Sanjivani College of Engineering, Kopargaon
(An Autonomous Institute) Affiliated to Savitribai Phule Pune University.
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Approved by AICTE, ISO 9001-2015 Certified, Accredited by NBA, Accredite NAAC,
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Department of Structural Engineering

COURSE STRUCTURE and SYLLABUS- 2020 PATTERN

M.Tech. (Structural Engineering)

Profile: The Sanjivani College of Engineering, Kopargaon was established in the year 1983, and Structural Engineering Department is part of the institute since 2020-2021. The Department has 7 qualified faculty members & 4 well equipped laboratories and is now recognized as one of the prominent and known for academic excellence in the Pune University area. Beside high quality teaching and instruction at UG and PG, the department is actively involved in basic and applied research and consultancy services. The department is providing quality technical and advisory support through consultancy to various private construction agencies, State Government, Central Government project.

Structural Engineering

Structural Engineering is a specialty within the field of Civil Engineering, which focuses on the analysis, and design of engineering structures, which includes bridges, flyovers, dams, buildings, stadiums, and tunnels, marine and offshore structures to withstand the loads and remain safe, stable and secure throughout their use. Infrastructure development is the only measure of development of any country. Thus, in a developing nation like India, Structural engineering will play an important role in the development of Nation and will provide better job opportunities to the structural engineering graduates. Structural Engineers can work independently as an Entrepreneur to shape the world around them.

Apart from academics we arrange regular interaction of our stake holders like students, parents and faculty along with a Training and Placement cell which works full time for bright future of our students.

The Infrastructure development in India is growing at a faster rate and there are many career paths for structural engineers. Structural engineers are essential in government sector, public and private sector and Multinational companies, to build various mega projects like highways, Industrial structures, smart cities, and reservoirs etc. The next decade will be most demanding and rewarding for Structural engineering graduates.

VISION OF THE INSTITUTE

To Develop World Class Professionals through Quality Education.

MISSION OF THE INSTITUTE

To create Academic Excellence in the field of Engineering and Management through Education, Training and Research to improve quality of life of people.

VISION OF THE DEPARTMENT

To Achieve National and International Recognition in Structural Engineering Education.

MISSION OF THE DEPARTMENT

To nurture graduates as problem solvers who develop innovative solutions for industry related problems.

To create graduates who possess the knowledge and skills for future challenges and lifelong learning as a structural engineer.

To maintain healthy environment in the department which encourage our graduates and faculty to achieve their best in academics and research.

Program Educational Objectives (PEOs)

PEO 1: To impart basic and advanced knowledge of structural engineering so that graduates are able to analyze and solve the industrial problems..

PEO 2: To provide hands on training to the graduates on latest equipment and latest software to make them suitable for industries and consultancies.

PEO 3: To equip the graduates with basic professional skills to work as a team member or leader for the socio-economical growth of the nation.

PEO 4: To motivate the graduates to pursue research, higher education and entrepreneurship in the structural engineering field.

Program Specific Outcomes (PSOs)

PSO1: Graduates will be able to provide the best possible solutions for the analysis and design problems using conventional and modern engineering tools for the sustainable development related to the structural engineering.

PSO2: Graduates will be able to identify societal and industrial needs through allied courses such as planning and drawing, infrastructural engineering, project management, materials, mechanics, etc.

M.Tech. (Structural Engineering) - Course Structure

w.e.f. 2020-21

List of Abbreviations			
Abbreviation	**Full Form**	**Abbreviation**	**Full Form**
PC	Professional Core	ESE	End-Semester Evaluation
PE	Professional Elective	OR	Oral Examination
OE	Open Elective	PR	Practical Examination
ISE	In-Semester Evaluation	TW	Continuous Term work Evaluation
CA	Continuous Internal Assessment	AC	Audit Course
MLC	Mandatory Learning Course	PRJ	Project/Seminar

First Year (Semester I)

Cat	Course Code	Course Title	Teaching Scheme (Hrs. /Week)		Credits	Evaluation Scheme (Marks)						
						Theory			OR	PR	TW	Total
			L	P		ISE	ESE	CA				
PC	ST601	Design of Advanced Steel Structures	3	-	3	30	50	20	-	-	-	100
PC	ST602	Advanced Design of Foundations	3	-	3	30	50	20	-	-	-	100
PE	ST603	**Elective – I** -Theory and Design of Plates and Shells. -Advanced Concrete Technology -Composite Materials	3	-	3	30	50	20	-	-	-	100
PE	ST604	**Elective – II** - Liquid Retaining Structures - Pavement and Cross Drainage Works Design -Theory of Elasticity and Plasticity	3	-	3	30	50	20	-	-	-	100
PC	ST605	Structural Design Lab-I	-	4	2	-	-	-	50*	-	-	50
PC	ST606	Advanced Concrete Lab	-	4	2	-	-	-	50*	-	-	50
MLC	ST607	Research Methodology and IPR	2	-	2	-	50	-		-	-	50
AC	AC101	Audit Course-1	2	-	-	-	-	-	-	-	-	-
		Total	16	8	18	120	250	80	100	-	-	550

*Oral will be based on the term work submitted by the student.

* Students should select audit course from the list provided or the department will finalize the audit course for the students.

First Year (Semester II)

Cat	Course Code	Course Title	Teaching Scheme (Hrs. /Week)		Credits	Evaluation Scheme (Marks)						
						Theory			OR	PR	TW	Total
			L	P		ISE	ESE	CA				
PC	ST608	Structural Dynamics and Earthquake Engineering	3	-	3	30	50	20	-	-	-	100
PC	ST609	Design of Advanced Concrete Structures.	3	-	3	30	50	20	-	-	-	100
PE	ST610	Elective – III - Design of Offshore Structures -Design of High Rise Structures - Structural Audit and Health Monitoring	3	-	3	30	50	20	-	-	-	100
PE	ST611	Elective – IV - FEM in Structural Engineering -Buckling of Structures -Design of Industrial Structures	3	-	3	30	50	20	-	-	-	100
PC	ST612	Structural Audit Lab	-	4	2	-	-	-	50*	-	-	50
PC	ST613	Structural Design Lab-II	-	4	2	-	-	-	50*	-	-	50
PRJ	ST614	Mini Project	-	4	2	-	-	-	50*	-	-	50
AC	AC201	Audit Course-2	2	-								
		Total	14	12	18	120	200	80	150	-	-	550

*Oral will be based on the term work submitted by the student.

*** Audit course 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Addition
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

Second Year (Semester III)

Cat	Course Code	Course Title	Hrs./Week			Credits	Evaluation Scheme (Marks)						
							Theory			OR	PR	TW	Total
			L	T	P		ISE	ESE	CA				
PE	ST701	Elective - V -Design of Prestressed Concrete Structures	3	-	-	3	30	50	20	-	-	-	100

		-Theory of Advanced Composite Plates and Shells -Bridge Engineering											
OE		**Open Elective**	3	-	-	3	30	50	20	-	-	-	100
	CE702	Industrial Safety and Management											
	ET702	Machine Learning											
	MB702	Start up and Venture Management											
	ME702	Project Planning and Operation Research.											
	ST702	Computational Techniques											
	CO702	Recent Trends in Computer Technology.											
PRJ	ST703	Dissertation Phase – I	-	-	20	10	--	--	--	50	-	-	50
		Total	6	-	20	16	60	100	40	50	-	-	**250**

Second Year (Semester IV)

Cat	**Course Code**	**Course Title**	**Hrs./Week**			**Credits**	**Evaluation Scheme (Marks)**						
			L	**T**	**P**		**Theory**			**OR**	**PR**	**TW**	**Total**
							ISE	**ESE**	**CA**				
PRJ	ST704	Dissertation Phase-II	-	-	32	16	--	--	--	100	-	50	150
		Total	-	-	32	16	--	--	--	100	-	50	150

Total Credits for the Programme = 18 + 18 +16 +16 = 68

Rules and Regulations for Evaluation Scheme

Every subject is evaluated in three parts

1) Continuous Internal Assessment (CIA):- 20 Marks.
2) In-Semester Examination (ISE):- 30 Marks
3) End-Semester Examination (ESE):- 50 Marks

Continuous Internal Assessment: - Assessment will be done by subject teacher based on the performance of students during the semester. For each subject, teacher will conduct three tests for 20 marks each, which will be scaled out of 10 in the final assessment. Remaining 10 marks will be assessed through assignments (05 Marks) and self-learning (05 Marks)

In-Semester Examination:-In-Semester examination will be based on 50% syllabus of the subject for 30 Marks.

