Soil as Spring and Elastic Half Space. • CO3: Analyze and design vibration isolation systems
Topics Covered	Introduction to machine foundation. (4) General theory: Theory of SDF and MDF system, damping of single and two degree freedom system, transient response and periodic response. (8) Design parameters: Dynamic soil parameters under compression, bending yawing etc, Evaluation of elastic base theory. (6) Block foundation: Mode of vibration, theoretical and recommended methods of dynamic analysis, design of reciprocatng machine foundation. (12) Hammer foundation (8) Turbogenerator foundation: Special consideration in planning and design, design data recommended, dynamic analysis and design. (2)
Text Books, and/or reference material	**TEXT BOOKS:** 1. Handbook of Machine Foundation . By.: C.V. Vaidyanathan and P. Srinivashalu 2. Design Aids in Soil Mechanics and Foundation Engineering S.R. Kaniraj **REFERENCE BOOKS:** 3. Dynamics of Structures by Madhujit Mukhopadyay

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

Course Ourcome	PO1	PO2	PO3	PO4
CO1	3		2	
CO2		2	3	1
CO3	3		3	

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9040	**Repair and Rehabilitation of Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Concrete Materials & Technology/ Advance Concrete Technology	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :

- CO1: understand various distress and damages to concrete and masonry structures.
- CO2: describe the importance of maintenance of structures, types and properties of repair materials etc.
- CO3: assess damage to structures and various repair techniques.
- CO4: describe the application and use of repair techniques for crack repair to rehabilitate damaged structures.

Topics Covered (Hrs)

Introduction: Maintenance, rehabilitation, repair, need for rehabilitation of structures.(4)
Cracks in R.C. Structures: Various cracks in R.C. Structures, causes and effects. (4)
Maintenance: Maintenance, importance of maintenance, routine and preventive maintenance. (2)
Damages to masonry structures: Various damages to masonry structures and causes. (2)
Repair materials: Various repair materials, Criteria for selection of material and methodology, Health and safety precautions for handling and applications of repair materials. (4)
Special mortars & concretes: Polymer Concrete and Mortar, Quick setting compounds.(2)
Grouting materials: Gas forming grouts, Salphoalumate grouts, Polymer grouts, Acrylate and Urethane grouts. (2)
Damage diagnosis and assessment: : Visual inspection, Non Destructive Testing using Rebound hammer, Ultra sonic pulse velocity, Semi destructive testing, Probe test, Pull out test, Chloride penetration test, Carbonation, Carbonation depth testing, Corrosion activity measurement. (8)
Substrate preparation: Importance of substrate/surface preparation, General surface preparation methods and procedure, Reinforcing steel cleaning. (2)
Crack repair: Various methods of crack repair, Grouting, Routing and sealing, Stitching, Dry packing, Autogenous healing, Overlays, Repair to active cracks, Repair to dormant cracks. (8)
Corrosion of embedded steel in concrete: Corrosion of embedded steel in concrete, Mechanism, Stages of corrosion damage, Repair of various corrosion damaged of structural elements. (4)

Text Books, and/or reference material(s)

Text Books:

1. Concrete Technology by M. S. Shetty, S. Chand & Co. Ltd., 2005.
2. Concrete Technology by M. L. Gambhir, Tata McGraw Hill, 2007.
3. Repair and protection of concrete structures by Noel P. Mailvaganam, CRC Press, 1991.
4. Building Repair and Maintenance Management by P. S. Gahlot & S. Sharma CBS Publishers & Distributors, 2006.
5. Concrete repair and maintenance Illustrated by Peter H. Emmons, Galgotia publications Pvt. Ltd, 2001.

Reference Books:

1. Failures and repair of concrete structures by S. Champion, John Wiley and Sons, 1961.
2. Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India, 2011.
3. Handbook of Analytical Technique in Concrete Science and Technology edited by V. S. Ramchandran and J.J Beaudoin, Standard Publishers Distributors, 2006.

