### I Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>CREDITS</th>
</tr>
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<tr>
<td>14CSE11</td>
<td>Computational Structural Mechanics</td>
<td>4 Lecture 2</td>
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<td>50 100 150</td>
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<td>14CSE12</td>
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<tr>
<td>14CSE13</td>
<td>Mechanics of Deformable Bodies</td>
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<td>14CSE14</td>
<td>Structural Dynamics</td>
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<td>14CSE15X</td>
<td>Elective - I</td>
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<tr>
<td>14CSE16</td>
<td>Structural Engineering Lab-1</td>
<td>-- 3</td>
<td>3</td>
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<td>14CSE17</td>
<td>Seminar</td>
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<td>25 -- 25</td>
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<td><strong>20 16 18</strong></td>
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<td><strong>300 550 850</strong></td>
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</table>

**Elective – 1**

- 14 CSE 151 Design of Industrial Structures
- 14 CSE 152 Special concretes
- 14 CSE 153 Repair and Rehabilitation of Structures
- 14 CSE 154 AI & Expert System in Structural Engineering
## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
### SCHEME OF TEACHING AND EXAMINATION FOR
#### M.Tech. Structural Engineering

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>CREDITS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>Practical / Field Work / Assignment/ Tutorials</td>
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<td>Exam</td>
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<tr>
<td>14CSE21</td>
<td>Design of Plates &amp; Shells</td>
<td>4</td>
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<tr>
<td>14 CSE 22</td>
<td>Earthquake Resistant Structures</td>
<td>4</td>
<td>2</td>
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<tr>
<td>14 CSE 23</td>
<td>Finite Element Method of Analysis</td>
<td>4</td>
<td>2</td>
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<td>14 CSE 24</td>
<td>Design concepts of Substructures</td>
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<tr>
<td>14 CSE 25X</td>
<td>Elective-II</td>
<td>4</td>
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<td>14 CSE 26</td>
<td>Structural Engineering Lab-2</td>
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<td>14 CSE 27</td>
<td>Seminar</td>
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<tr>
<td></td>
<td><strong>Project Phase-I(6 week Duration)</strong></td>
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</table>

**Elective – 2**
- 14 CSE 251 Reliability Analysis of Structures
- 14 CSE 252 Design of Tall Structures
- 14 CSE 253 Masonry structures
**Between the II Semester and III Semester, after availing a vocation of 2 weeks.**

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**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM**

**SCHEME OF TEACHING AND EXAMINATION FOR**

**M.Tech. Structural Engineering**

III Semester: **INTERNSHIP**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of the Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
<th>CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>Practical / Field Work</td>
<td>I.A.</td>
<td>Exam</td>
<td></td>
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<tr>
<td>14CSE31</td>
<td>Seminar / Presentation on Internship (After 8 weeks from the date of commencement)</td>
<td>-</td>
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<td>14 CSE 32</td>
<td>Report on Internship</td>
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<tr>
<td>14 CSE 33</td>
<td>Evaluation and Viva-voce</td>
<td>-</td>
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</table>

* The student shall make a midterm presentation of the activities undertaken during the first 8 weeks of internship to a panel comprising Internship Guide, a senior faculty from the department and Head of the Department.

# The College shall facilitate and monitor the student internship program.

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**The internship report of each student shall be submitted to the University.**

**Between the III Semester and IV Semester after availing a vacation of 2 weeks.**
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>CREDITS</th>
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<tr>
<td>14CSE41</td>
<td>Stability of Structures</td>
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<td>14 CSE 42X</td>
<td>Elective-3</td>
<td>4</td>
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<tr>
<td>14 CSE 43</td>
<td>Evaluation of Project Phase-I</td>
<td>-</td>
<td>-</td>
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<tr>
<td>14 CSE 44</td>
<td>Evaluation of Project Phase-II</td>
<td>-</td>
<td>-</td>
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<tr>
<td>14 CSE 45</td>
<td>Evaluation of Project Work and Viva-voce</td>
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<td>Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits</td>
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</table>

**Elective – 3**
- 14 CSE 421 Composite and Smart materials
- 14 CSE 422 Optimisation of Structures
- 14 CSE 423 Design of concrete bridges
Note:

1) Project Phase – I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carry out literature survey/visit to Industries to finalize the topic of dissertation.

