CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Structural Engineering) PROGRAM

FIRST SEMESTER TO FOURTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2015-2016 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Passed in Board of Studies meeting on 18.04.2015 Approved in 50th Academic Council meeting on 30.05.2015

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 global standards
- Encourage faculty and students to carry out socially relevant and forward looking research
- Offer consultancy services using state of the art facilities fulfilling the needs of the industry and society
- Enable our students, faculty and staff to play leadership roles for the betterment of the society in a sustainable manner.

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 advanced research.

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

Graduating Students of M.E. Structural Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	Acquire in-depth knowledge of Structural Engineering or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.	Scholarship of Knowledge
PO2.	Analyse complex Structural Engineering problems critically, apply independent judgement for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context	Critical Thinking
PO3.	Think laterally and originally, conceptualize and solve Structural 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	Problem Solving
PO4.	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze 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 Structural Engineering	Research Skill
PO5.	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations	Usage of modern tools
PO6.	Possess knowledge and understanding of group dynamics, recognize 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	Collaborative and Multidisciplinary work
PO7.	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 consideration of economical and financial factors.	Project Management and Finance
PO8.	Communicate with the engineering community, and with	Communication

	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 clear instructions	
PO9.	Recognize 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	Life-long Learning
PO10.	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	Ethical Practices and Social Responsibility
PO11.	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback	Independent and Reflective Learning

Department of Civil Engineering
M.E structural Engineering programme

Schedule of courses

Semesters	**Theory Courses**						**Theory cum Practical**	**Practical**	**Special Courses**	**Credits**
	1	2	3	4	5	6	7	8	9	
1st	15SE110-Applied Mathematics (3:1)	15SE120-Analysis and Design of Concrete Structures (3:1)	15SE130-Structural Mechanics (3:1)	15SE140-Theory of Elasticity and Plasticity (3:0)	15SE150-Prestressed Concrete (3:1)	15SE160-Forensic Engg. and Rehabilitation of structures (3:1)	-	15SE170-Structural Engineering Lab (0:1)	-	24
2nd	15SE210-Dynamics of Structures (3:0)	15SE220-Structural Steel Design (3:1)	15SEPX0-Programme Elective-I (4 credits)	15SEPX0-Programme Elective-II (4 credits)	15SEPX0-Programme Elective-III (4 credits)	15SEPX0-Programme Elective-IV (4 credits)	-	15SE270-Seminar (0:1)	-	24
3rd	15SE310-Design of Steel Concrete Composite Structures (3:1)	15SEPX0-Programme Elective-V (4 credits)	15SEPX0-Programme Elective-VI (4 credits)	-	-	-	-	15SE340-Project-I (0:4)	-	16
4th	-	-	-	-	-	-	-	15SE410-Project-II (0:12)	-	12
Total credits for curriculum activities										**76**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Structural Engineering) Program

COURSES OF STUDY

(For the candidates admitted from 2015-2016 onwards)

FIRST SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
THEORY						
15SE110	Applied Mathematics	BS	3	1	-	4
15SE120	Analysis and Design of Concrete Structures	PC	3	1	-	4
15SE130	Structural Mechanics	PC	3	1	-	4
15SE140	Theory of Elasticity and Plasticity	PC	3	0	-	3
15SE150	Prestressed Concrete	PC	3	1	-	4
15SE160	Forensic Engg. and Rehabilitation of structures	PC	3	1	-	4
PRACTICAL						
15SE170	Structural Engineering Lab	PC	-	-	2	1
Total			**18**	**5**	**2**	**24**

SECOND SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	T	P	
THEORY						
15SE210	Dynamics of Structures	PC	3	0	-	3
15SE220	Structural Steel Design	PC	3	1	-	4
15SEPX0	Programme Elective-I	PE	3	1	-	4
15SEPX0	Programme Elective-II	PE	3	1	-	4
15SEPX0	Programme Elective – III	PE	3	1	-	4
15SEPX0	Programme Elective – IV	PE	3	1	-	4
PRACTICAL						
15SE270	Seminar		-	-	2	1
Total			**18**	**5**	**2**	**24**

THIRD SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	**T**	**P**	
THEORY						
15SE310	Design of Steel Concrete Composite Structures	PC	3	1	-	4
15SEPX0	Programme Elective – V	PE	3	1	-	4
15SEPX0	Programme Elective – VI	PE	3	1	-	4
PRACTICAL						
15SE340	Project-I		-	-	8	4
Total			**9**	**3**	**8**	**16**

FOURTH SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			credits
			L	**T**	**P**	
PRACTICAL						
15SE410	Project-II		-	-	24	12
Total			**-**	**-**	**24**	**12**

*** BS- Basic Sciences; HSS-Humanities and Social Sciences; ES-Engineering Sciences; 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 2015-2016 onwards)

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	15SE110	Applied Mathematics	3	50	50	100	25	50
2	15SE120	Analysis and Design of Concrete Structures	3	50	50	100	25	50
3	15SE130	Structural Mechanics	3	50	50	100	25	50
4	15SE140	Theory of Elasticity and Plasticity	3	50	50	100	25	50
5	15SE150	Prestressed Concrete	3	50	50	100	25	50
6	15SE160	Forensic Engg. and Rehabilitation of structures	3	50	50	100	25	50
PRACTICAL								
7	15SE170	Structural Engineering Lab	3	50	50	100	25	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	15SE210	Dynamics of Structures	3	50	50	100	25	50
2	15SE220	Structural Steel Design	3	50	50	100	25	50
3	15SEPX0	Programme Elective-I	3	50	50	100	25	50
4	15SEPX0	Programme Elective-II	3	50	50	100	25	50
5	15SEPX0	Programme Elective – III	3	50	50	100	25	50
6	15SEPX0	Programme Elective - IV	3	50	50	100	25	50
PRACTICAL								
7	15SE270	Seminar	3	50	50	100	25	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	15SE310	Design of Steel Concrete Composite Structures	3	50	50	100	25	50
2	15SEPX0	Programme Elective – V	3	50	50	100	25	50
3	15SEPX0	Programme Elective – VI	3	50	50	100	25	50
PRACTICAL								
4	15SE340	Project-I	-	50	50	100	25	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	15SE410	Project-II	-	150	150	300	75	150

* 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	15SEPA0	Aseismic Design of Structures
2	15SEPB0	Bridge Engineering
3	15SEPC0	Computational methods in Structural Analysis
4	15SEPD0	Concrete Mechanics
5	15SEPE0	Design of Shell Structures
6	15SEPF0	Disaster Mitigation and Management
7	15SEPG0	Durability of Concrete Structures
8	15SEPH0	Experimental Techniques and Instrumentations
9	15SEPK0	Fracture Mechanics
10	15SEPL0	Industrial Structures
11	15SEPM0	Soil Structure Interaction
12	15SEPN0	Structural Design of Foundation
13	15SEPQ0	Theory of Plates.
14	15SEPR0	Computer Aided Design
15	15SEPS0	Finite Element Method in Structural Engineering
16	15SEPT0	Value Engineering

		Category	L	T	P	Credit
15SE110	**APPLIED MATHEMATICS**	BS	3	1	0	4

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

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

(CO1): apply Fourier transform methods for solving diffusion equation, wave equation and Laplace equation.(Apply)

(CO2): formulate variational problems and solve boundary value problems using variational techniques.(Apply)

(CO3): find eigen values and solve eigen value problems. (Apply)

(CO4): apply numerical integration of one and two dimension, multiple integral by using mapping function.(Apply)

(CO5):describe the random processes and apply the probabilistic model for characterising the random processes . (Apply)

Mapping with Programme Outcomes

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

S - Strong; M-Medium; L–Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	8	8	8	-
Understand	24	24	24	30
Apply	68	68	68	70

Course Level Assessment Questions

Course Outcome 1 (CO1):

1.List the boundary conditions associated with the wave equation.

2.Solve $u_{xx}(x,y)+u_{yy}(x,y)=0$, $-\infty < x < \infty$, y>0, $u_y(x,0)=f(x)$ $-\infty < x < \infty$, u is bounded as y→∞, u and $\frac{\partial u}{\partial x}$ both vanish as |x|→∞

Course Outcome 2 (CO2):

1. Test the extremum the functional $I[y(x)]=\int_0^{\pi/2}(y'^2-y^2)dx$ y(0)=0, y($\pi/2$)=1

2.Using the Ritz method, find an approximate solution of $\nabla^2 z=-1$ inside the square $-a \le x \le a$, $-a \le y \le a$ which vanishes on the boundary of the square.

Course Outcome 3 (CO3):

1. Formulate the characteristic polynomial equation by Faddeev-Levemier method for the three dimensional state of stress $\sigma=\begin{bmatrix}3 & -1 & 0\\ -1 & 2 & -1\\ 0 & -1 & 3\end{bmatrix}$

2. For $\begin{bmatrix}2 & -1 & 0\\ -1 & 4 & -1\\ 0 & -1 & 2\end{bmatrix}\{x\}=\lambda\begin{bmatrix}2 & . & .\\ . & 1 & .\\ . & . & 0\end{bmatrix}\{x\}$, use Ritz vectors $\begin{bmatrix}7/12 & 1/12\\ 1/6 & 1/6\\ 1/12 & 7/12\end{bmatrix}$ to calculate two eigen values and eigen vectors for the reduced matrix.

Course Outcome 4 (CO4):

1.State Gauss-Hermite quadrature formula.

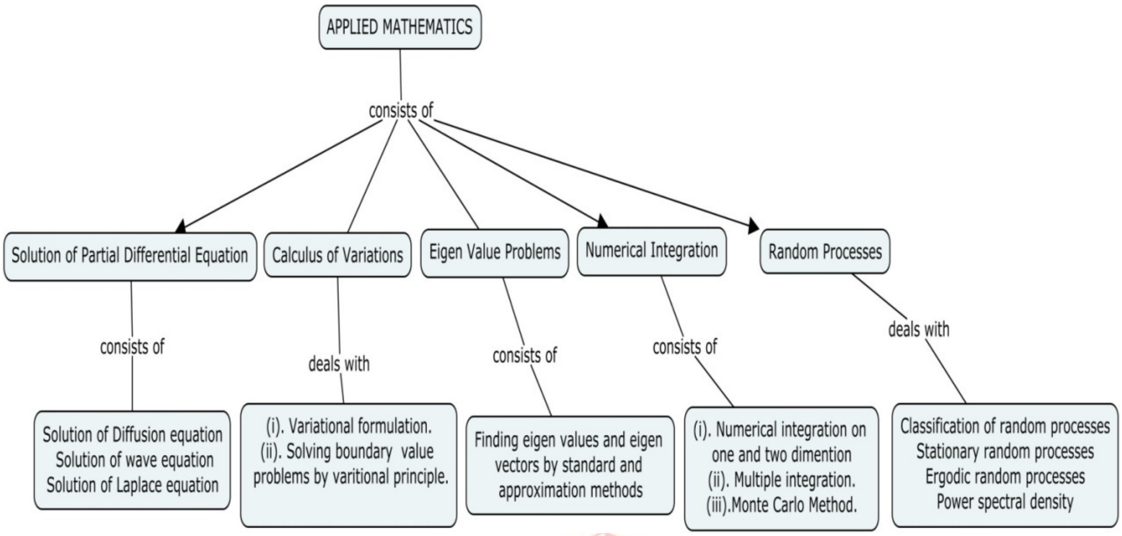
2. Integrate $f(x)=10+20x-\frac{3x^2}{10}+\frac{4x^3}{100}-\frac{5x^4}{1000}+\frac{6x^5}{10000}$ between 8 and 12.

Course Outcome 5 (CO5):

1. Classify the random process $X(t)=A\cos(w_0 t+\theta)$ where A and w_0 are constants and θ is uniformly distributed random variable in $(0,2\pi)$.

2. If the autocorrelation function of a stationary process $\{X(t)\}$ is $R(\tau)=10e^{-|\tau|}$,prove that $\{X(t)\}$ is ergodic both in mean and correlation.

Concept Map



Syllabus

SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS–Fourier transform methods-Solution of Diffusionequation-Solution wave equation –Solution of Laplace equation **CALCULUS OF VARIATIONS–**Concept of variation and its properties – Euler's equation – Functionalsdependant on first and higher order derivatives – Functionalsdependant on functions of several independent variables – Variational problems with moving boundaries – Direct methods-Ritz and Kontorovich method - **EIGEN VALUE PROBLEMS**–Methods of solutions: Faddeev – Leverrier Method, Power method with deflation – Approxiamate methods: Rayleigh-Ritz method – **NUMERICAL INTEGRATION** – Gaussian Quadrature – One and Two dimensions – Gauss Hermite Quadrature – Monte Carlo method – Multiple integration by using mapping function**RANDOM PROCESSES -** Classification of random processes-Stationary random processes-Ergodic processes-Power spectral density.

Reference Books

1. SankaraRao,K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997
2. Rajasekaran.S, "Numerical Methods in Science and Engineering A Practical Approach", A.H.Wheeler and Company Private Limited, 1986.
3. Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
4. Andrews, L.C. and Shivamoggi, B.K., "Integral Trasforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
5. Venkatarama Krishnan "Probability and Random Processes", John Wiley & sons, Inc. Hoboken, New Jersey, 2006.

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	2
	Tutorial	1
1.3	Solution wave equation	3
	Tutorial	1
1.4	Solution of Laplace equation	3
	Tutorial	1
2	**CALCULUS OF VARIATIONS**	
2.1	Concept of variation and its properties	2
2.2	Euler's equation	1
	Tutorial	1
2.3	Functional dependant on first and higher order derivatives	1
2.4	Functionalsdependant on functions of several independent variables	1
2.5	Variational problems with moving boundaries	1
	Tutorial	1
2.6	Direct methods-Ritz and Kontorovich method	3
	Tutorial	1
3	**EIGEN VALUE PROBLEMS**	
3.1	Methods of solutions: Faddeev – Leverrier Method	2
3.2	Power method	1
	Tutorial	1
3.3	Power method with deflation	1
3.4	Approxiamate methods: Rayleigh-Ritz method	2
	Tutorial	1
4	**NUMERICAL INTEGRATION**	
4.1	Gaussian Quadrature	2
4.2	One and Two dimensions	1
	Tutorial	1
4.3	Gauss Hermite Quadrature	1
4.4	Monte-Carlo method	1
4.5	Multiple integration by using mapping function	1
	Tutorial	1
5	**RANDOM PROCESSES**	
5.1	Classification of random processes	1
5.2	Stationary random processes	2
	Tutorial	1
5.3	Ergodic processes	2
5.4	Power spectral density	1
	Tutorial	1
	Total	**48**

Course Designers:

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15SE120	**ANALYSIS AND DESIGN OF CONCRETE STRUCTURES**	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

Reinforced concrete, as a composite material, has occupied a special place in the modern construction of dif ferent types of structures due to its several advantages. Due to its flexibility in form and superiority in performance, it has replaced, to a large extent, the earlier materials like stone, timber and steel. Its role in several straight-line structural forms like multistoried frames, bridges, foundations etc. are enormous. The design of these 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. Design of reinforced concrete structures started in the beginning of last century following purely empirical approach. Thereafter came the so-called rigorous elastic theory where the levels of stresses in concrete and steel are limited so that stress-deformations are taken to be linear. However, the limit state method, though semi-empirical approach, has been found to be the best for the design of reinforced concrete structures.

Prerequisite

Fundamentals of Mathematics, knowledge of properties of materials, load calculations and Design of RC elelments.

Course Outcomes

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

CO1: Design the elements under flexure, shear, torsion and compression	Create
CO2: Design the special RC elements	Create
CO3: Analyse and design the slabs	Create
CO4: Analyse the inelastic behaviour of concrete elements and Design	Create
CO5: Determine serviceability condition of concrere elements	Apply
CO6:Draw the reinforcerment detailing of structural elements	Evaluate

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	30	30	30	30
Analyse	-	-	-	-
Evaluate	10	10	10	10
Create	40	40	40	40

Course Level Assessment Questions

CO1: Design the elements under flexure, shear, torsion and compression

1. Give the assumptions made in the limit stste method of design.
2. Distinguish between under reinforced and over reindforced sections.
3. Determine ultimate moment resistance of a T-beam having the following data. Width of flange = 1550mm; breadth of web = 300mm; effective depth of beam = 620mm; depth of flange = 110mm. Area of tension reinforcement = 4775mm^2. Concrete M20 and steel Fe415.
4. Design reinforcement required for a circular rectangular beam of size 350mm x 550mm subjected to a bending moment of 140kNm, twisting moment of 18kNm and a shear force of 90kN under ultimate condition. Use M25 grade concrete and Fe415 as materials.

CO2: Design the special RC elements

1. Define the term: Deep beam.
2. Draw the reinforcement detailing of corbel.
3. Design a slender circular column of 350mm diameter with the following data. Unsupported length=8m; Effective length=5m; Axial load=500kN; Moment at top=60kNm; Moment at bottom=40kNm. The column bends in double curvature. Use concrete M25 and steel Fe415
4. Design a pile cap connecting three piles of size 300mm in diameter used to support a column at the CG of the section subjected to a load of 500 kN. The centre to centre distance between the piles is 1.5m. Use M20 and Fe415 as materials.

C03: Analyse and design the slabs

1. Explain virtual work method of analysis of slab.
2. Draw the yield line pattern of simply supported circular slab and triangular slab.
3. Analyse one way slab using the methods of yield line analysis and determine the collapse load for the slab having simply supported and fixed supports at the ends.
4. Design the flat slab for an office building having the interior panel of size 6.5m x 6.5m. The size of the column is 250mm diameter. Super imposed load is 5 kN/m^2. Floor finishes = 1.5 kN/m^2. Use M20 & Fe415 as materials.

CO4: Analyse the inelastic behaviour of concrete elelments

1. Define the term: Cracking moment.
2. Explain the Baker's method of limit state analysis of continuous beams in detail with neat sketches.
3. Design five spans continuous beam subjected to an UDL of 38 kN/m throughout its entire length. Use M20 and Fe500 as materials.

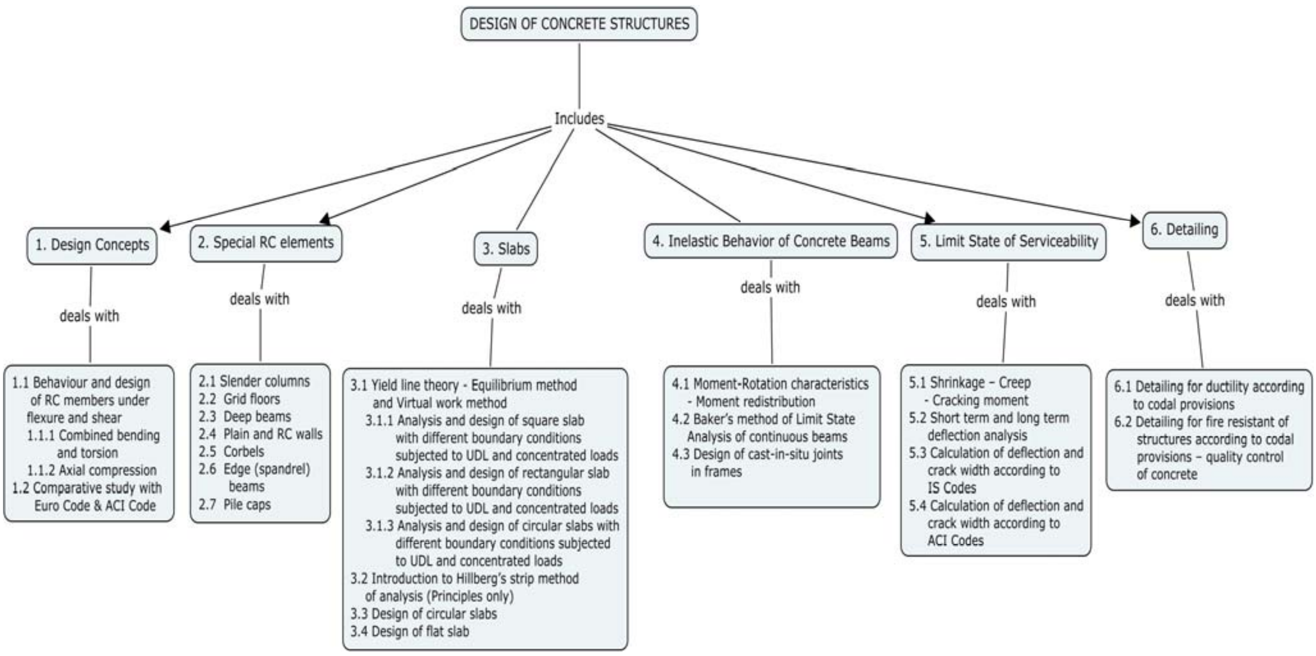
CO5: Determine serviceability condition of concrete elements

1. Explain span to effective depth ratio.
2. Define the term: Cracking moment
3. A cantiliver slab 100mm thick and reinforced with 10mm bars at 100mm c/c. The slab is extended 3m as a centilever. Calculate the shrinkage stresses and the deflection at the outer end due to a shrinkage strain of 0.00040. Assume modular ratio as 30 to approximate the creep effects and assuming (i) an uncracked slab section (ii) as a cracked section upto a depth of 60mm from top. Assume Es = $2x10^5$ N/mm^2 and Ec = $6.67x10^3$ N/mm^2.

CO6: Draw the reinforcement detailing of structural elements

1. Define the term: ductitlity
2. Explain the detailing of reinforcement for ductility and fire resistant of structures with neat sketches.
3. Evaluate the detailing of reinforcement according to safety and serviceability conditions.

Concept Map



Syllabus

Design concepts - review of basic concepts, behaviour and design of RC members under flexure, shear, combined shear and torsion, axial compression as per IS:456-2000, comparative study with EuroCode and ACI Code;**Special RC elements**- design of slender columns, grid floors, plain & reinforced concrete walls, edge (spandrel) beams, deep beams,corbels,pile caps, concept of strut and tie method – **Slabs -** yield line analysis 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, design of cast-in-situ joints in frames**;Limit state of serviceability–** shrinkage, creep, cracking moment, short term and long term deflection analysis, calculation of deflection and crack width according to IS and ACI Codes**; Detailing -** design and detailing of structures according to codal provisions, detailing for ductility, detailing for fire resistant of structures,quality control of concrete.

Reference Books

1. N. Krishna Raju, Advanced Reinforced Concrete Design (IS 456-2000), CBS Publishers & Distributors, New Delhi, 2010.
2. Arthur H.Nilson, George Winter, Design of Concrete Structures, 11th Edition, McGraw Hill Book Co., New York, 2009.
3. P. Bhatt, T.J. MacGinley, B.S. Choo, Ban Seng Choo and Thomas J. MacGinley, Reinforced Concrete; Design theory and examples, Routledge Publisher, 2006.
4. Edward G. Nawy, Reinforced Concrete – A fundamental Approach, 6th Edition, Prentice Hall, 2008.
5. P.C. Varghese, Advanced Reinforced Concrete Design, 2nd Edition, Prentice Hall of India Pvt., Ltd., New Delhi, 2009.
6. N. Krishna Raju, Advanced Reinforced Concrete Design (IS 456-2000), CBS Publishers & Distributors, New Delhi, 2010.
7. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, Tata Mc Graw Hill Publishing Company Ltd., New Delhi, 2007.
8. B.C. Punmia. Ashok K. Jain and Arun K. Jain, Comprehensive RCC Designs, Lakshmi Publications (P) Ltd., New Delhi, Ninth Edition, 2009.
9. P. Dayaratnam, Limit State Design of Reinforced Concrete Structures, Oxford & IBH Publishing Co. Pvt Ltd, 2008.
10. S.N. Sinha, Reinforced Concrete Design, Tata McGraw-Hill, New Delhi, 2002.
11. N.C. Sinha and S.K Roy, Fundamentals of Reinforced Concrete, S. Chand & Company Ltd, New Delhi, 2007.

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	2
1.1.2	Axial compression	1
1.2	Comparative study with Euro Code & ACI Code	1
2. Special RC elements		
2.1	Slender columns	2
2.2	Grid floors	2
2.3	Deep beams	2
2.4	Plain and RC walls	2
2.5	Corbels	2
2.6	Edge (spandrel) beams	2
2.7	Pile caps	2
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
3.4	Design of circular slabs	2
3.4	Design of flat slab	2
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	2
4.3	Design of cast-in-situ joints in frames	1
5. Limit State of Serviceability		
5.1	Shrinkage – Creep - Cracking moment	2
5.2	Short term and long term deflection analysis	2
5.3	Calculation of deflection and crack width according to IS Codes	2
5.4	Calculation of deflection and crack width according to ACI Codes	2

6. Detailing		
6.1	Detailing for ductility according to codal provisions	1
6.2	Detailing for fire resistant of structures according to codal provisions – quality control of concrete	2
	Total Hours	48

Course Designers:

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		Category	L	T	P	Credit
15SE130	**STRUCTURAL MECHANICS**	PC	3	1	0	4

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

CO1:	Illustrate the concept of beam on elastic foundation	Apply
CO2:	Outline the concept of shear center and unsymmetrical bending.	Analyse
CO3:	Calculate the stresses in curved flexural member.	Analyse
CO4:	Analyze the forces in beam and column.	Analyse
CO5:	Calculate the buckling stress in plates and bar.	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	L	M	-	-	-	-	-	-	-	-
CO2.	S	M	S	-	-	-	-	M	-	-	-
CO3.	S	M	S	-	-	-	-	-	-	-	-
CO4.	S	-	S	S	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	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	60	60	60	60
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1: Understand the concept of beam on elastic foundation

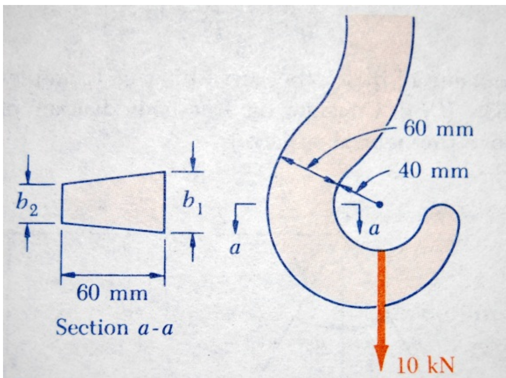
1. Calculate the maximum deflection, Bending moment, Shear force developed in the beam after deriving the expression from first principle for an infinitely long steel beam of ISMD250 with I_{XX}=2235x10^4mm^4 rests on a elastic foundation with a modulus of 18N/mm^2. The modulus of elasticity of steel is 2x10^5N/mm^2. The beam supports a concentrated load of 200kN.
2. Deduce the expression for the deflection, slope, shear force and bending moment for an semi-infinite beam subjected to force (P) and Moment (Mo) at their end.
3. Deduce the expression for the deflection, slope, shear force and bending moment for an infinite beam subjected uniformly varying load at their mid span.
4. Diagram the deflection, slope, shear force and bending moment for an infinite beam subjected to force (P) at their end.

CO2: Understand the concept of shear center and unsymmetrical bending.

1. Calculate maximum bending stress and locate the neutral axis also identify deflection induced in the section for a beam of rectangular section 80mm ×120mm deep is subjected to a bending moment of 12KN-m.The trace of the plane of loading is inclined 45degree to YY axes.
2. Determine the position of the shear centre for an 80mm by 40mm outside 5mm thick channel section.
3. Compute the shear centre of a section in the form of a circular arc of mean radius 75mm and of uniform thickness 5mm subtending an angle of 60 degree at the centre.

CO3: Calculate the stresses in curved flexural member.

1. Calculate the largest stress in section a-a,for the crane hook shown in fig. when $b_1 = 35$ mm and $b_2 = 25$ mm



2. Deduce the expression for winkler -bach equation for a curved member.
3. Calculate the vertical and horizontal deflection of a curved bar subjected to vertical load P.

4. Calculate the position of neutral axis and bending stress for a curved bar of rectangular section 40mm x 60mm and mean radius of curvature of 100mm and is subjected to a bending moment of 1800kNmm tending to straighten the bar.
5. Calculate the maximum stress at the horizontal section if a circular ring of internal diameter 200mm and external diameter 260mm has circular cross sections. The ring is subjected to vertical diametrical compressible loader 12kN. $E=2x10^5 N/mm^2$.

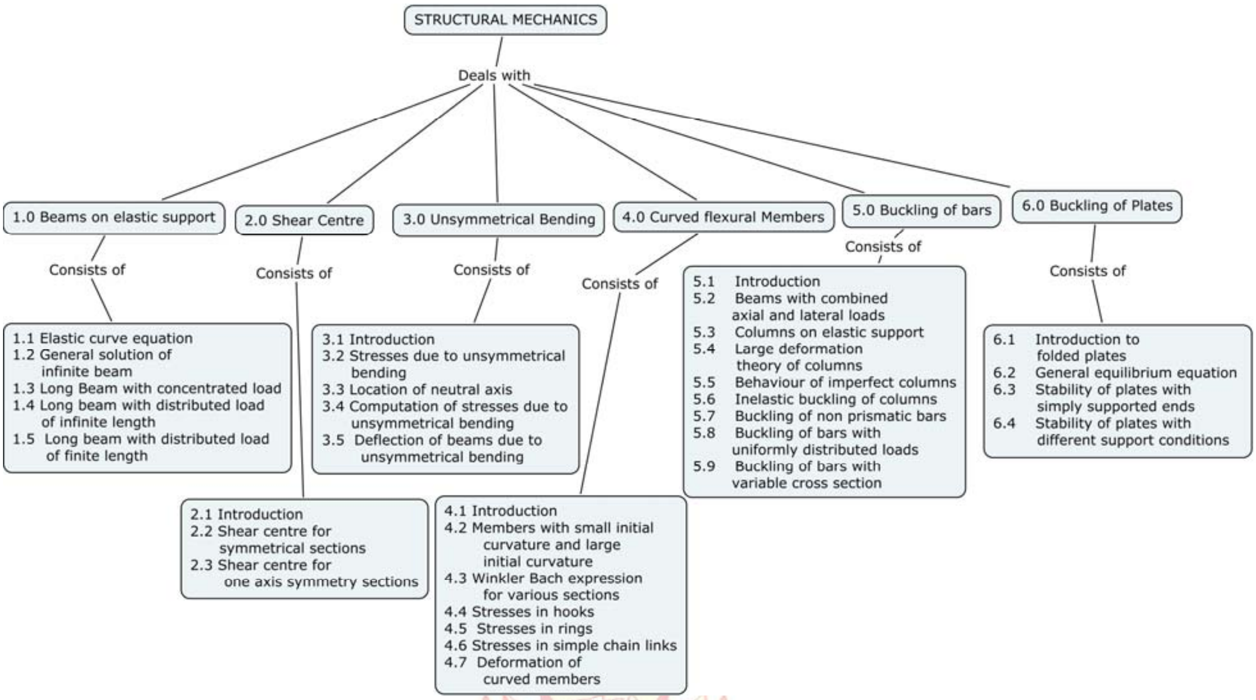
CO4: Analyse the forces in beam and column

1. Calculate the crippling load of a column having different moment of inertia. The column is built in at the base and free at the top. Let I_1, L_1 and I_2, L_2 are the length and moment of inertia for the lower half and upper half portions respectively. Let the total length of the column is L
2. Calculate from fundamental the crippling load of a built-up column having moment of inertia I and 2I for the top half potion and bottom half potion of a column fixed at the lower end and free at the top compressed by an axial load of P.
3. Deduce the expression for Euler's crippling load for a column one end fixed and the other is hinged

CO5: Examine the buckling stress in plates and bar

1. Deduce the expression for stability equation of a thin plate hinged at all 4 edges. A compressive forces of Fx and F_y are acting along the x and y axis
2. Calculate the crippling load of a thin plate with two opposite sides hinged and other two opposite sides are free. A compressive force F is acting along the hinged side.
3. Deduce the expression from fundamental the in elastic buckling of a thin plate simply supported at ends
4. Calculate the crippling load of a thin plate with two opposite sides hinged and other two opposite sides are free. A compressive force F is acting along the hinged side.

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	2
1.5	Long beam with distributed load of finite length	1
1.6	Tutorial -Semi-infinite beams	2
1.7	Tutorial -Finite beams with concentrated load	1
2	**Shear Centre**	
2.1	Introduction	1
2.2	Shear centre for symmetrical sections	1
2.3	Tutorial -Shear centre for one axis symmetry sections	1
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
3.5	Tutorial -Deflection of beams 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	2
4.4	Tutorial –winkler bach equation problems	2
4.5	Stresses in hooks	2
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	Tutorial -Behaviour of imperfect columns	2
5.6	Inelastic buckling of columns	1
5.7	Buckling of non prismatic bars	1
5.8	Buckling of bars with uniformly distributed loads	2
5.9	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	2
	Total	**48**

Course Designers:

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		Category	L	T	P	Credit
15SE140	**THEORY OF ELASTICITY AND PLASTICITY**	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

CO1:	Illustrate the 2D and 3D stresses and strains in Cartesian and polar coordinate systems and also Transfer these stresses and strains in Mohr Circle diagram.	Apply
CO2:	Calculate the induced stress in the 2D system using Airy's stress function	Analyse
CO3:	Calculate stresses in thick cylinder using the concept of axi-symmetry	Apply
CO4:	Calculate the capacity of circular, non-circular sections both solid and tubular sections using St.Venant's approach and Prandtl approach.	Analyse
CO5:	Apply energy theorem to elastic problems.	Apply
CO6:	Understand the physical behaviour of yield criteria of material	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	60	60	60	60
Analyse	20	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1: Illustrate the 2D and 3D stresses and strains in Cartesian and polar coordinate systems and also Transfer these stresses and strains in Mohr Circle diagram.

