VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.Tech. Structural Engineering (Tentative)

I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14CSE11	Computational Structural Mechanics	4	2	3	50	100	150	4
14 CSE 12	Advanced Design of RCC Structures	4	2	3	50	100	150	4
14 CSE 13	Mechanics of Deformable Bodies	4	2	3	50	100	150	4
14 CSE 14	Structural Dynamics	4	2	3	50	100	150	4
14 CSE 15X	Elective - I	4	2	3	50	100	150	4
14 CSE 16	Structural Engineering Lab-1	--	3	3	25	50	75	2
14 CSE 17	Seminar	--	3	--	25	--	25	1
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

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

II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14CSE21	Design of Plates & Shells	4	2	3	50	100	150	4
14 CSE 22	Earthquake Resistant Structures	4	2	3	50	100	150	4
14 CSE 23	Finite Element Method of Analysis	4	2	3	50	100	150	4
14 CSE 24	Design concepts of Substructures	4	2	3	50	100	150	4
14 CSE 25X	Elective-II	4	2	3	50	100	150	4
14 CSE 26	Structural Engineering Lab-2		3	3	25	50	75	2
14 CSE 27	Seminar	--	3	--	25	--	25	1
	**Project Phase-I(6 week Duration)	--	--	--	--	--	--	--
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

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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M.Tech. Structural Engineering

III Semester: INTERNSHIP **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
14CSE31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	1
14 CSE 32	Report on Internship	-	-	-		75	75	15
14 CSE 33	Evaluation and Viva-voce	-	-	-	–	50	50	4
	Total	**-**	**-**	**-**	**25**	**125**	**150**	**20**

* 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.

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.**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.Tech. Structural Engineering

IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
14CSE41	Stability of Structures	4	2	3	50	100	150	4
14 CSE 42X	Elective-3	4	2	3	50	100	150	4
14 CSE 43	Evaluation of Project Phase-I	-	-	-	25	-	25	1
14 CSE 44	Evaluation of Project Phase-II	-	-	-	25	-	25	1
14 CSE 45	Evaluation of Project Work and Viva-voce	–	-	3	-	100+100	200	18
	Total	**8**	**04**	**09**	**150**	**400**	**550**	**28**
Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits								

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 carryout 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.
3) Project Evaluation: 24 weeks duration in IV Semester. Project Work Evaluation shall be taken up at the end of the IV Semester. Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner (guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce).

   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).

COMPUTATIONAL STRUCTURAL MECHANICS

Subject Code	**: 14CSE11**	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 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.**

1. **Fundamental concepts:** Static and Kinematic indeterminacy, Concepts of stiffness and flexibility. Energy concepts. Principle of minimum potential energy and minimum complementary energy. Development of element flexibility and element stiffness matrices for truss, beam and grid elements.
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:

1. S.Rajasekaran, "**Computational Structural Mechanics**", PHI, New Dehi 2001.
2. F.W.Beaufait et al., "**Computer methods of Structural Analysis"**, Prentice Hall, 1970.
3. W.Weaver and J.H.Gere, "**Matrix Analysis of Framed Structures"**, Van Nastran, 1980.
4. H.Karde Stuncer, "**Elementary Matrix Analysis of Structures"**, McGraw Hill 1974.
5. A.K.Jain "**Advanced Structural Analysis with Computer Application"** Nemchand and Brothers, Roorkee, India.
6. M.F.Rubinstein "**Matrix Computer Methods of Structural Analysis** "Prentice – Hall.

ADVANCED DESIGN OF RCC STRUCTURES

Subject Code	**: 14CSE12**	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 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.**

1. Yield line method of design of slabs. Design of flat slabs.
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**
4. P.C.Varghese, "**Advanced Reinforced Concrete Design**”, Prentice-Hall of India, New Delhi, 2005.
5. Dr.B.C.Punmia, Ashok Kumar Jain and Arun Kumar Jain, **“Comprehensive RCC Design”**