2) Project Phase – II: 16 weeks duration during III Semester. Evaluation shall be taken during the Second week of the IV Semester. Total Marks shall be 25.


Marks of Evaluation of Project:

- The I.A. Marks of Project Phase – I & II shall be sent to the University along with Project Work report at the end of the Semester.

4) During the final viva, students have to submit all the reports.

5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university. (Out of two external examiners at least one should be present).
The objectives of this course is to make students to learn principles of Structural Analysis, To implement these principles through different methods and to analyse various types of structures. To evaluate the force and displacement parameters of the structures.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Structural Analysis
- Design and develop analytical skills.
- Summarize the Solution techniques
- Understand the concepts of structural behaviour.


2. **Analysis using Flexibility method:** Force-transformation matrix using Flexibility method, Development of global flexibility matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 6x6 flexibility matrix) Analysis of continuous beams, plane trusses and rigid plane frames by flexibility method (having not more than 3 coordinates – 3x3 flexibility matrix)

3. **Analysis using Stiffness Method:** Displacement-transformation matrix using Stiffness Method, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames (having not more than six co-ordinates – 6x6 stiffness matrix) Analysis of continuous beams, plane trusses and rigid plane frames by stiffness method (having not more than 3 coordinates – 3x3 stiffness matrix)

4. **Effects of temperature change and lack of fit:** Related numerical problems by flexibility and stiffness method as in Chapters 4 and 6.

5. **Solution techniques:** Solution techniques including numerical problems for simultaneous equation, Gauss elimination and Cholesky method. Bandwidth consideration.

**REFERENCE BOOKS:**

5. A.K.Jain “Advanced Structural Analysis with Computer Application” Nemchand and Brothers, Roorkee, India.
Objectives:

The objectives of this course is to make students to learn principles of Structural Design, To design different types of structures and to detail the structures. To evaluate performance of the structures.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Structural Design
- Design and develop analytical skills.
- Summarize the principles of Structural Design and detailing
- Understands the structural performance.

2. Design of grid floors.
3. Design of continuous beams with redistribution of moments
4. Design of Chimneys, Design of silos and bunkers.
5. Art of detailing earthquake resistant structures. Expansion and contraction joints

REFERENCE BOOKS:

1. A Park and Paulay, “Reinforced Reinforced and Prestressed Concrete”
2. Lin TY and Burns N H, “Reinforced Concrete Design”.
3. Kong KF and Evans T H “Design of Prestressed Concrete Structures
5. Dr.B.C.Punmia, Ashok Kumar Jain and Arun Kumar Jain, “Comprehensive RCC Design”
MECHANICS OF DEFORMABLE BODIES

Subject Code : 14CSE13
No. of Lecture Hrs./ Week : 04
Total No. of Lecture Hrs. : 50
IA Marks : 50
Exam Hrs : 03
Exam Marks : 100

Objectives:

The objectives of this course is to make students to learn principles of Analysis of Stress and Strain, To predict the stress-strain behaviour of continuum. To evaluate the stress and strain parameters and their inter relations of the continuum.

Course Outcomes: On completion of this course, students are able to

• Achieve Knowledge of design and development of problem solving skills.
• Understand the principles of stress-strain behaviour of continuum
• Design and develop analytical skills.
• Describe the continuum in 2 and 3- dimensions
• Understand the concepts of elasticity and plasticity.

1. **Theory of Elasticity:** Introduction: Definition of stress and strain and strain at a point, components of stress and strain at appoint of Cartesian and polar co-ordinates. Constitutive relations, equilibrium equations, compatibility equations and boundary conditions in 2-D and 3-D cases.
2. Transformation of stress and strain at a point, Principal stresses and principal strains, invariants of stress and strain, hydrostatic and deviatoric stress, spherical and deviatoric strains, max. shear strain.

REFERENCE BOOKS:

5. Chenn W.P and Hendry D.J, “Plasticity for Structural Engineers”, Springer Verlag
Objectives:

The objectives of this course is to make students to learn principles of Structural Dynamics, To implement these principles through different methods and to apply the same for free and forced vibration of structures. To evaluate the dynamic characteristics of the structures.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Structural Dynamics
- Design and develop analytical skills.
- Summarize the Solution techniques for dynamics of Multi-degree freedom systems
- Understand the concepts of damping in structures.