1. Calculate the associated body forces at (1,-1, 2) for equilibrium. The component of stress at a point is given by $\sigma_x = 3xy^2z + 2x$, $\sigma_y = 5xyz + 3y$, $\sigma_x = x^2y + y^2z$, $\tau_{xy} = 0$, $\tau_{yz} = \tau_{xz} = 3xy^2z + 2xy$.
2. Show that in plane strain as well as plane stress cases, in the absence of body forces the compatibility equation in terms of stress function is $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)(\sigma_x + \sigma_y) = 0\cdot$
3. Explain generalized hooks law. Derive the expression of equilibrium of compatibility condition in Cartesian coordinates for a two dimensional stress field.

CO2: Calculate the induced stress in the 2D system using Airy's stress function.

1. Show that $\phi = \frac{q}{8C^3}\left[x^2\left(y^3 - 3C^2y + 2C^3\right) - \frac{1}{5}y^3\left(y^2 - 2C^2\right)\right]$ is a valid stress unction.

   Find also what is the problem, the function may solve in the region $y = \pm C, x = 0$ on side x positive.

1. Relate principal stresses and maximum shear stresses in 3D stress system.

2. Show the following state of stress a possible one?

   $\sigma_x = \sigma_y = ky^2/x^2$

   $\tau_{xy} = ay/x^2$ assume k is a constant and zero body forces.

CO3: Calculate stresses in thick cylinder using the concept of axi-symmetry.

1. Deduce the expression for angle of twist, shear stress at any point and hence max shear stress in a bar of elliptical section due to twisting moment.
2. Show σ_θ variation around the whole periphery for a small circular hole of radius 'a' is cut away from a large thin plate. The plate is then subject to uniform shear at its ends?
3. Investigate the maximum stress magnitude and its location when a flat plate under in-plane tension with a circular hole?

CO4: Calculate the capacity of circular, non-circular sections both solid and tubular sections using St.Venant's approach and Prandtl approach.

1. Express the stresses induced in a torsion specimen in terms of Prandtl's stress function.
2. Draw the idealized stress strain diagram and mark the salient points.
3. Deduce the expression for stress components in a thin plate of infinite dimensions with central circular hole under uniform uniaxial tension.
3. Solve for an equilateral triangle of side 2h/√3 as shown in figure-1, the stress function is given by $\phi = \frac{G\theta}{2h}\left[\left\{x-\sqrt{3}y-\frac{2h}{3}\right\}\left\{x+\sqrt{3}y-\frac{2h}{3}\right\}\left\{x-\frac{h}{3}\right\}\right]$ and also show that $\theta = \frac{15\sqrt{3}T}{Gh^4}$.

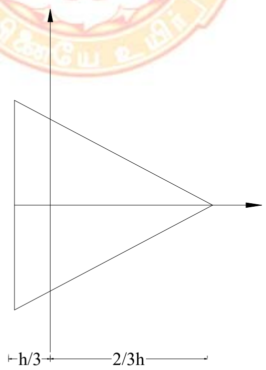


Figure-1

CO5: Apply energy theorem to elastic problems.

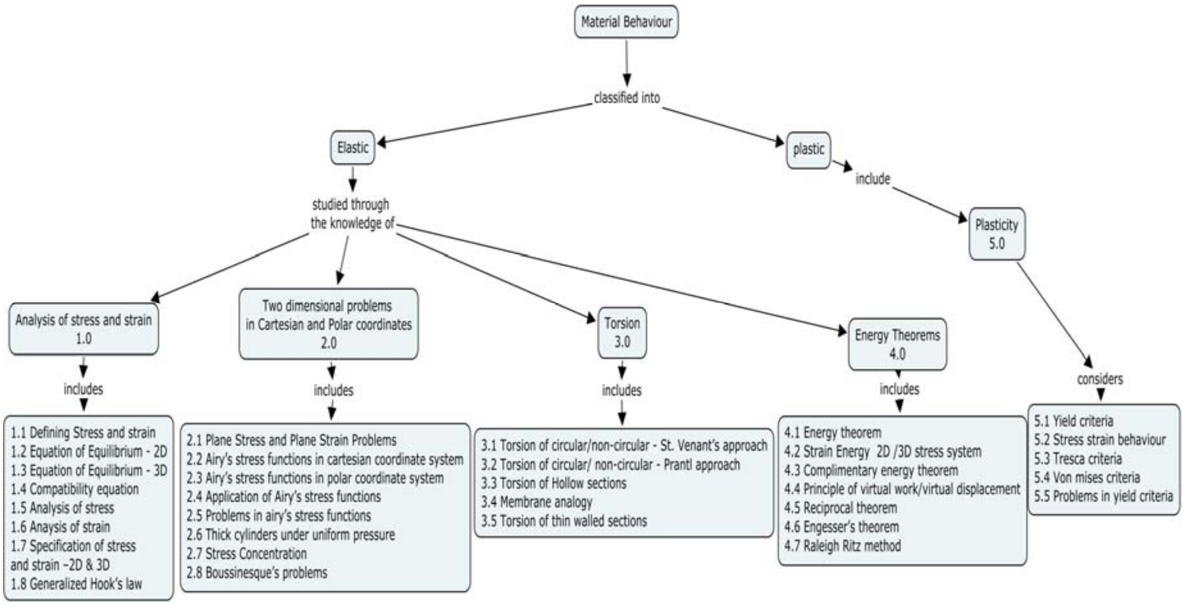
1. State and derive the principle of complementary energy of a two dimension system.
2. Calculate the critical load for column one end fixed and other end if free using Rayleigh Ritz method.
3. Calculate the critical load for column one end fixed and other end if pinned using Rayleigh Ritz method.

CO6: Understand the physical behaviour of yield criteria of material

1. Examine whether yielding of the material will occur or not according to the tresca and Mises. The state of stress at a point in a material is given by $\sigma_x = 75Mpa, \sigma_y = 95Mpa, \tau_{xy} = 55Mp\,a$. If the yield strength of the material is 120Mpa, Also calculate the appropriate factor of safety.

2. Calculate the diameter of a steel bolt is subjected to a bending moment of 250N-m and a torque of 150N-m. if the yield stress tension for the bolt material is 250Mpa. Using i) Tresca's Yield criteria ii) Von – Mises Yield criteria.
3. Calculate the value of axial load applied on the tube so that the tube is starts yielding according to Von-Mises criteria for a thin walled tube of mean radius 100mm and wall thickness is 4mm is subjected to a torque of 10 N-m. if the yield strength of material is 120 N/mm^2 .

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

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	1

	section & Problems	
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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		Category	L	T	P	Credit
15SE150	**PRESTRESSED CONCRETE**	PC	3	1	0	4

Preamble

Reinforced concrete is a very popular choice of material on construction of variety of structures. Concrete is reinforced with conventional rebar or with Prestressing wire or cables. While conventionally reinforced concrete construction hasn't changed much in the past four decades, prestressed concrete construction has become more and more popular. Prestressed concrete dates back to the beginning of the twentieth century but became popular only after World War-II in the bridge industry. In the 1960s, with the development of higher strength steel and better attachment hardware, the use of prestressed concrete to reinforce commercial structures gained popularity. Better construction techniques and simplified design methods have fueled the growth of prestressed concrete in construction industry ever since. By the early 1990's the popularity of prestressed concrete increased with further refinements to the tensioning process, the development of corrosion-resistant anchorages and availability of design software. As a result prestressing has become a preferred method for reinforcing concrete today in most developed countries.

Prerequisite

Fundamentals of Mathematics, knowledge of properties of materials and its applications

Course Outcomes

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

CO1: Explain the theory and systems of prestressed concrete and determine the losses of prestress and deflections of prestressed concrete members	Apply
CO2: Analyse and design the flexural members	Create
CO3: Design the tension and compression members	Create
CO4: Analyse the continuous members	Apply
CO5**:** Analyse the composite members and determine strength and deflection	Evalute

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	10	10	10	10
Create	20	20	20	20

Course Level Assessment Questions

CO1: Explain the theory and systems of prestressed concrete and determine the losses of prestress and deflections of prestressed concrete members

1. Give the reasons for using high strength concrete in prestressed concrete structures.
2. Explain partial prestressing.
3. Determine the percentage loss of stress in wires if (a) the beam is pretensioned and (b) the beam is post-tensioned using the following data: A prestressed concrete beam is of 250mm wide and 400mm deep is prestressed by 14 wires each of 7mm diameter initially stressed to 1300 N/mm^2 with their centroids located 120mm from the soffit. The span of the beam is 11m. Relaxation of steel stress = 5% of initial stress, Es=210kN/mm^2, Ec=35 kN/mm^2, creep coefficient=1.6 and residual shrinkage strain = $3x10^{-4}$ for pretensioning and $2x10^{-4}$ for post-tensioning, slip at anchorage=1mm, Frictional coefficient for wave effect=0.0020 per m.
4. Determine the short term deflection at the centre of beam having rectangular section 150mmwide and 350mm deep is prestressed by a parabolic cable carrying an initial force of 250kN. The cable has an eccentricity of 50mm at the centre of the span and is concentric at the supports. The span of the beam is 8m and the live load is 3 kN/m. E= 38N/mm^2, loss of prestress = 20% and creep coefficient is 2.0. Also estimate the long term deflection at the centre of span at this stage, assuming that the dead and live loads are simultaneously applied after the release of prestress.

CO2: Analyse and design the flexural members

1. Write down the formula for finding the ultimate shear resistance of a prestressed concrete section uncracked in flexure.
2. Give the IS specifications for the spacing of stirrups in prestressed concrete.
3. Explain problems involving in launching and erection of prestressed concrete girders.
4. Determine shear resistance of uncracked section at supports and design the shear reinforcement for a prestressed concrete beam of rectangular section 150mm x 300mm which is prestressed by a straight cable placed at an eccentricity 50mm below the neutral axis carrying an effective prestress of 180 kN. The beam supports an UDL of 18 kN/m including self-weight. Take fck=40 MPa and span=8m.
5. Design suitable shear reinforcement for a prestressed concrete beam using IS: 1343-1980 recommendations. The post tensioned prestressed concrete beam is of rectangular section 300mm wide x 700mm deep which is prestressed by an effective

force of 200 kN acting at an eccentricity of 200mm. At service load conditions, the section of beam is subjected to a bending moment of 220 kN-m and a transverse shear force of 90 kN. Assume f_{ck} = 40 N/mm^2, f_y = 415 N/mm^2, f_p = 1600 N/mm^2,. A_p = 250mm^2, f_{pe} = 800MPa.

6. Design the reinforcement required in the transmission zone for a prestressed concrete beam of 250mm wide and 600mm deep which is subjected to a total prestressing force of 1500kN. This force is transmitted by two symmetrically arranged cables each transmitting a force of 750kN. Two anchor plates 200mm wide and 240mm deep are provided one for each cable.

C03: Design the tension and compression members

1. Design the reinforcement required per meter height and the thickness of concrete required for a prestressed concrete tank of diameter 10m which has to resist an internal pressure head of 4m of water. Take Fc=Ultimate strength of concrete = 40 N/mm^2, fc=safe stress in concrete=0.5Fc at transfer, fs=1300 N/mm^2, loss of prestress =20%, m=8.0
2. Design a simply supported prestressed concrete slab for the following conditions. Span of the slab is 13m. Safe stress in concrete is 14N/mm^2. Safe stress in steel is 1200N/mm^2. Super imposed load is 23 kN/m^2.
3. Design a non-cylinder prestressed pipe of 600mm diameter to withstand a working pressure of 1 N/mm^2 and calculate the test pressure required to produce a tensile stress of 0.7 N/mm^2 in the concrete when applied immediately after tensioning. F_{et}=14 N/mm^2 and k=0.80.
4. Design a cylindrical prestressed water tank of internal diameter 32m and height 8m. Compressive stress in concrete is not to exceed 12.5 N/mm^2 at transfer. Minimum compressive stress at working loads is to be 1 N/mm^2. The prestress is to be provided by a circumferential winding of 6m diameter wire and 12 numbers of 5mm dia vertical cable wires in which the stress at transfer is 900 N/mm^2 and k=0.75.

CO4: Analyse the continuous members

1. Define the term: primary and secondary moments
2. Explain concordant cable profile
3. Give the advantages of providing continuous prestressed concrete members.
4. Calculate the extreme stresses in concrete at the section over the middle support of two equal span prestressed concrete continuous beam ABC, in which the tendon has an eccentricity of 0.05m at support A and is bent sharply at a distance of 4m from A having an eccentricity of 0.12m in the span AB below the centre of the beam. And the tendon has an eccentricity of 0.15m at the support B above the centre of the beam. Then the tendon has a parabolic profile for the span BC having mid point eccentricity of 0.15m below the centre of the beam and zero at the support C. Also locate the line of pressure (C-line) due to prestress alone. The prestressing force is 1200 kN. The size of the beam is 300mm x 600mm.

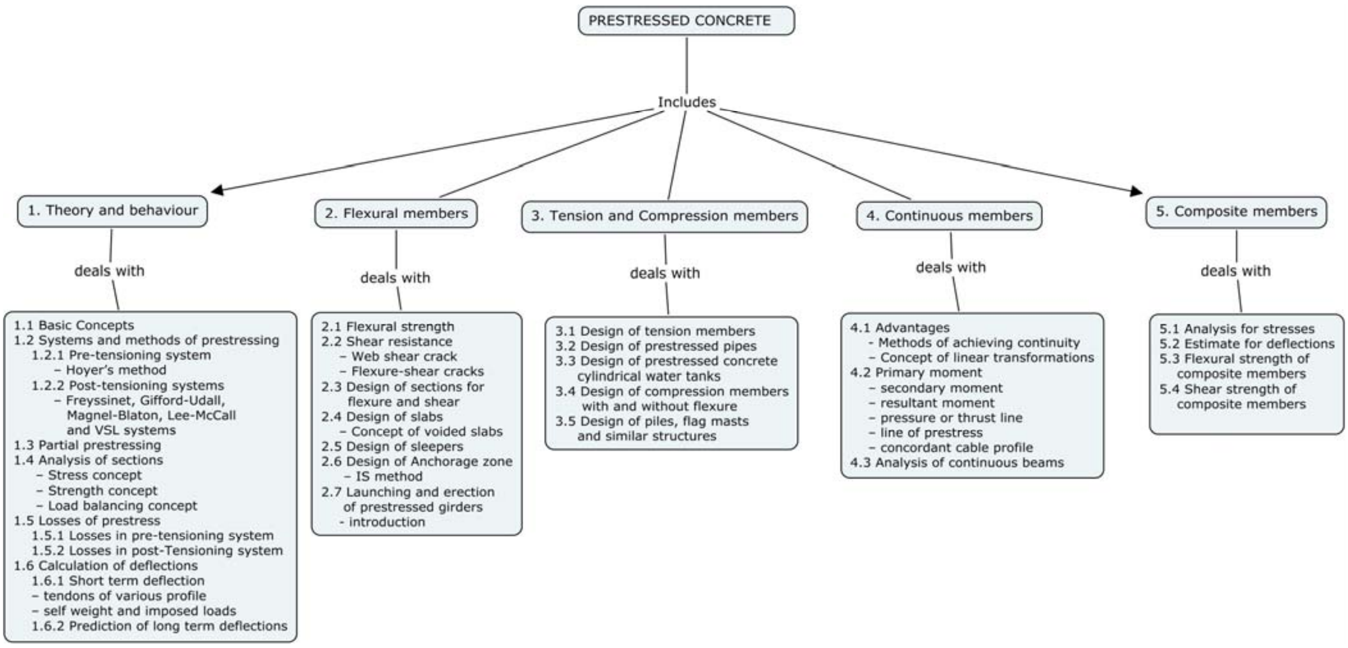
CO6: Analyse the composite members and determine strength and deflection

1. Distinguish between unpropped and propped method of composite construction.
2. Draw the stress distribution for propped prestresssed concrete construction.
3. Calculate the resultant stress developed in the precast and in-situ cast concrete when the beam is propped during the casting of slab. The size of the beam is 125mm x 250mm. Assume the same modulus of elasticity for concrete in precast beam and in-situ cast slab. The beam with an effective span of 5m is prestressed by tendons with their centroids coinciding with the bottom kern. The initial force in the tendons is 160 kN. The

loss of prestress may be assumed to be 15%. The beam is incorporated in a composite T-beam by casting a top flange of breadth 450mm and thickness 50mm. The composite beam supports a live load of 8 kN/m^2.

4. Compute the deflection for a composite T-beam for if it supports an imposed load of 3.2 kN/m for: (a) unpropped construction, and (b) propped construction. The composite T shaped girder is of span 5m is made up of a pre-tensioned rib, 100mm wide by 200mm deep, with an in-situ cast slab, 400mm wide and 40mm thick. The rib is prestressed by a straight cable having an eccentricity of 33.33mm and carrying an initial force of 150 kN. The loss of prestress may be assumed to be 15%. Assume a modulus of elasticity of 35 kN/mm^2 for both precast and in situ cast elements. Evaluate the deflection of above composite section with other prestressed concrete sections.

Concept Map



Syllabus

Theory and behavior - Basic concepts - Systems and methods of prestressing – Analysis of sections – Stress concept – Strength concept – Load balancing concept – Partial prestressing - Losses of prestress - Calculation of deflections – 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 – Design of sleepers **-** Design of Anchorage zone – IS method - Launching and erection of prestressed girders – introduction **- Tension and Compression members -** Design of tension members - Application in the design of prestressed pipes and prestressed concrete cylindrical water tanks - Design of compression members with and without flexure - Design of piles, flag masts and similar structures **- Continuous members -** Advantages - Methods of achieving continuity – Concept of linear transformations - Primary moment – secondary moment – resultant moment – pressure or thrust line – line of prestress – concordant cable profile - Analysis of continuous beams - **Composite members** - Analysis for stresses – Estimate for deflections – Flexural and shear strength of composite members.

Reference Books

1. Arthur H. Nilson, “Design of Prestressed Concrete”, John Wiley & Sons, New York, 1987.
2. Dayaratnam P, “Prestressed Concrete Structures”, Oxford and IBH, New Delhi, 2003.
3. James R. Libby, ‘Modern Prestressed Concrete: Design principles and Construction methods” - Van Standard Rainford Co., New York, 1994
4. Krishna Raju N., “Prestressed Concrete”, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2003.
5. Lin T.Y., & Ned. H. Burns, “Design of Prestressed Concrete Structures”, John Wiley & Sons, New York, 2010.
6. Rajagopalan N., “Prestressed Concrete”, Narosa Publishing House, New Delhi, 2002
7. Sinha N.C. & Roy S.K., “Fundamentals of Prestressed Concrete”, S.Chand & Company Ltd, New Delhi, 1999.

List of national and international standards

1. IS 1343:1980 Code of Practice for Pre Stressed Concrete
2. IS 3370 (Part 3):1965 Code of Practice for Concrete Structures for the Storage of Liquids- Part 3 Pre stressed Concrete
3. IS 3370 (Part 4):1965 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):1979 Code of Practice for Design and Construction of Pile Foundations
6. Part 1 Concrete Pile; Section 3 Driven Precast Concrete Piles
7. IS 2911 (Part 1/Sec 4): 1984 Code of Practice for Design and Construction of Pile Foundation
8. 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	Basic Concepts	1
1.2	Systems and methods of prestressing	
1.2.1	Pre-tensioning system – Hoyer’s method	1
1.2.2	Post-tensioning systems – Freyssinet, Gifford-Udall, Magnel-Blaton, Lee-McCall and VSL systems	2
1.3	Partial prestressing	1
1.4	Analysis of sections – Stress concept – Strength concept – Load balancing concept	2
1.5	Losses of prestress	

1.5.1	Losses in pre-tensioning system	1
1.5.2	Losses in post-Tensioning system	1
1.5.3	Tutorial	2
1.6	Calculation of deflections	
1.6.1	Short term deflection – tendons of various profile – self weight and imposed loads	2
1.6.2	Prediction of long term deflections	1
1.6.3	Tutorial	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	1
2.5	Design of sleepers	1
2.6	Design of Anchorage zone – IS method	1
2.7	Tutorial	2
2.8	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	1
3.5	Design of piles, flag masts and similar structures	1
3.6	Tutorial	2
4. Continuous members		
4.1	Advantages-Methods of achieving continuity – Concept of linear transformations	1
4.2	Primary moment – secondary moment – resultant moment – pressure or thrust line – line of prestress – concordant cable profile	1
4.3	Analysis of continuous beams	1
4.4	Tutorial	2
5. Composite members		
5.1	Analysis for stresses	1
5.2	Estimate for deflections	1
5.3	Flexural strength of composite members	2

5.4	Shear strength of composite members	1
5.5	Tutorial	2
	Total Hours	**48**

Course Designers:

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15SE160	FORENSIC ENGG. AND REHABILITATION OF STRUCTURES	Category	L	T	P	Credit
		PE	4	0	0	4

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 phenomena 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.

Prerequisite

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

CO1: Analyse the type of failures of structures and its causes	Analyse
CO2: Assess the failures using various testing techniques	Evaluate
CO3: Analyse the causes of failure due to environmental conditions and natural hazards.	Analyse
CO4: Provide solutions for retrofiitting and rehabliation of structures after carrying out vaious case studies	Evaluate

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	40	30	30	30
Analyse	40	30	30	30
Evaluate	--	20	20	20
Create	--	--	--	--

Course Level Assessment Questions

CO1: Analyse the type of failures of structures and its causes

1. Define the term: Distress in a structural member.
2. List out the various types of failures and its causes.
3. Explain in detail about the failures occurring in a structural member due to design and material deficiencies and its corrective measures.

CO2: Assess the failures using various testing techniques

1. Bring out the criterions by which visual inspection will be done to ascertain the distress.
2. List out the merits and demerits of Non-destructive testing.
3. Explain in detail about the working principle, methodology and limitations of Ultrasonic pulse velocity tester.
4. Describe about the fibre optic technology, which is used for predicting structural weakness.
5. Discuss the procedure for performing the pull out test and its limitations.
6. Compare the various NDT techniques in assessing the failure of a structure.

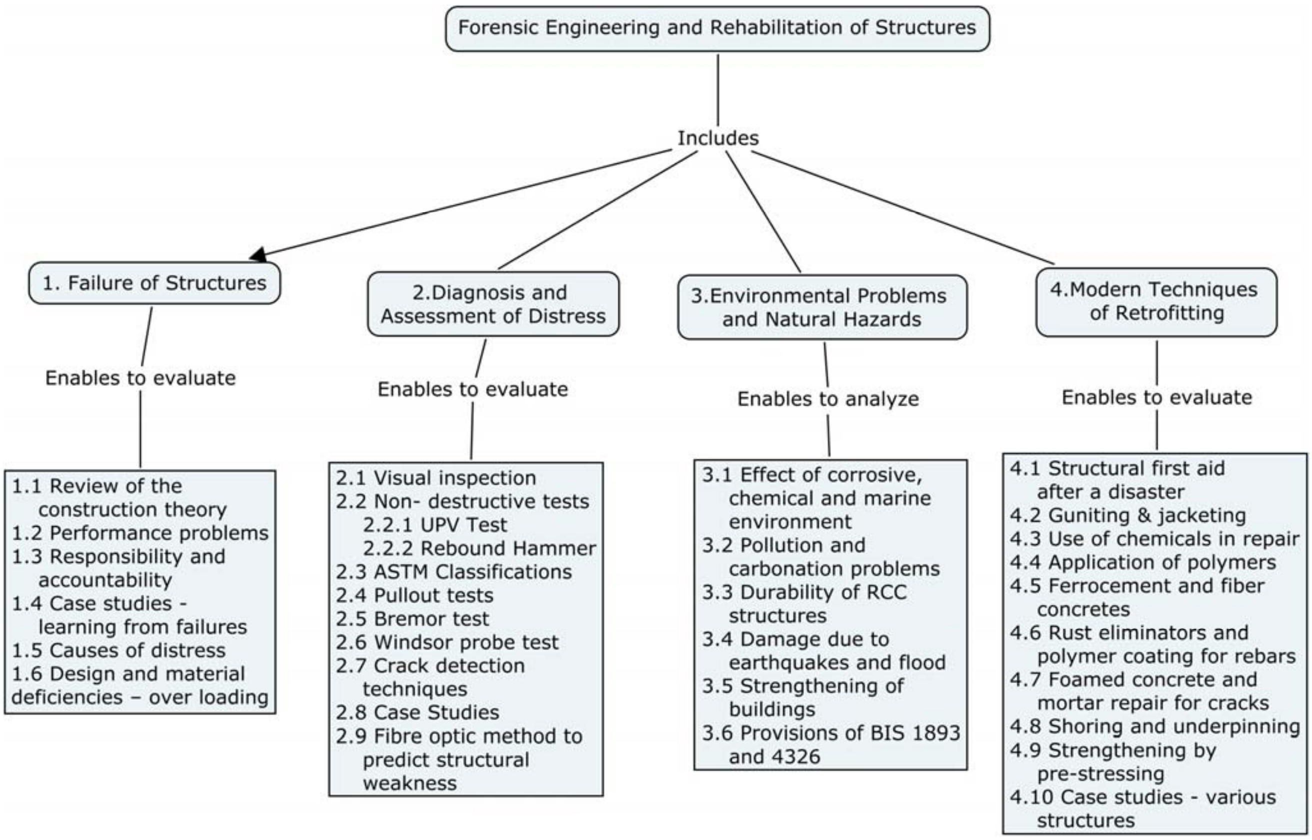
CO3: Analyse the causes of failure due to environmental conditions and natural hazards

1. Explain in detail about the factors affecting the durability of RCC structure.
2. Discuss in detail about the remedial measures on a structure which was subjected to earthquake in reference with the Indian standard codal provisions.
3. Define the term "carbonation" and explain the factors influencing it.

CO4: Provide solutions for retrofiitting and rehabliation of structures after carrying out vaious case studies

1. Define the term: Jacketing.
2. Distinguish between rehabilitation and retrofitting of structure.
3. Explain in detail about the various strengthening techniques that can be taken for a heritage building.
4. Mention the types of polymers, which are used to increase the performance of structure.
5. Discuss the various methods for preventing the reinforcement from corrosion.
6. As a rehabilitation engineer, provide suitable retrofitting method for member having low strength.

Concept Map



Syllabus

Failure of Structures - review of the construction theory, performance problems, responsibility and accountability, case studies, learning from failures, causes of distress in structural members, design and material deficiencies, over loading; **Diagnosis and Assessment of Distress** - 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 multistorey buildings, fibreoptic method for prediction of structural weakness; **Environmental Problems and Natural Hazards** - effect of corrosive, chemical and marine environment, pollution and carbonation problems, durability of RCC structures, damage due to earthquakes and flood- strengthening of buildings, provisions of BIS 1893 and 4326; **Modern Techniques of Retrofitting** - structural first aid after a disaster, guniting, jacketing, use of chemicals in repair, application of polymers, ferrocement and fiber concretes as rehabilitation materials, rust eliminators and polymer coating for rebars, foamed concrete, mortar repair for cracks, shoring and underpinning, strengthening by pre-stressing; **Case studies** – buildings, heritage buildings, high rise buildings, water tanks, bridges and other structures

Reference Books

1. Allen R.T and Edwards S.C, "Repair of Concrete Structures", Blakie and Sons, UK, 1987
2. Dayaratnam.P and Rao.R, "Maintenance and Durability of Concrete Structures", University Press, India, 1997.
3. Denison Campbell, Allen and Harold Roper, "Concrete Structures, Materials, Maintenance and Repair", Longman Scientific and Technical, UK, 1991.
4. Gary L. Lewis, "Guidelines for Forensic Engineering Practice", ASCE, U.S.A., 2003.
5. Guha R. K., "Maintenance and Repairs of Buildings", New Central Book Agency (P) Ltd, Calcutta, 1985.
6. Johnson S. M., Deterioration, "Maintenance and Repair of Structures", McGraw-Hill Book Company, Newyork, 1965.
7. Natarajan C., R. Janardhanam, Shen-En Chen, Ryan Schmidt, Ino-U.S. "Forensic Practices - Investigation Techniques and Technology", NIT, Tiruchirappalli, 2010.
8. Peter H.Emmons, "Concrete Repair and Maintenance Illustrated", Galgotia Publications pvt. Ltd., 2001.
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List Of National And International Standards

1. SP25-84 – Hand Book on Causes and Prevention of Cracks on Buildings, Indian Standards Institution, New Delhi, 1984.
2. EN1992-96 – European standards for design and detailing.
3. EN206-1 – European standards for Concrete: specifications, performance, production and conformity.
4. Euro Code 8 – Design Provisions for Earthquake Resistance of Structures – Part 1-4 General Rules for Strengthening and Repair of Buildings

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Failure of Structures		
1.1	Review of the construction theory	1
1.2	Performance problems	1
1.3	Responsibility and accountability	1
1.4	Case studies - learning from failures	2
1.5	Causes of distress in structural members	2
1.6	Design and material deficiencies – over loading	2
2. Diagnosis and Assessment of Distress		
2.1	Visual inspection	1
2.2	Non- destructive tests	

2.2.1	Ultrasonic pulse velocity method	2
2.2.2	Rebound hammer technique	1
2.3	ASTM classifications	1
2.4	Pullout tests – Bremor test, Windsor probe test	2
2.5	Crack detection techniques	2
2.6	Case studies – single and multistorey buildings	1
2.7	Fibre optic method for prediction of structural weakness	1
3. Environmental Problems and Natural Hazards		
3.1	Effect of corrosive, chemical and marine environment	2
3.2	Pollution and carbonation problems	2
3.3	Durability of RCC structures	2
3.4	Damage due to earthquakes and flood	2
3.5	Strengthening of buildings	2
3.6	Provisions of BIS 1893 and 4326	1
4. Modern Techniques of Retrofitting		
4.1	Structural first aid after a disaster	1
4.2	Guniting and jacketing	2
4.3	Use of chemicals in repair	2
4.4	Application of polymers	1
4.5	Ferrocement and fiber concretes as rehabilitation materials	2
4.6	Rust eliminators and polymer coating for rebars	1
4.7	Foamed concrete- mortar repair for cracks	2
4.8	Shoring and underpinning	1
4.9	Strengthening by pre-stressing	2
4.10	**Case studies**	
4.10.1	Buildings - heritage buildings- high rise buildings	2
4.10.2	Water tanks – bridges and other structures	1
	Total periods	**48**

Course Designers:

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15SE170	STRUCTURAL ENGINEERING LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

The objective of this laboratory course is to impart knowledge on mix design, testing of fresh and hardened concrete, the moment rotation behaviour RC beam, axial compressive strength behaviour of RC column, NDE of concrete material and also analysing and designing of RC and Steel members 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

CO1: Design a nominal mix for concrete by IS method and cast specimens	Apply
CO2: Conduct test on fresh and hardened concrete through DTs and NDTs	Analyze
CO3: Interpret the axial compressive behaviour of RC column	Analyze
CO4: Understanding the moment rotation behaviour of RC beam	Analyze
CO5: Design RC elements and simple structures	Create
CO6: Design steel elements and trusses	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

List of Experiments

1. Design of concrete mix by IS method and casting
2. Test on fresh concrete
   (a) Slump cone test

(b) Compaction Factor test

3. Test on hardened concrete- Study of stress and strain characteristics, and determination of Young's modulus- Split Tensile Test
4. a)Test on hardened concrete using Non - Destructive Testing Techniques
   i. Ultrasonic method
   ii. Rebound Hammer method
   iii. Comparison of destructive test results with the NDT results
5. Study on Axial compressive strength of RC column
6. Study of Moment rotation behavior of RC beam
7. Design of RC elements using software and validating the software results with manual calculations using Excell spread sheet.
8. Design simple RC framed structure using software and detailing the rebars.
9. Design of elemental steel members using software and validating the results with manual calculations using Excell spread sheet.
10. Design a small to medium span trusses using software and details the members and joints.
11. Determination of Endurance Limit using Fatigue testing machine (Demo)
12. Determination of material fringe value using Transmission Polariscope (Demo)
13. Determination of damping coefficient from free vibration and evaluate mode shapes by Dynamic testing of cantilever steel beam (Demo)

Course Designers:

1. S. Arul Mary samciv@tce.edu

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15SE210	DYNAMICS OF STRUCTURES	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

This course deals with the dynamic analysis of various degrees of freedom system. The dynamic response of single degree of freedom system with damping subjected to harmonic excitation. This course deals with the response of linear two and multi degree of freedom systems with regard to natural frequencies and mode shapes. This course also deals with base isolation technique and dynamic analysis of machine foundation.

Prerequisite

Fundamentals of Mathematics, knowledge of basic Science.

Course Outcomes

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

CO1	Analyse the single degree of freedom with free vibration.	Analyse
CO2	Analyse the single degree of freedom forced vibration with harmonic excitation.	Analyse
CO3	Analyse the two degree of freedom with free vibration.	Analyse
CO4	Analyse the two degree of freedom forced vibration with harmonic excitation.	Analyse
CO5	Analyse the Multi degree of freedom with free and forced vibration.	Analyse
CO6	Apply the principle of vibration to the sub structure design.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	30	30	30	30
Analyse	50	50	50	50
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1: Analyse the single degree of freedom with free vibration.

1. Deduce the expression for viscous damping and criticize various damping system.
2. Calculate the natural frequency of the system shown in fig1. The mass of the beam is negligible in comparison to the suspended mass. E =2x 10^5 N / mm^2 .

