BOARD OF STUDIES MEETING

M.E Degree (Structural Engineering) Program

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

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
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Web: www.tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Structural Engineering) PROGRAM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
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Board of Studies meeting on 27.08.11

Department of Civil Engineering

Graduating Students of M.E program of Structural Engineering will be able to

1. Apply the concept of mechanics both in elastic and plastic states of structural members
2. Analyze structural members under static and dynamic conditions
3. Design Reinforced concrete, prestressed concrete, steel and steel-concrete composite members following the provisions of Indian and international standards using manual and computer aided approach
4. Construct and maintain structures through retrofitting and rehabilitation techniques

Thiagarajar College of Engineering, Madurai-625015

Department of Civil Engineering (Structural Engineering)

Scheduling of Courses

Semester	Theory Courses						Practical / Project	
4th (12)							J41 Project Phase- II 0:12	
3rd (16)	J31 Design of Steel Concrete Composite Structures 3:1	Elective V 4:0	Elective VI 4:0				J34 Project Phase – I 0:4	
2nd (25)	J21 Structural Dynamics 3:1	J22 Finite element analysis 3:1	Elective I 4:0	Elective II 4:0	Elective III 4:0	Elective IV 4:0	J27 Seminar 0:1	
1st (25)	J11 Applied Mathematics 3:1	J12 Design of Concrete Structures 3:1	J13 Structural Mechanics 3:1	J14 Theory of Elasticity and Plasticity 3:1	J15 Pre stressed concrete 3:1	J16 Computer Aided design 3:1	J17 Concrete Technology & Structural Engineering Laboratory 0:1	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
J11	Applied Mathematics	BS	3	1	-	4
J12	Design of Concrete Structures	DC	3	1	-	4
J13	Structural Mechanics	Dc	3	1	-	4
J14	Theory of Elasticity and Plasticity	DC	3	1	-	4
J15	Prestressed Concrete	DC	3	1	-	4
J16	Computer Aided Design	DC	3	1	-	4
PRACTICAL						
J17	Concrete Technology & Structural Engineering Laboratory	P	-	-	3	1
Total			**18**	**6**	**3**	**25**

BS : Basic Science
DC : Department Core
DE : Department Elective
GE : General Elective
L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	**T**	**P**	
THEORY						
J21	Structural Dynamics	DC	3	1	-	4
J22	Finite Element Analysis	DC	3	1	-	4
J2W	Elective I	DE	3	1	-	4
J2Y	Elective II	DE	4	-	-	4
J2Y	Elective III	DE	4	-	-	4
J2Z	Elective IV	DE	4	-	-	4
PRACTICAL						
J27	Seminar	P	-	-	3	1
	Total		**21**	**3**	**3**	**25**

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	**T**	**P**	
THEORY						
J31	Design of Steel Concrete Composite Structures	DC	3	1	-	4
J 3Y	Elective V	DE	4	-	-	4
J 3Z	Elective VI	DE	4	-	-	4
PRACTICAL						
J 34	Project Phase- I	P	-	-	12	4
	Total		**11**	**1**	**12**	**16**

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
J41	Project Phase- II	P	-	-	36	12
	Total		**-**	**-**	**36**	**12**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 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	J11	Applied Mathematics	3	50	50	100	25	50
2	J12	Design of Concrete Structures	3	50	50	100	25	50
3	J13	Structural Mechanics	3	50	50	100	25	50
4	J14	Theory of Elasticity and Plasticity	3	50	50	100	25	50
5	J15	Pre stressed Concrete	3	50	50	100	25	50
6	J16	Computer Aided Design	3	50	50	100	25	50
PRACTICAL								
7	J17	Concrete Technology & Structural Engineering Laboratory	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

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

Sub Code	Lectures	Tutorial	Practical	Credit
J11	3	1	-	4

J11 Applied Mathematics 3:1

Preamble:

It deals with the concept of eigen values and eigen vectors to solve problem in engineering applications. It consists of variation problems in calculus. This course aims how to solve ordinary and partial differential equations encountered in engineering applications. A statistical hypothesis is a quantitative statement about the probability distribution characterizing a population which we want to verify on the basis of information available from a sample.

Prerequisite: Matrix**,** Differentiation

Competencies: At the end of the course the student should be able to

1. Compute eigen values ,eigen vectors and Diagonalization of a matrix.
2. Minimize or maximize the boundary value problems.
3. solve the ostrogradsky equation
4. determine the Solutions of ordinary differential equations of second order
5. solve solutions of partial differential equations
6. state a statistical inference from information contained in random samples about the populations from which the samples were obtained.
7. demonstrate the characteristic of the population with degree of confidence from the random sample.