MECHANICS OF DEFORMABLE BODIES

Subject Code	**: 14CSE13**	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 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 deviatric stress, spherical and deviatoric strains, max. shear strain.
3. Plane stress and plane strain: Airy's stress function approach to 2-D problems of elasticity, simple problems of bending of beams. Solution of axi-symmetric problems, stress concentration due to the presence of a circular hole in plates.
4. Elementary problems of elasticity in three dimensions, stretching of a prismatical bar by its own weight, twist of circular shafts, torsion of non-circular sections, membrane analogy, Propagation of waves in solid media. Applications of finite difference equations in elasticity.
5. **Theory of Plasticity:** Stress – strain diagram in simple tension, perfectly elastic, Rigid – Perfectly plastic, Linear work – hardening, Elastic Perfectly plastic, Elastic Linear work hardening materials, Failure theories, yield conditions, stress – space representation of yield criteria through Westergard stress space, Tresca and Von-Mises criteria of yielding.

REFERENCE BOOKS:

1. Timoshenko & Goodier, "**Theory of Elasticity**", McGraw Hill
2. Srinath L.S., **Advanced Mechanics of Solids**, 10th print, Tata McGraw Hill Publishing company, New Delhi, 1994
3. Sadhu Singh, "**Theory of Elasticity**", Khanna Publishers
4. Verma P.D.S, "**Theory of Elasticity**", Vikas Publishing Pvt. Ltd
5. Chenn W.P and Hendry D.J, "**Plasticity for Structural Engineers**", Springer Verlag
6. Valliappan C, "**Continuum Mechanics Fundamentals**", Oxford IBH Publishing Co. Ltd.
7. Sadhu Singh, "**Applied Stress Analysis**", Khanna Publishers
8. Xi Lu, "**Theory of Elasticity**", John Wiley.

STRUCTURAL DYNAMICS

Subject Code	**: 14CSE14**	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 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.**

1. Introduction: Introduction to Dynamic problems in Civil Engineering, Concept of degrees of freedom, D'Alembert's principle, principle of virtual displacement and energy principles Dynamics of Single-degree-of-freedom systems: Mathematical models of Single-degree-of-freedom systems system, Free vibration response of damped and undamped systems. Methods of evaluation of damping.
2. Response of Single-degree-of-freedom systems to harmonic loading (rotation unbalance, reciprocating unbalance) including support motion, vibration isolation, transmissibility, Numerical methods applied to Single-degree-of-freedom systems - Duhamel integral, principle of vibration-measuring instruments – seismometer and accelerometer.
3. Dynamics of Multi-degree freedom systems: Mathematical models of multi-degree-of-freedom systems, Shear building concept, free vibration of undamped multi-degree-of-freedom systems - Natural frequencies and mode shapes – orthogonality property of modes.
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:

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. **Vibrations, structural dynamics- M. Mukhopadhaya : Oxford IBH**
4. **Structural Dynamics- Mario Paz : CBS publishers.**
5. **Structural Dynamics- Clough & Penzien : TMH**
6. **Vibration Problems in Engineering Timoshenko, S, Van-Nostrand Co.**

DESIGN OF INDUSTRIAL STRUCTURES

Subject Code	**: 14CSE151**	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 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.

4. Forms of light guage sections, Effective width computation of unstiffened, stiffened, multiple stiffened compression elements of cold formed light guage sections. Concept of local buckling of thin elements. Limiting width to thickness ratio. Post buckling strength.

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:

1. Bureau of Indian Standards, IS800-2007, IS875-1987, IS-801-1975. Steel Tables, SP 6 (1) – 1984
2. N Subramanian- “Design of Steel Structure” oxford University Press
3. B.C. Punmia, A.K. Jain “Design of Steel Structures”, Laxmi Publications, New Delhi**.**
4. . Ramchandra and Virendra Gehlot “ Design of Steel Structures “ Vol 1 and Vol.2, Scientific Publishers, Jodhpur
5. Duggal “Limit State Design of Steel Structures” TMH

ELECTIVE - I

SPECIAL CONCRETE

Subject Code	**: 14CSE152**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

The objectives of this course is to make students to learn principles of Concrete mix design, To differentiate between different types of concrrete . 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.**
- **Summerize 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, pozzolona, fly ash, silica fume, rice husk ash, recycled aggregates, chemical admixtures. Mix proportioning of Concrete: Principles and methods.

2. Light Weight concrete: Introduction, classification, properties, strength and durability, mix proportioning and problems. High density concrete: Radiation shielding ability of concrete, materials for high density concrete, mix proportioning, properties in fresh and hardened state, placement methods.