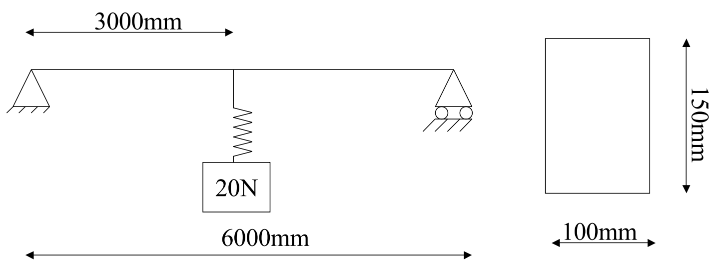


Fig 1

3. Deduce the expression for Logarithmic decrement and prove that $\delta = 2\Pi\xi$ for damped free vibration.
4. A single degree of freedom system having a mass of 2.5 kg is set into motion with viscous damping and allowed to oscillate freely. The frequency of oscillation is found to be 20Hz and measurement of the amplitude of vibration shows two successive amplitudes to be 6mm and 5.5mm. Calculate the viscous damping coefficient.

CO2: Analyse the single degree of freedom forced vibration with harmonic excitation.

1. An SDOF system consists of a mass of 20 kg, a spring of stiffness 2200N/m and a dashpot with a damping coefficient of 60N-s/m is subjected to harmonic excitation of F=200 sin 5t. write the complete solution of the equation of motion.
2. Deduce the expression for damped harmonic excitation.
3. Write a steady state response of undamped harmonic excitation with transient vibration

CO3: Analyse the two degree of freedom with free vibration.

1. Calculate the natural frequency and amplitude ratio of the system for two degree of freedom system of your choice by using Lagrange's equation.

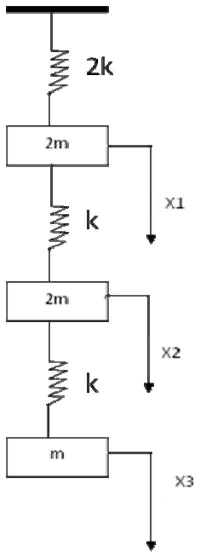
2. Deduce the expression response spectra for two degree of freedom undamped free vibration.
3. Calculate the natural frequencies and normal mode of this mode for a cantilever bar is to be modelled by a massless uniform bar to which are attached with two lumped masses representing the mass of original system as K=2AE/L and m=αAL.

CO4: Analyse the two degree of freedom forced vibration with harmonic excitation.

1. Explain coordinate coupling of two degree of freedom system and derive amplitude ratio and frequencies.
2. Examine measurement of damping using half-power bandwidth method.
3. Deduce the expression for damped forced vibration with harmonic excitation.

CO5: Analyse the Multi degree of freedom with free and forced vibration.

1. Deduce the expression for the response of Multi degree of freedom system for free undamped vibration.
2. Deduce the expression for the response of Multi degree of freedom system for forced damped vibration.
3. Calculate the natural frequency and mode shape as shown in fig



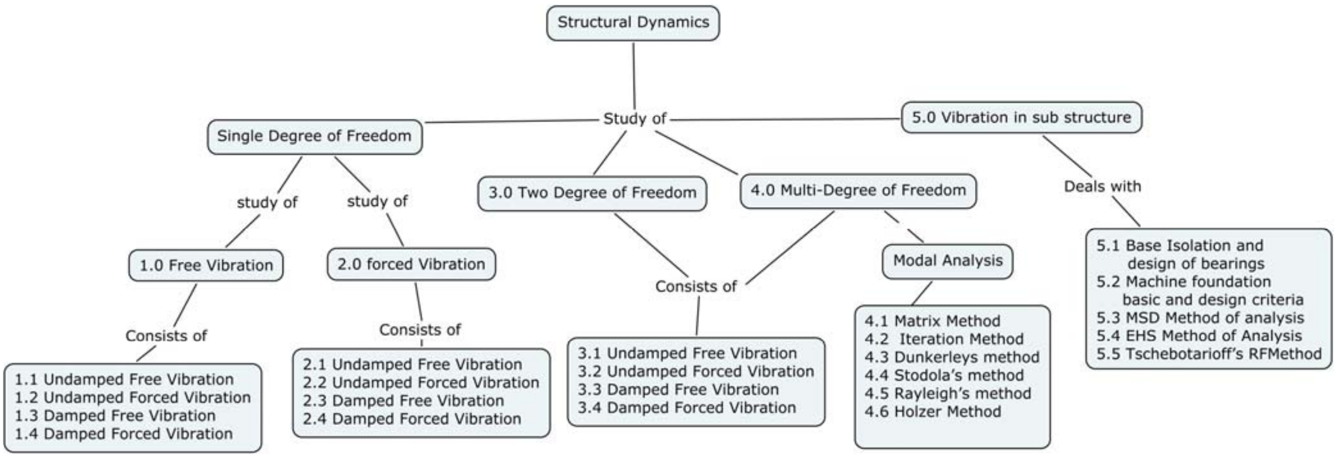
Fig

4. Calculate the vertical deflection of cantilever beam is subjected to free end mass(m) using Rayleigh method. Using function of $x= 3y/L^3 (Lx^2/2 - x^3/6)$.
5. Investigate in detail Dunkerleys method and Stodola's method of modal analysis.
6. Calculate lateral force with subjected to static and dynamic condensation.

CO6: Apply the principle of vibration to the sub structure design

1. Explain in detail base isolation techniques.
2. List out different types of bearings with neat sketches.
3. Enumerate basic and design criteria of MSD Method of analysis and EHS Method of Analysis.
4. Differentiate MSD Method of analysis and EHS Method of Analysis.
5. Explain in detail Tschebotarioff's reduced frequency method.

Concept Map



Syllabus

Introduction to vibration and Damping: Simple Harmonic motion-Longitudinal Vibrations Equation of motion- SDOF analysis-Undamped SDOFs- dynamic equation of motion- D'Alemberts principle- equivalent stiffness-Springs connected in series and parallel-frequency and period Amplitude of motion- Energy method for the equation of motion-Damped SDOFs- underdamped and overdamped -Damped SDOFs- critically damped Logarithmic decrement ,method of determining damping. **Forced vibration of single degree of freedom system:** Undamped harmonic excitation. Damped harmonic excitation-Evaluation of damping at resonance-Response to support motion Torsional vibration-Dynamic Magnification Factor. **Two degrees of freedom:** Principle modes of vibration and equation of motion for two degree of freedom-Two degrees of freedom for torsional system-Vibrations of undamped Two degrees of freedom-Forced Vibrations-Undamped forced vibration for two degrees of freedom -Orthogonality Principle. **Multi degree of freedom system:** Equation of motion of multi degree of freedom-Stiffness, mass and damping matrices. Influence Coefficient-Eigen vector normalisations, problems-Modal co-ordinates. Introduction of modal analysis-Matrix Method –Rayleigh Method – Holzer Method -Dunkerleys method -Natural frequencies and mode shapes-Modal analysis – damped undamped free vibration. **Vibration Analyse in Sub Structure-** Base Isolation and design of bearings- Machine foundation- types , basic and design criteria- MSD Method of analysis-EHS Method of Analysis- Tschebotarioff's reduced frequency method- design problems.

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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. Introduction to vibration and Damping		
1.1	Free vibration of single degree of freedom systems, Simple Harmonic motion	1
1.2	Longitudinal Vibrations Equation of motion, SDOF analysis	1
1.3	Undamped SDOFs- dynamic equation of motion with electrical equivalent	1
1.4	Newtons law of motion, D’Alemberts principle- equivalent stiffness	1
1.5	Springs are connected in series and parallel, frequency and period, problems	1
1.6	Amplitude of motion, Energy method for the equation of motion	1
1.7	Damped SDOFs- underdamped, overdamped and critically damped	1
1.8	Logarithmic decrement ,method of determining damping	2
2. Forced Vibration of Single Degree of Freedom		
2.1	Forced vibration of single degree of freedom system	1
2.2	Undamped harmonic excitation	1
2.3	Damped harmonic excitation with electrical equivalent	1
2.4	Response to support motion Torsional vibration and Dynamic Magnification Factor	1
2.5	Impulsive loading problems using Fourier series	2
2.6	Forced vibration problems using Laplace transform method	1
2.7	Numerical evaluation of Duhamel’s integral for damped system	2
3. Two Degree of Freedom		
3.1	Two degrees of freedom	1
3.2	Principle modes of vibration and equation of motion for two degree of freedom	1

3.3	Two degrees of freedom for torsional system, Vibrations of undamped Two degrees of freedom	2
3.4	Forced Vibrations and Undamped forced vibration for two degrees of freedom	1
4. Multi Degree of Freedom		
4.3	Stiffness, mass, damping matrices and Influence Coefficient	1
4.4	Modal analysis – damped undamped free vibration	2
4.5	Matrix Method and Matrix Iteration Method	1
4.6	Dunkerleys , Stodola's , Rayleigh's and Holzer Method	1
4.8	Dynamic analysis method to evaluate lateral forces, Static and dynamic condensation	2
5.Vibration Analyse in Sub Structure		
5.1	Base Isolation and design of bearings	1
5.2	Machine foundation- types , basic and design criteria	1
5.3	MSD Method of analysis	1
5.4	EHS Method of Analysis	1
5.4	Tschebotarioff's reduced frequency method- design problems	2
	Total Hours	36

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		Category	L	T	P	Credit
15SE220	**STRUCTURAL STEEL DESIGN**	PE	3	1	0	4

Preamble

This course deals with the plastic analysis of structures. The design and detailing of members subjected to torsion and bending, towers, masts, and chimneys were dealt in detail. In addition design of cold formed steel sections is also discussed.

Prerequisite

Knowledge of structural analysis, steel member design and foundation design

Course Outcomes

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

CO1: Analyse the continuous beam and frames using plastic theory	(Analyse)
CO2: Design the member under combined torsion and bending	(Create)
CO3: Design the Tower, masts and tower foundation	(Create)
CO4: Design the self-supporting and guyed chimneys	(Create)
CO5: Design the moment resistant end plate connections	(Create)
CO6: Design the cold formed steel cross sections under axial / bending effects	(Create)

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

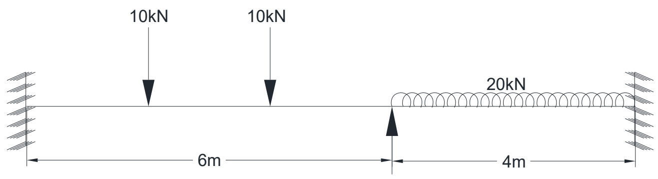
Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	20	20	20	20
Evaluate	-	-	-	-
Create	40	40	40	40

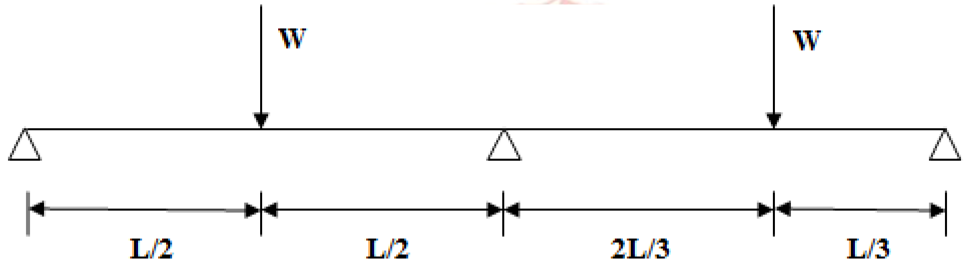
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A two span fixed continuous beam of uniform cross section loaded with ultimate load as shown in figure. Determine the required plastic moment of resistance.

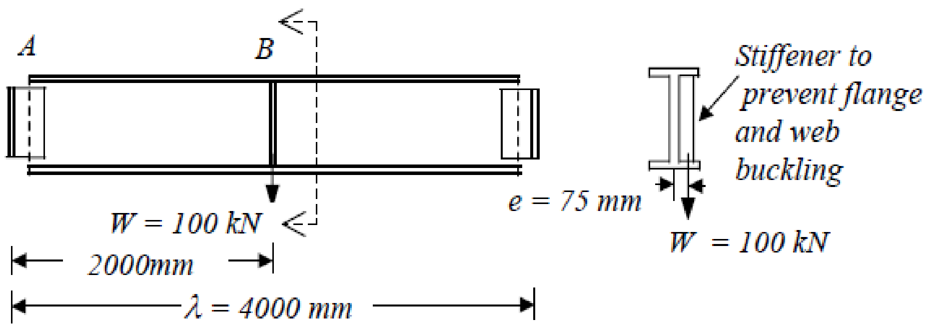


2. ABCD is a rectangular portal frame with the bases A and D fixed. Column AB is 4 m and DC is 6 m in height, so that the horizontal beam BC is 6 m long. E and F are mid-points of AB and BC respectively. It carries horizontal forces W each at E and B, and a vertical downward force of 2W at F. Determine the collapse load W for uniform M_p. Draw the bending Moment diagram.
3. Determine the collapse for the continuous beam as shown in figure. The beam is of uniform cross section.



Course Outcome 2 (CO2):

1. Show an example where the warping is restrained in a torsion member and also sketch the torsional behaviour
2. Derive the state of stress in a non circular member subjected to non uniform torsion under the two cases a) ends are restrained against warping b) ends free against warping.
3. The beam shown below is unrestrained along its length. An eccentric load is applied to the bottom flange at the centre of the span in such a way that it does not provide any lateral restraint to the member. The end conditions are assumed to be simply supported for bending and fixed against torsion but free for warping. For the factored loads shown, check the adequacy of the trial section.



Course Outcome 3 (CO3):

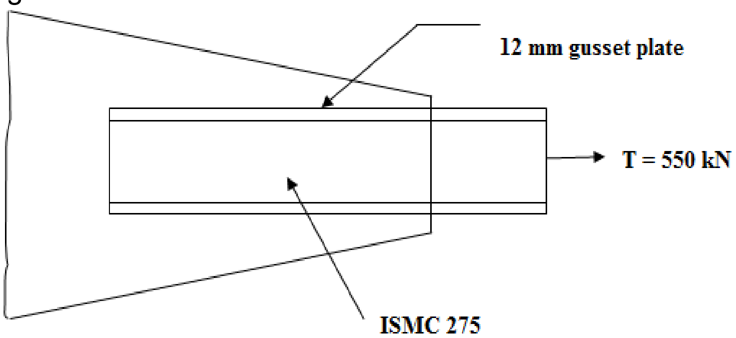
1. Evaluate the various loads on a transmission line tower of capacity 220kV and its calculation procedures.
2. Design a member of a transmission line tower to transmit a factored compressive force of 150kN and tensile force of 80kN. The length of the member is 3.5m. Assume that the conditions at both ends are simply supported. Use fy=250MPa
3. Discuss in detail about the load calculation on the transmission line tower.

Course Outcome 4 (CO4):

1. Design for Delhi a self-supporting steel stack 72m above the foundation. The diameter of the cylindrical part of the chimney is 3m. The foundation has to rest on medium soil having bearing capacity of 200kN/m^2. The thickness of fire brick work lining is 100mm, the lining is supported by the stack throughout the height. The chimney has one breech opening. The topography at the site is almost flat, and the location is of terrain category is 2.
2. Design a self-supporting welded chimney as per IS : 6533 – 1989 for the following design parameter:
    a. Height of Chimney - 48 m
    b. Diameter of Chimney - 2.5 m
    c. Terrain category 2 , Class B Building , Flat Topography, V_b = 55 m / s
    d. Thickness of Fire brick lining - 100 mm
    e. Additional thickness for corrosion - 3 mm
3. Describe the guy wire force system for a two stage stiffened Mast and other load calculations on the same.

Course Outcome 5(CO5):

1. For the connection of member with gusset plate shown in figure, determine the number of bolts required if the slip is not permitted. The bolts used are 24 mm diameter, high strength type of grade 8.8



2. An Industrial building of plan 15m×30m is to be constructed at Noida. Analyze the single span portal frame with gabled roof and design a corner connection with haunch. The frame has a span of 15 m, the column height is 6m and the rafter rise is 3 m and the frames are spaced at 5 m centre-to-centre. Purlins are provided over the frames at 1.3 m c/c and support AC sheets. The dead load of the roof system including sheets, purlins and fixtures is 0.4 kN/m2 and the live load is 0.52 kN/m2. The portal frames support a gantry girder at 3.25 m height, over which an electric overhead travelling (EOT) crane is to be operated. The crane capacity is to be 300 kN and the crane girder weighs 300 kN while the crab (trolley) weight is 60 kN.
3. Distinguish between flush and extended end plate connections.

Course Outcome 6(CO6):

1. The built up two stiffened channel section of dimension shown in figure-1 are used as a simply supported beam to span about 6m long. Determine the deflection in the beam in the beam when the udl causes the max allowable moment at the mid span section. The maximum allowable moment is 512 kg-m.

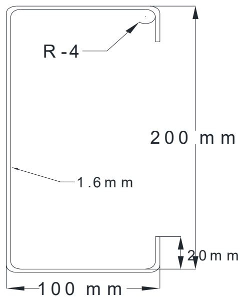


Figure-1

2. An I section shown in figure-2 is used as an axially loaded compression member having an effective length of 4.5m. If it is made of St-42-1079 steel [Fy=2400kg/mm^2, F=1450kg/mm^2] determine the allowable load on the column.

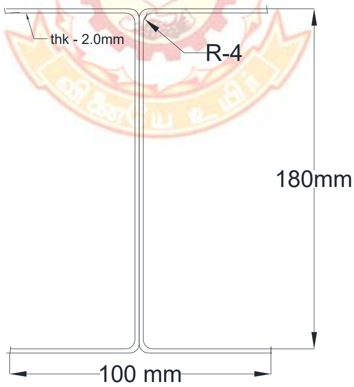


Figure-2

3. Two channels 200x80 with bent lips are connected with webs to act as beam as shown in figure-3. The thickness of the plate is 2.5mm and the depth of lip is 25mm. The beam has a effective span of 4m and is subjected to a total udl of 8.86kN/m. Estimate the design bending capacity of beam and also check its shear capacity.

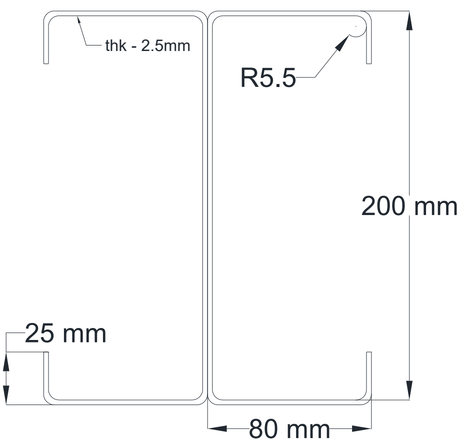
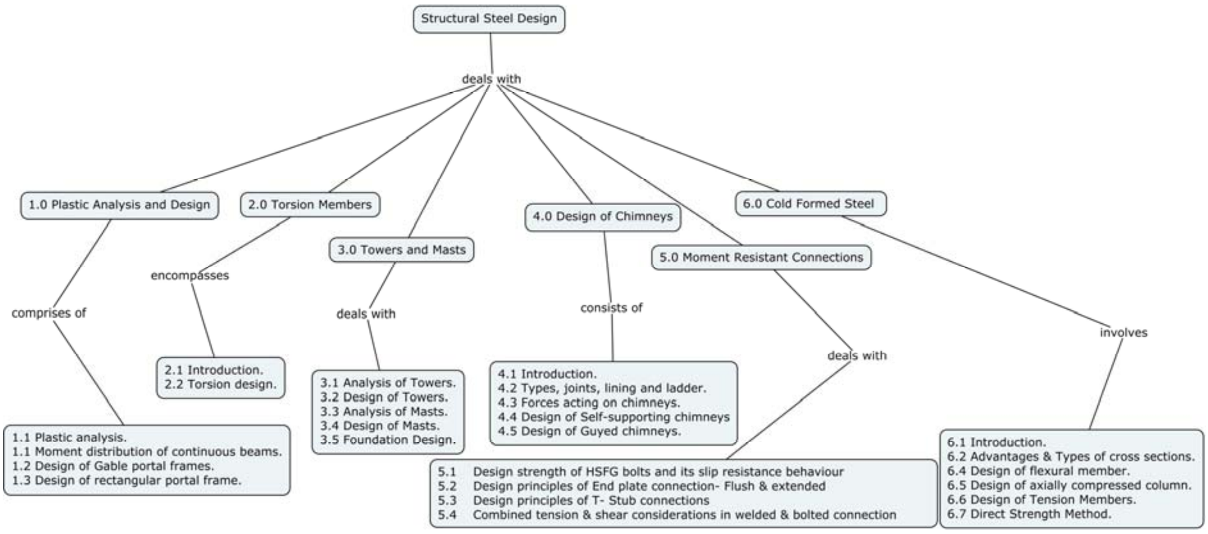


Figure-3

Concept Map



Syllabus

Plastic Analysis and Design: 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. **Torsion Members:** Introduction – uniform torsion – non uniform torsion - Torsion design – distortion. **Towers and Masts:** Analysis of Towers Design of Towers - Analysis of Masts - Design of Masts - Foundation design. **Design of chimneys:** Introduction to chimneys - Types, joints, lining and ladder- Chimneys - Forces acting on chimneys - Design of Self-supporting chimneys - Design of Guyed chimneys. **Moment Resistant Connections:** Design strength of HSFG bolts and its slip resistance behaviour- Design principles of End plate connection- Flush & extended - Design principles of T- Stub connections - Combined tension & shear considerations in welded & bolted connection - problems. **Cold Formed Steel:** Introduction to cold formed steel - Advantages of cold formed steel sections – Types of cross sections – local buckling and lateral buckling - Design of flexural member - Design of axially compressed column - Combined bending and compression - Design of Tension Members - Direct Strength Method

Reference Books

1. Dayaratnam.P, "Design of Steel Structures", A.H.Wheeler, India, 2007.
2. Englekirk R, "Steel Structures: Controlling Behaviour through Design", John-Wiley & Sons, Inc, 2003.
3. John E. Lothers, "Design in Structural Steel", Prentice Hall of India, New Delhi, 1990.
4. Linton E. Grinter, "Design of Modern Steel Structures", Eurasia Publishing House, New Delhi, 1996.
5. Lynn S. Beedle, "Plastic Design of Steel Frames", John Wiley and Sons, NewYork, 1990.
6. Subramanian N," Design of Steel Structures", Oxford University Press, New Delhi, 2008.
7. Teaching resource for, "Structural Steel Design," Volume 1, 2 & 3, Institute for Steel Development and Growth (INSDAG), 2002.

8. 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.
9. Wie Wen Yu, “Design of Cold Formed Steel Structures”, Mc Graw Hill BookCompany, New York, 1996.

List of National and International Standards

1. IS 800-1984, Code of practice for General construction in Steel, BIS, New Delhi.
2. IS 800: 2007, Code of practice for General construction in Steel, BIS, New Delhi.
3. IS 801 - 1975, Code of Practice for use of cold formed light gauge steel structural member’s in general building construction, BIS, New Delhi.
4. IS 811 – 1987, Specification for cold formed light gauge structural steel sections, BIS, New Delhi.
5. IS 875-1987 (Part1-5), Code of practice for design load (other than Earth quake) for building and structures, BIS, New Delhi.
6. IS 6533 – 1989 (Part 2), Code of practice for design and construction of steel chimney (structural aspects), BIS, New Delhi.
7. 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 Lectures
1.0	**Plastic Analysis and Design**	
1.1	Plastic analysis – theory & assumptions, yield criteria, plastic modulus & shape factor	2
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	2
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	**Torsion Members**	
2.1	Introduction – uniform torsion – non uniform torsion	2
2.2	Torsion design – distortion	1
2.2.1	Tutorial – Torsion Design	1
3.0	**Towers and Masts**	
3.1	Analysis of Towers	2
3.2	Design of Towers	1
3.2.1	Tutorial - Design of Towers	1
3.3	Analysis of Masts	2

3.4	Design of Masts	1
3.4.1	Tutorial - Design of Masts	1
3.5	Foundation Design	2
4.0	**Design of chimneys**	
4.1	Introduction to chimneys	1
4.2	Types, joints, lining and ladder- Chimneys	1
4.3	Forces acting on chimneys	2
4.4	Design of Self-supporting chimneys	1
4.4.1	Tutorial - Design of Self-supporting chimneys	2
4.5	Design of Guyed chimneys	1
4.5.1	Tutorial - Design of Guyed chimneys	2
5.0	**Moment Resistant Connections**	
5.1	Design strength of HSFG bolts and its slip resistance behaviour	1
5.2	Design principles of End plate connection- Flush & extended	1
5.3	Design principles of T- Stub connections	2
5.4	Combined tension & shear considerations in welded & bolted connection	1
5.3.1	Tutorial	1
6.0	**Cold Formed Steel**	
6.1	Introduction to cold formed steel	1
6.2	Advantages & types of cross sections – local buckling and lateral buckling	1
6.3	Design of flexural member	2
6.3.1	Tutorial - Design of flexural member	1
6.4	Design of axially compressed column	1
6.5	Design of Tension Members	1
6.5.1	Tutorial - Design of axially compressed column and Tension Members	1
6.6	Direct Strength Method	2
	Total	48

Course Designers:

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		Category	L	T	P	Credit
15SE310	**DESIGN OF STEEL CONCRETE COMPOSITE STRUCTURES**	PC	3	1	0	4

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 Structural Steel Design

Course Outcomes

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

CO1:	Understand the mechanism of composite action between steel and concrete and thereby determining it's the ultimate carrying capacity.	Apply
CO2:	Comprehend the Indian and International code provision in designing the steel concrete composite member design.	Understand
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
CO4:	Design a composite slab with the provision of profile decking sheet using Euro code - 4.	Create
CO5:	Design an encased as well as in-filled composite columns using Euro code - 4.	Create
CO6:	Design a composite truss using Euro code - 4.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

S.NO	Bloom's Category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	20	20	20
4	Analyse	-	-	-
5	Evaluate	10	10	10
6	Create	50	50	50

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive moment of inertia of un-cracked composite section with full interaction under sagging bending.
2. Draw the bending stress diagram of a composite beam with the provision of profile sheeting when the neutral axis is within the concrete slab.
3. Discuss the enhancement of bending resistance and reduced deflection of a rectangular composite beam under NO INTERACTION case and FULL INTERACTION case also calculate the slip at the interface.

Course Outcome 2 (CO2):

1. Discuss about the behaviour of local buckling and the concept of section classification steel section according to IS: 800-2007.
2. Justify the effective breadth of the composite beam considered in EURO-4.
3. Draw the stress block for a composite slab when the neutral axis is expected within the decking sheet.

Course Outcome 3 (CO3):

1. Design a simply supported composite beam of span 10m as shown in the figure.1. The thickness of slab is 125mm. The floor is to carry an imposed load of 2.0kN/m^2, partition load of 1.0kN/m^2 and a floor finish of 0.5kN/m^2. Assume the grade of concrete as M30, yield stress of structural steel is 280N/mm^2 and density of concrete is 25kN/m^3. Use partial safety factor for both live load as 1.5 and dead load as 1.4. Check the deflection serviceability condition alone.

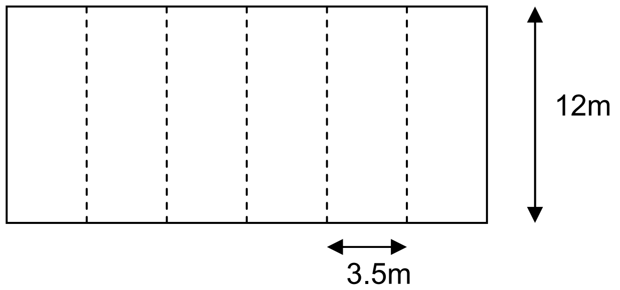


Figure.1

2. A simply supported composite beam with 12m span and spacing of beam is about 2.5m. The thickness of slab is 120mm. Assume the construction load as 1.0kN/m^2. Use M30 concrete and yield stress of structural steel 250N/mm^2. Design a steel beam for its construction stage and also calculate the deflection during construction stage.
3. A three span continuous beam is spaced at 3m centre to centre. The effective length of each span is 6m. The thickness of the composite slab is 125mm. The beam has to carry a construction load of 1.0 kN/m^2. Design the beam for its construction stage. Use partial safety factor 1.5for live load and 1.25 for dead load. Assume M30 grade concrete and Fe415 grade reinforcing steel

Course Outcome 4 (CO4):

1. Define ponding effect?
2. Discuss in detail about the various types of shear connectors with the help of sketches.
3. Check the adequacy of the continuous composite profile deck slab spanning 2m. The cross section of the profiled sheeting is as shown in figure.2. The live load on the slab is 2kN/m^2. The slab is propped at the centre during construction stage. Use M30 concrete. Consider the construction load as 0.75kN/m^2

   <u>Decking sheet data</u>

a.	Yield strength of steel		- 300N/mm^2
b.	Design thickness		- 1.2mm
c.	Effective area of cross section		- 1231mm^2/m
d.	Moment of inertia		- 0.605 $\times 10^6$ mm^4/m
e.	Plastic moment of resistance		- 3.18kN-m/m
f.	Distance of centroid above base		- 22.5mm
g.	Distance of plastic neutral axis above base		- 25mm
h.	Resistance to vertical shear		- 30kN/m
i.	For resistance to longitudinal shear	m	- 184N/mm^2,
		k	- 0.0530N/mm^2
j.	Modulus of elasticity of steel		- 2×10^5 N/mm^2

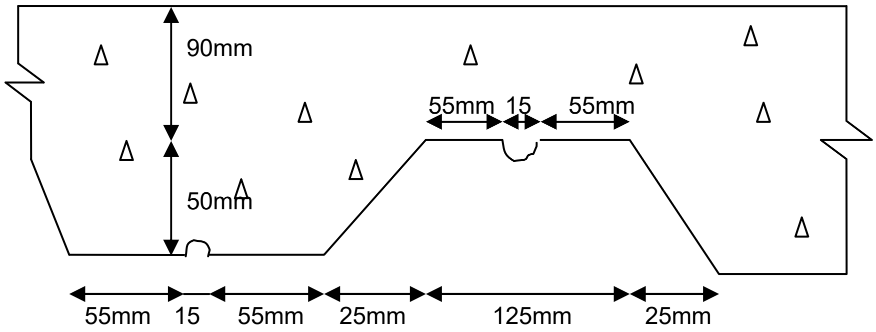


Figure.2

Course Outcome 5 (CO5):

1. Obtain the plastic resistance of a encased composite column made of ISHB350 embedded in M30 grade concrete. The height of the column is 3.5m and is pinned at its ends. The dimension of the column is 425mm×425mm, Use 0.5% of gross concrete area Fe 415 as reinforcing steel
2. Obtain plastic resistance of a steel tubular section 350mm external diameter and 320mm internal diameter filled with M25 grade concrete. The height of the column is 3m and is pinned at its ends.
3. Check the adequacy of a concrete encased composite section for uni-axial bending. The details of the section are given as
   a. The height of the column is 3.5m and pinned ended
   b. The dimension of the column is 400mm × 400mm
   c. Use M30 grade of concrete
   d. Use ISMB 350 RSJ section
   e. Reinforcing steel Fe 415 of 4no, of 14mm diameter bar
   f. Design axial load is 1500kN
   g. The design bending moment 125kN-m

Course Outcome 6 (CO6):

1. Discuss any two applications of composite trusses and its cost effectiveness.
2. Describe a suitable truss configuration for a composite truss of span 30m.
3. A composite truss of span 10 as shown in figure-3 with following data,
   a. Slab thickness - 130m
   b. Profile depth - 80mm
   c. Self weight of the slab - 2.81kN/m^2
   d. Spacing of truss - 3.25m c/c
   e. Construction load -1.0kN/m^2
   f. Live load - 2.5kN/m^2
   g. Maximum laterally unstrained length in top chord is 1.5m
   h. Grade of concrete is M20

   Design the top and bottom chord of the composite truss

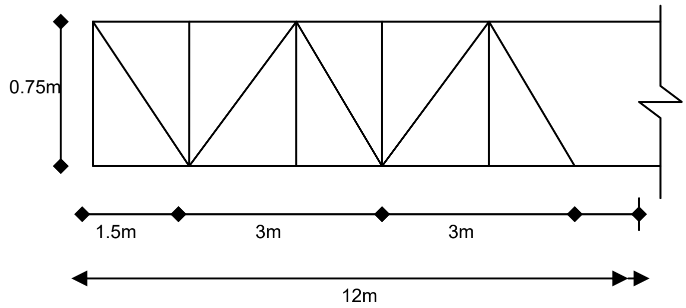
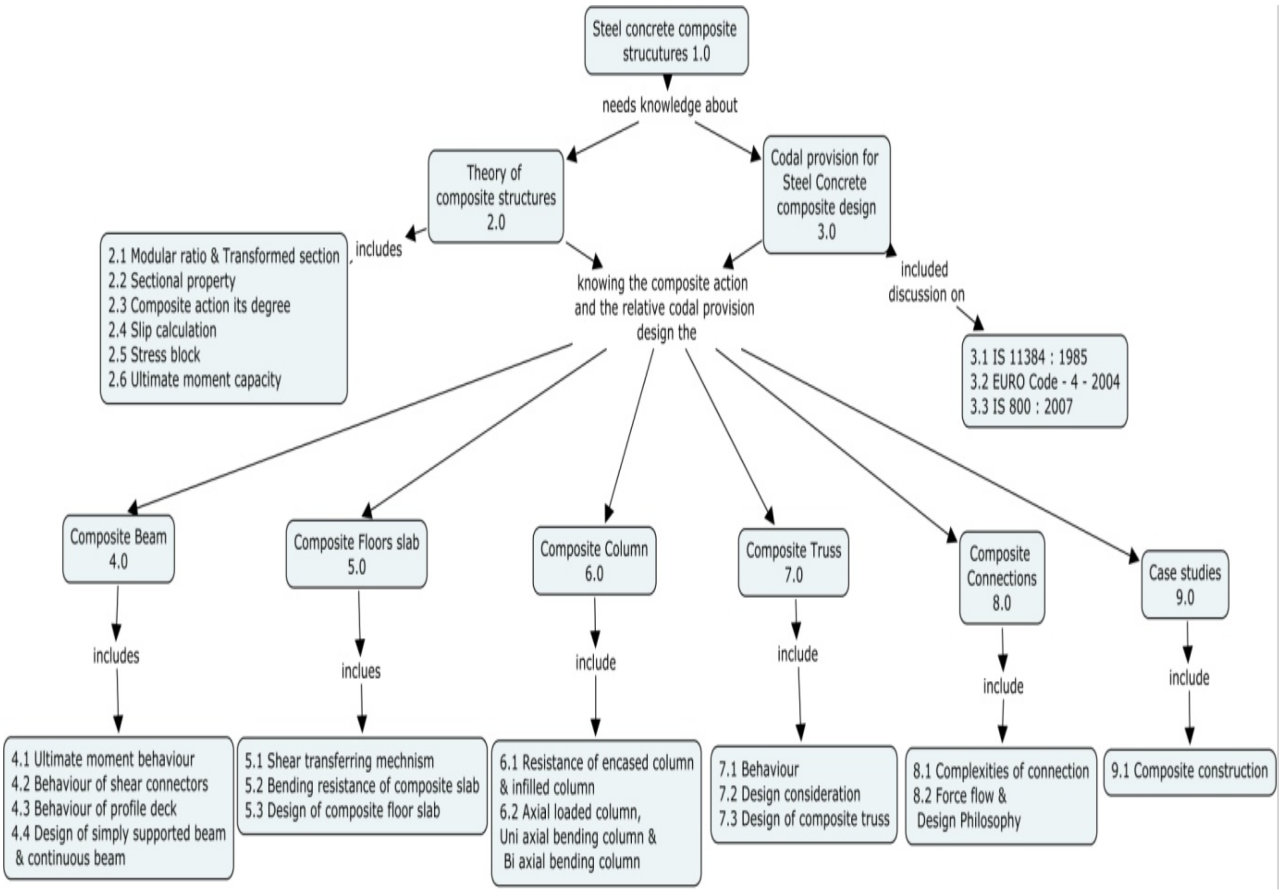


Figure-3

4. Prepare a cost comparison study of a multi-storeyed steel concrete composite construction Vs conventional multi-storeyed RCC building

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. Handbooks of INSDAG (periodicals)
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. Teaching resource for, "Structural Steel Design," Volume 2 of 3, Institute for Steel Development and Growth (INSDAG), 2002.
5. Website: www.steel-insdag.org

List of National and International standards

1. IS: 11384, Code of practice for composite construction in Structural Steel and Concrete
2. Provisions of IS 800 : 2007, Code of practice for General construction in Steel
3. Provisions of Euro Code-4-2004, Design of composite steel and concrete structures

Course Contents and Lecture Schedule

S.NO.	TOPICS	PERIODS
1.0	**Introduction to Steel Concrete Composite Construction**	1
2.0	**Theory of Composite Structures**	1
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**	1
3.1	Provisions of IS: 11384, Code of practice for composite	1

	construction in Structural Steel and Concrete	
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	
3.3.2.1	Tutorials	2
4.0	**Composite Beams**	1
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)	
4.4.1	Tutorials	2
4.5	Introduction to skewed beams-Design philosophy	1
5.0	**Composite floors**	1
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	
5.3.1	Tutorials - Design of Composite floor	2
5.4	Introduction to skewed slabs-Design philosophy	1
6.0	**Composite columns**	1
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	2
7.0	**Composite trusses**	1
7.1	Behaviour and application of composite truss	1
7.2	Design consideration of composite truss	
7.2.1	Tutorial - Stud specifications	1
7.2.2	Tutorial - Load calculation	1
7.3	Tutorials - Design of composite truss	2
8.0	**Composite connections**	1

8.1	Complexities of composite connections and its design philosophies	1
8.2	Force flow in the joint	1
9.0	**Case studies**	1
9.1	Composite constructions	1
	Total	48

Course Designers:

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15SEPA0	ASEISMIC DESIGN OF STRUCTURES	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

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

Prerequisite

Design of Steel Structures and RC structures.