4. Response of Shear buildings for harmonic loading without damping using normal mode approach. Response of Shear buildings for forced vibration for harmonic loading with damping using normal mode approach, condition of damping uncoupling.

5. Approximate methods: Rayleigh’s method Dunkarley’s method, Stodola’s method. Dynamics of Continuous systems: Free longitudinal vibration of bars, flexural vibration of beams with different end conditions., Stiffness matrix, mass matrix (lumped and consistent); equations of motion for the discretised beam in matrix form.

Books for Reference:

2. Earthquake Resistant Design of Building Structures, Vinod Hosur, WILEY (India)
3. Vibrations, structural dynamics- M. Mukhopadhyay : Oxford IBH
5. Structural Dynamics- Clough & Penzien : TMH
Objectives:

The objectives of this course is to make students to learn principles of Design of industrial building , To design different components of industrial structures and to detail the structures. To evaluate the performance of the Pre- engineered buildings.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the industrial building and the components.
- Design and develop analytical skills.
- Summarize the principles of Structural Design and detailing
- Understands the concept of Pre- engineered buildings.

1. Analysis of industrial building for Gravity and Wind load. Analysis and design of framing components namely, girders, trusses, gable frames
2. Analysis and design of gantry column (stepped column / column with bracket), purlins, girts, bracings including all connections.
3. Analysis of transmission line towers for wind load and design of towers including all connections.
5. Concept of Pre- engineered buildings, Design of compression and tension members of cold formed light guage sections, Design of flexural members (Laterally restrained / laterally unrestrained).

REFERENCE BOOKS:

2. N Subramanian- “Design of Steel Structure” oxford University Press
5. Duggal “Limit State Design of Steel Structures” TMH
The objectives of this course is to make students to learn principles of Concrete mix design, To differentiate between different types of concrete . To characterize the high Performance concrete.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Concrete mix design
- Design and develop analytical skills.
- Summarize the Light Weight concrete, Fibre reinforced concrete and High Performance concrete:
- Understand the concepts of high Performance concrete.

1. Components of modern concrete and developments in the process and constituent materials : Role of constituents, Development in cements and cement replacement materials, pozzolana, fly ash, silica fume, rice husk ash, recycled aggregates, chemical admixtures. Mix proportioning of Concrete: Principles and methods.

REFERENCE BOOKS:
1. Neville A.M, “Properties of Concrete” Pearson Education Asis, 2000
4. Gambhir “Concrete Technology” TMH.
ELECTIVE - I
REPAIR AND REHABILITATION OF STRUCTURES

Subject Code : 14CSE153  IA Marks : 50
No. of Lecture Hrs./ Week : 04  Exam Hrs : 03
Total No. of Lecture Hrs. : 50  Exam Marks : 100

Objectives:

The objectives of this course is to make students to investigate the cause of deterioration of concrete structures, To strategise different repair and rehabilitation of structures. To evaluate the performance of the materials for repair.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the cause of deterioration of concrete structures.
- Design and develop analytical skills.
- Summarize the principles of repair and rehabilitation of structures
- Understands the concept of Serviceability and Durability.

1. General: Introduction, Cause of deterioration of concrete structures, Diagnostic methods & analysis, preliminary investigations, experimental investigations using NDT, load testing, corrosion mapping, core drilling and other instrumental methods Quality assurance for concrete construction as built concrete properties strength, permeability, thermal properties and cracking.

2. Influence on Serviceability and Durability: Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection.


5. Examples of Repair to Structures: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering wear, fire, leakage, marine exposure, engineered demolition techniques for dilapidated structures - case studies

REFERENCE BOOKS:

1. Sidney, M. Johnson “Deterioration, Maintenance and Repair of Structures”.
4. Raiker R.N., “Learning for failure from Deficiencies in Design, Construction and Service”- R&D Center (SDCPL)
The objectives of this course is to make students to learn principles of Software design process, To Compare the procedure – oriented programming and object oriented programming . To characterize the high Expert systems.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Object Oriented Programming
- Design and develop analytical skills.
- Summarize the Artificial Intelligence and Expert Systems
- Understands the concept of Knowledge representation.