End-Semester Examination: - End-Semester examination will be based on entire syllabus of the subject for 50 Marks in which the topic covered in the In-semester examination will be assessed for 10 marks and remaining syllabus will be for 40 marks.

Semester I

Professional Core (ST601) – Design of Advanced Steel Structure (Credits - 3)

Teaching Scheme: 3 hrs/week **Evaluation Scheme**

Continuous Internal Assessment (CIA): 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks
Total: 100 Marks

Course outcomes: At the end of the course, students will be able to

1. Remember the basic concepts of design of bolted and welded connections used for beams and columns.
2. Understand the fundamental concepts of design of steel Chimneys.
3. Apply the basic concepts to design the Transmission and Microwave tower.
4. To design the formwork used for different RCC structural elements.

Course Contents:

Unit 1: Design of Eccentrically Loaded Connections: Eccentric and moment connections Beam to beam, Beam-column connections subjected to combined bending and shear, bolted framed connections, seated connections and moment connections, Welded bracket and moment resisting connections. Seismic analysis of steel connections.

Unit 2: Design of Steel Chimneys: Different types, components parts, Lined and unlined chimneys, various forces acting on steel chimneys, Variation of wind force across the height, Design of self-supporting steel chimneys, Design of base plate, Design base connection.

Unit 3: Design of Transmission Towers: Transmission Towers, Introduction, structural configuration, bracing systems, analysis and design, Codal provision for design of tower and foundation. Microwave Towers- Introduction, Types, structural configuration, function, analysis and design.

Unit 4: Design of Formwork: Design of Formwork: Requirements and selection of formwork, different material used. Formwork design: concepts, formworks design for foundations, walls, columns, slab and beams. Overhead water tank, bridges, etc. Formwork failures: causes and case studies in formwork failure, formwork issues in multi- story building construction.

NOTE: The end semester examination will be based on the total syllabus. While for In- semester, half of the syllabus will be considered.

References Books:

1. Subramanian N., *Design of Steel Structure*, Oxford University Press, (2015).
2. Ram Chandra, *Design of Steel Structures*-Vol. II, Standard Book House Delhi, (2017).
3. Dayaratnam P., *Design of Steel Structures*, S. Chand Publication, (2014).
4. Duggal S.K., Limit state Design of Steel Structures, McGraw Hill education, 2016.

5. Peurify, R. L.,Garold, D.A. *Formwork for Concrete Structures*, Mc Graw Hill India, 2015
6. Kumar Neeraj Jha, *Formwork for Concrete Structures*, Tata McGraw Hill Education, 2012.
7. Teaching Resource for Structural Steel Design by Institute for Steel Development and Growth (INSDAG), Kolkatta.
8. IS 14687: 1999, False work for Concrete Structures - Guidelines, BIS, India.
9. I.S.800-2007, General constructions in Steel-Code of Practice, BIS, India.
10. I.S.802-2015, Use of Structural Steel in Overhead Transmission Line Towers- Code of Practice BIS, India
11. I.S.875, Part 1 to 5, and Part-3 (2015 Edition), BIS, India.
12. I.S.6533 Part I & II, Code of Practice for Design and Construction of Steel Chimney, BIS, India

E-resources:

1. https://nptel.ac.in/courses/105/105/105105162/
2. https://onlinecourses.nptel.ac.in/noc21_ce40/preview , www.steel-insdag.org Steel Development and Growth (INSDAG), India

Professional Core (ST602) – Advanced Design of Foundations (Credits - 3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course Outcomes:

At the end of this course students will learn

1. Different types of foundations
2. Analysis/Design of foundations
3. IS and IRC code provisions for foundation.
4. Dynamic Analysis of foundation.

Syllabus:

Unit 1: Static: Open /Deep foundations

1) Sliding /Overturning / Bearing capacity analysis.
2) Analysis for pinned support foundation , fix support foundation
3) Pile foundations
4) Foundation for blast resistance buildings

Unit 2: Dynamic Analysis

General Theory /Evaluation of Design parameters /Analysis & Design of Block type machine foundations /Framed foundation for high speed machinery /Foundation for misc. Machines /Vibration isolation/Construction Details of machine foundations /

NOTE: The end semester examination will be based on the total syllabus. While for In- semester, half of the syllabus will be considered.

Reference Books:

1. Kurian, N. P., *Design of Foundation System*, Narosa Publishing House
2. Bowles, J. E., *Foundation Analysis and Design*, Tata McGraw Hill New York
3. Saran Swami, *Analysis and Design of Substructures*, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/105/105105176/.

Professional Elective (ST603A) – Theory and Design of Plates and Shells (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Use analytical methods for the analysis of thin rectangular and circular plates.
2. Understand the fundamentals of shell structure.
3. Design thin plates and shells.

Syllabus:

Unit 1: Bending of Rectangular Plates: Classical Plate Theory/Kirchhoff Plate Theory: Assumptions, Governing Equation, Boundary Conditions. Navier's Method for bending analysis of Simply Supported Rectangular Plates. Levy's Method for Bending analysis of Rectangular Plates under Different Boundary Conditions. Design of rectangular plates

Unit 2: Bending of Circular Plates: Pure bending of plates – Relations between bending moments and curvature, Particular cases of pure bending of rectangular plates, Synclastic bending and Anticlastic bending.
Circular plates – Differential equation of equilibrium, bending of circular plates with simply supported and fixed boundary conditions subjected to Uniform load and point load. Design of Circular Plates.

Unit 3: Fundamentals of Shells: Basic Concepts of Shell Type of Structures - Classification of shells, Membrane action, Stress-strain and force displacement relations, stress resultants, Load transfer mechanism, Characteristics of shell surfaces, etc.

Unit 4: Theories of Cylindrical shells: Membrane and Bending Theories for Circular Cylindrical Shells, General Theory of Cylindrical Shells:- A circular cylindrical shell loaded symmetrically with respect to its axis, symmetrical deformation, pressure vessels, cylindrical tanks, Design of Cylindrical Shells

Unit 5: Membrane Theory of Shells of Revolution: Introduction to shells of double curvatures, Basic Equations of Equilibrium, Ellipsoidal and Spherical Shells Subjected to Axisymmetric Loads, Conical Shells, Wind Loads. Design of Shells of Revolution.

NOTE: The end semester examination will be based on the total syllabus. While for In- semester, half of the syllabus will be considered.

Reference Books:

1. Timoshenko, S. P. and Woinowsky-Krieger, *Theory of plates and shells*, McGraw-Hill, (1959).

2. Ugural, A. C., *Stresses in plates and shells*, McGraw-Hill, (1999).
3. Varadan, T. K. and Bhaskar, K., *Analysis of plates*, Narosa Publishing House, (1999).
4. Flugge, *Stresses in Shells*, Blaisdell Publishing Co, (1966).
5. Ramaswamy, G. S., *Design and construction of concrete shell roofs*, CBS Publishers& Distributors, (1986).
6. Szilard, R., *Theory and Analysis of Plates – Classical Numerical Methods*, Prentice Hall inc, (1974).
7. Gould, P. L., *Analysis of Shells and Plates*, Springer-Verlag, New York, (1988).
8. Eduard Ventsel and Theodor Krauthammer, *Thin Plates & Shells: Theory, Analysis, & Applications*, CRC; 1st edition, (2001).
9. Jawad, M. H., *Theory and design of plate and shell structures*, Kluwer Academic Pub

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/105/105105176/.

Professional Elective (ST603B) – Advanced Concrete Technology (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to,

- Identify Quality Control tests on concrete making materials
- Understand the behavior of fresh and hardened concrete
- Design concrete mixes as per IS and ACI codes
- Understand the durability requirements of concrete
- Understand the need for special concretes

Course Contents:

Unit 1: Properties of Concrete: Cement and its types: Bogus Compounds – Hydration Process, water requirement for hydration, alkali aggregate reaction. Aggregate: grading curves of aggregates. Admixtures – Chemical and Mineral Admixtures.

