CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Structural Engineering) PROGRAM

FIRST SEMESTER TO FOURTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2022-2023

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided, Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Approved in 64th Academic Council Meeting on 11.01.2023

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015
DEPARTMENT OF CIVIL ENGINEERING

Vision

To establish process of learning to meet the global standards for sustainable built environment

Mission

We are committed to:

- Provide quality education through innovation in teaching and learning practices meeting the globalstandards
- Encourage faculty and students to carry out socially relevant and forwardlookingresearch
- Offer consultancy services using state of the art facilities fulfilling the needs of the industry andsociety
- Enable our students, faculty and staff to play leadership roles for the betterment of the society in a sustainablemanner.

Programme Educational Objectives (PEOs) of M.E. (Structural Engineering)

PEO1: Graduates of the programme will be competent in Structural Engineering to apply in-depth technical knowledge, effective design skills and sustainability principles to address evolving engineering challenges of the industry and society with professional ethics.

PEO2: Graduates of the programme will have commitment for continuing professional development in this field or in related inter disciplinary fields with a background in civil engineering.

PEO3: Graduates of the programme will engage in continual learning by pursuing advancedresearch.

Programme Specific Objectives (PSOs) of M.E. (Structural Engineering)

PSO1	Apply in-depth Structural Engineering professional knowledge in solving complex problems with conceptual, lateral and appropriate research thinking skills using modern tools to address evolving engineering challenges of the industry and society with professionalethics.
PSO2	Communicate effectively and engage in continual learning through advanced research and professional development in multi - disciplinary fields with enthusiasm to improve knowledge and competentcontinuously.

Programme Outcomes (POs) of M.E. (Structural Engineering)

Graduating Students of M.E. Structural Engineering programme are as following:

1. Scholarship ofKnowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

2. CriticalThinking

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. ProblemSolving

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. ResearchSkill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. Usage of moderntools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of thelimitations.

6. Collaborative and Multidisciplinarywork

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Project Management andFinance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.

8. Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clearinstructions.

9. Life-longLearning

Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Ethical Practices and SocialResponsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Independent and ReflectiveLearning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on externalfeedback

Department of Civil Engineering
M.E Structural Engineering programme

Schedule of courses

Semesters	Theory Courses					Theory cum Practical	Laboratory	Project	Credits
	1	2	3	4	5	6	7	8	
1st	21SE110- Applied Mathematics (3Credits)	21SE120- Finite Element Method (3Credits)	21SE130- Theory of Elasticity and Plasticity (3Credits)	21SE140- Dynamics of Structures (3Credits)	21SEPX0 - Programme Elective-I (3credits)	21SE160- Forensic Engg. and Rehabilitationof structures (3Credits)	21SE171- Structural Engineering Laboratory (2 Credits)	-	20
2nd	21SEPX0- Programme Elective-II (3 credits)	21SEPX0- Programme Elective-III (3 credits)	21PGPX0 -Open Elective (2Credits)	21PG250 Research Methodology and IPR (2 Credits)	-	21SE260 – Experimental Techniques and Instrumentation	21SE271- Dynamics Laboratory (2 Credits)	21SE280 – Mini Project (2 Credits)	17
3rd	21SEPX0- Programme Elective-IV (3 credits)	21SEPX0- Programme Elective-V (3 credits)	-	-	-	-	-	21SE380- Dissertation Phase-I (10 Credits)	16
4th	-	-	-	-	-	-	-	21SE480- Dissertation Phase-II (15Credits)	15
Total credits for curriculum activities									**68**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Structural Engineering) Program

COURSES OF STUDY

(For the candidates admitted from 2022-23)

FIRST SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
THEORY						
21SE110	Applied Mathematics	FC	2	1	-	3
21SE120	Finite Element Method	PC	2	1	-	3
21SE130	Theory of Elasticity and Plasticity	PC	3	-	-	3
21SE140	Dynamics of Structures	PC	3	-	-	3
21SEPX0	Programme Elective-I	PE	3	-	-	3
THEORY CUM PRACTICAL						
21SE160	Forensic Engg. and Rehabilitation of structures	TCP	2	-	2	3
PRACTICAL						
21SE171	Structural Engineering Laboratory	PC	-	-	4	2
	Total		**1**	**2**	**6**	**20**

SECOND SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
THEORY						
21SEPX0	Programme Elective-II	PE	3	-	-	3
21SEPX0	Programme Elective – III	PE	3	-	-	3
21PG250	Research Methodology and IPR	CC	2	-	-	2
21PGPX0	Open Elective	PE	2	-	-	2
THEORY CUM PRACTICAL						
21SE260	Experimental Techniques and Instrumentation	TCP	2	-	2	3
PRACTICAL						
21SE271	Dynamics Laboratory	PC	-	-	4	2
21SE280	Mini Project	PC	-	-	4	2
	Total		**12**	**-**	**1**	**17**

THIRD SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
THEORY						
21SEPX0	Programme Elective – IV	PE	3	-	-	3
21SEPX0	Programme Elective – V	PE	3	-	-	3
PRACTICAL						
21SE380	Dissertation Phase-I	PC	-	-	20	10
Total			**6**	**-**	**10**	**16**

FOURTH SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
21SE480	Dissertation Phase-II	PC	-	-	30	15
Total			**-**	**-**	**30**	**15**

*** BS- Basic Sciences; HSS-Humanities and Social Sciences; ES-Engineering Sciences; FC- Foundation Core; PC- Programme Core; PE-Programme Elective; GE-General Elective; OC-One Credit Course; TC- Two Credit Course; SS-Self-Study Course (in the list of ProgrammeElectives)*

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

PROCEDURE FOR AWARDING MARKS FOR INTERNAL ASSESSMENT

For all the theory courses, laboratory courses, theory courses with laboratory component and project work the continuous assessment shall be awarded as per the procedure given below:

THEORY COURSES

Two assessments each carrying 100 marks shall be conducted during the semester by the Department / College concerned. The total marks obtained in all assessments put together out of 200, shall be proportionately reduced for 40 marks and rounded to the nearest integer (This also implies equal weightage to the two assessments).

Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total** Internal Assessment
Individual Assignment / Case Study / Seminar / Mini Project / any other experiential Learning	Written Test	Individual Assignment / Case Study / Seminar / Mini Project / any other experiential Learning	Written Test	
40	60	40	60	200*

**The weighted average shall be converted into 40 marks for internal Assessment.*

A minimum of two internal assessments will be conducted as a part of continuous assessment. Eachinternalassessmentistobeconductedfor100marksandwillhavetobedistributedintwo parts viz., Individual Assignment/Case study/Seminar/Mini project and Test with each having a weightage of 40% and 60% respectively. The tests shall be in written mode. The total internal assessment marks of 200 shall be converted into a maximum of 40 marks and rounded to the nearestinteger.

LABORATORY COURSES

The maximum marks for Internal Assessment shall be 60 marks in case of practical courses. Every practical exercise / experiment shall be evaluated based on conduct of experiment / exercise and records are to be maintained. There shall be at least one test. The criteria for arriving at the Internal Assessment marks of 60 is as follows: 75 marks shall be awarded forsuccessfulcompletionof alltheprescribedexperimentsdoneintheLaboratoryand25marks for the test. The total mark shall be converted into a maximum of 60 marks and rounded to the nearestinteger.

Internal Assessment (100 Marks)*	
Evaluation of Laboratory Observation, Record	Test
75	25

** Internal assessment marks shall be converted into 60 marks*

THEORY COURSES WITH LABORATORY COMPONENT / LABORATORY COURSES WITH THEORY COMPONENT

Weightageofinternalassessmentandendsemesterexaminationmarkswillbe50%each. The distribution of marks for the theory and laboratory components in the internal assessmentsandendsemesterexaminationfordifferenttypesofcoursesareprovidedin thetable.

L	***T***	***P***	***C***	***Internal***		***End semester examination***
				Assessment 1	***Assessment 2***	
1	*0*	*4*	*3*	*Laboratory (25%)*	*Theory (25%)*	*Laboratory only (50%)*
1	*0*	*2*	*2*	*Laboratory (25%)*	*Theory (25%)*	*Laboratory only (50%)*
2	*0*	*2*	*3*	*Theory (25%)*	*Laboratory (25%)*	*Theory (25%)* *Laboratory (25%)*
3	*0*	*2*	*4*	*Theory (25%)*	*Laboratory (25%)*	*Theory (35%)* *Laboratory (15%)*
2	*0*	*4*	*4*	*Theory (25%)*	*Laboratory (25%)*	*Theory (15%)* *Laboratory (35%)*

The procedure for the conduct of internal assessments for theory and laboratory components shall be as per the clause 12.1 and 12.2 respectively.*

The weighted average shall be converted into 50 marks for internal Assessment.

** Autonomous Colleges may adopt Theory courses with Laboratory component and Laboratory courses with Theory component with different L T P C formats and the weightage of marks for Theory and Laboratory components may be fixed in proportion to lecture and practical contact periods. However, the weightage for internal and end semester examination marks will remain as 50%each.*

PROJECT WORK / INTERNSHIP AND LABORATORY COURSES

For the Project Work / Internship and Laboratory Courses fixed grading procedure shall be followed.

PASSING REQUIREMENTS

A student who secures not less than 50% of total marks prescribed for the course [Internal Assessment + End semester University Examinations] with a minimum of 45% of the marks prescribed for the end-semester University Examination, shall be declared to have passed the course and acquired the relevant number of credits. This is applicable for both theory and laboratory courses (including project work).

If a student fails to secure a pass in a theory course / laboratory course (except electives), the student shall register and appear only for the end semester examination in the subsequent semester. In such case, the internal assessment marks obtained by the student in the first appearance shall be retained and considered valid for all subsequent attempts till the student secures a pass. However, from the third attempt onwards if a student fails to obtain pass marks (IA + End Semester Examination), then the student shall be declared to have passed the examination if he/she secures a minimum of 50% marks prescribed for the University end semester examinations alone.

AWARD OF LETTER GRADES

The award of letter grades will be decided based on relative grading principle. The relative grading is applicable to ONLY those students who have passed the examination as per the passing requirements enumerated above. For those students who have not passed the examination, Reappearance (U) shall be awarded as shown in the below Table.

For those students who have passed the course, the relative grading shall be done. The marks of those students who have passed only shall be inputted in the software developed for relative grading. The evolved relative grading method normalizes the results data using the BOX-COX transformation method and computes the grade range for each course separately and awards the grade to each student. For a given course, if the students' strength is greater than 30, the relativegradingmethodshallbeadopted.However,ifthestudents'strengthislessthanorequal to 30 then the fixed grading shall be followed with the grade range as specifiedbelow.

O	A+	A	B+	B	C	*U*
91 - 100	81 - 90	71 - 80	61 - 70	56 - 60	50 – 55	< 50

The performance of a student shall be reported using letter grades, each carrying certain points as detailed below:

Letter Grade	Grade Points*
O (Outstanding)	10
A +(Excellent)	9
A (VeryGood)	8
B +(Good)	7
B (Average)	6
C (Satisfactory)	5
U(Re-appearance)	0
SA (Shortage of Attendance)	-
WD (Withdrawal)	-

A student is deemed to have passed and acquired the corresponding credits in a particular course if he/she obtains any one of the following grades: "O", "A+", "A", "B+","B", "C".

'SA' denotes shortage of attendance and hence prevented from writing the end semester examinations. 'SA' will appear only in the result sheet.

"U" denotes that the student has failed to pass in that course. "**WD**" denotes **withdrawal** from the exam for the particular course. The grades U and WD will figure both in the Grade Sheet as well as in the Result Sheet. In both cases, the student has to appear for the End Semester Examinations.

If the grade U is given to **Theory Courses**/ **Laboratory Courses it is not required to satisfy the**attendancerequirements,buthastoappearfortheendsemesterexaminationandfulfilthe passing requirements to earn a pass in the respectivecourses.

If the grade U is given to **EEC (Employability Enhancement Course) (except Project Work), which are evaluated only through internal assessment,** the student shall register forthecourseagaininthesubsequentsemester,fulfillthepassingrequirementstoearnpass in the course. However, attendance requirement need not besatisfied.

CLASSIFICATION OF THE DEGREE AWARDED FIRST

CLASS WITH DISTINCTION

A student who satisfies the following conditions shall be declared to have passed the examination in **First class with Distinction:**

- Should have passed the examination in all the courses of all the eight semesters (10SemestersincaseofMechanical(Sandwich)and6semestersinthecaseofLateral Entry) in the student's First Appearance within **five** years (S ix years in the case of Mechanical (Sandwich) and Four years in the case of Lateral Entry). Withdrawal from examination will not be considered as anappearance.
- Should have secured a CGPA of not less than**8.50**.
- One year authorized break of study (if availed of) is included in the five years (Six years in the case of Mechanical (Sandwich) and four years in the case of lateral entry) for award of First class withDistinction.
- Should NOT have been prevented from writing end semester examination due to lack of attendance in anysemester.

FIRST CLASS:

A student who satisfies the following conditions shall be declaredtohavepassedtheexamination in **Firstclass:**

- Should have passed the examination in all the courses of all eight semesters (10 Semesters in case of Mechanical (Sandwich) and 6 semesters in the case of Lateral Entry) **within five years**. (Six years in case of Mechanical (Sandwich) and Four years in the case of LateralEntry).
- One year authorized break of study (if availed of) or prevention from writing the End Semester examination due to lack of attendance (if applicable) is included in the durationof five years (Six years in case of Mechanical (Sandwich) and four years in the case of lateral entry) for award of Firstclass.
- Should have secured a CGPA of not less than**6.50.**

SECOND CLASS:

All other students who qualify for the award of the degree shall be declared to have passed the examination in **Second Class**.

The corresponding specific changes are to be made to B.Arch. / M.Arch. / M.Plan. / MBA / M.Sc.(5years).

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Structural Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-23)

FIRST SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SE110	Applied Mathematics	3	40	60	100	27	50
2	21SE120	Finite Element Method	3	40	60	100	27	50
3	21SE130	Theory of Elasticity and Plasticity	3	40	60	100	27	50
4	21SE140	Dynamics of Structures	3	40	60	100	27	50
5	21SEP X0	Programme Elective – I	3	40	60	100	27	50
THEORY CUM PRACTICAL								
6	21SE160	Forensic Engg. and Rehabilitation of structures	3	50	50	100	22.5	50
PRACTICAL								
7	21SE171	Structural Engineering Laboratory	3	60	40	100	18	50

SECOND SEMESTER

S. No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SEPX0	Programme Elective-II	3	40	60	100	27	50
2	21SEPX0	Programme Elective – III	3	40	60	100	27	50

3	21PG250	Research Methodology and IPR	3	40	60	100	27	50
4	21PGPX0	Open Elective	3	40	60	100	27	50
THEORY CUM PRACTICAL								
5	21SE260	Experimental Techniques and Instrumentation	3	50	50	100	22. 5	50
PRACTICAL								
6	21SE271	Dynamics Laboratory	3	60	40	100	18	50
7	21SE2	Mini Project	-	50	50	100	22.	50

THIRD SEMESTER

S. No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SEPX0	Programme Elective – IV	3	40	60	100	27	50
2	21SEPX0	Programme Elective – V	3	40	60	100	27	50
PRACTICAL								
3	21SE380	Dissertation Phase-I	-	50	50	100	22. 5	50

FOURTH SEMESTER

S. No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	21SE480	Dissertation Phase-II	-	50	50	100	22.5	50

LIST OF ELECTIVES

Sl.No	Subject Code	Course Name
1	21SEPA0	Analysis and Design of Concrete Structures
2	21SEPB0	Aseismic Design of Structures
3	21SEPC0	Bridge Engineering
4	21SEPD0	Blast Resistant Design of structures
5	21SEPE0	Computational methods in Structural Analysis
6	21SEPF0	Computer Aided Design
7	21SEPG0	Creep and Fatigue behaviour of Materials
8	21SEPH0	Design of Foundation and Substructure
9	21SEPK0	Design of Steel Concrete Composite Structures
10	21SEPL0	Fracture mechanics
11	21SEPM0	Industrial Structures
12	21SEPN0	Prestressed Concrete
13	21SEPQ1	Structural Steel Design
14	21SEPR0	Structural Mechanics
15	21SEPS0	Theory of plates

LIST OF OPEN ELECTIVES

Sl.No	Course Name
1	Business Analytics
2	Industrial Safety
3	Operations Research
4	Cost Management of Engineering Projects
5	Composite Materials
6	Waste to Energy

LIST OF AUDIT COURSE 1 & 2

A student has to complete 2 Audit courses of 24 hours duration. The courses will normally be conducted on weekends.

Sl.No	Course Name
1	English for Research Paper Writing
2	Disaster Management
3	Sanskrit for Technical Knowledge
4	Value Education
5	Constitution of India
6	Pedagogy Studies
7	Stress Management by Yoga
8	Personality Development through Life Enlightenment Skills
9	Value Engineering

21SE110	**APPLIED MATHEMATICS**	Category	L	T	P	Credit
		FC	2	1	0	3

Preamble

Engineering is concerned with the application of the basic sciences and mathematics to solve real world problems. Structural Engineers design, create, solve problems, innovate and use mathematics and science to shape the world. The course comprises the partial differential equations, variational formulation and its application in solving boundary value problems associated with engineering application, eigen value problems, numerical integration techniques, their application to obtain solutions for heat and flow problems of one and two dimensional conditions and random processes. The course is designed to impart the knowledge and awareness of Applied Mathematics to structural engineering and apply them in their areas of specialization.

Prerequisite

Engineering Mathematics, Probability and Statistics

Course Outcomes

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency
CO1	Apply Fourier transform methods for solving diffusion equation, wave equation and Laplace equation.	Apply	75	B
CO2	Formulate variational problems and solve boundary value problems using variational techniques	Apply	75	B
CO3	Find Eigen values and solve Eigen value problems.	Apply	75	B
CO4	Apply numerical integration of one and two dimension, multiple integral by using mapping function	Apply	75	B
CO5	Describe the random processes and apply the probabilistic model for characterizing the random processes	Apply	75	B

Mapping with Programme Outcomes

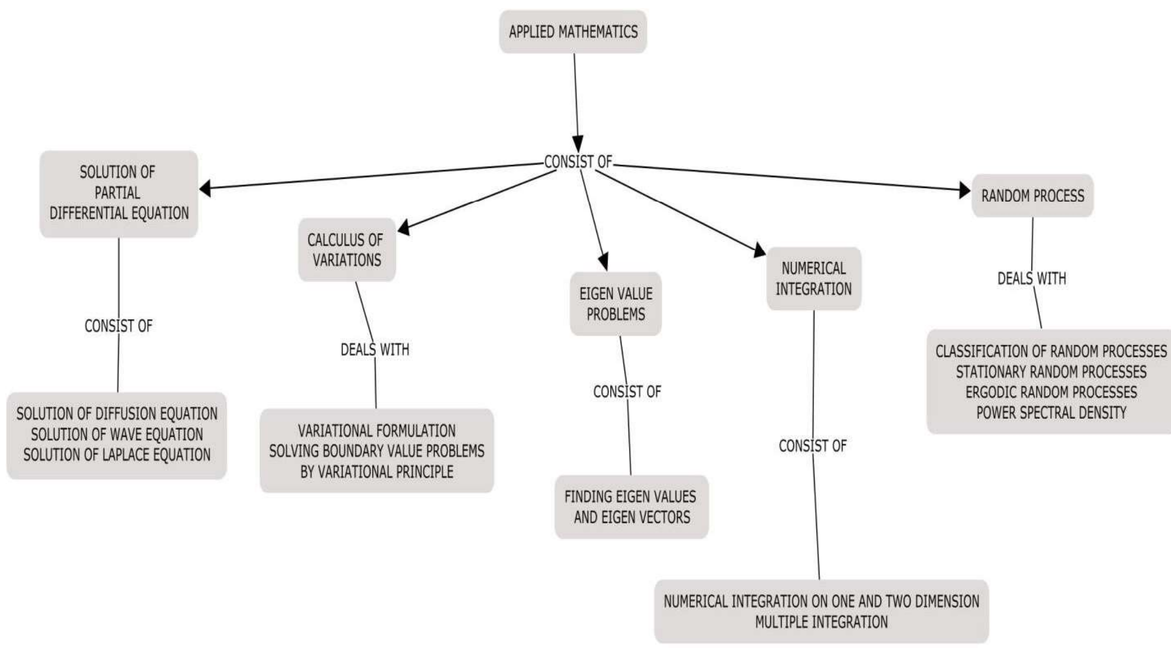
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO10	PO11	PO12	PSO1	PSO2
CO1.	**S**	**S**	**S**	M	-	-	-	-	-	-	-	M	M
CO2.	**S**	**S**	**S**	M	-	-	-	-	-	-	-	-	-
CO3.	**S**	**S**	**S**	M	-	-	-	-	-	-	-	M	M
CO4.	**S**	**S**	**S**	M	-	-	-	-	-	-	-	-	-
CO5.	**S**	**S**	**S**	M	-	-	-	-	-	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Cognitive Levels	Continuous Assessment Tests		Assignment		Terminal Examination
	1	2	1	2	
Remember	10	10			
Understand	30	30			30
Apply	60	60	100	100	70
Analyse					
Evaluate					
Create					

Concept Map



Syllabus

SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS – Fourier transform methods- Solution of Diffusion equation – Solution of wave equation – Solution of Laplace equation **CALCULUS OF VARIATIONS –** Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Direct method in variational problems – Rayleigh – Ritz method - **EIGEN VALUE PROBLEMS –** Methods of solutions: Faddeev – Leverrier Method, Vector iteration techniques – Deflation methods - **NUMERICAL INTEGRATION** – Gaussian Quadrature – One and Two dimensions – Monte Carlo method – Multiple integration by using mapping function **RANDOM PROCESSES -** Classification of random processes-Stationary random processes - Ergodic processes - Power spectral density- Engineering Applications.

Reference Books

1. Sankara Rao,K., "Introduction to Partial Differential Equations", Prentice Hall of India

Pvt. Ltd., New Delhi, 1997
2. Gupta, A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Rajasekaran.S, “Numerical Methods in Science and Engineering A Practical Approach”, A.H.Wheeler and Company Private Limited, 1986.
4. Andrews, L.C. and Shivamoggi, B.K., “Integral Trasforms for Engineers”, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
5. Zach Liang. George C. Lee Random Vibration: Mechanical, Structural, and Earthquake Engineering Applications, CRC Press Taylor and Francis Group, London 2015.

Course Contents and Lecture Schedule

Module No	Topic	No.of Lectures
1	**SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**	
1.1	Fourier transform methods	1
1.2	Solution of Diffusion equation	1
1.3	Tutorial	1
1.4	Solution wave equation	1
1.5	Solution of Laplace equation	1
1.6	Tutorial	1
2	**CALCULUS OF VARIATIONS**	
2.1	Concept of variation and its properties	1
2.2	Euler’s equation	1
2.3	Tutorial	1
2.4	Functional dependant on first and higher order derivatives	1
2.5	Functionals dependant on functions of several independent variables	1
2.6	Tutorial	1
2.7	Direct method in variational problems – Rayleigh – Ritz method	2
2.8	Tutorial	1
3	**EIGEN VALUE PROBLEMS**	
3.1	Methods of solutions: Faddeev – Leverrier Method	1
3.2	Vector iteration techniques	1
3.3	Tutorial	1
3.4	Deflation methods	2
3.5	Tutorial	1
4	**NUMERICAL INTEGRATION**	
4.1	Gaussian Quadrature	1
4.2	One and Two dimensions	1
4.3	Tutorial	1
4.4	Monte-Carlo method	1
4.5	Multiple integration by using mapping function	1
4.6	Tutorial	1
5	**RANDOM PROCESSES**	
5.1	Classification of random processes	1
5.2	Stationary random processes	1
5.3	Tutorial	1
5.4	Ergodic processes	2
5.5	Tutorial	1
5.6	Power spectral density	2
5.7	Tutorial	1
	Total	**36**

Course Designer:

Dr. Rammohan. R rr_maths@tce.edu

21SE120 FINITE ELEMENT METHOD

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

This course provides an introduction to the finite element analysis, from engineering rather than a purely mathematical point of view.

Prerequisite

Fundamentals of Mathematics, knowledge of forces and resolution and equilibrium concepts.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's level	Expected attainment level (%)	Expected proficiency (grade)
CO1	Illustrate the relation between stress and strain	Analyze	80	A
CO2	Compute weighted integral and weak formulation	Analyze	80	A
CO3	Calculate the nodal displacement, stresses and reaction forces in ID bar and plane truss element	Analyze	80	A
CO4	Calculate the nodal displacement, stresses and reaction forces in 2D element	Analyze	80	A
CO5	Outline different meshing techniques and use of finite element Software	Analyze	80	A

Mapping with Programme Outcomes

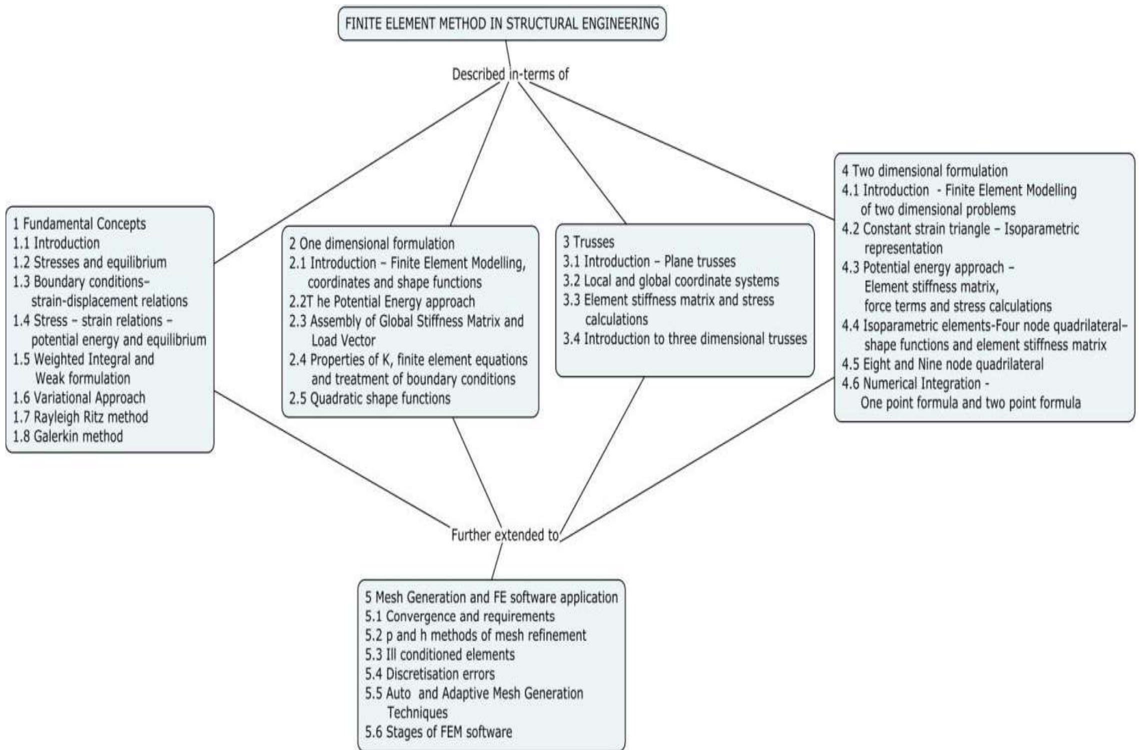
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO2.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO3.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO4.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO5.	S	M	M	M	M	L	-	M	M	L	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	45	45	45
Analyse	35	35	35
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Fundamental Concepts: Stresses and equilibrium – Boundary conditions – strain-displacement relations – stress-strain relations – potential energy and equilibrium – weighted integral and weak formulation – variational approach – Rayleigh Ritz method – Galerkin method**. One dimensional formulation:** Finite element modelling – coordinates and shapes functions – Assembly of global stiffness matrix and global load vector – properties of K – finite element equations – treatment of boundary conditions – quadratic shape functions – temperature effects. **Trusses:** Plane trusses – local –global transformation - stiffness matrix – stress calculations**. Two dimensional formulation:** Finite element modelling – constant strain triangle – problem modelling and boundary conditions - stress calculations – Isoparametric elements – four node quadrilateral and nine node quadrilateral elements-Numerical Integration-One point formula and two point formula – two dimensional integrals. **Mesh Generation and FE software application:** Convergence - Requirements for convergence – p and h methods of mesh refinement – ill conditioned elements – Discretisation errors – Auto and Adaptive Mesh Generation – Error evaluation – stages of FEM software.

Reference Book

1. Reddy, J.N, “An Introduction to the finite element method”, McGraw Hill International Edition, New York, 3rd edition 2008.
2. Tirupathi R. Chandrupatla, Ashok D. Belegundu, “Introduction to finite elements in engineering”, Prentice Hall of India, New Delhi, 2007.

3. Krishnamoorthy,C.S, "Finite Element Analysis Theory and Programming", Tata McGraw Hill Publishing Co.Ltd. New Delhi 2004.
4. Moaveni,S., Finite Element Analysis : Theory and Application with ANSYS, Prentice Hall Inc., 1999.
5. Zienkiewicz, O.C, and Taylor, R.L., The Finite Elements Methods , Mc Graw Hill , 6th edition 1987.

Course Contents and Lecture Schedule

S.NO	TOPICS	NO. OF LECTURES
1	**Fundamental Concepts**	
1.1	Introduction	1
1.2	Stresses and equilibrium	1
1.3	Boundary conditions – strain-displacement relations	1
1.4	Stress – strain relations – potential energy and equilibrium	1
1.5	Weighted Integral and Weak formulation	1
1.6	Variational Approach	1
1.7	Rayleigh Ritz method	1
1.8	Galerkin method	1
2	**One dimensional formulation**	
2.1	Introduction – Finite Element Modelling, coordinates and shape functions	1
2.2	The Potential Energy approach	1
2.3	Assembly of Global Stiffness Matrix and Load Vector	1
2.4	Properties of K, finite element equations and treatment of boundary conditions	2
2.5	Quadratic shape functions	2
3	**Trusses**	
3.1	Introduction – Plane trusses	1
3.2	Local and global coordinate systems	1
3.3	Element stiffness matrix and stress calculations	1
3.4	Introduction to three dimensional trusses	1
4	**Two dimensional formulation**	
4.1	Introduction - Finite Element Modelling of two dimensional problems	1
4.2	Constant strain triangle – Isoparametric representation	2
4.3	Potential energy approach – Element stiffness matrix, force terms and stress calculations	2
4.4	Isoparametric elements - Four node quadrilateral – shape functions and element stiffness matrix	1
4.5	Eight and Nine node quadrilateral	2
4.6	Numerical Integration - One point formula and two point formula	1
5	**Mesh Generation and FE software application**	
5.1	Convergence and requirements	1
5.2	p and h methods of mesh refinement	2
5.3	Ill conditioned elements	1
5.4	Discretisation errors	2

5.5	Auto and Adaptive Mesh Generation Techniques	1
5.6	Stages of FEM software	1
	Total Hours	**36**

Course Designers:

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21SE130	**THEORY OF ELASTICITY AND PLASTICITY**	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

This course discusses the behaviour of material under elastic and plastic range. The behavioural study includes determination of stresses and strains in various coordinate systems. In 2D analysis both plane stress and plane strain states also discussed in detail. Numeric problems are also taken into discussion to explain the application the principles.