2. Object Oriented Programming: Comparison between procedure – oriented programming and object oriented programming, Advantages of OOP objects, Classes, Data encapsulation, Inheritance, Polymorphism etc. Application of OOP in Analysis and design of RC, PSC and steel structural elements.


REFERENCE BOOKS:

The objectives of this course is to make students to learn principles of design of experiments, To investigate the performance of structural elements. To evaluate the different testing methods and equipments.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of experimenting skills.
- Understand the principles of design of experiments
- Design and develop analytical skills.
- Summarize the testing methods and equipments.

1. Testing of beams for deflection, flexure and shear 12 Hrs
2. Experiments on Concrete, including Mix design 12 Hrs
3. Experiments on vibration of multi storey frame models for Natural frequency and modes. 12Hrs
4. Use of Non destructive testing (NDT) equipments – Rebound hammer, Ultra sonic pulse velocity meter and Profometer 12 Hrs
The objectives of this course is to make students to learn different methods of analysis and design of plates and shells, To critically detail the plates, folded plates and shells. To evaluate the performance of spatial structures.

Course Outcomes: On completion of this course, students are able to
- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Analysis and Design
- Design and develop analytical skills.
- Summarize the performance of shells
- Understand the concepts of energy principle..

1. Introduction to plate theory, Small deflection of laterally loaded thin rectangular plates for pure bending. Navier’s and Levy’s solution for various lateral loading and boundary conditions (No derivation), Numerical examples.
2. Energy methods for rectangular and circular plates with clamped edges subjected to symmetric loadings.
3. Introduction to curved surfaces and classification of shells, Membrane theory of spherical shells, cylindrical shells, hyperbolic paraboloids, elliptic paraboloid and conoids
5. Design and detailing of folded plates with numerical examples Design and Detailing of simple shell problems – spherical domes, water tanks, barrel vaults and hyperbolic paraboloid roofs

REFERENCE BOOKS:
The objectives of this course is to make students to learn principles of engineering seismology, To design the reinforced concrete buildings for earthquake resistance. To evaluate the seismic response of the structures.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of engineering seismology
- Design and develop analytical skills.
- Summarize the Seismic evaluation and retrofitting of structures.
- Understand the concepts of earthquake resistance of reinforced concrete buildings.

1. Introduction to engineering seismology, Geological and tectonic features of India, Origin and propagation of seismic waves, characteristics of earthquake and its quantification – Magnitude and Intensity scales, seismic instruments. Earthquake Hazards in India, Earthquake Risk Evaluation and Mitigation. Structural behavior under gravity and seismic loads, Lateral load resisting structural systems, Requirements of efficient earthquake resistant structural system, damping devises, base isolation systems.


4. Design of Reinforced concrete buildings for earthquake resistance-Load combinations, Ductility and energy absorption in buildings, confinement of concrete for ductility, design of columns and beams for ductility, ductile detailing provisions as per IS-1893. Structural behavior, design and ductile detailing of shear walls.


Books for Reference:
1. Dynamics of Structures – Theory and Application to Earthquake Engineering- 2nd ed. – Anil K. Chopra, Pearson Education.
2. Earthquake Resistant Design of Building Structures, Vinod Hosur, WILEY (india)
3. Earthquake Resistant Design of Structures, Duggal, Oxford University Press
4. Earthquake resistant design of structures - Pankaj Agarwal, Manish Shrikande - PHI India
7. Seismic Design of Reinforced Concrete and Masonry Buildings, T Paulay and M J N Priestley, John Wiley and Sons
The objectives of this course is to make students to learn principles of Analysis of Stress and Strain. To apply the Finite Element Method for the analysis of one and two dimensional problems. To evaluate the stress and strain parameters and their inter relations of the continuum.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of stress-strain behaviour of continuum
- Design and develop analytical skills.
- Describe the state of stress in a continuum
- Understand the concepts of elasticity and plasticity.


5. Application to Plates & Shells- Choice of displacement function ($C_0$, $C_1$ and $C_2$ type) – Techniques for Non – linear Analysis.