Assessment Pattern

Sl.No.	Bloom's Category	Test I	Test II	Test III / End semester examination
1.	Remember	10	10	0
2.	Understand	30	30	30
3.	Apply	60	60	70
4.	Analyze	0	0	0
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course Level Learning Objectives

Remember

1. Find is the sum of the squares of the eigenvalues of the matrix $\begin{pmatrix} 3 & 1 & 4 \\ 0 & 2 & 6 \\ 0 & 0 & 5 \end{pmatrix}$
2. Identify the other forms of Euler's equation.
3. Define Geodesics.
4. Examine the following equation $\frac{\partial^2 z}{\partial x^2} + y^2 \frac{\partial^2 z}{\partial y^2} = y$
5. one Define tailed and two–tailed tests.

Understand

1. Predict the eigen values and eigen vectors of the matrix A= $\begin{pmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \\ 1 & -1 & 2 \end{pmatrix}$
2. Discuss the transversality condition for the functional $v = \int_{x_0}^{x_1} A(x, y)\sqrt{[1 + (\frac{dy}{dx})^2]}dx$
3. State and prove brachistochrone problem.
4. Solve the equation $(1+x)^2 \frac{d^2 y}{dx^2} + (1+x)\frac{dy}{dx} + y = 4\cos\log(1+x)$
5. In a large city A, 20% of a random sample of 900 school boys had a slight physical defect. In another

large city B, 18.5% of a random sample of 1600 school boys had the same defect. Identify whether the

difference between the proportions is significant or not.

5. The following information was obtained in a sample of 40 small general shops:

	Shops in areas	
	Urban	Rural
Owned by Men	17	18
Owned by Women	3	12

Discuss is it possible to say that there are more women owners in rural areas than in urban areas? Use Yate's Correction for continuity.

Apply

1. Given that the differential equation of a vibrating membrane (such as the membrane of a drum) is $\frac{\partial^2 z}{\partial t^2} = c^2 (\frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial y^2})$, find the deflection z(x,y,t) of the rectangular membrane of sides 1 and 2, if it is fastened along the edges and excited from rest with an initial displacement $f(x, y) = k \sin \pi x \sin \pi y$

2. Calculate the dominant eigen value of A= $\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$ by power method.

3. Solve the equation $x^2 (\log x)^2 \frac{d^2 y}{dx^2} - 2x \log x \frac{dy}{dx} + [2 + \log x - 2(\log x)^2]y = x^2 (\log x)^3$

4. Reduce the quadratic form $2x_1^2+5x_2^2+3x_3^2+4x_1x_2$ to canonical form by orthogonal reduction. Find also the nature of the quadratic form and rank, index, signature

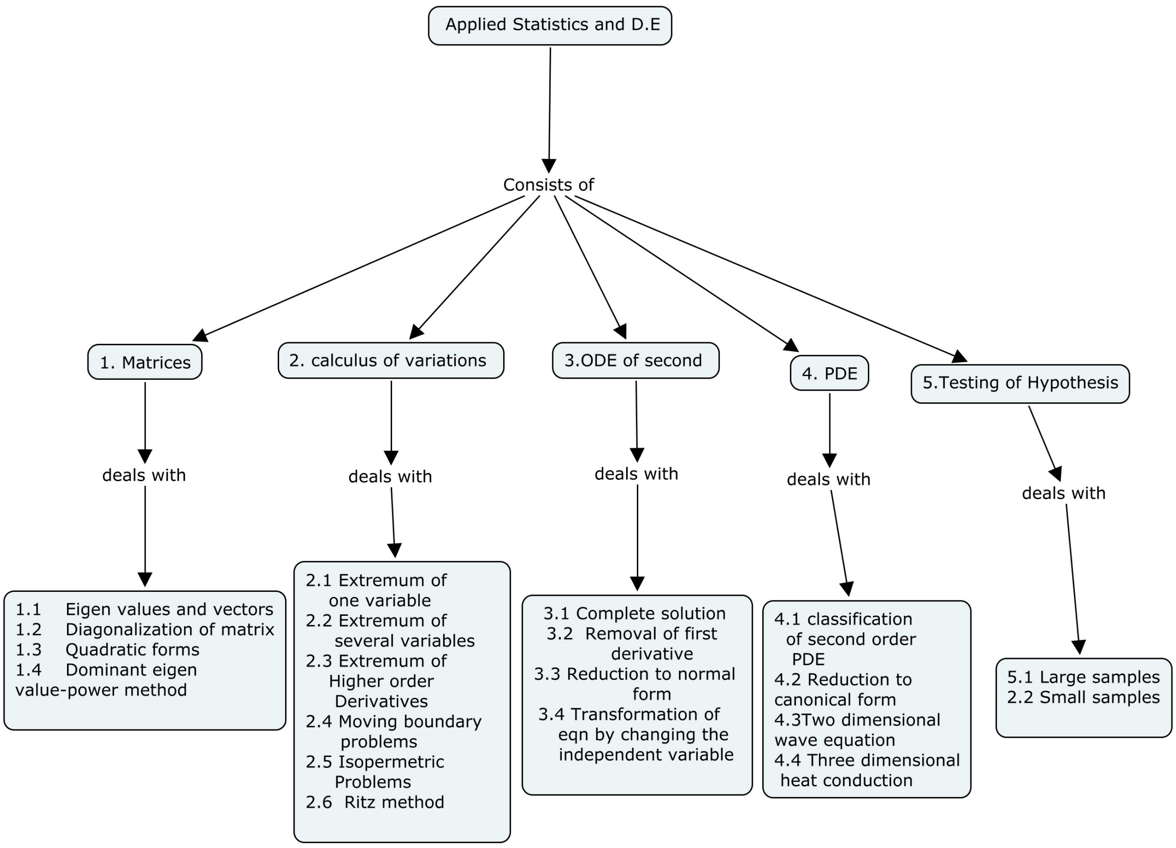
5. Reduce the equation $r - (2\sin x)s - (\cos^2 x)t - (\cos x)q = 0$ to canonical form and hence solve it .