Concrete: properties of fresh concrete, w/c ratio, w/b ratio, gel space ratio, maturity concept, cement bond strength, curing and its method. Durability Tests on Concrete – Non Destructive Testing of Concrete.

Unit 2: High Strength Concrete: Microstructure – Manufacturing and Properties – Design of HSC Using Erintroy Shaklok method – Ultra High Strength Concrete. High Performance Concrete – Requirements and Properties of High Performance Concrete – Design Considerations

Unit 3: Special Concretes: Self-Compacting concrete, Polymer Concrete, Fibre Reinforced Concrete - Reactive Powder Concrete – Requirements and Guidelines – Advantages and Applications. Concrete Mix Design: Quality Control – Quality Assurance – Quality Audit – Mix Design Method – BIS Method – DOE Method – Light Weight Concrete, Self-Compacting Concrete.

Unit 4: Concrete Mix Design: Concrete mix design, Basic considerations and choice a mix proportions, various methods of mix designs including IS Code method. Quality control and quality assurance of concrete, Acceptance criteria, Quality management in concrete construction, Inspection and testing of concrete. Non-destructive testing of concrete, core test and load test.

NOTE: End semester examination will be based on entire syllabus. While for in semester examination half of the syllabus will considered.

References Books:

1. Shetty M. S., *Concrete Technology Theory and Practice*, S. Chand & Co. Ltd, (2018).

2. Nayak N.V., *Hand book on advanced concrete technology*, (2020).
3. Gambhir M L, *Concrete Technology: Theory and Practice 5th Edition*, Mc Grow Hill (2013)
4. Pama R. P *Ferrocement – Theory and Applications*, IFIC, (1980).
5. Swamy R.N., *New Concrete Materials, 1st Ed.*, Blackie, Academic and Professional, Chapman & Hall, (1983).
6. Neville A.M and Brooks J.J, *Concrete Technology*, *Second Edition*, Pearson, (2010).
7. E Resources:
   http://52.7.61.3/civil/,https://nptel.ac.in/courses/105/106/105106176/,
   https://onlinelibrary.wiley.com/doi/book/10.1002/9780470950067

Professional Elective (ST603C) – Composite Materials (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to,

1. Study the characteristics of composite materials.
2. Understand the applications of composite materials.
3. Understand the manufacturing of matrix composites.
4. Understand the manufacturing of polymer matrix composites

Course Contents:

Unit 1: Introduction to Composite materials:

Definition – Classification and characteristics of Composite materials. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance

Unit 2: Applications of composite materials:

Metal and Ceramic Matrix Composites, Applications of Composites, Composite Joints, Review, Environmental Issues

Unit 3: Manufacturing of Matrix Composites:

Manufacturing of Metal Matrix Composites Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

Unit 4: Manufacturing of Polymer Matrix Composites:

Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepages – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

NOTE: End semester examination will be based on entire syllabus. While for in semester examination half of the syllabus will considered.

References Books:

1. Agarwal.B.D, Broutman.L.J, and Chandrashekara.K. *Analysis and Performance of Fiber Composites*, John-Wiley and Sons, (2006).
2. Daniel.I.M, and Ishai.O, *Engineering Mechanics of Composite Materials*, Oxford University Press,

(2005).

3. Hyer M.W., and White S.R., *Stress Analysis of Fiber-Reinforced Composite Materials*, D.Estech Publications Inc., (2009).
4. Jones R.M., *Mechanics of Composite Materials*, Taylor and Francis Group (1999).
5. Mukhopadhyay.M, *Mechanics of Composite Materials and Structures*, Universities Press, India, (2005).
6. Crawley, E and de Luis, J., *Use of piezoelectric actuators as elements of intelligent structures*, AIAA Journal, Vol. 25 No 10, Oct 1987, pp. 1373-1385.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/108/105108124/, https://www.springer.com/gp/book/9781493950157

Professional Elective (ST604A) – Design of liquid retaining structures (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course outcomes:

After studying this course, students will be able to:

1. Analysis of the liquid retaining structures.
2. Analyze and execute the design of liquid retaining structures.
3. Analyze and execute the various methods of designing liquid retaining structures

Course Contents:

Unit 1: Water Storage structures Properties of un-cracked section – Calculation of thickness and reinforcement for Liquid retaining structure, Design and Detailing of underground, Ground Level reservoirs

Unit 2: Elevated service reservoir – Rectangular and Circular type only flat bottom, Design of staging for wind and earthquake forces, Effect of joint reactions and continuity

Unit 3: Overhead water tanks Circular, Rectangular on framed and Shaft type of Staging systems as per IS 3370 Parts 1 to 4.

Unit 4: Introduction, types, function, codal provisions, methods of analysis and design of circular, square, and rectangular water tanks resting on ground.

Reference Books:

1. Punmia, B.C. Jain, Ashok K. , Jain, Arun K., *Reinforced Concrete Structures Vol. II*, Laxmi Publications, New Delhi
2. Sinha, N.C., and Roy, S.K., *Fundamentals of Reinforced Concrete*, S. Chand & Co. Ltd, New Delhi.
3. Anchor, R. D., *Design of Liquid-retaining Concrete Structures,* Survey University.
4. James Keith Green, Philip Harold Perkins, *Concrete Liquid Retaining Structures: Design, Specification and Construction*.
5. IS: 3370-Indian Standard code of practice for concrete structures for storage of liquids, Bureau of Indian Standards, New Delhi.

Professional Elective (ST604B) – Pavement and Cross-Drainage work Design (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Ability to analyse the stresses in the pavement.
2. Ability to design flexible pavement by various methods.
3. Ability to design rigid pavement by various methods

Unit 1: Pavement Materials: Types and Component parts of Pavements - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Bituminous mix design methods, specifications and testing – Superpave mix design and material testing. Factors affecting Design and Performance of Pavements**:** Comparison between Highway and Airport pavements - Functions and Significance of Subgrade properties, Various Methods of Assessment of Subgrade Soil Strength for Pavement Design - Causes and Effects of variation in Moisture Content and Temperature - Depth of Frost Penetration.

Unit 2: Analysis & Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2- layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels - ESAL – VDF - Repeated Loads and EWL factors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical, Analytical and Mechanistic-empirical approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods – Mechanistic Empirical Pavement Design – Guidelines and examples.

Unit 3: Analysis & Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacing, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of Design - – Mechanistic Empirical Pavement Design.

Unit 4: Alternate Materials for durable pavements: Artificial aggregates – Industrial waste materials – fly ash, pond ash, marble dust, GGBS, Geo-polymer coated aggregates – waste plastics, fibres – recycled aggregate and RAP. Nanomaterials for pavements: Nano clay, Nano silica, Carbon Nano Tube (CNT) and other nanomaterials – warm mix technologies: additives and modifiers, design guidelines

Unit 5: Cross drainage works: Types- selection of suitable type of CD works- aqueduct and Syphon aqueduct, determination of maximum flood discharge and waterway for drain, Super Passage, Level Crossing, Inlet and Outlet, fluming of canal- uplift pressure on underside of barrel roof and

at the floor of the culvert- design of bank connections.

Unit 6: Canal regulation works: Canal fall- necessity and location- types of falls- Cross regulator and distributory head regulator- their functions, Silt control devices, Canal escapes- types of escapes.