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	-	3	-	-	-
CO2	3	-	-	-	-
CO3	-	-	3	-	
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9041	**Engineering Elasticity and Plasticity**	**PEL**	**3**	**0**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods					
No pre-requisites		Continuous (CT) and end assessment (EA). CT+EA					
Course Outcomes	• CO1: Understand /Develop Stress theories in the space • CO2: Solve elasticity /plasticity problems. • CO3: understand various distress and damages						
Topics Covered	**3-Dimensional stress strain analysis**, Principal stress and maximum shear stress, Stress invariants, Equilibrium and compatibility equations, Boundary conditions, 2-Dimensional problems in Cartesian, Polar co-ordinates, Bending of beam, Thick cylinder under pressure, Complex variable, Harmonic and bi-harmonic functions, Torsion of rectangular bars including hollow section energy principles. (13) **Plastic stress-strain relations**, Tensile test, Universal stress-strain relations for strain hardening of metals, Treska and Mises' yield conditions, St. Venant's theory of plastic flow, Reuss's theory, Work during plastic deformations (10). **Thick walled spherical shell** under internal pressure, Equation of equilibrium conditions for yielding, Stresses and deformations, Plane stress and plane strain condition. (10) Solids and annular rotating cylinders and discs.(5)						
Text Books, and/or reference material	***Text Books:*** 1. Richard. G. Budynas, "Advanced Strength and Applied Stress Analysis" Mc Graw-Hill, New Delhi, Second Edition, 2011 2. Chakrabarty JN, "Theory of Plasticity", Tata McGraw Hill Book Co., New Delhi, Third Edition, 2006 ***Reference Books:*** 1. Mendelson. A., "Plasticity - Theory and Applications", Krieger Pub Co., Florida, U.S.A, Second edition,1983. 2. Chwo. P. C. and Pagano. N. J. "Elasticity Tensor, Dyadic and Engineering Applications", D. Van Nastrand and Co., Inco. 1990 3. Wang CK, "Applied Elasticity", Mc Graw Hill, New Delhi, 1990						

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	-	-	-	-	-
CO2	2	-	-	-	-
CO3	-	-	3	-	-
CO4	-	-	-	2	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Contact Hours				Credit
			L	T	P	H	
CE9042	**Retrofitting and Strengthening of Structures**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
UG Course in Civil /Construction Engineering	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: understanding Repair, rehabilitation and retrofitting • CO2: Seismic evaluation and need of retrofitting • CO3: Non-linear evaluation • CO4: Retrofitting and strengthening techniques
Topics Covered	**Introduction**: Terminology; Repair, rehabilitation and retrofitting, causes of deterioration and durability (5) **Qualitative Methods of Seismic Evaluation**: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; non-destructive testing (NDT) method. (10) **Quantitative Methods of Seismic Evaluation:** Performance based method using nonlinear static push-over analysis (NSP) and non- linear dynamic method of analysis (NDP) (10) **Rehabilitation methods**: Materials for repairs, rehabilitation and retrofitting processes (5) Shortcreting; Grouting, Epoxy-cement mortar injection, Crack ceiling, Local and Global Methods of Seismic Retrofitting of RC and Masonry Buildings; Introduction to supplemental energy dissipation and base isolation. (10)
Text Books, and/or reference material(s)	*Text Books:* 1. Earthquake resistant design of structures by Pankaj Agarwal and Manish Shrikhande, Prentice-Hall of India, 2006. 2. Handbook on Repair and Rehabilitation of RCC buildings, Published by CPWD, Delhi, 2002 *Reference Books:* 4. Seismic Evaluation and retrofit of concrete building – Vol. I & II,1996, Applied Technology Council, California, ATC 40. 5. Rapid Visual Screening of Buildings for Potential Seismic Hazards, 2002, Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C., FEMA 154/155.

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reporting	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1		3	-	-	-
CO2	2	-	3	-	3
CO3	2	-	3	3	-
CO4	-	3	3	3	

M.TECH. IN STRUCTURAL ENGINEERING

EVEN SEMESTER (Elective- IV) : CE 9051-60

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			L	T	P	H	
CE9051	**Advanced Finite Element Method in Structural Engineering**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisite(s)	Course Assessment methods
Finite Element Method, Structural Analysis and Structural Dynamics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs)	• CO1: Knowledge of advanced FEM and application of such knowledge to real life Structural Engineering applications. • CO2: Skill to predict behaviour of engineering structures realistically through FE modeling and analysis • CO3: Development of computing skills for most efficient utilization of available computational facilities • CO4: Confidence and skill of implementing FE based formulation of engineering problems relevant to industry and research through development of codes and using commercially available FE software
Topics Covered (Hrs)	**Review** of Introduction to Finite Element Method (3) **Two dimensional Finite Element Analysis**: Introduction, Review of Theory of Elasticity, Application of three dimensional equations for two dimensional analysis, CST Element for plane stress and plane strain analysis, Triangular elements, four node rectangular element for plane problems (12) **Finite Element Analysis of Plates and Shells**: Introduction, Review of plate theories, formulation of triangular and rectangular elements for plate bending analysis, introduction to analysis of shells (6) **Dynamic Analysis** using Finite Element Method: Introduction, Governing Equations, Mode superposition methods, direct time integration method (5) **Application** of Finite Element Method in real life engineering applications (4) **Computer Implementation** of Finite Element Method: Introduction, static condensation procedure, application of static condensation (3) **Exposure to FEM software** for industrial and research applications and introduction to CAE using FEM (3) **Symmetry concept** and its application in Finite Element Method (3) **Error analysis** in Finite Element Method (3)
Text Books, and/or reference material(s)	Text Books: 1. The Finite Element Method, O. C. Zienkiewicz, 3rd Ed., McGraw-Hill, 1997. 2. Fundamentals Of Finite Element Analysis by David V. Hutton Publisher: Tata Mcgraw Hill Education Private Limited (2005) 3. Concepts and Applications of Finite Element Analysis by R. D. Cook, 2003, John Wiley & Sons, INC. 4. An Introduction to the Finite Element Method, Reddy, J. N., 2005. Reference Books: 1. Finite Element Procedures by Klaus-Jsrgen Bathe Publisher: Prentice-Hall (2009) 2. Finite Element Analysis Theory and Application with ANSYS by Moaveni Publisher: Pearson (2008) 3. Finite element analysis: Theory and programming by C Krishnamoorthy (2001) Tata McGraw Hill Education