6. Examine whether the two samples for which the data are given in the following table could have been drawn from populations with the same SD.

	Size	S.D
Sample 1	100	5
Sample 2	200	7

7.The heights of 10 males of a given locality are found to be 175, 168, 155, 170, 152, 170, 175, 160, and 165 cm. Based on this sample, determine the 95% confidence limits for the height of males in that locality.

Concept map:



Course Contents and Lecture schedule

S.No	Topics	No.of Lectures
	Matrices	
1.1	Eigen values and vectors, properties	2
1.2	Diagonalization of matrices	2
1.3	Quadratic forms classification , reduction to canonical form	2
1.4	Dominant eigen value by power method	2
	Calculus of variations	
2.1	Extremum of functional of one variable	2
2.2	Extremum of several variable	2
2.3	Extremum of functional having higher order derivatives	1
2.4	Moving boundary problems	1

2.5	Isoperimetric problems	1
2.6	Ritz method	1
	Ordinary Differential Equations of second order	
3.1	Complete solutions if one integral of C.F is known	2
3.2	Removal of first derivative	2
3.3	Reduction to normal form	2
3.4	Transformation of equation by changing the independent variable	2
	Partial Differential Equations	
4.1	Classification of second order PDE	2
4.2	Reduction to canonical form	2
4.3	Solution of two dimensional wave equation	2
4.4	Steady state heat equation of three dimensional heat conduction equation	2
	Testing of Hypothesis	
5.1	Testing of hypothesis-inferences concerning to means, variances and proportions	2
5.2	t-test	2
5.3	Chi-Square test	2
5.4	F-test	2
	Total	**40**

Syllabus

Matrices Eigen values and vectors, properties, Digitalization of matrices, Quadratic forms classification , reduction to canonical form, Dominant eigen value by power method.**Calculations of variations** Extremum of functional of one variable, Extremum of several variable, Extremum of functional having higher order derivatives, Moving boundary problems, Isoperimetric problems, Ritz method. **Ordinary Differential Equations of second order** Complete solutions if one integral of C.F is known, Removal of first derivative, Reduction to normal form, Transformation of equation by changing the independent variable.**Partial Differential Equations** Classification of second order PDE, Reduction to canonical form, Solution of two dimensional wave equation, Steady state heat equation of three dimensional heat conduction equation**.**

Testing of Hypothesis Testing of hypothesis-inferences concerning to means, variances and proportions, t-test, Chi-Square test, F-test.

Reference books:

1. M.D.Raisinghania, Advanced differential equations, S.Chand and Co., Ltd.,1995
2. Irwin Miller, John E.Freund "Probability and Statistics for Engineers" Prentice Hall of India Pvt. Ltd.; New Delhi, 1977.
3. M.K Venkatraman, "Higher Mathematics for Engineering and science", National Publication company, New Delhi, 1999 Vol.
4. S.G.Deo, V.Lakshmikantham and V.Raghavendra, "Text Book for Ordinary Differential equations" ,TMH, Delhi, 1997
5. T.Veerarajan "Probability, Statistics and Random Processes" Tata McGraw-Hill, New Delhi, 2003.