Prerequisite

Fundamentals of Mathematics, knowledge of basic Science.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Explain the equilibrium and compatibility conditions for 2D and 3D stresses and strains in Cartesian & polar coordinate systems and Compute principle stresses in Cartesian system.	Apply	75	A
CO2	Investigate the 2D stress system using Airy's stress function in Cartesian and Polar Coordinates.	Analyse	75	A
CO3	Calculate the capacity of circular, non-circular sections both solid and tubular sections under torsion using St.Venant's approach and Prandtl approach.	Analyse	70	B
CO4	Demonstrate energy theorems for elastic medium.	Apply	70	B
CO5	Illustrate the behaviour of yield through Tresca and Von Mises criteria	Apply	70	B

Mapping with Programme Outcomes

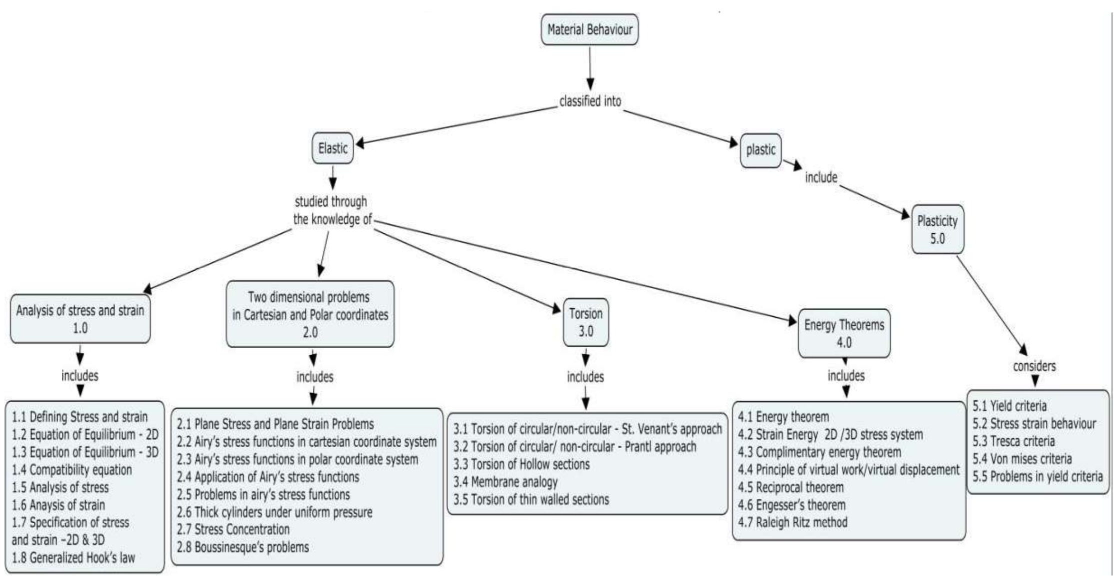
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	M	-	-	-	-	L	-	L	M	L
CO2	M	M	M	L	-	-	-	-	L	-	L	M	L
CO3.	M	M	M	L	-	-	-	-	L	-	L	M	L
CO4.	M	M	L	L	-	-	-	-	L	-	L	M	L
CO5.	M	M	L	L	-	-	-	-	L	-	-	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	60	60	60
Analyse	20	20	20
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Analysis of stress and strain - Analysis of stress and strain - Stress-strain relationship-Generalised Hooke's Law-Compatibility equations-Two and three dimensional problems in Cartesian, Polar coordinates. Mohr Circle Theory. **Two dimensional problems in Cartesian and Polar coordinates -** Plane stress and plane strain – Airy's stress function - Bending of beam by uniform load - Thick cylinder under uniform pressure - Shrink and force fits - Stress concentration – Flat plate subjected to in plane traction and shear with Circular hole - Boussinesque's Equation-wedge problem subjected to inclined loading. **Torsion -** Torsion of non-circular and prismatic bars-St.Venant's approach- Prandtl approach- Hollow section- Membrane analogy of torsion-Torsion of thin walled open and closed cells- Multi-celled sections - **Energy Theorems -** Strain energy for 2D and 3D – Principle of Complementary energy - Principle of virtual work – Reciprocal theorem - Engesser Theorems - Raleigh Ritz method. **Plasticity -** Physical assumptions-Yield criteria for metals-Plastic stress-strain relations-Strain hardening -Application to simple problems in tension, compression, bending and torsion.

Reference Books

1. Timoshenko S. &.Goodier T.N , “Theory of Elasticity,” II Edition McGraw Hill Book Company, New York, USA, 1998.
2. Wang C.T, “Applied Elasticity,” McGraw Hill Book Company, NewYork, USA, 1953.
3. Mendelson, “Plasticity Theory and Application,” Mac Millan company, London, 1998.
4. Chow P.C. &.Pango N.J, “Elastic Tensor, Dyadic and Engineering Applications,” D.Van.Nostrand, New York, USA, 1967.
5. Sadhu Singh, “Theory of Plasticity,” Khanna Publishers, NewDelhi, 2000.

Course Contents and Lecture Schedule

S.NO.	TOPICS	PERIODS
1.0	**Analysis of stress and strain**	
1.1	Analysis of stress and strain in 2D and 3D system - Introduction	1
1.2	Equation of Equilibrium – 2D (Cartesian & Polar coordinate system) & Problems	2
1.3	Equation of Equilibrium - 3D (Cartesian system) & Problems	1
1.4	Compatibility equation	1
1.5	Analysis of stress – 2D(Cartesian & Polar coordinate system) & Problems	1
1.6	Analysis of strain – 2D(Cartesian & Polar coordinate system) & Problems	2
1.7	Specification of stress and strain –2D & 3D & Problems	2
1.8	Generalized Hook’s law, Stress-Strain relationship- Mohr Circle	1
2.0 Two dimensional problems in Cartesian and Polar coordinates		
2.1	Plane Stress and Plane Strain Problems.	1
2.2	Derivation of Airy’s stress functions in cartesian coordinate system	1
2.3	Derivation of Airy’s stress functions in polar coordinate system	1
2.4	Application of Airy’s stress functions	1
2.5	Problems in airy’s stress functions	1
2.6	Thick cylinders under uniform pressure, Shrink & Force fit & Problems	1
2.7	Stress Concentration-Flat Plate under in-plane traction & shear with small circular hole	1
2.8	Boussinesque’s problems(Wedge Problems)	1
3.0 Torsion		
3.1	Torsion of circular non-circular and Prismatic bar by St. Venant’s approach	1
3.2	Torsion of circular non-circular and Prismatic bar by Prandtl approach & Problems	1
3.3	Torsion of Hollow sections and Open sections	1

3.4	Membrane analogy of torsion of Closed section and Multi celled section & Problems	1
3.5	Torsion of thin walled sections & Problems	1
4.0	**Energy Theorems**	
4.1	Introduction to energy theorem	1
4.2	Strain Energy for 2D & 3D stress system	1
4.3	Complimentary energy theorem	1
4.4	Principle of virtual work & virtual displacement	1
4.5	Reciprocal theorem	1
4.6	Engesser’s theorem & Castingliano’s theorem	1
4.7	Raleigh Ritz method	1
5.0	**Plasticity**	
5.1	Introduction, Assumption, Yield criteria and principles	1
5.2	Plastic stress strain relations & Strain hardening effect	1
5.3	Tresca criteria & Problems	1
5.4	Von mises criteria & Problems	1
5.5	Application to simple problem in tension and compression / bending and torsion	1
	Total	**36**

Course Designers

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Mr.R.Sankaranarayanan rsciv@tce.edu

		Category	L	T	P	Credit
21SE140	**DYNAMICS OF STRUCTURES**	PC	3	0	0	3

Preamble

This course deals with the dynamic analysis of various degrees of freedom system under undamped and damped cases. The dynamic analysis includes single degree of freedom system to harmonic, periodic and impulse excitation. This course also deals with the response of linear two and multi degree of freedom systems with regard to ground motion.

Prerequisite

Fundamentals of Mathematics, knowledge of basic Science.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainmentlevel (%)	Expected Proficiency (grade)
CO1	Solve the equation of motion for single degree of freedom system with free vibration under undamped or damped cases	Apply	80	A
CO2	Compute the response of SDOF system to harmonic, periodic and impulseloads	Apply	75	B
CO3	Evaluate the equation of motion of Multi degree of freedom with free vibration.	Analyse	75	B
CO4	Solve the equation of motion of SDOF system under applied force or ground acceleration	Analyse	75	B
CO5	Demonstrate the multi DOF systems subjected to earthquake ground motion	Apply	75	B

Mapping with Programme Outcomes

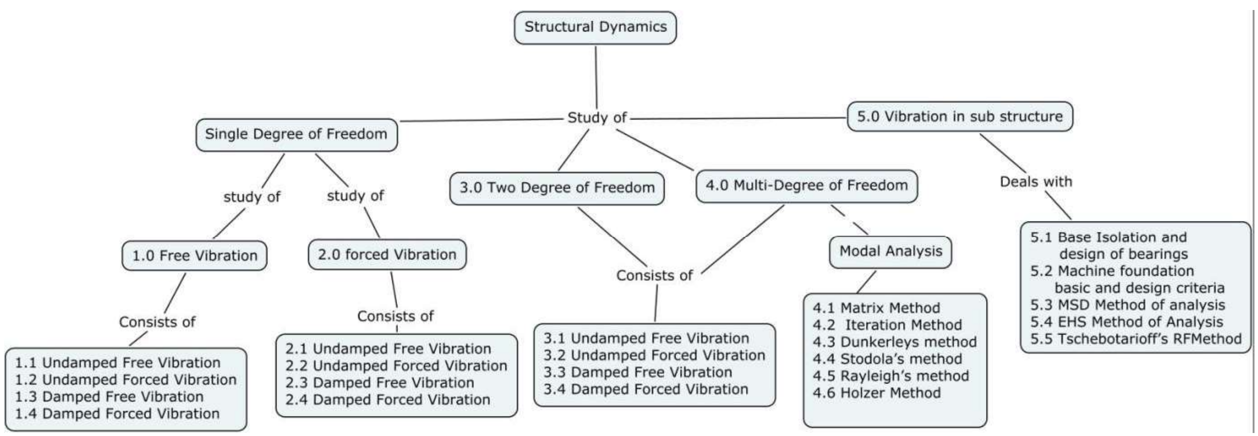
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	M	M	-	-	-	-	M	-	L	M	M
CO2.	S	M	M	M	-	-	-	-	M	-	L	M	M
CO3.	S	M	M	M	L	-	-	-	M	-	L	M	M
CO4.	S	M	M	M	L	-	-	-	M	-	-	M	M
CO5.	M	M	M	M	-	-	-	-	M	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	50	50	50
Analyse	30	30	30
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Introduction to vibration and Damping - Overview of structural dynamics -**Single degree of freedom systems** --Analysis of free Vibrations -Un damped and damped system-Estimation for damping by logarithmic decrement method - Formulation of equation of motion for generalized SDOF -Dynamic problem using Virtual work method- **Response of single degree of freedom system-** to harmonic, periodic, impulse loads- **Multi degree of freedom** - Formulation of equation of motion for two/three degree of freedom system -Finding mode shapes and frequencies by solving the determinantal equation and iterative techniques -Use of sweeping matrices for obtaining higher modes -Proof of convergence -Model superposition and Response spectrum methods **-Response of single and multi degree of freedom systems to earthquake loading-** using time -stepping method based on Forward Cauchy Euler Backward Cauchy Euler and Trapezoidal rule -accuracy stability and algorithmic damping in step-by-step methods - **Earthquake response analysis of multi- DOF systems** subjected to earthquake ground motion - concept of modal mass and modal participation factors etc.- Newmark & Halls linear and inelastic response spectra for earthquake- Introduction to IS code provisions regarding Earthquake.

Reference Books

1. Anil K.Chopra, “Dynamics of Structures: Theory and Applications to Earthquake Engineering”, Prentice Hall, Englewood Cliffs, New Jersy, Second Edition, 2001.
2. Berg. Glen v., “Elements of Structure Dynamics” ‘Prentice Hall Englewood Cliffs, New Jersy.1989.
3. Cheng, F.Y., “Matrix Analysis of Structure Dynamics”, Marcel Dekker, New York, 2001.
4. Clough, R.W.and Penzien,J., “ Dynamics of Structure”,McGraw-Hill,inc.,New York,1993.
5. Grover.G.K, “Mechanical vibrations, “New Chand and Bros., Roorkee.
6. Hurty.W.C, Rubinstein.M.F,”Dynamic of Structure”, Prentice Hall of India Pvt Ltd.New Delhi.
7. Manicka Selvam K., “Elementary Structural Dynamics”, Dhanpatrai and sons, New Delhi,2001.
8. Mario Paz, “Structural Dynamics: Theory and Computation”, CBS Publications, New Delhi, 1994.
9. William Thomson, “Theory of Vibration and its applications”, George Allen Pub.

Course Contents and Lecture Schedule

S.NO	TOPICS	PERIOD
1	Overview of structural dynamics and Single degree of freedom systems	**2**
Single degree of freedom systems		
1.1	Formulation of equation of motion for generalized SDOF	2
1.2	Analysis of free Vibrations - Undampe	1
1.3	Damped free vibration	1
2. Response of single degree of freedom system		
2.1	SDOF system to harmonic	2
2.2	SDOF system to periodic	2
2.3	SDOF system to impulse loads	2
3.Multi degree of freedom systems		
3.1	Static condensation	1
3.2	Formulation of equation of motion for two/three degree of freedom system	2
3.3	Natural vibration Frequency and modes	2
3.4	Damping in structures	2
3.5	Analysis of Two degree of freedom system without damping	2
4.MDOF to earthquake loading		
4.1	Modal analysis	2
4.2	Model superposition	1
4.3	Modal response contributions	2
4.4	Response spectrum methods	2
4.5	Numerical evaluation of dynamic response – time step	2

5.Earthquake response analysis		
5.1	Design spectrum and response quantities	1
5.2	Modal contribution factor	1
5.3	Newmark & Halls linear and inelastic response spectra	2
5.4	Introduction to IS code provisions regarding Earthquake	2
	Total Hours	**36**

Course Designers:

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21SE160	FORENSIC ENGG. AND REHABILITATION OF STRUCTURES

Category	L	T	T	Credit
PC	2	0	2	3

Preamble

The colossal number of seismically deficient structures throughout the world forced the researchers to work on developing rapid and effective rehabilitation techniques. It is therefore essential to maintain them in functional condition. Since, deterioration of structures is a phenomenon and has started exhibiting in large number of structures; a systematic approach is needed in dealing with such problems. Identification of the causes of deterioration and consequent repair/rehabilitation strategy at optimum cost needs a scientific evaluation and solution. This course covers the subject starting from causes of deterioration; investigate methods, design principles, selection criteria of repair materials & methods, guidelines for repair and rehabilitation of structures.

Prerequisites

Fundamentals of Mathematics, knowledge of properties of construction materials and its mechanics and concrete technology.

Course Outcomes

On the successful completion of the course, students will be able to

COs for Theory part:

COs	Course Outcome	Bloom's Level	Expected Attainment Level in %	Expected Proficiency Level in grade
CO1	Study the type of failures of structures and itscauses	Remember & Understand	75	A
CO2	Assess the failures using various testing techniques	Apply	75	A
CO3	Identify the causes of failure due to environmental conditions and natural hazards	Apply	75	A
CO4	Analyse the retrofitting and rehabilitation methods by using modern techniques and materials	Apply	75	A
CO5	Analyse the case studies on rehabilitation of various types of structures.	Analyze	75	A

COs for Practical part:

CO6	Investigating the stability of old masonry structure.	Apply	75	A
CO7	Asses the existing condition of different classes of buildings.	Apply	75	A
CO8	Prepare the report on the observation and investigation made from the	Apply	75	A
CO9	Investigate the performance of repair material and its bond between older	Apply	75	A
CO10	Conduct non destructive test to examine the present condition on	Apply	75	A
CO11	Recommend suitable repair methods and techniques that can be adopt to	Apply	75	A

Mapping with Programme Outcomes

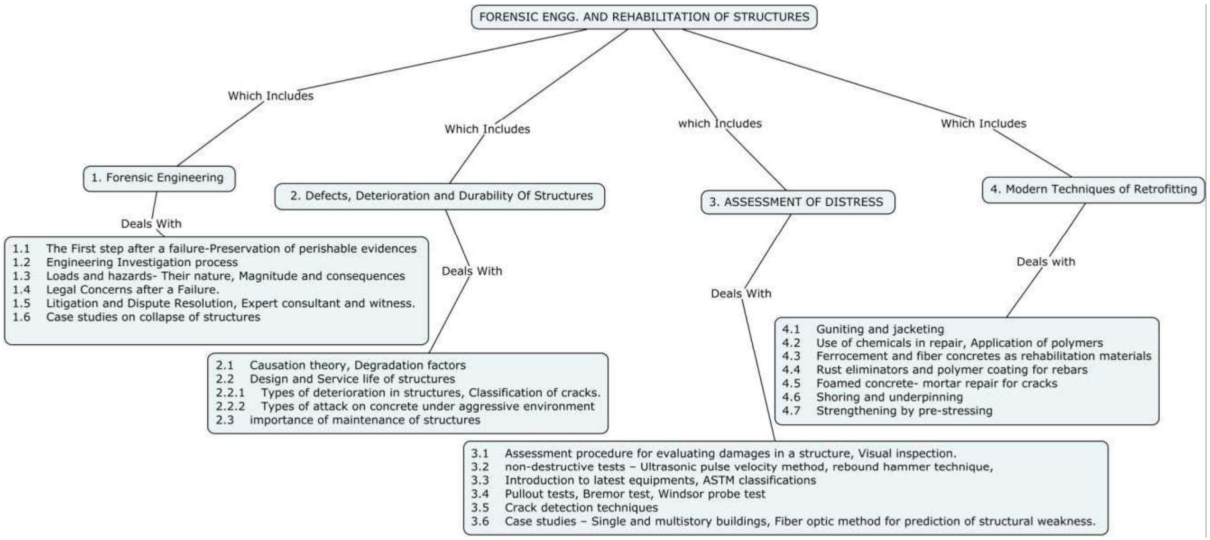
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	M	S	L	-	-	-	M	-	-	M	L
CO2	S	S	M	S	S	-	-	-	M	-	-	M	L
CO3	S	S	S	M	L	-	-	-	M	-	-	M	L
CO4	S	S	M	S	S	-	-	-	S	M	-	M	L
CO5	S	S	M	M	M	S	M	-	M	M	-	M	L
CO6	S	S	M	M	M	S	M	-	M	M	-	M	L
CO7	S	S	M	M	L	M	-	-	M	-	-	M	L
CO8	S	S	M	L	L	M	S	M	M	-	-	M	L
CO9	S	S	L	M	L	M	-	-	S	-	-	M	L
CO10	S	S	S	S	S	S	-	-	S	M	-	M	L
CO11	S	S	M	M	L	M	-	-	M	-	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination	
	Theory Part		Practical Part	Theory part	Practical Part
	1	2			
Remember	10	10	Observation, Record, Model Test (100 marks)	10	100 marks
Understand	30	30		30	
Apply	60	60		60	
Analyse	--	--		--	
Evaluate	--	--		--	
Create	--	--		--	

Concept Map



Syllabus

Forensic Engineering: The First step after a failure-Preservation of perishable evidences, Engineering Investigation process, Loads and hazards- Their nature, Magnitude and consequences, Legal Concerns after a Failure, Litigation and Dispute Resolution, Expert consultant and witness. Case studies on collapse of structures.
Defects, Deterioration and Durability Of Structures – Causation theory, Degradation factors, Design and Service life of structures, Types of deterioration in structures, Classification of cracks, Types of attack on concrete under aggressive environment, Importance of maintenance of structures.
ASSESSMENT OF DISTRESS- Assessment procedure for evaluating damages in a structure, Visual inspection, non-destructive tests – Ultrasonic pulse velocity method, rebound hammer technique, Introduction to latest equipments, ASTM classifications, Pullout tests, Bremor test, Windsor probe test, Crack detection techniques, case studies – Single and multistory buildings, Fiber optic method for prediction of structural weakness.
MODERN TECHNIQUES OF RETROFITTING - Guniting, jacketing, use of chemicals in repair, application of polymers, ferrocement, fiber concrete as rehabilitation materials, rust eliminators and polymer coating for rebars, foamed concrete, mortar repair for cracks, shoring and underpinning, strengthening by prestressing.

Reference Books

1. Robert T. Ratay “Forensic Structural Engineering Handbook, Second Edition” 2010, the McGraw-Hill Companies, Inc ISBN: 9780071498845.
2. Allen R.T and Edwards S.C, “Repair of Concrete Structures”, Blakie and Sons, UK, 1987.
3. Dayaratnam.P and Rao.R, “Maintenance and Durability of Concrete Structures”,University Press, India, 1997.

4. Denison Campbell, Allen and Harold Roper, “Concrete Structures, Materials, Maintenance and Repair”, Longman Scientific and Technical, UK, 1991.
5. Gary L. Lewis, “Guidelines for Forensic Engineering Practice”, ASCE, U.S.A., 2003.
6. Natarajan C., R. Janardhanam, Shen-En Chen, Ryan Schmidt, Indo-U.S. “ForensicPractices - Investigation Techniques and Technology”, NIT, Tiruchirappalli, 2010.

Course Contents and Lecture schedule

Module No.	Topic	No. of Lectures
1. Forensic Engineering		
1.1	The First step after a failure-Preservation of perishable evidences	1
1.2	Engineering Investigation process	1
1.3	Loads and hazards- Their nature, Magnitude and consequences	1
1.4	Legal Concerns after a Failure.	1
1.5	Litigation and Dispute Resolution, Expert consultant and witness.	1
1.6	Case studies on collapse of structures	1
2. Defects, Deterioration and Durability Of Structures		
2.1	Causation theory, Degradation factors	1
2.2	Design and Service life of structures	1
2.2.1	Types of deterioration in structures, Classification of cracks.	1
2.2.2	Types of attack on concrete under aggressive environment	1
2.3	importance of maintenance of structures	1
3. ASSESSMENT OF DISTRESS		
3.1	Assessment procedure for evaluating damages in a structure, Visual inspection.	1
3.2	non-destructive tests – Ultrasonic pulse velocity method, rebound hammer technique,	1
3.3	Introduction to latest equipments, ASTM classifications	1
3.4	Pullout tests, Bremor test, Windsor probe test	1
3.5	Crack detection techniques	1
3.6	Case studies – Single and multistory buildings, Fiber optic method for prediction of structural weakness.	1
4. Modern Techniques of Retrofitting		
4.1	Guniting and jacketing	1
4.2	Use of chemicals in repair, Application of polymers	1

4.3	Ferrocement and fiber concretes as rehabilitation materials	1
4.4	Rust eliminators and polymer coating for rebars	1
4.5	Foamed concrete- mortar repair for cracks	1
4.6	Shoring and underpinning	1
4.7	Strengthening by pre-stressing	1
	Total periods	**24**

LIST OF EXERCISES

Module No	Exercise	No of Lectures
1	To check the stability of the 50 years old TCE structures	2
2	Take up conditional assessment of 5 different structures like residential, commercial, industrial, government buildings and ancient buildings. Prepare inspection data sheets of the same.	3
3	Report on buildings surveyed, to highlight all the defects seen through photographs. Indicate the source and symptoms for the distress.	2
4	To compare the compatibility between the substrate material concrete and any repair material For eg. Compare the bond strength of polymer modified mortar and conventional mortar with concrete.	2
5	To investigate the efficiency of repair materials for enhancing the strength of concrete after initial cracks.	2
6	Prepare a report on proposing a repairing technique of a deteriorated bridge in your living place.	2
7	Conduct a field visit to Thirumalainayakar Mahal and carry out nondestructive tests on the distressed members of the building.	3
8	Conduct a field visit to Meenakshi amman temple and carry out nondestructive tests on the distressed members of the building.	3
9	Propose a novel repair technique for the deteriorated pipelines of a chemical sludge treatment plant.	2
10	To investigate the disposed waste materials in Madurai and prepare a report on using those waste materials in repair techniques.	3
	TOTAL HOURS	**24**

Course Designers:

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Mr.R.Sankaranarayanan, **rsciv@tce.edu**

21SE171	STRUCTURAL ENGINEERING LABORATORY	Category	L	T	P	Credit
		PC	0	0	4	2

Preamble

The objective of this laboratory course is to impart knowledge on analysing and designing of RCC and Steel structures with 2D and 3D systems under static loads which develops the intellectual and psychomotor skills of the students.

Prerequisite

Knowledge in concrete technology, Basic RC and steel design theory and design

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1:	Analyse 2D Beams and frame systems against the load specified in IS: 875 Part 1-3 using software	Analyze	80	A
CO2:	Analyse 3D frame system against the load specified in IS: 875 Part 1-3 using software.	Analyze	75	B
CO3:	Develop a design templates for RCC beams, Columns and beam-columns based on the IS provisions.	Apply	80	A
CO4:	Develop a design templates for Steel Tension member, compression members, flexural members and beam-columns based on the IS provisions.	Apply	80	A
CO5:	Design of 2D system / 3D frame system at least of G+3 considering as RCC or Structural Steel using software and comparing results with design templates and detailing of the designed elements.	Evaluate	80	A
CO6:	Develop a Design template for foundation type of isolated and combined footings and compare the results with foundation design software. Detailing of the foundation using detailing software.	Analyze	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	M	L	M	-	-	M	M	L	L	M	L
CO2.	S	S	M	L	M	-	-	M	M	L	L	M	L
CO3	S	M	L	-	L	-	-	L	M	L	L	L	L
CO4	S	M	L	-	L	-	-	L	M	L	L	L	L
CO5	S	S	S	M	M	-	-	M	M	L	L	S	L
CO6	S	S	M	L	M	-	-	M	M	L	L	S	L

S- Strong; M-Medium; L-Low

List of Experiments

1	Analyse a statically indeterminate beam with or without yielding of support using software and generate a report including all the necessary analysis results	
2	Analyse a 2D frame system with or without sway incorporating gravity and lateral loads using software and generate report incorporating all the necessary analysis results	
3	Analyse a 3D frame system with or without sway incorporating all possible load combinations as per IS provisions using software and generate a report containing all the necessary analysis results	
4	Develop a spreadsheet for the design of RCC beams, columns and member subjected to axial compression & bending. Display the design abstract in an excel sheet.	
5	Develop a spreadsheet for the design of steel tension member, compression member, flexural member and beam-columns. Display the design abstract in an excel sheet.	
6	Design a 2D RCC frame system using the software as per IS provisions and generate the design report. Comparing the design results with design templates.	
7	Design a 3D RCC structure of at least G+3 using the software as per IS provisions and generates the design report. Comparing the design results with design templates.	
8	Detailed the designed RCC frame component details using suitable detailing software and generate the design drawing.	
9	Design a 2D steel truss system using the software as per IS provisions and generate the design report. Comparing the design results with design templates.	
10	Design a 3D steel frame structure of at least G+3 using the software as per IS provisions and generate the design report. Comparing the design results with design templates.	
11	Develop a Design template for foundation type of isolated and combined footings and compare the results with suitable design software. Detailing of the foundation details.	

Course Designers:

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21SE260	EXPERIMENTAL TECHNIQUES AND INSTRUMENTATIONS

Category	L	T	T	Credit
PC	3	0	1	3

Preamble

This course offers various experimental techniques and measurements needed for analyse and design of structures. The course covers the basic aspects of experimental stress analysis that includes exhaustive treatment of the most versatile techniques like photo elasticity and strain gauges.

Prerequisite

Engineering Physics, structural Analysis, strength of materials

Course Outcomes

On the successful completion of the course, students will be able to

COs for Theory part:

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Able to remember the various strain gauges and understand the principle of operation	Understand	75	A
CO2	Able to apply the principle to operation of the strain gauges into various practical problems	Apply	75	A
CO3	Able to apply the photo elasticity theory to stress analysis.	Apply	75	A
CO4	Able to do understand various NDT technique and its principle of operation	Understand	75	A
CO5	Able to do understand the various instrumentation involved in the measurement of structural parameters	Understand	75	A

COs for Practical part:

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO6	Calibration of a photo elastic model for stress fringe value.	Apply	75	A
CO7	Calibration of proving ring	Apply	75	A
CO8	Determination of shear modulus for a pipe specimen under torsional loading	Apply	75	A
CO9	Determination of endurance limit for the given specimen by using rotating bending fatigue	Apply	75	A
CO10	Determination of axial stress in bracing in Lattice column using electrical strain gauges in Wheatstone Bridge along with data acquisition system	Apply	75	A

CO11	Determinations of Young's Modulus of the given material by Huggenbergertensometer	Apply	75	A
CO12	Force measurement by using load cell	Apply	75	A
CO13	Dynamic characteristics of piezo laminated cantilever beam	Apply	75	A
CO14	Determination of Sensitivity of strain gauge by using cantilever beam	Apply	75	A
CO15	Characteristics of transducers - LVDT,thermocouple,Thermistor	Apply	75	A
CO16	Visualisation of transducer using LABVIEW	Apply	75	A
CO17	Evaluating the characteristics of LVDT	Apply	75	A

Mapping with Programme Outcomes

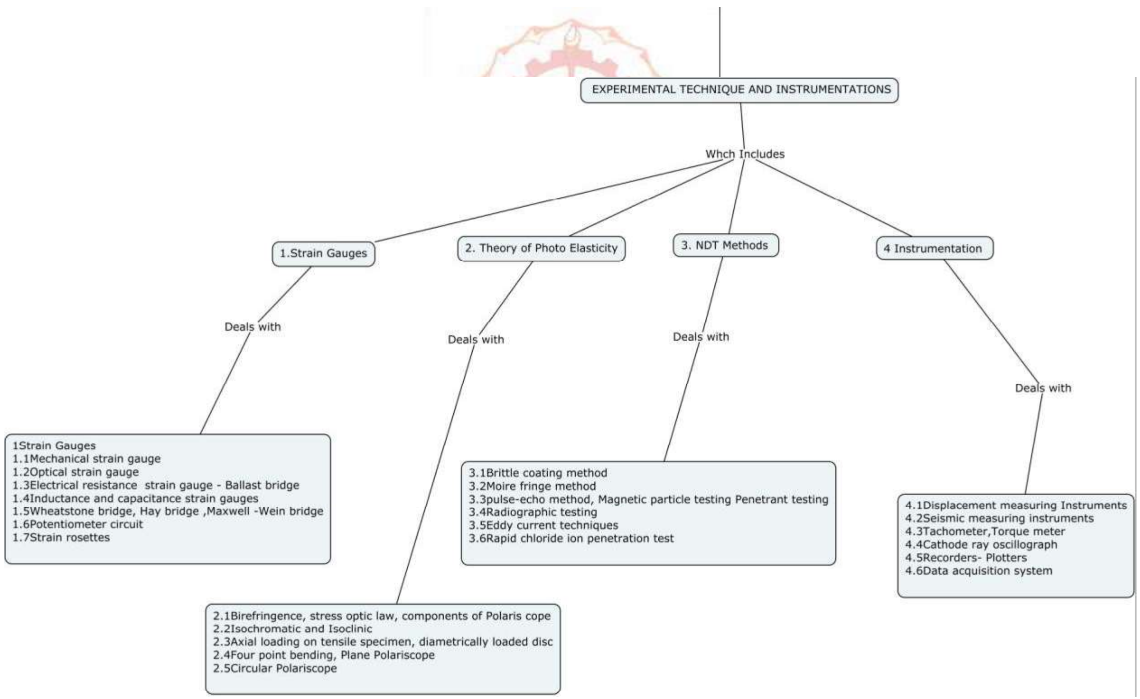
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2
CO1.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO2.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO3.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO4.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO5.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO6.	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO7	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO8	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO9	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO10	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO11	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO12	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO13	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO14	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO15	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO16	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L
CO17	M	**L**	M	M	M	M	**L**	L	L	M	M	**M**	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination	
	Theory Part		Practical Part	Theory part	Practical Part
	1	2			
Remember	10	10	Observation, Record, Model Test (100 marks)	10	100 marks
Understand	30	30		30	
Apply	60	60		60	
Analyse	--	--		--	
Evaluate	--	--		--	
Create	--	--		--	

Concept Map



Syllabus

Strain Gauge - Mechanical strain gauge- Optical strain gauge- Electrical resistance strain gauge - Inductance LVDT and capacitance strain gauges - Wheatstone bridge-Hay bridge ,Maxwell bridge-Wein bridge Potentiometer circuit Strain rosettes- **Theory of Photo Elasticity -** Birefringence, stress optic law, components of Polaris cope - Isochromatic and Isoclinic - Axial loading on tensile specimen, diametrically loaded disc- Four point bending,Plane polariscope- Circular polariscope- **NDT Methods** Brittle coating method- Moire fringe method - Rebound hammer method , Transmission and pulse-echo method, straight beam and angle beam- data representation, A-Scan, B-Scan, C-Scan - Radiographic testing - Rapid chloride ion penetration test- Eddy current Technique Magnetic particle testing Penetrant testing **Instrumentation-** Displacement measuring Instruments, Seismic measuring instruments -Tachometer - Cathode ray oscillograph – Recorders- XY plotter ,chart plotter - Digital acquisition systems

Reference Books

1. Dalley .J.W and Riley.W.F, “Experimental Stress Analysis”, McGraw Hill Book Company, N.Y.1991.
2. W.N.Sharpe (Ed), Springer Handbook of Experimental Solid Mechanics, Springer, 2008.
3. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata Mc Graw Hill, 1984.
4. Ravisankar.K and Chellappan.A., “Advanced Course on Non-Destructive Testing and Evaluation of Concrete Structures”, SERC, Chennai, 2007.
5. Sadhu Singh, “Experimental Stress Analysis”, Khanna Publishers, New Delhi, 2006.