Course Outcomes

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

CO1	Determine the seismic hazard parameters	(Understand)
CO2	Calculate the effect of EQ forces and response of the structure	(Apply)
CO3	Compresence the Indian codal provisions and interprets the suitable application of codal provisions.	(Understand)
CO4	Suggest capacity design of RC structures	(Create)
CO5	Identify suitable configuration, Loads and perform push over analysis for Steel structures.	(Create)
CO6	Analyse and design of structures by using ETABS	(Create)

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	30	30	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	50	50	50	50

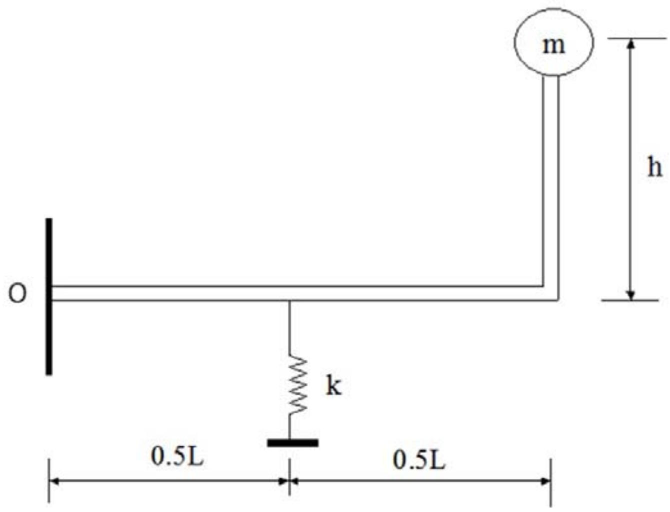
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish the magnitude and intensity of earthquake
2. Describe the two approaches followed for the prediction of earthquakes.
3. Name the major plates of the earth.
4. Compare Oscillator circuits with Spring Mass System of free undamped vibration system

Course Outcome 2 (CO2):

1. Define storey drift.
2. Define 'torsional effect' on buildings?
3. Define modal mass and modal participation factor.
4. An L Shaped mass less rigid member with a mass m at the tip is supported by a spring of stiffness 'K' and hinged at point 'O" as shown in fig1. Find the following
   Derive the equation for an angular motion about O
   Determine natural frequency of the system



5. Write the Equation of motion of the vibrating system as shown in fig2

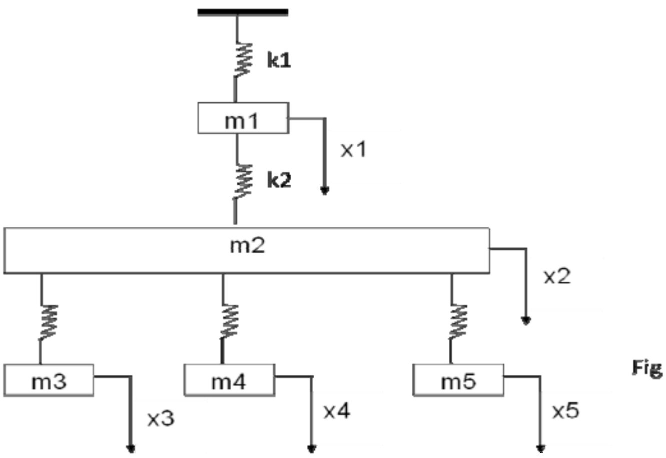


fig 2

Course Outcome 3 (CO3):

1. Explain the concepts and types of Response spectrum. Write step by step procedure of constructing response spectrum diagrams with neat sketch.
2. Design fig 1.a & 1.b by using Response spectrum method. The Free Vibration Properties of the building for vibration in the X-Direction is shown below

Beam size 25 x 35 mm
Column size 30 x 40mm
Slab thickness 18mm
Wall thickness 15mm

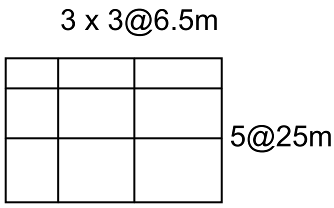


Fig.1.a PLAN

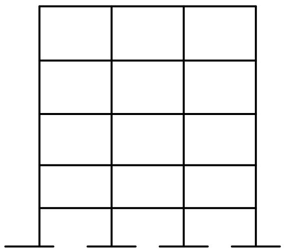


Fig.1.b ELEVATION

	Mode 1	Mode 2	Mode 3
Natural Period (sec) T	0.765	0.321	0.135
Mode Shape			
Roof	1.000	1.000	1.000
3rd Floor	0.924	0.185	-0.731
2nd Floor	0.786	-0.608	-0.528
1st Floor	0.441	-0.921	1.016

Course Outcome 4 (CO4):

1. Explain the factors affecting ductility of RCC members.
2. Analyse a three storied RC building by static method and also determine modal mass and modal participation factor as per IS 1893 (PART 1): 2002 for the following data.
   Seismic zone = IV
   Floor height = 4.0m
   Length of building = 10m
   Infill wall = 250mm thick in longitudinal and 150mmmm in transverse direction.
   Imposed load = 3.5 kN/m^2
   Size of columns = 250mm x 400mm.
   Size of beams = 300mm x 400mm in longitudinal and 300mm x 350mm in transverse direction
   Depth of slab = 120mm .
3. Design for lintel and Roof band of a single room building of size 6.m x 4m. The walls are 200mm thick in modular bricks built in 1:5 cement sand mortar. The height of building up to lintel level is 3m and the vertical distance between the roof band and lintel band is 1.5m.The roof band weighs 750 kg/ m^2. The bands are required for a design earthquake coefficient of 0.12. Weight of wall is 450 kg/ m^2 .Weight of masonry is 1900 kg/ m^2.
4. The stiffness and mass matrices of a two storey building are given below
   $[M] = \begin{bmatrix} 350000 & 0 \\ 0 & 350000 \end{bmatrix} kg$ & $[k] = \begin{bmatrix} 0.105 \times 10^9 & -0.105 \times 10^9 \\ -0.105 \times 10^9 & 0.315 \times 10^9 \end{bmatrix}$ N/m
   Take unit of mass is kg and that of stiffness is N/m.

Determine
Natural frequencies
Corresponding mode shapes. Scale them so that max displacement is 1.0. Sketch the two modes

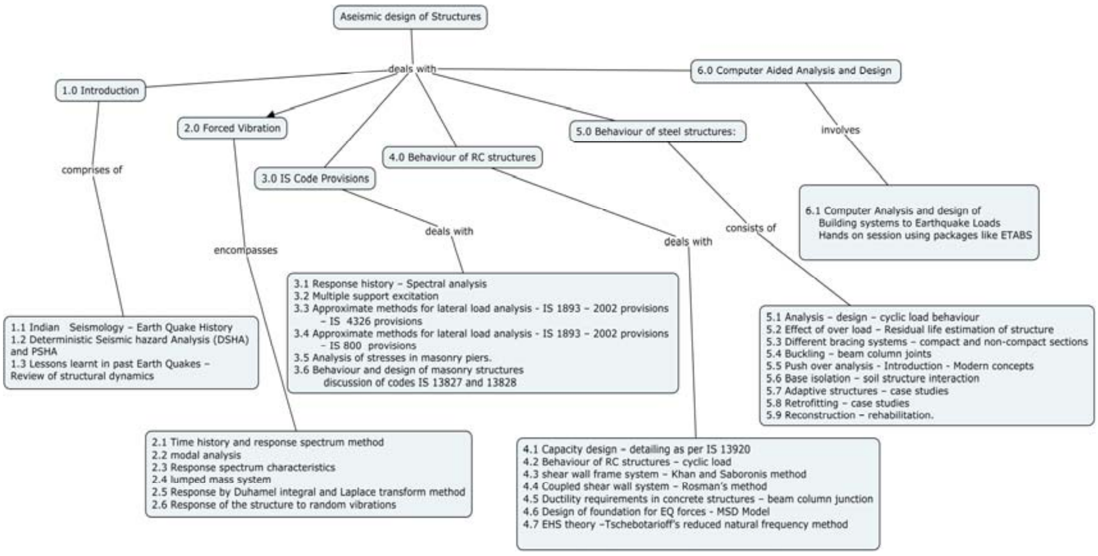
Course Outcome 5 (CO5):

1. Analyse a three storied steel frame by static method and also determine modal mass and modal participation factor as per IS 1893 (PART 1): 2002 for the following data.
   Seismic zone = IV
   Floor height = 4.0m
   Length of building = 10m
   Imposed load = 3.5 kN/m^2
   Size of columns = ISMB 600.
   Size of beams = ISMB 300
   Chequered type of flooring of thickness 6mm.
2. Explain the impact of bracings in steel frame subjected to seismic forces
3. Discuss the behaviour of beam column connections in seismic forces.
4. Evaluate the performance point for a RC multi-storey building of your choice by performing Static Push over analysis and interpret the results
5. Elaborate the seismic detailing requirements of a shear wall and elements of RC framed Structures as per IS: 13920 – 1993

Course Outcome 6(CO6):

1. Analyse and design using ETABS a three storied RC building by static method and also determine modal mass and modal participation factor as per IS 1893 (PART 1): 2002 for the following data.
   Seismic zone = IV
   Floor height = 4.0m
   Length of building = 10m
   Infill wall = 250mm thick in longitudinal and 150mmmm in transverse direction.
   Imposed load = 3.5 kN/m^2
   Size of columns = 250mm x 400mm.
   Size of beams = 300mm x 400mm in longitudinal and 300mm x 350mm in transverse direction: Depth of slab = 120mm.

Concept Map



Syllabus

Introduction: Indian Seismology – Earth Quake History –Deterministic Seismic hazard Analysis (DSHA) and PSHA– lessons learnt in past Earth Quakes –Review of structural dynamics **Forced Vibration:** Time history and response spectrum method - modal analysis – Earth quake response to linear systems - Response spectrum characteristics – ground motion parameters – lumped mass system – shear building – symmetrical and unsymmetrical buildings. –Response by Duhamel integral and Laplace transform method - Response of the structure to random vibrations **IS Code Provisions:** Modal response contribution – modal participation factor – Response history – Spectral analysis - Multiple support excitation – introduction to deterministic Earth quake response to continuous systems on rigid base – Approximate methods for lateral load analysis - IS 1893 – 2002 provisions – IS 4326& IS 800 provisions – Analysis of stresses in masonry piers - Behaviour and design of masonry structures – discussion of codes IS 13827 and 13828.**Behaviour of RC structures**: Capacity design – detailing as per IS 13920 - Behaviour of RC structures – cyclic load – shear wall frame system – Khan and Saboronis method – Coupled shear wall system – Rosman's method – ductility requirements in concrete structures – beam column junction - Design of foundation for EQ forces - MSD Model - EHS theory –Tschebotarioff's reduced natural frequency method **Behaviour of steel structures**: Behaviour of steel structures – design – cyclic load behaviour – Effect of over load – Residual life estimation of structure- different bracing systems – compact and non-compact sections – buckling – beam column joints - Push over analysis - Introduction - Modern concepts – base isolation – soil structure interaction – adaptive structures **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.	Topic	No. of Lectures
1	**Introduction**	
1.1	Indian Seismology – Earth Quake History	1
1.2	Deterministic Seismic hazard Analysis (DSHA) and PSHA	1
1.3	Lessons learnt in past Earth Quakes –Review of structural dynamics	2
2	**Forced Vibration:-**	
2.1	Time history and response spectrum method	1
2.2	modal analysis – Earth quake response to linear systems	2
2.3	Response spectrum characteristics – ground motion parameters	2
2.4	Lumped mass system - shear building symmetrical and unsymmetrical buildings	1
2.5	Response by Duhamel integral and Laplace transform method	1
	Tutorial	1
2.6	Response of the structure to random vibrations	1
3	**IS Code Provisions:-**	
3.1	Modal response contribution – modal participation factor	1
3.2	Response history – Spectral analysis	1
3.3	Multiple support excitation – introduction to deterministic Earth quake response to continuous systems on rigid base	1
3.4	Approximate methods for lateral load analysis - IS 1893 – 2002 provisions – IS 4326 provisions	1
3.4.1	Tutorial	1
3.5	Approximate methods for lateral load analysis - IS 1893 – 2002 provisions – IS 800 provisions	1

3.5.1	Tutorial	1
3.6	Analysis of stresses in masonry piers.	1
3.6.1	Tutorial	1
3.7	Behaviour and design of masonry structures – discussion of codes IS 13827 and 13828	1
	Tutorial	1
4	**Behaviour of RC structures**:	
4.1	Capacity design – detailing as per IS 13920	1
4.2	Behaviour of RC structures – cyclic load	1
4.3	shear wall frame system – Khan and Saboronis method	1
	Tutorial	1
4.4	Coupled shear wall system – Rosman's method	1
	Tutorial	1
4.5	Ductility requirements in concrete structures – beam column junction	2
4.6	Design of foundation for EQ forces - MSD Model	1
	Tutorial	1
4.7	EHS theory –Tschebotarioff's reduced natural frequency method	1
5	**Behaviour of steel structures**:	
5.1	Analysis – design – cyclic load behaviour	1
5.1.1	Tutorial	1
5.2	Effect of over load – Residual life estimation of structure	1
5.3	Different bracing systems – compact and non-compact sections	1
5.4	Buckling – beam column joints	1
5.4.1	Tutorial	1
5.5	Push over analysis - Introduction - Modern concepts	1
5.6	Base isolation – soil structure interaction	1
5.7	Adaptive structures – case studies	1
5.8	Retrofitting – case studies	1
5.9	Reconstruction – rehabilitation.	1
6	**Computer Aided Analysis and Design** (Only for Internal Assessment)	
6.1	Tutorial - Computer Analysis and design of Building systems to Earthquake Loads – Hands on session using packages like ETABS	2
	Total Hours	48

Course Designers:

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		Category	L	T	P	Credit
15SEPB0	**BRIDGE ENGINEERING**	PE	3	1	0	4

Preamble

A structure built to span and provide passage over a river, chasm, road, or any other physical hurdle. The function required from the bridge and the area where it is constructed decides the design of the bridge. The main types of bridges are girder bridges, arch bridges, cable-stayed bridges, rigid frame bridges and truss bridges. The traditional building materials for bridges are stones, timber and steel, and more recently reinforced and pre-stressed concrete. For bridges one should use that material which results in the best bridge regarding shape, technical quality, economics and compatibility with the environment. This course offers the design of bridges such as RCC bridges, prestressed concrete bridges, design principles of steel and composite bridges, 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

Fundamentals of Mathematics, knowledge of forces and its calculations, design concepts of RCC, prestressed concrete and steel structures.

Course Outcomes

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

CO1	Determine the type of bridge and its basic requirements for particular location	Apply
CO2	Design the box culverts and deck slab bridges	Create
CO3	Design the T-beam bridges	Create
CO4	Design the steel and composite bridges	Create
CO5	Design the prestressed concrete bridges	Create
CO6	Analyse and design the bridge bearings, piers and abutments	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	60	60	60	60

Course Level Assessment Questions

CO1: Determine the type of bridge and its basic requirements for particular location

1. Define Linear waterway.
2. Write the Lacey's formula for calculating the Linear water way.
3. State the minimum width of carriage way for single lane traffic?
4. Write the different classes of IRC loading standards?
5. Explain the IRC Specifications for live load for IRC class A loading?
6. Explain in detail the points to be considered while selecting a ideal bridge site?
7. Explain the IRC Specifications for live load for IRC class AA loading?

CO2: Analyse and design the box culverts and deck slab

1. Draw a neat sketch of a bridge and mark all its components, also explain the importance of each component.
2. Give the equation for calculating the effective width of deck slab?
3. List out the various components of box culvert bridge.
4. Design a deck slab bridge for the following data:
   Clear distance between abutments : 7m
   Road : NH (Two Lane)
   Foot path : 1m on either side
   Width of bearing : 400 mm
   Wearing coat : 80mm average
   Loading : IRC Class AA (Tracked)
   Materials : M30 concrete and Fe 415 Steel
5. A reinforced concrete simply supported slab is required for the deck of a road bridge having the data given below:
   Width of carriageway - 9.5 m
   Width of kerb – 600 mm
   Clear span – 5m
   Width of bearing – 400 mm
   Type of loading I.R.C. class A.
   Materials: M30 concrete and Fe 415 Steel

CO3: Design the T-beam bridges

1. Draw the position of IRC class 'AA' Tracked vehicle wheel load for getting maximum bending moment.
2. Determine the reaction factor for guider using Courbon's Theory?
3. Determine the maximum Shear force and Bending moment of R.C.C Tee beam and slab deck using the following data:
   Spacing of the main 'T' beam = 3m
   Span of 'T' beam = 20m (length of the bridge)
   Cross girders are provided at 5m c/c
   Loading: IRC class "AA" Wheeled vehicle.
   Also sketch the variations of the same.
4. Design a RCC Tee beam girder bridge for the following data:

Clear width of road way	: 7.5 m
Span (Centre to centre of bearing)	: 16 m
Live load	: IRC class AA Tracked vehicle
Average thickness of wearing coat	: 80 mm
No. of main girders	: 4
Spacing of cross girders	: 4m
Materials	: M30 concrete and Fe 415 Steel

CO4: Design the steel and composite bridges

1. Draw the neat sketches of truss bridges
2. Explain the loads considered in Railway bridges
3. Explain in finding the economical depth of the plate Girder?
4. Give the advantages of plate girder bridges?
5. Design a deck type welded plate girder bridge to suit the following data:
   Effective span of the girder – 30 m
   Dead load – 7.5 kN/m
   Equivalent total live load for bending moment calculation/track – 2727 kN
   Equivalent total live load for shear calculation/track – 2927 kN
6. Design a steel trussed bridges to suit the following data:
   Effective span – 33m
   Roadway -7.5m (two lane)
   Kerbs -600mm
   Loading : IRC class AA tracked vehicle
   Materials : M25 Grade concrete and Fe415 HYSD bars for deck slab. Rolled steel sections with an yield stress of 236 N/mm^2.

CO5: Design the prestressed concrete bridges

1. Give the advantages of Prestressed concrete bridges
2. Draw any two cross sections for the pre- tensioned concrete bridges
3. Draw any two cross sections for the post- tensioned concrete bridges
4. Define the terms: Maximum and Minimum prestressing forces
5. Explain in detail in finding the eccentricity of cables in prestressed concrete bridges
6. Design a post tensioned prestressed concrete slab bridge deck to suit the following data:

Clear span	: 12m
Width of bearing	: 400 mm

Clear width of road way : 7.5m
Foot path : 1m on either side
Kerb : 600 mm wide
Thickness of wearing coat : 80 mm
Loading : IRC Class AA tracked vehicle
Compressive strength at Transfer : 35 N/mm^2
Materials: M40 grade concrete and 7 mm diameter high tensile wires with an ultimate strength of 1500 N/mm^2. For supplementary reinforcement adopt Fe415 grade steel bars.

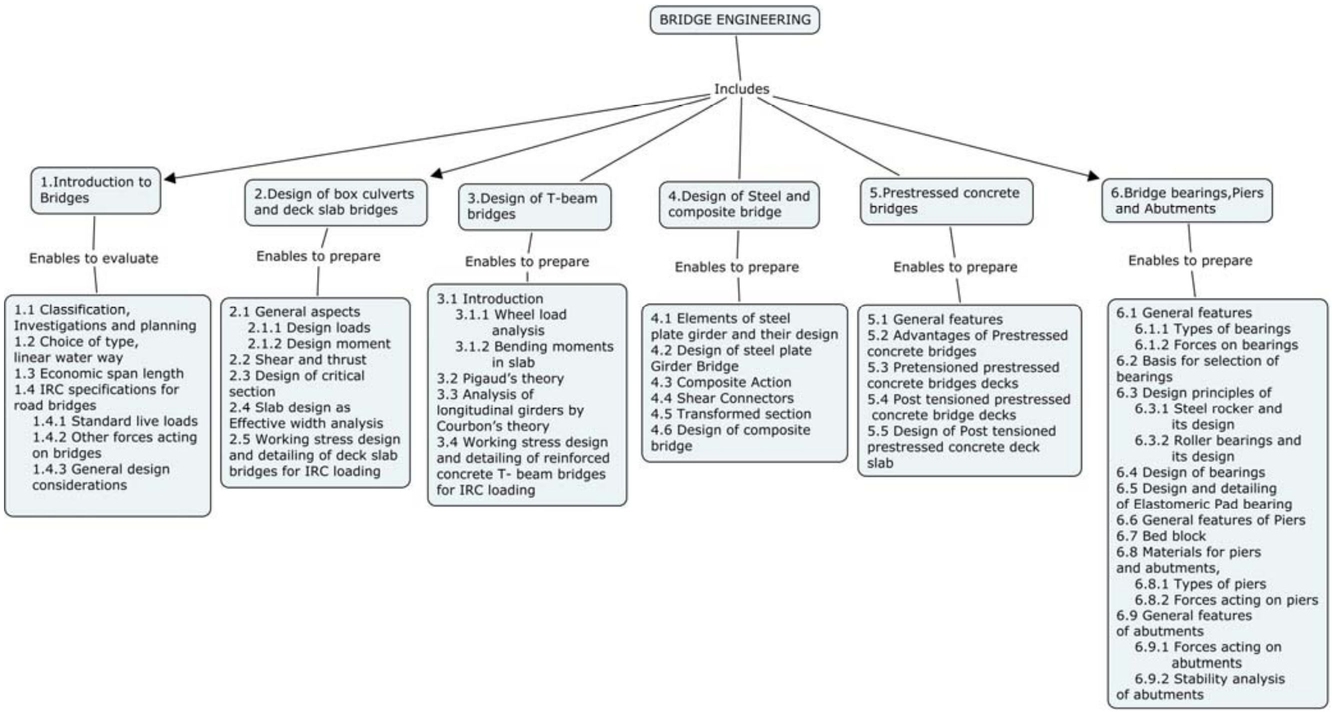
7. Design a post tensioned prestressed concrete T- beam and slab bridge deck to suit the following data:
   Effective span : 24 m
   Width of carriage way :7.5 m
   Kerbs 600 mm wide on either side of the road
   Spacing of main girders : 2m
   Spacing of cross girders : 4m
   Loading is IRC Class AA tracked vehicle
   Adopt M-45 Grade concrete and High tensile steel strands conforming to Fe415 Grade HYSD bars. Permissible stresses are as specified in IRC: 18- 2000. Loss ratio = 0.85

CO6: Analyse and design the bridge bearings, piers and abutments

1. Write the equation for calculating the scour depth for natural streams in alluvial soil.
2. Explain the design principles pyloyns with neat sketches.
3. List out the various classification of fixed bearings.
4. Define the term: Afflux
5. List the various types of Expansion bearing for Girder bridge
6. Design a R.C rocker bearing to transmit a support reaction of 1000 kN.permissible bearing stress in concrete is 8 Mpa. Use M30 grade concrete and Fe 415 grade steel.

Draw typical sketch of different types of pier.

Concept Map



Syllabus

Introduction: classification, investigations and planning, choice of type, linear water way, economic span length, IRC specifications for road bridges, standard live loads, other forces acting on bridges, general design considerations. **Design of box culverts:** general aspects, design loads, design moment, shear and thrust, design of critical section. **Design of deck slab bridges:** effective width analysis, working stress design and detailing of deck slab bridges for IRC loading. **Design of T-beam bridges:** wheel load analysis, bending moments in slab, Pigaud's theory, analysis of longitudinal girders by courbon's theory, working stress design and detailing of reinforced concrete T- beam bridges for IRC loading. **Design of steel and composite bridges:** steel plate girder bridge, elements of plate girder and their design, design of steel plate girder Bridge, composite bridge, composite action, shear connectors, transformed section, design of composite bridge. **Prestressed concrete bridges:** general features, advantages, pretensioned prestressed concrete bridges, post tensioned prestressed concrete bridge decks, design of post tensioned prestressed concrete slab bridge deck. **Bridge bearings:** general features, types of bearings, forces on bearings, basis for selection of bearings, design principles of steel rocker and roller bearings and its design, design and detailing of elastomeric pad bearing. **Piers:** general features, bed block, materials for piers and abutments, types of piers, forces acting on piers, design of pier, stability analysis of piers. **Abutments:** general features of abutments, forces acting on abutments, stability analysis of abutments.

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. Johnson Victor.D, “Essentials of Bridge Engineering”, 6th Edition, Oxford & IBH Publishers Co. Pvt. Ltd, New Delhi 1999.
4. Krishna Raju. N. “Design of Bridges”, 4th Edition, Oxford & IBH, New Delhi 2010.
5. Ponnuswamy.S., “Bridge Engineering”, 2nd Edition, Tata McGraw Hill Publications, New Delhi, India 2007
6. Raina,Concrete.V. K. “Bridge Design and Practice”, 3rd Edition, Shroff Publishers, India 2010
7. Rowe, R. E.,” Concrete Bridge Design”, C.R. Books Ltd. London 2002.

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

S.NO	TOPICS	NO. OF PERIODS
1	**Introduction**	
1.1	Classification, investigations and planning, choice of type, linear water way, economic span length	2
1.2	IRC specifications for road bridges - standard live loads, other forces acting on bridges, general design considerations	2
2	**Design of box culverts and deck slab bridges**	
2.1	General aspects - Design loads , Design moment	1
2.2	Shear and thrust, Design of critical section	1
2.3	Tutorial	2
	Design of deck slab bridges	
2.4	Slab design as Effective width analysis	2
2.5	Working stress design and detailing of deck slab bridges for IRC loading	1
2.6	Tutorial	1
3	**Design of T-beam bridges**	
3.1	Introduction - Wheel load analysis, bending moments in slab	1
3.2	Pigaud's theory & Analysis of longitudinal girders by Courbon's theory	2
3.3	Working stress design and detailing of reinforced concrete T- beam bridges for IRC loading	1
3.4	Tutorial	2
4	**Design of Steel and composite bridge**	
	Steel plate Girder Bridge	
4.1	Elements of plate girder and their design	1
4.2	Design of steel plate Girder Bridge	2
4.3	Tutorial	1
	Composite bridge	
4.4	Composite Action, Shear Connectors, Transformed section	2
4.5	Design of composite bridge	2
4.6	Tutorial	1
5	**Prestressed concrete bridges**	
5.1	General features, advantages	1
5.2	Pretensioned prestressed concrete bridges, Post tensioned prestressed concrete bridge decks	2
5.3	Design of Post tensioned prestressed concrete deck slab	2
5.4	Tutorial	1
6	**Bridge bearings**	
6.1	General features - Types of bearings, Forces on bearings, Basis for selection of bearings	2
6.2	Design principles of steel rocker and its design	2
6.3	Design principles of roller bearings and its design	1
6.4	Design of bearings	1
6.5	Design and detailing of Elastomeric Pad bearing	1
6.6	Tutorial	3

	Piers and Abutments	
6.7	General features, bed block - Materials for piers and abutments,	1
6.8	Types of piers - Forces acting on piers	1
6.9	General features of abutments - Forces acting on abutments, Stability analysis of abutments.	2
6.10	Tutorial	1
	Total Hours	**48**

Course Designers:

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15SEPC0	COMPUTATIONAL METHODS IN STRUCTURAL ANALYSIS	Category	L	T	P	Credit
		PE	3	1	0	4

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

CO1: Analyse transformation of force and displacement from element to system	Analyze
CO2: Analyse beams, frames, trusses and grids by flexibility method	Analyze
CO3: Analyse beams, frames, trusses and grids by stiffness method	Analyze
CO4: Analyse the structures by matrix displacement method	Analyze
CO5: Analyse trusses, grids, plane and space frames by direct stiffness method	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	60	60	60	60
Evaluate	--	--	--	--
Create	--	--	--	--

Course Level Assessment Questions

CO1: Analyse transformation of force and displacement from element to system

1. Distinguish between element stiffness and global stiffness.
2. List out the coordinate systems used for transformations.
3. State the contragradient law.
4. Calculate the flexibility matrix of the nonprismatic cantilever beam which has second moment of area of 2I up to its middle portion and the remaining portion has second moment of area of I. The beam subjected to concentrated loads of F_2 at free end and F_1 at centre of beam.

CO2: Analyse beams, frames, trusses and grids by flexibility method

1. Define the term: kinematic redundancy.
2. List out the procedure for analyzing a structure using method of consistent deformations.
3. Analyze by flexibility method, two span continuous beam has which has one end fixed and another end pinned supports a UDL of 10 kN/m throughout its length. The span lengths of first and second spans are 8m and 6m respectively. Also draw the bending moment diagram.

C03: Analyse beams, frames, trusses and grids by stiffness method

1. Define the term: Degree of freedom.
2. List out the criterion to arrive at the basic equations of stiffness method.
3. Analyse by stiffness matrix method, the three span continuous beam ABCD which has fixed ends at the exterior supports. First span AB of span 4m length subjected to a concentrated load of 8 kN acting at a distance of 1.5m from the left end. Middle span BC of 4m length subjected to UDL of 3 kN/m throughout its length. Final span CD of 3m length subjected to a concentrated load of 16 kN acting at a distance of 1m from the left end.