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
J12	3	1	0	4

J12 Design of Concrete Structures **3:1**

Preamble

The objective of this course is for structural engineering students to expand their knowledge of the behavior and design of reinforced concrete structural components and systems for various types of loading, including loading beyond the elastic range of behavior with the background of current design codal specifications. It also aims at determination of safe as well as economical sections and their reinforcement under various types of load combinations.

Competencies: At the end of the course, the students will be able to

1. State the basis of the analysis of the structure.
2. State the basis of determining the combination of different loads acting on the structure
3. Calculate design loads in reinforced concrete structures based on IS 875 (1-5):1987.
4. Understand the background of codes to design reinforced concrete structures under various loadings.
5. Understand design principles of reinforced concrete structures subjected to bending, shear, axial compression and their combinations with consideration of cracking and deflection.
6. Prepare fabrication sketches of the designed components of RCC structure.

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	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	40	40	40

Course level learning objectives

Remember

1. What are the assumptions made in the limit state method?
2. Define the term: Deep beam.
3. Draw the reinforcement detailing of corbel.
4. Draw the yield line pattern of simply supported circular slab and triangular slab.
5. Define the term: Cracking moment.
6. What is ductility?

Understand

1. Write down IS specification for the spacing of reinforcement in flat slab.
2. How to find the moment in the case of deep beams?
3. Explain equilibrium method of analysis of slab.
4. What do you mean by shrinkage of concrete?
5. Under what circumstances the flat slab can be provided?
6. Write down the formula for finding design surface crack width as per IS specifications.

Apply

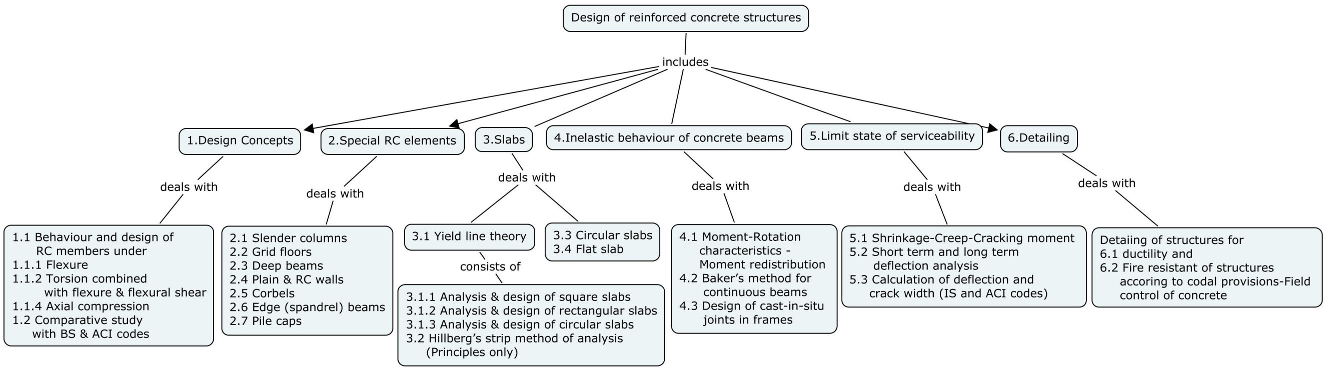
1. Determine ultimate moment resistance of a T-beam having the following data. Width of flange = 1550mm; breadth of web = 300mm; effective depth of beam = 620mm; depth of flange = 110mm. Area of tension reinforcement = 4775mm^2. Concrete M20 and steel Fe415.
2. Determine the collapse load in a 6m x 4m rectangular slab fixed at all edges for which the support moment capacities are the same as the midspan moment capacities in each direction. Assume Mpx = 0.30Mpy, that is the moment capacity in the long direction is 30% of that in the short direction.
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. Compute the moments in columns and middle strips of a flat slab to be provided for an interior panel of size 5m x 5m subjected to super imposed load of 5 kN/m^2 and Floor finish of 1.5 kN/m^2.

5. Determine the bending moments and shear forces of a simply supported main beam of span 9m in the grid floor slab system subjected to an UDL of 30kN/m and point loads of 20kN, 25kN and 20kN acting at 3m intervals from left end of the beam.
6. Explain the Baker's method of limit state analysis of continuous beams in detail with neat sketches.
7. Explain the detailing of reinforcement for ductility and fire resistant of structures with neat sketches.

Create

1. 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
2. Design a single span deep beam to suit the following data: Effective span = 6m; Overall depth = 6m; Width of support = 0.6m; Width of beam = 0.4m; Total load on beam including self weight = 400 kN/m; Material = M20 & Fe 415.
3. 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.
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.
5. Design five spans secondary beam in grid floor slab system subjected to an UDL of 38 kN/m throughout its entire length. Use M20 and Fe500 as materials.
6. Design the reinforcement required for a simply supported main beam in the grid floor beams having span of 7.5m subjected to an UDL of 20kN/m and point loads of 15kN, 18kN and 15kN acting at 2.5m intervals from left end of the beam. Consider M25 and Fe415 as materials.