Course Contents and Lecture Schedule

Module	Topics	No. of
1	**Strain Gauges**	
1.1	Mechanical strain gauge	1
1.2	Optical strain gauge	1
1.3	Electrical resistance strain gauge - Ballast bridge	1
1.4	Inductance and capacitance strain gauges	1
1.5	Wheatstone bridge, Hay bridge ,Maxwell -Wein bridge	1
1.6	Potentiometer circuit	1
1.7	Strain rosettes	1
2	**Theory of Photo Elasticity**	
2.1	Birefringence, stress optic law, components of Polaris cope	1
2.2	Isochromatic and Isoclinic	1
2.3	Axial loading on tensile specimen, diametrically loaded disc	1
2.4	Four point bending, Plane Polariscope	1
2.5	Circular Polariscope	1
3	**NDT Methods**	
3.1	Brittle coating method	1
3.2	Moire fringe method	1
3.3	pulse-echo method, Magnetic particle testing Penetrant testing	1
3.4	Radiographic testing	1
3.5	Eddy current techniques	1
3.6	Rapid chloride ion penetration test	1
4	**Instrumentation**	
4.1	Displacement measuring Instruments	1
4.2	Seismic measuring instruments	1
4.3	Tachometer,Torque meter	1
4.4	Cathode ray oscillograph	1
4.5	Recorders- Plotters	1
4.6	Data acquisition system	1
	Total Hours	**24**

List of Exercises for Practical Part

Module No.	Exercise No.	No. of Lectures
1.	Calibration of a photo elastic model for stress fringe value.	2
2.	Calibration of proving ring	2
3.	Determination of shear modulus for a pipe specimen under torsional loading	2
4.	Determination of endurance limit for the given specimen by using rotating bending fatigue	2
5.	Determination of axial stress in bracing in Lattice column using electrical strain gauges in Wheatstone Bridge along with data acquisition system	2
6.	Determinations of Young's Modulus of the given material by Huggenberger tensometer	2
7	Force measurement by using load cell	2
8	Dynamic characteristics of piezo laminated cantilever beam	2
9	Determination of Sensitivity of strain gauge by using cantilever beam	2
10	Characteristics of transducers - LVDT,thermocouple ,Thermistor	2
11	Visualisation of transducer using LABVIEW	2
12	Evaluating the characteristics of LVDT	2
	Total Hours	**24**

Course Designers:

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21SE271	DYNAMICS LABORATORY	Category	L	T	P	Credit
		PC	0	0	4	2

Preamble

The objective of this laboratory course is to impart knowledge on dynamics study of a single and Multi-Degree freedom system subject to hormonic, periodic excitation. Behaviour of multi-degree freedom system with or without infill walls and with or without bracing were also dealt in this course. Development of approximate mathematical model for the system under the study. Exposure about the FFT analyser and actuators.

Prerequisite

Knowledge in Basic physics, Dynamics of structure, structural analysis

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Demonstrate the phenomenon of vibration of structures under base motions, occurrence of resonancesin multi degreeof-freedom (dof) systems,	Apply	75	B
CO2	Examine the concept of displacement transmissibility and conditions under which, an isolation device would be effective.	Analyze	75	B
CO3	Show the modes of a two span simply supported beam and their relation to modes of single span simply supported and propped cantilever beams.	Apply	75	B
CO4	Differentiate the dynamics behavior of a four storied building model with and without an open ground floor	Analyze	75	B
CO5	Discover the liquefaction in soil layers subjected to dynamic base motions.	Create	70	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	L	-	-	L	-	L	M	-	L	M	L
CO2.	S	M	L	-	-	L	-	L	M	-	L	M	L
CO3	S	M	L	-	-	L	-	L	M	-	L	M	L
CO4	S	M	L	-	-	L	-	L	M	-	L	M	L
CO5	S	M	L	-	-	L	-	L	M	-	L	M	L

S- Strong; M-Medium; L-Low

List of Experiments

Physical Lab- [With Physical experimentations]

1. Dynamics of a three storied building frame subjected to harmonic base motion.
2. Dynamics of a one-storied building frame with planar asymmetry subjected to harmonic base motions.
3. Dynamics of a three storied building frame subjected to periodic (non-harmonic) base motion.
4. Dynamics of a four storied building frame with and without an open ground floor
5. Dynamics of one-span and two-span beams
6. Dynamics of free-standing rigid bodies under base motions
7. Seismic wave amplification, liquefaction and soil-structure interactions.
8. Earthquake induced waves in rectangular water tanks
9. Study of vibration using FFT analyser
10. Study the performance of hydraulic actuator

Virtual Lab [With Virtual experimentations

11. Simple harmonic oscillator experiment is to understand the concept of time period (natural frequency) in harmonic oscillations
12. Single degree of freedom system by vibrating with initial excitation (i.e, initial displacement and/or initial velocity and with or without damping).
13. Single degree of freedom system under time varying force i.e ground motion is applied.
14. Single degree of freedom system to arbitrary, step and pulse excitations
15. Construction of response spectrum for a given component of ground motion.
16. Determination of natural frequencies and natural mode shapes of multi degree of freedom system and also the response of each floor to a given ground motion.
17. Determination of the responses of 3 DOF's (2 translations and 1 rotation) of a single storey structure especially torsional response along with translations.

Course Designers:

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21SEPA0	**ANALYSIS AND DESIGN OF CONCRETE STRUCTURES**	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The design of modern reinforced concrete structures may appear to be highly complex. However, most of these structures are the assembly of several basic structural elements such as beams, columns, slabs, walls and foundations. Accordingly, the designer has to learn the design of these basic reinforced concrete elements. The joints and connections are then carefully developed. The aim of this course is to keep students up to date with various advanced mechanics and theories on reinforced concrete structures and to develop their skills to conduct analysis and practical design of real-life RC structures.

Prerequisites

Applied Mathematics,Structural Mechanics

Course Outcomes

On the successful completion of the course, students will be able to

COs	**Course Outcome**	**Bloom's Level**	**Expected Attainment level (%)**	**Expected Proficiency (grade)**
CO1	Make the students be familiar with the limit state design of RCC beams and columns	Apply	85	A
CO2	Identify and apply the relevant codal provisions to design the RC special elements such as slender columns, grid floors, concrete walls, spandrel beams, deep beams, corbels and pile cap	Apply	75	B
CO3	Study the crack pattern of slabs using yield line theory and design them based on their analysis and design the flat slab according to IS method	Apply	75	B
CO4	Explain the inelastic behavior of concrete elements and design the frames using moment rotation characteristics	Apply	75	B
CO5	Make the students be familiar with the detailing of beams, columns and its joints against ductility	Apply	75	B

Mapping with Programme Outcomes

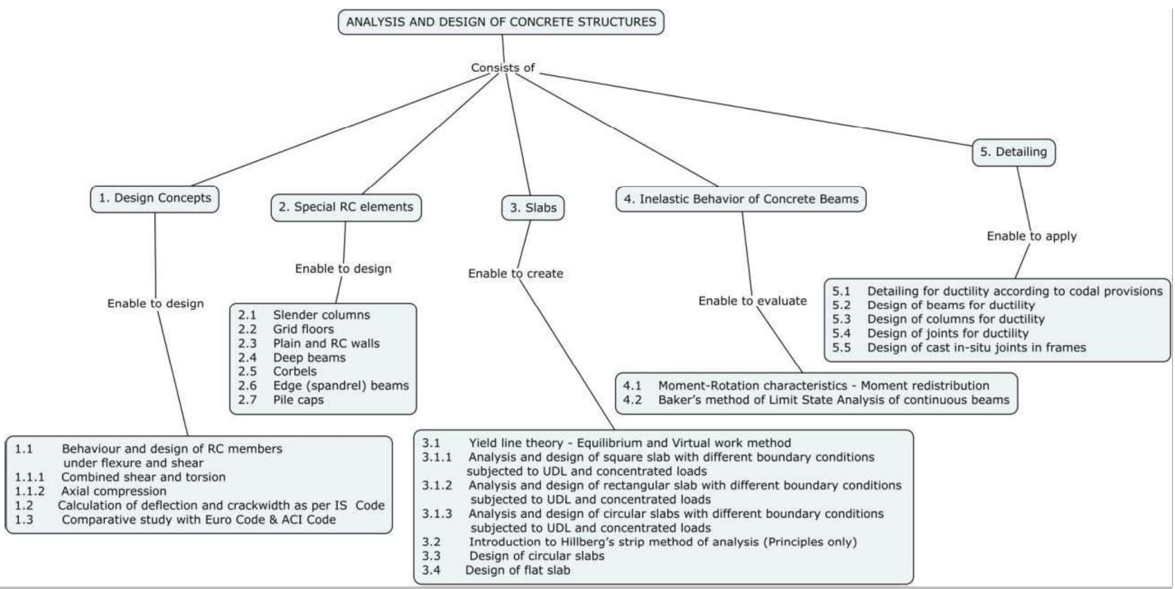
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1.	S	S	S	S	M	-	S	-	-	S	S	M	M
CO2.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO3.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO4.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO5.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO6.	S	S	S	S	M	-	S	-	-	S	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Design concepts - review of basic concepts, behaviour and design of RC members under flexure, shear, combined shear and torsion, axial compression and calculation of deflection and crackwidth as per IS Code, comparative study with EuroCode and ACI Code;**Special RC elements**- design of slender columns, grid floors, plain & reinforced concrete walls, edge (spandrel) beams, concept of strut and tie method, deep beams,corbels,pile caps;**Slabs** - yield line theory of slabs, virtual work method and equilibrium method, introduction to Hillberg's strip method of analysis (principles only), design of circular and flat slabs;**Inelastic behavior of concrete beams -** moment-rotation characteristics, moment redistribution, Baker's method of limit state analysis of continuous beam;**Ductile Detailing –**concept of ductiltity, design of beams columns and joints for ductility, design of cast in-situ joints in frames, detailing for ductility.

Reference Books

1. Dr.N. Subramanian, Design of Reinforced Concrete Structures, Oxford Publishers, 2013
2. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, Mc Graw Hill Education, New Delhi, 2017.
3. Arthur H.Nilson, George Winter, Design of Concrete Structures, 11th Edition, McGraw Hill Book Co., New York, 2009.
4. P. Bhatt, T.J. MacGinley, B.S. Choo, Ban Seng Choo and Thomas J. MacGinley, Reinforced Concrete; Design theory and examples, Routledge Publisher, 2006.
5. Edward G. Nawy, Reinforced Concrete – A fundamental Approach, 6th Edition, Prentice Hall, 2008.
6. Prab Bhatt, T.J. MacGinley, Ban SengChoo, Reinforced Concrete Design to Eurocodes: Design Theory and Examples, Fourth Edition, CRC Press, 2014

List of national and international standards

1. IS 456:2000 Plain and Reinforced Concrete – Code of Practice.
2. IS 875 (1-5):1987 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.
3. SP 16:1980 Design Aids for Reinforced Concrete to IS 456:1978.
4. SP 34:1987 Handbook of concrete reinforcement and detailing.
5. IS 13920:1993 Ductile detailing of Reinforce Concrete Structures subjected to Seismic forces-Code of Practice.
6. ACI224R – 80 Control of cracking in concrete structures ACI Committee 224, Concrete International, 1980
7. EN1992 – Eurocode 2 (EC2) – European standards for design of concrete structures.
8. ACI318-08 Building Code Requirements for Structural Concrete & Commentary

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Design Concepts		
1.1	Behaviour and design of RC members under flexure and shear	2
1.1.1	Combined shear and torsion	1
1.1.2	Axial compression	1
1.2	Calculation of deflection and crackwidth as per IS Code	1
1.3	Comparative study with Euro Code & ACI Code	1
2. Special RC elements		
2.1	Slender columns	2
2.2	Grid floors	1
2.3	Plain and RC walls	1
2.4	Deep beams	2

2.5	Corbels	2
2.6	Edge (spandrel) beams	1
2.7	Pile caps	1
3. Slabs		
3.1	Yield line theory - Equilibrium and Virtual work method	2
3.1.1	Analysis and design of square slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.2	Analysis and design of rectangular slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.3	Analysis and design of circular slabs with different boundary conditions subjected to UDL and concentrated loads	2
3.2	Introduction to Hillberg's strip method of analysis (Principles only)	1
3.3	Design of circular slabs	1
3.4	Design of flat slab	1
4. Inelastic Behavior of Concrete Beams		
4.1	Moment-Rotation characteristics - Moment redistribution	1
4.2	Baker's method of Limit State Analysis of continuous beams	1
5. Detailing		
5.1	Detailing for ductility according to codal provisions	1
5.2	Design of beams for ductility	1
5.3	Design of columns for ductility	1
5.4	Design of joints for ductility	2
5.5	Design of cast in-situ joints in frames	2
	Total Hours	36

Course Designers:

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21SEPB0	ASEISMIC DESIGN OF STRUCTURES	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course offers design of structures subjected seismic forces. This also includes Design concepts of seismic analysis and application using ETABS.

Prerequisite

Dynamics of Structures and RC & Steel structure design

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Determine the seismic hazard parameters at given site	Understand	75	A
CO2	Evaluate the liquefaction potential and estimate the frequency content of seismic signals	evaluate	75	A
CO3	Analyse the lateral forces as per the codal provisions and design masonry and shear wall	analyse	75	A
CO4	Analyse Lateral load analysis of steel structure design isolation bearings	analyse	75	A
CO5	Estimate the residual strength parameters and do push over analysis for Steel structures.	evaluate	75	A
CO6	Able to do analysis and design using ETABS	analyse	75	A

Mapping with Programme Outcomes

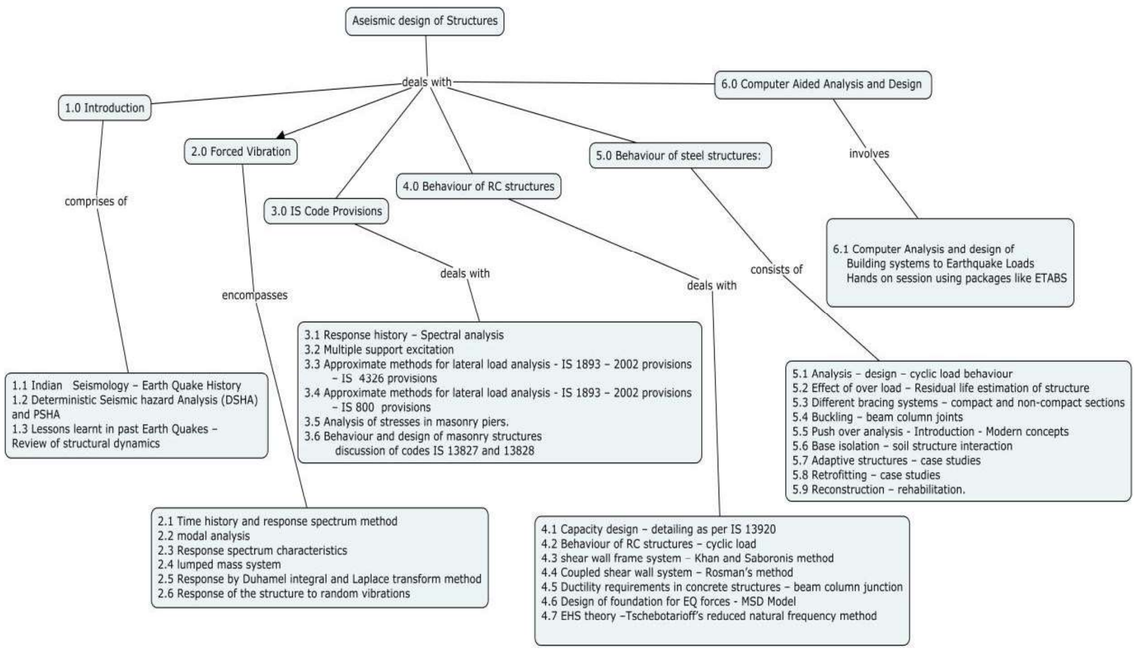
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	S	M	S	S	-	M	M	M	M	L	L
CO2.	S	S	S	M	S	S	-	M	M	M	M	M	L
CO3.	S	S	S	M	S	S	-	M	M	M	M	L	L
CO4.	S	S	S	M	S	S	-	M	M	M	M	L	M
CO5.	M	S	S	M	S	S	-	M	M	M	M	M	L
CO6.	M	S	S	M	S	S	-	M	M	M	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	--	---	--
Create	--	---	--

Concept Map



Syllabus

Introduction- Introduction Seismology – Earth Quake History - Deterministic Seismic hazard Analysis (DSHA) - PSHA -completeness Analysis – Seismic Hazard curves - UHRS, Ground Response Analysis ,lessons learnt in past Earth Quakes **Response of the structure to random vibrations -** Response by Duhamel integral and Laplace transform method - Response of the structure to random vibrations and repeated loading- Strong Ground Motion parameters, Tripartite response spectra problems-Dynamic Soil properties Field and Lab test - Liquefaction potential evaluation- Measures to overcome Liquefaction - One dimensional Ground response analysis - Transfer function Response of layer over the half space - Estimation of frequency content parameters - Fourier Analysis to seismic signals - Selection of ground motion prediction relationships **Design of RC structures** IS codal provisions on Earthquake resistant design - Seismic coefficient and Response spectrum method - Analysis of stresses in masonry piers -Design of non structural member - lateral load analysis of un reinforced brick masonry building -Design of shear wall – Khan and Saboronis method Coupled shear wall system – Rosman's method Design of foundation for

EQ forces MSD Model - EHS theory **Behaviour of steel structures**: Lateral load analysis of steel structure - different bracing systems – design of bracing – cyclic load behaviour – Effect of over load – Residual life estimation of structure-Push over analysis -base isolation Base isolation -Types of bearings, forces on bearings, Design of steel rocker bearing - Design of roller bearing **Computer Aided Analysis and Design** (Only for Internal Assessment) Computer Analysis and design of Building systems to Earthquake Loads – Hands on session using packages like ETABS.

Reference Books

1. Anil.K.Chopra,"Dynamics of Structures" (Theory and Applications to Earthquake Engineering), Prentice Hall of India Private Limited, 2nd Edition, New Delhi, 2003.
2. Clough R W and Penzien J, "Dynamics of structures", McGraw Hill
3. Jaykrishna, "Elements of earthquake engineering" , Saritha Prakasan, Naunchandi, Meerut.
4. Mukhopadhyay, M., "Structural Dynamics", Ane Books, India, 2006
5. Pankaj Agarwal and Manish Shrikandhe, "Earthquake Resistant Design of Structures", PHI.
6. Park & Paulay, "Reinforced concrete", McGraw-Hill.

List of national and international Standard Codes

1. IS:1893 - (Part I), Criteria for Earthquake Resistant structures-General Provisions and Buildings
2. IS:13935 – Repair and Seismic strengthening of buildings
3. IS:4326 - Earthquake Resistant Design and Constructions of buildings
4. IS:13827 – Improving Earthquake Resistance of Earthen buildings
5. IS: 13828 - Improving Earthquake Resistance of Low strength Masonry buildings.
6. IS: 13920 – Ductile detailing of RC Structures subject to Seismic forces.

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1	**Introduction**	
1.1	Introduction Seismology – Earth Quake History	1
1.2	Deterministic Seismic hazard Analysis (DSHA)	1
1.3	PSHA -completeness Analysis – Seismic Hazard curves	1
1.4	UHRS,Ground Response Analysis ,lessons learnt in past Earth Quakes	1
2	**Response of the structure to random vibrations**	
2.1	Response by Duhamel integral and Laplace transform method	1
2.2	Response of the structure to random vibrations and repeated loading	1
2.3	Strong Ground Motion parameters, Tripartite response spectra problems	1
2.4	Dynamic Soil properties Field and Lab tests	1
2.5	Liquefaction potential evaluation	1
2.6	Measures to overcome Liquefaction	1
2.7	One dimensional Ground response analysis	1

2.8	Transfer function Response of layer over the half space	1
2.9	Estimation of frequency content parameters	1
2.1	Fourier Analysis to seismic signals	1
2.11	Selection of ground motion prediction relationships	1
3	**Design of RC structures**	
3.1	IS codal provisions on Earthquake resistant design	1
3.2	Seismic coefficient and Response spectrum method	3
3.3	Analysis of stresses in masonry piers	2
3.4	Design of non structural member	1
3.5	lateral load analysis of un reinforced brick masonry building	1
3.6	Design of shear wall – Khan and Saboronis method	2
3.7	Coupled shear wall system – Rosman's method	1
3.8	Design of foundation for EQ forces	1
3.9	MSD Model - EHS theory	1
4	**Behaviour of steel structures: Lateral load analysis of steel structure**	
4.1	Different bracing systems	1
4.2	Design of bracing ,cyclic load ,Effect of over load	1
4.3	Residual life estimation of structure	1
4.4	Push over analysis	1
4.5	Base isolation -Types of bearings, forces on bearings, Design of steel rocker bearing - Design of roller bearing	2
5	**Computer Aided Analysis and Design Hands on session using packages like ETABS.**	2
	Total Hours	**36**

Course Designers:

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Mrs.G.Celine Reena	celinereena@tce.edu

21SEPC0	BRIDGE ENGINEERING	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it. This course offers the design of bridges such as RCC bridges, design principles of steel and prestressed concrete bridges, design principles of substructure and design of different types of bearings as per IRC loadings standards, Indian Railway standards bridge rules and MOST codes. It aims at determination of safe as well as economical section using different kinds of material used in construction and maintenance.

Prerequisite

Structural Mechanics ,Computational methods of structural analysis,Design of Steel Structures,Analysis and design of concrete structures,Prestressed Concrete

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Identify the type of bridge and its basic requirements for particular location	Understand	75	A
CO2	Design the culverts and deck slab bridges	Create	75	A
CO3	Design the long span bridges	Create	75	A
CO4	Demonstrate the design principles of steel bridges	Apply	75	A
CO5	Explain the design principles of prestressed concrete bridges	Apply	75	A
CO6	Design the bridge bearings and piers	Create	75	A

Mapping with Programme Outcomes

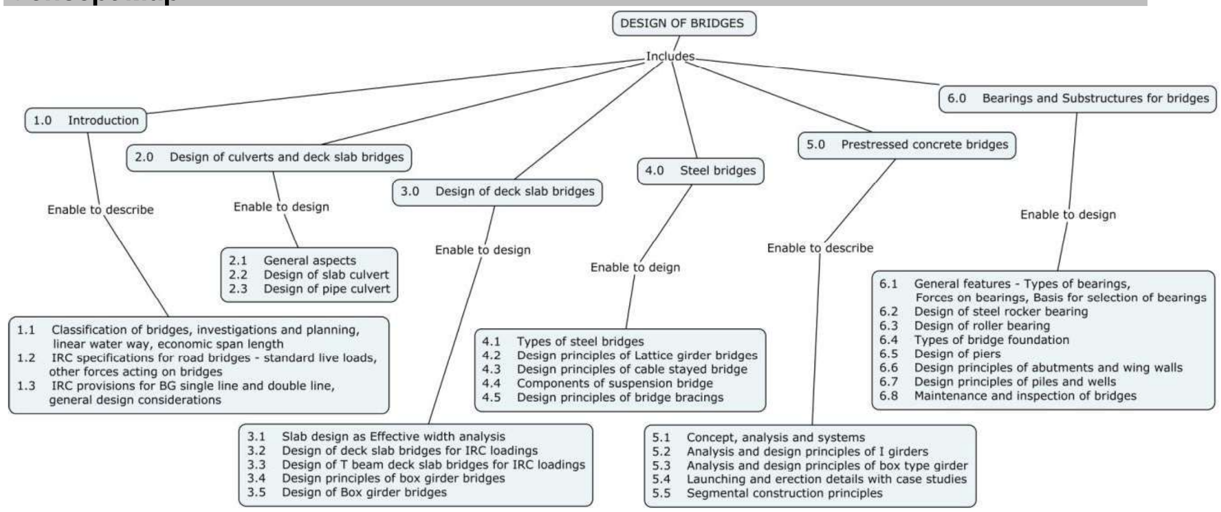
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	L	M	S	L	L	L	L	L	L	S	L	L
CO2.	S	S	S	S	L	M	L	L	L	M	S	L	L
CO3.	S	S	S	S	L	M	L	L	L	M	S	L	L
CO4.	S	S	M	M	L	M	L	L	L	M	S	L	L
CO5.	S	S	M	M	L	M	L	L	L	M	S	L	L
CO6.	S	S	S	S	L	M	L	L	L	M	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Introduction: Classification of bridges, investigations and planning, linear water way, economic span length- IRC specifications for road bridges -standard live loads, other forces acting on bridges - Indian Railway codal provisions for broad gauge single line and double line, general design considerations **Design of culverts and deck slab bridges:** General aspects - design of slab culvert - design of pipe culvert- slab design as effective width analysis - design of deck slab bridges for IRC loadings **Long Span Girder Bridges:** Design principles of box girder bridges- design of balanced cantilever bridges- cantilever portion – articulation - simply supported portion **Steel bridges:** Types of steel bridges - design principles of lattice girder bridges - cable stayed bridge - components of suspension bridge - design of bridge bracings **Prestressed concrete bridges:** Concept, analysis and systems - analysis and design principles of I girders - analysis and design principles of box type girder - launching and erection details with case studies - segmental construction principles **Bearings and substructures for bridges:** Types of bearings, forces on bearings, basis for selection of bearings - design of steel rocker bearing - design of roller bearing - Types of bridge foundation - design of piers - design principles of abutments and wing walls - piles and wells - general features - maintenance and inspection of bridges.

Reference Books

1. Aswanin.Mc, Vazarani.V.N and Ratwani.MM, "Design of Concrete Bridges", 2nd Edition, Khanna Publishers, New Delhi, India, 2004.
2. Jagadeesh.F.R., Jay Ram.M.A, "Design of Bridge Structures", 2nd Edition, Eastern

Economy Edition, New Delhi, India, 2009.
3. Raina,Concrete.V. K. “Bridge Design and Practice”, 3rd Edition, Shroff Publishers, India 2010
4. Rowe, R. E.,” Concrete Bridge Design”, C.R. Books Ltd. London 2002.
5. Robinson J.R. (1966), “Piers Abutments and Form work for Bridges”, B.I.Publications, Bombay.
6. Hayden A.G. & Barron N. (1926), “Rigid Frame Bridge”, John willey and Sons – New York, U.S.A.
7. Johnson victor (1984), “Design of Bridges”, Oxford and IBH publication.
8. Krishna Raju. N. “Design of Bridges”, 4th Edition, Oxford & IBH, New Delhi 2010.
9. Ponnuswamy.S., “Bridge Engineering”, 2nd Edition, Tata McGraw Hill Publications, New Delhi, India 2007

List of National and International Standards

1. IRC: 78, “Standard specifications & Code of practice for Road Bridges”.
   a. Section VII-Foundation and Substructures.
2. IRC: 6-2000, “ Standard specifications & Code of practice for Road Bridges”.
   a. Section II-Loads and Stresses.
3. IRC: 21-2000, “ Standard specifications & Code of practice for Road Bridges”.
   a. Section III-Cement Concrete (Plain and Reinforced).
4. IRC: 83 Part II-1987, “Standard specifications & Code of practice for Road Bridges”.
   a. Section : 9 Bearing, Part II – Elastomeric Bearings.
5. IRC: 45-1972, “ Recommendations for Estimating the resistance of soil below the maximum scour level in the Design of Well foundations of Bridges.
6. IRC: 24-2000 “Standard specifications & code of practice for steel bridges”.
7. IRC: 87-1984, “Guidelines for the Design and Erection of False work for Road Bridges.
8. IS 1343:1980 Code of Practice for Pre Stressed Concrete
9. IRS: 1 1977, Bridge rules.
10. IRS: 2, “Code of practice for plain, reinforced and prestressed concrete for general bridge construction.
11. MOST standard plans for 3.0m to 10m span reinforced cement concrete solid slab superstructure with and without foot paths for highways, (1991).
12. MOST standard plans for highways bridges RCC.T-Beams and slab superstructure – span from 10m to 24m width.
13. MOST standard plans for highway bridges PSC girder and RC slab composite superstructure for 30m span with and without foot paths, 35m span with footpaths, 40m span without foot paths, 1992.
14. MOST standard drawings for road bridges- RCC solid slab superstructure (15° and 30° SKEW) span 4m to 10m (with and without foot paths), 1992.
15. MOST standard drawing for road bridges-RCC solid slab superstructure (22.5°SKEW) span 4m to 10m (with and without foot paths), 1996.
16. IS 2911, 1980 code of practice for pile foundation.

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1.0	**Introduction**	
1.1	Classification of bridges, investigations and planning, linear water way, economic span length	1
1.2	IRC specifications for road bridges - standard live loads, other forces acting on bridges	1
1.3	Indian Railway codal provisions for broad gauge single line and double line, general design considerations	1
2.0	**Design of culverts and deck slab bridges**	
2.1	General aspects	1
2.2	Design of slab culvert	2
2.3	Design of pipe culvert	2
3.0	**Design of deck slab bridges**	
3.1	Slab design as Effective width analysis	2
3.2	Design of deck slab bridges for IRC loadings	2
3.3	Design of T beam deck slab bridges for IRC loadings	2
3.4	Design principles of box girder bridges	1
3.5	Design of Box girder bridges	1
4.0	**Steel bridges**	
4.1	Types of steel bridges	1
4.2	Design principles of Lattice girder bridges	1
4.3	Design principles of cable stayed bridge	1
4.4	Components of suspension bridge	1
4.5	Design principles of bridge bracings	2
5.0	**Prestressed concrete bridges**	
5.1	Concept, analysis and systems	1
5.2	Analysis and design principles of I girders	1
5.3	Analysis and design principles of box type girder	1
5.4	Launching and erection details with case studies	1
5.5	Segmental construction principles	1
6.0	**Bearings and Substructures for bridges**	
6.1	General features - Types of bearings, Forces on bearings, Basis for selection of bearings	1
6.2	Design of steel rocker bearing	1
6.3	Design of roller bearing	1
	Substructures for bridges	
6.4	Types of bridge foundation	1
6.5	Design of piers	2
6.6	Design principles of abutments and wing walls	1

6.7	Design principles of piles and wells	1
6.8	Maintenance and inspection of bridges	1
	TOTAL	**36**

Course Designers:

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21SEPD0	**BLAST RESISTANT DESIGN OF STRUCTURES**	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Blast induced impulsive loads on structures can have devastating effect on civil infrastructure including buildings, bridges, monumental structures etc., and subsequently can cause loss of lives. Hence, blast resistant and anti-terrorism design is extremely necessary in order to safeguard civil infrastructure and human lives. The mechanism of formation of shocks and blast waves are investigated and predictions for a blast wave using the Buckingham Pi theorem and some empirical methods. The Design of blast resistant structures requires thorough understanding on the structural dynamics, behaviour of materials under high strain rate of loading and blast analysis methodologies.

Prerequisite

Applied Mathematics, Dynamics of Structures ,Finite Element Analysis .