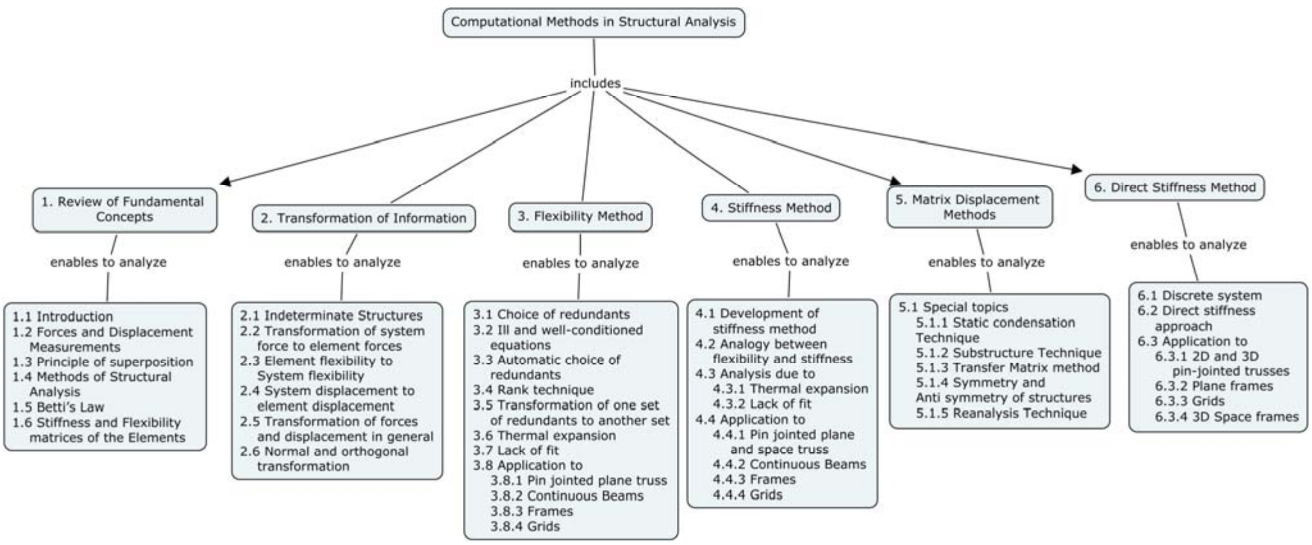
CO4: Analyse the structures by matrix displacement method

1. Define the term: static condensation.
2. Analyze a portal frame of bay length ‘l’ and floor height ‘l’ which has only one bay and storey which is subjected to a horizontal load of ‘P’ at the top of the floor using static condensation technique assuming EI is constant for all the members.
3. Differentiate between symmetric and anti-symmetric responses.

CO5: Analyse trusses, grids, plane and space frames by direct stiffness method

1. State the skew boundary conditions.
2. Define the term: Nodal displacement.
3. Calculate the element stiffness matrix for a three dimensional pin jointed truss element.

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	2
2.5	Normal and orthogonal transformation	1
2.6	Tutorial	2
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	Tutorial	2
3.6	Application to pin jointed plane truss	2
3.7	Continuous beams	1
3.8	Frames and grids	1
3.9	Tutorial	2
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	2
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
5.6	Tutorial	2
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	Three dimensional space frames	2
6.7	Tutorial	2
	Total periods	**48**

Course Designers

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15SEPD0 **CONCRETE MECHANICS**

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

Concrete encompasses both the art and science of engineering. This course presents the theory of concrete as a direct application of the laws of statics and mechanics of materials. In addition, it emphasizes that a successful design not only satisfies design rules, but also is capable of being built in a timely fashion and for a reasonable cost. Topics are normally introduced at a fundamental level, and then move to higher levels where prior educational experience and the development of engineering judgment will be required. Upon successful completion of the course, students will have an advanced understanding of concrete behavior as well as knowledge of specific modeling theories that can be used for the numerical simulation of concrete structures. Having successfully completed this course, students will have the necessary skills to conduct concrete research as well as to solve advanced concrete design problems.

Prerequisite

Fundamentals of Mathematics, knowledge of Mechanics of Materials, Statics, Concrete Technology and Concrete Design.

Course Outcomes

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

CO1: Perform tests on concrete and determine experimental characterization	Apply
CO2: Perform modeling and explain macroscopic behavior of concrete	Apply
CO3: Analyse the failure and size effect of structural concrete	Evaluate
CO4: Carry cyclic and dynamic loading and fatigue of structural concrete and describe its behaviour	Evaluate
CO5: Analyze concrete at early age	Evaluate

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	--	--	--	--
Evaluate	60	60	60	60
Create	--	--	--	--

Course Level Assessment Questions

CO1**:** Perform tests on concrete and determine experimental characterization

1. Bring out the criterion to induce an uniaxial stress in concrete.
2. Explain in detail about the experimental techniques used in diffusion tension test with neat sketches.
3. Discuss the differences between the testing techniques of uniaxial compression and uniaxial torsion.

CO2: Perform modeling and explain macroscopic behavior of concrete

1. Distinguish between discrete and continuous approach of modeling.
2. Explain the detailed procedure for studying the macroscopic behavior of concrete using continuous approach of modeling.

CO3: Analyse the failure and size effect of structural concrete

1. Differentiate between the probabilistic and deterministic size effects.
2. Expalin in detail about the fractality and size effects in failure of structural concrete.
3. Discuss in detail about the calibration techniques used for non-local models.
4. State the necessity for calibration in modelling.

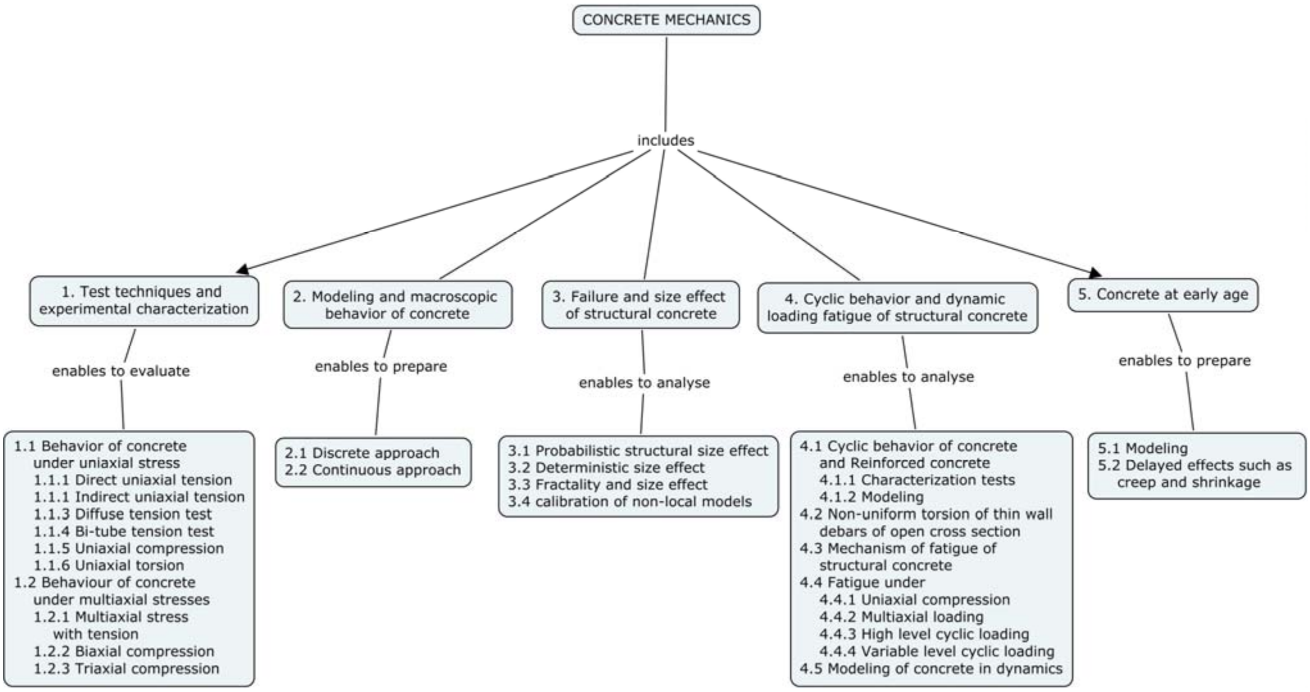
CO4: Carry cyclic and dynamic loading and fatigue of structural concrete and describe its behaviour

1. List out the characterization tests for studying the cyclic behavior of concrete.
2. Define the term: stress intensity factor.
3. State the effects in structural concrete which is subjected to dynamic uniaxial compression loading.
4. Explain in detail about the modeling concepts used for concrete under dynamic loading and their importance.
5. Compare the behavior of structural concrete under cyclic and dynamic loading conditions.

CO5: Analyze concrete at early age

1. State the modeling techniques used to emulate the rheological behavior of concrete.
2. Discuss in detail about the concepts used to incorporate the long term effects during modeling of concrete.

Concept Map



Syllabus

Test techniques and experimental characterization – behavior of concrete under uniaxial stress: direct uniaxial tension, indirect uniaxial tension, diffuse tension test, bi-tube tension test, uniaxial compression, uniaxial torsion; behaviour of concrete under multiaxial stresses - multiaxial stress with tension, biaxial compression, triaxial compression; **Modeling and macroscopic behavior of concrete** - discrete approach, continuous approach; **Failure and size effect of structural concrete** - probabilistic structural size effect, deterministic size effect, fractality and size effect and calibration of non-local models; **Cyclic behavior of concrete and reinforced concrete** - characterization tests, modeling; **Cyclic and dynamic loading fatigue of structural concrete** - mechanism, fatigue under uniaxial compression, fatigue under multiaxial loading, fatigue under high-level cyclic loading, fatigue under variable level cyclic loading, modeling of concrete in dynamics; **Concrete at early age** – modeling, delayed effects such as creep and shrinkage.

Reference Books

1. Adam M. Neville, “Properties of Concrete”, 3rd Edition, Pitman, 1981,
2. Amin Ghali and Rene Favre, “Concrete Structures: Stresses and Deformations”, Chapman & Hall, New York, 1986.
3. Bažant. Z. P and Planas.J. “Fracture and Size Effect”, 1st edition, CRC Press, 2000.

4. Hibbeler.R.C., "Structural Analysis", Seventh Edition, Pearson Prentice Hall, New Jersey, 2009.
5. James K. Wight, James G. MacGregor, "Reinforced Concrete: Mechanics and Design", Pearson Educational—Prentice Hall, 2012.
6. Jean-Michel Torrent, Giles Pijaudier-Cabot and Jean-Marie Reynouard, " Mechanical Behaviour of Concrete", 1st edition ,John Wiley & Sons. Inc, USA, 2010.
7. Jirásek.M. and. Bažant.Z. P, "Inelastic Analysis of Structures", Wiley Publications, 2001.
8. Newman. K and Newman.J. B., "Failure Theories and Design Criteria for Plain Concrete," Part 2 in M. Te'eni (ed.), "Solid Mechanics and Engineering Design", Wiley-Interscience, New York, 1972.
9. Sidney Mindess, J. Francis Young, and David Darwin, "Concrete", 2nd Edition, Pearson Educational—Prentice Hall, New Jersey, 2003.
10. Van Mier.J. G. M., "Fracture Processes of Concrete", CRC Press, 1996.

List Of National and international Standards

1. ACI, Prediction of creep, shrinkage and temperature effects in concrete structures, 209 R-9, ACI, 1992.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Test techniques and experimental characterization		
1.1	Behavior of concrete under uniaxial stress	
1.1.1	Direct uniaxial tension	2
1.1.2	Indirect uniaxial tension	2
1.1.3	Diffuse tension test	2
1.1.4	Bi-tube tension test	1
1.1.5	Uniaxial compression	2
1.1.6	Uniaxial torsion	1
1.2	Behaviour of concrete under multiaxial stresses	
1.2.1	Multiaxial stress with tension	2
1.2.2	Biaxial compression	2
1.2.3	Triaxial compression	2
2. Modeling and macroscopic behavior of concrete		
2.1	Discrete approach	3
2.2	Continuous approach	3
3. Failure and size effect of structural concrete		
3.1	Probabilistic structural size effect	2
3.2	Deterministic size effect	2

3.3	Fractality and size effect and calibration of non-local models	2
4. Cyclic behavior of concrete and reinforced concrete		
4.1	Characterization tests	2
4.2	Modeling	2
5. Cyclic and dynamic loading fatigue of structural concrete		
5.1	Mechanism	1
5.1.1	Fatigue under uniaxial compression	2
5.1.2	Fatigue under multiaxial loading	2
5.1.3	Fatigue under high-level cyclic loading	2
5.1.4	Fatigue under variable level cyclic loading	2
5.2	Modeling of concrete in dynamics	2
6. **Concrete at early age**		
6.1	Modeling	3
6.2	Delayed effects such as creep and shrinkage	2
	Total periods	**48**

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		Category	L	T	P	Credit
15SEPE0	**DESIGN OF SHELL STRUCTURES**	PE	3	1	0	4

Preamble

Thin shells as structural elements occupy a leadership position in engineering and, in particular, in civil, mechanical, architectural, aeronautical, and marine engineering. Another application of shell engineering is in the field of biomechanics: shells are found in various biological forms, such as the eye and the skull, and plant and animal shapes. In addition to the mechanical advantages such as efficiency of load carrying behaviour, high degree of reserved strength and structural integrity, high strength to weight ratio, and containment of space, shell structures enjoy the unique position of having extremely high aesthetic value in various architectural designs. The objective of this course is to offer a comprehensive and methodical presentation of the fundamentals of structural behaviour of shell 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 shell structures in engineering.

Prerequisite

Fundamentals of Mathematics, knowledge of strength of materials and its mechanics and theory of elasticity and plasticity.

Course Outcomes

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

CO1:	Understand the structural behaviour of shell under different loading conditions and the analysis techniques.	Apply
CO2:	Understand the analytical solution for various types of shells using different methods.	Apply
CO3:	Determine the deflection, moment and stress in shells.	Apply
CO4:	Analyse the strength, stability and vibrations of different types of technically	Apply
CO5:	Prepare fabrication sketches of the designed components of shell structures.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	64	64	64	64
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	16	16	16	16

Course Level Assessment Questions

CO1: Understand the structural behaviour of shell under different loading conditions and the Analysis techniques.

1. Derive the second fundamental magnitudes and hence expressions for curvature for shells of revolution.
2. Derive the equations of equilibrium of a shell element.
3. Determine the stress resultants in a spherical dome subjected to a uniformly distributed load over the plan of the shell.

CO2: Understand the analytical solution for various types of shells using different Methods

1. Derive the equations of equilibrium for cylindrical shells in terms of displacement components u, v and w.
2. Explain in details various types of cylindrical shell with neat sketches.
3. Derive the governing equations for a cylindrical shell subjected to axially symmetric loads.

CO3: Determine the deflection, moment and stress in shells.

1. A hinged immovable shell of subjected to its own weight. Analyse the shell.
2. Explain the beam theory of analysis of shell with neat sketches.
3. Analyse a spherical dome supporting a light skylight structure or lantern and subjected to its own weight.

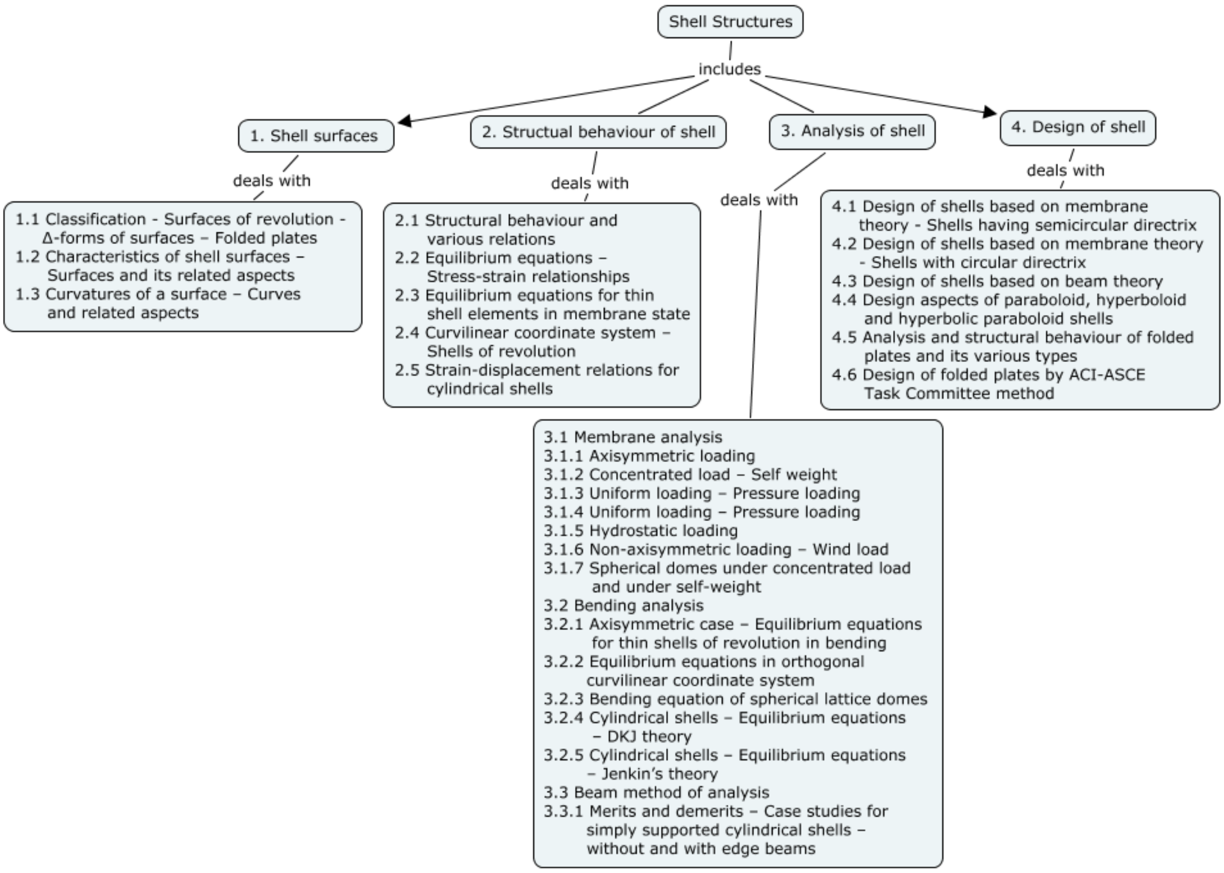
CO4: Analyse the strength, stability and vibrations of different types of technically Important shell structures.

1. A circular cylindrcal shell with edge beam has the following particulars: Radius of the shell=10.10m; central rise=2.35m; chord width=13.0m; span=30.0m; thickness of shell=80mm; semi-central angle=40^0; edge beam size=200mm x 1800mm; reinforcement in edge beam=16 x 32mm dia. Analyse rge shell for stress in concrete and steel if the live load on the shell is 1 kN/m^2.
2. A circular-cylindrcal shell of length 100cm, radius 50cm and thickness 8cm is filled with liquid of specific gravity γ. The shell is simply supported at the ends. Analyse the shell using Donnell's equations.
3. Explain in details analysis of cylindrical shell using,
   i) DKJ theory
   ii) Jenkin's theory

CO5: Prepare fabrication sketches of the designed components of shell structures.

1. Design the hyper shell roof of the inverted umbrella type to suit the followinf data: Area to be covered in plan-12m x 13m; Use M20 and Fe415 as materials. Sketch the reinforcement details in shell and edge beams.
2. A market hall measuring 20m x 30m is to be covered by turkey shed using hyper shell units. Design the hyper shell roof using the supports at the mid points of the sides of the grid. Adopt M20 and Fe415 as materials.
3. Describe in details various types of folded plates and also explain structural behaviour of folded plates.

Concept Map



Syllabus

Shell surfaces - Classification of shell surfaces – Surfaces of revolution - Δ-forms of surfaces – Folded plates – Characteristics of shell surfaces – Surfaces and its related aspects – Curvatures of a surface – Curves and related aspects - **Structural behaviour of shell** - Structural behaviour and various relations – Equilibrium equations – Stress-strain relationships –Equilibrium equations for thin shell elements in membrane state – Curvilinear coordinate system –Shells of revolution – Strain-displacement relations for cylindrical shells - **Analysis of shells - Membrane analysis of shells of revolution** – Axisymmetric loading – Concentrated load – Self weight – Uniform loading – Pressure loading – Hydrostatic loading - Non-axisymmetric loading – Wind load – Spherical domes under concentrated load and under self-weight - **Bending analysis of shells of revolution** – Axisymmetric case – Equilibrium equations for thin shells of revolution in bending – Equilibrium equations in orthogonal curvilinear coordinate system – Bending equation of spherical lattice domes – Bending analysis of cylindrical shells – Equilibrium equations – DKJ theory – Jenkin's theory - **Beam method of analysis** – Merits and demerits – Case studies for simply supported cylindrical shells – without and with edge beams – **Design of shells -** Based on membrane theory – Shells having semicircular directrix – Shells with circular directrix – Design of shells based on beam theory - Design aspects of paraboloid, hyperboloid and hyperbolic paraboloid shells – Folded plates – Analysis and structural behaviour – Various types – Design of folded plates by ACI-ASCE Task Committee method.

Reference Books

1. Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.
2. Arthur. W. Leissa, "Vibration of Shells," Acoustical Society of America Publications on Acoustics, USA, 1993.
3. ASCE Manual of Engineering Practice No.3, "Design of Cylindrical concrete shell roofs," ASCE, New York, 1952.
4. Bhavikatti S.S., 'Theory of plates and shells', New Age International Publication, 2014
5. Chandrashekhara K., 'Analysis of Concrete Shells', New Age International Edition, 2011
6. Chatterjee B.K., "Theory and Design of concrete shells," Oxford IBH, India, 1990.
7. Ramasamy G.S., "Design and Construction of Concrete shell roofs," McGraw hill Book Company, New York, 2002.
8. Reddy J.N., "Theory and Analysis of Elastic Plates and Shells", McGraw Hill Book Company, 2006.
9. Timoshenko S. and. Kruger S.W, "Theory of Plates and Shells," McGraw Hill Book Company, New York, 2008.
10. Ventsel E. and Krauthammer T., "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001

List of national and international standards

1. IS 2210:1988, Criteria for Design of Reinforced Concrete Shell Structures and Folded Plates
2. IS 2204:1962, Code of Practice for Construction of Reinforced Concrete Shell Roof.

Course Contents and Lecture Schedule

S.No	TOPICS	PERIODS
1.	**Shell surfaces**	
1.1	Classification of shell surfaces – Surfaces of revolution - Δ-forms of surfaces – Folded plates	2
1.2	Characteristics of shell surfaces – Surfaces and its related aspects	2
1.3	Curvatures of a surface – Curves and related aspects	2
2.	**Structural behaviour of shell**	
2.1	Structural behaviour and various relations	1
2.2	Equilibrium equations – Stress-strain relationships	2
2.3	Equilibrium equations for thin shell elements in membrane state	2
2.4	Curvilinear coordinate system – Shells of revolution	2
2.5	Strain-displacement relations for cylindrical shells	1
3.	**Analysis of shells**	
3.1	Membrane analysis	2
3.1.1	Axisymmetric loading	2
3.1.2	Concentrated load – Self weight	1
3.1.3	Uniform loading – Pressure loading	2
3.1.4	Hydrostatic loading	2
3.1.5	Non-axisymmetric loading – Wind load	1
3.1.6	Spherical domes under concentrated load and under self-weight	2
3.2	**Bending analysis**	
3.2.1	Axisymmetric case – Equilibrium equations for thin shells of revolution in bending	2
3.2.2	Equilibrium equations in orthogonal curvilinear coordinate system	2
3.2.3	Bending equation of spherical lattice domes	2
3.2.4	Cylindrical shells – Equilibrium equations – DKJ theory	2

3.2.5	Cylindrical shells – Equilibrium equations – Jenkin's theory	2
3.3	**Beam method of analysis**	
3.3.1	Merits and demerits – Case studies for simply supported cylindrical shells – without and with edge beams	2
4.	**Design of shells**	
4.1	Design of shells based on membrane theory - Shells having semicircular directrix	2
4.2	Design of shells based on membrane theory - Shells with circular directrix	1
4.3	Design of shells based on beam theory	2
4.4	Design aspects of paraboloid, hyperboloid and hyperbolic paraboloid shells	2
4.5	Analysis and structural behaviour of folded plates and its various types	1
4.6	Design of folded plates by ACI-ASCE Task Committee method	2
	Total periods	**48**

Course Designers:

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15SEPF0	DISASTER MITIGATION AND MANAGEMENT	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

This course deals with the various disasters and to expose the students about the measures, its effect against built structures, and Hazard Assessment procedure in India. This course also deals with the methods of mitigating various hazards such that their impact on communities is reduced.

Course Outcomes

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

CO1:	Understand the various types of disaster viz Hydrological, Coastal and Marine Disasters, Atmospheric Disasters, Geological, Mass Movement and Land Disasters, Wind and Water Driven Disasters.	Understand
CO2:	To identify the potential deficiencies of existing buildings for EQ disaster and suggest suitable remedial measures.	create
CO3:	Derive the guide lines for the precautionary measures and rehabilitation measures for EQ disaster.	Apply
CO4:	Understand the effects of disasters on built structures	Understand
CO5:	Derive the protection measures against floods, cyclone, land slides	Apply
CO6:	Understand the hazard Assessment procedure	Understand
CO7:	Design a community contingency plan prepared by the local community	create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	-	-	-	M	-	M	-	M	-
CO2.	S	S	S	-	-	S	M	-	L	S	M
CO3	S	S	S	L	-	S	-	-	L	S	M
CO4	S	M	-	-	-	-	-	-	-	M	-
CO5	S	S	S	-	-	S	-	-	-	S	M
CO6	S	M	-	-	-	M	-	-	-	M	-
CO7	S	S	-	-	-	S	M	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	30	30	30
Apply	0	20	20	20
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	40	30	30	30

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Richter Magnitude?
2. Explain in detail Peak ground Acceleration?
3. Investigate in details the site soil affect the EQ response of structures?

Course Outcome 2 (CO2):

1. Design the plan, Mass and Geometric regularities in the RC buildings. Discuss how irregularities adversely affect the performance of the RC buildings during Earthquake
2. Create strategies or the specific efforts to mitigate disasters in India

Course Outcome 3(CO3):

1. If you were the relief commissioner of the state of Assam which is affected by floods every year list out five departments that you need to contact.
2. Identify four different task forces and list out two responsibilities of each of the task forces
3. Briefly explain the components of follow-up activities in psychological rehabilitation of disaster affected people.

Course Outcome 4(CO4):

1. Describe various types of hazards and impacts associated with earthquakes and highlight the lessons learnt.
2. Discuss the effect on tsunami on off shore structures.
3. Explain in details magnitude and intensity and also list out Tsunami wave characteristics.

Course Outcome 5(CO5):

1. Investigate in which areas are more prone to heat and cold waves in India? Discuss the preventive and preparedness measures that are mostly adopted for protection from heat and cold waves
2. Explain the classification and causes of landslides indicating the places where they could occur in India.
3. List the different types of droughts and highlight its various causes.

Course Outcome 6(CO6):

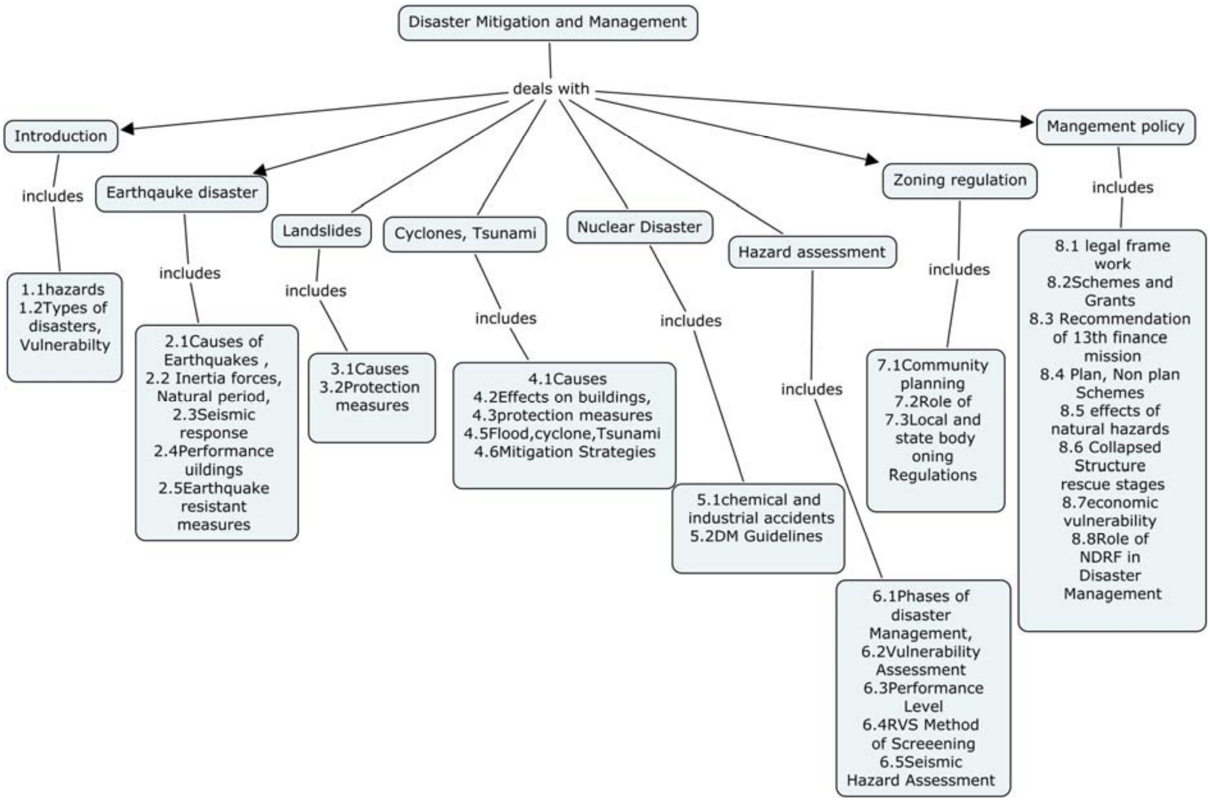
1. Briefly explain the components of follow-up activities in psychological rehabilitation of disaster affected people.
2. Explain in details mitigation strategies and also list out merits and demerits.

3. Describe Seismic Hazard Analysis in details.

Course Outcome 7(CO7):

1. Create the community contingency plan and preventive measures to be taken by the local community during any one of the disaster
2. Investigate the disaster risk can be reduced through community participation?
3. Explain the role of central Government in responding to disasters
4. Describe suitable mitigation and preparedness measures that the community should take in advance to guard a EQ disaster occurring again.

Concept Map



Syllabus

Introduction Difference between hazards and disaster –Types of disasters-Phases of disaster Management -Hazards -Classification of Hazards - Hazards affecting buildings - Building safety against hazards –Floods – Cyclone – Landslides –Tsunami Fire

Earthquake Disaster - Earthquake Hazard Map -Causes of Earthquakes -Classification of Earthquakes - -Seismic waves -Energy release - Inertia forces, Natural period -Resonance, Damping -Seismic response of free vibration -Seismic response of damped vibration - Performance of ground and buildings in past Earthquakes-Earthquake resistant measures in RC and Masonry buildings -Potential deficiencies of RC and Masonry buildings

Land slides – Landslide zoning map **-** Causes –Protection measures **Floods –** Flood zone map **-** Effects on buildings – protection measures from damage to buildings – Mitigation Strategies. **Tropical cyclones** - Effects on buildings – protection measures from damage to buildings **Tsunami -** Tsunami magnitude and intensity -Tsunami wave characteristics -

Peculiarities of tsunami deposits -Tsunami impact on coastal lines -Effects of Tsunami on built structures **Nuclear disaster** – chemical and industrial accidents - Mitigation strategies **Hazard Assessment** Vulnerability Assessment and seismic strengthening of buildings - Vulnerability Assessment of Buildings procedure -Hazard Assessment-Visual Inspection and Study of Available Documents-Detailed In - situ Investigation Planning and Interpretation of Results-Foundation Capability -Non- structural Components -Seismic Strengthening of Buildings-Repairs Restoration Strengthening of Existing Buildings Strengthening Materials-Retrofitting of Load Bearing Wall Buildings Retrofitting of RC Buildings-RVS Method of Screening – RC and Masonry Structures -Seismic Hazard Assessment – Deterministic Seismic Hazard Analysis –PSHA. **Landuse Zoning Regulations & Quality control** Introduction-Community planning Community Contingency plan –Report building and initial awareness- Recommendations For Land use Zoning Regulations - -Construction Quality Control -Evolution of Quality Management -Reasons for poor construction -Construction of Quality control in Masonry Structures.**Disaster Management Policy and Procedure –** legal frame work – Institutional Mechanism –Schemes and Grants on DM – Recommendation of 13th finance commission – plan schemes – Non plan Schemes – Externally Aided Schemes Role of NDRF in Disaster Management Medical First Responder Flood Rescue &Relief Management.