Concept Map



Course content and Lecture schedule

S.No	TOPICS	PERIODS
1. Design Concepts		
1.1	Behaviour and design of RC members under	1
1.1.1	Flexure	1
1.1.2	Torsion combined with flexure & flexural shear	1
1.1.3	Axial compression	1
1.2	Comparative study with BS & ACI codes	1
2. Special RC elements		
2.1	Slender columns	1
2.2	Grid floors	2
2.3	Deep beams	2
2.4	Plain and RC walls	2
2.5	Corbels	1
2.6	Edge (spandrel) beams	2
2.7	Pile caps	1
3. Slabs		
3.1	Yield line theory - Equilibrium and Virtual work method	2
3.1.1	Analysis and design of square slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.2	Analysis and design of rectangular slab with different boundary conditions subjected to UDL and concentrated loads	2
3.1.3	Analysis and design of circular slabs with different boundary conditions subjected to UDL and concentrated loads	2
3.2	Introduction to Hillberg's strip method of analysis (Principles only)	1

3.4	Design of circular slabs	1
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	2
5. Limit State of Serviceability		
5.1	Shrinkage – Creep - Cracking moment	1
5.2	Short term and long term deflection analysis	2
5.3	Calculation of deflection and crack width according to IS Codes	1
5.4	Calculation of deflection and crack width according to ACI Codes	1
6. Detailing		
6.1	Detailing for ductility according to codal provisions	2
6.2	Detailing for fire resistant of structures according to codal provisions – Field control of concrete	1
	Total	**40**

Syllabus

Design concepts - Review of basic concepts – Behaviour and design of RC members considering flexure, torsion combined with flexure and flexural shear, axial compression as per IS:456-2000 – Comparative study with BS and ACI codes. **Special RC Elements -** Design of Slender Columns - Grid Floors - Deep Beams - Plain & reinforced Concrete Walls - Corbels - Edge (Spandrel) Beams – Pile caps. **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 & Flat Slabs. **Inelastic Behavior of Concrete Beams**

Moment-Rotation characteristics - Moment redistribution - Baker's method of Limit State Analysis of continuous beams – 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 – Field control of concrete

Reference Books

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

IS Codes

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. BS8110:1997 Code of practice for structural use of concrete
8. ACI318-08 Building Code Requirements for Structural Concrete & Commentary

Course Designer

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Sub Code	Lectures	Tutorial	Practical	credit
J13	3	1	0	4

J13 Structural Mechanics 3:1

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.

Competencies: At the end of the course, the students will be able to

1. Understand the principle of mechanics of materials
2. Evaluate the stresses in curved flexural member
3. Evaluate the buckling stresses in plates and bars
4. Analyze the forces in beam and column.

Assessment Pattern:

Sl NO	Bloom's Category	Test 1	Test II	Test III / End
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	40	40	40
4	Analyse	40	40	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Understand

1. What are the different types of elastic foundation and give examples
2. List out the circumstances under which unsymmetrical bending occurs
3. What is length coefficient in the buckling of bar
4. Explain the post buckling strength of plates
5. How will you increase the stability of plate

Remember

1. Define in elastic buckling
2. List the assumptions made in Winkler Bach equation
3. Define tangent modulus
4. Define spring constant
5. What do you understand by beam on elastic support?
6. Distinguish between semi infinite and finite length beam
7. Explain un symmetrical bending