REFERENCE BOOKS:
DESIGN CONCEPTS OF SUBSTRUCTURES

The objectives of this course is to make students to learn principles of subsoil exploration, To design the sub structures. To evaluate the soil shear strength parameters.

Course Outcomes: On completion of this course, students are able to
- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of subsoil exploration
- Design and develop analytical skills.
- Identify and evaluate the soil shear strength parameters.
- Understand the concepts of Settlement analysis.

1. Introduction, Site investigation, In-situ testing of soils, Subsoil exploration, Classification of foundations systems. General requirement of foundations, Selection of foundations, Computations of Loads, Design concepts.
2. Concept of soil shear strength parameters, Settlement analysis of footings, Shallow foundations in clay, Shallow foundation in sand & C-Φ soils, Footings on layered soils and sloping ground, Design for Eccentric or Moment Loads.
4. Deep Foundations: Load Transfer in Deep Foundations, Types of Deep Foundations, Ultimate bearing capacity of different types of piles in different soil conditions, Laterally loaded piles, tension piles & batter piles, Pile groups: Bearing capacity, settlement, uplift capacity, load distribution between piles, Proportioning and design concepts of piles.

IMPORTANT NOTE:
Only design principles of all type footings as per relevant BIS codes are to be covered, design of RC elements need not be covered

REFERENCE BOOKS:
ELECTIVE - II
RELIABILITY ANALYSIS OF STRUCTURES

Subject Code : 14CSE251 IA Marks : 50
No. of Lecture Hrs./ Week : 04 Exam Hrs : 03
Total No. of Lecture Hrs. : 50 Exam Marks : 100

Objectives:

The objectives of this course is to make students to learn principles of reliability, To implement the Probability Concepts for the Reliability Analysis . To evaluate different methods of reliability analysis.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of reliability.
- Design and develop analytical skills.
- Summarize the Probability distributions
- Understands the concept of System reliability.

1. Preliminary Data Analysis: Graphical representation- Histogram, frequency polygon, Measures of central tendency- grouped and ungrouped data, measures of dispersion, measures of asymmetry. Curve fitting and Correlation: Fitting a straight line, curve of the form $y = ab^x$, and parabola, Coefficient of correlation.

2. Probability Concepts: Random events-Sample space and events, Venn diagram and event space, Measures of probability-interpretation, probability axioms, addition rule, multiplication rule, conditional probability, probability tree diagram, statistical independence, total probability theorem and Baye’s theorem.


5. System reliability: Influence of correlation coefficient, redundant and non-redundant systems-series, parallel and combined systems, Uncertainty in reliability assessments- Confidence limits, Bayesian revision of reliability. Simulation Techniques: Monte Carlo simulation- Statistical experiments, sample size and accuracy, Generation of random numbers- random numbers with standard uniform distribution, continuous random variables, discrete random variables

REFERENCE BOOKS:

The objectives of this course is to make students to learn principles of stability of tall buildings, To design the tall buildings for earthquake and wind resistance. To evaluate the performance of tall structures for strength and stability.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of strength and stability
- Design and develop analytical skills.
- Summarize the behavior of various structural systems.
- Understand the concepts of P-Delta analysis.


2. **Wind loading:** static and dynamic approach, Analytical and wind tunnel experimentation method. Earthquake loading: Equivalent lateral force, modal analysis, combinations of loading, working stress design, Limit state design, Plastic design.

3. **Behavior of Various Structural Systems:** Factors affecting growth, Height and structural form; High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Futigger – braced and hybrid mega system.

4. **Analysis and Design:** Modeling for approximate analysis, accurate analysis and reduction techniques, analysis of building as total structural system considering overall integrity and major subsystem interaction, analysis for member forces; drift and twist, computerized general three dimensional analyses.

5. **Stability of Tall Buildings:** Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first order and P-Delta analysis, Transnational, Torsional instability, out of plum effects, stiffness of member in stability, effect of foundation rotation. Structural elements: sectional shapes, properties and resisting capacities, design, deflection, cracking, pre-stressing, shear flow. Design for differential movement, creep and shrinkage effects, temperature effects and fire

**REFERENCE BOOKS:**

2. Wilf gang Schuller, “High rise building structures”- John Wiley
4. T.Y Lin & D.Stotes Burry, “Structural concepts and system for Architects and Engineers”- John Wiley
7.
The objectives of this course is to make students to learn performance of masonry structures, To design the masonry structures for earthquake resistance. To evaluate the strength and stability of the masonry structures.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of design and construction of masonry structures
- Design and develop analytical skills.
- Summarize the masonry Characteristics.
- Evaluate the strength and stability of the masonry structures.