Reference Books

1. Annual Report,2009-10,Ministry of Home Affairs,GOI
2. Ayaz Ahmad “Disaster Management: Through the New Millennium” By Anmol Publications
3. Berg.GV “Seismic Design codes and procedures”, EERI, CA,1982.
4. Booth, Edmund, “Concrete Structures in earthquake regions; Design and Analysis”, Longman,1994.
5. Dowrick. D.J “Earthquake resistant design for Engineers and Architects”, Second Edition ,John Wiley & Sons,1987.
6. Ghosh G.K., “Disaster Management” By A.P.H. Publishing Corporation
7. Goel, S. L. Encyclopaedia of Disaster Management By Deep & Deep Publications Pvt Ltd
8. Jaikrishna & A.R.Chandrasekaran “Elements of Earthquake Engineering”,Sarita Prakashan, Meerut,1996.
9. Singh R.B., Disaster Management By Rawat Publications
10. Thirteenth Finance Commision Report,Ministry of Finance,GOI

List of national and international standards

1. IS: 4326-1984, “Indian Std Code of practice for Earthquake Resistant Design and Construction of Buildings”.
2. IS: 1893 (Part I)-2002 “Code of practice for Earthquake Resistant Design of Structures

Course Contents and Lecture Schedule

Sl	Topics	Periods
1	**Introduction - Disaster**	
1.1	hazards and disaster, phases of Disaster Management	1
1.2	Types of disasters, Vulnerabilty, Risk	2
2	**Earthquake Disaster**	
2.1	Causes of Earthquakes, Earthquake Size Seismic waves	2
2.2	Inertia forces, Natural period, Damping, Types of damping	1
2.3	Seismic response of free and damped vibration	1
2.4	Performance of ground and buildings in past Earthquakes	1
2.5	Earthquake resistant measures in RC and Masonry buildings	2
3	**Land slide**	
3.1	Introduction ,Causes ,Landslide zoning map	2
3.2	Protection measures	2
4	**Floods ,Tropical cyclones,Tsunami**	
4.1	Introduction- Causes	2
4.2	Effects on buildings, protection measures from damage to buildings	2
4.3	Flood,cyclone,Tsunami zone map	2
4.4	Mitigation Strategies	2
5	**Nuclear disaster**	
5.1	chemical and industrial accidents	2
5.2	DM Guidelines for Biological disaster, chemical disaster	1
6	**Hazard Assessment Procedure**	
6.1	Phases of disaster Management, Alternate communication systems	2
6.2	Vulnerability Assessment and seismic strengthening of buildings	1
6.3	Performance Level	1
6.4	RVS Method of Screeening – RC and Masonry Structures	2
6.5	Seismic Hazard Assessment – Deterministic Seismic Hazard Analysis	2
7	**Landuse Zoning Regulations & Quality control**	
7.1	Community planning Community Contingency plan	1
7.2	Role of Local and state bodies	1
7.3	Recommendations For Land use Zoning Regulations For natural disaster	1
8	**Disaster Management Policy and Procedure**	
8.1	legal frame work ,Institutional mechanism of Disaster Management in India	2
8.2	Schemes and Grants on Disaster Management	1
8.3	Recommendation of 13th finance commission	1
8.4	Plan, Non plan Schemes – Externally Aided schemes	1
8.5	Effects of natural hazards on economy & Development	1
8.6	Collapsed Structure rescue stages	1
8.7	economic vulnerability – Role of Policy makers in disaster risk reduction –	1

8.8	Role of NDRF in Disaster Management	1
8.9	Medical First Responder	1
8.1	Collapsed structure Search & Rescue	1
8.11	Flood Rescue &Relief Management	1
	Total Hours	48

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15SEPG0	DURABILITY OF CONCRETE STRUCTURES	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

Durability is the capability of maintaining the serviceability of a structure over a specified time, or a characteristic of the structure to function for a certain time with required safety and corresponding characteristics, which provide serviceability. Structures contain elements that can last more than 100 years such as foundations, walls and floor slabs, while on the other hand there are components that need frequent replacing. The durability of a structure is its resistance against the actions from the environment surrounding the structure. However, some structures, depending on their quality and environmental aggressiveness, have not satisfactory durability. Hence this course is mainly for studying deterioration resulting from reinforcement corrosion, alkali-aggregate reaction, and cyclic freezing and thawing. It provides information on causes, implications, prevention, and control. It also covers concepts of non-destructive testing and evaluation, including a brief description of the methods available, their limitations, and interpretation of results obtained. The course also offers a better perspective of nondestructive testing methods and explores the emerging thought of including maintenance and repair of concrete structures in a comprehensive design framework.

Prerequisite

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

CO1: Interact the concrete and the environment	Apply
CO2: Analyse physical mechanisms of concrete degradation	Apply
CO3: Analyse chemical mechanisms of concrete degradation	Apply
CO4: Analyse the corrosion induced in the concrete	Evaluate
CO5: Analyse the specification and design of durable concrete	Evaluate
CO6: Construct of durable concrete structures	Evaluate
CO7: Provide solution to repair and maintenance of concrete structures	Evaluate

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	S	S	S	S	-	M	S	-	-	S
CO2.	S	S	S	S	S	-	M	S	-	-	S
CO3.	S	S	S	S	S	-	M	S	-	-	S
CO4.	S	S	S	S	S	-	M	S	-	-	S
CO5.	S	S	S	S	S	-	M	S	-	-	S
CO6.	S	S	S	S	S	-	M	S	-	-	S
CO7.	S	S	S	S	S	-	M	S	-	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	--	--	--	--
Evaluate	60	60	60	60
Create	--	--	--	--

Course Level Assessment Questions

CO1: Interact the concrete and the environment

1. List out the environmental factors affecting the strength of concrete.
2. Explain the various reactions with the atmospheric agents which the concrete undergoes during fresh as well as hardened state.

CO2: Analyse physical mechanisms of concrete degradation

1. Define the term: Shrinkage.
2. State the factors influencing the thermal cracking of concrete.
3. Distinguish between the terms Abrasion and Erosion.
4. Explain in detail about the effects of concrete subjected to freezing and thawing attack and the ways to minimize it.

C03: Analyse chemical mechanisms of concrete degradation

1. Explain about sulphate attack.
2. Explain briefly about the factors controlling the sulphate attack in concrete.
3. State the chemical reaction occurring during the alkali – aggregate reaction and explain its effects.
4. Explain in detail about the ways of minimizing the effects due to acid attack.
5. Define the term: acid rain.

CO4: Analyse the corrosion induced in the concrete

1. Differentiate between the terms: pitting corrosion and crevice corrosion.
2. State the reasons for corrosion of concrete structures.
3. Explain briefly about chloride ingress into concrete and its effects.
4. Describe the reaction occurring in concrete during carbonation.

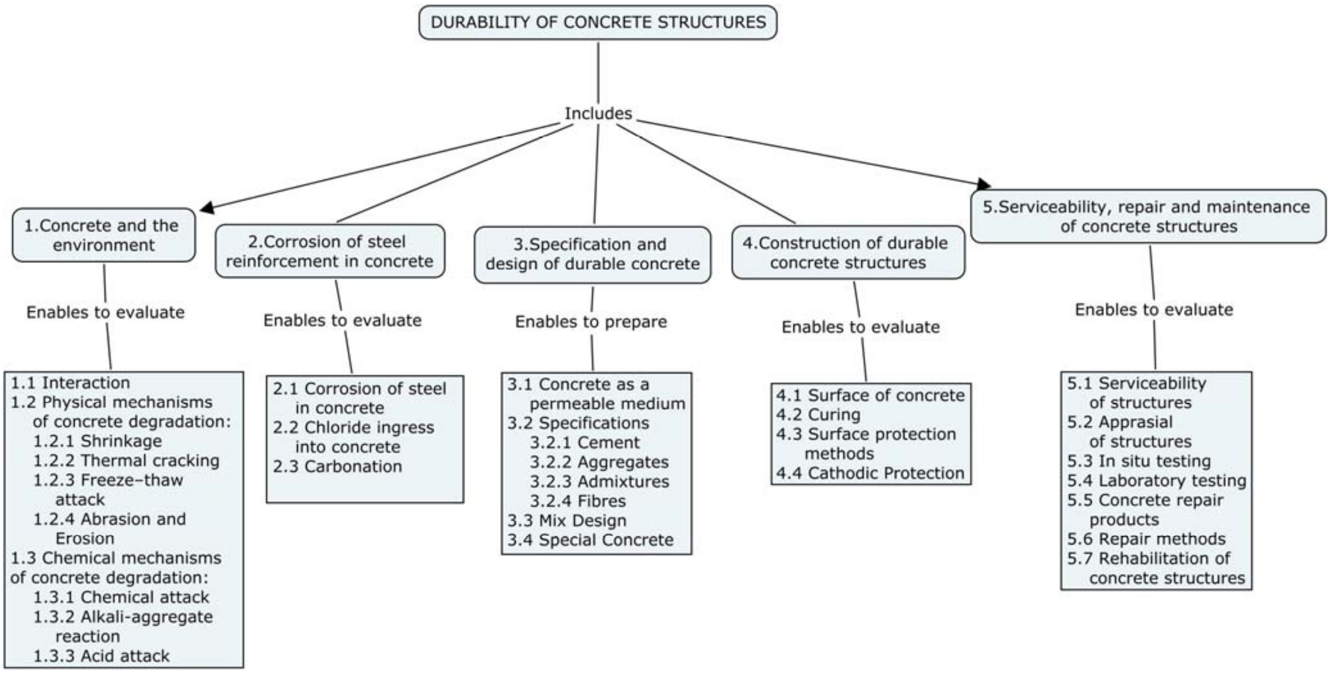
CO5: Analyse the specification and design of durable concrete

1. Define the term: Permeability of concrete.
2. Explain in detail about the experimental procedures used for measuring permeability of concrete.
3. Distinguish between High performance concrete and High strength concrete.
4. Explain the characteristics of fibres which will improve the durability of concrete.
5. Define the term: Aspect ratio of fibres.

CO6: Construct of durable concrete structures
1. Discuss the surface preparation methods of concrete which will improve the durability.
2. Explain in detail about the curing methods during hot weather concreting and cold weather concreting.
3. Describe the cathodic protection of reinforcement in a concrete structure with neat sketches.

CO7: Provide solution to repair and maintenance of concrete structures
1. Distinguish between repair and rehabilitation of structures.
2. Define the term: retrofitting of structures.
3. Explain in detail about the in-situ testing procedures to assess the performance of concrete.

Concept Map



Syllabus

Concrete and the environment - interaction; **Physical mechanisms of concrete degradation -** shrinkage, thermal cracking, freeze–thaw attack, abrasion and erosion; **Chemical mechanisms of concrete degradation -** sulphate attack, alkali–aggregate reactions, acid attack; **Corrosion of steel reinforcement in concrete -** corrosion of steel in concrete, chloride ingress into concrete, carbonation; **Specification and design of durable concrete -** concrete as a permeable medium, cement, aggregates, admixtures, fibres, specifying durable concrete, concrete mix design, special concrete; **Tests for measuring durability -** permeability, RCPT, shrinkage, heat of hydration and resistivity tests; **Construction of durable concrete structures -** surface of concrete, curing, surface protection systems, cathodic protection; **Serviceability, repair and maintenance of concrete structures -** serviceability of structures, appraisal of structures, in situ testing, laboratory testing, concrete repair products, repair methods, rehabilitation of concrete structures – general principles.

Reference Books

1. Dayaratnam.P and Rao.R, “Maintenance and Durability of Concrete Structures”, University Press, India, 1997.
2. Kumar Mehta.P. and Paulo.J.M.Monteiro, “Concrete micro structure properties and materials”, Mc Graw hill Education (India) private Limited, NewDelhi, 2013.
3. Marios Soutsos, “Concrete Durability: A Practical Guide to The Design of Durable Concrete Structures”, Thomas Telford Publisher, 2010.
4. Peter H.Emmons, “Concrete Repair and Maintenance Illustrated”, Galgotia Publications pvt. Ltd., 2001.
5. Raikar, R.N., “Learning from failures - Deficiencies in Design, Construction and Service” - RandD Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
6. Santhakumar A.R., “Concrete Technology” Oxford University Press, Printed in India by Radha Press, New Delhi, 110 031, 2007.
7. Thomas Dyer. “Durable Concrete”, 1st edition, CRC Press, 2014.

List Of National and International standards

1. SP25-84 – Hand Book on Causes and Prevention of Cracks on Buildings, Indian Standards Institution, New Delhi, 1984.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1. Concrete and the environment		
1.1	Interaction	1
1.2	Physical mechanisms of concrete degradation: shrinkage	2
1.2.1	Thermal cracking, freeze–thaw attack	2
1.2.2	Abrasion and erosion	1
1.3	Chemical mechanisms of concrete degradation: Sulphate attack	1
1.3.1	Alkali–aggregate reactions	2
1.3.2	Acid attack	1
2. Corrosion of steel reinforcement in concrete		
2.1	Corrosion of steel in concrete	2
2.2	Chloride ingress into concrete	2
2.3	Carbonation	2
3. Specification and design of durable concrete		
3.1	Concrete as a permeable medium	1
3.1.1	Cement, aggregates, admixtures	2
3.1.2	Fibres specifying durable concrete	2

3.1.3	Mix design	2
3.2	Special concrete	2
4. **Tests for measuring durability**		
4.1	Permeability, RCPT	3
4.2	Shrinkage, heat of hydration and resistivity tests	3
5. Construction of durable concrete structures		
5.1	Surface of concrete	1
5.2	Curing	2
5.3	Surface protection systems	2
5.4	Cathodic protection	1
6. Serviceability, repair and maintenance of concrete structures		
6.1	Serviceability of structures	1
6.2	Appraisal of structures	1
6.3	In situ testing	2
6.4	Laboratory testing	2
6.5	Concrete repair products	1
6.6	Repair methods	2
6.7	Rehabilitation of concrete structures	2
	Total periods	**48**

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15SEPH0	EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

This course is useful for the verification of stresses obtained by theoretical methods. This course involves the combination of analytical and experimental techniques. This deals with study of strain gauges, design of models for direct and indirect analysis. This also deals with distress management and control, instrumentation and Non destructing test methods.

Prerequisite

Fundamentals of Mathematics, knowledge of basic Science.

Course Outcomes

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

CO1:	Understand the working principles and uses of different types of strain Gauges.	Apply
CO2:	Understand the behavior of photo elastic techniques and applied to the structures.	Apply
CO3:	Understand the different types of Non destructing test methods used in structures	Apply
CO4:	Design the suitable model after applying the principle of model analysis to the prototype	create
CO5:	Understand the working principle of various measuring display Instrumentation.	Apply
CO6:	Design vibrating measuring system for various range of frequencies.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	60	60	60	60
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	20	20	20	20

Course Level Assessment Questions

CO1: Understand the working principles and uses of different types of strain Gauges.

1. Calculate the principle strains, principle stresses and the principle angles Φ1 and Φ2, the following observations are made with a rectangular rosette mounted on a steel specimen.(E = 207GPa and v =0.30 €a = 1800με €b = 600με €c = -400με
2. Categorize the various types of Mechanical strain gauges? Explain Huggenberger tensometer in detail.
3. List the types of mechanical strain gauges?
4. Sketch T-Delta rosette strain gauges?

CO2: Understand the behavior of photo elastic techniques and applied to the Structures.

1. Explain with necessary equations how isoclinics are eliminated in circular polariscope setup. What are the properties of isochromatics?
2. Explain the effects of a stressed model in a circular polariscope with neat sketch.
3. Explain the working of Huggenbergertensometer.

CO3: Understand the different types of NDT methods used in structures.

1. Explain ultrasonic pulse velocity of NDT technique?
2. Compose the Moiré method in brief and discuss the fundamental properties of Moire fringes
3. Compare X-ray method and Gamma ray method of NDT techniques?
4. Describe Moire fringes?

CO4: Design a model by applying the principle of model analysis to the prototype.

1. Summarize the methods commonly used for establishing similarity relationship between the model and the prototype.? Explain these methods briefly giving their limitations.

2. Design a single model made up of aluminium with elastic modulus as 70GPa. Determine the load to be applied to the model.
3. Deduce the expression the π terms used in the model analysis a cantilever beam of 6m is loaded with a point load of 20kN at the free end. The cross section of the beam is 120mm x 360mm. young's modulus is 200 GPa.
4. Differentiate direct and indirect model analysis?
5. List the uses of Begg Enys Deformeter?
6. Explain the working of Begg Eny'sdeformeter.

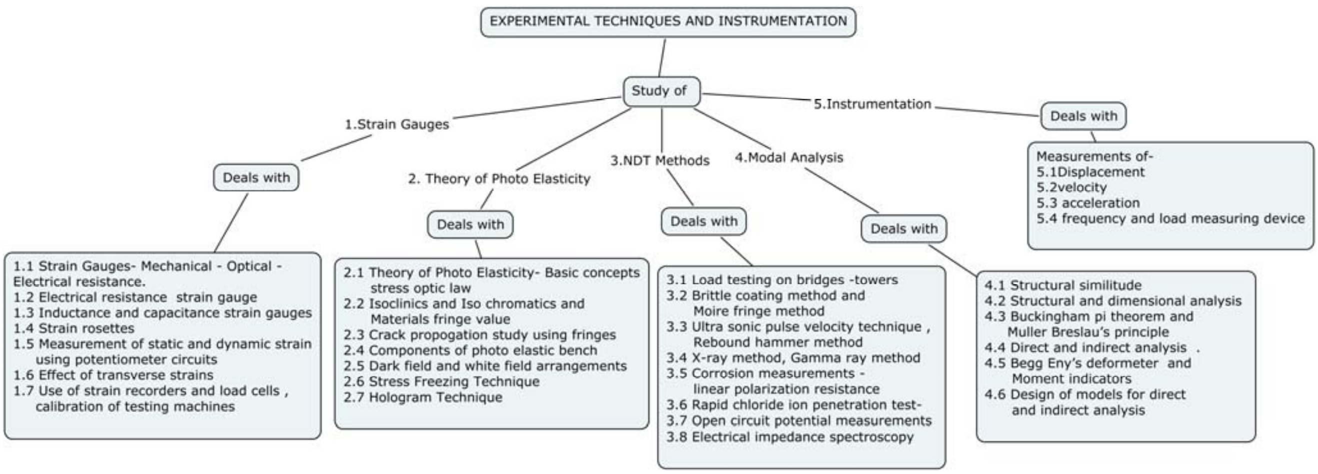
CO5: Understand the working principle of various measuring and display Instrumentation

1. Describe the principle of operation of seismo meter and accelero meter and so how the displacement and acceleration measurements are carried out?
2. Draw the block diagram of data acquisition systems and explain how the recording is done?
3. Interpret the output of XY-plotter and X-T Plotter of display units?

CO6: Design vibrating measuring system for various range of frequencies

1. Design a seismic Vibrometer for natural frequencies of 20 Hz and damping ratio of 0.7.the forcing frequencies expected are 30Hz and 1kHz
2. Design a piezo electric accelerometer for damping constant 0.2 the forcing frequencies of 2 kHz,amplitude of output displacement is 1.295x 10^{-3} mm voltage sensitivity 250V/mm and the amplitude of the output voltage is 0.324V
3. Create a vibration record that would be obtained by a seismic instruments of damping ratio 0.65 and the natural frequencies of 1500Hz.The motion of a vibrating machine is given by the equation x = 0.10sin60πt +0.05sin120πt

Concept Map



Syllabus

Strain Gauges – mechanical strain gauge – optical strain gauge – electrical resistance strain gauge - description and operation – inductance and capacitance strain gauges-strain rosettes – measurement of static and dynamic strain – effect of transverse strains –use of strain recorders and load cells –calibration of testing machines. **Theory of Photo Elasticity** Theory of Photo Elasticity- Basic concepts ,stress optic law **-**Isoclinics and Iso chromatics and Materials fringe value- Crack propogation study using fringes- Components of photo elastic bench-Dark field and white field arrangements of photo elastic bench- Stress Freezing Technique- Hologram Technique. **NDT Methods-** Load testing towers - brittle coating method - Moire fringe method- Ultra sonic pulse velocity technique - Rebound hammer method - X-ray method - Gamma ray method - corrosion measurements - linear polarization resistance - rapid chloride ion penetration test-open circuit potential measurements –Electrical impedance spectroscopy.**Model Analysis** – structural similitude – use of models –structural and dimensional analysis – Buckingham pi theorem – Muller Breslau's principle for direct and indirect analysis – use of Begg Eny's deformeter– moment indicators – design of models for direct and indirect analysis. **Instrumentation**- LVDT(linear variable differential transducer) –transducers for velocity and acceleration measurement-vibration meter – seismographs – vibration analyser –display and recording signals –cathode ray oscillograph – XY plotter - chart plotter – digital acquisition systems.

Reference Books

1. Dally J. W. & Riley W.F , "Experimental Stress Analysis" , McGraw Hill Book Company, New York , USA,1991.
2. Dove.R.C. & Aedams .P.H, "Experimental Stress Analysis and Motion measurements", Prentice Hall of india Ltd ,NewDelhi ,1965.
3. Sadhu Singh , "Experimental Stress Analysis" , Khanna Publishers , New Delhi , 2000
4. Sirohi.R.S Radhakrishna.H.C "Mechanical measurements", new Age International (p) Ltd.1997
5. Srinath.L.S , "Experimental Stress Analysis" , Tata McGraw Hill Publishing Co. Ltd, New Delhi 1991.

Course Contents and Lecture Schedule

S.No	TOPICS	PERIODS
1.Introduction of Strain Gauges		
1.1	Strain Gauges- Mechanical strain gauge- Optical strain gauge and Electrical resistance strain gauge	2
1.2	Electrical resistance strain gauge using Wheatstone bridge	1
1.3	Inductance and capacitance strain gauges	1
1.4	Strain rosettes	1
1.5	Measurement of dynamic strain using potentiometer circuits	1

1.6	Use of strain gauges in load cells proving ring torque meter.	1
1.6.1	Tutorials – Strain gauge	2
2. Theory of Photo Elasticity		
2.1	Theory of Photo Elasticity- Basic concepts,stress optic law	1
2.2	Components of photo elastic bench	1
2.3	Isoclinics and Iso chromatics and Materials fringe value	1
2.4	Effect of stress field in plane polarisocope both dark and white field.by using Jones calculus.	1
2.5	Crack propagation study using fringes	1
2.6	Dark field and white field arrangements of photo elastic bench	1
2.7	Stress Freezing Technique	1
2.8	Hologram Technique	1
2.8.1	Tutorials- Isoclinics and Iso chromatics and Materials fringe value	2
3.NDT Methods		
3.1	Load testing on bridges , towers	1
3.2	Brittle coating method and Moire fringe method	1
3.3	Ultra sonic pulse velocity technique , Rebound hammer method	1
3.3.1	Tutorials-NDT	2
3.4	X-ray method, Gamma ray method and holography	1
3.5	Corrosion measurements - linear polarization resistance	1
3.6	Rapid chloride ion penetration test	1
3.7	Open circuit potential measurements	1
3.7.1	Tutorials- Corrosion measurements	2
3.8	Electrical impedance spectroscopy	1
4.Model Analysis		
4.1	Structural similitude	1
4.2	Structural and dimensional analysis	1
4.3	Buckingham pi theorem and Muller Breslau's principle	1
4.4	Direct and indirect analysis .	1
4.4.1	Tutorials- Buckingham pi theorem and Muller Breslau's principle	2
4.5	Begg Eny's deformeter Moment indicators and curvature meter	1
4.6	Design of models for direct and indirect analysis	1
5.Instrumentation		
5.1	Classification of transducers,Capacitive, inductive, photo electric transducer	1

5.2	Seismic Instruments,Load cell, Hydraulic load cell	1
5.3	Pneumatic load cell, Torque meter,LVDT ,velocity transducer	1
5.4	Maxwell mesh current analysis for displacement measurement	1
5.5	Frequency measuring devices,Angular motion measurement, Eddy current drag cup tachometer	1
5.5.1	Tutorials –Seismic Instruments	2
5.6	Vibration analyser ,display and recording signals	1
5.7	Cathode ray oscillograph	1
5.8	Strip chart recorder,X-Y,Galvanometric type strip chart recorder	1
5.9	Digital acquisition systems	1
	TOTAL	**48**

Course Designers

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15SEPK0	FRACTURE MECHANICS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The conventional design of a structure does not take in to account of 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 elastic 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

Fundamentals of Mathematics, knowledge of basic strength of material.

Course Outcomes

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

CO1: Evaluate the fracture failure parameters

CO2: Evaluate the linear elastic fracture mechanics problems

CO3: Explain the concept of elastic plastic fracture mechanics

CO4: Estimate the residual life of fatigue Crack Growth in structure.

CO5: Suggest suitable crack arrest parameters using various techniques

CO6: Evaluate the fracture parameters using direct and indirect methods

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

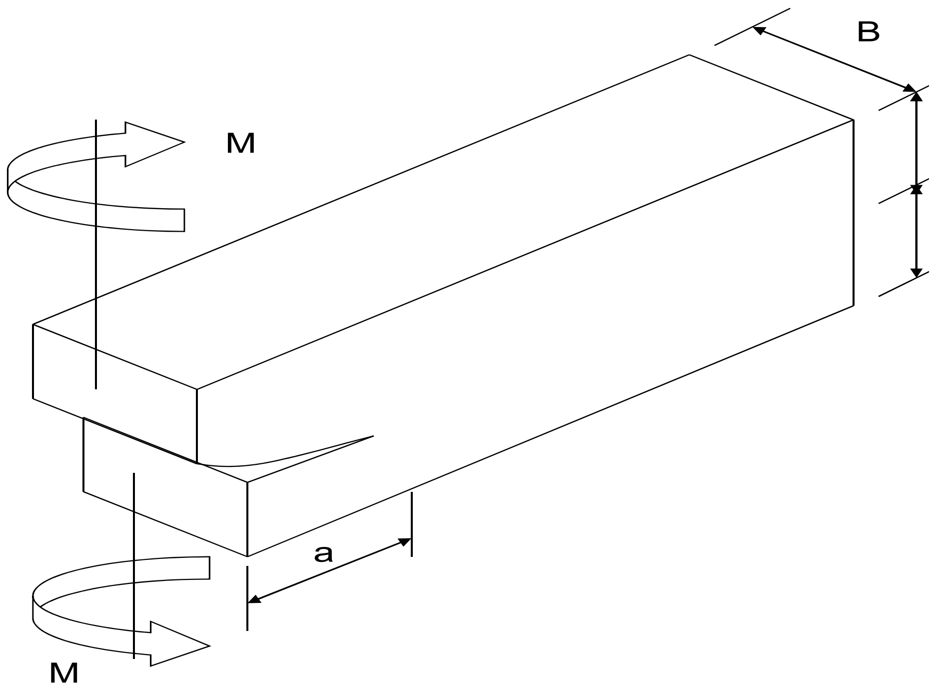
Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	30	30	30	30
Apply	10	**10**	**10**	**10**
Analyse	-	-	-	-
Evaluate	50	50	50	50
Create	-	-	-	-

Course Level Assessment Questions

CO1: Evaluate the fracture failure parameters

1. Determine the energy release rate for an edge crack loaded as shown in fig.



2. Define fracture toughness of a material ?
3. Explain various fracture modes in details.

CO2: Evaluate the linear elastic fracture mechanics problems

1. Draw the standard test specimen for KIC testing

2. Discuss the situation under which “K” approach becomes inapplicable.
3. Determine the energy release rate of DCB Specimen through the change in strain energy approach for constant load.
4. Explain how is the small scale yielding at the crack tip is taken care by Irwin. Illustrate its physical significance.
5. Derive westerguard approach to solve stresses around the crack tip in infinite plate for mode I crack problems.

CO3: Explain the concept of elastic plastic fracture mechanics

1. Determine the strain energy release rate of DCB specimen through change in strain energy approach for constant load.
2. Discuss the Stresses due to elliptical hole in a plate.
3. Explain Brittle to ductile transition in steel.

CO4: Estimate the residual life of fatigue Crack Growth in structure.

1. Explain the development of fatigue crack growth laws.
2. Explain Load interaction and retardation in fatigue crack growth.
3. Explain the most effective method of improving fatigue performance is design of residual stress in crack propagation.

CO5: Suggest suitable crack arrest parameters using various techniques

1. Determine the strain energy release rate of DCB specimen through change in strain energy approach for constant load
2. Draw a neat sketch of CT and SENB specimen as per ASTM Standard and explain the method of pre cracking in these specimens.
3. Discuss the Stresses due to elliptical hole in a plate.
4. Explain Brittle to ductile transition in steel

CO6: Evaluate the fracture parameters using direct and indirect methods

1. During water quenching of steel components with a section thickness of 30 mm, heat transfer calculations indicate that a peak stress of 130 MPa is generated in the section. Prior to heat treatment, the components were ultrasonically inspected to detect defects. The inspection technique has a minimum detection size of 0.5 mm.

    a) What type of defect will be most critical?

    b) Calculate the size of defect which would cause fracture of the component during the quenching operation, given that the aspect ratio of the crack is $2c/a = 10$.

    c) Would this inspection procedure guarantee integrity of the component if the quenching stresses approached the proof stress of the steel?

Note that the value of the plane strain fracture toughness K_{1C} = 30 MPa $m^{½}$ and the proof stress = 620 MPa.

2. Solve the difference between the stress predictions of these two equations at a distance *r* = 0.02*a* ahead of the crack tip for a through-thickness crack in an infinite plate, the tensile stress distribution ahead of the crack tip is accurately described by the equation:

$$\sigma = \frac{\sigma_{nom}}{\left(1 - \frac{a^2}{x^2}\right)^{\frac{1}{2}}}$$

where *x* is distance along the crack from its centre-line, as shown in the diagram below. In terms of the stress intensity factor, the stress very near to the crack tip can be approximated as: $\sigma = \frac{K}{\sqrt{2\pi r}}$

where *r* is distance ahead of the crack tip.

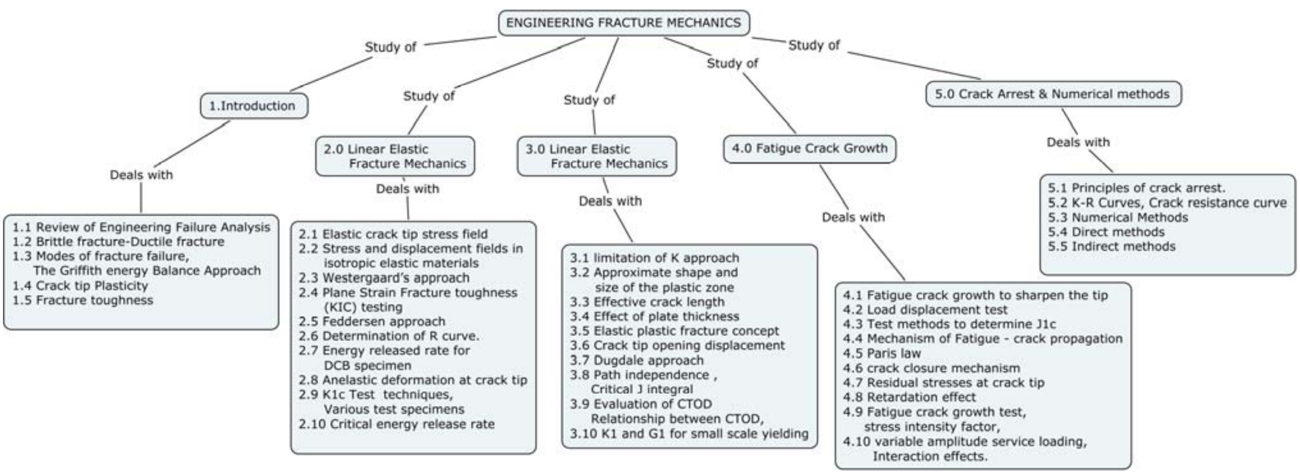
3. Explain in details:

i) Principles of crack arrest

ii) Techniques involved in crack arrest

iii) K-R Curves and Crack resistance curve.

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 fieldStress and displacement fields in isotropic elastic materials-Westergaard's approach (opening mode)-Plane Strain Fracture toughness (KIC) testing-Feddersen approachDetermination of R curve,Energy released rate for DCB specimen-Anelastic 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-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, K-R Curves, Crack resistance curve, Numerical Methods and Approaches in Fracture Mechanics, Direct methods to determine fracture parameters Indirect methods to determine fracture parameters.

Reference Books

1. Barson M. & Stanely T. Rolfe, "Fracture and Fatigue Control in Structure," Prentice Hall Inc, USA,1987.
2. Bhushan L. Karihaloo, "Fracture Mechanics and Structural Concrete," Longman Scientific Publishers, USA, 1972.
3. David Broek, "Elementary Engineering Fracture Mechanics, " Martinus Nijhoff Publishers, The Hague, 1982.
4. Gdoutos E. E., " Fracture Mechanics – An introduction," Kluwer Academic publishers, Dordrecht, 1993.
5. Jean Lemative & Jean Louis Chboche, "Mechanics of Solid Materials," Cambridge University Press, Cambridge,1987.

6. Knott J. F., "Fundamentals of Fracture Mechanics," John Wiley & Sons, New York 1973.
7. Simha K. R. Y ., "Fracture Mechanics for Modern Engineering Design," University Press (India) Ltd, Hyderabad, 2001.
8. Suresh S., "Fatigue of Materials," Cambridge University Press, Cambridge 1991.