3. Ferro cement: Ferrocement materials, mechanical properties, cracking of ferrocement, strength and behaviour in tension, compression and flexure, Design of ferrocement in tension, ferrocement constructions, durability, and applications.

4. ***Fibre reinforced concrete:*** Fibre materials, mix proportioning, distribution and orientation, interfacial bond, properties in fresh state, strength and behavior in tension, compression and flexure of steel fibre reinforced concrete, mechanical properties, crack arrest and toughening mechanism, applications.

5. High Performance concrete: constituents, mix proportioning, properties in fresh and hardened states, applications and limitations. Ready Mixed Concrete, Self Compacting Concrete, Reactive powder concrete, bacterial concrete.

REFERENCE BOOKS:

1. Neville A.M, "**Properties of Concrete"** Pearson Education Asis, 2000
2. P. Kumar Mehta, Paul J.N.Monterio, CONCRETE, "**Microstructure, Properties and Materials"-** Tata McGraw Hill
3. A.R.Santhakumar, (2007) "**Concrete Technology**"-Oxford University Press, New Delhi, 2007
4. Gambhir "Concrete Technology" TMH.
5. Short A and Kinniburgh.W, "**Light Weight Concrete"**- Asia Publishing House, 1963
6. Aitcin P.C**. "High performance concrete"**-E and FN, Spon London 1998
7. Rixom.R. and Mailvaganam.N., "**Chemical admixtures in concrete"-** E and FN, Spon London 1999
8. Rudnai.G., "**Light Wiehgt concrete"**- Akademiaikiado, Budapest, 1963.

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.

3. Maintenance and Repair Strategies: Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance Preventive measures on various aspects.Inspection, Assessment procedure for evaluating a damaged structure causes of deterioration - testing techniques.

4. Materials for Repair: Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, Ferro cement, Fiber reinforced concrete. Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete Epoxy injection, Mortar repair for cracks, shoring and underpinning.

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**”.
2. Denison Campbell, Allen & Harold Roper, “**Concrete Structures – Materials, Maintenance and Repair”-** Longman Scientific and Technical
3. R.T.Allen and S.C. Edwards, “**Repair of Concrete Structures**”-Blakie and Sons
4. Raiker R.N., “**Learning for failure from Deficiencies in Design, Construction and Service**”- R&D Center (SDCPL)

AI & EXPERT SYSTEM IN STRUCTURAL ENGINEERING

Subject Code	**: 14CSE154**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.**
- **Summerize the Artificial Intelligence and Expert Systems**
- **Understands the concept of Knowledge representation.**

1. Software Engineering: Introduction of software engineering – Application areas – Software design process – various design – representation techniques.Top – down design, Bottom – up design – modular programming – structural programming – Conversion of non structured programs – Software testing – Software reliability and availability.

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.

3. Artificial Intelligence: Artificial Intelligence, Introduction, AI – Application fields, defining the problems – state space representation – problem characteristics – production system – production system characteristics.

4. Knowledge representation – Formal logic – predicate logic – logic programming – forward v/s backward reasoning – matching control knowledge. Search and control: Concepts – uniformed blind search: depth first search: depth first search – breadth first search – bi – directional search – informed search – heuristic graph search – generate and test – hill climbing – best first search AND Orgraph search. Non formal knowledge representation – semantic networks – frames – scripts – productions systems. Programming in LISP.

5. Expert Systems: Their superiority over conventional software – components of an expert system – expert system life cycle – expert system developments process – nature of expert knowledge – techniques of soliciting and encoding expert knowledge. Inference: Forward chaining- backward chaining – rule value approach.