Course Outcomes

On the successful completion of the course, students will be able to

COs	**Course Outcome**	**Bloom's Level**	**Expected Attainment level (%)**	**Expected Proficiency (grade)**
CO1	Reproduce the fundamentals of blast engineering and related blast dynamics.	Understand	80	A
CO2	Relate the theoretical and practical aspects of the recent advancementsmade in blast resistant and anti-terrorism design of structures andfacilities.	Analyse	80	A
CO3	Analyse the high strain rate material behaviour, Blast analysis of structures.	Analyse	80	A
CO4	Design blast resistant structural and non structural components using available Commercial finite element (FE) packages and empirical approaches.	Analyse	80	A
CO5	Compare the Indian/international guidelines in design of blast resistant structure for intended level of threat scenario from chosen material.	Evaluate	80	B

Mapping with Programme Outcomes

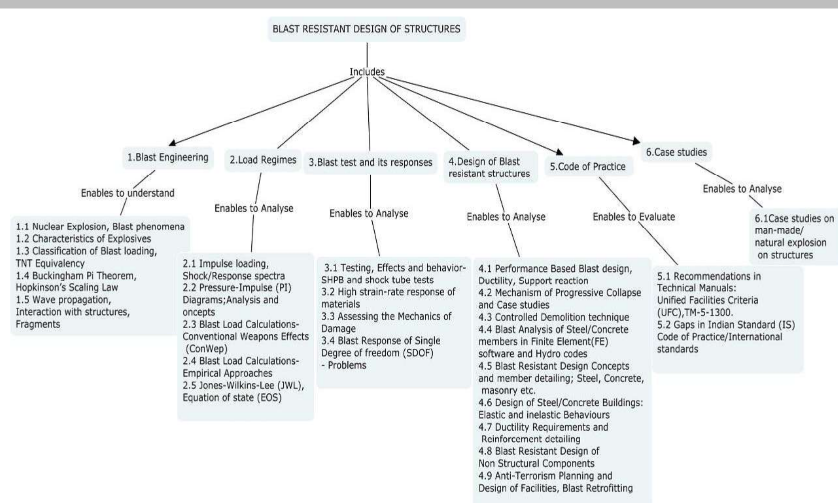
C O	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
C	S	M	L	S	M	S	-	-	-	-	L	S	S
C	S	M	L	S	M	M	-	-	-	-	L	S	M
C	S	M	S	S	M	M	-	-	-	-	L	M	M
C	S	S	S	S	S	S	-	-	-	-	L	S	S
C	M	L	L	M	L	L	-	-	-	-	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	40	40	40
Analyse	40	40	40
Evaluate	--	--	--
Create	--	--	--

Concept Map



Syllabus

Blast Engineering: Nuclear Explosion, Blast phenomena, Characteristics of Explosives, Classification of Blast loading, TNT Equivalency, Buckingham Pi Theorem, Hopkinson's Scaling Law, Wave propagation, Interaction with structures, Fragments. **Load Regimes:** Impulse loading, Shock/Response spectra, Pressure-Impulse (PI) Diagrams; Analysis and concepts , Blast Load Calculations-Conventional Weapons Effects (ConWep) and Empirical Approaches, Jones-Wilkins-Lee (JWL),Equation of state (EOS) **Blast test and its responses:** Testing, Effects and behavior-SHPB and shock tube tests, High strain-rate response of materials, Assessing the Mechanics of Damage , Blast Response of Single Degree of freedom (SDOF)-Problems, **Design of Blast resistant structures:** Performance Based Blast design, Ductility, Support reaction, Mechanism of Progressive Collapse and Case studies, Controlled Demolition technique, Blast Analysis of Steel/Concrete members in Finite Element(FE) software and Hydro codes, Blast Resistant Design Concepts and member detailing- Steel, Concrete, masonry etc, Design of Steel/Concrete Buildings: Elastic and inelastic Behaviours, Ductility Requirements and Reinforcement detailing , Blast Resistant Design of Non Structural Components, Anti-Terrorism Planning and Design of Facilities, Blast Retrofitting. **Code of Practice:** Recommendations in Technical Manuals: Unified Facilities Criteria (UFC), TM-5-1300. Gaps in Indian Standard (IS) Code of Practice/International standards. **Case studies:** Case studies on man-made/natural explosion on structures.

Reference Books

1. Smith, P.D. and Hetherington, J.G. (1994). "Blast and Ballistic Loading of Structures", Oxford, Butterworth-Heinemann.
2. Mays, G.C. and Smith, P.D. (1995). "Blast Effects on Buildings", Thomas Telford Publications, London, UK.
3. Meyers, M.A. (1994). "Dynamic Behavior of Materials", Wiley, New York (NY), USA.
4. Kinney, G.F. and Graham, K.J. (1985). "Explosive Shocks in Air", Springer, Berlin, Germany.
5. Dusenberry, D.O. (2010). "Handbook for Blast Resistant Design of Buildings", John Wiley and Sons, New Jersey (NJ), USA.
6. Krauthammer, T. (2008). "Modern Protective Structures", CRC Press, Boca Raton, Florida (FL), USA.
7. Bangash, M.Y.H. and Bangash, T. (2006). "Explosion-Resistant Buildings Design, Analysis and Case Studies", Springer, Berlin, Germany.
8. Henrych, J. (1979). "The Dynamics of Explosion and Its Use", Elsevier, Amsterdam, Netherlands .
9. Zukas, J.A. (2004). "Introduction to Hydrocodes", Oxford, Elsevier.
10. Goel, M.D. and Matsagar, V.A. (2014). "Blast Resistant Design of Structures", Practice

Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE), Vol. 19, No. 2, Article Number 04014007.

11. NPTEL notes-Introduction to Explosions and explosion safety.

List Of National And International Standards

1. IS 4991: 1968 Criteria for blast resistant design of structures for explosions above ground.
2. IS 6922: 1973 Criteria for safety and design of structures subject to underground blasts.
3. Publications by: (1) the Department of Defense (DoD), Unified Facilities Criteria (UFC) Program, Washington, DC, USA; (2) the Federal Emergency Management Agency (FEMA), Washington, DC, USA; (3) the American Society of Civil Engineers (ASCE), Reston, Virginia (VA), USA.

List Of Software

LS-DYNA, ABAQUS

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Blast Engineering		
1.1	Nuclear Explosion, Blast phenomena	1
1.2	Characteristics of Explosives	1
1.3	Classification of Blast loading, TNT Equivalency	1
1.4	Buckingham Pi Theorem, Hopkinson's Scaling Law	1
1.5	Wave propagation, Interaction with structures, Fragments	1
2. Load Regimes		
2.1	Impulse loading, Shock/Response spectra	1
2.2	Pressure-Impulse (PI) Diagrams; Analysis and concepts	1
2.3	Blast Load Calculations-Conventional Weapons Effects (ConWep)	1
2.4	Blast Load Calculations-Empirical Approaches	1
2.5	Jones-Wilkins-Lee (JWL),Equation of state (EOS)	1
3. Blast test and its responses		
3.1	Testing, Effects and behavior-SHPB and shock tube tests	1
3.2	High strain-rate response of materials	1

3.3	Assessing the Mechanics of Damage	1
3.4	Blast Response of Single Degree of freedom (SDOF)- Problems	1
4. Design of Blast resistant structures		
4.1	Performance Based Blast design, Ductility, Support reaction	2
4.2	Mechanism of Progressive Collapse and Case studies	2
4.3	Controlled Demolition technique	1
4.4	Blast Analysis of Steel/Concrete members in Finite Element(FE) software and Hydro codes	3
4.5	Blast Resistant Design Concepts and member detailing; Steel, Concrete, masonry etc.	3
4.6	Design of Steel/Concrete Buildings: Elastic and inelastic Behaviours	2
4.7	Ductility Requirements and Reinforcement detailing	2
4.8	Blast Resistant Design of Non Structural Components	2
4.9	Anti-Terrorism Planning and Design of Facilities, Blast Retrofitting	2
5. Code of Practice		
5.1	Recommendations in Technical Manuals: Unified Facilities Criteria (UFC),TM-5-1300.	1
5.2	Gaps in Indian Standard (IS) Code of Practice/International standards	1
6. Case studies		
6.1	Case studies on man-made/natural explosion on structures	1
	Total periods	**36**

Course Designers:

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21SEPE0	COMPUTATIONAL METHODS IN STRUCTURAL ANALYSIS	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

It is common practice to use approximate solutions of differential equations as the basis for structural analysis. This is usually done using numerical approximation techniques. The most commonly used numerical approximation in structural analysis is the Finite Element Method. This course end eavours to fulfill two principal objectives. First, it acquaints matrix methods of structural analysis and their underlying concepts and principles. After a thorough presentation of mathematical tools and theory required for linear elastic analysis of structural systems, the course focuses flexibility and stiffness methods of analysis for computer usage. The direct stiffness method is the backbone of most computer programs is also discussed. Besides, the physical behavior of structures is analysed throughout with the help of axial thrust, shear force, bending moment and deflected shape diagrams.

Prerequisite

Fundamentals of Mathematics, basic knowledge of mechanics of structures and structural analysis.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1:	Illustrate the transformation of force and displacement from element level to system level	Apply	80	A
CO2:	Solve beams, frames, trusses and grids by flexibility method	Analyse	80	A
CO3:	Calculate displacement variables of beams, frames, trusses and grids by stiffness method	Analyse	80	A
CO4:	Relate the static condensation, substructure techniques in matrix methods	Analyse	75	B
CO5:	Solve trusses, grids, plane and space frames by direct stiffness method	Analyse	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	S	M	-	-	-	-	M	-	L	S	S

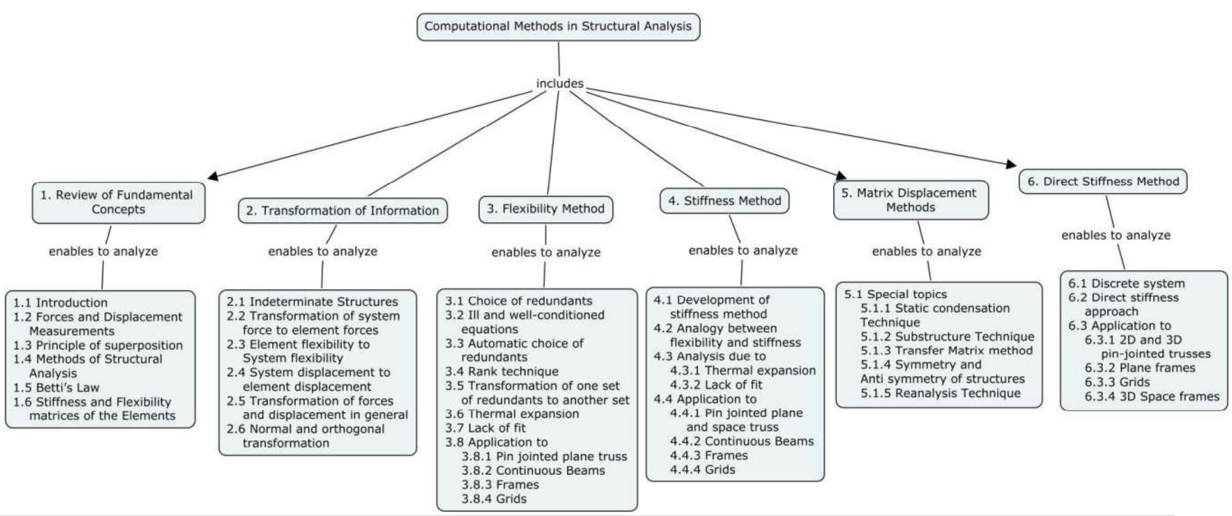
CO2.	S	S	S	M	L	-	-	-	M	-	L	S	S
CO3.	S	S	S	M	L	-	-	-	M	-	L	S	S
CO4.	S	M	M	M	-	-	-	-	M	-	L	M	M
CO5.	S	S	M	M	L	-	-	-	M	-	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	60	60	60
Analyse	20	20	20
Evaluate	--	--	--
Create	--	--	--

Concept Map



Syllabus

Review of Fundamental Concepts: Introduction – Forces and Displacement Measurements – Principle of superposition – Methods of Structural Analysis – Betti's Law – Stiffness and Flexibility matrices of the Elements – a review. **Transformation of Information:** Indeterminate Structures – Transformation of system force to element forces – Element flexibility to System flexibility – system displacement to element displacement – Transformation of forces and displacement in general – Normal and orthogonal transformation. **Flexibility Method:** Choice of redundants – ill and well-conditioned equations – Automatic choice of redundants – Rank technique – Transformation of one set of redundants to another set – Thermal expansion – Lack of fit – Application to pin jointed plane truss – continuous beams - frames and grids. **Stiffness Method:** Development of stiffness method – analogy between flexibility and stiffness – Analysis due to thermal expansion, lack of fit – Application to pin-jointed plane and space trusses – Continuous beams – frames and grids – problem solving. **Matrix Displacement Methods - Special Topics:** Static condensation Technique – Substructure Technique - Transfer Matrix method – Symmetry & Anti symmetry of structures – Reanalysis Technique. **Direct Stiffness Method:** Discrete system – Direct stiffness approach – Application to two and three dimensional pin-jointed trusses - plane frames – Grids – Three dimensional space frames.

Reference Books

1. Damodar Maity, "Computer Analysis of Framed Structures", I K International, 2007
2. Meek J.L., "Matrix Structural Analysis", McGraw Hill, 1971.
3. Moshe F Rubinstein– "Matrix Computer Analysis of Structures"– Prentice Hall, 1969.
4. Mukhopadhyay M., "Matrix Finite Element Computer and Structural Analysis", Oxford & IBH, 1984.
5. Pezemieniecki, J.S, "Theory of Matrix Structural Analysis", McGraw Hill Co.,1984.
6. Rajesekharan & Sankarasubramanian G., "Computational Structural Mechanics", Prentice Hall of India, 2001.
7. Reddy C.S., "Basic Structural Analysis", Tata McGraw Hill Publishing Co.1996.
8. Seeli F.B.& Smith J.P., "Advanced Mechanics of Materials", John Wiley &Sons, 1993.
9. Smith J.C. "Structural Analysis", Macmillian Pub.Co.1985.
10. Wang C.K & Solomon C.G.," Introductory Structural Analysis", McGraw Hill,1968.
11. Weaver & Gere, "Matrix Analysis of Structures", 3rd edition, East West Press, 1988.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Review of Fundamental Concepts		
1.1	Introduction – Forces and Displacement Measurements	1
1.2	Principle of superposition	1
1.3	Methods of Structural Analysis – Betti's Law	1
1.4	Stiffness and Flexibility matrices of the Elements – a review	1
2. Transformation of Information		
2.1	Indeterminate Structures - Transformation of system force to element forces	1
2.2	Element flexibility to System flexibility	1

2.3	System displacement to element displacement	1
2.4	Transformation of forces and displacement in general	1
2.5	Normal and orthogonal transformation	1
2.6	Tutorial	1
3. Flexibility Method		
3.1	Choice of redundants	1
3.2	Ill and well-conditioned equations, Automatic choice of redundants	1
3.3	Rank technique, Transformation of one set of redundants to another set	1
3.4	Thermal expansion – Lack of fit	1
3.5	Application to pin jointed plane truss	1
3.6	Continuous beams	1
3.7	Frames and grids	1
3.8	Tutorial	1
4. Stiffness Method		
4.1	Development of stiffness method	1
4.2	Analogy between flexibility and stiffness	1
4.3	Analysis due to thermal expansion, lack of fit	1
4.4	Application to pin-jointed plane and space trusses	1
4.5	Continuous beams	1
4.6	Frames and grids	1
4.7	Tutorial	1
5. Matrix Displacement Methods - Special Topics:		
5.1	Static condensation Technique	1
5.2	Substructure Technique	1
5.3	Transfer Matrix method	1
5.4	Symmetry & Anti symmetry of structures	1
5.5	Reanalysis Technique	1

6. Direct Stiffness Method		
6.1	Discrete system	1
6.2	Direct stiffness approach	1
6.3	Application to two and three dimensional pin-jointed trusses	1
6.4	Plane frames	1
6.5	Grids	1
6.6	Tutorial	1
	Total periods	**36**

Course Designers

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		Category	L	T	P	Credit
21SEPF0	**COMPUTER AIDED DESIGN**	PE	3	0	0	3

Preamble

This course provides essentials of formulating algorithm for analysis method, design of steel, concrete and prestressed concrete members which helps development of Computer aided analysis and design software.

Prerequisite

Fundamentals of Mathematics, knowledge of analysis and design of RCC, prestressed concrete and steel structures.

Course Outcomes

On the successful completion of the course, students will be able to

Cos	**Course Outcome**	**Bloom's level**	**Expected attainment level (%)**	**Expected proficiency (grade)**
CO1	Formulate algorithm for solving equations by matrix method and construct algorithm for computer aided design of truss problems	Evaluate	75	A
CO2	Construct algorithm for computer aided design of reinforced concrete members	Apply	75	A
CO3	Construct algorithm for computer aided design of steel and light gauge steel members	Apply	75	A
CO4	Construct algorithm for analysis of prestressed concrete members	Apply	75	A
CO5	Develop computer aided analysis and design software	Evaluate	75	A

Mapping with Programme Outcomes

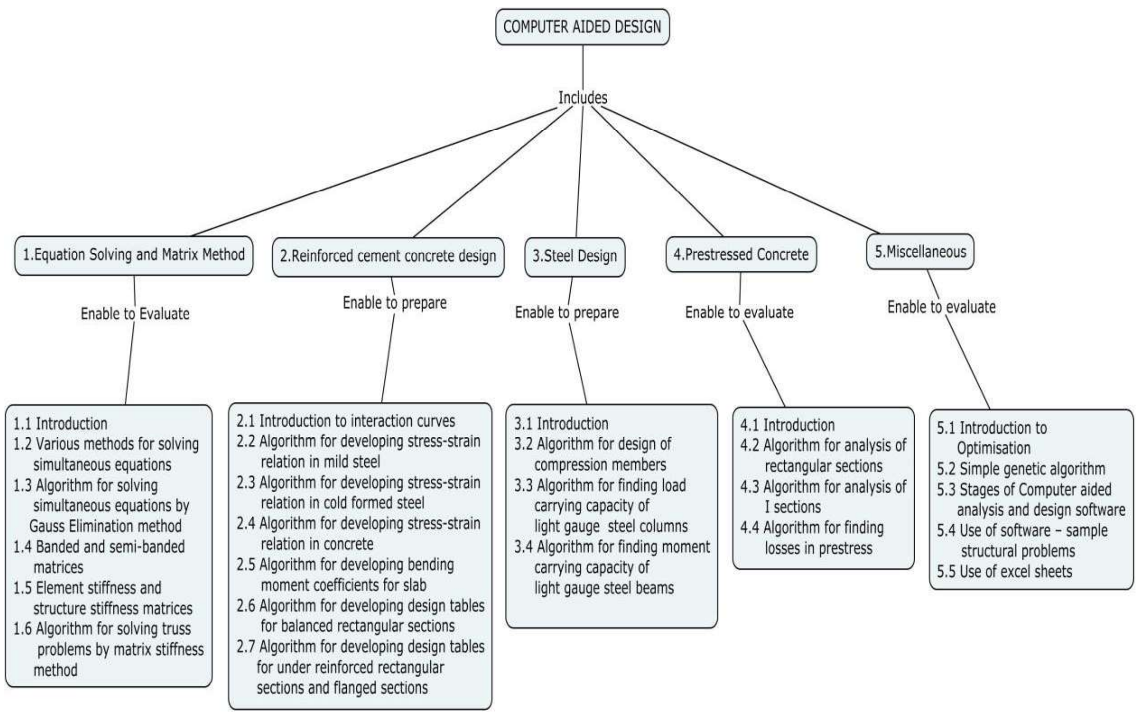
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	M	M	L	-	L	M	L	L	M	L
CO2	S	M	M	M	M	L	-	L	M	L	L	M	L
CO3	S	M	M	M	M	L	-	L	M	L	L	M	L
CO4	S	M	M	M	M	L	-	L	M	L	L	M	L
CO5	S	M	M	M	M	L	-	L	M	L	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	30	30	30
Analyse	-	-	-
Evaluate	50	50	50
Create	-	-	-

Concept Map



Syllabus

Equation solving and Matrix method - algorithm for solving simultaneous equations – gauss elimination method – banded and semi-banded matrices – local and global coordinate system – element stiffness matrix – structure stiffness matrix – algorithm for solving trusses by matrix stiffness method. **Reinforced cement concrete design -** algorithm for stress-strain relationship in mild steel – cold formed steel – stress-strain relationship in concrete – algorithm for bending moment coefficients in slab – algorithm for developing design tables for beams – rectangular and flanged sections. **Steel design -** algorithm for analysis and design of compression members – algorithm for finding load carrying capacity of light gauge steel columns – algorithm for moment carrying capacity of light gauge steel beams. **Prestressed concrete -** algorithm for analysis of prestressed rectangular and i sections in flexure – algorithm for finding losses in prestress. **Miscellaneous** - introduction to optimisation – simple genetic algorithm – stages of computer aided analysis and design software – software applications.

Reference Books

1. Krishnamoorthy, C.S and Rajeev, S, "Computer Aided Design", Narosa Publication House, New Delhi, 2005.
2. Krishnaraju N, "Prestressed Concrete", Tata McGraw-Hill, New Delhi, 2006.
3. Pandit G, Gupta, S, "Structural Analysis – A Matrix Approach", McGraw-Hill Education, India, New Delhi, 2008.
4. Peter W, Christensen, A, "An Introduction to Structural Optimisation", Springer 2009.
5. Punmia B C and Jain,A.K, "Comprehensive Design of Steel Structures", Laxmi Publications, 2006.

Course Contents and Lecture Schedule

S.NO	TOPICS	NO. OF LECTURES
1	**Equation Solving and Matrix Method**	
1.1	Introduction	1
1.2	Various methods for solving simultaneous equations	1
1.3	Algorithm for solving simultaneous equations by Gauss Elimination method	2
1.4	Banded and semi-banded matrices	1
1.5	Element stiffness and structure stiffness matrices	1
1.6	Algorithm for solving truss problems by matrix stiffness method	2
2	**Reinforced cement concrete design**	
2.1	Introduction to interaction curves	1
2.2	Algorithm for developing stress-strain relation in mild steel	1
2.3	Algorithm for developing stress-strain relation in cold formed steel	1
2.4	Algorithm for developing stress-strain relation in concrete	1
2.5	Algorithm for developing bending moment coefficients for slab	1
2.6	Algorithm for developing design tables for balanced rectangular sections	1
2.7	Algorithm for developing design tables for under reinforced rectangular sections and flanged sections	1
3	**Steel Design**	
3.1	Introduction	1
3.2	Algorithm for design of compression members	2
3.3	Algorithm for finding load carrying capacity of light gauge steel columns	1
3.4	Algorithm for finding moment carrying capacity of light gauge steel beams	1
4	**Prestressed Concrete**	
4.1	Introduction	1
4.2	Algorithm for analysis of rectangular sections	2
4.3	Algorithm for analysis of I sections	2
4.4	Algorithm for finding losses in prestress	1
5	**Miscellaneous**	

5.1	Introduction to Optimisation	2
5.2	Simple genetic algorithm	2
5.3	Stages of Computer aided analysis and design software	2
5.4	Use of software – sample structural problems	2
5.5	Use of excel sheets	2
	Total Hours	**36**

Course Designers:

Mr. R.Indrajith Krishnan jith@tce.edu

21SEPG0	CREEP AND FATIGUE BEHAVIOUR OF MATERIALS	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course offers to the students having studied the basics of properties and strength of materials, shall be introduced to dislocation theories of plasticity behaviour, initiation and fatigue crack propagation. It will expose students to failure mechanisms due to fatigue and creep as well as in their testing methods.

Prerequisite

Strength of Materials, physics.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	demonstrate and understanding of the elastic, plastic properties and behaviour of materials.	Understand	75	B
CO2	Use suitable mathematical equation to predict ability the fatigue crack growth rate and Ability to perform failure analysis	Evaluate	75	B
CO3	demonstrate the ability to identify and analyse engineering problem in using plastic deformation, fatigue, fracture and creep	Analyse	75	B
CO4	Identify suitable Non destructive technique to inspect industrial and structural component	Evaluate	75	B
CO5	Incorporate the concept of LEFM and estimate the effects of cracks in material and structure.	Analyse	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	M	M	M	M	L	M	L	L	M	L	M	M	L
CO2.	M	M	M		L	M	L	L		L	M	M	L
CO3.			M		L	M	L	L		L	M	M	L
CO4.			M	M	L		L	L		L	M	M	L

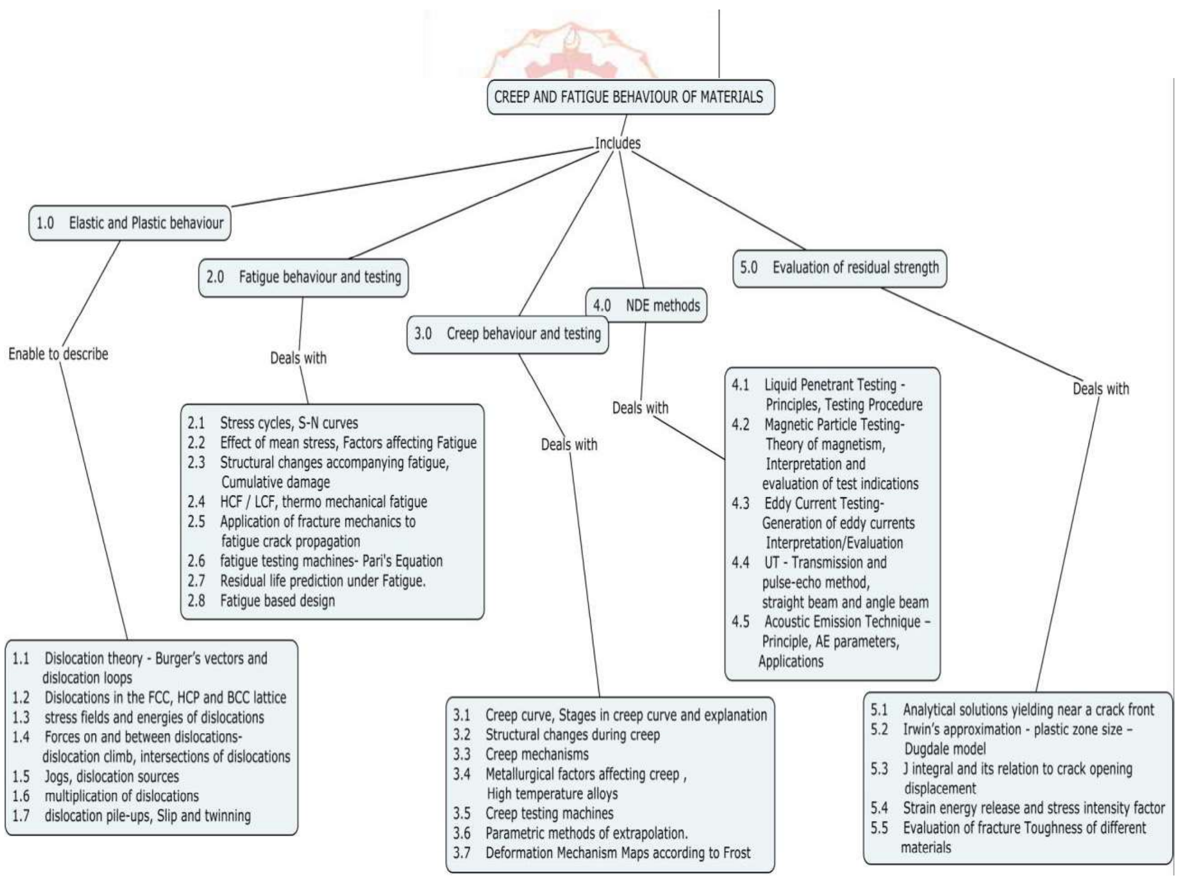
CO5.	M		M	M	L		L	L	M	L	M	M	L
CO6.	M	M	M	M	L	M	L	L	M	L	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	--	--	--
Analyse	30	30	30
Evaluate	50	50	50
Create	--	---	--

Concept Map



Syllabus

Elastic and Plastic behaviour -Elastic behaviour of materials - plastic behaviour: dislocation theory - Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice - stress fields and energies of dislocations, forces on and between dislocations-dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning.

Fatigue behaviour and testing-Fatigue: Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, Cumulative damage, HCF / LCF, thermo mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines- Pari's Equation, Residual life prediction under Fatigue. Fatigue based design.

Creep behaviour and testing -Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep, High temperature alloys, Stress rupture testing, Creep testing machines, Parametric methods of extrapolation. Deformation Mechanism Maps according to Frost.

NDE methods -Liquid Penetrant Testing - Principles, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Interpretation and evaluation of test indications, demagnetization Eddy Current Testing-Generation of eddy currents Interpretation/Evaluation- UT and AE - Transmission and pulse-echo method, straight beam and angle beam- data representation, A-Scan, B-Scan, C-Scan. Phased Array Ultrasound, Acoustic Emission Technique –Principle, AE parameters, Applications

Evaluation of residual strength -Elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdale model – J integral and its relation to crack opening displacement. Strain energy release and stress intensity factor. Evaluation of fracture Toughness of different materials: size effect & control.

Reference Books

1. Dieter, G. E., "Mechanical Metallurgy", McGraw-Hill Co., SI Edition, 1995.
2. Richard.W. Hertzberg," Deformation and Fracture Mechanism of Engineering Materials", John Willey and Sons, 4th edition, 1996.
3. Ravi Prakash, "Non-Destructive Testing Techniques", New Age International Publishers, 1st revised edition, 2010
4. Honeycombe R. W. K., "Plastic Deformation of Materials", EdwardArnold Publishers, 1984.
5. Anderson, T. L.," Fracture Mechanics: Fundamentals and Applications", CRC Press, 2nd edition, 1995.
6. ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1	**Elastic and Plastic behaviour**	
1.1	Dislocation theory - Burger's vectors and dislocation loops	1
1.2	Dislocations in the FCC, HCP and BCC lattice	1
1.3	stress fields and energies of dislocations	1
1.4	Forces on and between dislocations- dislocation climb, intersections of dislocations	1
1.5	Jogs, dislocation sources	1
1.6	multiplication of dislocations	1
1.7	dislocation pile-ups, Slip and twinning	1

2	**Fatigue behaviour and testing**	
2.1	Stress cycles, S-N curves	1
2.2	Effect of mean stress, Factors affecting Fatigue	1
2.3	Structural changes accompanying fatigue, Cumulative damage	1
2.4	HCF / LCF, thermo mechanical fatigue	1
2.5	Application of fracture mechanics to fatigue crack propagation	1
2.6	fatigue testing machines- Pari's Equation	1
2.7	Residual life prediction under Fatigue.	1
2.8	Fatigue based design	3
3	**Creep behaviour and testing**	
3.1	Creep curve, Stages in creep curve and explanation	1
3.2	Structural changes during creep	1
3.3	Creep mechanisms	1
3.4	Metallurgical factors affecting creep ,High temperature alloys	1
3.5	Creep testing machines	1
3.6	Parametric methods of extrapolation.	1
3.7	Deformation Mechanism Maps according to Frost	1
4	**NDE methods**	
4.1	Liquid Penetrant Testing - Principles, Testing Procedure	1
4.2	Magnetic Particle Testing- Theory of magnetism, Interpretation and evaluation of test indications,	1
4.3	Eddy Current Testing-Generation of eddy currents Interpretation/Evaluation	1
4.4	UT - Transmission and pulse-echo method, straight beam and angle beam- data representation, A-Scan, B-Scan, C-Scan	1
4.5	Acoustic Emission Technique –Principle, AE parameters, Applications	1
5	**Evaluation of residual strength**	
5.1	Analytical solutions yielding near a crack front	1
5.2	Irwin's approximation - plastic zone size – Dugdale model	2
5.3	J integral and its relation to crack opening displacement	1
5.4	Strain energy release and stress intensity factor	1
5.5	Evaluation of fracture Toughness of different materials	2
	Total Hours	**36**

Course Designers:

Dr.R.Ponnudurai rpdciv@tce.edu

21SEPH0	DESIGN OF FOUNDATION AND SUBSTRUCTURE	Category	L	T	P	C
		PE	2	1	0	3

Preamble

This course aims at equipping students with adequate knowledge on design principles of sheet pile walls, analysis and design of raft foundation and design of pile foundations. Furthermore, students would be able to estimate the lateral resistance of piles, load carrying capacity, settlement of pile groups, design pile caps, stone columns and caisson foundation.