Mapping of Course Outcomes COs→POs

	PO1	PO2	PO3	PO4	PO5
CO1	-	-	3	2	-
CO2	1	-	2	3	-
CO3	-	-	3	1	-
CO4	2	-	2	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9052	Applied Numerical Methods	PEL	3	0	0	3	3

Pre-requisite(s)	Course Assessment methods
Engineering Mathematics	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes (COs) :	• CO1: Assess the error involved in a numerical method • CO2: Solve problems in engineering and science with a required accuracy using appropriate numerical methods • CO3: Write algorithm for the numerical methods for efficient coding of program • CO4:Understand the mathematics concepts underlying the numerical methods
Topics Covered (Hrs)	**Fundamentals of numerical methods**, Elements of matrix algebra, Solution of Linear equations and eigenvalue problems; Solution of differential equationsError analysis and stability of algorithms. (2) **Nonlinear equations:** Newton Raphson method, Muller's method, system of non-linear equations. Roots of polynomial equations. (6) **Linear system of algebraic equations:** Gauss elimination method, LU decomposition method; matrix inversion, iterative methods, ill conditioned systems. Eigenvalue problems: Jacobi, Given's and Householder's methods for symmetric matrices, Power and inverse power methods. (8) **Interpolation and approximation**:Newton's, Lagrange and Hermite interpolating polynomials, cubic splines; least square and minimax approximations. (6) **Numerical differentiation and integration:** Newton-Cotes and Gaussian type quadrature methods. (6) **Ordinary differential equations:**Initial value problems: single step and multistep methods, stability and their convergence. Boundary value problems: functional approximation, finite difference method, finite element method. (8) **Partial Differential Equations:** Difference methods for solution of parabolic and hyperbolic equations in one and two-space dimensions, stability and their convergence, difference methods for elliptic equations. Computer oriented algorithms; Numerical solution of different problems. (6)
Text Books, and/or reference material(s)	**TEXT BOOKS:** 1. Numerical Methods for Scientists and Engineers, R. W. Hamming, Dover Publications; 2 edition 2. Numerical Methods: Problems and Solutions, Mahinder Kumar Jain (Author), S.R.K. Iyengar (Author), R. K. Jain, New age publishers **REFERENCE BOOKS:** 3. Applied Numerical Methods for Engineers Using Matlab and C, Robert J. Schilling(Author), Sandra L. Harris, Nelson Engineering; Har/Cdr edition.

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	2	1		2	2
CO2	2	1	2	2	2
CO3	2	1	3	2	2
CO4	2	1		2	2

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CE 9053	Machine Learning in Civil Engineering	PEL	3	0	0	3	3
Pre-requisites		Engineering Mathematics, Basic of Civil Engineering					
		CT+EA					
Course Outcomes	• CO1: understand the basic of machine learning • CO2: understand the theory of machine learning based on knowledge of probability statistics and linear algebra. • CO3: solve different engineering problems applying the machine learning methods. • CO4: apply the different software of machine learning to solve civil engineering problems.						
Topics Covered	**Introduction to Machine Learning:** What is learning, What is machine learning, Machine learning activities, Basic types of data in machine learning. **(4 hours)** **Basis of Probability and Statistics:** Axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' theorem and independence, Random Variable , Few Distributions, Joint Distributions**, Some Basic Statistics. (4 hours)** **Linear Algebra:** Linear algebra and problem. (**2 hours**) **Artificial Neural Network**: Understanding biological neuron, artificial neuron, architectures of neural network, learning process of ANN. (**8 hours**) **Bayesian Learning:** Bayes theorem and concept learning. Naïve Bayes classifier**. (2 hours)** **Machine Learning:** Types of machine learning Approach: Supervised learning, Unsupervised learning and Reinforced learning, Applications of machine learning**,** usage of different software**.** (6 **hours**) **Supervised Learning: (a)** Supervised learning-classification- Basics of supervised learning classification, Decision tree, Support vector machine. (**10 hours**) (b) Supervised learning -Regression- Simple regression, Other regression techniques. (**4 hours**) **Applications of Machine Learning**: Apply machine learning methods to solve Civil Engineering problems using **Python, TensorFlow**. (**4 hours**)					
Text Books, and/or reference material	*TEXT BOOKS***:** 1.Goulet, James-A, Probabilistic Machine Learning for Civil Engineers, MIT Press. 2. Mitchell Tom M. Machine Learning, McGraw-Hill Education. *REFERENCE BOOKS:* 1. Dutta, Saikat, Chandramouli, Subramanian, Das, Amit Kumar, Machine Learning, Pearson 2. Marsland Stephen, Machine Learning, CRC Press. 3.Ang, A. H.-S. and Tang, W. H. 1984. Probability Concepts in Engineering Planning and Design: Volume 2 Decision, Risk and Reliability, Wiley, New York.					