6. Uncertainty – symbolic reasoning under uncertainty: logic for non – monotonic reasoning. Statistical reasoning: Probability and Bayes theorem – certainty factor and rule based system – Bayesian network – Dempster – Shafer theory. Fuzzy reasoning. Features of rule based, netwoks based and frame based expert system – examples of expert systems in Construction Management and Structural Engg., Expert system shells. Neural Networks, An introduction – their possible applications in Civil Engg.,

REFERENCE BOOKS:

1. M.L.Shooman, “**Software Engineering**”- McGraw Hill.
2. Richard Fairly, “**Software Engineering Concepts**”- McGraw Hill.
3. Timothy Budd, “**An Introduction to Object Oriented Programming in Turbo C++**”- Addison – Wesley Publications.
4. Rober Lafore, “**Object Oriented Programming in Turbo C++**”- Gelgotia Publishers.
5. Balaguruswamy, “**Object Oriented Programming with C++**”- TMH Publishing Company Ltd.
6. Patterson D W, “**Artificial Intelligence and Expert Systems”-**Prentice Hall, New Jersy.
7. Rich, E and Knight K. “**Artificial Intelligence**”- TMH, New Delhi.
8. Rolston, D.W **“Artificial Intelligence and Expert Systems”-** McGraw Hill, New York.
9. Nilson, N.J., “**Principals of Artificial Intelligence”-** Narosa, New Delhi.
10. Adeli, H., **“Expert Systems in Constructions and Structural Engg”-** Chapman & Hall, New York.
11. Elaine Rick and Keuin Knight, “**Artificial intelligence**”- Tata McGraw Hill Edition.
12. H.Adeli**, “Expert system in structural design and construction**”- Chapman and Hall, 1988.
13. Kostem, “**Expert systems in Civil Engineering**”- ASCE, 1987.
14. C.S.Krishnamoorthy and S Rajeev Computer Aided Design Narosa Publishing House.

STRUCTURAL ENGINEERING LAB-1

Subject Code	**: 14CSE16**	IA Marks	: 25
No. of Lab Hrs./ Week	: 03	Exam Hrs	: 03
Total No. of Lab Hrs.	**: 48**	Exam Marks	:50

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.**
- **Summerize 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

II SEMESTER

DESIGN OF PLATES AND SHELLS

Subject Code	**: 14CSE21**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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
4. Axially symmetric bending of shells of revolution, Closed cylindrical shells, water tanks, spherical shells and Geckler's approximation. Bending theory of doubly curved shallow shells.
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:

1. Timosheko, S. and Woinowsky-Krieger, W., "**Theory of Plates and Shells"** 2nd Edition, McGraw-Hill Co., New York, 1959
2. Ramaswamy G.S. – "**Design and Constructions of Concrete Shell Roofs**" – CBS Publishers and Distributors – New Delhi – 1986.
3. Ugural, A. C. "**Stresses in Plates and Shells"**, 2nd edition, McGraw-Hill, 1999.
4. R. Szilard, "**Theory and analysis of plates - classical and numerical methods"**, Prentice Hall,1994
5. Chatterjee.B.K. – "**Theory and Design of Concrete Shell**", – Chapman & Hall, Newyork-third edition, 1988

EARTHQUAKE RESISTANT STRUCTURES

Subject Code	**: 14CSE22**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.
2. The Response history and strong motion characteristics. Response Spectrum – elastic and inelastic response spectra, tripartite (D-V-A) response spectrum, use of response spectrum in earthquake resistant design.Computation of seismic forces in multi-storeyed buildings – using procedures (Equivalent lateral force and dynamic analysis) as per IS-1893.
3. Structural Configuration for earthquake resistant design, Concept of plan irregularities and vertical irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. Effect of infill masonry walls on frames, modeling concepts of infill masonry walls. Behaviour of masonry buildings during earthquakes, failure patterns, strength of masonry in shear and flexure, Slenderness concept of masonry walls, concepts for earthquake resistant masonry buildings – codal provisions.
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.
5. Seismic response control concepts – Seismic demand, seismic capacity, Overview of linear and nonlinear procedures of seismic analysis. Performance Based Seismic Engineering methodology, Seismic evaluation and retrofitting of structures.

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**
5. **IS – 1893 (Part I): 2002, IS – 13920: 1993, IS – 4326: 1993, IS-13828: 1993**
6. **Design of Earthquake Resistant Buildings, Minoru Wakabayashi, McGraw Hill Pub.**
7. **Seismic Design of Reinforced Concrete and Masonry Buildings, T Paulay and M J N Priestley, John Wiley and Sons**

FINITE ELEMENT METHOD OF ANALYSIS

Subject Code	**: 14CSE23**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.**

1. Basic concepts of elasticity – Kinematic and Static variables for various types of structural problems – approximate method of structural analysis – Rayleigh – Ritz method – Finite difference method – Finite element method. Variation method and minimization of Energy approach of element formulation.Principles of finite element method – advantages & disadvantages – Finite element procedure. Finite elements used for one, two & three dimensional problems – Element aspect ratio – mesh refinement vs. higher order elements – Numbering of nodes to minimize band width.