Prerequisite

Fundamentals of Mathematics, knowledge of Geotechnical engineering and Foundation engineering.

Course Outcomes

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Understand and analyse various types of sheet pile walls	Apply	80	A
CO2	Analyse and design raft foundation	Apply	80	A
CO3	Analyse and design piles subjected to vertical loads, pile caps and stone columns	Apply	80	A
CO4	Analyse and estimate the capacity of batter piles, piles subjected to lateral loads and pile groups.	Analyse	80	A
CO5	Analyse and design caisson foundation.	Apply	75	B

Mapping with Programme Outcomes

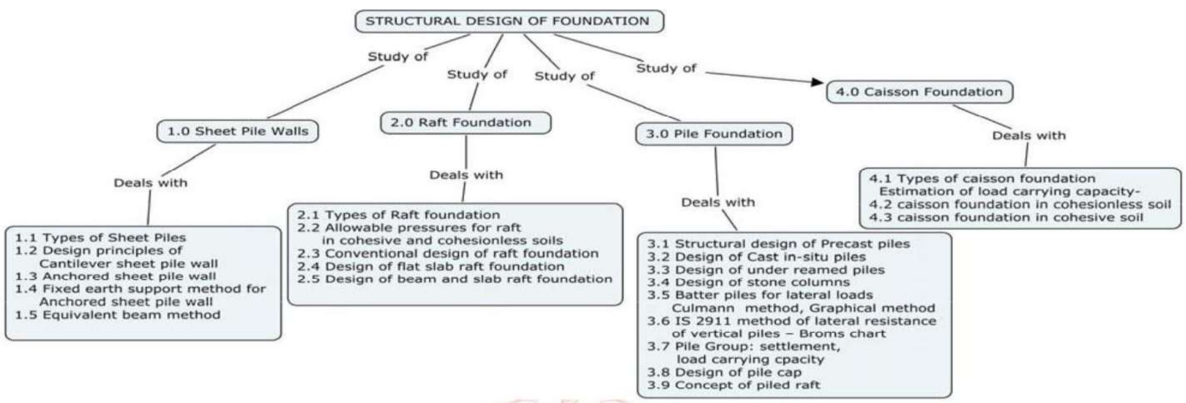
COs	P O	P O	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	M	-	-	-	-	-	-	-	-	-	L
CO2.	-	S	M	M	-	-	-	-	-	-	-	L	L
CO3	-	-	S	M	-	-	-	-	-	-	-	M	L
CO4	-	-	S	S	-	-	-	-	-	-	-	M	L
CO5	-	-	S	M	-	-	-	-	-	-	-	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	60	60
Analyse	-	20	20
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Sheet Pile Walls: Types of Sheet Piles, Design principles of Cantilever sheet pile wall, Anchored sheet pile wall, fixed earth support method for Anchored sheet pile wall, Equivalent beam method. **Raft Foundation**: Types of Raft foundation, Allowable pressures for raft in cohesive and cohesionless soils, Conventional design of raft foundation, Design of flat slab raft foundation, Design of beam and slab raft foundation. **Pile Foundation**: Structural design of Precast piles, Design of Cast in-situ piles, Design of under reamed piles, Design of stone columns, Batter piles for lateral loads – Culmann method, Graphical method, IS 2911 method of lateral resistance of vertical piles – Broms chart, **Pile Group:** Pile spacing and efficiency of pile group, Load carrying capacity of pile groups, Pile group subjected to eccentric vertical load, Settlement of pile group, Design of pile cap, Concept of piled raft.
Caisson Foundation: Types of caisson foundation, Estimation of load bearing capacity of caisson foundation in cohesionless and cohesive soil, Stability Analysis by limit equilibrium method.

Reference Books:

1. Bowles J.E., "Foundation analysis and design", Tata McGraw Hill, New Delhi, 2005.
2. Braja M. Das, Nagaratnam Sivakugan., "Principles of Foundation Engineering", Nineth Edition,2016 (India), Thomson.

3. Murthy, V.N.S., “Advanced Foundation Engineering”, CBS Publishers & Distributors, New Delhi, 2007.
4. Varghese. P.C., “Foundation Engineering”, Prentice Hall of India Private Limited, New Delhi, 2012.
5. Prakash S., and Sharma, H. D., “Pile Foundations in Engineering Practice.” John Wiley & Sons, New York, 1990.

List Of National And International Standards

1. IS: 2911 Part 1 (Section: 4) -1984, Code of practice for Design and Construction of pile foundation. Part 1 –Concrete Piles, Section 4-Bored cast in-situ piles.
2. IS: 2950 (Part 1) -1981, Code of Practice for Design and construction of raft.
3 .IS 15284-(Part 1)- 2003, Design and construction for ground improvement - Guidelines, Part 1: Stone columns.

Module No.	Topics	No. of Lecture
1	**Sheet Pile Walls**	
1.1	Types of Sheet Piles	1
1.2	Design principles of Cantilever sheet pile wall	1
1.3	Anchored sheet pile wall	1
1.3.	Tutorials - Anchored sheet pile wall	1
1.4	Fixed earth support method for Anchored sheet pile wall	1
1.4.	Tutorials - Fixed earth support method	1
1.5	Equivalent beam method	1
1.5.	Tutorials – Equivalent beam method	1
2	**Raft Foundation**	
2.1	Types of Raft foundation	1
2.2	Allowable pressures for raft in cohesive and cohesionless soils	1
2.3	Conventional design of raft foundation	1
2.3.	Tutorials – Conventional design of raft foundation	1
2.4	Flat slab raft foundation	1
2.4.	Tutorials – Design of flat slab raft foundation	1
2.5	Beam and slab raft foundation	1
2.5.	Tutorials – Design of beam and slab raft foundation	1
3	**Pile Foundation**	
3.1	Structural design of Precast piles	1
3.2	Cast in-situ piles	1
3.2.	Tutorials – Design of Cast in-situ piles	1
3.3	Under reamed piles	1
3.4	Stone columns	1

3.4.1	Tutorials – Design of stone columns	1
3.5	Batter piles for lateral loads – Culmann method – Graphical method	1
3.6	IS 2911 method of lateral resistance of vertical piles – Broms chart	1
3.6.1	Tutorials – Lateral loads on pile	1
3.7	Pile Group: Pile spacing and efficiency of pile group	1
3.7.1	Load carrying capacity of pile groups	1
3.7.2	Pile group subjected to eccentric vertical load	1
3.7.3	Settlement of pile group	1
3.8	Design of pile cap	1
3.9	Concept of piled raft	1
3.9.1	Tutorials – Pile group	1
4	**Caisson Foundation**	
4.1	Introduction and types of caisson foundation	1
4.2	Estimation of load bearing capacity of caisson foundation in cohesionless soil and in cohesive soil	1
4.3	Stability Analysis by limit equilibrium method	1
4.3.1	Tutorials – Caisson Foundation	1
	Total	36

Course Designers:

Dr.R. Sanjay Kumar sanjaykumar@tce.edu

	Category	L	T	P	Credit
21SEPK0 DESIGN OF STEEL CONCRETE COMPOSITE STRUCTURES	PE	3	0	0	3

Preamble

This course deals with limit state design of steel concrete composite structures. The discussion on the concept of limit state design based on new IS: 800-2007, EURO CODE-4 has been included in this course. The design and detailing of composite beam, column, slab, truss etc. were dealt in detail. Some case studies have also been included.

Prerequisite

Elemental Steel Design and Concrete Design

Course Outcomes

On the successful completion of the course, students will be able to

COs	**Course Outcomes**	**Bloom's Level**	**Expected Attainment level (%)**	**Expected Proficiency (grade)**
CO1	Understand the mechanism of composite action between steel and concrete and thereby determining it's the ultimate carrying capacity.	Apply	75	B
CO2	Comprehend the Indian and International code provision in designing the steel concrete composite member design.	Understand	75	B
CO3	Design a composite beams with or without profile decking sheet either simply supported or continuous end conditions using Indian and Euro code-4	Create	80	A
CO4	Design a composite slab with the provision of profile decking sheet using Euro code - 4.	Create	75	B
CO5	Design an encased as well as in-filled composite columns using Euro code - 4.	Create	80	A
CO6	Design a composite truss using Euro code - 4.	Create	75	B

Mapping with Programme Outcomes

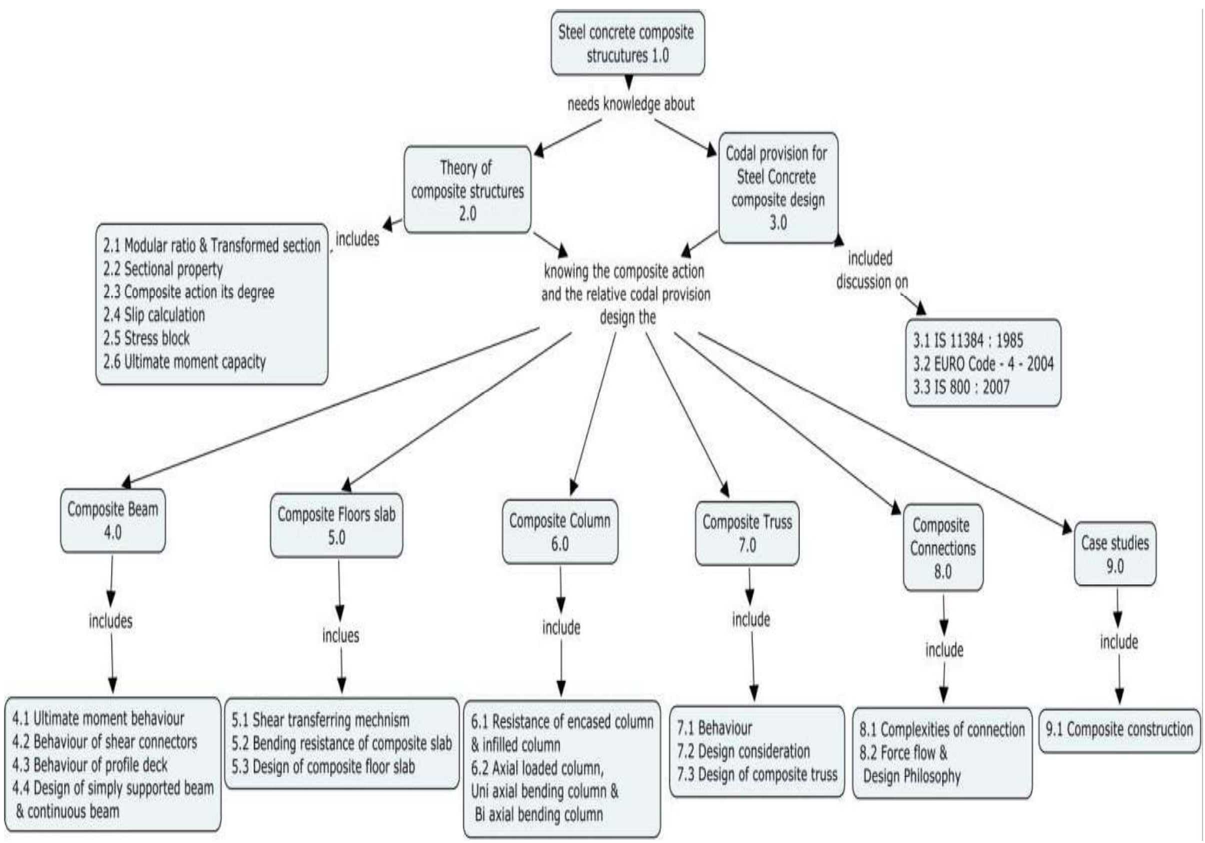
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	M	L	-	-	-	-	M	-	M	S	M
CO2.	S	M	M	L	-	-	-	-	M	-	M	M	M
CO3.	S	S	S	M	-	-	-	L	M	L	M	S	S
CO4.	S	S	M	M	-	-	-	L	M	L	M	S	M
CO5.	S	S	S	M	-	-	-	L	M	L	M	S	M
CO6.	S	M	M	M	-	-	-	L	M	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	70	70	70
Analyse	-	-	-
Evaluate	10	10	10
Create	-	-	-

Concept Map



Syllabus

Introduction to Steel Concrete Composite Structures - Theory of Composite Structures – Modular ratio – Transformed section – Sectional property like moment of inertia - Composite action – No interaction - Full interaction – Slip calculation -Stress block – Ultimate moment capacity. **Codal provisions for steel concrete composites design –**- Local buckling and section classification - Partial Safety Factors – design provisions for tension, compression, bending members and connections. **Composite Beams** - Introduction to Composite beams - Ultimate moment behaviour – Types and load transferring mechanism of Shear connectors - Types, merits and behaviour of profiled decking - Design consideration for simply supported and continuous composite beam (with or without profile deck) – Problems -Introduction to skewed beams- Design philosophy. **Composite floors -** Introduction of composite floors - Discuss on shear transferring mechanism in profile deck system - Bending resistance of composite slab - Design consideration of composite floor - Design of Composite floor- Introduction to skewed slabs- Design philosophy **Composite columns** - Introduction to composite columns and its applications - Resistance of encased composite column cross section and infilled composite column cross section under compression - Design consideration of both encased and infilled composite column under - axial compression, uniaxial bending and biaxial bending – Problems. **Composite trusses –** Behaviour and application of composite truss - Design consideration – stud specifications – Load calculation - Design of composite truss. **Composite connections** - Complexities of composite connections and its design philosophies - Force flow in the joint. **Case studies-** composite constructions

Reference Books

1. Teaching resource for, “Structural Steel Design,” Volume 2 of 3, Institute for Steel Development and Growth (INSDAG), 2002.
2. Johnson R.P (1994), “Composite Structures of Steel and Concrete”, volume I, Black well scientific publication, U.K.1999.
3. Narayanan R, “Composite steel structures – Advances, design and construction”, Elsevier, Applied science, UK, 1987
4. Handbooks of INSDAG (periodicals)
5. Website: www.steel-insdag.org

List of National and International standards

1. IS 11384-1985, Code of Practice for Composite Construction in Structural Steel and Concrete
2. Eurocode 4: Design of composite steel and concrete structures -Part 1-1: General rules and rules for buildings
3. Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
4. Eurocode 2: Design of concrete structures - Part 1-1 : General rules and rules for buildings
5. IS 875-1987, (Part-1,2 &3) Code of Practice for Design Load (other than Earthquake).
6. SP:6(1)-1964, Handbook for structural Engineers 1 – Structural Steel Sections
7. IS 456-2000 Code of Practice for general construction in RCC.
8. IS 800-2007 Code of Practice general construction in steel.

Course Contents and Lecture Schedule

S.NO.	TOPICS	PERIODS
1.0	**Introduction to Steel Concrete Composite Construction**	1
2.0	**Theory of Composite Structures**	
2.1	Modular ratio and Transformed section	1
2.2	Sectional property like moment of inertia	1
2.3	Composite action - No interaction - Full interaction	1

2.4	Slip calculation	1
2.5	Stress block	1
2.6	Ultimate moment capacity	1
3.0	**Codal provisions for steel concrete composites design**	
3.1	Provisions of IS: 11384, Code of practice for composite construction in Structural Steel and Concrete	1
3.2	Provisions of Euro Code-4-2004, Design of composite steel land concrete structures	1
3.3	Provisions of IS 800 : 2007, Code of practice for General construction in Steel	1
3.3.1	Local buckling and section classification, Partial Safety Factors	1
3.3.2	Design provisions for tension , compression, bending members and connections	1
3.3.2.1	Tutorials	1
4.0	**Composite Beams**	
4.1	Introduction to Composite beams Ultimate moment behaviour	1
4.2	Types and load transferring mechanism of Shear connectors	1
4.3	Types, merits and behaviour of profiled decking	1
4.4	Design consideration for simply supported and continuous composite beam (with or without profile deck)	1
4.4.1	Tutorials-case studies	1
4.5	Introduction to skewed beams-Design philosophy	1
5.0	**Composite floors**	
5.0.1	Introduction of composite floors	1
5.1	Discuss on shear transferring mechanism in profile deck system	1
5.2	Bending resistance of composite slab	1
5.3	Design consideration of composite floor	1
5.3.1	Tutorials - Design of Composite floor	1
5.4	Introduction to skewed slabs-Design philosophy-Case studies	1
6.0	**Composite columns**	
6.0.1	Introduction to composite columns and its applications	1
6.1	Resistance of encased composite column cross section and infilled composite column cross section under compression	1
6.2	Design consideration of both encased and infilled composite column axial compression, uniaxial bending and biaxial bending	1
6.2.1	Tutorials-case studies	1
7.0	**Composite trusses**	
7.1	Behaviour and application of composite truss	1

7.2	Design consideration of composite truss	1
7.2.1	Tutorial - Load calculation	1
7.3	Tutorials - Design of composite truss	1
8.0	**Composite connections**	
8.1	Complexities of composite connections and its design philosophies	1
8.2	Force flow in the joint	1
	Total	36

Course Designers:

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Dr. G.Celine Reena celinereena@tce.edu

		Category	L	T	P	Credit
21SEPL0	**FRACTURE MECHANICS**	PE	3	0	0	3

Preamble

The conventional design of a structure does not take in to account flaws or cracks in the materials, which largely affect the residual strength of a structure. The aim of this course is to predict the crack front growth and instability under elastic and elasto plastic conditions and to compute the stress intensity factors and stain energy release rate .This course is designed to show how these concepts can be integrated and applied to practical engineering problems using modern computational mechanics techniques.

Prerequisite

Structural mechanics, Theory of elasticity and plasticity

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	**Understand the various theories of failures of structural materials with pre existing cracks**	**Underst and**	**70**	**B**
CO2	**Understand the principles of Linear Elastic Fracture Mechanic**	**Apply**	**70**	**B**
CO3	Understand Elastic Plastic Fracture Mechanics	Understand	70	B
CO4	Understand Fatigue Crack Growth	Understand	70	B
CO5	Able to identify Crack Arrest	Create	70	B
CO6	Able to do Numerical methods	Create	70	B

Mapping with Programme Outcomes

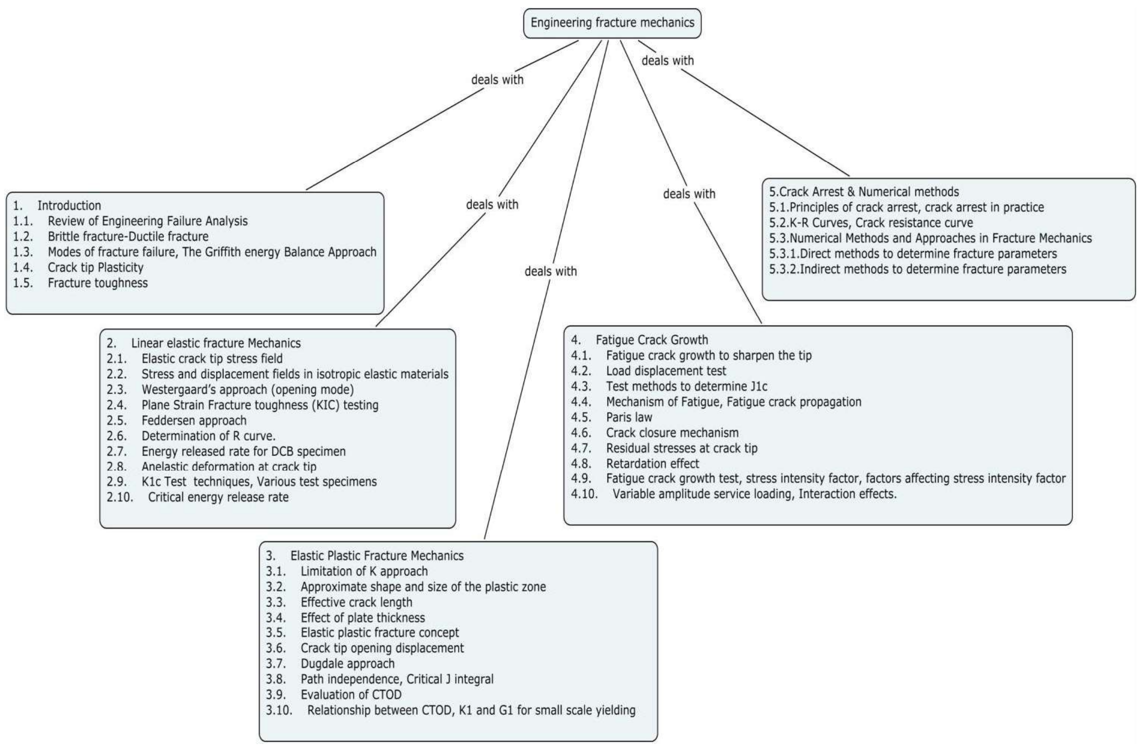
COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	M	M	M	M	L	M	L	L	M	L	M	M	L
CO2.	M	M	M	-	L	M	L	L	-	L	M	M	L
CO3	-	-	M	-	L	M	L	L	-	L	M	M	L
CO4	-	-	M	M	L	-	L	L	-	L	M	M	L
CO5	M	-	M	M	L	-	L	L	M	L	M	M	L
CO6	M	M	M	M	L	M	L	L	M	L	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	60	60	60
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Introduction-Review of Engineering Failure Analysis-Brittle fracture-Ductile fracture Modes of fracture failure, The Griffith energy Balance Approach-Crack tip Plasticity-Fracture toughness **Linear elastic fracture Mechanics-**Elastic crack tip stress field Stress and displacement fields in isotropic elastic materials-Westergaard's approach (opening mode)-Plane Strain Fracture toughness (KIC) testing-Feddersen approach, Determination of R curve, Energy released rate for DCB specimen-An elastic deformation at crack tip-K_{1c} Test techniques, Various test specimens-Critical energy release rate **Elastic Plastic Fracture Mechanics-**Limitation of K approach -Approximate shape and size of the plastic zone-Effective crack length-Effect of plate thickness-Elastic plastic fracture concept-Crack tip opening displacement-Dugdale approach-Path independence, Critical J integral-Evaluation of CTOD-Relationship between CTOD, K_1 and G_1 for small scale yielding **Fatigue Crack Growth-**Fatigue crack growth to sharpen the tip, SN curve-methods to determine

J_{1c}Mechanism of Fatigue, Fatigue crack propagation-Paris law-Crack closure mechanism-Residual stresses at crack tip-Retardation effect fatigue crack growth test, stress intensity factor, factors affecting stress intensity factor-Variable amplitude service loading, Interaction effects **Crack Arrest & Numerical methods** Principles of crack arrest, crack arrest in practice-R Curves, Crack resistance curve, Eutectic process Numerical Methods and Approaches in Fracture Mechanics, Direct methods to determine fracture parameters Indirect methods to determine fracture parameters

Reference Books

1. John M. Barson&Stanely T. Rolfe, "Fracture and Fatigue Control in Structure," Prentice Hall Inc, USA,1987.
2. David Broek, "Elementary Engineering Fracture Mechanics, " MartinusNijhoff Publishers, The Hague, 1982.
3. Jean Lemative& Jean Louis Chboche, "Mechanics of Solid Materials," Cambridge University Press, Cambridge,1987.
4. Gdoutos E. E., " Fracture Mechanics – An introduction," Kluwer Academic publishers, Dordrecht, 1993.
5. Knott J. F., "Fundamentals of Fracture Mechanics," John Wiley & Sons, New York 1973.
6. Suresh S., "Fatigue of Materials," Cambridge University Press, Cambridge 1991.
7. Bhushan L. Karihaloo, "Fracture Mechanics and Structural Concrete," Longman Scientific Publishers, USA, 1972.
8. Simha K. R. Y ., "Fracture Mechanics for Modern Engineering Design," University Press (India) Ltd, Hyderabad, 2001.

Course Contents and Lecture Schedule

1.0	**Introduction**	
1.1	Review of Engineering Failure Analysis	1
1.2	Brittle fracture-Ductile fracture	1
1.3	Modes of fracture failure, The Griffith energy Balance Approach	1
1.4	Crack tip Plasticity,Fracture toughness	1
2.0	**Linear Elastic Fracture Mechanics**	
2.1	Elastic crack tip stress field	1
2.2	Stress and displacement fields in isotropic elastic materials	1
2.3	Westergaard's approach (opening mode)	1
2.4	Plane Strain Fracture toughness (KIC) testing	1
2.5	Feddersenapproach,Determination of R curve.	1
2.6	Energy released rate for DCB specimen	1
2.7	Anelastic deformation at crack tip	1
2.8	K_{1c} Test techniques, Various test specimens	1
2.9	Critical energy release rate	1
3.0	**Elastic Plastic Fracture Mechanics**	
3.1	limitation of K approach	1
3.2	Approximate shape and size of the plastic zone	1
3.3	Effective crack length	1
3.4	Effect of plate thickness	1
3.5	Elastic plastic fracture concept	1

3.6	Crack tip opening displacement	1
3.7	Dugdale approach	1
3.8	Path independence ,Critical J integral	1
3.9	Evaluation of CTOD	1
3.10	Relationship between CTOD, K_1 and G_1 for small scale yielding	1
4.0	**Fatigue Crack Growth**	
4.1	Fatigue crack growth to sharpen the tip	1
4.2	Load displacement test	1
4.3	Test methods to determine J_{1c}	1
4.4	Mechanism of Fatigue ,Fatigue crack propagation	1
4.5	Paris law, crack closure mechanism	1
4.6	Residual stresses at crack tip,Retardation effect	1
4.7	Fatigue crack growth test, stress intensity factor, factors affecting stress intensity factor	1
4.8	variable amplitude service loading, Interaction effects.	1
5.0	**Crack Arrest & Numerical methods**	
5.1	Principles of crack arrest, crack arrest in practice	1
5.2	K-R Curves, Crack resistance curve	1
5.3	Numerical Methods and Approaches in Fracture Mechanics	1
5.4	Direct methods to determine fracture parameters	1
5.5	Indirect methods to determine fracture parameters	1
	Total	**36**

Course Designers

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21SEPM0	INDUSTRIAL STRUCTURES	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course offers planning and functional requirements of industrial structures, Pre – engineered structures and design of connections and foundations for industrial structures. This also includes material handling systems and conveyor system etc. Design concepts of storage systems and environmental control structures are also dealt in detail. Some case studies have also been included.

Prerequisite

- Knowledge of Structural analysis, Structural steel design, Foundation design

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment Level in %	Expected Proficiency Level in grade
CO1	Explain the planning and functional requirements of IndustrialStructures	Apply	75	A
CO2	Develop suitable section details for the Pre – Engineered structures and foundations.	Create	75	A
CO3	Demonstrate the structural aspects of machine foundation and containment structures.	Apply	75	A
CO4	Predict the adequacy of the Turbo generator foundations & conveyor systems	Create	75	A
CO5	Prepare the design details of steel bunker and silos.	Create	75	A
CO6	Explain the design concept of hyperbolic cooling towers	Analyze	75	A

Mapping with Programme Outcomes

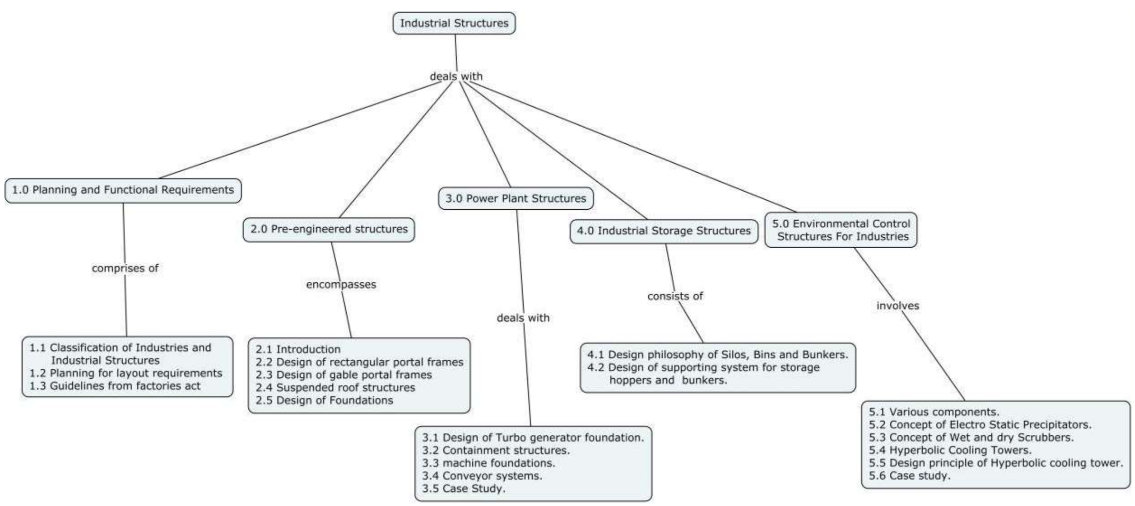
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	M	M	S	M	-	-	-	-	M	M	M	M	M
CO2.	S	M	S	M	-	-	-	M	M	M	M	M	M
CO3	M	M	S	M	-	-	-	-	M	M	M	M	M
CO4	M	M	S	M	-	-	-	-	M	M	M	M	M
CO5	M	M	S	M	-	-	-	M	M	M	M	M	M
CO6	M	M	S	M	-	-	-	-	M	M	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	70	70	70
Analyse	10	10	10
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Planning and Functional Requirements: Classification of Industries and Industrial Structures – planning for layout requirements regarding lighting, ventilation and fire safety - protection against noise and vibration – guidelines from factories act - structural loads. **Pre-engineered structures:** Introduction- Design of rectangular portal frames -analysis and design- Design of gable portal frames- analysis and design - Design of corner connection with and without haunches - Suspended roof structures analysis and design -Design of Foundations for industrial structures - **Power Plant Structures:** Types of power plants – Design of Turbo generator foundation – containment structures - Structural aspects of machine foundations. Material Handling Systems: Conveyor systems – Supports for conveyor systems - case study **Industrial Storage Structures**: Silos, Bins and Bunkers – Design of supporting system for storage hoppers and bunkers. **Environmental Control Structures For Industries:** Various components – Concept of Electro Static Precipitators functioning and components – Wet and dry Scrubbers – Hyperbolic Cooling Towers-design principle - case study on design of Hyperbolic cooling tower.

Reference Books

1. Alexander Newman, "Metal Building Systems – Design and Specification's", second Edition Mc Graw Hill, NewDelhi, 2004.
2. Edwin Henry Gaylord, Charles N. Gaylord "Design of steel bins for storage of bulk solids", Prentice Hall International ,1984 .
3. Gaylord E H, Gaylord N C and Stallmeyer J E, "Design of Steel Structures", 3rd edition, McGraw Hill Publications, 1992.
4. Jurgen Axel Adam, Katharria Hausmann, Frank Juttner, Klauss Daniel, "Industrial Buildings: A Design Manual", Birkhauser Publishers, 2004.
5. Metal Building Manufacturers Association (MBMA) " Design Manual "based on IBC 2006/2010.
6. Srinivasulu P and Vaidyanathan.C, "Handbook of Machine Foundations", Tata McGraw Hill, 1976.
7. Subramanian N," Design of Steel Structures", Oxford University Press, NewDelhi, 2008.
8. Teaching Resource for Structural Steel Design, Vol. 1, 2, 3 (2000), INSDAG- Institute for Steel Development and Growth, Kolkatta.