References Books:

1. Yoder and Witezak, *Principles of Pavement Design*, John Wiley and sons, (1975).

2. Yang, *Design of functional pavements*, McGraw-Hill, (1973).

3. Harold, N. Atkins, *Highway Materials, Soils, and Concrete*, Prentice Hall, (2002).

4. Robert, D. Krebs, *Highway Materials*, McGraw Hill Text, (1971).

5. IRC: 37-2012, Guidelines for the Design of Flexible Pavements.

6. IRC: 58-2015, Guidelines for the Design of Rigid Pavements.

7. RRL, DSIR, Concrete Roads, HMSO, IRC Publications

8. Lavin, P G, *Asphalt Pavement*s, Spon Press, (2003).

9. MORTH Specifications for Road and Bridge Works, Indian roads Congress

10. Kett, I, *Asphalt Materials & Mix Design* Manual, Noyes Publications, (1999).

11. Kim, Y R, *Modelling of asphalt Concrete*, ASCE Press, (2008).

12. Mechanistic Empirical Pavement Design Guide, NCHRP, TRB, (2008).

EResources:http://52.7.61.3/civil/,https://nptel.ac.in/courses/105/105/105105177/, https://ocw.snu.ac.kr/node/2695

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Professional Elective (ST604C) – Theory of Elasticity and Plasticity (Credits - 3)

Teaching Scheme: 3 hrs/week **Evaluation Scheme**

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

Course outcomes: At the end of the course, students will be able to

5. To apply the basic concepts to understand the concept of elasticity.
6. To apply the basic concepts of stress and strain to derive the equations of elasticity.
7. To derive the compatibility equations of elasticity.
8. To solve 2-D problems of elasticity.
9. To analyze the bars subjected to torsion.

Course Contents:

Unit 1: Introduction to Elasticity: Displacement, Strain and Stress Fields, Constitutive Relations, Cartesian Tensors and Equations of Elasticity.

Unit 2: Strain and Stress Field: Elementary Concept of Strain, Stain at a Point, Principal Strains and Principal Axes, Compatibility Conditions, Stress at a Point, Stress Components on an Arbitrary Plane, Differential Equations of Equilibrium, Hydrostatic and Deviatoric Components.

Unit 3: Equations of Elasticity: Equations of Equilibrium, Stress- Strain relations, Strain Displacement and Compatibility Relations, Boundary Value Problems, Co-axiality of the Principal Directions.

Unit 4: Two-Dimensional Problems of Elasticity: Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates.

Unit 5: Torsion of Prismatic Bars: Saint Venant's Method, Torsion of Rectangular Bar. Torsion of elliptical cross section bar, equilateral triangular cross sectional bar, Torsion of hollow c/s bar, Torsion of hollow elliptical c/s bar.

Unit 6: Theory of Plasticity: Physical Assumptions – Yield criteria, Failure theories, Yield criteria, Plastic work, Flow rate, and Plastic potential, plastic stress strain relationship.

References Books:

1. Timoshenko, S. and Goodier, J. N., *Theory of Elasticity*, McGraw Hill, (1961).
2. Sadd, M. H., *Elasticity*, Elsevier, (2005).
3. Ragab, A. R. and Bayoumi, S. E., *Engineering Solid Mechanics*, CRC Press, (1999).
4. Ameen, M., *Computational Elasticity*, Narosa, (2005).
5. Kazimi, S. M. A., *Solid Mechanics*, Tata McGraw Hill, (1994).

6. Srinath, L. S., *Advanced Mechanics of Solids*, Tata McGraw Hill, (2000).
7. Sadhu Sing, *Theory of Plasticity*, Khanna Publisher, New Delhi, (1988).
8. Chakrabarty, J., *Theory of Plasticity*, Elsevier Butterworth- Heinemann UK.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/105/105105177/, https://ocw.snu.ac.kr/node/2695

Professional Core (ST605) – Structural Design Lab (Credits - 2)

Teaching Scheme: 4 hrs/week

Evaluation Scheme

Oral : 50 Marks

Course outcomes*:* At the end of the course, students will be able to

1. Design the different eccentric connections used in different steel structure.
2. Design the Steel chimney, Transmission tower and formwork using relevant I.S.Code.

Term work:

A) Design and detailed drawing of Industrial Building / Transmission Tower / Steel formwork by individual student using latest relevant IS codes.

B) Design of Steel chimney or Transmission tower using any suitable software.

Professional Core (ST606) – Advanced Concrete Lab (Credits - 2)

Teaching Scheme: 4 hrs/week

Evaluation Scheme

Oral Exam: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Design high grade concrete and study the parameters affecting its performance.
2. Conduct Non Destructive Tests on existing concrete structures.
3. Apply engineering principles to understand behavior of structural/ elements.

List of Experiments/Assignments:

1. Study of stress-strain curve of high strength concrete.
2. Effect of cyclic loading on steel.
3. Behavior of Deep Beam under flexure, Shear and Torsion.

Reference Books:

1. Properties of Concrete, Neville A. M., 5th Edition, Prentice Hall, 2012.
2. Concrete Technology, Shetty M. S., S. Chand and Co., 2006.

Mandatory Learning Course (ST607) – Research Methodology and IPR

Teaching Scheme: 2 hrs/week

Evaluation Scheme

Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Course Contents:

Unit 1: Research Science: Meaning of research, types and objectives of research, Research approaches, Significance of research, Research process, Criteria of good research, Problems Encountered by Researchers in India. Research Proposal-Format of research proposal

Unit 2: Literature Review and Research Design: Definition of literature and literature survey, need of literature survey, sources of literature, elements and objectives of literature survey, styles of literature survey, and strategies of literature survey. Concept and Importance in Research, Features of a good research Design: Exploratory Research Design, concept, types and uses, Descriptive Research Designs: concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

Unit 3: Data collection ,Measuring, Sampling and Scaling: Classification of data, benefits and drawbacks of data, evaluation of data, qualitative methods of data collection, methods of qualitative research, Sampling, sample size, sampling strategy, attitude measurement and scaling, types of measurements, criteria of good measurements, classification of scales.

Unit 4: Advanced data analysis techniques- Correlation and regression analysis, Descriptive statistics,

inferential statistics, Factor analysis

Unit 5: Intellectual Property: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: international cooperation on Intellectual Property. Procedure for rants of patents, Patenting under PCT. Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

References Books:

1. Research Methodology: concepts and cases—Deepak Chawla and Neena Sondhi,Vikas Publishing House Pvt.Ltd. (ISBN 978-81-259-5205-3)
2. Research Methods for Business—Sekaran—Wiley,India
3. Research Methodology: Methods and Trends', by Dr. C. R. Kothari--- New Age International Publishers.
4. Research Methods in Education---Louis Cohen,Manion,Morrison---Routledge(Taylor &Francis Group) / -- Cambridge University Press India Pvt. Ltd.-ISBN-978-0-415-58336-7
5. Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville
6. Research Methodology: A Step by Step Guide for Beginners', by Ranjit Kumar
7. Research in Education---John Best and James Kahn,Prentice Hall of India Pvt.Ltd.

Semester II

Professional Core (ST 608) Structural Dynamics and Earthquake Engineering (Credit 3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme

Continuous Internal Assessment: 20 Marks

Insem. Evaluation: 30 Marks

End Sem. Evaluation: 50 Marks

Course Outcomes:

At the end of the course, students will be able to

1. Know the terminology related to earthquake and characteristics of earthquake motion.
2. Find response of free and force vibration (harmonic, periodic and transient) of SDOF system.
3. Memorize the concepts MDOF systems its response to earthquake.
4. Find natural frequency and mode shapes of MDOF system
5. Summarize the earthquake resistance design philosophy.
6. Calculate the earthquake forces using IS code.

Course Contents:

Unit 1: Introduction -Definitions, Introduction to Seismic hazards, Earthquake phenomenon, Seismic zones of India, Earthquake size, Isoseismic Maps, Earthquake magnitude, Tsunami.

Unit 2: Single Degree of Freedom System- Characteristics of dynamic loading, lumped and continuous mass model, Single-Degree-of Freedom (SDOF) systems, Free vibrations,

Unit 3: Response to Dynamic Loading- Harmonic Loading, Harmonic base motion, Resonance, Dynamic Amplification Factor, Transmissibility, and Vibration Isolation. Response to general dynamic loading.

Unit 4: Multi-Degree of Freedom (MDOF) systems- Formulation of equations of motion, Free-vibrations, Frequencies and mode shapes. Multistoried buildings with symmetric and unsymmetrical plan, Torsional response.

Unit 5: Earthquake resistant design philosophy- Introduction to seismology, Strong motion and their measurement, Characteristics of earthquake ground motion, Response Spectrum.

Unit 6: Provisions of IS: 1893-2016-Part-I - Estimation of earthquake forces using the code.

(Equivalent Static Force Method and Response Spectrum Method)

Reference Books:

1. Clough, R. W. and Penzien, J., *Dynamics of Structures*, 2nd ed, CBS Publications, India (2015).
2. Paz, M., *Structural Dynamics- theory and Computations*, 2nd ed, CBS Publications, India (2004).

