

# Sanjivani College of Engineering, Kopergaon

(An Autonomous Institute) Affiliated to Savitribai Phule Pune University.

At Sahajanandnagar, Post Shingnapur-423603, Ta.: Kopergaon, Dist.: Ahmednagar (MS)

Approved by AICTE, ISO 9001-2015 Certified, Accredited by NBA, Accredited 'A' Grade by NAAC,

Website: www.sanjivanicoe.org.in, Email: principalcoe@sanjivani.org.in,

Ph.No.: (+91) 9130191301, Fax: (02423)-222682



## Department of Structural Engineering

### 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 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)						
			L	P		Theory			OR	PR	TW	Total
						ISE	ESE	CA				
PC	ST601	Advanced Steel Structures	3	-	3	30	50	20	-	-	-	100
PC	ST602	Advanced Design of Foundations	3	-	3	30	50	20	-	-	-	100
PE	ST603	<b>Elective – I</b> -Theory and Design of Plates and Shells -Advanced Concrete Technology -Composite Materials	3	-	3	30	50	20	-	-	-	100
PE	ST604	<b>Elective – II</b> - 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	-	-	-	-	-	-	-	-	-
<b>Total</b>			<b>16</b>	<b>8</b>	<b>18</b>	<b>120</b>	<b>250</b>	<b>80</b>	<b>100</b>	<b>-</b>	<b>-</b>	<b>550</b>

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

## First Year (Semester II)

Cat	Course Code	Course Title	Teaching Scheme (Hrs./Week)		Credits	Evaluation Scheme (Marks)						
			L	P		Theory			OR	PR	TW	Total
						ISE	ESE	CA				
PC	ST608	Structural Audit and Health Monitoring	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 Dynamics and Earthquake Engineering	3	-	3	30	50	20	-	-	-	100
PE	ST611	Elective – IV - FEM in Structural Engineering -Theory of Structural Stability -Design of Industrial Structure	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	-								
<b>Total</b>			14	12	18	120	200	80	150	-	-	550

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

## Second Year (Semester III)

Cat	Course Code	Course Title	Hrs./Week			Credits	Evaluation Scheme (Marks)						
			L	T	P		Theory			OR	PR	TW	Total
							ISE	ESE	CA				
PE	ST701	Elective - V -Design of Prestressed Concrete Structures -Theory of Advanced Composite Plates and Shells -Bridge Engineering	3	-	-	3	30	50	20	-	-	-	100
OE	CE702 ET702 MB702 ME702 ST702 CO702	<b>Open Elective</b> Industrial Safety and Management Machine Learning Start up and Venture Management Project Planning and Operation Research Computational Techniques Recent Trends in Computer Technology	3	-	-	3	30	50	20	-	-	-	100
PRJ	ST703	Dissertation Phase – I	-	-	20	10	--	--	--	50	-	-	50
<b>Total</b>			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
		<b>Total</b>	-	-	32	16	--	--	--	100	-	50	150

**Total Credits for the programme = 18 + 18 +16 +16 = 68**

### 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.

### Rules and Regulations for Evaluation

Every subject is evaluated in three parts

- 1) Teachers Assessment (TA):- 20 Marks.
- 2) In-Semester Examination (ISE):- 30 Marks
- 3) End-Semester Examination (ESE):- 50 Marks

**Teachers 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) – Advanced Steel Structure (Credits - 3)

Teaching Scheme: 3 hrs/week

#### Evaluation Scheme

Teacher Evaluation: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

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

- 1 To 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 of design of Microwave and Transmission tower.
- 4 To analyse and design the formwork used for RCC work.

### Course Contents

- Eccentric and moment connections, Beam to beam, Beam-column connections subjected to combined bending and shear, Bolted framed connections, seated connections, Bracket connections, moment connections, Welded bracket and moment resisting connections. Seismic analysis of steel connections.
- Design of steel chimneys, Types, components, Lined and unlined chimneys, Forces acting on steel chimneys, Design of self-supporting steel chimneys, Design of base plate.
- Microwave Towers – Introduction, structural configuration, function, analysis and design, Transmission Towers, Introduction, structural configuration, bracing systems, analysis and design, Codal provision for design of tower and foundation.
- Design of Formwork: Requirements and selection of formwork. different materials used,. Formwork design: concepts, formwork 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.

### Text Books:

- 1 Design of steel structures-Vol. II by Dr. Ram Chandra, Standard Book House Delhi
- 2 Design of Steel Structures, A. S. Arya and J. L. Ajmani, Nemchand & Bros., Roorkee
- 3 Design of Steel Structures Galyord & Gaylord, Publisher ; Tata Mc Graw Hill, Education. Edition 2012.

- 4 Design of Steel Structure by N. Subramanian, Oxford university press
- 5 Limit state Design of Steel Structures, S K Duggal , McGraw Hill education, 2010
- 6 Design of Steel Structures, P. Dayaratnam, Publisher : S. Chand, Latest Edition
- 7 Teaching Resource for Structural Steel Design by Institute for Steel Development and Growth (INSDAG), Kolkatta.
- 8 SP: 6 Handbook for Structural Engineers: Application of plastic Theory in steel design.
- 9 Formwork for Concrete Structures, Peurify, Mc Graw Hill India, 2015.
- 10 Formwork for Concrete Structures, Kumar NeerajJha, Tata McGraw Hill Education, 2012.
- 10 IS 14687: 1999, False workfor Concrete Structures - Guidelines, BIS

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

Teaching Scheme: 3 hrs /week

Evaluation Scheme

Teacher Evaluation: 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:**

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

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 /

#### **Reference Books:**

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

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

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Teacher Evaluation: 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:**

- **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

- **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

- **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.

- **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

- **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.