List of national and international standards

1. IS: 800 – 2007, Code of Practice for general construction in steel, BIS, New Delhi
2. IS: 800 – 1984, Code of Practice for general construction in steel, BIS, New Delhi
3. SP 6 (1) – Structural steel sections
4. IS: 816 - 1969, Code of practice for use of metal arc welding for general construction in mild steel
5. National Building Code – 2005, BIS
6. IS: 2974(Part-3) - 1992, Code of practice design and construction of machine foundations

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.0	**Planning and Functional Requirements**:–	
1.1	Classification of Industries and Industrial Structures	1
1.2	Planning for layout requirements regarding lighting, ventilation and fire safety & protection against noise and vibration	1
1.3	Guidelines from factories act –structural loads.	1
2.0	**Pre-engineered structures**:–	
2.1	Introduction	1
2.2	Design of rectangular portal frames - analysis and design	1
2.2.1	Tutorial-1	2
2.3	Design of gable portal frames- analysis and design - corner connection with and without haunches	1
2.3.1	Tutorial-2	2
2.4	Suspended roof structures analysis and Design	1

2.4.1	Tutorial-3	2
2.5	Design of Foundations for Industrial structures	1
2.5.1	Tutorial-4	2
3.0	**Power Plant Structures**:–	
3.1	Types of power plants – Design philosophy of Turbo generator foundation	1
3.1	Design of Turbo generator foundation	1
3.1.1	Tutorial-5	2
3.2	Containment structures	2
3.3	Structural aspects of machine foundations.	1
3.4	Conveyor systems – Supports for conveyor systems.	1
3.5	Case Study	1
4.0	**Industrial Storage Structures**:–	
4.1	Design philosophy of Silos, Bins and Bunkers	1
4.2	Design of supporting system for storage hoppers and Bunkers	2
4.2.1	Tutorial-6	2
5.0	**Environmental Control Structures For Industries**:–	
5.1	Various components of environmental control structures	1
5.2	Concept of Electro Static Precipitators functioning and components	1
5.3	Concept of Wet and dry Scrubbers	1
5.4	Hyperbolic Cooling Towers	1
5.5	Design principle of Hyperbolic cooling tower	1
5.6	Case study on design of Hyperbolic cooling tower	1
	Total	36

Course Designers:

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2. Dr.G.Celine Reena celinereena@tce.edu
3. Mr.R.Sankaranarayanan rsciv@tce.edu

21SEPN0	PRESTRESSED CONCRETE	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Prestressed concrete is used extensively in bridges, multistory buildings and many other important parts of today's modern infrastructure. The inherent weakness of concrete in tension is offset by introducing a pre-compression in a prestressed member, which improves its service load behavior, leading to reduced deflections and cracking. This course will provide a detailed coverage on behaviour of prestressed concrete, analysis and design for strength and serviceability of prestressed concrete members, such as beams and slabs including continuous members, composite members and anchorage design and losses in prestress. It also aims to train the students on the practical design of prestressed concrete structures in an interactive manner.

Prerequisites

Applied Mathematics , Structural MechanicsCourse Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Describe the systems and methods of prestressing and suggest suitable method of prestressing for the given condition and its analysis	Apply	85	A
CO2	Determine the losses of prestress and deflection of prestressed concrete members under various loading conditions	Apply	80	A
CO3	Identify and apply relevant codal provisions to analyse and design the flexural members	Apply	75	B
CO4	Identify and apply relevant codal provisions in designing the tension and compression members	Apply	75	B
CO5	Explain the behavior and analysis of continuous prestressed concretemembers	Apply	75	B
CO6	Explain the behavior and analysis of the composite prestressed concrete members	Apply	75	B

Mapping with Programme Outcomes

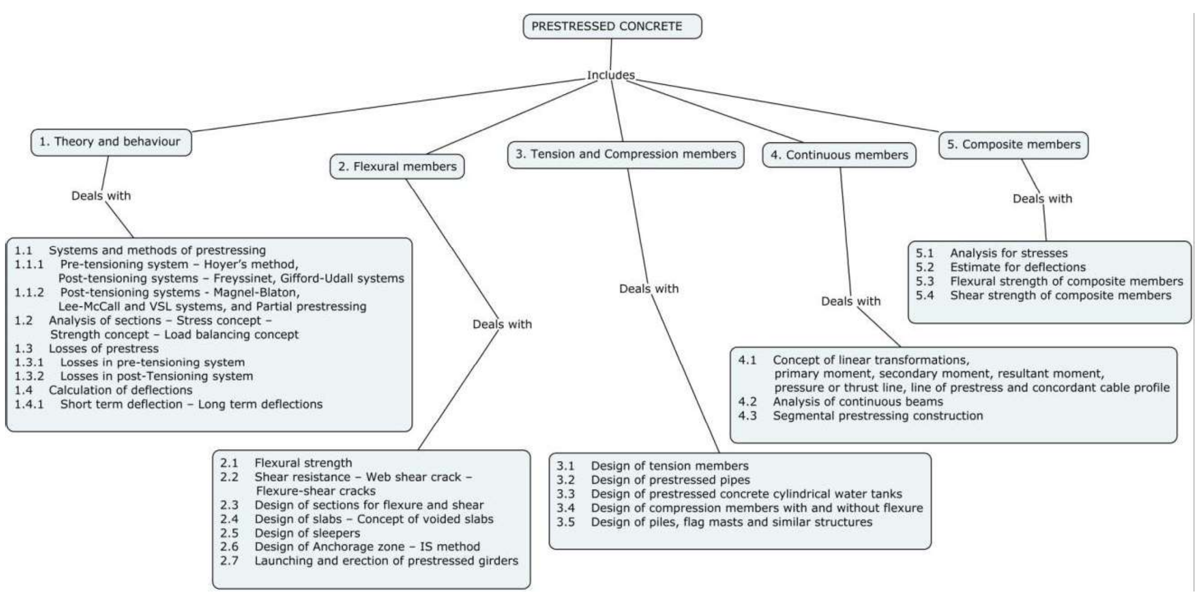
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	S	S	M	-	S	-	-	S	S	L	L
CO2.	S	S	S	S	M	-	S	-	-	S	S	L	L
CO3.	S	S	S	S	M	-	S	-	-	S	S	M	M
CO4.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO5.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO6.	S	S	S	S	M	-	S	-	-	S	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Theory and behaviour - systems and methods of prestressing; analysis of sections - stress concept, strength concept, load balancing concept; losses of prestress; short term and long term deflections; **Flexural members -** flexural strength, shear resistance, web shear crack, flexure-shear cracks; design of sections for flexure and shear; design of slabs, concept of voided slabs; design of sleepers; design of anchorage zone; launching and erection of prestressed girders; **Tension and compression members -** design of tension members, pipes and cylindrical water tanks; design of compression members with and without flexure, piles, flag masts; **Continuous members –** concept of linear transformations, primary moment, secondary moment, resultant moment, pressure or thrust line, line of prestress, concordant cable profile, analysis of continuous beams, segmental prestressing construction; **Composite members** - analysis for stresses; estimate for deflections; flexural and shear strength of composite members.

Reference Books

1. N. Krishna Raju, Prestressed Concrete, McGraw Hill Education; Sixth edition, New Delhi, 2018.
2. T.Y. Lin, & Ned. H. Burns, Design of Prestressed Concrete Structures, John Wiley & Sons, New York, 2010.
3. Arthur H.Nilson, Design of Prestressed Concrete, John Wiley & Sons, New York, 2004.
4. James R.Libby, Modern Prestressed Concrete: Design principles and Construction methods - Van Standard Rainford Co., New York, 1990
5. N. Rajagopalan, Prestressed Concrete, Narosa Publishing House, New Delhi, 2008
6. P. Dayaratnam, Prestressed Concrete Structures, Oxford and IBH, New Delhi, 2003.
7. N.C. Sinha & S.K. Roy, Fundamentals of Prestressed Concrete, S.Chand & Company Ltd, New Delhi, 2007.

List of national and international standards

1. IS 1343:2012 Code of Practice for Pre Stressed Concrete
2. IS 3370 (Part 3):1967 Code of Practice for Concrete Structures for the Storage of Liquids-Part 3 Pre stressed Concrete
3. IS 3370 (Part 4):1967 Code of Practice for Concrete Structures for the Storage –Part-4 Design Tables
4. IS 784:2001 Prestressed concrete pipes (including specials) – Specification
5. IS 2911 (Part 1/Sec 3): 2010 Code of Practice for Design and Construction of Pile Foundations Part 1 Concrete Pile; Section 3 Driven Precast Concrete Piles
6. IS 2911 (Part 1/Sec 4): 2010 Code of Practice for Design and Construction of Pile Foundation Part 1 Concrete Pile; Section 4 Bored Precast Concrete Piles

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Theory and behaviour		
1.1	Systems and methods of prestressing	
1.1.1	Pre-tensioning system – Hoyer's method, Post-tensioning systems – Freyssinet, Gifford-Udall systems	1
1.1.2	Post-tensioning systems - Magnel-Blaton, Lee-McCall and VSL systems, and Partial prestressing	1
1.2	Analysis of sections – Stress concept – Strength concept – Load balancing concept	1
1.3	Losses of prestress	
1.3.1	Losses in pre-tensioning system	2
1.3.2	Losses in post-Tensioning system	1
1.4	Calculation of deflections	
1.4.1	Short term deflection – tendons of various profile – self weight and imposed loads - Long term deflections	2
2. Flexural members		
2.1	Flexural strength	1
2.2	Shear resistance – Web shear crack – Flexure-shear cracks	1
2.3	Design of sections for flexure and shear	2
2.4	Design of slabs – Concept of voided slabs	2
2.5	Design of sleepers	1
2.6	Design of Anchorage zone – IS method	2
2.7	Launching and erection of prestressed girders - introduction	1
3. Tension and Compression members		
3.1	Design of tension members	2
3.2	Design of prestressed pipes	2
3.3	Design of prestressed concrete cylindrical water tanks	2
3.4	Design of compression members with and without flexure	2
3.5	Design of piles, flag masts	2
4. Continuous members		
4.1	Concept of linear transformations, primary moment, secondary moment, resultant moment, pressure or thrust line, line of prestress and concordant cable profile	1

4.2	Analysis of continuous beams	2
4.3	Segmental prestressing construction	1
5. Composite members		
5.1	Analysis for stresses	1
5.2	Estimate for deflections	1
5.3	Flexural strength of composite members	1
5.4	Shear strength of composite members	1
	Total Hours	36

Course Designers:

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21SEPQ1	STRUCTURAL STEEL DESIGN	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course deals with the plastic analysis of structures, buckling of thin plate element concept and its application in plate girder design. This course discusses about the cold form steel section design using effective width method also direct strength approach. Also this course covers topics like members subjected to combined forces and slip resistance connection design along with the design principles of moment resisting connection.

Prerequisite

Knowledge of structural analysis, Design steel elements and structures.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome Statement	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Calculate the collapse load factor or plastic Moment capacity for indeterminate beams and frames	Apply	80	A
CO2	Demonstrate the local buckling of thin plates and its post buckling strength by which provide a optimised plate girder design as per IS:800	Analyse	75	B
CO3	Investigate the adequacy of the cold formed steel cross sections under axial or bending effects as per IS:801.	Apply	80	A
CO4	Comprehends the behaviour of members under combined forces and provide an effective design as per IS:800	Analyse	75	B
CO5	Demonstrate the behaviour of slip critical connection at its service and ultimate state also estimate the connection capacity under combined effect of tension & shear and moment & shear	Apply	80	A

Mapping with Programme Outcomes

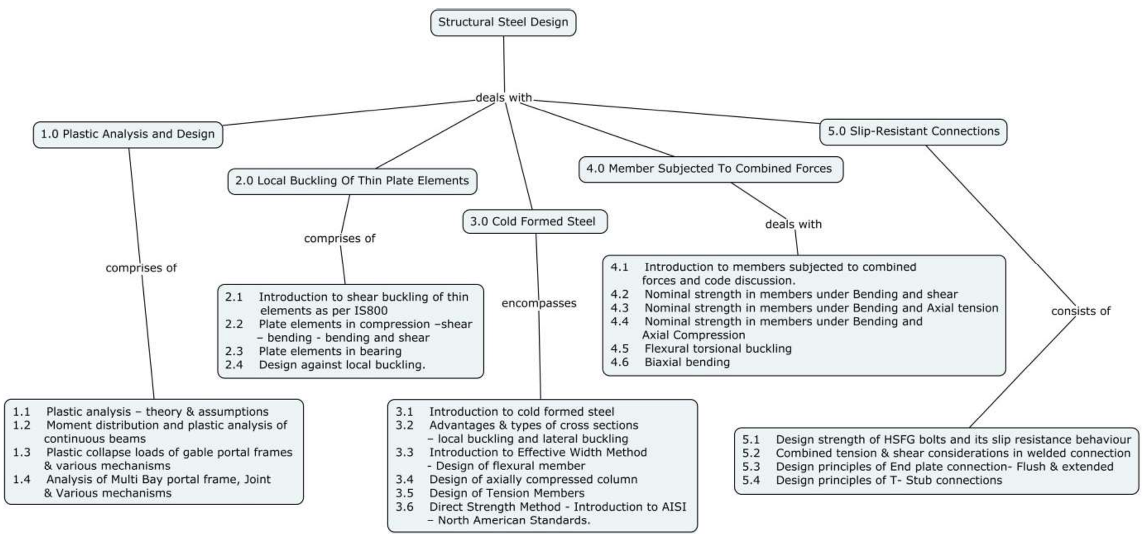
COs	PO1 K3	PO2 K4	PO3 K5	PO4 K6	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	L	-	-	-	-	-	M	L	L	L	L
CO2	S	S	M	L	-		-	-	M	L	L	M	L
CO3	S	M	L	-	L	-	-	-	M	L	-	L	L
CO4	S	S	M	L	-	-	-	-	M	-	-	M	L
CO5	S	M	L	-	-	-	-	-	M	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	-	-	-
Understand	10	10	10
Apply	60	60	60
Analyse	30	30	30
Evaluate	-	-	-
Create	-	-	

Concept Map



Syllabus

Plastic Analysis: Theory & assumptions, yield criteria, plastic modulus & shape factor - Moment distribution and plastic analysis of continuous beams - Plastic collapse loads of gable portal frames & various mechanisms - Analysis of Multi Bay - Single Storey rectangular portal frame, Joint & Various mechanisms. **Local Buckling of Thin Plate Elements:** Introduction – plate elements in compression –shear – bending – bending and shear – bearing – design against local buckling. **Cold Formed Steel:** Introduction to cold formed steel - Advantages of cold formed steel sections – Types of cross sections – local buckling and lateral buckling –Effective Width Method - Design of flexural member - Design of axially compressed column - Combined bending and compression - Design of Tension Members - Direct Strength Method - Introduction to AISI – North American Standards. **Member Subjected To Combined Forces** – Introduction – Bending and shear – Bending and Axial tension – Bending and Axial Compression: Flexural torsional buckling – Biaxial bending. **Slip- Resistant Connections:** Design strength of HSFG bolts and its slip resistance behaviour- Combined tension & shear considerations bolted connection - problems. Design principles of End plate connection- Flush & extended - Design principles of - Stub connections.

Reference Books

1. Plastic Design of frames – fundamentals, John Baker, Jacques Heyman, Cambridge University Press, 2008
2. Dayaratnam.P, "Design of Steel Structures", A.H.Wheeler, India, 2007.
3. Englekirk R, "Steel Structures: Controlling Behaviour through Design", John-Wiley & Sons, Inc, 2003.
4. John E. Lothers, "Design in Structural Steel", Prentice Hall of India, New Delhi, 1990.
5. Linton E. Grinter, "Design of Modern Steel Structures", Eurasia Publishing House, New Delhi, 1996.
6. Lynn S. Beedle, "Plastic Design of Steel Frames", John Wiley and Sons, NewYork, 1990.
7. Subramanian N," Design of Steel Structures", Oxford University Press, New Delhi, 2008.
8. Teaching resource for, "Structural Steel Design," Volume 1, 2 & 3, Institute for Steel Development and Growth (INSDAG), 2002.
9. Trahair N S, Brandford M A, Nethercot D,m Gardner L, "The Behaviour and Design of Steel Structures EC3", Fourth edition, Taylor& Francis, London & Newyork, 2008.
10. Wie Wen Yu, "Design of Cold Formed Steel Structures", Mc Graw Hill BookCompany, New York, 1996.

List of National and International Standards

1. IS 800: 2007, Code of practice for General construction in Steel, BIS, New Delhi.
2. IS 801 - 1975, Code of Practice for use of cold formed light gauge steel structural member's in general building construction, BIS, New Delhi.
3. IS 811 – 1987, Specification for cold formed light gauge structural steel sections, BIS, New Delhi.
4. IS: 808 – 1989 Dimensions For Hot Rolled Steel Beam, Column, Channel and Angle Sections.
5. SP: 6(1)-1964, Handbook for structural Engineers 1-Structural Steel Sections

Website

1. www.steel-insdag.org

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture
1.0	**Plastic Analysis:**	**6**
1.1	Plastic analysis – theory & assumptions, yield criteria, plastic modulus & shape factor	1
1.2	Moment distribution and plastic analysis of continuous beams	1
1.2.1	Tutorial – Problems on plastic analysis of continuous beams	1
1.3	Plastic collapse loads of gable portal frames & various mechanisms	1
1.4	Analysis of Multi Bay - Single Storey rectangular portal frame, Joint & Various mechanisms	1
1.4.1	Tutorial – Problems on analysis of Multi Bay - Single Storey rectangular portal frame	1

2.0	**Local Buckling of Thin Plate Elements:**	**8**
2.1	Introduction to shear buckling of thin elements as per IS800	2
2.2	Plate elements in compression –shear – bending	1
2.3	Plate elements in bending and shear	2
2.3.1	Plate elements in bearing	1
2.4	Design against local buckling.	1
2.5	Tutorial problems	1
3.0	**Cold Formed Steel**	**8**
3.1	Introduction to cold formed steel	1
3.2	Advantages & types of cross sections – local buckling and lateral buckling	1
3.3	Introduction to Effective Width Method - Design of flexural member	1
3.3.1	Tutorial - Design of flexural member	1
3.4	Design of axially compressed column	1
3.5	Design of Tension Members	1
3.5.1	Tutorial - Design of axially compressed column and Tension Members	1
3.6	Direct Strength Method - Introduction to AISI – North American Standards.	1
4.0	**Member Subjected To Combined Forces**	**7**
4.1	Introduction to members subjected to combined forces and code discussion.	1
4.2	Nominal strength in members under Bending and shear	1
4.3	Nominal strength in members under Bending and Axial tension	1
4.4	Nominal strength in members under Bending and Axial Compression	1
4.5	Flexural torsional buckling	1
4.6	Biaxial bending	1
4.7	Tutorial problems	2
5.0	**Slip- Resistant Connections:**	**7**
5.1	Design strength of HSFG bolts and its slip resistance behaviour	1
5.2	Combined tension & shear considerations in welded connection	1
5.3	Design principles of End plate connection- Flush & extended	1
5.4	Design principles of T- Stub connections	1
5.5	Tutorial Problems	2
	Total	**36**

Course Designers:

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2. Ms.G.Celine Reena celinereena@tce.edu

21SEPR0	STRUCTURAL MECHANICS	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course deals with the advanced mechanics of materials in which beams on elastic support, curved flexural members, buckling of plates and bars, Inelastic buckling of straight column, shear centre, unsymmetrical bending are discussed.

Prerequisite

Fundamentals of Mathematics, knowledge of basic Strength of Material.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment Level in %	Expected Proficiency Level in grade
CO1	Illustrate the concept of beam on elasticfoundation	Apply	75	B
CO2	Outline the concept of shear center for one axis symmetricsection	Analyse	75	B
CO3	Analyze the stress and deflection in unsymmetrical section	Analyse	75	B
CO	Calculate the stresses in curved flexuralmember	Analyse	75	B
CO5	Analyze the forces in beam and column	Analyse	75	B
CO6	Examine the buckling stress in plates and bar	Analyse	75	B

Mapping with Programme Outcomes

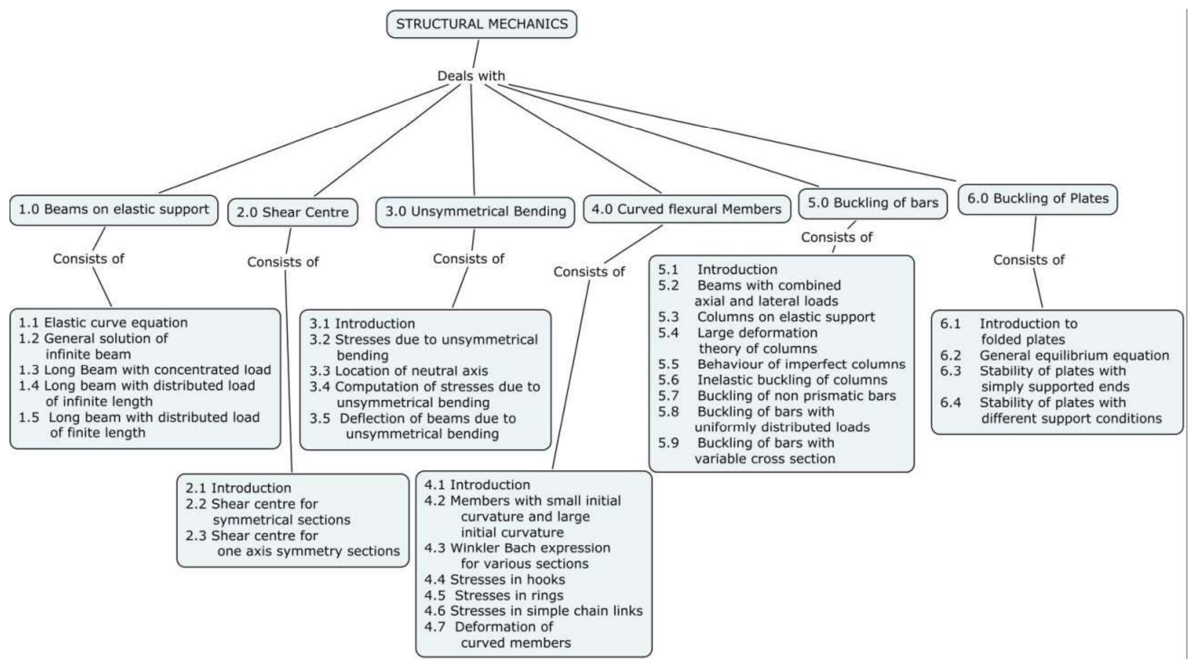
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	S	M	M	L	L	-	-	M	-	L	M	L
CO2	S	S	M	M	L	L	-	-	M	-	L	M	L
CO3	S	S	M	M	L	L	-	-	M	-	L	M	L
CO4	S	S	M	M	L	L	-	-	M	-	L	M	L
CO5	S	S	M	M	L	L	-	-	M	-	L	M	L
CO6	S	S	M	M	L	L	-	-	M	-	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	60	60	60
Analyse	20	20	20
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Beam on elastic support-Elastic curve equation-General solution of infinite -Long Beam with different types of loading-semi infinite and finite length beams **Shear Centre-** Shear centre for symmetrical one axis symmetry sections **Unsymmetrical Bending-** stresses-deflections- **Curved flexural Members-**small and large curvature bars**-**stresses in hooks, rings and chain links-deformation-**Buckling of bars**-combined axial and bending-column on elastic support-large deformation theory-behaviour of imperfect column-inelastic buckling-buckling of non prismatic and variable cross section bars-**Buckling of plates-** Introduction to folded plates- general equilibrium equation-stability of plates with different support conditions.

Reference Book

1. Glen Murphy, "Advanced Mechanics of Materials", McGraw Hill Book Company, New York, U.S.A.1988.
2. Sadhu singh, "Theory and Solved Problems in Advanced Strength of Materials", khanna Publishers, 2006.
3. Seely and Smith, "Advanced Mechanics of Materials", John Willey and Sons, Newyork, U.S.A.1957.

4. Srinath L S, "Advanced Mechanics of Solids", Mc Graw Hill Education, 3rd Edition, 2009.

Course Contents and Lecture Schedule

	Topics	Periods
1	**Beams on elastic support**	
1.1	Elastic curve equation	1
1.2	General solution of infinite beam	1
1.3	Long Beam with concentrated load	1
1.4	Long beam with distributed load of infinite length	1
1.5	Long beam with distributed load of finite length	1
2	**Shear Centre**	
2.1	Introduction	1
2.2	Shear centre for symmetrical sections	2
3	**Unsymmetrical Bending**	
3.1	Introduction	1
3.2	Stresses due to unsymmetrical bending	1
3.3	Tutorial - Location of neutral axis	1
3.4	Computation of stresses due to unsymmetrical bending	1
4	**Curved flexural Members**	
4.1	Introduction	1
4.2	Members with small initial curvature and large initial curvature	1
4.3	Winkler Bach expression for various sections	1
4.4	Tutorial –winkler bach equation problems	1
4.5	Stresses in hooks	1
4.6	Stresses in rings	1
4.7	Stresses in simple chain links	1
4.8	Deformation of curved members	2
5	**Buckling of bars**	
5.1	Introduction	1

5.2	Beams with combined axial and lateral loads	2
5.3	Columns on elastic support	1
5.4	Large deformation theory of columns	2
5.5	Inelastic buckling of columns	1
5.6	Buckling of non prismatic bars	1
5.7	Buckling of bars with uniformly distributed loads	1
5.8	Buckling of bars with variable cross section	1
6	**Buckling of Plates**	
6.1	Introduction to folded plates	1
6.2	General equilibrium equation	2
6.3	Stability of plates with simply supported ends	1
6.4	Tutorial - Stability of plates with different support conditions	1
	Total	**36**

Course Designers

Mr.R.Sankaranarayanan rsciv@tce.edu

21SEPS0	THEORY OF PLATES	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The form of plates and shells are encountered in many branches of technology such as civil, mechanical, aeronautical, marine, and chemical engineering. Such a widespread use of plate structures arises from their intrinsic properties. When suitably designed, even very thin plates, can support large loads. Thus, they are utilized in structures such as aerospace vehicles in which light- weight is essential. The objective of this course is to offer a comprehensive and mathematical presentation of the fundamentals of thin plate theories based on a strong foundation of mathematics and mechanics with emphasis on engineering aspects and also to apply the theories and methods to the analysis and design of thin plate structures in engineering.

Prerequisites

Applied Mathematics
Structural Mechanics
Theory of Elasticity and Plasticity

Course Outcomes

On the successful completion of the course, the students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Describe the behavior and analysis of long rectangular plates using thin plate theory with various edgeconditions	Apply	75	B
CO2	Explain the behaviour and analysis of circular plates with various loading conditions	Apply	75	B
CO3	Describe the analysis of rectangular plates with Navier's Solution and Levy's Method	Apply	75	B
CO4	Explain the behavior and analysis of thin plates with various edge conditions using finite difference method	Apply	75	B
CO5	Describe the behavior and analysis of anisotropic plates	Apply	75	B

Mapping with Programme Outcomes

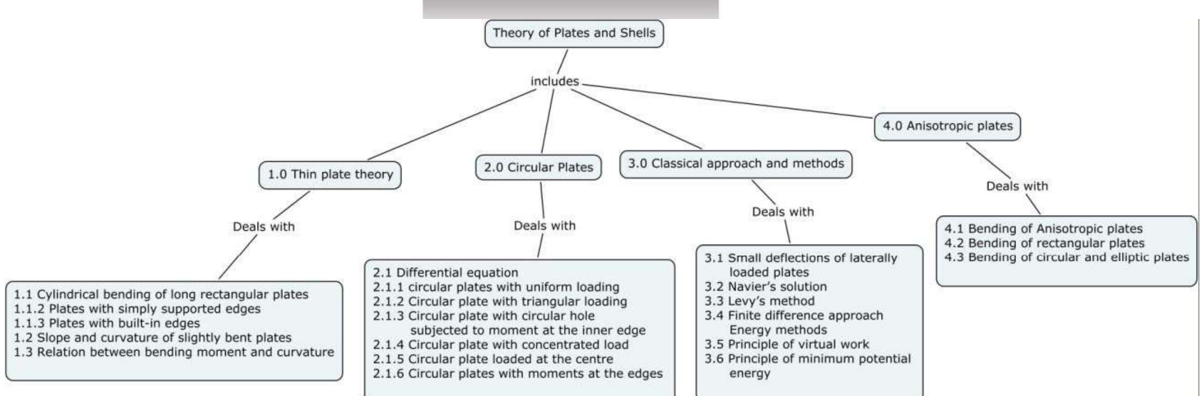
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	S	S	M	-	S	-	-	S	S	M	S
CO2.	S	S	S	S	M	-	S	-	-	S	S	M	S
CO3.	S	S	S	S	M	-	S	-	-	S	S	M	S
CO4.	S	S	S	S	M	-	S	-	-	S	S	M	S
CO5.	S	S	S	S	M	-	S	-	-	S	S	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Thin plate theory – Assumptions, Bending of long rectangular plates to a cylindrical surface – Differential equation; Plates with simply supported edges; Plates with built-in edges; Pure bending of plates; Slope and curvature of slightly bent plates; Relation between bending moment and curvature; **Circular plates** - Symmetrical bending of laterally loaded circular plates – Differential equation; Uniformly loaded circular plates; Circular plate with triangular loading; Circular plate with circular hole; Circular plate concentrically loaded; Circular plate loaded at the centre; Circular plates with moments; **Classical approach and Methods** - Small deflections of laterally loaded plates – Differential equation of the deflection surface; Simply supported rectangular plates under sinusoidal loading; Navier's solution for simply supported rectangular plates under uniform loading, under hydrostatic pressure, under concentrated load and under a load uniformly distributed over the area of a rectangle; Levy's method - Advantages over Navier's solution; Simply supported rectangular plates under uniform loading and under hydrostatic pressure; Finite difference approach – Bending of laterally loaded thin plates - Differential equation; Simply supported and fixed square and rectangular plates under uniform loading, partial loading, triangular loading and trapezoidal loading; Energy methods - Principle of virtual work, Principle of minimum potential energy; **Anisotropic plates** - Bending of Anisotropic plates - Differential equation of the bent plate; Bending of rectangular plates; Bending of circular and elliptic plates.

Reference Books

1. Timoshenko S. and Kruger S.W. "Theory of plates and Shells," McGraw Hill Education, New York, 2017.
2. Ansel. C. Ugural, "Stresses in Beams, Plates and Shells," Taylor and Francis, 2009.
3. Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.
4. Bairagi N. K., "A text book of Plate Analysis," Khanna Publishers, New Delhi, 1996
5. Chandrashekahara K., "Theory of Plates," University Press (India) Ltd., Hyderabad, 2001.
6. Reddy J.N., "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006.
7. Szilard R., "Theory and Analysis of Plates, Classical and Numerical methods" Prentice Hall, USA, 2009.
8. Szilard R., "Theories and Application of Plate Analysis: Classical, Numerical and Engineering methods" Wiley, USA, 2004
9. Ventsel E. and T. Krauthammer, "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001.

Course Contents and Lecture Schedule

S.No	TOPICS	NO OF PERIODS
1. Thin plate theory		
1.1	Cylindrical bending of long rectangular plates - Differential equation	1
1.1.1	Plates with simply supported edges	2
1.1.2	Plates with built-in edges	2
1.2	Slope and curvature of slightly bent plates	1
1.3	Relation between bending moment and curvature	1
2. Circular plates		
2.1	Symmetrical bending of laterally loaded circular plates – Differential equation	1
2.1.1	circular plates with uniform loading	1
2.1.2	Circular plate with triangular loading	1

2.1.3	Circular plate with circular hole subjected to moment at the inner edge	1
2.1.4	Circular plate with concentrated load	2
2.1.5	Circular plate loaded at the centre	1
2.1.6	Circular plates with moments at the edges	1
3. Classical approach and methods		
3.1	Small deflections of laterally loaded plates – Differential equation	1
3.1.1	Simply supported rectangular plates under sinusoidal loading	1
3.2	**Navier's solution**	
3.2.1	Simply supported rectangular plates under uniform loading	2
3.2.2	Simply supported rectangular plates under hydrostatic pressure	2
3.2.3	Simply supported rectangular plates under concentrated load	2
3.2.4	Simply supported rectangular plates under uniform loading over an area of a rectangle	2
3.3	**Levy's method**	
3.3.1	Simply supported rectangular plates under uniform loading	1
3.3.2	Simply supported rectangular plates under hydrostatic pressure	1
3.4	**Finite difference approach**	
3.4.1	Bending of laterally loaded thin plates – Differential equation	1
3.4.2	Simply supported and fixed square and rectangular plates under uniform loading	1
3.4.3	Simply supported and fixed square and rectangular plates under partial loading	1
3.4.4	Simply supported and fixed square and rectangular plates under triangular loading	1
3.4.5	Simply supported and fixed square and rectangular plates under trapezoidal loading	1
3.5	Energy methods - Principle of virtual work- Principle of minimum potential energy	1
4. Anisotropic plates		

4.1	Bending of Anisotropic plates – Differential equation	1
4.1.1	Bending of rectangular plates	1
4.1.2	Bending of circular and elliptic plates	1
	Total No. of periods	**36**

Course Designers:

Mr. R.Sankaranarayanan, rsciv@tce.edu

21PG250	RESEARCH METHODOLOGY AND IPR

Category	L	T	T	Credit
AC	2	0	0	2

Preamble

The course on the Research Methodology and IPR is offered as common Core course. The objective of this course is to understand and analyze Research Methodology and IPR protection.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	20
Understand	40	40	40
Apply	40	40	40
Analyse	0	0	0
Evaluate	0	0	0
Create	0	0	0

Syllabus

Module 1: Meaning of research problem, Sources of research problem, Criteria, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Module 2: Effective literature studies approaches, analysis Plagiarism, Research ethics

Module 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development.