3. Chopra, A. K., *Dynamics of Structures: Theory and Applications to Earthquake Engineering*, 5th ed, Pearson Publications, (2020).
4. Agrawal, P. and Shrikhande, M., *Earthquake Resistant Design of Structures*, PHI Publications, New Delhi (2017)
5. Manohar, S. N. and Madhekar, S. N., *Seismic Design of RC Buildings*, Springer (2014).

E Resources: http://52.7.61.3/civil/, https://ocw.tudelft.nl/course-lectures/2-1-structural-dynamics-part-1/, https://nptel.ac.in/courses/105/106/105106151/

Reference Codes

1. IS 1893(Part 1): 2016, Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings, 6th Revision.
2. IS 13920:2016, Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, 1st Revision.
3. IS 4326:1993, Earthquake Resistant Design and Construction of Buildings, 3rd Edition

Profession Core (ST 609) – Design of Advanced Concrete Structures -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to,

1. Students learn IS code specification and codal provisions for design of RCC structures.
2. Understand the special detailing requirement in flat slab.
3. Students able to apply Airy's theory, Janssen's theory for analysis of bunker silos structures.
4. Students able to apply Silo theory for analysis silos structures.
5. Students able to design RCC structural elements by limit state design.
6. Students understand the concept of ductile detailing.

Course Contents

Unit 1: Design Philosophy-Review of limit state design of beams, slabs and columns according to IS Codes. Calculation of deflection and crack width

Unit 2: Flat Slab- Design of Flat Slabs- Modes of failure of flat slabs. I.S code Provisions for the design of simple and continuous flat slabs. Special detailing requirements of flat slabs.

Unit 3: Design of Bunkers- Introduction, components of bunkers, Airy's theory, Janssen's theory, IS code specification, design of rectangular/square bunker.

Unit 4: Design of Silos- Parameters for silos design, design of silos using working stress method, Application of silo theory.

Unit 5: Design of Special RC Elements- Design of slender columns - Design of RC walls - ordinary and shear walls. Strut and tie method of analysis for corbels and deep beams, Design of corbels, Deep-beams and grid floors, Design of pile cap foundation and raft/strip foundation.

Unit 6: Ductile Detailing- Concept of Ductility – Detailing for ductility – Design of beams, columns for ductility - Design of cast-in-situ joints in frames.

Reference Books:

1. Shah V L and Karve S R., *Limit State theory and design of reinforced concrete*, 8th edition, Structures Publishers.(2005)
2. G.S. Ramaswamy, *Design and Construction of Concrete shell Roofs*, McGraw Hill.

3. Gambhir.M.L., *Design of Reinforced Concrete Structures*, Prentice Hall of India, 2012.
4. Purushothaman, P, *Reinforced Concrete Structural Elements: Behaviour Analysis and Design*, Tata McGraw Hill, 1986.
5. Krishnaraju N, *Design of reinforced concrete structures (IS 456:2000),* 3rd edition, CBS Publishers & Distributors.
6. Punmia B. C., Jain A. K. and Jain A. K., *Limit State Design of R.C. Structures* Laxmi Publications Pvt. Ltd., (2008).
7. Vergese P. C., *Limit State Design of Reinforced Concrete*, PHI Learning Pvt. Ltd., (2008).
8. IS: 456, IS: 875, SP16, SP34 - relevant IS codes and Explanatory handbooks to be used.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/105/105105105/
https://drive.google.com/file/d/1aPNNyQvjB4B0ic_cWB9rmAPbo2Jd2OsW/view

Elective III (ST 610 A) – Design of Offshore Structures -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1) Determine the forces due to ocean waves.
2) Analyse and Design offshore structures like platforms, helipads, jackets, towers etc.
3) Summarize the different types of loads on offshore structures.
4) Analyze the offshore structures.
5) Design offshore structures.

Course Contents:

Unit 1: Wave Theories-Wave generation process, small, finite amplitude and nonlinear wave theories.

Unit 2: Offshore Structure Modelling- Different types of offshore structures, concepts of fixed platform jacket and deck- jacket concepts, redundant framing arrangements, launch and lift jackets, simple deck configuration for lift and float over installations,

Unit 3: Loads on Offshore Structures- Types of loads –gravity, environmental, load combinations, load estimation and distribution, materials used and corrosion for offshore structures.

Unit 4: Analysis of Offshore Structures- Static method of analysis, Fatigue analysis, Ship impact analysis.

Unit 5: Foundation and Analysis -foundation analysis and dynamics of offshore structures.

Unit 6: Design of Offshore Structures- Design of platforms, helipads, Jacket tower, analysis and design of mooring cables and pipe lines.

Reference Books:

1. API RP 2A-WSD, *Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design*- API Publishing Services, 2005
2. Chakrabarti, S.K., *Handbook of Offshore Engineering* by, Elsevier, 2005.
3. Chakrabarti, S.K., *Hydrodynamics of Offshore Structures*, WIT press, 2001.
4. Dawson.T.H., *Offshore Structural Engineering*, Prentice Hall Inc Englewood Cliffs, N.J. 1983.
5. James F. Wilson, *Dynamics of Offshore Structures*, John Wiley & Sons, Inc, 2003.

6. Reddy, D.V. and Arockiasamy, M., *Offshore Structures*, Vol.1 and Vol.2, Krieger Publishing Company, 1991.
7. Turgut Sarpkaya,, *Wave Forces on Offshore Structures*, Cambridge University Press, 2010.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/114/106/114106043/

Elective III (ST 610 B) – Design of High Rise Structures -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Analyse, design and detail Transmission/ TV tower, Mast and Trestles with different loading conditions.
2. Analyse, design and detail the RC and Steel Chimney.
3. Analyse, design and detail the tall buildings subjected to different loading conditions using relevant codes.
4. Summarize the behavior of various structural systems.
5. The graduates are expected to apply technical design principles and techniques such as p-delta effect, soil-structure interaction, etc for a design of high-rise building.

Course Contents:

Unit 1: Design of transmission/ TV tower, Mast and trestles: Introduction, Configuration, bracing system.

Unit 2: Analysis and design of Towers for vertical transverse and longitudinal loads

Unit 3: Introduction to different types of foundation systems like Pile foundation, raft foundation etc, Foundation design for varied soil strata.

Unit 4: Tall Buildings: Structural Concept, Configurations, various systems, Wind and Seismic loads, Dynamic approach,

Unit 5: Structural design, considerations and IS code provisions for Tall buildings. Fire fighting design provisions.

Unit 6: Cooling towers: types, components, design forces, analysis and design.

Reference Books:

1. Varyani U. H., *Structural Design of Multi-storeyed Buildings*, 2nd Ed., South Asian Publishers, New Delhi, (2002).
2. Taranath B. S., *Structural Analysis and Design of Tall Buildings*, Mc Graw Hill,(1988).
3. Shah V. L. and Karve S. R., *Illustrated Design of Reinforced Concrete Buildings (GF+3storeyed)*, Structures Publications, Pune, (2013).
4. *Design of Multi Storeyed Buildings*, Vol. 1 & 2, CPWD Publications, (1976).

5. Smith Byran S. and Coull Alex., *Tall Building Structures*, Wiley India.(1991).
6. Wolfgang Schueller., *High Rise Building Structures*, Wiley, (1971).

E Resources: http://52.7.61.3/civil/,

Reference Codes:

1. IS:6533 (Part 2) –Code of Practice for Design and Construction of Steel Chimney
2. IS:4998 (Part 1)- Criteria for Design of Reinforced Concrete Chimneys
3. IS: 4091 Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.
4. IS 16700: 2017 on 'Criteria for structural Safety of Tall Concrete Buildings'.

Elective III (ST 610) -- Structural Audit and Health Monitoring -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes: At the end of the course, students will be able to,

1. Diagnosis the distress in the structure understanding the causes and factors.
2. Assess the health of structure using static and dynamic field methods.
3. Study the static and dynamic field tests.
4. Study the behavior of structures.
5. Study the specifications for structural repair work.
6. Able to suggest repairs and rehabilitation measures of the structure.