Evaluate

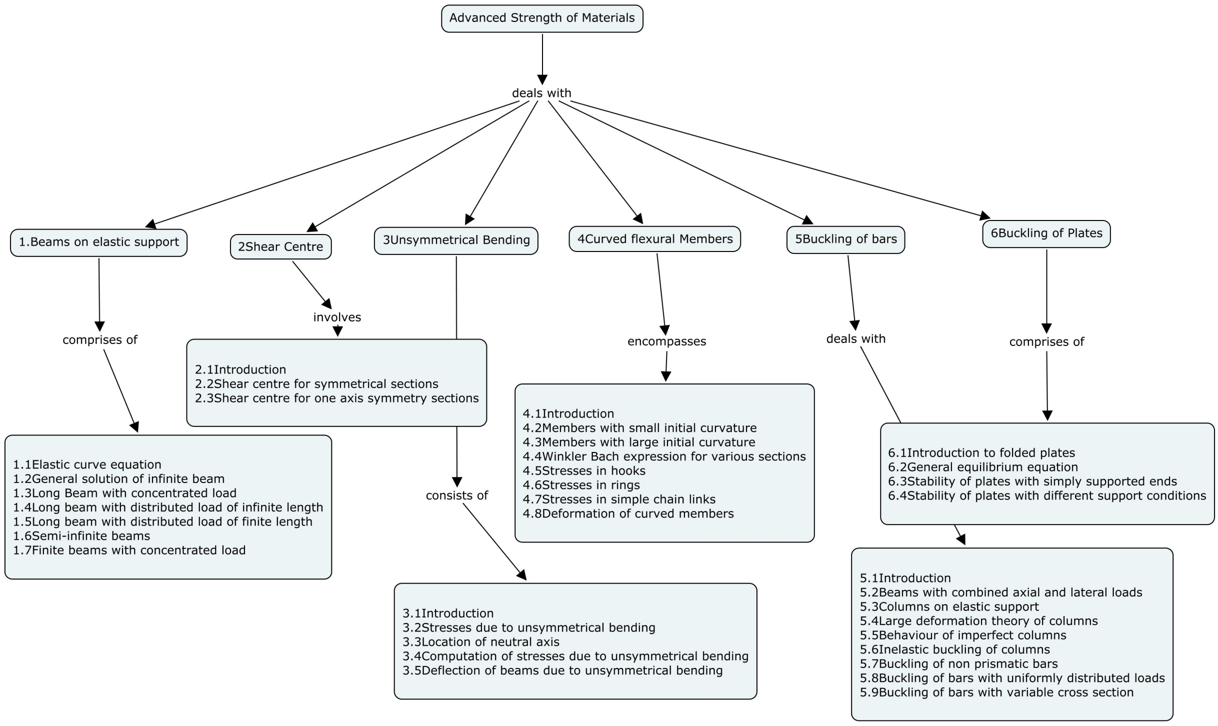
1. An infinitely long steel beam of ISMD250 with $I_{XX}=2235x10^4 mm^4$ rests on a elastic foundation with a modulus of $18N/mm^2$. The modulus of elasticity of steel is $2x10^5 N/mm^2$. The beam supports a concentrated load of 200kN. Estimate the maximum deflection, Bending moment, Shear force developed in the beam after deriving the expression from first principle.
2. Derive 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
3. 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. Find the position of neutral axis and bending stress
4. 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. Determine the maximum stress at the horizontal section if $E=2x10^5 N/mm^2$ and $N=8x10^4$ N/mm^2.
5. Find 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.

Analyse

1. Derive the 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. Derive 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

3. Find 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.
4. Derive 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.
5. Derive from fundamental the in elastic buckling of a thin plate simply supported at ends

Concept Map:



Course Content and Lecture Schedule:

Sl No	Topics	Periods
1	**Beams on elastic support**	
1.1	Elastic curve equation	1
1.2	General solution of infinite beam	1
1.3	Long Beam with concentrated load	1
1.4	Long beam with distributed load of infinite length	1
1.5	Long beam with distributed load of finite length	1
1.6	Semi-infinite beams	1
1.7	Finite beams with concentrated load	1

2	**Shear Centre**	
2.1	Introduction	1
2.2	Shear centre for symmetrical sections	1
2.3	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	Location of neutral axis	1
3.4	Computation of stresses due to unsymmetrical bending	1
3.5	Deflection of beams due to unsymmetrical bending	1
4	**Curved flexural Members**	
4.1	Introduction	1
4.2	Members with small initial curvature	1
4.3	Members with large initial curvature	2
4.4	Winkler Bach expression for various sections	1
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	1
5	**Buckling of bars**	
5.1	Introduction	1
5.2	Beams with combined axial and lateral loads	1
5.3	Columns on elastic support	1
5.4	Large deformation theory of columns	1
5.5	Behaviour of imperfect columns	1
5.6	Inelastic buckling of columns	1
5.7	Buckling of non prismatic bars	1
5.8	Buckling of bars with uniformly distributed loads	1
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	Stability of plates with different support conditions	2
	Total	**40**

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 Books

1. L.S.Srinath, "**Advanced Mechanics of Solids**" ,Mc Graw Hill Education,3rd Edition,2009
2. Seely and Smith, "**Advanced Mechanics of Materials**", John Willey and Sons, Newyork, U.S.A.1957
3. Glen Murphy, "**Advanced Mechanics of Materials**", McGraw Hill Book Company, New York, U.S.A.
4. James W. Dally & William F. Riley, "**Experimental Stress Analysis**", Mc-GrawHill International Edition, 1991
5. Sadhu singh , "**Theory and Solved Problems in Advanced Strength of Materials**", khanna Publishers,2006

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
J 14	3	1	0	4

J 14 Theory of Elasticity and Plasticity 3:1

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 indetail. Numeric problems are also taken into discussion to explain the application the principles.