2. Nodal displacement parameters – Convergence criterion – Compatibility requirements – Geometric invariance – Shape function – Polynomial form of displacement function. Generalized and Natural coordinates – Lagrangian interpolation function – shape functions for one, two & three dimensional elements.

3. Isoparametric elements - Internal nodes and higher order elements – Serendipity and Lagrangian family of Finite Elements – Sub parametric and Super parametric elements – Condensation of internal nodes – Jacobian transformation Matrix. Development of strain – displacement matrix and stiffness matrix, consistent load vector, numerical integration.

4. Application of Finite Element Method for the analysis of one & two dimensional problems - Analysis of simple beams and plane trusses – Application to plane stress / strain / axisymmetric problems using CST & Quadrilateral Elements.

5. Application to Plates & Shells- Choice of displacement function (C^0, C^1 and C^2 type) – Techniques for Non – linear Analysis.

REFERENCE BOOKS:

1. Krishnamoorthy C S, "**Finite Element Analysis"-** Tata McGraw Hill
2. Desai C and Abel J F, "**Introduction to the Finite Element Method**"- East West Press Pvt. Ltd., 1972
3. Bathe K J, "**Finite Element Procedures in Engineering Analysis**"- Prentice Hall
4. Rajasekaran. S, "**Finite Element Analysis in Engineering Design"-**Wheeler Publishing
5. Cook R D, Malkan D S & Plesta M.E, "**Concepts and Application of Finite Element Analysis" -** 3rd Edition, John Wiley and Sons Inc., 1989
6. Shames I H and Dym C J, "**Energy and Finite Element Methods in Structural Mechanics**"- McGraw Hill, New York, 1985

DESIGN CONCEPTS OF SUBSTRUCTURES

Subject Code	**: 14CSE24**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.
3. Types of rafts, bearing capacity & settlements of raft foundation, Rigid methods, Flexible methods, soil-structure interaction, different methods of modeling the soil. Combined footings (rectangular & trapezoidal), strap footings & wall footings, Raft – super structure interaction effects & general concepts of structural design, Basement slabs.
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.
5. Types of caissons, Analysis of well foundations, Design principles, Well construction and sinking. Foundations for tower structures: Introduction, Forces on tower foundations, Selection of foundation type, Stability and design considerations, Ring foundations – general concepts.

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:

1. Swami Saran – “**Analysis & Design of Substructures**”- Oxford & IBH Pub. Co. Pvt. Ltd., 1998.
2. Nainan P Kurian – “**Design of Foundation Systems**”- Narosa Publishing House, 1992.
3. R.B. Peck, W.E. Hanson & T.H. Thornburn – “**Foundation Engineering”-** Wiley Eastern Ltd.,Second Edition, 1984.
4. J.E. Bowles – “**Foundation Analysis and Design**”- McGraw-Hill Int. Editions, Fifth Ed., 1996.
5. W.C. Teng – “**Foundation Design”-** Prentice Hall of India Pvt. Ltd., 1983.
6. Bureau of Indian Standards:IS-1498, IS-1892, IS-1904, IS-6403, IS-8009, IS-2950, IS-11089, IS-11233, IS-2911 and all other relevant codes.

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.
3. **Random variables:** Probability mass function, probability density function, Mathematical expectation, Chebyshev's theorem. Probability distributions: Discrete distributions- Binomial and poison distributions, Continuous distributions- Normal, Log normal distributions.
4. **Reliability Analysis:** Measures of reliability-factor of safety, safety margin, reliability index, performance function and limiting state. Reliability Methods-First Order Second Moment Method (FOSM), Point Estimate Method (PEM), and Advanced First Order Second Moment Method (Hasofer-Lind's method)
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:

1. Ranganathan, R. (1999). "**Structural Reliability Analysis and design"-** Jaico publishing house, Mumbai, India.
2. Ang, A. H. S., and Tang, W. H. (1984). "**Probability concepts in engineering planning and design"**- Volume –I, John Wiley and sons, Inc, New York.
3. Ang, A. H. S., and Tang, W. H. (1984). "**Probability concepts in engineering planning and design"**-Volume –II, John Wiley and sons, Inc, New York.
4. Milton, E. Harr (1987). "**Reliability based design in civil engineering"-** Mc Graw Hill book Co.
5. Nathabdndu, T., Kottegoda, and Renzo Rosso (1998). Statistics, "**Probability and reliability for Civil and Environmental Engineers"-** Mc Graw Hill international edition, Singapore.
6. Achintya Haldar, and Sankaran Mahadevan (2000). "**Probability, Reliability and Statistical methods in Engineering design"-** John Wiley and Sons. Inc.
7. Thoft-christensen, P., and Baker, M., J., (1982), "**Structural reliability theory and its applications**"- Springer-Verlag, Berlin, NewYork.
8. Thoft-christensen, P., and Murotsu, Y. (1986). "**Application of structural systems reliability theory"-** Springer-Verlag, Berlin, NewYork.

DESIGN OF TALL STRUCTURES

Subject Code	**: 14CSE252**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.**

1. **Design Criteria:** Design philosophy, loading, sequential loading, and materials – high performance concrete, fiber reinforced concrete, lightweight concrete, design mixes. Loading and Movement: Gravity loading: Dead and live load, methods of live load reduction, Impact, Gravity loading, Construction loads
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:

1. Taranath B.S, "**Structural Analysis and Design of Tall Buildings**"- McGraw Hill
2. Wilf gang Schuller, "**High rise building structures**"- John Wiley
3. Bryan Stafford Smith & Alexcoull, "**Tall building structures Analysis and Design**"- John Wiley
4. T.Y Lin & D.Stotes Burry, "**Structural concepts and system for Architects and Engineers"-** John Wiley
5. Lynn S.Beedle, "**Advances in Tall Buildings**"- CBS Publishers and Distributors.
6. Dr. Y.P. Gupta – Editor, "**Proceedings National Seminar on High Rise Structures**- **Design and Construction practices for middle level cities"-** New Age International Limited.
7.

MASONRY STRUCTURES

Subject Code	**: 14CSE253**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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
6. Jagadish K S, Venkatarama Reddy B V and Nanjunda Rao K S, “**Alternative Building Materials and Technologies**”- New Age International, New Delhi & Bangalore
7. IS 1905, BIS, New Delhi.
8. SP20(S&T),New Delhi

STRUCTURAL ENGINEERING LAB-2

Subject Code	**: 14CSE26**	IA Marks	: 25
No. of Lab Hrs./ Week	: 03	Exam Hrs	: 03
Total No. of Lab Hrs.	**: 48**	Exam Marks	:50

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.**
- **Summerize 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

STABILITY ANALYSIS OF STRUCTURES

Subject Code	**: 14CSE41**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.
2. **Buckling of frames and continuous beams. Elastica. Energy method** – Approximate calculation of critical loads for a cantilever. Exact critical load for hinged – hinged column using energy approach.Buckling of bar on elastic foundation. Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section. Effect of shear force on critical load. Column subjected to non – conservative follower and pulsating forces.
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.
4. **Lateral buckling of beams** – differential equation – pure bending – cantilever beam with tip load – simply supported beam of I section subjected to central concentrated load. Pure Torsion of thin – walled bars of open cross section. Non – uniform Torsion of thin – walled bars of open cross section.
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:

1. Stephen P.Timoshenko, James M Gere, "**Theory of Elastic Stability**"-2nd Edition, McGraw – Hill, New Delhi.
2. Robert D Cook et.al, "**Concepts and Applications of Finite Element Analysis**"-3rd Edition, John Wiley and Sons, New York.
3. S.Rajashekar, "**Computations and Structural Mechanics**"-Prentice – Hall, India.
4. Ray W Clough and J Penzien, "**Dynamics of Structures**" - 2nd Edition, McGraw Hill, New Delhi
5. H.Zeiglar, "**Principles of Structural Stability**"-Blaisdall Publications.