Course Contents:

Unit 1: Structural Health- Factors affecting Health of Structures, Causes of Distress, Regular Maintenance.

Unit 2: Structural Health Monitoring: Concepts, Various Measures, and Structural Safety in Alteration.

Unit 3: Structural Audit- Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures. Non-destructive testing of concrete, steel structures, Various NDT tests, codal provisions, Proof Load testing.

Unit 4: Static and Dynamic Field Testing- Types of Static Tests, Simulation and Loading Methods, sensor systems and Hardware requirements, Static Response Measurement. Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition Systems, Remote Structural Health Monitoring.

Unit 5: Retrofitting of structures – Introduction, types, factors, materials used, design and techniques. Behavior of structures (bridge/building/highway/industry)

Unit 6: Introduction to Repairs and Rehabilitations of Structures- Case Studies (Site Visits), piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique.

Reference Books:

1. Victor Giurglutiu, *Structural Health Monitoring with Wafer Active Sensors*, Academic Press Inc, (2007).

2. Kaustubh Raiker and Chetan Raiker, *Structural Health Evalution Vis – A – Vis Prescriptive "Mandatory Format of Structural Audit*, Proceeding by Indian Society of Structural Engineers, (2020).
3. Arun Kelkar, *Building: Structural Audit, Repairs and Restoration*, Majestic Publishing House (2018).
4. Handbook on Repair and Rehabilitation of RCC Buildings, by CPWD, Govt. of India.2002.\
5. IS code IS CODE 13311 Part-1: UPV Test
6. Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, *Structural Health Monitoring*, John Wiley and Sons, (2006).
7. Douglas E Adams, *Health Monitoring of Structural Materials and Components Methods with Applications*, John Wiley and Sons, 2007.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/114/106/114106046/, https://www.springer.com/gp/book/9789811609442,
https://www.ripublication.com/ijcer_spl/ijcerv5n4spl_17.pdf

Elective IV (ST 611 A) – FEM in Structural Engineering -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes:

At the end of the course, students will be able to

1. Use finite element method for structural analysis.
2. Execute the finite element program/software.
3. Solve continuum problems using finite element analysis.

Course Contents:

Unit 1: Introduction to FEA- Introduction, Basic Concepts of Finite Element Analysis, Introduction to Elasticity, Steps in Finite Element Analysis

Unit 2: Finite Element Formulation Techniques - Virtual Work and Variational Principle, Galerkin Method, Finite Element Method: Displacement Approach, Stiffness Matrix and Boundary Conditions

Unit 3: Element Properties- Natural Coordinates, Triangular Elements, Constant Strain Triangle, Linear Strain Triangle, Rectangular Elements, Lagrange and Serendipity Elements, Axisymmetric Element, Shape functions, Isoparametric Formulation, Stiffness Matrix of various elements.

Unit 4: Analysis of Frame Structures-Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Element Analysis of Continuous Beam, Plane Frame Analysis, Analysis of Grids

Unit 5: FEM for Plates and Shells:- Introduction to Plate Bending Problems, DOFs, Finite Element Analysis of Plates and Shells

Unit 6: Additional Applications of FEM –a) Thermal and Fluid Problems: Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 1-D heat conduction, heat transfer through thin fins; Potential flow problems

b) Dynamic Problems: Formulation of dynamic problems, consistent and lumped mass matrices for 1-D and 2-D element, Solution of eigenvalue 1-D problems: Transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method.

c) Axisymmetric Problems

d) Software Applications

Reference Books:

1. C.S. Krishnamoorty, *Finite Element Analysis*, Tata McGraw-Hill

2. David V. Hutton, *Fundamentals of Finite Element Analysis*, McGraw Hill
3. D. Maity, *Computer Analysis of Framed Structures*, I.K. International Pvt. Ltd. New Delhi
4. Erik G. Thompson, *Introduction to the Finite Element Method: Theory, Programming and Applications*, John Wiley
5. H. C. Martin and G. F. Carey, *Introduction to Finite Element Analysis - Theory and Application*, New York, McGraw-Hill
6. Irving H. Shames, Clive L. Dym, *Energy and Finite Element Methods in Structural Mechanics*; New Age International
7. K. J. Bathe, *Finite Element Procedures*, Prentice-Hall of India, New Delhi, India
8. M. Mukhopadhyay, *Matrix, Finite Element, Computer and Structural Analysis*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India
9. O. C. Zienkiewicz and Y.K. Cheung, *The Finite Element Method in Structural and Soild Mechanics*, McGraw Hill, London
10. P.E. Ceruzzi, *A History of Modern Computing*, The MIT Press, Cambridge, MA, 1998.
11. R. D. Cook, *Concepts and Applications of Finite Element Analysis* , Wiley
12. S.S. Rao, *Finite Element Analysis*, Elsevier Butterworth-Heinemann
13. W. Weaver Jr. and J. M. Gere, *Matrix Analysis of Framed Structure*, CBS Publishers & Distributors, New Delhi, India
14. Darrell W. Pepper and Juan C. Heinrich *The Finite Element Methods, Basic Concepts and Applications*, 2nd edition, Taylor & Francis Publication.
15. Reddy. J.N., *An Introduction to the Finite Element Method*, 3rd Edition, Tata McGraw-Hill, 2005
16. Seshu, P, *Text Book of Finite Element Analysis*, Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.

E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/105/105105041/

Elective IV (ST 611 B) – Buckling of Structures -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes:

At the end of the course, students will be able to

1. Determine stability of columns and frames.
2. Determine stability of beams and plates.
3. Use stability criteria and concepts in the analysis of discrete and continuous systems.

Course Contents:

Unit 1: Buckling of columns- Introduction; Elastic Buckling of straight columns – Effect of shear stress on buckling – Eccentrically and laterally loaded columns, buckling of bars on elastic foundations, buckling of bars with change in cross-section.

Unit 2: Buckling of beam-columns- Elastic Buckling of Frames/Beam-Column Theory, Differential equations for beam columns- beam columns with concentrated loads – continuous lateral loads- couples- beam columns with built in ends.

Unit 3: Buckling of beams- Continuous beams with axial load – application of trigonometrically series. Lateral-torsional buckling of beams. Evaluation of critical buckling load. Lateral restraints and buckling lengths. Implementation of structural design procedures.

Unit 4: Buckling of curved members- Buckling failure of curved members, Bending of a thin curved bar with a circular axis, Condition of in extensional deformation of curved members, Buckling of a circular ring under uniform pressure, Arch action and types of arches, Buckling of a uniformly loaded circular arch.

Unit 5: Buckling of thin plates- Buckling of simply supported Rectangular plates, unidirectional buckling, bi-directional buckling, Derivation of equation of plate subjected to constant compression in one and two directions, Numerical examples.

Unit 6: Buckling of shells -Buckling of Cylindrical Shells

References Books:

1. Timoshenko and Gere, *Theory of elastic Stability*, McGraw Hill.
2. Blunch, *Stability of metallic structures*, McGraw Hill.
3. Chem and Atste, *Theory of Beam Columns Vol. I*, McGraw Hill.
4. Ashwini Kumar, Stability *Theory of Structures*, Allied Publishers.

5. Alexandar Chajes, *Principles of Structural Stability Theory*, Prentice Hall, New Jersey, (1980)
6. Iyenger, N.G.R. *Structural Stability of columns and plates*, Affiliated East west press Pvt. Ltd., (1990).
7. Bleich F., *Buckling Strength of metal structures*, McGraw Hill (1991).
8. A. Kumar, *Stability of Structures*, Allied Publishers Ltd., New Delhi,(1998).