1. **Introduction, Masonry units, materials and types:** History of masonry Characteristics of Brick, stone, clay block, concrete block, stabilized mud block masonry units – strength, modulus of elasticity and water absorption. Masonry materials – Classification and properties of mortars, selection of mortars.

2. **Strength of Masonry in Compression:** Behaviour of Masonry under compression, strength and elastic properties, influence of masonry unit and mortar characteristics, effect of masonry unit height on compressive strength, influence of masonry bonding patterns on strength, prediction of strength of masonry in Indian context, Failure theories of masonry under compression. Effects of slenderness and eccentricity, effect of rate of absorption, effect of curing, effect of ageing, workmanship on compressive strength.

3. **Flexural and shear bond, flexural strength and shear strength:** Bond between masonry unit and mortar, tests for determining flexural and shear bond strengths, factors affecting bond strength, effect of bond strength on compressive strength, orthotropic strength properties of masonry in flexure, shear strength of masonry, test procedures for evaluating flexural and shear strength.

4. **Design of load bearing masonry buildings:** Permissible compressive stress, stress reduction and shape reduction factors, increase in permissible stresses for eccentric vertical and lateral loads, permissible tensile and shear stresses, Effective height of walls and columns, opening in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action, lintels; Wall carrying axial load, eccentric load with different eccentricity ratios, wall with openings, freestanding wall; Design of load bearing masonry for buildings up to 3 to 8 storeys using BIS codal provisions.

5. **Earthquake resistant masonry buildings:** Behaviour of masonry during earthquakes, concepts and design procedure for earthquake resistant masonry, BIS codal provisions. Masonry arches, domes and vaults: Components and classification of masonry arches, domes and vaults, historical buildings, construction procedure.

**REFERENCE BOOKS:**

1. Hendry A.W., *“Structural masonry”*- Macmillan Education Ltd., 2nd edition
2. Sinha B.P & Davis S.R., *“Design of Masonry structures”*- E & FN Spon
3. Dayaratnam P, *“Brick and Reinforced Brick Structures”*- Oxford & IBH
4. Curtin, *“Design of Reinforced and Prestressed Masonry”*- Thomas Telford
5. Sven Sahlin, *“Structural Masonry”*-Prentice Hall
7. IS 1905, BIS, New Delhi.
8. SP20(S&T), New Delhi
The objectives of this course is to make students to learn the soft wares for structural analysis and design, To investigate the performance of structures for static and dynamic forces.

Course Outcomes: On completion of this course, students are able to
- Achieve Knowledge of design and development of programming skills.
- Understand the principles of structural analysis and design
- Design and develop analytical skills.
- Summarize the performance of structures for static and dynamic forces.

1. Static and Dynamic analysis of Building structure using software (ETABS / STAADPRO) 12 Hrs
2. Design of RCC and Steel structure using software (ETABS / STAADPRO) 12 Hrs
3. Analysis of folded plates and shells using software. 12 Hrs
4. Preparation of EXCEL sheets for structural design. 12 Hrs
The objectives of this course is to make students to learn principles of stability of structures. To analyse the structural elements for stability. To evaluate the use of strain energy in plate bending and stability.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of strength and stability
- Design and develop analytical skills.
- Appraise the Stability analysis by finite element approach.
- Understand the concepts of Lateral buckling of beams.

1. **Beam – column** – Differential equation. Beam column subjected to (i) lateral concentrated load, (ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series, Euler’s formulation using fourth order differential equation for pined – pined, fixed – fixed, fixed – free and fixed – pinned column.


3. **Stability analysis by finite element approach** – deviation of shape function for a two nodded Bernoulli – Euler beam element (lateral and translation of) – element stiffness and element geometric stiffness matrices – assembled stiffness and geometric stiffness matrices for a discretised column with different boundary condition – calculation of critical loads for a discretised (two elements) column (both ends built in). Buckling of pin jointed frames (maximum of two active dof) – symmetrical single bay portal frame.