Competencies: At the end of the course, the students will be able to

1. Determine the 2D and 3D stresses and strains in Cartesian and polar coordinate systems and also express these stresses and strains in Mohr Circle diagram
2. Determine the induced stress in the 2D system using Airy's stress function
3. Evaluate stresses in thick cylinder using the concept of axi-symmetry
4. Estimate the capacity of circular, non-circular sections both solid and tubular sections using St.Venant's approach and Prantl approach.
5. Apply energy theorem to elastic problems
6. Apply the plastic behaviour of the material to simple problems like bending and torsion

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	80	80	80
4	Analyse	-	-	-
5	Evaluate	-	-	-
6	Create	-	-	-

Course level learning objectives

Remember

1. Define the term: (i) Homogeneous (ii) Isotropy
2. Write the second form of compatibility condition in Cartesian system
3. Define Generalised Hooke's law

4. Write the concept of membrane analogy.
5. What is strain energy?
6. What is strain hardening?

Understand

1. Relate principal stresses and maximum shear stresses in 3D stress system
2. 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. Sketch σ_θ variation around the hole periphery?
3. What will be the maximum stress magnitude and its location when a flat plate under in-plane tension with a circular hole?
4. Show that the prandtl's stress function'ψ'is a constant around the boundary
5. Express the stresses induced in a torsion specimen in terms of Prandtl's stress function.
6. Draw the idealized stress strain diagram and mark the salient points.

Apply

1. The component of stress at a point is given by $\sigma_x = 3xy^2z + 2x$, $\sigma_y = 5xyz + 3y$, $\sigma_x = x^2y + y^2z$, $\tau_{xy} = 0$, $\tau_{yz} = \tau_{xz} = 3xy^2z + 2xy$. Determine the associated body forces at (1,-1, 2) for equilibrium.

2. Given $\phi = \frac{1}{6}Cxy^3 + Bxy$ where C and B are constants. Solve the cantilever problem shown in figure-1. Show that $B = \frac{3}{2}\frac{P}{bh}$ and $C = -\frac{8B}{h^2}$. Find the stress field.

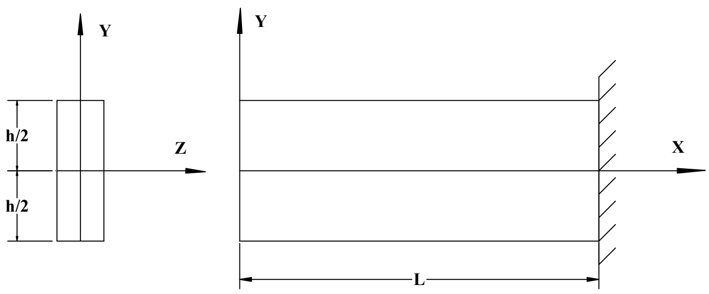


Figure-1

3. 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 $\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)(\sigma_x + \sigma_y) = 0$.

4. For an equilateral triangle of side 2h/√3 as shown in figure-1, the stress function is given by $\phi = \frac{G\theta}{2h}\left[\left\{x - \sqrt{3}y - \frac{2h}{3}\right\}\left\{x + \sqrt{3}y - \frac{2h}{3}\right\}\left\{x - \frac{h}{3}\right\}\right]$. Show that $\theta = \frac{15\sqrt{3}T}{Gh^4}$.