E Resources: http://52.7.61.3/civil/

Elective IV (ST 611 C) – Design of Industrial Structures -- (Credit-3)

Teaching Scheme: 3 hrs /week

Evaluation Scheme
Continuous Internal Assessment: 20 Marks
Insem. Evaluation: 30 Marks
Endsem. Evaluation: 50 Marks

Course Outcomes:

At the end of the course, students will be able to

1. Analyze and Design technological and modular industrial structures.
2. Analyze and Design industrial RCC structures.

Course Contents:

Unit 1: Understanding of Industrial Plant Layout & Structures

Unit 2: Pipe Racks:

- Introduction: What is Pipe Rack? Geometry, Application, General Support conditions, Design Guide lines
- Loads & Load combination: Gravity Loads, Friction Loads, Seismic Loads, wind loads, Anchor loads
- Various load combinations. Study of Live example
- Pipe Supports, Types, Design Guide lines, its application
- Cable Trays, Types of Trays & Support, Design of Tray supports

Unit 3: Technological Plant Engineering Structures:

- Introduction: Geometry, Application, General Support conditions, Design Guide lines, Expansion Joints, RCC & Steel structures
- Loads & Load combination: Gravity Loads, Seismic Loads, wind loads, Equipment loads
- Modular Structures: Introduction & Design Guide lines
- Connection Concept & Design

Unit 4: Portal Frames & Trusses:

- Introduction: Geometry, Application, General Support conditions, Design Guide lines,
- Loads & Load combination: Gravity Loads, Seismic Loads, wind loads,
- Analysis of Frames & Trusses

Unit 5: Industrial RCC Buildings

- Types of Buildings: Control Room, MCC, Admin Building
- Design Concept & Guide lines
- Loads Introduction

Unit 6: Effluent Treatment Plant:

- Introduction, Standard Units in Plant
- Design Guide lines,
- Introduction of water-resistant structures

Reference Books:

1) Mohamed A. El-Reedy, *Construction Management and Design of Industrial Concrete and Steel Structures*, CRC Press, (2019).
2) S.S. Bhavikatti, *Design of Steel Structures (By Limit State Method As Per Is: 800 2007*), Fifth Edition, I K International Publishing House Pvt. Ltd, India, (2013).
3) Indrajit Chowdhury and Shambhu P. Dasgupta, *Earthquake Analysis and Design of Industrial Structures and Infra-structures*, Springer, (2019).
4) S K Duggal, *Limit State Design of Steel Structures*, McGraw Hill Education, (2010).
5) Bhavikatti S. S., *Advance RCC Design*, 3rd Edition, New Age International Private Limited, (2008).
6) Krishnam Raju, N., *Design of Reinforced Concrete Structures*, 2nd Edition, CBS Publishers and Distributors, New Delhi, (2007).
7) Varghese P.C. *Advanced Reinforced Concrete Design*, 2nd Edition, Prentice -Hall of India, , (2008)
8) Indian Standard Code 456-2000, "Plain and Reinforced Concrete - Code of. Practice".
9) Indian Standard Code 800-2007, "General construction in steel-Code for practice".

E Resources: http://52.7.61.3/civil/

Professional Core (ST 612) – Structural Audit Lab. -- (Credit-2)

Teaching Scheme: 4 hrs /week (Lab) Evaluation Scheme

Oral: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Diagnosis the distress in the structure understanding the causes and factors.
2. Assess the health of structure using static and dynamic field methods.
3. Suggest repairs and rehabilitation measures of the structure

Course Contents:

1. Non-Destructive Tests

A. Study of Rebound Hammer test on concrete

B. Ultrasonic Pulse Velocity test on Concrete

C. Study of half-cell Potentiometer and measurement of corrosion in RCC.

D. Core removal from concrete structure and compression testing

E. Carbonation Test on concrete

2. Structural Dynamics:

A. Free vibration analysis of cantilever beam.

B. Free vibration analysis of simply supported beam.

C. Free vibration analysis of simply supported beam with tuned mass

3. Case study report on Structural Audit

Reference Books:

1. Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, *Structural Health Monitoring*, John Wiley and Sons, 2006.
2. Douglas E Adams ,*Health Monitoring of Structural Materials and Components Methods with Applications*, , John Wiley and Sons, 2007.
3. J. P. Ou, H. Li and Z. D. Duan, Structural *Health Monitoring and Intelligent Infrastructure*, *Vol1*, Taylor and Francis Group, London, UK, 2006.
4. Victor Giurglutiu, *Structural Health Monitoring with Wafer Active Sensors*, Academic Press Inc, 2007.

Professional Core (ST 613) – Structural Design Lab-II -- (Credit-2)

Teaching Scheme: 4 hrs /week (Lab) Evaluation Scheme

Oral: 50 Marks

Course Outcomes: At the end of the course, students will be able to

1. Design of all the special RC elements like corbel, deep beam, grid floor etc
2. Aware the various specification of IS code.
3. Aware about the reinforcement detailing in various advanced RCC structures.
4. Study the software used for design of RCC structure.

Course Content:

1. Design of RC any 3 elements out of Shear wall/Corbel/Deep beam/ Grid Floor as per the IS code specifications
2. Design of Flat Slab
3. Design of Silos/Bunker
4. Assignment based on concept of Ductility
5. Design above any two structures using Design Software

Reference Books:

1. Karve S.R. and Shah V.C., *Design of Reinforced Cement Concrete Structures using Limit State Approach*, Structures Publishers.
2. G.S. Ramaswamy , *Design and Construction of Concrete shell Roofs*, McGraw Hill.
3. Gambhir.M.L., *Design of Reinforced Concrete Structures*, Prentice Hall of India, 2012.
4. Purushothaman, P, *Reinforced Concrete Structural Elements: Behaviour Analysis and Design*, Tata McGraw Hill, 1986

Project (ST 614) – Mini Project -- (Credit-2)

Teaching Scheme: 4 hrs /week (Lab) Evaluation Scheme: Oral: 50 Marks

Course Outcomes: At the end of the course, the students will be able to

1. Reframe their carrier/employment opportunities through research skill/ techniques.
2. Invent new techniques in the field of structural engineering.

A) Guidelines on mini project:

Mini Project: A short report on any significant and innovative topic in structural engineering domain that is observed during the course as a part of curriculum. As a part of this students are required to write a short report named as a mini project under the guidance of supervisor.

Benefits to the Students: The basic purpose of writing a mini project is to allow students to explore the breadth of research that is performed during the P.G. course. This research experience may give a platform to the students to extend the topic for thesis of M.Tech. Degree and also will help the students to build their carrier and employment opportunities.

Expected outcomes of mini project: It is up to the student and the supervisor to choose the title/topic for mini project from any significant and innovative topic in structural engineering. The expected outcomes of the mini project must be in the form of either research paper or I.P.R.

B) Guidelines for report writing: The mini project in general should include the following components.

i. **Abstract:** The brief summary of the project between 200 to 500 words covering the methodology and the outcomes of the project.
ii. **Introduction:** Give the background of the proposed work and the context in which the work is performed.
iii. **Aims and Objectives:** Give the aims and objectives of the proposed work.
iv. **Motivation:** Give the motivation behind the proposed work.
v. **Methodology:** Give description about what you have done and how it is done.
vi. **Results/Findings:** Give the findings of your work.
vii. **Research Contribution:** Give what you have contributed through your research/project.
viii. **Conclusions:** Give summary of the project based on the results drawn.
ix. **Future Scope:** What is the scope of your work?
x. **References:** Enlist the references you have referred during the work.

Semester III

Professional Elective (ST701A) – Design of Prestressed Concrete Structures (Credits - 3)

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Continuous Internal Assessment (CIA): 20 Marks
Insem. Evaluation: 30 MarksEndsem. Evaluation: 50 Marks
Total: 100 Marks

Course outcomes: At the end of the course, students will be able to

1. Find out losses in the prestressed concrete. Understand the basic aspects of prestressed concrete fundamentals, including pre and post-tensioning processes.
2. Analyze prestressed concrete deck slab and beam/ girders.
3. Design prestressed concrete deck slab and beam/ girders.
4. Design of end blocks for prestressed members.
5. Analyze and design prestressed concrete pipes.

Contents:

Unit 1: Introduction to prestressed concrete: types of prestressing, systems and devices, materials, losses in prestress. Analysis of PSC flexural members: basic concepts,stresses at transfer and service loads, ultimate strength in flexure, code provisions.

Unit 2: Statically determinate PSC beams: design for ultimate and serviceability limit states for flexure, analysis and design for shear and torsion, code provisions. Transmission of prestress in pretensioned members; Anchorage zone stresses for posttensioned members, Design of end blocks.

Unit 3: Statically indeterminate structures - Analysis and design - continuous beams and frames, choice of cable profile, linear transformation and con-cordancy.