International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

Reference Books

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’” 2ndEdition,
2. “Research Methodology: A Step by Step Guide forbeginners”
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd,2007.
4. Mayall, “Industrial Design”, McGraw Hill,1992.
5. Niebel, “Product Design”, McGraw Hill,1974.
6. Asimov, “Introduction to Design”, Prentice Hall,1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”,2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

Course Designers:

1. Adapted from AICTE Model Curriculum for Postgraduate Degree Courses in Engineering & Technology, Volume-I, January2018.

		Category	L	T	P	Credit
21SEGA0	**PROJECTMANAGEMENT**	OE	1	1	0	2

Preamble

Complex research and development projects can be managed effectively if the project managers have the means to plan and control the schedules and costs of the work required to achieve their technical performance objectives. When planning of a project is undertaken aspects such as resources needed for its accomplishment, its cost, its duration should be determined. The answers to all these questions can be found by adopting the modern techniques of project management.

Prerequisite

Nil

Course Outcomes:

On successful completion of the course the students will be able to:

(CO 1)	Explain the concept of projects, its process, objectives and functions of project	Understand
(CO 2)	Analyze and Manage time in projects through Gantt charts, CPM and PERT	Apply
(CO 3)	Balance resource requirements of projects so as to avoid idling of resources	Apply
(CO4)	Update projects and determine revised schedule of activities and critical path if	Apply
(CO 5)	Crash projects to determine its optimum time- minimum cost relationships	Apply

Mapping with Programme Outcomes

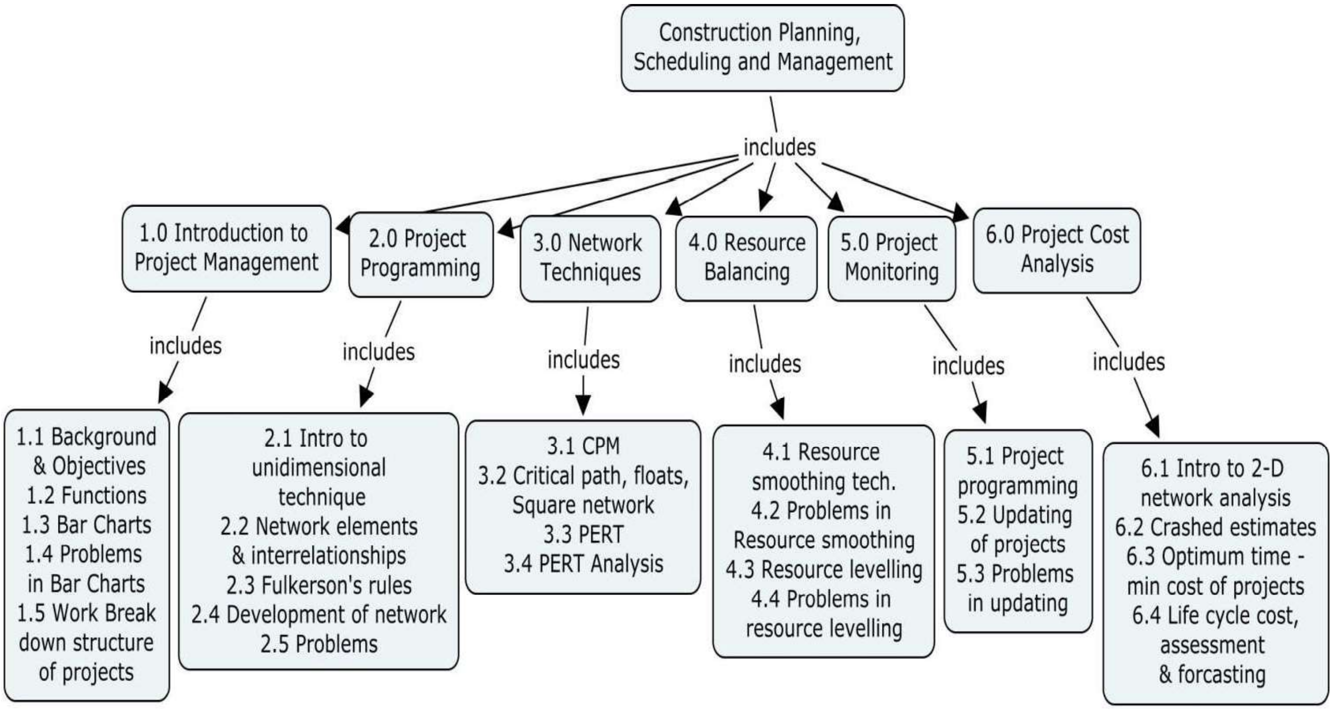
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	---	---	---	---	M	S	S	---	M	---
CO2.	S	S	S	M	M	M	---	---	---	---	---
CO3	S	S	S	M	M	M	---	---	---	---	---
CO4	S	S	S	M	M	M	---	---	---	---	---
CO5	S	S	S	M	M	M	---	---	---	---	---

S- Strong; M-Medium;L-Low

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**Terminal Examination**
	1	**2**	
Remember	20	10	10
Understand	30	40	30
Apply	50	50	60
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Project and its process- Define project and process, boundaries of project, Objectives and functions of Project management, characteristics and types of projects, organization structure / styles, roles of project management group, project management office and its role, project knowledge area, project integration- process group interaction. Project flow, project life cycle- influencing factors. - Case study. **Project Time Management:** Project Scope Management - Work break down structure- Activity/ Task- Events- Case study. Project planning tools- Rolling wave planning. Gantt Charts, Milestone chart, Program Progress chart- Creating milestone plan. Project Network- Fulkerson’s rules – A-O-A and A-O-N networks. Analyze project time- Critical path method (deterministic approach- activity oriented network analysis- 80-20 rule- Case study, type of time estimates & Square network diagram. Project updating and monitoring- Case study. Estimate time- Program Evaluation & Review Technique (Probabilistic Approach)- Event oriented network analysis- Optimistic, Pessimistic and Most likely time, Degree of variability in average time, Probabilistic estimate, % utilization of resources. **Resource Management:** Types of resource- Time, Men, Material, Machinery, Money, Space. Balancing of resource- Resource Smoothing technique- Time constraint. Resource leveling technique- Resource constraint- Case study. **Resource optimization:** Types of cost – Direct, Indirect and Total Cost. Variation of Cost with time. Schedule Compression Techniques- Crashing, Fast Tracking & Re-estimation- Crash time and crash cost. Optimize project cost for time and resource. CPM Cost model. Life cycle assessment- impacts and economical assessment, Life cycle cost- maintenance and operation, life cycle forecasting – concept and applications. **Emerging trends in project management:** Agile Project management and Project Management using latest tools- Case study.

References

1. "A Guide to the Project Management Body of Knowledge (PMBOK Guide) - Fourth Edition, An American National Standard, ANSI/PMI990001-2008"
2. A Risk Management Standard, AIRMIC Publishers, ALARM, IRM:2002
3. Gene Dixon, "Service Learning and Integrated Collaborative Project Management", Project Management Journal, DOI:10.1002/pmi, February 2011,pp.42-58
4. Jerome D. Wiest and Ferdinand K. Levy, "A Management Guide to PERT/CPM", Prentice Hall of India Publishers Ltd., New Delhi,1994.
5. Punmia B. C. and Khandelwal K.K., "Project Planning and Control with PERT/CPM", Laxmi publications, New Delhi,1989.
6. Srinath L.S., "PERT & CPM- Principles and Applications", Affiliated East West Press Pvt., Ltd., New Delhi,2008
7. Sengupta. B and Guha. H, "Construction Management and Planning", Tata McGraw Hill, New Delhi, 1995
8. SangaReddi. S and Meiyappan. PL, "Construction Management", Kumaran Publications, Coimbatore,1999
9. https://nptel.ac.in/courses/105106149/ Project Planning and Control - Prof. Koshy Varghese, IITM,Chennai

Course Contents and LectureSchedule

Module	Topic	No. of Lectures
1.0	**Introduction to Project Management**	
1.1	Define project and process, boundaries of project Introduction to project management concept, background of management, purpose, objectives, Characteristics of projects, Organization structure / styles of project and Functions of management	1
1.2	Roles of project management group, project management office and its role, Project knowledge area, project integration- process group interaction, Project flow, project life cycle- influencing factors, Case study	2
1.3	Traditional management systems – Gantt approach, progress- chart, Bar-chart- Merits and limitations	2
1.4	Problems in Bar-chart	2
1.5	Work study, work break down structure, time estimate	2
	Tutorial	2
2.0	**Project Programming**	
2.1	Introduction to modern management concepts, uni-dimensional management techniques	1
2.2	Introduction to network concepts, network elements and inter-relationships	1
2.3	Network techniques, network logic- inter- relationships activity information, data sheets	1
2.4	Development of network based on Fulkerson's rules	2
2.5	Problems in development of network	2
	Tutorial	2
3.0	**Network Techniques**	
3.1	Critical Path Method (CPM) for management, CPM network	2

3.2	Identification of critical path, floats, square network diagrams-problems	2
3.3	Programme Evaluation and Review Technique (PERT) network-introduction to theory of probability and statistics, probabilistic time estimation for activities	1
3.4	Analysis of PERT network – problems, Delta Charts – concept and applications	1
	Tutorial	2
4.0	**Resource Balancing**	
4.1	Resource balancing- objectives, resource smoothing technique – concept and procedure	1
4.2	Problems using resource smoothing technique	2
4.3	Resource Levelling technique - concept and procedure	2
4.4	Problems using Resource Levelling technique	1
	Tutorial	2
5.0	**Project Control and Monitoring**	
5.1	Project programming, phasing of activities programmes, scheduling project control	1
5.2	Reviewing, updating and monitoring – concept	1
5.3	Problems in updating of projects – determination of revised critical path	2
	Tutorial	2
6.0	**Project Cost**	
6.1	Introduction to two-dimensional network analysis – activity cost information, cost –time relationship	1
6.2	Crashed estimates for the activities, compression potential, cost slope, utility data sheet, project direct and indirect cost	1
6.3	Crashed programmes, network compression, least cost solution, least time solution and optimum time solution-Problems	1
	Tutorial	2
6.4	Life cycle assessment- impacts and economical assessment, Life cycle cost- maintenance and operation, life cycle forecasting – concept and applications, Time value of money. Emerging trends in project management: Project Management using latest tools- Case study	1
	Total Periods	**48**

Course Designers:

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Mr. B.Dinesh Kumar bdk@tce.edu

- **Revised Schedule of courses**
- **Change in category of the course "Analysis and Design of Reinforced Concrete Structures" from Programme Elective to Programme core**
- **Change in category of the course "Finite Element Method" from Programme core to Programme Elective**

M.E DEGREE (Structural Engineering) PROGRAM

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC

YEAR 2023-2024 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(An Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41

Fax: 0452 2483427

Web: www.tce.edu

Approved in 65th Academic Council Meeting on 27.05.2023

Department of Civil Engineering
M.E Structural Engineering programme
Schedule of courses

Semesters	Theory Courses						Theory cum Practical	Laboratory	Project	Credits
	1	2	3	4	5	6	7	8	9	
I	21SE110- Applied Mathematics (3 Credits)	23SE120- Analysis and Design of Concrete Structures (3Credits)	21SE130- Theory of Elasticity and Plasticity (3Credits)	21SE140- Dynamics of Structures (3Credits)	-	-	21SE160- Forensic Engg. and Rehabilitation of structures (3Credits)	21SE171- Structural Engineering Laboratory (2 Credits)	-	17
II	21SEPX0- Programme Elective-I (3 credits)	21SEPX0- Programme Elective-II (3 credits)	21SEPX0- Programme Elective-III (3 credits)		21PG250 Common Core (2 Credits)	21PGPX0 - Open Elective (2Credits)	21SE260 – Experimental Techniques and Instrumentation (3)	21SE270- Dynamics Laboratory (2 Credits)	21SE280 – Mini Project (2 Credits)	20
III	21SEPX0- Programme Elective-IV (3 credits)	21SEPX0- Programme Elective-V (3 credits)	-	-	-	-	-	-	21SE380- Dissertation Phase-I (10 Credits)	16
IV	-	-	-	-	-	-	-	-	21SE480- Dissertation Phase-II (15)	15
Total credits for curriculum										**68**

A student has to complete 2 audit courses of 24 hours duration. The courses will normally be conducted on weekends.

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Structural Engineering) Program

COURSES OF STUDY
(For the candidates admitted from 2020-21 onwards)

FIRST SEMESTER

Course code	Name of the Course	Category **	No. of Hours			Credits
			L	T	P	
THEORY						
21SE110	Applied Mathematics	FC	2	1	-	3
23SE120	Analysis and Design of Concrete Structures	PC	2	1	-	3
21SE130	Theory of Elasticity and Plasticity	PC	3	-	-	3
21SE140	Dynamics of Structures	PC	3	-	-	3
21SE160	Forensic Engg. And Rehabilitation of Structures	PC	2	-	2	3
PRACTICAL						
21SE171	Structural Engineering Laboratory	PC	-	-	4	2
Total			**12**	**2**	**6**	**17**

SECOND SEMESTER

Course code	Name of the Course	Category **	No. of Hours			credits
			L	T	P	
THEORY						
21SEPX0	Programme Elective-I	PE	2	1	-	3
21SEPX0	Programme Elective-II	PE	3	-	-	3
21SEPX0	Programme Elective – III	PE	3	-	-	3
21PG250	Common Core	PC	2	-	-	2
21PGPX0	Open Elective	PE	2	-		2
21SE260	Experimental Techniques and Instrumentation	PC	2	-	2	3
PRACTICAL						
21SE270	Dynamics Laboratory	PC	-	-	4	2
21SE280	Mini Project	PC	-	-	4	2
Total			**15**	**1**	**10**	**20**

THIRD SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
THEORY						
21SEPX	Programme Elective –	PE	3	-	-	3
21SEPX	Programme Elective –	PE	3	-	-	3
PRACTICAL						
21SE380	Dissertation Phase-I	PC	-	-	20	10
Total			**5**	**-**	**20**	**16**

FOURTH SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
21SE480	Dissertation Phase-II	PC	-	-	30	15
Total			**-**	**-**	**30**	**15**

*** BS- Basic Sciences; HSS-Humanities and Social Sciences; ES-Engineering Sciences; FC- Foundation Core; PC- Programme Core; PE-Programme Elective; GE-General Elective; OC-One Credit Course; TC- Two Credit Course; SS-Self-Study Course (in the list of Programme Electives)*

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit 2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Structural Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2023-24 onwards)

FIRST SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SE110	Applied Mathematic	3	40	60	100	27	50
2	23SE120	Analysis and Design of Concrete Structures	3	40	60	100	27	50
3	21SE130	Theory of Elasticity and Plasticity	3	40	60	100	27	50
4	21SE140	Dynamics of Structures	3	40	60	100	27	50
5	21SE160	Forensic Engg. and Rehabilitation of structures	3	50	50	100	22.5	50
PRACTICAL								
7	21SE171	Structural Engineering Laboratory	3	60	40	100	18	50

SECOND SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SEPX0	Programme Elective-I	3	40	60	100	27	50
2	21SEPX0	Programme Elective-II	3	40	60	100	27	50

3	21SEPX0	Programme Elective –	3	40	60	100	27	50
4	21SEPX0	Programme Elective –	3	40	60	100	27	50
5	21PG250	Common Core	3	40	60	100	27	50
6	21PGPX0	Open Elective	3	40	60	100	27	50
7	21SE260	Experimental Techniques and Instrumentation	3	50	50	100	22.5	50
PRACTICAL								
8	21SE270	Dynamics Laborator	3	3	6	40	100	18
9	21SE280	Mini Project	-	40	60	100	27	50

THIRD SEMESTER

S. No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	21SEPX0	Programme Elective – V	3	40	60	100	27	50
PRACTICAL								
2	21SE380	Dissertation Phase-I	-	40	60	100	27	50

FOURTH SEMESTER

S. No.	Sub Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	21SE480	Dissertation Phase-II	-	40	60	100	27	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

LIST OF ELECTIVES

Sl. No	Subject Code	Course Name
1	23SEPA0	Finite Element Method
2	21SEPB0	Aseismic Design of Structures
3	21SEPC0	Bridge Engineering
4	21SEPD0	Blast Resistant Design of structures
5	21SEPE0	Computational methods in Structural Analysis
6	21SEPF0	Computer Aided Design
7	21SEPG0	Creep and Fatigue behaviour of Materials
8	21SEPH0	Design of Foundation and Substructure
9	21SEPK0	Design of Steel Concrete Composite Structures
10	21SEPL0	Fracture mechanics
11	21SEPM0	Industrial Structures
12	21SEPN0	Prestressed Concrete
13	21SEPQ1	Structural Steel Design
14	21SEPR0	Structural Mechanics
15	21SEPS0	Theory of plates

LIST OF OPEN ELECTIVES

Sl. No	Course Name
1	Business Analytics
2	Industrial Safety
3	Operations Research
4	Cost Management of Engineering Projects
5	Composite Materials
6	Waste to Energy

LIST OF AUDIT COURSE 1 & 2

A student has to complete 2 Audit courses of 24 hours duration. The courses will normally be conducted on weekends.

Sl. No	Course Name
1	English for Research Paper Writing
2	Disaster Management
3	Sanskrit for Technical Knowledge
4	Value Education
5	Constitution of India
6	Pedagogy Studies
7	Stress Management by Yoga
8	Personality Development through Life Enlightenment Skills
9	Value Engineering

23SE120	ANALYSIS AND DESIGN OF CONCRETE STRUCTURES	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

The design of modern reinforced concrete structures may appear to be highly complex. However, most of these structures are the assembly of several basic structural elements such as beams, columns, slabs, walls and foundations. Accordingly, the designer has to learn the design of these basic reinforced concrete elements. The joints and connections are then carefully developed. The aim of this course is to keep students up to date with various advanced mechanics and theories on reinforced concrete structures and to develop their skills to conduct analysis and practical design of real-life RC structures.

Prerequisites

Applied Mathematics, Structural Mechanics

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Make the students be familiar with the limit state design of RCC bems and columns	Apply	85	A
CO2	Identify and apply the relevant codal provisions to design the RC special elements such as slender columns, grid floors, concrete walls, spandrel beams, deep beams, corbels and pile cap	Apply	75	B
CO3	Study the crack pattern of slabs using yield line theory and design them based on their analysis and design the flat slab according to IS method	Apply	75	B
CO4	Explain the inelastic behavior of concrete elements and design the frames using moment rotation characteristics	Apply	75	B
CO5	Make the students be familiar with the detailing of beams, columns and its joints against ductility	Apply	75	B

Mapping with Programme Outcomes

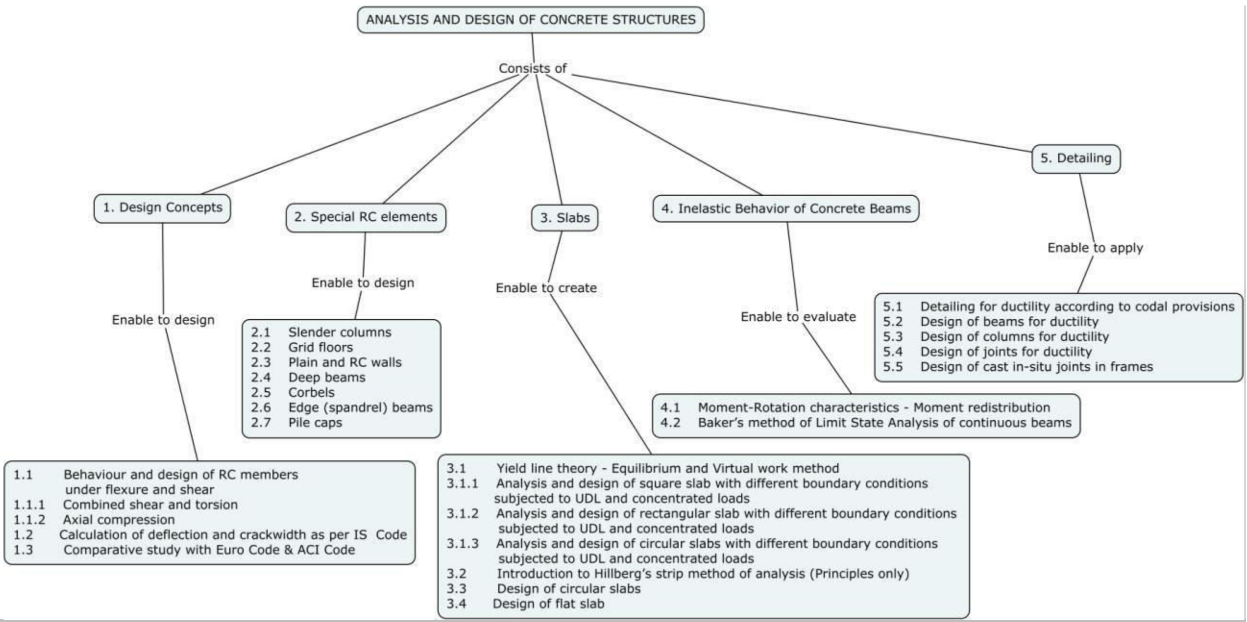
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	S	S	S	M	-	S	-	-	S	S	M	M
CO2.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO3.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO4.	S	S	S	S	M	-	S	-	-	S	S	S	M
CO5.	S	S	S	S	M	-	S	-	-	S	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Design concepts - review of basic concepts, behaviour and design of RC members under flexure, shear, combined shear and torsion, axial compression and calculation of deflection and crackwidth as per IS Code, comparative study with EuroCode and ACI Code;**Special RC elements**- design of slender columns, grid floors, plain & reinforced concrete walls, edge (spandrel) beams, concept of strut and tie method, deep beams,corbels,pile caps;**Slabs** - yield line theory of slabs, virtual work method and equilibrium method, introduction to Hillberg's strip method of analysis (principles only), design of circular and flat slabs;**Inelastic behavior of concrete beams -** moment-rotation characteristics, moment redistribution, Baker's method of limit state analysis of continuous beam;**Ductile Detailing –**concept of ductiltity, design of beams columns and joints for ductility, design of cast in-situ joints in frames, detailing for ductility.

Reference Books

1. Dr.N. Subramanian, Design of Reinforced Concrete Structures, Oxford Publishers, 2013
2. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, Mc Graw Hill Education, New Delhi, 2017.
3. Arthur H.Nilson, George Winter, Design of Concrete Structures, 11th Edition, McGraw Hill Book Co., New York, 2009.
4. P. Bhatt, T.J. MacGinley, B.S. Choo, Ban Seng Choo and Thomas J. MacGinley, Reinforced Concrete; Design theory and examples, Routledge Publisher, 2006.
5. Edward G. Nawy, Reinforced Concrete – A fundamental Approach, 6th Edition, Prentice Hall, 2008.
6. Prab Bhatt, T.J. MacGinley, Ban SengChoo, Reinforced Concrete Design to Eurocodes: Design Theory and Examples, Fourth Edition, CRC Press, 2014

List of national and international standards

1. IS 456:2000 Plain and Reinforced Concrete – Code of Practice.
2. IS 875 (1-5):1987 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.
3. SP 16:1980 Design Aids for Reinforced Concrete to IS 456:1978.
4. SP 34:1987 Handbook of concrete reinforcement and detailing.
5. IS 13920:1993 Ductile detailing of Reinforce Concrete Structures subjected to Seismic forces-Code of Practice.
6. ACI224R – 80 Control of cracking in concrete structures ACI Committee 224, Concrete International, 1980
7. EN1992 – Eurocode 2 (EC2) – European standards for design of concrete structures.
8. ACI318-08 Building Code Requirements for Structural Concrete & Commentary

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Design Concepts		
1.1	Behaviour and design of RC members under flexure and shear	2
1.1.1	Combined shear and torsion	1
1.1.2	Axial compression	1
1.2	Calculation of deflection and crackwidth as per IS Code	1
1.3	Comparative study with Euro Code & ACI Code	1
2. Special RC elements		
2.1	Slender columns	2
2.2	Grid floors	1
2.3	Plain and RC walls	1
2.4	Deep beams	2

2.5	Corbels	2
2.6	Edge (spandrel) beams	1
2.7	Pile caps	1
3. Slabs		
3.1	Yield line theory - Equilibrium and Virtual work method	2
3.1.1	Analysis and design of square slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.2	Analysis and design of rectangular slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.3	Analysis and design of circular slabs with different boundary conditions subjected to UDL and concentrated loads	2
3.2	Introduction to Hillberg's strip method of analysis (Principles only)	1
3.3	Design of circular slabs	1
3.4	Design of flat slab	1
4. Inelastic Behavior of Concrete Beams		
4.1	Moment-Rotation characteristics - Moment redistribution	1
4.2	Baker's method of Limit State Analysis of continuous beams	1
5. Detailing		
5.1	Detailing for ductility according to codal provisions	1
5.2	Design of beams for ductility	1
5.3	Design of columns for ductility	1
5.4	Design of joints for ductility	2
5.5	Design of cast in-situ joints in frames	2
	Total Hours	36

Course Designers:

R.Sankaranarayanan, rsciv@tce.edu

23SEPA0	FINITE ELEMENT METHOD	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

This course provides an introduction to the finite element analysis, from engineering rather than a purely mathematical point of view.

Prerequisite

Fundamentals of Mathematics, knowledge of forces and resolution and equilibrium concepts.

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's level	Expected attainment level (%)	Expected proficiency (grade)
CO1	Illustrate the relation between stress and strain	Apply	80	A
CO2	Compute weighted integral and weak formulation	Apply	80	A
CO3	Calculate the nodal displacement, stresses and reaction forces in ID bar and plane truss element	Apply	80	A
CO4	Calculate the nodal displacement, stresses and reaction forces in 2D element	Apply	80	A
CO5	Outline different meshing techniques and use of finite element Software	Apply	80	A

Mapping with Programme Outcomes

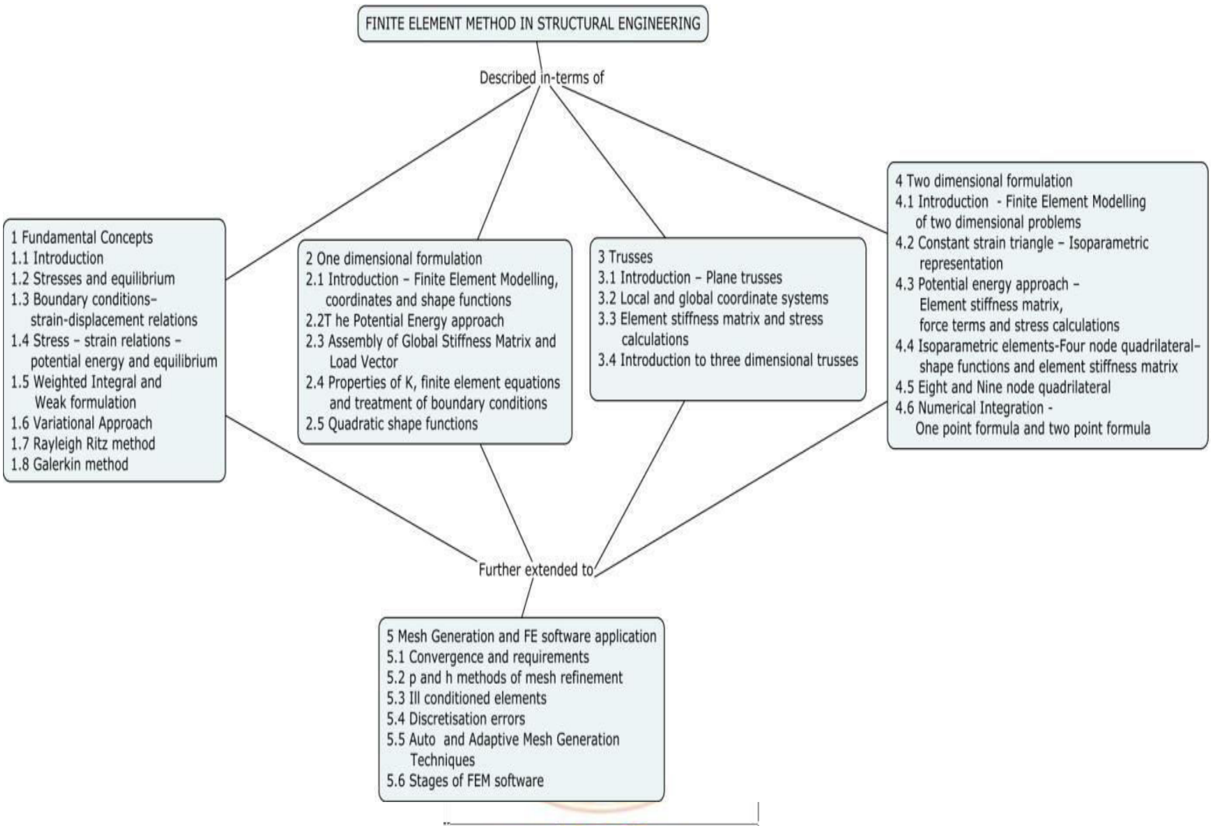
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO2.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO3.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO4.	S	M	M	M	M	L	-	M	M	L	L	M	L
CO5.	S	M	M	M	M	L	-	M	M	L	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	10	10	10
Apply	80	80	80
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Concept Map



Syllabus

Fundamental Concepts: Stresses and equilibrium – Boundary conditions – strain-displacement relations – stress-strain relations – potential energy and equilibrium – weighted integral and weak formulation – variational approach – Rayleigh Ritz method – Galerkin method**. One dimensional formulation:** Finite element modelling – coordinates and shapes functions – Assembly of global stiffness matrix and global load vector – properties of K – finite element equations – treatment of boundary conditions – quadratic shape functions – temperature effects. **Trusses:** Plane trusses – local –global transformation - stiffness matrix – stress calculations**. Two dimensional formulation:** Finite element modelling – constant strain triangle – problem modelling and boundary conditions - stress calculations – Isoparametric elements – four node quadrilateral and nine node quadrilateral elements- Numerical Integration-One point formula and two point formula – two dimensional integrals. **Mesh Generation and FE software application:** Convergence - Requirements for convergence – p and h methods of mesh refinement – ill conditioned elements – Discretisation errors – Auto and Adaptive Mesh Generation – Error evaluation – stages of FEM software.

Reference Book

1. Reddy, J.N, “An Introduction to the finite element method”, McGraw Hill International Edition, New York, 3rd edition 2008.
2. Tirupathi R. Chandrupatla, Ashok D. Belegundu, “Introduction to finite elements in engineering”, Prentice Hall of India, New Delhi, 2007.

3. Krishnamoorthy,C.S, “Finite Element Analysis Theory and Programming”, Tata McGraw Hill Publishing Co.Ltd. New Delhi 2004.
4. Moaveni,S., Finite Element Analysis : Theory and Application with ANSYS, Prentice Hall Inc., 1999.
5. Zienkiewicz, O.C, and Taylor, R.L., The Finite Elements Methods , Mc Graw Hill , 6th edition 1987.