Course Contents and Lecture Schedule

S.NO.	Topics	Periods
1.Introduction		
1.1	Review of Engineering Failure Analysis	1
1.2	Brittle fracture-Ductile fracture	1
1.3	Tutorial - Modes of fracture failure, The Griffith energy Balance Approach	2
1.4	Crack tip Plasticity	1
1.5	Fracture toughness	1
2.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	Tutorial - Westergaard's approach (opening mode)	2
2.4	Plane Strain Fracture toughness (KIC) testing	1
2.5	Feddersen approach	1
2.6	Tutorial -Determination of R curve.	2
2.7	Energy released rate for DCB specimen	1
2.8	Anelastic deformation at crack tip	1
2.9	K_{1c} Test techniques, Various test specimens	1
2.10	Critical energy release rate	1
3. 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	Tutorial -Crack tip opening displacement	2
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	2
4. 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	1
4.6	crack closure mechanism	1
4.7	Tutorial -Residual stresses at crack tip	2
4.8	Retardation effect	1
4.9	Fatigue crack growth test, stress intensity factor, factors affecting stress intensity factor	1
4.10	variable amplitude service loading, Interaction effects.	1
5. **Crack Arrest & Numerical methods**		
5.1	Principles of crack arrest, crack arrest in practice	1
5.2	K-R Curves, Crack resistance curve	2
5.3	Numerical Methods and Approaches in Fracture Mechanics	1
5.4	Direct methods to determine fracture parameters	1
5.5	Tutorial -Indirect methods to determine fracture parameters	2
	Total	48

Course Designers:

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15SEPL0	**INDUSTRIAL STRUCTURES**	Category	L	T	P	Credit
		PE	3	1	0	4

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 portal frame analysis,structural steel design, foundation design

Course Outcomes

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

CO1:Explain the planning and functional requirements of Industrial Structures	(Apply)
CO2: Design the Pre – Engineered structures and foundations.	(Create)
CO3: Demonstrate the structural aspects of machine foundation and containment structures.	(Apply)
CO4: Design the Turbo generator foundations & conveyor systems	(Create)
CO5: Design a bunker and silos.	(Create)
CO6: Explain the design concept of hyperbolic cooling towers	(Analyze)

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	10	10	10	10
Evaluate	-	-	-	-
Create	50	50	50	50

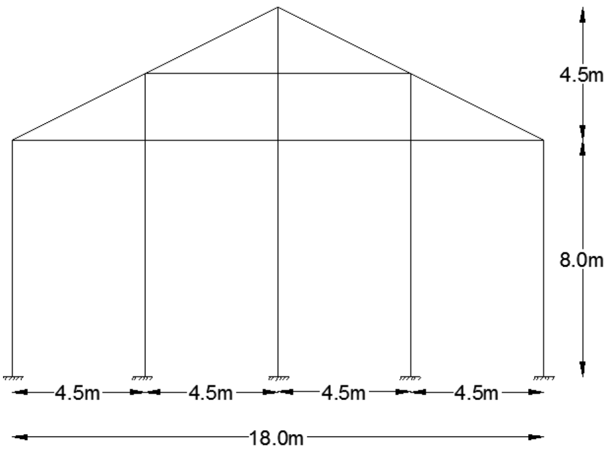
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain
   (i) Methods of providing Ventilation.
   (ii) Protection against noise and Vibration in Industrial Buildings.
2. Discuss briefly how the planning for layout requirement is done for an industrial building. Supplement your answer with sketches.
   a. State the important guidelines from Factories act with reference to planning of industrial buildings.
   b. Explain various methods of providing lighting for industrial buildings
3. List the items to be considered while selecting a cladding system.

Course Outcome 2 (CO2):

1. Design gable rafter, side and gable columns for the industrial building shown below



2. An Industrial building of plan 15m×30m is to be constructed at Noida. Analyse the single span portal frame with gabled roof and design a corner connection with haunch. The frame has a span of 15 m, the column height is 6m and the rafter rise is 3 m and the frames are spaced at 5 m centre-to-centre. Purlins are provided over the frames at 1.3 m c/c and support AC sheets. The dead load of the roof system including sheets, purlins and fixtures is 0.4 kN/m2 and the live load is 0.52 kN/m2. The portal frames support a gantry girder at 3.25 m height, over which an

electric overhead travelling (EOT) crane is to be operated. The crane capacity is to be 300 kN and the crane girder weighs 300 kN while the crab (trolley) weight is 60 kN.

3. Illustrate the concepts of pre-engineered structures.

Course Outcome 3 (CO3):

1. Describe the steps involved while designing the foundation for reciprocating machines.
2. Define nuclear containment structures?
3. Design a block foundation with a machine operating at 300 rpm, ξ=0.25, maximum value of the exciting force is 4000kg and k=35*10^6kg/m and weight of the machine is 5 ton.

Course Outcome 4 (CO4):

1. Write about Material handling structures
2. Explain the working principle of a turbo generator foundation.
3. Discuss about various types of conveyor systems.

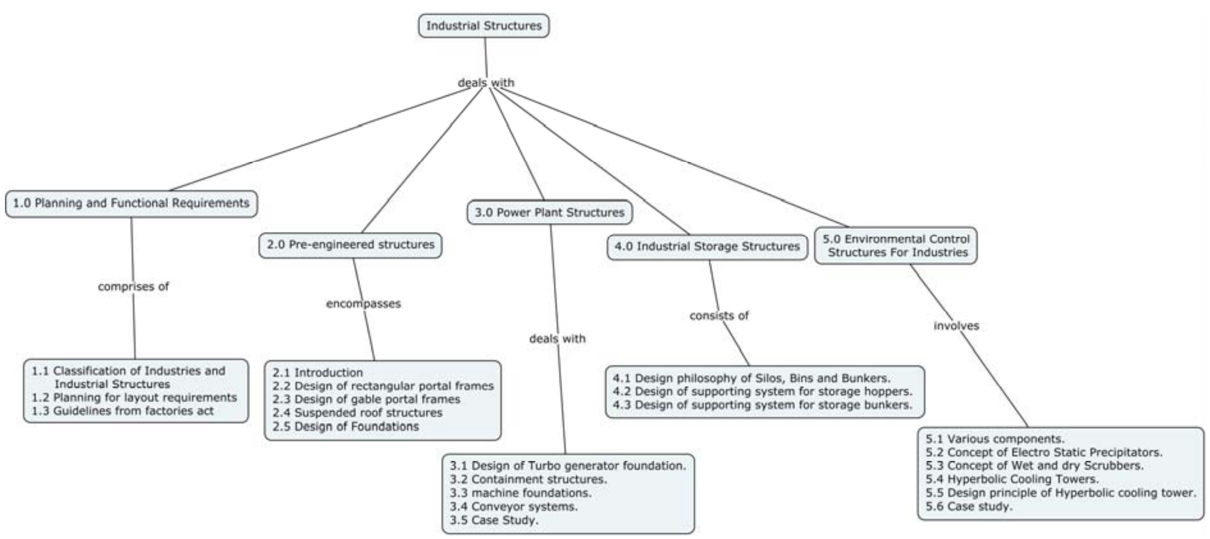
Course Outcome 5 (CO5):

1. Distinguish between bunker and silo.
2. Design a rectangular steel bunker of 12m length and 6m width supported on eight columns (four along each long side) to store coal of bulk density 80 kN/m³ and angle of internal friction 35º.
   Height of vertical portion = 4m
   Height of hopper = 4m
3. Design a steel bunker to store 3600 kN of coal for a loco running shed. The unit weight of coal is 80 kN/m³. Provide 500 mm x 500 mm hopper opening. The angle of response for coal is 35º

Course Outcome 6(CO6):

1. Discuss the uses of cooling towers
2. Illustrate the design principles involved in Hyperbolic cooling towers
3. Explain the various components of a hyperbolic cooling tower in detail.

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	2
1.2	Planning for layout requirements regarding lighting, ventilation and fire safety & protection against noise and vibration	2
1.3	Guidelines from factories act –structural loads.	2
2.0	**Pre-engineered structures**:–	
2.1	Introduction	2
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	1
2.3.1	Tutorial-2	2
2.4	Suspended roof structures analysis	1
2.5	Suspended roof structure design	
2.5.1	Tutorial-3	2
2.6	Design of Foundations for industrial structures	1
2.6.1	Tutorial-4	1
3.0	**Power Plant Structures**:–	
3.1	Types of power plants – Design philosophy of Turbo generator foundation	2
3.2	Design of Turbo generator foundation	1
3.2.1	Tutorial-5	1
3.3	Containment structures	2
3.4	Structural aspects of machine foundations.	2
3.5	Conveyor systems – Supports for conveyor systems.	2
3.6	Case Study	2
4.0	**Industrial Storage Structures**:–	
4.1	Design philosophy of Silos, Bins and Bunkers	2
4.2	Design of supporting system for storage hoppers	1
4.2.1	Tutorial-6	1
4.3	Design of supporting system for storage bunkers	1
4.3.1	Tutorial-7	1
5.0	**Environmental Control Structures For Industries**:–	
5.1	Various components of environmental control structures	2
5.2	Concept of Electro Static Precipitators functioning and components	2
5.3	Concept of Wet and dry Scrubbers	2
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
5.6.1	Tutorial-8	2
	Total	48

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		Category	L	T	P	Credit
15SEPM0	**SOIL – STRUCTURE INTERACTION**	PC	3	1	0	4

Preamble

To provide an understanding of the relevance and significance of soil-structure interaction in the case of different types of structures, including embedded and buried structures and how to take soil structure interaction into account in design.

Prerequisite

Fundamentals of Mathematics, knowledge of Geotechnical Engineering and Foundation Engineering

Course Outcomes

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

CO1	Formulate solutions for general soil structure interaction problems like shallow foundation and sheet pile walls	Apply
CO2	Understand various soil structure interaction parameters involved in the foundation design and soil – pile behaviour	Apply
CO3	Appreciate the soil structure interaction involved in Retaining structures	Analyse

Mapping with Programme Outcomes

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

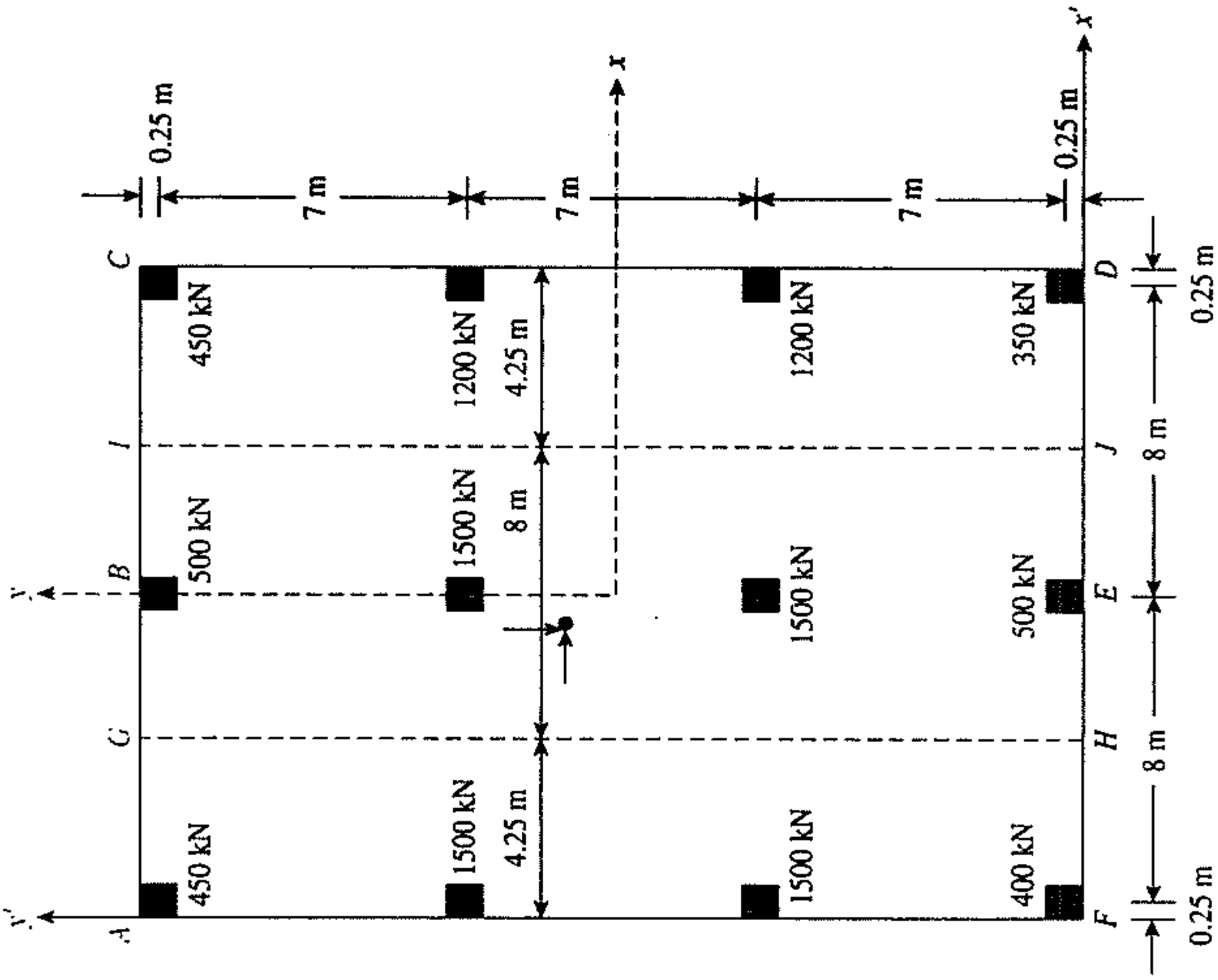
Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	40	40	40	40
Analyse	40	40	40	40
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1: Formulate solutions for general soil structure interaction problems like shallow foundations and sheet pile walls.

1. For the design of a raft in clay soil, it is divided into strips. One of the strips is 3.3m wide and 22m in length with a number of columns at equal spacing. Determine (a) conditions under which strip can be designed as a rigid strip; (b) conditions where ACI method can be used. The allowable net bearing capacity of the soil is assumed to be 5 t/m^2. (Assume q_u = 2.4 times net bearing capacity).
2. Draw the contact pressure distribution underneath a flexible and a rigid footing resting in sand and in clay and discuss about their settlement.
3. Calculate the soil pressures at points A,B,C,D,E and F as shown in the plan of the Mat Foundation. (Note: All column sections are planned to be 0.5m x 0.5m)



CO2: Understand various soil structure interaction parameters involved in the Foundation design and soil – Pile behaviour

1. Compute the maximum deflection and slope of a finite beam subjected to a concentrated load P = 9 kN at its mid length and a uniform loading p = 7.5 kN/m. Length of the beam L = 0.15m, EI = 8.4 MN/m^2 and k = 14 MPa.
2. Write notes on the following

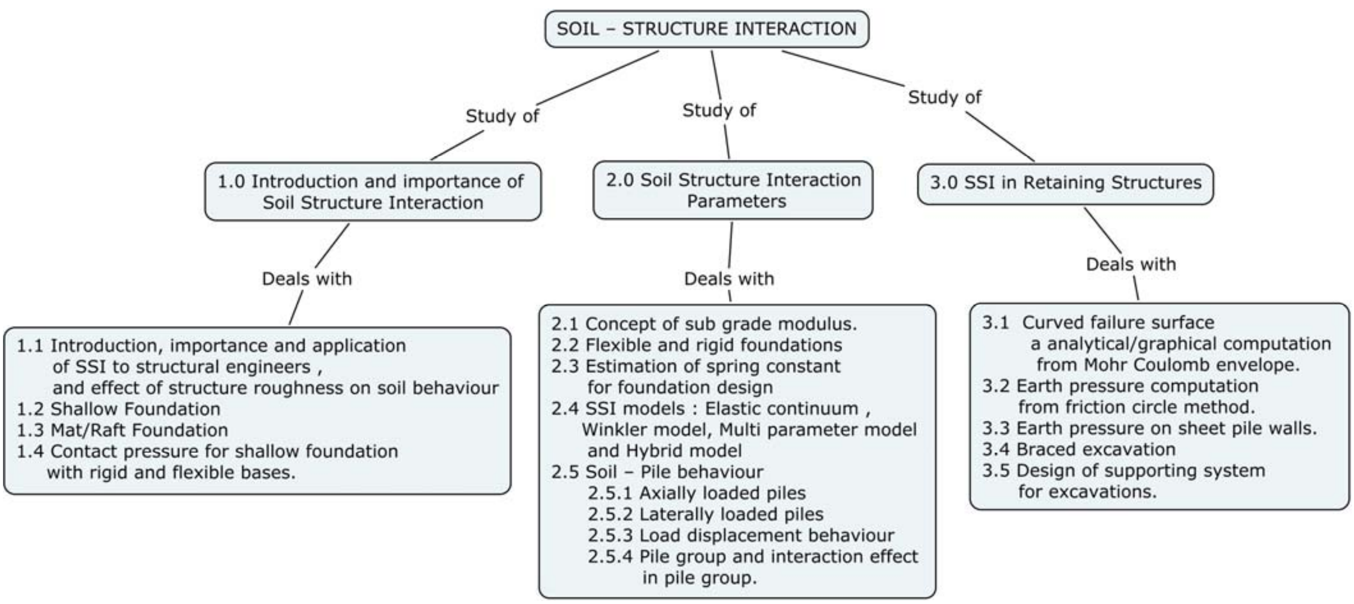
a) Elastic continuum approach for laterally loaded piles
b) Lateral capacity of pile groups
c) Parameters for foundation design

3. Determine the ultimate load that can be applied on a 300mm square wooden pile, driven 5m below ground level in pre-loaded clay. The load to be applied is 1m above the ground. M_U = 100kNm. Assume K_h = 15 MN/m^2, E = 10 x 10^2 MN/m^2 and cohesion of clay = 1 kg/cm^2

CO3: Appreciate the soil structure interaction involved in Retaining structures

1. Determine the depth of embedment of the anchored sheet pile wall by fixed end and free end method. Illustrate the difference between the two methods. Show which method arrives at a lesser depth of embedment. The anchor is at a depth of 2.5m from the top. The water level on both sides is 3m from top of sheet pile wall. The dredge level is at 8m below the top of sheet pile wall.
2. Calculate the depth of penetration required for the stability of a cantilever sheet pile installed in a cohesionless soil of unit weight 2 t/m^3 and Ø = 30^0. The height above the dredge level is 6m and the water level above the dredge level is 3m. Also compute the theoretical maximum bending moment in the pile.
3. Compute the load on the struts placed laterally at 3.5m c/c (along the length of the cut) and vertically at 2.5m c/c in a braced cut. The braced cut has to be excavated in medium dense sand for a depth of 7m. Given γ = 18 kN/m^3, c = 0 and Ø = 35^0. Also calculate the maximum moment of the sheet pile section.

Concept Map



Syllabus

Introduction and importance of Soil Structure Interaction: Introduction, importance and application of SSI to structural engineers and effect of structure roughness on soil behaviour- Shallow Foundation- Mat/Raft Foundation- Contact pressure for shallow foundation with rigid and flexible bases. **Soil Structure Interaction Parameters:** Concept of sub grade modulus- Flexible and rigid foundations- Estimation of spring constant for foundation design- SSI models : Elastic continuum , Winkler model, Multi parameter model and Hybrid model- Soil – Pile behaviour- Axially loaded piles- Laterally loaded piles- Load displacement behaviour- Pile group and interaction effect in pile group**. SSI in Retaining Structures:** Curved failure surface and determination of lateral earth pressure by analytical and graphical method - Earth pressure computation from friction circle method- Earth pressure on sheet pile walls- Diaphragm wall- Braced excavation- Design of supporting system for excavations.

Reference Books

1. Bowels J E., “Analytical and Computer Methods in Foundation”, McGraw Hill Book Co. New York,1990.
2. Prakash S., and Sharma, H. D., “Pile Foundations in Engineering Practice.” John Wiley & Sons, New York, 1990.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.	Introduction and importance of Soil Structure Interaction	
1.1	Introduction, importance and application of SSI to structural engineers and effect of structure roughness on soil behaviour	2
1.2	Shallow Foundation	2
1.2.1	Tutorials - Shallow Foundation	2
1.3	Mat/Raft Foundation	2
1.3.1	Tutorials - Mat/Raft Foundation	1
1.4	Contact pressure for shallow foundation with rigid and flexible bases.	2
1.4.1	Tutorials – Contact pressures	1
2.	Soil Structure Interaction Parameters	
2.1	Concept of sub grade modulus.	2
2.2	Flexible and rigid foundations	2
2.3	Estimation of spring constant for foundation design	2
2.4	SSI models : Elastic continuum , Winkler model, Multi parameter model and Hybrid model	3
2.5	Soil – Pile behaviour	
2.5.1	Axially loaded piles	2
2.5.2	Laterally loaded piles	2
2.5.3	Load displacement behaviour	2
2.5.4	Pile group and interaction effect in pile group.	2
2.5.5	Tutorials – Soil pile behaviour	4
3.	SSI in Retaining Structures:	

Module No.	Topic	No. of Lectures
3.1	Curved failure surface and analytical/graphical computation from Mohr Coulomb envelope.	2
3.1.1	Tutorials – Mohr Coulomb envelope	1
3.2	Earth pressure computation from friction circle method.	1
3.2.1	Tutorials – friction circle method	1
3.3	Earth pressure on sheet pile walls.	2
3.3.1	Tutorials – Earth pressure on sheet pile walls	1
3.4	Diaphragm wall	3
3.5	Braced excavation	2
3.6	Supporting system for excavations.	1
3.6.1	Tutorials – Design of supporting system for excavations	1
	Total Hours	48

Course Designers:

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15SEPN0	STRUCTURAL DESIGN OF FOUNDATION	Category	L	T	P	Credit
		PE	3	1	0	4

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 and design caisson foundation.

Prerequisite

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

Course Outcomes

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

CO1	Understand and analyse various types of sheet pile walls	Apply
CO2	Analyse and design different types of raft foundation	Apply
CO3	Design various types of piles and estimate the load carrying capacity of the piles & pile group	Analyse
CO4	Analyse and design caisson foundation	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	60	60	60	60
Analyse	20	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1: Understand and analyse various types of sheet pile walls

1. Calculate the depth of penetration needed for stability of the cantilever sheet pile wall installed in granular soil of unit weight 19.33 kN/m^3 and Ø = 32^0. The height above the dredge level is 5m and the water level above the dredge level is 3m. Also compute the total length of the sheet pile wall, for a 30% increase in depth of penetration.
2. Determine the required depth of penetration of a cantilever sheet pile wall in a cohesion less deposit with γ = 17 KN/m^3 and Ø = 34^0 by considering the actual pressure distribution. Height of Backfill to be retained above dredge level is 4m.
3. Discuss the procedure of finding the depth of embedment of a cantilever sheet pile wall penetrating a clay deposit.

CO2: Analyse and design different types of raft foundation

1. Calculate the soil pressures at points A, B, C, D, E, and F of a raft foundation with column loads shown in Figure 1. The size of the raft is 16.5m x 21.5m. All columns are 0.5m x 0.5m in section. Given that the net allowable bearing capacity of the soil is 60 kN/m^2. Check whether the soil pressures are less than the net allowable bearing capacity of the soil.

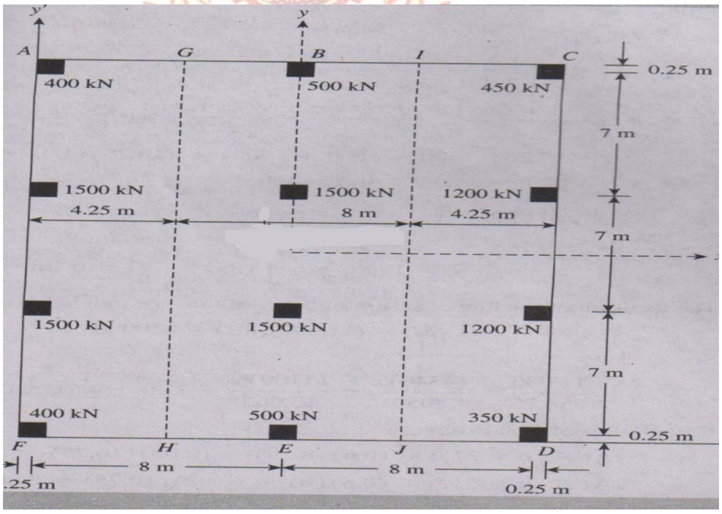


Figure 1: Raft Foundation

2. Determine the allowable bearing capacity of a 10m x 14m raft in clay founded at a depth of 1.5m below the ground surface. The pressure underneath the raft is 60kN/m^2. Depth of the clay layer below the raft is 10m and the material below that depth is sand. The avg SPT value of the clay is 8. Water table is located at the base level of the foundation. For the clay layer below water table, w_L= 65%, w = 45%, G= 2.7 and γ_{sat} = 19.5 kN/m^3. Compute the expected settlement of the raft.
3. Estimate the allowable bearing capacity of a raft 9m x 12m in a sand deposit with avg SPT value of 13. Depth of the raft is 2m, γ = 18.5 kN/m^3 and an allowable settlement of 25mm. What is the expected differential settlement?

CO3: Design various types of piles and estimate the load carrying capacity of the Piles & pile group

1. Compute the allowable lateral load for a steel H-pile (HP 250 x 85) 25 m long, embedded fully in a granular soil. Assume that n_h = 12000kN/m^3. The allowable displacement at the top of the pile is 8mm. Let M_g = 0. Use the elastic solution
2. Calculate the deflection at the pile head of a concrete pile with 450mm dia and 12m long installed in a sand deposit. Its coefficient of subgrade reaction is 10 x 10^6 N/m^3. Consider it as a free head pile under a horizontal force of 25 kN.
3. Calculate the group capacity and the efficiency of a friction pile group in clay deposit. The pile group consists of 9 piles of 450mm dia spaced at 0.9m apart. The piles are 12m in length and the cohesion of the clay is 50kN/m^2. Also calculate the settlement of the pile group if the settlement at the carrying capacity of the single pile is 2.5mm.
4. Design the layout of stone columns required for supporting a tank of 50m in diameter, exerting a pressure of 150 kN/m^2. The tank is to be founded in a soft clay deposit of 8m thickness with an average SPT value of 6. Take the unit weight of the clay as 19kN/m^3. Also design a under reamed pile for the same soil condition. Would you prefer stone column or under reamed for the given sub soil condition

CO4: Analyse and design caisson foundation

1. Compute the grip length of a caisson foundation as per limit state equilibrium method. The caisson foundation with an external diameter of 6.4m has to be sunk in a soil deposit to support a bridge pier. The caisson is founded in sandy soil.
Following data are available:
Dimensions of caisson:
    External diameter of caisson = 6.4m
    Cross sectional area = 32.2sq.m
    Height of bearing level above maximum scour level = 26.6m

    Design loads:

Type of load	Seismic condition	Non-seismic condition
Total vertical load including weight of pier and the caisson	1930 tonnes	1930 tonnes
Total lateral load at scour level	85 tonnes	37 tonnes
Total moment at scour level	2240 t-m	1050 t-m

Soil Properties:

Relative density = 60%

Submerged unit weight = 1.05 t/m^3

Angle of internal friction = 33^0

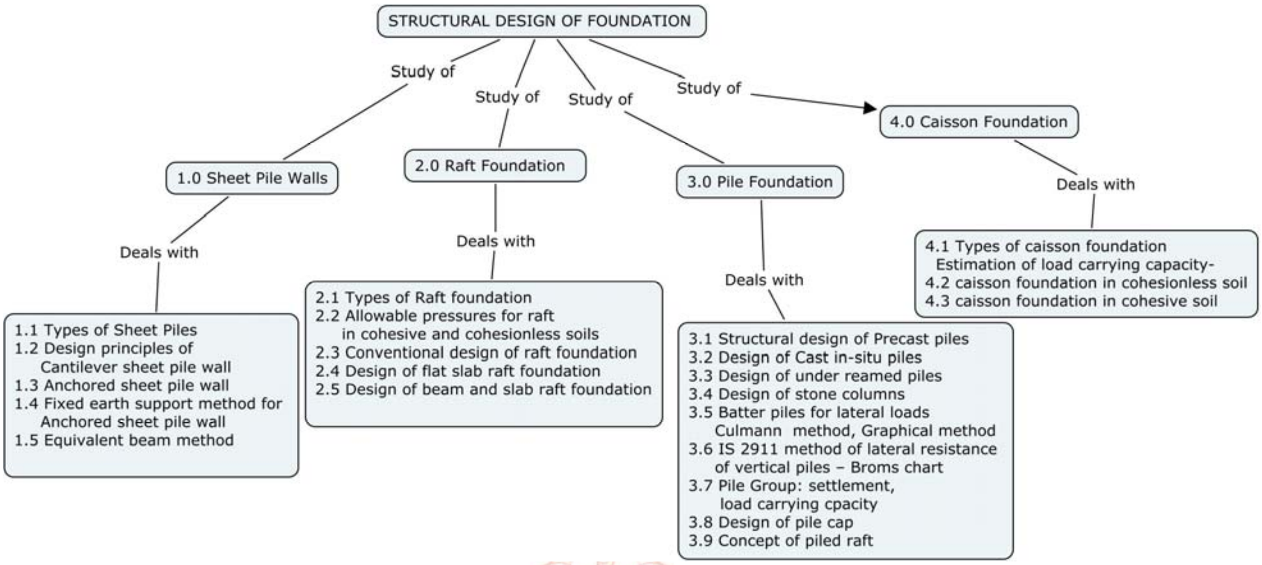
Angle of wall friction = 27^0

Also check if the length provided is adequate or not.

2. Explain in detail various types of caisson's foundation with neat sketches.

3. Explain design procedure of load bearing capacity of caisson foundation in cohesion less and cohesive soil.

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. Das, B.M., “Principles of Foundation Engineering”, Sixth Edition (India), Thomson, 2007.
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, 2007.

List Of National And International Standards

1. IS: 2974(Part 1 to 5) -1982, Code of Practice for Design and Construction of Machine Foundations.
2. 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.
3. IS: 2950 (Part 1) -1981, Code of Parctice for Design and construction of raft foundation.

Course Contents and Lecture Schedule

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	2
1.3	Anchored sheet pile wall	1
1.3.1	Tutorials - Anchored sheet pile wall	1
1.4	Fixed earth support method for Anchored sheet pile wall	1
1.4.1	Tutorials - Fixed earth support method	1
1.5	Equivalent beam method	1
1.5.1	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	2
2.3	Conventional design of raft foundation	1
2.3.1	Tutorials – Conventional design of raft foundation	1
2.4	Flat slab raft foundation	1
2.4.1	Tutorials – Design of flat slab raft foundation	1
2.5	Beam and slab raft foundation	1
2.5.1	Tutorials – Design of beam and slab raft foundation	1
3	**Pile Foundation**	
3.1	Structural design of Precast piles	2
3.2	Cast in-situ piles	1
3.2.1	Tutorials – Design of Cast in-situ piles	1

3.3	Under reamed piles	1
3.3.1	Tutorials – Design of under reamed piles	1
3.4	Stone columns	2
3.4.1	Tutorials – Design of stone columns	1
3.5	Batter piles for lateral loads – Culmann method – Graphical method	2
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	2
3.7.1	Load carrying capacity of pile groups	1
3.7.2	Pile group subjected to eccentric vertical load	2
3.7.3	Settlement of pile group	2
3.8	Design of pile cap	3
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	2
4.3	Stability Analysis by limit equilibrium method	1
4.3.1	Tutorials – Caisson Foundation	1
	Total	48

Course Designers:

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15SEPQ0	**THEORY OF PLATES**	Category	L	T	P	Credit
		PE	3	1	0	4

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 methodical 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.

Prerequisite

Fundamentals of Mathematics, knowledge of strength of materials and its mechanics and theory of elasticity and plasticity.

Course Outcomes

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

CO1	Analyse bending of long rectangular plates using thin plate theory	Evaluate
CO2	Analyse circular plates with various loading conditions	Evaluate
CO3	Analyse rectangular plates using classical approach and methods	Evaluate
CO4	Analyse bending of Anisotropic plates	Evaluate

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests 1	2	3	Terminal Examination
Remember	10	10	10	10
Understand	10	10	10	10
Apply	20	20	20	20
Analyse	-	-	-	-

Evaluate	60	60	60	60
Create	-	-	-	-

Course Level Assessment Questions

CO1: Analyse bending of long rectangular plates using thin plate theory.

1. Give the basic assumptions made in the theory of thin plates with small deflections.
2. Write the relationship between bending moments and curvature in pure bending of plates.
3. Give the expressions for the slope and curvature of slightly bent rectangular plates.
4. Compute the governing differential equation for the laterally loaded plates by considering the twisting moments and shear in addition to the moments.
5. Analyse the cylindrical bending of simply supported and uniformly loaded rectangular plate and determine the maximum deflection.

CO2**:** Analyse circular plates with various loading conditions

1. Give the governing differential equation for the symmetrical bending of laterally loaded circular plates.
2. Write the equation for M_r for a circular plate with loading q (r, θ) in terms of deflection.
3. Give the relationships between Cartesian and Polar coordinates in the circular plates?
4. Compute the governing differential equation for symmetrical bending of laterally loaded circular plates.
5. Determine the maximum deflection and maximum bending moment for a clamped circular plate of radius ‘a’ subjected to uniform loading of intensity ‘P’.
6. Analyse a simply supported circular plate of radius ‘a’ with a central hole of radius ‘b’ subjected to the moment ‘m’ along the inner boundaries and determine the expression for deflection.