Unit 4: Composite construction with precast PSC beams and cast in-situ RC slab - Analysis and design, creep and shrinkage effects. Partial prestressing - principles, analysis and design concepts, crack- width calculations

Unit 5: Analysis and design of prestressed concrete pipes, columns with moments.

NOTE: The end semester examination will be based on the total syllabus. While for In-semester, half of the syllabus will be considered.

References Books:

1. Lin T.Y, *Design of Prestressed Concrete Structures*, Asia Publishing House, (1955).
2. Krishna Raju N., *Prestressed Concrete*, Tata McGraw Hill, New Delhi, (1981).
3. Guyon, Y., *Limited State Design of Prestressed Concrete*, Applied Science Publishers, (1972).
4. Krishna Raju N., *Problems and Solutions in prestressed Structures*, CBS Publishing Company, 3rd Ed., (2017).
5. IS: 1343- 2012, Code of Practice for Prestressed Concrete
6. E Resources: http://52.7.61.3/civil/, https://nptel.ac.in/courses/105/106/105106117/.

Professional Elective (ST701B) – Theory of Advanced Composite Plates and Shells.(Credits - 3)

Teaching Scheme: 3 hrs/week **Evaluation Scheme**

Continuous Internal Assessment (CIA): 20 Marks
Insem. Evaluation: 30 MarksEndsem. Evaluation: 50 Marks
Total: 100 Marks

Course outcomes: At the end of the course, students will be able to

1. Understand classical laminated plates theory and its applications.
2. Apply classical laminated shell theory for bending, buckling and vibration problems.
3. Analyze bending, buckling and vibration problems using laminated shell theory.
4. Analyze plates and shells using finite element analysis method.

Contents:

Unit I: Laminated Plates: Cross-ply, angle-ply lamination schemes, Classical laminated Plate Theory: Assumptions, Governing Equation, and Boundary Conditions. Navier's Method of Solution for Simply Supported Rectangular Plates – Application to Bending, Buckling and Free vibration Problems.

Unit II: Singly-curved laminated Shells: Classical laminated Shell Theory: Assumptions,Governing Equation, and Boundary Conditions. Navier's Method of Solution for Simply Supported **singly-curved Shells** – Application to Bending, Buckling and Free vibration Problems.

Unit III: Doubly-curved laminated shells: Classical laminated Shell Theory: Assumptions, Governing Equation, and Boundary Conditions. Navier's Method of Solution for Simply Supported **doubly-curved Shells** – Application to Bending, Buckling and Freevibration Problems.

Unit IV: **Finite element analysis of laminated plates and shells:** Introduction to FEM, finite element modeling of plates and shells, Application of Classical and first order laminated theories for the FE analysis of laminated plates and shells.

NOTE: The end semester examination will be based on the total syllabus. While for In- semester, half of the syllabus will be considered.

References Books:

1. Reddy J. N., *Mechanics of Laminated Composite Plates and Shells: Theory and Analysis*, Second Edition by, CRC Press, (2003).
2. Reddy J. N., and Ozden O. Ochoa, *Finite Element Analysis of Composite Laminates*, Springer Science & Business Media, (1992).
3. Reddy J. N., Mechanics *of Composite Materials: Selected Works of Nicholas J. Pagano*, Springer Netherlands, (2013).
4. Reddy J.N., *Theory and Analysis of Elastic Plates and Shells*, CRC Press, (2006).
5. Arthur W. Leissa, *Buckling of Laminated Composite Plates and Shell Panels*, Arthur W. Leissa, PN Publishers, (1985).
6. Jones, R. M., *Mechanics of Composite Materials*, Taylor & Francis, (1998).

E Resources: http://52.7.61.3/civil/,https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-me65/

Professional Elective (ST701C) – Bridge Engineering (Credits - 3)

Teaching Scheme: 3 hrs/week **Evaluation Scheme**

Continuous Internal Assessment (CIA): 20 Marks
Insem. Evaluation: 30 MarksEndsem. Evaluation: 50 Marks
Total: 100 Marks

Course outcomes: At the end of the course, students will be able to

1. Understand various parameters required for the design of bridges.
2. Design box culvert and its components.
3. Apply various methods for the design of girder bridges.
4. Design and analysis of PSC bridges.
5. Explain different types of long span bridges.

Unit 1: Introduction: Standard specification for bridges, Site selection, Classification, Forces acting on Bridges. IRC loadings for road bridges, IRS bridge rules, Layout, planning, Structural forms of bridge decks, beam and slab decks, concept of box girder, cellulardecks.

Unit 2: **RCC Bridges**: Design of solid slab bridges for IRC loading - Design of kerb - Design of tee beam bridges - Design of panel and cantilever for IRC loading

Unit 3: Box Culvert: Different loading cases, , Wheeled and Class A Loading, working out the worst combination of loading, Design of slab culverts and its components, Moment Distribution, Calculation of BM & SF, structural, Design of slab culvert with reinforcement details.

Unit 4: Girder Bridges: Introduction to Courbon's method, Henry-Jaegar method and Guyon-Massonet method. Design of T-beam PC bridges using Courbon's method.

Unit 5: PSC Bridges: Introduction to Pre and Post Tensioning, Proportioning of Components, Analysis and Structural Design of Slab, Analysis of Main Girder using COURBON's Method for IRC Class AA tracked vehicle, Calculation of pre-stressing force, cable profile and calculation of stresses.

Unit 6: Introduction to long span bridges - Cantilever, arch, cable stayed and suspension bridges. Segmental bridge construction method. Bridge foundations, design of open well, Pile and Caisson foundation

References Books:

1. Raju K., *Design of Bridges*, Oxford & IBH Publishing Co Pvt.Ltd
2. Victor Johnson, *Essentials of Bridge Engineering*, Oxford & IBH Publishing Co Pvt.Ltd.
3. António J Reis and José J Oliveira Pedro, *Bridge Design: Concepts and Analysis*, John Willey Pub., 2019.
4. Ponnuswamy, S., *Bridge Engineering 3rd edition*, McGraw Hill India, (2017).
5. Krishnaraju, N., *Design of Bridges*, Oxford and IBH, (1988).
6. Jagadeesh and Jayaram, M. A., *Design of Bridge Structures*, Prentice-Hall Of India Pvt. Limited, (2004).

Open Elective (ST702)

1. (CE702) Industrial Safety and Management
2. (ET702) Machine Learning
3. (MB702) Start-up and Venture Management
4. (ME702) Project Planning and Operation Research
5. (ST702) Composite Material
6. (CO702) Recent Trends in Computer Technology

Dissertation Phase I (ST703) (Credits- 10)

Teaching Scheme: 20 hrs/week

Evaluation Scheme
Oral Exam: 50 Marks

Course Outcomes: At the end of the course, the student will be able to:

- Identify structural engineering problems reviewing available literature.
- Identify appropriate techniques to analyze complex structural systems.
- Apply engineering and management principles through efficient handling of project

Contents:

Dissertation-I will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions and must bring out individuals contribution.

There will be three presentations for Phase I as below. The presentations will be monitored by the departmental committee.

a) First presentation for topic approval

b) Second presentation at mid semester.

c) Third presentation at the end of semester.

Semester - IV

Dissertation phase - II (ST704) (Credits- 16)

Teaching Scheme: 32 hrs/week Evaluation Sche
me

Oral Exam: 100 MarksTerm-work: 50 Marks

Course Outcomes: At the end of the course, the student will be able to:

1. Solve complex structural problems by applying appropriate techniques and tools.
2. Exhibit good communication skill to the engineering community and society.
3. Demonstrate professional ethics and work culture.

Syllabus:

Dissertation – II will be extension of the to work on the topic identified in Dissertation – I.

Continuous assessment should be done of the work done by adopting the methodology decided involving numerical analysis/ conduct experiments, collection and analysis of data, etc. There will be pre submission seminar at the end of academic term. After the approval the student has to submit the detail report and external examiner is called for the viva-voceto assess along with guide.

There will be three presentations for Phase II as below. The presentations will be monitored by the departmental committee.

a) First presentation in the beginning of the semester.

b) Second presentation at mid semester.

c) Third presentation at the end of semester.

Documents to be submitted by the students at the time of final submission

a) Copy right form

b) Plagiarism Report.