ELECTIVE - III

COMPOSITE AND SMART – MATERIALS

Subject Code	**: 14CSE421**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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.**
- **Summerize the smart materials and structures**
- **Understand the concepts of control systems.**

1. **Introduction:** Introduction to Composite materials, classifications and applications. Anisotropic elasticity – unidirectional and anisotropic laminae, thermo – mechanical properties, micro – mechanical analysis, characterization tests.
2. Classical composite lamination theory, cross and angle – play laminaes, symmetric, antisymmetric and general symmetric laminates, mechanical coupling. Analysis of simple laminated structural elements ply-stress and strain, lamina failure theories – first fly failure, vibration and buckling analysis. Sandwich structure face and core materials, secondary failure modes environmental effects, manufacturing of composites.
3. Introduction to smart materials and structures – piezoelectric materials – coupled electromechanical constitutive relations – depoling and coercive field – field – strain relation – hysterics – creep – strain rate effects – manufacturing.
4. Actuators and sensors: single and dual actuators – pure extension, pure bending – bending extension relations – uniform strain beam model – symmetric induced strain actuators – bond shearing force – Bernoulli Euler (BE) beam model – embedded actuators.
5. Assymetric induced strain actuators in uniform strain and Euler – Bernoulli models. Uniform strain model – energy principle formulation – BE model – single and dual surface bonded actuators – Extension – bending and torsion model. Introductions to control systems: Open loop and close loop transfer functions – stability criteria – deflection control of beam like structures – using piezoelectric sensors and actuators – shape memory alloys.

REFERENCE BOOKS:

1. Mechanics of Composite Materials and Structures by M. Mukhopadhya- Universities Press 2009
2. Robart M.Jones, "**Mechanical of Composite Materials**"- McGraw Hill Publishing Co.
3. Bhagwan D Agarvalm, and Lawrence J Brutman, "**Analysis and Performance of Fiber Composites**"- John Willy and Sons.
4. 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.
5. Crawley, E and Anderson, E., "**Detailed models of Piezoceramic actuation of beams**" - Proc. of the 30th AIAA/ASME/ASME/ASCE/AHS/ASC – Structural dynamics and material conference, AIAA, Washington DC, April 1989.

OPTIMIZATION TECHNIQUES

Subject Code	**: 14CSE422**	IA Marks	: 50
No. of Lecture Hrs./ Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs.	: 50	Exam Marks	: 100

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
2. S.S. Rao, “**Optimization – Theory and Practice**”- Wiley Eastern Ltd.
3. Uri Krisch, “**Optimum Structural Design**”- McGraw Hill
4. Richard Bronson, “**Operation Research**”- Schaum’s Outline Series
5. Bhavikatti S.S.- “**Structural optimization using sequential linear programming”-** Vikas publishing house.

DESIGN OF CONCRETE BRIDGES

Subject Code	**: 14CSE423**	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 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.

3. T Beam Bridge Slab Design: Proportioning of Components Analysis of interior Slab & Cantilever Slab Using IRC Class AA Tracked, Wheeled Class A Loading, Structural Design of Slab, with Reinforcement Detail. T Beam Bridge Cross Girder Design: Analysis of Cross Girder for Dead Load & Live Load Using IRC Class AA Tracked, Wheeled Class A Loading A Loads, Structural Design of Beam, with Reinforcement Detail.

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-JAEGER and MORICE-LITTLE Method for IRC Class AA Tracked vehicle only, BM & SF for different loads, Structural Design of Main Girder With Reinforcement Details

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, Design of End block and detailing of main girder.

REFERENCE BOOKS:

1. **"Essentials of Bridge Engineering**"- D Johnson Victor, Oxford & IBH Publishing Co New Delhi
2. **"Design of Bridges"-** N Krishna Raju, Oxford & IBH Publishing Co New Delhi
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
6. IS 456 – 2000 "**Indian Standard Plain and Reinforced Concrete Code of Practice"-** (Fourth Revision) BIS 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
9. Bakht B & Jaeggar, "**Bridge Analysis Simplified**"- McGraw Hill
10. Ponnuswamy . S, "**Bridge Engineering**"- Tata McGraw Hill.
11. Derrick Beckett, "**An Introduction to Structural Design of Concrete Bridges**"- Surrey University Press