Course Contents and Lecture Schedule

S.NO	TOPICS	NO. OF LECTURES
1	**Fundamental Concepts**	
1.1	Introduction	1
1.2	Stresses and equilibrium	1
1.3	Boundary conditions – strain-displacement relations	1
1.4	Stress – strain relations – potential energy and equilibrium	1
1.5	Weighted Integral and Weak formulation	1
1.6	Variational Approach	1
1.7	Rayleigh Ritz method	1
1.8	Galerkin method	1
2	**One dimensional formulation**	
2.1	Introduction – Finite Element Modelling, coordinates and shape functions	1
2.2	The Potential Energy approach	1
2.3	Assembly of Global Stiffness Matrix and Load Vector	1
2.4	Properties of K, finite element equations and treatment of boundary conditions	2
2.5	Quadratic shape functions	2
3	**Trusses**	
3.1	Introduction – Plane trusses	1
3.2	Local and global coordinate systems	1
3.3	Element stiffness matrix and stress calculations	1
3.4	Introduction to three dimensional trusses	1
4	**Two dimensional formulation**	
4.1	Introduction - Finite Element Modelling of two dimensional problems	1
4.2	Constant strain triangle – Isoparametric representation	2
4.3	Potential energy approach – Element stiffness matrix, force terms and stress calculations	2
4.4	Isoparametric elements - Four node quadrilateral – shape functions and element stiffness matrix	1
4.5	Eight and Nine node quadrilateral	2
4.6	Numerical Integration - One point formula and two point formula	1
5	**Mesh Generation and FE software application**	
5.1	Convergence and requirements	1
5.2	p and h methods of mesh refinement	2
5.3	Ill conditioned elements	1
5.4	Discretisation errors	2

5.5	Auto and Adaptive Mesh Generation Techniques	1
5.6	Stages of FEM software	1
	Total Hours	**36**

Course Designers:

Dr.S.Nagan nagan_civil@tce.edu
R.Indrajith Krishnan jith@tce.edu

- **Syllabus for M.E Structural Engineering Practical Course 23SE270 – Non Destructive Testing and Dynamics Laboratory**

For the Students admitted from the academic year 2023-2024 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 66rd Academic Council Meeting held on 16.12.2023

23SE270	**NON DESTRUCTIVE TESTING AND DYNAMICS LABORATORY**

Category	L	T	P	Credit
PC	0	0	4	2

Preamble

The objective of this laboratory course is to impart knowledge on Non-destructive testing and dynamics study of systems. Developing a practical skill for inspection and evaluation of various structural components using different NDT methods in accordance with IS codal provisions. Dynamics study of a single and Multi-Degree freedom system subject to hormonic, periodic excitation were dealt in this course. Students will also be introduced to virtual dynamics lab.

Prerequisite

Knowledge in Basic physics, Construction materials and technology, Dynamics of structure, structural analysis

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Design the concrete mix proportion using IS codal provisions	Apply	75	B
CO2	Test the properties of concrete using non-destructive approaches.	Apply	75	B
CO3	Learn the effects of systems subjected to vibration.	Apply	75	B
CO4	Demonstrate the phenomenon of vibration of Multi-degree-of-freedom (dof) systems under harmonic including the occurrence of resonances in the system	Apply	75	B
CO5	Conduct the vibration study of multi- degree-of-freedom (dof) systems under periodic motion including the occurrence of resonances in the system	Apply	75	B
CO6	Differentiate the dynamics behaviour of a three storied building model with and without an open ground floor	Apply	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1	PSO	PSO
CO1	S	M	L	-	-	L	-	L	M	-	L	M	L
CO2	S	M	L	-	-	L	-	L	M	-	L	M	L
CO3	S	M	L	-	-	L	-	L	M	-	L	M	L
CO4	S	M	L	-	-	L	-	L	M	-	L	M	L
CO5	S	M	L	-	-	L	-	L	M	-	L	M	L
CO6	S	M	L	-	-	L	-	L	M	-	L	M	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Mix design of high strength concrete as per IS method, use of admixture/plasticizer.
2. Determination of Flow Characteristics/workability of concrete
3. Nondestructive evaluation of concrete specimen- Ultrasonic pulse velocity, Rebound hammer test.
4. Testing the strength of concrete subjected to time dependent loading and compare the non-destructive and Destructive approach.
5. Field study – Evaluating the internal flaws and properties of concrete in structural members using NDT methods.
6. Field study – Evaluating the corrosion of reinforcement in structural members using corrosion resistivity meter and Rapid chloride penetration test (RCPT).
7. Dynamics of SDOF and three storied building frame subjected to harmonic base vibration.
8. Dynamics of a SDOF and three storied building frame subjected to non-harmonic vibration.
9. Dynamics of a three storied building frame subjected to periodic (non-harmonic) base motion.
10. Free and Forced vibration using FFT analyzer
11. Virtual lab- Single degree of freedom system by vibrating with initial excitation (i.e, initial displacement and/or initial velocity and with or without damping)
12. Virtual lab- Determination of natural frequencies and natural mode shapes of multi degree of freedom system and also the response of each floor to a given ground motion.

Course Designers:

Dr.D.Rajkumar rajkumarcivil@tce.edu
Mr.R.Sankaranarayanan rsciv@tce.edu

- **Revised syllabus for M.E Structural Engineering Practical Course**

21SE172 – Structural Engineering Laboratory

For the Students admitted from the academic year 2024-25 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

67th Academic Council Meeting held on 25.05.2024

21SE172	STRUCTURAL ENGINEERING LABORATORY

Category	L	T	P	Credit
PC	0	0	4	2

Preamble

The objective of this laboratory course is to impart knowledge on various construction material selection through testing based on specifications. Developing a practical skill for inspection and evaluation of various structural components using both destructive and Nondestructive testing methods in accordance with IS codal provisions.

Prerequisite

Knowledge in Basic physics, Construction materials and technology, structural analysis

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Design the concrete mix proportion using IS codal provisions	Apply	75	B
CO2	Test the fresh and hardened properties of concrete	Apply	75	B
CO3	Perform the corrosion test in RCC members.	Apply	75	B
CO4	Conduct the test on RCC beam under static load	Apply	75	B
CO5	Conduct the test on RCC column with concentric and eccentric loading.	Apply	75	B
CO6	Design steel elements and trusses Create	Apply	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1	PSO	PSO
CO1	S	M	L	-	-	L	-	L	M	-	L	M	L
CO2	S	M	L	-	-	L	-	L	M	-	L	M	L
CO3	S	M	L	-	-	L	-	L	M	-	L	M	L
CO4	S	M	L	-	-	L	-	L	M	-	L	M	L
CO5	S	M	L	-	-	L	-	L	M	-	L	M	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Mix design of high strength concrete as per IS method.
2. Effect of minerals and chemical admixtures in concrete at fresh and hardened state with relevance to workability, strength and durability
3. Determination of Flow Characteristics/workability of self-compacting concrete
4. Nondestructive evaluation of concrete - Ultrasonic pulse velocity, Rebound hammer test.
5. Evaluating the internal flaws and properties of concrete in existing structural members using NDT methods.
6. Permeability test on hardened concrete using Rapid chloride penetration test (RCPT).
7. Carbonation Test on concrete cubes and cylinders.
8. Evaluating the corrosion of reinforcement in structural members using corrosion meter.
9. Fabrication, casting and testing of reinforced concrete beam subjected to static load.
10. Fabrication, casting and testing of reinforced concrete column subjected to concentric and eccentric loading
11. Design of elemental steel members using software and validating the results with manual calculations using Excell spread sheet.
12. Design of small to medium span trusses using software and detailing the members and joints.

Course Designers:

Dr. D. Rajkumar	rajkumarcivil@tce.edu
Mr. R. Sankaranarayanan	rsciv@tce.edu

M.E DEGREE (Structural Engineering) PROGRAMME

- **21SEPB1 – ASEISMIC DESIGN OF STRUCTURES**

For the Students admitted from the academic year 2024-2025 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 68th Academic Council Meeting held on 21.12.2024

21SEPB1	ASEISMIC DESIGN OF STRUCTURES

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

This course offers design of structures subjected seismic forces.

Prerequisite

Knowledge in Basic physics, Dynamics of structure, Structural analysis

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency	Expected Attainment level (%)
CO1	Understand the fundamentals of earthquake engineering and assess their impact on structural design.	TPS2	B	75
CO2	Apply the Seismic Hazard Analysis to evaluate seismic hazard Parameters	TPS3	B	75
CO3	Apply the Indian codal provisions to analyze the RC structures.	TPS3	B	75
CO4	Apply the Indian codal provisions to design a shear wall and masonry structures	TPS3	B	75
CO5	Analyze seismic design techniques to evaluate performance.	TPS3	B	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	M	L	-	-	-	L	-	L	M	-	L	M	L
CO2.	S	M	L	-	-	L	-	L	M	-	L	M	L
CO3	S	M	L	-	-	L	-	L	M	-	L	M	L
CO4	S	M	L	-	-	L	-	L	M	-	L	M	L
CO5	S	M	L	-	-	L	-	L	M	-	L	M	L

S- Strong; M-Medium; L-Low

Syllabus

Engineering Seismology – rebound theory- plate tectonics - Seismic design concepts EQ load on simple buildings – load path floor and roof diaphragms – seismic resistant building architecture – plan configuration – vertical configuration – pounding effects – mass and stiffness irregularities – torsion in structural system.

Seismic Hazard analysis- Deterministic Seismic hazard Analysis (DSHA) - PSHA -completeness Analysis – Seismic Hazard curves- Uniform Hazard Response Spectrum (UHRS). lessons learnt in past Earth Quakes **Design of RC structures** IS codal provisions on Earthquake resistant design (IS1893, IS 13920) - Seismic coefficient and Response spectrum method - Ductile Detailing – Building systems – frames – braced frames- layout design of Moment Resisting Frames (MRF) – Design of shear wall- Design of Masonry structures.

Cyclic loading behaviour of RCC and Steel elements (Damage Models) – **Seismic Design techniques**- base isolation – Energy dissipating devices – case studies. **Performance Based Seismic Design** - Seismic performance evaluation of structural and non-structural components and systems.

Reference Books:

1. Anil.K.Chopra,"Dynamics of Structures" (Theory and Applications to Earthquake Engineering), Prentice Hall of India Private Limited, 2nd Edition, New Delhi, 2003.
2, Pankaj Agarwal and Manish ShriKhande, Earthquake Resistant Design of Structures, Prentice- Hall of India, New Delhi, 2007.
3. Bullen K. E., Introduction to the Theory of Seismology, Great Britain at the University Printing houses, Cambridge University Press, 1996.
4. S K Duggal, "Earthquake Resistant Design of Structures", Oxford University Press, 2007.
5. Paulay, T and Priestly, M. N. J., "A Seismic Design of Reinforced Concrete and Masonry buildings", John Wiley and Sons, 1991.
6. Srinivasan Chandrasekaran, Luciano Nunzinate, Giorgio Seriino, Federico Caranannate, Seismic Design Aids for Nonlinear analysis of Reinforced Concrete Structures, CRC Press, Florida (USA), 2009.
7. NPTEL: Introduction to Earthquake Engineering https://archive.nptel.ac.in/courses/105/101/105101004/
8. NPTEL: Seismic Analysis of Structureshttps://archive.nptel.ac.in/courses/105/102/105102016/

List of national and international standard Codes :

1. IS:1893 - (Part I), Criteria for Earthquake Resistant structures-General Provisions and Buildings
2. IS:13935 – Repair and Seismic strengthening of buildings
3. IS:4326 - Earthquake Resistant Design and Constructions of buildings
4. IS: 13828 - Improving Earthquake Resistance of Low strength Masonry buildings.
6. IS: 13920 – Ductile detailing of RC Structures subject to Seismic forces.

Course Contents and Lecture schedule:

Module No.	Topic	No. of Lectures
1.1	Introduction- Engineering Seismology	1
1.2	Rebound theory, plate tectonics	1
1.3	Seismic design concepts	1
1.4	EQ load on simple buildings	2
1.5	EQ load on non-symmetrical buildings	1
1.6	Seismic resistant building architecture, plan configuration, vertical configuration	2
1.7	Pounding effects	1
1.8	Mass and stiffness irregularities, Torsion in structural system	1
2. Seismic Hazard analysis-		
2.1	Deterministic Seismic hazard Analysis (DSHA)	1
2.2	PSHA – Seismic Hazard curves	2
2.3	Seismic Hazard curves- Uniform Hazard Response Spectrum (UHRS).	1
2.4	Lessons learnt in past Earth Quakes	1
3. Design of RC structures		
3.1	IS codal provisions on Earthquake resistant design (IS1893, IS 13920)	2
3.2	Seismic coefficient and Response spectrum method	3
3.3	Ductile Detailing, Building systems, braced frames	2
3.4	Design of shear wall	2
3.5	Layout design of Moment Resisting Frames (MRF)	1
3.6	Design of Masonry structures.	2
3.7	Cyclic loading behaviour of RCC and Steel elements.	2
3.8	Different types of Damage Models	1
4.Seismic Design techniques		

4.1	Base isolation -Types of bearings, forces on bearings, Design of steel rocker bearing - Design of roller bearing	2
4.2	Energy dissipating devices – case studies	2
4.3	Performance Based Seismic Design- Seismic performance evaluation of structural and non-structural components and systems.	2
	Total periods	**36**

Course Designers:

Dr.D.Rajkumar rajkumarcivil@tce.edu

M.E DEGREE (Structural Engineering) PROGRAMME

- **24SE270 - STRUCTURAL ENGINEERING DESIGN STUDIO**

For the Students admitted from the academic year 2024-2025 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 68th Academic Council Meeting held on 21.12.2024

24SE270	STRUCTURAL ENGINEERING DESIGN STUDIO

Category	L	T	P	Credit
PC	0	0	4	2

Preamble

To design a structure using modern software tools available like STAAD etc. and present it in the form of a complete detailed drawing. Students have to work individually with standard codes, computational tools and software packages for analyzing, designing and detailing a structure. A detailed report on the work done shall be submitted by individual students in the form of a report and presentation.

Dynamics study of a single and Multi-Degree freedom system subject to hormonic, periodic excitation were dealt in this course. Students will also be introduced to virtual dynamics lab.

Prerequisite

Knowledge in concrete technology, Basic RC and steel design theory and design
Knowledge in Basic physics, C, Dynamics of structure, structural analysis

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency	Expected Attainment level (%)
CO1	Analyze the structure for various loads and load combinations according to the relevant IS codes	TPS3	B	75
CO2	Design and detail structures using computer software/tools and check the correctness using manual approximate methods	TPS3	B	75
CO3	Design steel elements and trusses using computer software/tools	TPS3	B	75
CO4	Demonstrate the phenomenon of vibration of Multi- degree-of-freedom (dof) systems under harmonic including the occurrence of resonances in the system	TPS3	B	75
CO5	Conduct the vibration study of multi- degree-of- freedom (dof) systems under periodic motion including the occurrence of resonances in the system	TPS3	B	75

CO6	Differentiate the dynamics behaviour of a three storied building model with and without an open ground floor	TPS3	75	B

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	S	M	L	-	-	L	-	L	M	-	L	M	L
CO2.	S	M	L	-	-	L	-	L	M	-	L	M	L
CO3	S	M	L	-	-	L	-	L	M	-	L	M	L
CO4	S	M	L	-	-	L	-	L	M	-	L	M	L
CO5	S	M	L	-	-	L	-	L	M	-	L	M	L
CO6	S	M	L	-	-	L	-	L	M	-	L	M	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Design of RC elements using software and validating the software results with manual calculations using Excel spread sheet.
2. Design single storied RC framed structure using software and detailing the rebars.
3. Design multistoried RC framed structure using software and detailing the rebars.
4. Analysis of multistoried RC framed structure under seismic forces.
5. Design of elemental steel members using software and validating the results with manual calculations using Excel spread sheet.
6. Design a small to medium span trusses using software and details the members and joints.
7. Dynamics of SDOF and three storied building frame subjected to harmonic base vibration.
8. Dynamics of a SDOF and three storied building frame subjected to non-harmonic vibration.
9. Dynamics of a three storied building frame subjected to periodic (non-harmonic) base motion.
10. Free and Forced vibration using FFT analyzer
11. Virtual lab- Single degree of freedom system by vibrating with initial excitation (i.e, initial displacement and/or initial velocity and with or without damping)
12. Virtual lab- Determination of natural frequencies and natural mode shapes of multi degree of freedom system and also the response of each floor to a given ground motion.

Course Designers:

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M.E DEGREE (Structural Engineering) PROGRAMME

- ***21SEGB1 - Finance for Engineers (General Elective Course)***

For the Students admitted from the academic year 2025-2026 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in 69th Academic council meeting held on 28.06.2025

21SEGB1	FINANCE FOR ENGINEERS

Category	L	T	P	Credit
CEG	2	0	0	2

Preamble

This course work is designed to bridge the gap between engineering expertise and financial literacy. It introduces key financial principles and equips engineering students with the tools necessary to analyze capital investments, perform cost analysis, evaluate project feasibility, and make informed economic decisions in both corporate and entrepreneurial settings.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Apply financial concepts relevant to engineering decisions	Apply	70	A
CO2	Integrate financial concepts with engineering project management to improve overall project performance and economic viability.	Apply	70	A
CO3	Develop Organizational and personal financial plans that align with financial goals	Apply	70	A
CO4	Demonstrate the awareness of the ethical, environmental, and sustainability considerations in financial decision-making within engineering contexts	Apply	70	A

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2
CO1	S	M	L	-	-	L	S	L	M	L	M	-	-
CO2	S	M	L	-	-	L	S	L	M	L	M	-	-
CO3	S	M	L	-	L	M	S	L	M	L	M	-	-
CO4	S	M	L	-	L	M	S	L	M	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Terminal						Assignment 1						Assignment 2					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	20	20	-	-	-	-	-	-	-	-	-	5	10	-	-	-	-	-	-	50		-	-	-	-	-	-	-	-

CO2	10	20	20	-	-	-	-	-	-	-	-	-	5	10	15	-	-	-	-	-	50		-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	10	20	20	5	10	15	-	-	-	-	-	-		-	-	-	-	50	-	-	-
CO4	-	-	-	-	-	-		-	-	10	20	20	5	10	10	-	-	-	-	-	-	-	-	-	-		50	-	-	-

Syllabus

Fundamentals of Financial Engineering :Role of finance in Engineering, Accounting and systems of accounting, Time value of money-present and future value, Annuities and sinking funds Depreciation ,Inflation and Taxes **Capital budgeting and Project evaluation:** Project selection and Appraisal, Capital budgeting-Nature and process, Capital budgeting Techniques-NPV,IRR,PI,ARR&BCR, Cost concepts and control, Risks in engineering projects, Techniques of risk analysis **Financial management:** Goals of financial management, Sources of Finance & Working capital management, Financial planning - setting personal financial goals, Financial ratios in personal finance, Investment avenues, Insurance and Risk management **Financial Decision:** Value analysis& Value engineering, Behavioural finance, Risk and Return, Economical Decision making –Lifecycle cost Analysis, CSR & ESG (Environmental, Social, Governance) factors, Recent developments in Financial Management.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures	CO
1.	**Fundamentals of Financial Engineering**		
1.1	Role of finance in Engineering	1	CO1
1.2	Accounting and systems of accounting	1	CO1
1.3	Time value of money-present and future value	1	CO1
1.4	Annuities and sinking funds	1	CO1
1.5	Depreciation ,Inflation and Taxes	2	CO1
	Capital budgeting and Project evaluation		
2.1	Project selection and Appraisal	1	CO2
2.2	Capital budgeting-Nature and process	1	CO2
2.3	Capital budgeting Techniques-NPV,IRR,PI,&BCR	1	CO2
2.4	Cost concepts and control	1	CO2
2.5	Risks in engineering projects	1	CO2
2.6	Techniques of risk analysis	1	CO2
3.	**Financial management**		
3.1	Goals of financial management	1	CO3
3.2	Sources of Finance & Working capital management	1	CO3
3.3	Financial planning -setting personal financial goals	1	CO3
3.4	Financial ratios in personal finance	1	CO3
3.5	Investment avenues	1	CO3
3.6	Insurance and Risk management	1	CO3
4	**Financial Decision**		
4.1	Value analysis& Value engineering	1	CO4
4.2	Behavioural finance	1	CO4
4.3	Risk and Return	1	CO4

4.4	Economical Decision making –Lifecycle cost Analysis.	1	CO4
4.5	CSR & ESG (Environmental, Social, Governance) factors	1	CO4
4.6	Recent developments in Financial Management	1	CO4
	TOTAL	**24**	

Reference Books

1. Theusen G.J., Fabrycky W.J., Engineering Economy, 9th Edition, Prentice-Hall, Inc., New Delhi, India,2001.

2. Engineering Economics by R. Panneerselvam, 1st Edition PHI Learning Private Limited, New Delhi. (ISBN-978-81-203-1743-7)

3 Crundwell F.K., Finance for Engineers-Evaluation and Funding of Capital Projects, Springer, London, UK, 2008. (ISBN 978-1-84800-032-2).

Course Designers:

1. Dr. V. Ravi Sankar environmentengr@tce.edu

2. Mr.B.Dinesh Kumar bdkciv@tce.edu

M.E DEGREE (Structural Engineering) PROGRAMME

- ***21SE290 - Finite Element Analysis of Structures (Theory Cum Practical Course)***
  [This course is offered instead of the theory cum practical course 21CE260 - Experimental Techniques and Instrumentation]
- ***21SEGC0 - Engineering Safety and Management (Open Elective Course)***

For the Students admitted from the academic year 2025-2026 onwards

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015

Approved in the 70th Academic Council Meeting held on 13.12.2025

21SE290	FINITE ELEMENT ANALYSIS OF STRUCTURES

Category	L	T	P	Credit
PC	2	0	2	3

Preamble

This course provides the basic concepts of finite element method and its applications to wide range of engineering problems. This course deals with various modelling techniques and uses different numerical methods for solving a system of governing equations over the domain of a continuous physical system (such as structural problem, thermal problem, fluid mechanics problem), which is discredited into simple geometric shapes called finite element.

Prerequisites

Fundamentals of mathematics, knowledge of forces and resolution, Equilibrium concepts

Course Outcomes

On the successful completion of the course, students will be able to

CO's for Theory part:

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (Grade)
CO1	Understand the concept of finite element method and illustrate the relation between stress and strain	Apply	75	A
CO2	Formulate and derive element stiffness matrices and load vectors for one-dimensional and truss elements using shape functions and boundary conditions.	Apply	75	A
CO3	Develop and analyze finite element models for truss elements subjected to various loading and boundary conditions.	Apply	75	A
CO4	Develop and analyze finite element models for beam elements subjected to various loading and boundary conditions.	Apply	75	A
CO5	Demonstrate the process of mesh generation, convergence in finite element analysis and applying FEM software tools to perform structural analyses.	Apply	75	A

CO's for Practical part:

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (Grade)
CO6	Create different geometric models and one-dimensional linear element with different material properties	Apply	75	A
CO7	Perform static analysis of cantilever beams under various loading conditions using FEM software.	Apply	75	A

CO8	Perform static analysis of simply supported beams under various loading conditions using FEM software.	Apply	75	A
CO9	Perform static analysis of fixed beams under various loading conditions using FEM software.	Apply	75	A
CO10	Analyze plane trusses and 2D frame structures under different support and loading conditions using finite element principles.	Apply	75	A
CO11	Perform finite element analysis of reinforced concrete beams	Apply	75	A

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	L	-	M	L	-	M	M	L	L	M	L
CO2	S	M	L	-	M	L	-	M	M	L	L	M	L
CO3	S	M	L	-	M	L	-	M	M	L	L	M	L
CO4	S	M	L	-	M	L	-	M	M	L	L	M	L
CO5	S	M	L	-	M	L	-	M	M	L	L	M	L
CO6	S	M	L	-	S	L	-	S	M	M	L	M	S
CO7	S	M	L	-	M	L	-	S	S	M	L	M	S
CO8	S	M	L	-	M	L	-	S	L	M	-	M	-
CO9	S	M	L	-	M	L	-	M	M	M	L	M	-
CO10	S	M	L	-	M	L	-	M	-	L	L	S	-
CO11	S	M	L	-	S	L	-	-	-	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination	
	Theory part		Practical part	Theory part	Practical part
	1	2	3		
Remember	10	10	Observation, Record, Model test (100 marks)	10	-
Understand	10	10		10	
Apply	80	80		80	
Analyse	-	-		-	
Evaluate	-	-		-	
Create	-	-		-	

Syllabus

Introduction to Finite Element Analysis- Basic Concepts: Introduction, Engineering applications, advantages, steps in FEM, element types, stress strain relationship for 1D, 2D and 3D cases, plane stress and plain strain conditions: **One dimensional formulation** - Finite element modelling – coordinates and shapes functions – Assembly of global stiffness matrix and global load vector – properties of K – finite element equations – treatment of boundary conditions – quadratic shape functions ;**Trusses** - Formulation of Plane truss element – local –global transformation - stiffness matrix – stress calculations, Numerical problems on truss; **Two Dimensional formulation -** Formulation of beam element – problem modelling and boundary conditions - stress calculations- Numerical problems on beams carrying point loads and UDL loads; **Mesh Generation and FE software application –** Convergence - Requirements for convergence – p and h methods of mesh refinement – ill conditioned elements – Discretisation errors – Auto and Adaptive Mesh Generation – Error evaluation – stages of FEM software.

Reference Books

1. Reddy, J.N, "An Introduction to the finite element method", McGraw Hill International Edition, New York, 3rd edition 2008.
2. Tirupathi R. Chandrupatla, Ashok D. Belegundu, "Introduction to finite elements in engineering", Prentice Hall of India, New Delhi, 2007.
3. Krishnamoorthy, C.S, "Finite Element Analysis Theory and Programming", Tata McGraw Hill Publishing Co.Ltd. New Delhi 2004.
4. Moaveni, S., Finite Element Analysis: Theory and Application with ANSYS, Prentice Hall Inc., 1999.
5. Zienkiewicz, O.C, and Taylor, R.L., The Finite Elements Methods, Mc Graw Hill, 6th edition 1987.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome
1	**Introduction to Finite Element Analysis**		
1.1	Basic Concepts: Introduction, Engineering applications, advantages	1	CO1
1.2	Steps in FEM, element types	1	CO1
1.3	Stress strain relationship for 1D	1	CO1
1.4	Stress strain relationship for 2D	1	CO1
1.5	Stress strain relationship for 3D and plane stress and plain strain conditions	1	CO1
2	**One dimensional formulation**		
2.1	Finite element modelling – coordinates and shapes functions	1	CO2
2.2	Assembly of global stiffness matrix and global load vector	1	CO2
2.3	Properties of K – finite element equations	1	CO2
2.4	Treatment of boundary conditions – quadratic shape functions- temperature effects	1	CO2
2.5	Numerical Integration	1	CO2
3	**Trusses**		
3.1	Formulation of Plane truss element	1	CO3

3.2	Local –global transformation	1	CO3
3.3	Stiffness matrix – stress calculations	1	CO3
3.4	Tutorial - Truss problems	2	CO3
4	**Two Dimensional formulation**		
4.1	Formulation of beam element	1	CO4
4.2	Problem modelling and boundary conditions	1	CO4
4.3	Stress calculations	1	CO4
4.4	Tutorial – Two dimensional problems	2	CO4
5	**Mesh Generation and FE software application**		
5.1	Convergence - Requirements for convergence	1	CO5
5.2	p and h methods of mesh refinement	1	CO5
5.3	ill conditioned elements – Discretisation errors	1	CO5
5.4	Auto and Adaptive Mesh Generation – Error evaluation – Stages of FEM software	1	CO5
	Total Hours	**24**	

List of Experiments:

1. Creation of various geometric models using basic modelling tools
2. Analysis of one-dimensional linear elements with different material properties
3. Static analysis of cantilever beams subjected to uniformly distributed loads
4. Static analysis of simply supported beams under point loads
5. Static analysis of fixed beams
6. Static analysis of continuous beams
7. Analysis of truss with different support conditions
8. Static analysis of solid pipe
9. Static analysis of hollow pipe
10. Analysis of rectangular plate with a circular hole subjected to pressure loading
11. Buckling analysis of column sections
12. Analysis of a simply supported reinforced concrete beam

Course Designer:

Dr. V Ganga vgaciv@tce.edu

21SEGC0	ENGINEERING SAFETY AND MANAGEMENT

Category	L	T	P	Credit
OE	2	0	0	2

Preamble

Safety is a fundamental requirement in modern engineering due to increasing project complexity, technological advancements and the responsibility to protect people, equipment and the environment. This course introduces the essential principles of safety, basic legal requirements and the roles and responsibilities within an organisation. It familiarizes students with simple methods for hazard identification, risk assessment, accident prevention and safety communication. The subject also highlights practical workplace improvement tools such as 5S, ergonomics and basic safety audits. Emphasis is placed on understanding occupational health needs and developing a positive safety culture. By learning these concepts, students gain the ability to make responsible decisions and contribute to safer engineering practices in their professional careers.

Prerequisites

Nil

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Describe basic safety concepts, accident causes and the need for safety in engineering.	Understand	80	A
CO2	Demonstrate correct application of safety rules, legal acts, standards and roles in workplace settings.	Apply	75	A
CO3	Identify hazards, assess risks and propose suitable control measures.	Apply	75	A
CO4	Explain the components of a safety management system, conduct simple safety audits and understand occupational health aspects.	Apply	75	A

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	L	-	-	-	L	M	L	L	L	L	L	M
CO2	S	M	L	-	-	M	M	L	L	S	M	L	M
CO3	S	M	L	-	-	M	S	L	L	M	M	M	S
CO4	S	M	L	-	-	M	S	L	L	S	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Terminal Examination
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	60	60	60
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

Syllabus

Fundamentals of Safety Management - Introduction to safety - Importance of safety in engineering - Simple definitions: hazard, risk, accident - Causes of accidents - Basics of accident prevention - Role of engineers in safety; **Legislation, Standards & Responsibilities -** Overview of Factories Act, BOCW Act, Employee's Compensation Act - Safety policy - Roles and duties of safety officer, supervisor & worker - ISO, OSHA guidelines - Safety communication: signs & symbols - Application of legal requirements and safety standards through case studies and workplace scenarios; **Hazard Identification & Risk Assessment -** Simple hazard identification: checklists & walk -throughs - Basic risk assessment techniques - Risk rating : low, medium & high - Hierarchy of controls - Ergonomics: posture, lifting, workstation design, fatigue reduction; **SMS, Audits & Occupational Health -** Safety Management System (SMS): Basic components - Safety training & awareness, Safety audit steps - 5S Audit: checklist, scoring, workplace improvement - Occupational health: physical, chemical & welfare factor.

Reference Books

1. R.K. Jain & Sunil S. Rao – Safety, Health and Environment Management Systems, Khanna Publishers, 2015.
2. John Ridley – Safety at Work, Butterworth-Heinemann, 2012.
3. Hughes, P. & Ferrett, E. – Introduction to Health and Safety in Engineering, Routledge, 2016.
4. Dr. K.U. Mistry – Safety Management in Engineering, Charotar Publishing, 2018.
5. National Building Code of India (NBC 2016), Part 7 – Constructional Practices and Safety.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	COs
1. Fundamentals of Safety Management			**CO1**
1.1	Introduction to safety	1	
1.1.1	Importance of safety in engineering	1	

1.2	Simple definitions: hazard, risk, accident	1	
1.3	Causes of accidents (unsafe acts & conditions)	1	
1.4	Basics of accident prevention	1	
1.5	Role of engineers in safety	1	
2. Legislation, Standards & Responsibilities			**CO2**
2.1	Overview of Factories Act, BOCW Act, Employee's Compensation Act.	1	
2.2	Safety policy, Roles and duties of safety officer, supervisor & worker	1	
2.3	ISO 45001 basics, OSHA guidelines	1	
2.4	Safety communication: signs & symbols	1	
2.5	Application of legal requirements and safety standards through case studies and workplace scenarios	2	
3. Hazard Identification & Risk Assessment			**CO3**
3.1	Simple hazard identification: checklists & walk-throughs	2	
3.2	Basic risk assessment techniques	1	
3.3	Risk rating (low–medium–high)	1	
3.4	Hierarchy of controls	1	
3.5	Ergonomics: posture, lifting, workstation design, fatigue reduction	1	
4. SMS, Audits & Occupational Health			**CO4**
4.1	Safety Management System (SMS): Basic components	1	
4.2	Safety training & awareness, Safety audit steps	1	
4.3	5S Audit: checklist, scoring, workplace improvement	2	
4.4	Occupational health: physical, chemical & welfare factors	1	
	Total Hours	**24**	

Course Designers:

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