CO3: Analyse rectangular plates using classical approach and methods

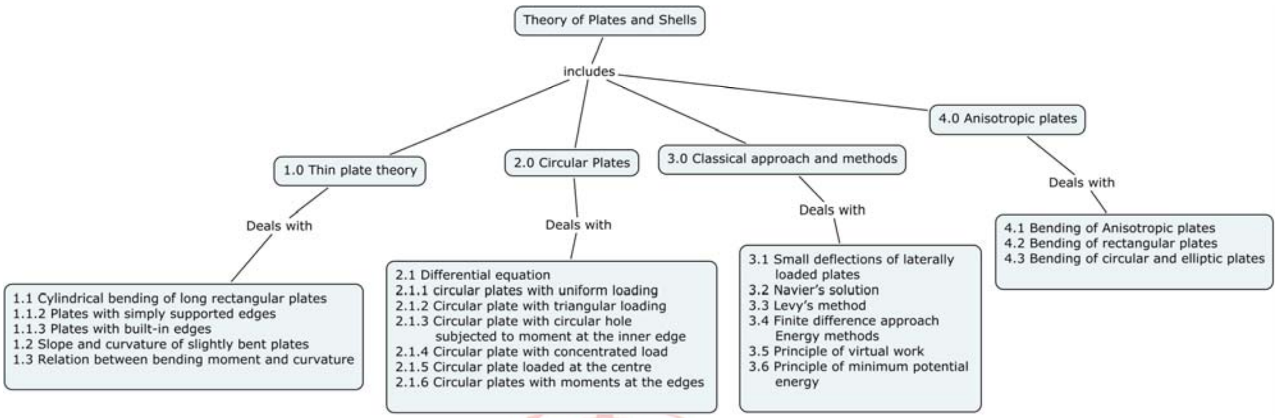
1. State the basic difference between Navier’s solution and Levy’s method.
2. Give the conditions to be satisfied for applying Levy’s method?
3. Give the advantages of finite difference method over classical methods?
4. List various numerical methods for analysis of plates.
5. Determine maximum deflection of a simply supported rectangular plate subjected to uniformly distributed load of P. Apply Levy’s method.
6. Construct the governing differential equation for small deflections of laterally loaded plates considering the moments and shearing forces.
7. Determine the approximate deflection at the pivotal points of a simply supported rectangular plate of sides 6m and 3m, supports a uniformly distributed load of 12 kN/m^2 over the central half of the plate. Use a grip spacing of 1m. Thickness of plate = 50mm E = 200 GPa Poisson’s ratio = 0.3.
8. Compute maximum deflection of a simply supported rectangular plate subjected to hydrostatic pressure. Apply Navier’s solution method.

CO4: Analyse a bending of Anisotropic plates

1. Explain about anisotropic plates.
2. Distinguish between anisotropic plates and isotropic plates
3. Determine the maximum deflection of fixed supported circular anisotropic plate subjected to uniformly distributed load.

4. Determine the maximum deflection and maximum moment for bending of simply supported rectangular anisotropic plate subjected to uniformly distributed load.

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. Ansel. C. Ugural, "Stresses in Beams, Plates and Shells," CRC Press, 2009.
2. Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.
3. Bairagi N. K., "A text book of Plate Analysis," Khanna Publishers, New Delhi, 1996

4. Chandrashekahara K., "Theory of Plates," University Press (India) Ltd., Hyderabad, 2001.
5. Reddy J.N., "Theory and Analysis of Elastic Plates and Shells", McGraw Hill Book Company, 2006.
6. Szilard R., "Theory and Analysis of Plates, Classical and Numerical methods" Prentice Hall, USA, 1975.
7. Szilard R., "Theories and Application of Plate Analysis: Classical, Numerical and Engineering methods" Prentice Hall, USA, 2004
8. Timoshenko S. and.Kruger S.W."Theory of plates and Shells," McGraw Hill Book Company,New York, 2008.
9. Ventsel E. and T. Krauthammer, "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001.

List of National and International Standards

1. IS 2210:1988 Criteria for Design of Reinforced Concrete Shell Structures and Folded Plates

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	2
1.1.1	Plates with simply supported edges	1
1.1.2	Plates with built-in edges	1
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	1
2.1.5	Circular plate loaded at the centre	1
2.1.6	Circular plates with moments at the edges	1
	Tutorial	2

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	1
3.2.2	Simply supported rectangular plates under hydrostatic pressure	2
3.2.3	Simply supported rectangular plates under concentrated load	1
3.2.4	Simply supported rectangular plates under uniform loading over an area of a rectangle	1
3.2.4.1	Tutorial -	2
3.3	**Levy's method**	
3.3.1	Simply supported rectangular plates under uniform loading	2
3.3.2	Simply supported rectangular plates under hydrostatic pressure	1
3.3.2.1	Tutorial	2
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
3.4.3.1	Tutorial	2
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	2
3.5.1	Tutorial	2
4. Anisotropic plates		
4.1	Bending of Anisotropic plates – Differential equation	2
4.1.1	Bending of rectangular plates	2

4.1.2	Bending of circular and elliptic plates	2
4.1.2.1	Tutorial	2
	Total No. of periods	**48**

Course Designers:

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15SEPR0	**COMPUTER AIDED DESIGN**	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

The syllabus of subject "Computer Aided Design" of structures includes the main concepts of informatics, computer hardware and software, principles for design and types of operational systems (Windows), work with interpreter, compilers and linkage editors. The main aspects of programming with MS Visual C++ considered are: variables and types of data, arithmetical, logical and relational operations, main operators, functions, objects, classes, input-output operators, etc. This course provides the essentials of performing computer-aided design, from engineering rather than a purely mathematical point of view.

Prerequisite

Fundamentals of Mathematics, knowledge of design of RCC, prestressed concrete and steel structures and also algorithm and program development

Course Outcomes

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

CO1: Formulate algorithm for solving equations by matrix method and construct algorithm for computer aided design of truss problems	Evaluate
CO2: Construct algorithm for computer aided design of reinforced concrete members	Apply
CO3: Construct algorithm for computer aided design of steel and light gauge steel members	Apply
CO4: Construct algorithm for analysis of prestressed concrete members	Apply
CO5: Develop computer aided analysis and design softwares	Evaluate

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	30	30	30	30
Analyse	-	-	-	-
Evaluate	50	50	50	50
Create	-	-	-	-

Course Level Assessment Questions

CO1: Formulate algorithm for solving equations by matrix method and construct algorithm for computer aided design of truss problems List the methods of solving simultaneous equations.

1. Write the equation for obtaining structure stiffness matrix.
2. Explain Gauss Elimination method of solving simultaneous equations.
3. Illustrate with an example the matrix stiffness method of solving a truss.
4. Determine the forces in the members of the truss shown in Fig.1 by matrix stiffness method. Take E = 200 GPa.

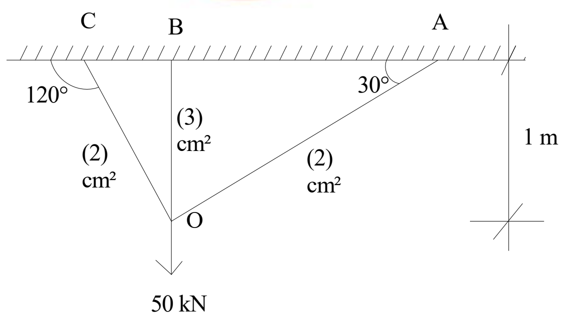


Fig.1

5. Solve the following system of equations by Gauss elimination method.

$$3x_1 - 4x_2 - x_4 = 2$$
$$x_2 + x_3 + 4x_4 = 3$$
$$x_1 - 3x_2 + 6x_3 - 2x_4 = -3$$
$$x_2 + 2x_3 + 3x_4 = -4$$

6. Generate the algorithm for solving simultaneous equations by Gauss Elimination Method.

CO2: Construct algorithm for computer aided design of reinforced concrete members

1. Write the algorithm for determination of bending moment coefficients for two way simply supported slab.
2. Compare the stress-strain relation for mild steel with that of cold formed steel.

3. Write the algorithm for determination of bending moment coefficients for two way simply supported slab
4. Compute the values of design chart for balanced and under reinforced rectangular sections.

CO3: Construct algorithm for computer aided design of steel and light gauge steel members

1. Define stiffened elements in light gauge sections.
2. Summarise the conditions for providing stiffeners in welded plate girder.
3. Determine the maximum uniformly distributed load inclusive of self weight that can be supported by the beam which has two light gauge channel sections without bent lips 200mm x 50mm are connected with webs to act as a beam. The thickness of channel is 4mm. The effective span of simply supported beam is 3.5m.
4. Determine the web and flange sections, intermediate and end bearing stiffeners required for a welded plate girder section which will be provided for a hall. The superimposed load exclusive of self weight is 150kN/m. The span of the girder is 20m.
5. Generate the detailed algorithm for finding load carrying capacity of a light gauge column section.
6. Write the algorithm for analysis and design of single and built up steel beam sections.
7. Write the algorithm for design of web and flange section of a welded plate girder.

CO4: Construct algorithm for analysis of prestressed concrete members

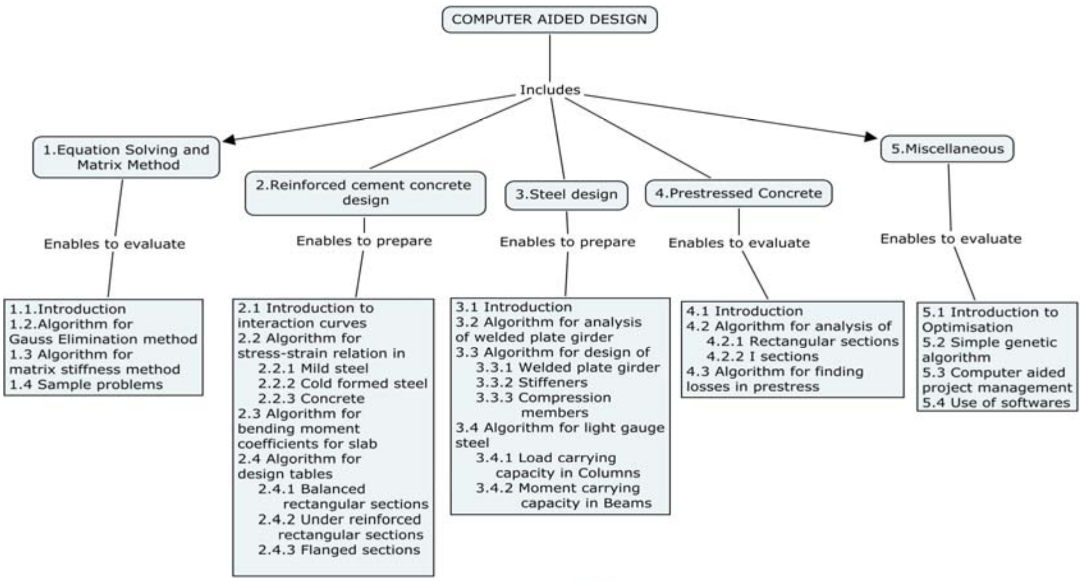
1. Mention the various losses of prestress.
2. Express the equations for analysis of prestressed concrete members due to self weight and prestress.
3. Compute the stresses at the central section for the following cases for a prestressed concrete beam.
   a.) Prestress + self weight (density of concrete = 24 kN/m^3)
   b.) Prestress + self weight + live load.

   The concrete beam is of symmetrical I-section spanning 8m has flange width and thickness of 200 and 60mm respectively. The overall depth of the beam is 400mm. The thickness of the web is 80mm. The beam is prestressed by a parabolic cable with an eccentricity of 15mm at the centre and zero at the supports with an effective force of 100kN. The live load on the beam is 2kN/m.
4. Outline the algorithm for analyzing prestressed concrete members.

CO5: Develop computer aided analysis and design softwares

1. List the softwares for analysis and design of structural members.
2. Describe the different stages of computer aided design softwares.
3. Describe the step by step procedure of analysing and designing a two bay two storeyed portal frame using any computer aided design software.

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 softwares – 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 PERIODS
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
1.7	Tutorial	3
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
2.9	Tutorial	3
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
3.5	Tutorial	2
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
4.5	Tutorial	2
5	**Miscellaneous**	
5.1	Introduction to Optimisation	2
5.2	Simple genetic algorithm	2
5.3	Stages of Computer aided analysis and design softwares	2
5.4	Use of softwares – sample structural problems	2
5.5	Use of excel sheets	2
5.6	Tutorial	2
	Total Hours	**48**

Course Designers:

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15SEPS0	FINITE ELEMENT METHOD IN STRUCTURAL ENGINEERING	Category	L	T	P	Credit
		PC	3	1	0	4

• 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

CO1	Illustrate the relation between stress and strain	Analyze
CO2	Compute weighted integral and weak formulation	Analyze
CO3	Calculate the nodal displacement, stresses and reaction forces in ID bar and plane truss element	Analyze
CO4	Calculate the nodal displacement, stresses and reaction forces in 2D element	Analyze
CO5	Outline different meshing techniques and mesh refinement	Analyze
CO6	Correlate analytical results using finite element Software	Analyze

• Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

• Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	45	45	45	45
Analyse	35	35	35	35
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

CO1:Illustrate the relationship between stress and strain

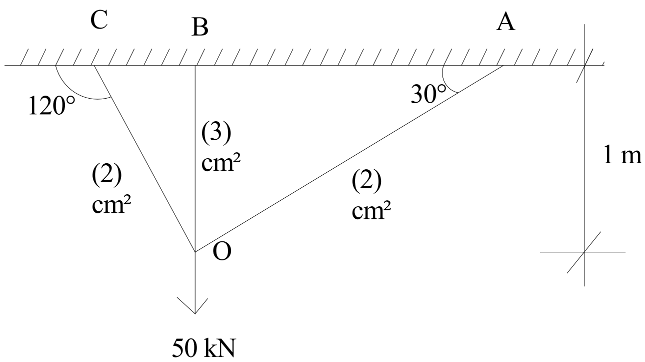
1. Explain constitutive matrix in case of a plane strain problem.
2. Compare internal and external forces with examples.
3. Differentiate plane stress and plane strain problem with examples.

CO2: Compute weighted integral and weak formulation

1. Outline the basic concept of Rayleigh Ritz method.
2. Discuss weighted integral and weak formulation with examples.
3. Prepare the step by step procedure of obtaining weak form and also apply the various boundary conditions by Taking a differential equation,
4. Compute the deflection at the centre of a simply supported beam subjected to uniformly distributed load over the entire span, Using Rayleigh Ritz method.
5. Compute the deflection of cantilever beam subjected to uniformly distributed load over the entire span, Using Rayleigh Ritz method.

CO3: Calculate the nodal displacement, stresses and reaction forces in ID bar and plane truss element

1. Evaluate the forces in the members of the truss shown in Fig by finite element method. Take E = 200 GPa.



2. Calculate the nodal displacement, stresses in each element and reaction forces.(E=2x10^5 N/mm^2). Axial force P=20N is applied as shown in fig.

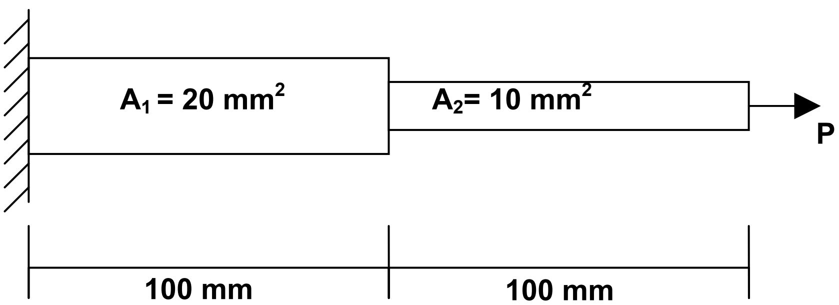
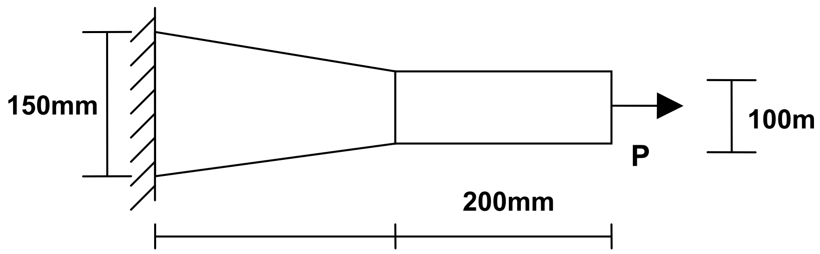


Fig.

3. Deduce the expression for the element stiffness matrix and element body force matrices of a line element.

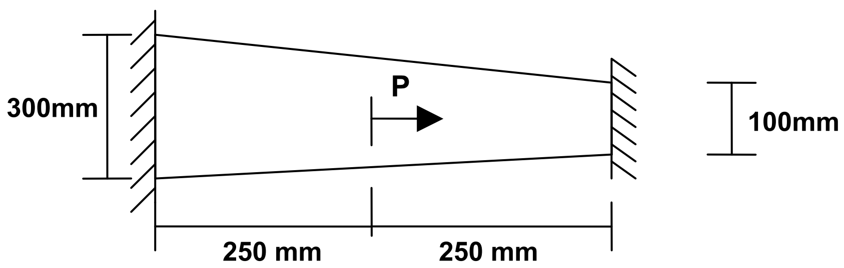
4. Compute the nodal displacement, stresses in each element and reaction forces. Axial force P=500KN is applied as shown in fig.



Thickness = 30mm
E = 2x10^5 N/mm^2
ρ = 78.5 KN/m^3

Fig.

5. Show the nodal displacements, element stresses and reaction force for the bar shown in fig.P = 30kN

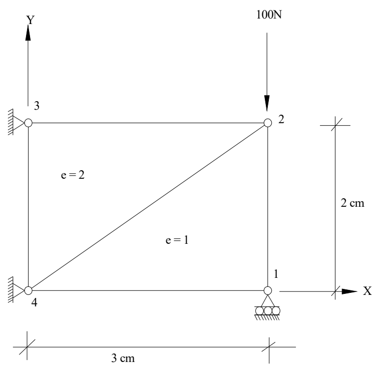


Thickness = 25mm
E = 2x10^5 N/mm^2
ρ = 78.5 kN/m^3

Fig.

CO4: Calculate the nodal displacement, stresses and reaction forces in 2D element

1. Calculate the displacements of nodes 1 and 2 and the element stresses using plane stress conditions. Body force may be neglected in comparison with the external forces.

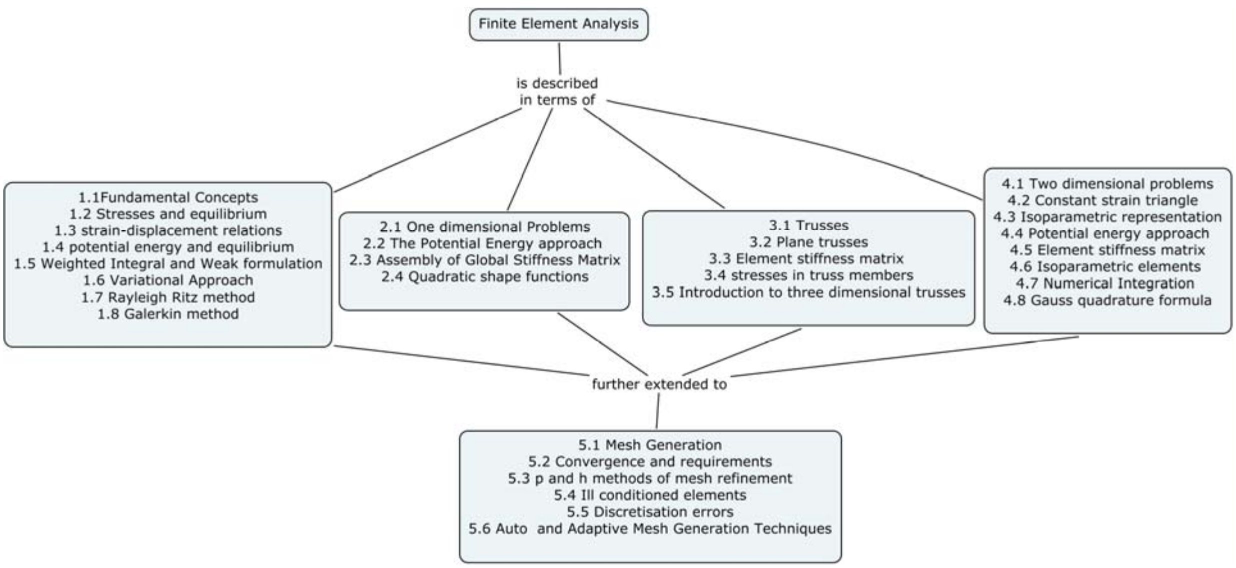


2. Compute the direct strain at x and y and shear strain at the point x = 1, y=0. If a displacement field is described by
   $u = (-x^2 + 2y^2 + 6xy)\ 10^{-4}$
   $v = (3x + 6y - y^2)\ 10^{-4}$
3. Solve the integral $\int 3e^x + x^2 + \frac{1}{x+2} dx$ using one point and two point Gauss quadrature formula
4. Solve $\int_{-1}^{1}\int_{-1}^{1} (x^2 + y^2 + 2xy) dxdy$ using Gauss numerical integration.

CO5: Outline different meshing techniques and mesh refinement
1. Explain Super Convergent Patch Recovery used in Error estimation.
2. Discuss adaptive mesh generation technique taking an example.
3. Distinguish between Remeshing and Mesh Enrichment.

CO6: Correlate analytical results using finite element Software
1. Write the step by step procedure of finding deflection of simply supported beam subjected to uniformly varying load 5KN/m at mid span over a span of 5m using any finite element software.
2. Write the step by step procedure of finding deflection of a cantilever beam subjected to its own weight using any finite element software.
3. Describe how would you develop the model and analyse for plotting stress contour. For a rectangular plate subjected to pressure on both sides.

- **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 modeling – 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 modeling – constant strain triangle – problem modeling 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 softwares.

- **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 PERIODS
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
1.7.1	Tutorial- Rayleigh Ritz method	2
18	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	One dimensional problems - Tutorial	2
2.6	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	Tutorial-Problems in finding stresses in truss members	2
3.5	Introduction to three dimensional trusses	1
4	**Two dimensional formulation**	
4.1	Introduction - Finite Element Modeling 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	Tutorial-Problems in two dimensional stress field	2
4.5	Isoparametric elements - Four node quadrilateral – shape functions and element stiffness matrix	1
4.6	Eight and Nine node quadrilateral	2
4.7	Numerical Integration - One point formula and two point formula	1
4.8	Tutorial-Problems in numerical integration using Gauss quadrature formula	2
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 softwares	1
5.7	Tutorial- Practice session	2
	Total Hours	48

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15SEPT0	VALUE ENGINEERING	Category	L	T	P	Credit
		HSS	4	0	0	4

Common to 14ENPP0, 15IMPP0

Preamble

New Product development is on rise and developing these products without compromising quality and cost is a challenge. In such development, it has become necessary to reduce the cost or eliminating the unnecessary cost, while improving the product performance or otherwise quality. This course deals with improving the quality in terms of the requirements of customer at the same or reduced cost by ensuring adequate system performance. Value engineering is a systematic approach for value improvement and contains seven broader phases. Hence, for product development, both cost and quality related issues need to be tackled concurrently.

Prerequisite

Probability and Statistics

Course Outcomes

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

CO1	Establish the Value engineering methodology	Apply
CO2	Recognize the various phases of value engineering	Understand
CO3	Perform function cost worth analysis	Apply
CO4	Create the ideas for solving the problems	Apply
CO5	Analyse the functional importance and functional cost	Apply
CO6	Recommend the present facts and present costs	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	20	20	20	20
Apply	20	20	20	20
Analyse	40	40	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the objectives of value engineering?
2. Name the types of value
3. Define : Function

Course Outcome 2 (CO2):

1. Outline the techniques of value engineering plan
2. Differentiate between ex-factory selling price and life cycle cost of a product
3. Compare real savings and false savings

Course Outcome 3 (CO3):

1. How would you determine the costs required to accomplish various functions of a product? Explain with an example.

2. Explain how the low cost promising ideas for various customer desired functions combined together to develop a number of workable solutions.

3. A product is manufactured at the break-even point. The management is considering a change in the product design in spite of the fact that the fixed costs will increase 50%. The sale of the new product is expected to shoot up by 100%. What should be the profitability of the new design (as compared to the present design) so that the company realizes a profit equal to the initial fixed cost per year?

Course Outcome 4 (CO4):

1. A company proposes to invest Rs.40000 in a new machine. The service life of machine is 10 years.

   a) What should be the annual savings if the minimum acceptable rate of return is 20%?
   b) If the actual savings over this period are Rs.8000/- per year. What is the actual rate of return (internal) on investment?

2. A man needs Rs.300000immediately for the purchase of a house. He will be required to repay the loan in equal six monthly installments over the next 10 years. What are the required payments at

   a) 6% interest compounded semi annually
   b) 10% interest compounded semi annually.

3. A new office copying machine costing $5600 will enable a company to save $0.03 per sheet on some duplicating work. The present usage is approximately 9000 sheets per month. Calculate the after tax IRR

Economic life	8 years
Depreciation term	10 Years
Depreciation method	Straight line
Incremental tax rate	50 percent
Interest rate	10 percent

Course Outcome 5 (CO5):

1. Consider the following decision making situation involving alternatives A & B

	A (RS.)	**B(RS.)**
Investment	20000	30000
Salvage Value	4000	0
Annual receipts	10000	14000
Annual costs	4400	8600
Life (years)	5	10

If minimum acceptable rate of return (MARR) is 15% and period of analysis is 10 years, alternative is to be chosen (use NPW method)

2. Consider the following three alternatives

	ALT A	ALTB	ALTC
Investment cost	28000	16000	23500
Net cash flow per year	5500	3300	4800
Salvage value	1500	0	500
Life (Years)	10	10	10

Assuming MARR = 15% and using IRR method, chosse the best alternative of the above.

3. Assume an initial investment of an asset as Rs.100000 and salvage value of Rs.10000 with the life of the assets as 10 years
   Consider the following three methods of depreciation:
   i) Straight line (ii) SYD (iii) Declining balance method (with 10% rate)
   For these methods, plot the profile of book value as a function of life. Assuming interest rate of 15%, Compute the net present worth of cash flows if above methods are to be used. Incremental tax rate is 50%. Also rank the depreciation methods.

Course Outcome 6 (CO6):

1. An equipment is purchased for Rs.50000 that will reduce materials and labour cost by Rs.14000 each year for N years. After N years, there will be no need for the equipment and since it is specially designed, it will have no salvage value at any time. However, according to the company tax procedure, this equipment must be depreciated on a straight line basis for the tax life of 5 years. If the tax rate is 50%, what is the minimum number of years (that is N) that the company must operate the equipment to earn a minimum 10% after tax return.

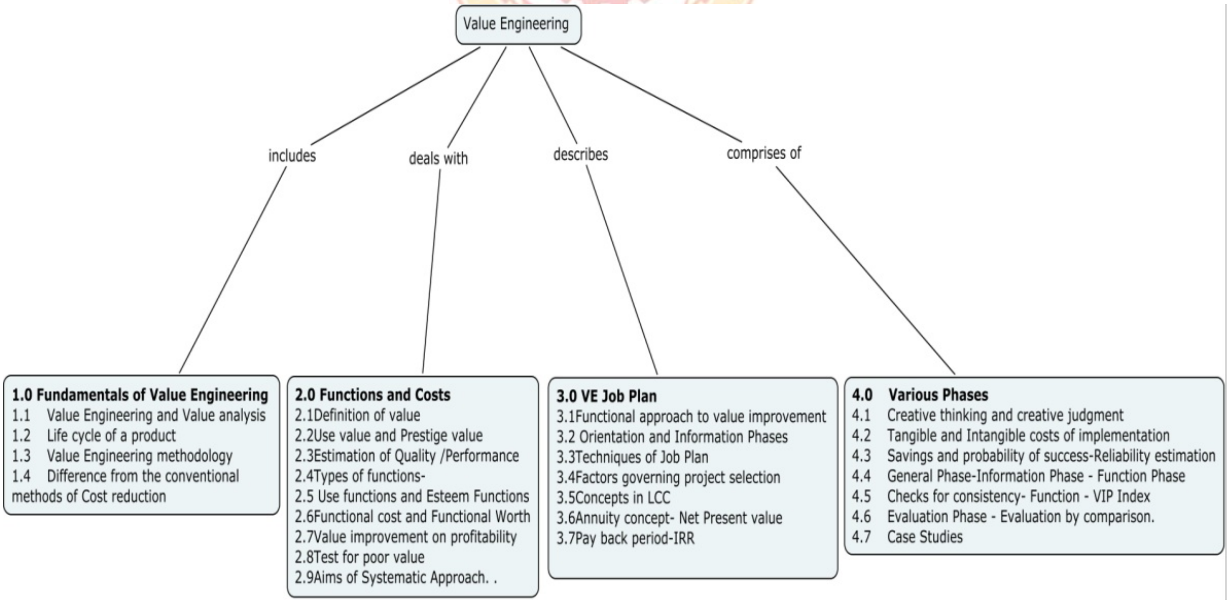
2. Consider the following data for two machines X & Y

Machine	Initial Cost	Annual costs	Salvage value
X	25000	4000	0
Y	15000	8000	0

The machines can be used fir 5 years or they can be retained for use after the 5th year. If so, the total useful life will be 20 years. The company is permitted to write off the machine in 5 years for tax purpose, or it can write off the machine in 20 years. Compare the results of using the long (20 years) or short (5 years) write off periods of the tax rate is 50% and sum of year's digits (SYD) method is used for depreciation. Assume interest rate of 10%.

A plant manager is attempting to determine whether his firm should purchase a component part or make it at its own facilities. If he purchases the item, it will cost the company Rs.10 per unit. The company can make the item on an assembly line at a variable cost of RS.2.50 per unit with a fixed cost of Rs.20000/- per year, or it can make it at individual stations at a variable cost of Rs.5.00 per unit with a fixed cost of Rs.10000 per year. Assuming that the annual demand is expected to be 3500 units, determine which alternative the plant manager should select. Also, frame decision rules for MAKE/BUY for various levels of annual demand.

Concept Map



Syllabus

Value Engineering (VE) and Value Analysis(VA) - Life Cycle of a product-Methodology of value engineering – Difference from the conventional methods of cost reduction-Unnecessary costs reasons- Quantitative definition of value- Use value and Prestige value. Estimation of product Quality/performance-Types of functions- Relationship between Use functions and Esteem Functions in product design – Functional cost and Functional Worth – Effect of Value improvement on profitability-Test for poor value –Aims of Systematic Approach. Functional approach to value improvement-various phases and techniques of Job Plan – Factors governing project selection – Types of Projects-Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC – Present value concept-Annuity concept- Net Present value-Pay back period-Internal rate of return on Investment (IRR)-Examples and Illustrations. Creative thinking and creative judgment- positive or constructive discontent-Tangible and Intangible costs of implementation-False material-labour and overhead saving – Relationship between savings and probability of success-Reliability estimation-System reliability- Reliability elements in series and parallel. General Phase-Information Phase – Type of costs- Function Phase – Evaluation of Functional Relationships- Checks for consistency-Function –cost-weight-matrix-VIP Index – High cost and Poor value areas-Creativity/Speculation Phase – Rules of creativity-Brainstorming- Idea activators- Result accelerators – Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.

Reference Books

1. Arthur E Mudge, "Value Engineering", McGraw Hill Book Company, 1971
2. A.D.Raven, Profit Improvement through Value Analysis, value Engineering and Purchase Price Analysis, Cassell and Co. London. (1971)
3. Richard J Park, "Value Engineering – A Plan for Inventions", St.Lucie Press, London, 1999
4. S S Iyer," Value Engineering – A How to Manual", 3rd edition, New Age Publishers, Chennai, ISBN: 978-81-224-2405-8,2006
5. Value engineering, Mukhopadhyaya, Anil Kumar, Response Books, New Delhi , , ISBN: 0-7619-9788-1, 2003

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Value Engineering and Value analysis	2
1.2	Life cycle of a product	2
1.3	Value Engineering methodology	2
1.4	Difference from the conventional methods of Cost reduction	1
2	**Reasons for unnecessary costs**	
2.1	Definition of value	1
2.2	Use value and Prestige value	1
2.3	Estimation of Quality /Performance	1
2.4	Types of functions-	1
2.5	Relationship between Use functions and Esteem Functions in product design	2
2.6	Functional cost and Functional Worth	2
2.7	Effect of Value improvement on profitability	1
2.8	Test for poor value	1
2.9	Aims of Systematic Approach. Functional approach to value improvement	1
3	**VE Job Plan**	
3.1	Functional approach to value improvement	1
3.2	Orientation and Information Phases	2
3.3	Techniques of Job Plan	2
3.4	Factors governing project selection – Types of Projects	2
3.5	Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC –	2
3.6	Present value concept-Annuity concept- Net Present value	3
3.7	Pay back period-Internal rate of return on Investment (IRR)- Examples and Illustrations	3

4	**Various phases**	
4.1	Creative thinking and creative judgment- positive or constructive discontent	2
4.2	Tangible and Intangible costs of implementation-False material-labour and overhead saving	2
4.3	Relationship between savings and probability of success-Reliability estimation-System reliability- Reliability elements in series and parallel.	2
4.4	General Phase-Information Phase – Type of costs - Function Phase	2
4.5	Evaluation of Functional Relationships - Checks for consistency-Function – cost-weight-matrix - VIP Index – High cost and Poor value areas-	2
4.6	Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.	2
4.7	Case Studies	3
	Total	**48**

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