Mapping of Course Outcomes COs→POs (mentioning Correlation Level)

	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	3	-	-	-	-
CO3	-	-	3	-	-
CO4	-	-	-	3	-

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total contact hours				Credit
			L	T	P	H	
CE9054	**Structural Optimization**	**PEL**	**3**	**0**	**0**	**3**	**3**

Pre-requisites:	Course Assessment methods
No pre-requisites	Continuous (CT) and end assessment (EA). CT+EA

Course Outcomes	• CO1: Develop optimization models for any engineering system. • CO2: Solve optimization problems. • CO3: To learn about modern optimization methods
Topics Covered	**Introduction:** Model, Steps in modeling: Formulation, Deduction, Interpretation, Ten Principles of Modeling, Design Process, Differences Between Engineering Analysis and Design, Comparison Between Conventional Design and Optimal Design. **(4)** **Introduction to optimization model formulation in engineering design:** Objective & Constraint function, Development of objective & constraint functions, Example formulations, Classification of optimization models**. (4)** **Solution Techniques:** Linear programming: Linear Programming Problem, Graphical Solution, Linear Programming in Standard Form, Handling Inequality Constraints, Handling Variables Unrestricted in Sign, Basic Definitions in LP, Canonical reduction, Principles of the Simplex Method, Simplex Method in TABLEAU Form, Computational Problems, Big M Simplex Method, Two-Phase Simplex Method. Revised Simplex Method, Integer Programming, Fixed Charge Problem Formulation. **(8)** **Nonlinear programming – 1:** Single variable unconstrained minimization, Basic Definitions, Optimality Criteria, Introduction to line search techniques**. (4)** **Nonlinear programming – 2:** Multivariable unconstrained optimization, Optimality Criteria, Introduction to various Algorithms for Minimization. **(4)** **Nonlinear programming – 3:** Multivariable constrained optimization, Equality Type Constraints, Lagrange Multiplier, Inequality type Constraints, Optimality Criteria Transformation Methods, Penalty Function Algorithm, Linearization Methods, Reduced Gradient Method, quadratic programming, Introduction to projected augmented Lagrangian Method. **(10)** **Introduction to Advanced topics:** Dynamic & Geometric programming, Chance constrained & Multiple objective optimization, Soft computing techniques - Genetic Algorithm, Simulated Annealing Technique, Fuzzy logic, Artificial Neural Networks. **(8)**
Text Books, and/or reference material	***Text Books:*** 1. Engineering Hydrology by R. S. Varshney, Nem Chand & Bros. Roorkee (U.P.) 1986. 2. Operations Research – Principles and Practice by A. Ravindran, D. J. Philips and J. J. Solberg, 2nd Edition, John Weley & Sons, New York, 1987. 3. Engineering Optimization – Theory and Practice by S. S. Rao, 3rd Edition, New Age Int. (P) Ltd. Publishers, New Delhi, 2001. 4. Optimization: Theory and Applications by S.S.Rao ***Reference Books:*** 1. Nonlinear Programming – Theory and Algorithms by M. S. Bazaraa & C. M. Shetty, John Wiley & Sons, New York, 1990. 2.Introduction to Optimum Design by J. S. Arora, McGraw Hill Int. Editions, McGraw Hill Book Co. Singapore, 1989.

Mapping of Course Outcomes Cos→POs (mentioning Correlation Level)

	Independent investigation capability	Technical Reportng	Mastery on Specialization	Advanced knowledge & Design Solution	Team work in Multidisciplinary Project
	PO1	PO2	PO3	PO4	PO5
CO1	-	-	-	-	-
CO2	-	-	-	-	-
CO3	-	-	-	-	-

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