### **References:**

1. Theory of plates and shells by S.P.Timoshenko and S.Woinowsky-Krieger, McGraw-Hill, 1959.
2. Stresses in plates and shells by A.C.Ugural, McGraw-Hill, 1999.
3. Analysis of plates by T.K.Varadan and K.Bhaskar , Narosa Publishing House, 1999.

4. "Stresses in Shells" by Flugge. Blaisdell Publishing Co, 1966
5. Design and construction of concrete shell roofs by G.S.Ramaswamy, CBS Publishers & Distributors, 1986.
6. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall inc, 1974.
7. P.L Gould, Analysis of Shells and Plates, Springer-Verlag, New York, 1988.
8. O.P Billington, Thin Shell Concrete Structures
9. Eduard Ventsel & Theodor Krauthammer, Thin Plates & Shells: Theory, Analysis, & Applications CRC; 1st edition, 2001
10. Maan H. Jawad, Theory and design of plate and shell structures, Kluwer Academic Pub

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

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Teacher Evaluation: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

#### **Course Outcomes:**

- 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

#### **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, aggregate cement bond strength, curing and its method. Durability Tests on Concrete – Non Destructive Testing of Concrete.

#### **High Strength Concrete**

Microstructure – Manufacturing and Properties – Design of HSC Using Eirintroy Shaklok method – Ultra High Strength Concrete. High Performance Concrete – Requirements and Properties of High Performance Concrete – Design Considerations

#### **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.

## 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.

### References:

1. Concrete Technology Theory and Practice by M. S. Shetty, S. Chand & Co. Ltd, revised edition.
2. Hand book on advanced concrete technology by N.V. Nayak, 2020
3. Concrete Technology: Theory and Practice | 5th Edition by M L Gambhir, Mc Grow Hill Publication.
4. Ferrocement – Theory and Applications, Pama R. P., IFIC, 1980.
5. New Concrete Materials, Swamy R.N., 1<sup>st</sup>Ed., Blackie, Academic and Professional, Chapman & Hall, 1983.
6. Concrete Technology, Second Edition Book by A.M.Neville and J.J.Brooks.

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

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Teacher Evaluation: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

### Course Outcomes:

- Study the characteristics of composite materials.
- Understand the applications of composite materials.
- Understand the manufacturing of matrix composites.

### Syllabus:

- **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
- **Applications of composite materials**  
Metal and Ceramic Matrix Composites, Applications of Composites, Composite Joints, Review, Environmental Issues
- **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.
- **Manufacturing of Polymer Matrix Composites**  
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds



and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

## References-

1. Agarwal.B.D., Broutman.L.J., and Chandrashekar.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. Mukhopadhyay.M, “Mechanics of Composite Materials and Structures”, Universities Press, India, 2005.
5. 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.
6. Crawley, E and Anderson, E., “Detailed models of Piezoceramic actuation of beams”, Proc. of the 30th AIAA /ASME/ASCE/AHS/ASC Structural dynamics and material conference, AIAA Washington DC, April 1989.

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

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Teacher Evaluation: 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

**Module 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

**Module -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

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

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

#### REFERENCE BOOKS:

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

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

Teaching Scheme: 3 hrs/week

Evaluation Scheme

Teacher Evaluation: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

#### **Course Outcomes:**

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

#### **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.

#### **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.

#### **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.

### **Alternate Materials for durable pavements**

Artificial aggregates – Industrial waste materials – fly ash, pond ash, marble dust, GGBS, Geopolymer 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

### **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.

### **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:**

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 Pavements, 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.

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

**Teaching Scheme:** 3 hrs/week

**Evaluation Scheme**

Teacher Evaluation: 20 Marks

Insem. Evaluation: 30 Marks

Endsem. Evaluation: 50 Marks

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

1. Solve simple problems of elasticity and plasticity understanding the basic concepts.
2. Apply numerical methods to solve continuum problems.

### **Syllabus:**

- **Introduction to Elasticity:** Displacement, Strain and Stress Fields, Constitutive Relations, Cartesian Tensors and Equations of Elasticity.
- **Strain and Stress Field:** Elementary Concept of Strain, Strain 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.
- **Equations of Elasticity:** Equations of Equilibrium, Stress- Strain relations, Strain Displacement and Compatibility Relations, Boundary Value Problems, Co-axiality of the Principal Directions.
- **Two-Dimensional Problems of Elasticity:** Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates.
- **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.
- **Theory of Plasticity:** Physical Assumptions – Yield criteria, Failure theories, Yield criteria, Plastic work, Flow rate, Plastic potential, Plastic stress strain relationship.

### **References:**

1. Theory of Elasticity, Timoshenko S. and Goodier J. N., McGraw Hill, 1961.
2. Elasticity, Sadd M.H., Elsevier, 2005.
3. Engineering Solid Mechanics, Ragab A.R., Bayoumi S. E., CRC Press, 1999.
4. Computational Elasticity, Ameen M., Narosa, 2005.
5. Solid Mechanics, Kazimi S. M. A., Tata McGraw Hill, 1994.
6. Advanced Mechanics of Solids, Srinath L.S., Tata McGraw Hill, 2000.
7. Theory of Plasticity, Sadhu Sing, Khanna Publisher, New Delhi.
8. Theory of Plasticity, Chakrabarty, J. Elsevier Butterworth- Heinmann UK.

### **Professional Core (ST605) – Structural Design 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  
Design and Detail all the Structural Components of Steel Structure.

### **Syllabus:**

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

### **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

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasize the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- 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.

#### **Syllabus:**

- **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
- **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.

- **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.
- **Advanced data analysis techniques-** Correlation and regression analysis, Descriptive statistics, Inferential statistics, Factor analysis
- **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 grants of patents, Patenting under PCT. Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

#### **References:**

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.