5. **Expression for strain energy in plate bending with in plate forces (linear and non – linear). Buckling of simply supported rectangular plate** – uniaxial load and biaxial load. Buckling of uniformly compressed rectangular plate simply supported along two opposite sides perpendicular to the direction of compression and having various edge condition along the other two sides.

**REFERENCE BOOKS:**

The objectives of this course is to make students to learn principles of Composite materials, To identify the actuators and sensors. To characterize smart materials.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Composite materials
- Design and develop analytical skills.
- Summarize the smart materials and structures
- Understand the concepts of control systems.


REFERENCE BOOKS:

The objectives of this course is to make students to learn principles of optimization, To implement the optimization Concepts for the structural engineering problems. To evaluate different methods of optimization.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of optimization.
- Design and develop analytical skills.
- Summarize the Linear, Non-linear and Geometric Programming
- Understands the concept of Dynamic programming.

1. **Introduction:** Introduction to optimization, engineering applications of optimization, Formulation of structural optimization problems as programming problems. Optimization Techniques: Classical optimization techniques, single variable optimization, multivariable optimization with no constraints, unconstrained minimization techniques and algorithms constrained optimization solutions by penalty function techniques, Lagrange multipliers techniques and feasibility techniques.

2. **Linear Programming:** Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, simplex algorithms, revised simpler methods, duality in linear programming.

3. **Non-linear programming:** Non-linear programming, one dimensional minimization methods, elimination methods, Fibonacci method, golden section method, interpolation methods, quadratic and cubic methods, Unconstrained optimization methods, direct search methods, random search methods, descent methods.

4. **Constrained optimization techniques** such as direct methods, the complex methods, cutting plane method, exterior penalty function methods for structural engineering problems. Formulation and solution of structural optimization problems by different techniques.

5. **Geometric programming:** Geometric programming, conversion of NLP as a sequence of LP/ geometric programming.

**Dynamic programming:** Dynamic programming conversion of NLP as a sequence of LP/ Dynamic programming.

**REFERENCE BOOKS:**

1. Spunt, "Optimum Structural Design"- Prentice Hall
OBJECTIVES:

The objectives of this course is to make students to learn principles of Structural Design, To design different types of structures and to detail the structures. To evaluate performance of the structures.

COURSE OUTCOMES:

On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Explain the Bridge substructures and superstructures
- Design and develop analytical skills.
- Summarize the principles of design and detailing of bridges
- Understands the different types of bridges.

1. Introduction: Historical Developments, Site Selection for Bridges, Classification of Bridges Forces on Bridges. Bridge substructures: Abutments, piers and wing walls Balanced Cantilever Bridge: Introduction and proportioning of components, Design of simply supported portion and design of cantilever portion, design of articulation

2. Box Culvert: Different Loading Cases IRC Class AA Tracked, Wheeled and Class A Loading, working out the worst combination of loading, Moment Distribution, Calculation of BM & SF, Structural Design of Slab Culvert, with Reinforcement Details.


4. T Beam Bridge Main Girder Design: Analysis of Main Girder for Dead Load & Live Load Using IRC Class AA Tracked, Wheeled Class A Loading Using COURBON’S Method, Analysis of Main Girder Using HENDRY-JAEGGER and MORICE-LITTLE Method for IRC Class AA Tracked vehicle only, BM & SF for different loads, Structural Design of Main Girder With Reinforcement Details


REFERENCE BOOKS:

3. “Principles and Practice of Bridge Engineering”- S P Bindra Dhanpat Rai & Sons New Delhi
4. IRC 6 – 1966 “Standard Specifications And Code Of Practice For Road Bridges”- Section II Loads and Stresses, The Indian Road Congress New Delhi
5. IRC 21 – 1966 “Standard Specifications And Code Of Practice For Road Bridges”-Section III Cement Concrete (Plain and reinforced) The Indian Road Congress New Delhi
7. IS 1343 – “Indian Standard Prestressed Concrete Code of Practice”- BIS New Delhi
8. Raina V.K., “Concrete Bridge Practice”- Tata McGraw Hill