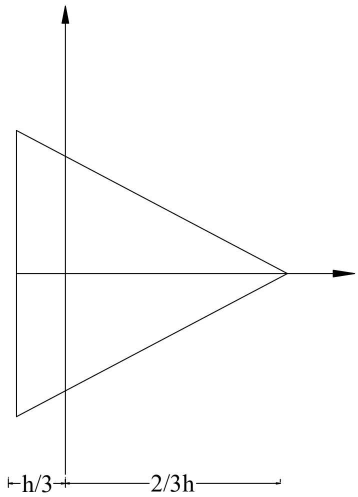
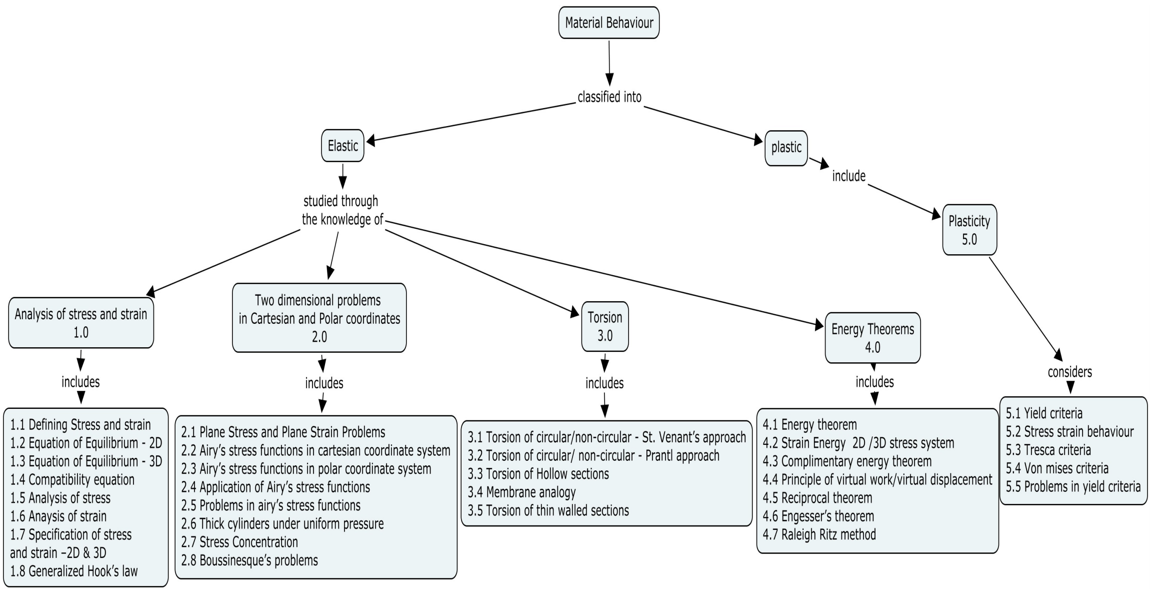


Figure-2

5. State and derive the principle of complementary energy of a two dimension system.
6. A steel bolt is subjected to a bending moment of 250kN-m and torque 150kN-m. If the yield stress in tension for the bolt material is 260MPa. Find the diameter of the bolt, according to i) Tresca's ii) Von Mises.

Concept Map



Course content 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	1
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	1
1.7	Specification of stress and strain –2D & 3D & Problems	1
1.8	Generalized Hook's law, Stress-Strain relationship	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 Prantl approach & Problems	1
3.3	Torsion of Hollow sections and Open sections	1
3.4	Membrane analogy of torsion of Closed section and Multi celled section & Problems	2
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	2
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	2
5.4	Von mises criteria & Problems	2
5.5	Application to simple problem in tension and compression / bending and torsion	2
	Total	**40**

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

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
J15	3	1	0	4

J15 Prestressed Concrete **3:1**

Preamble

This course offers analysis and design of prestressed concrete structures. The course will focus on explaining the basic concepts of prestressed concrete, methods of prestressing, losses involved and the design methods for prestressed concrete members under codal provisions.

Competencies: On completion of this course, the students will be able to

1. Determine loads on the structures, apply load factors and determine design loads.
2. Understand the background of IS codes to analyse and design the prestressed concrete elements under various loadings.
3. Understand design principles of prestressed concrete members subjected to bending and shear and their combinations with consideration of cracking and deflection.
4. Carryout design of commonly used prestressed concrete systems using fundamental principles and codal provisions.
5. Develop professional level competence in the design of commonly used prestressed concrete structures.
6. Prepare fabrication sketches of the prestressed concrete components.

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	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	20

Course level learning objectives

Remember

1. Define the term: Tendon

2. Write down the formula for finding the ultimate shear resistance of a prestressed concrete section uncracked in flexure
3. Define the term secondary moment.
4. Draw the location of P-line and C-line in the prestressed concrete circular water tank.
5. State Mohr's second theorem.
6. What is concordant cable profile?

Understand

1. What do you mean by prestressed concrete?
2. What are the reasons for using high tensile steel wires in prestressed concrete structures?
3. Differentiate between pretensioning and post tensioning systems.
4. Enumerate the factors influencing the deflection of prestressed concrete structures.
5. Explain load balancing concept.
6. What do you mean by unpropped method of composite construction?

Apply

1. A prestressed concrete beam 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. 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: 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.
2. A pretensioned T-section is having flange width of 1300mm and thickness 125mm. the width and depth of rib is 230mm and 1500mm respectively. The area of high tensile steel is 5000mm^2 located at an effective depth of 1550mm. If the characteristic strength of concrete and steel are 40 N/mm^2 and 1600 N/mm^2, calculate the flexural strength of T-beam.
3. 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.

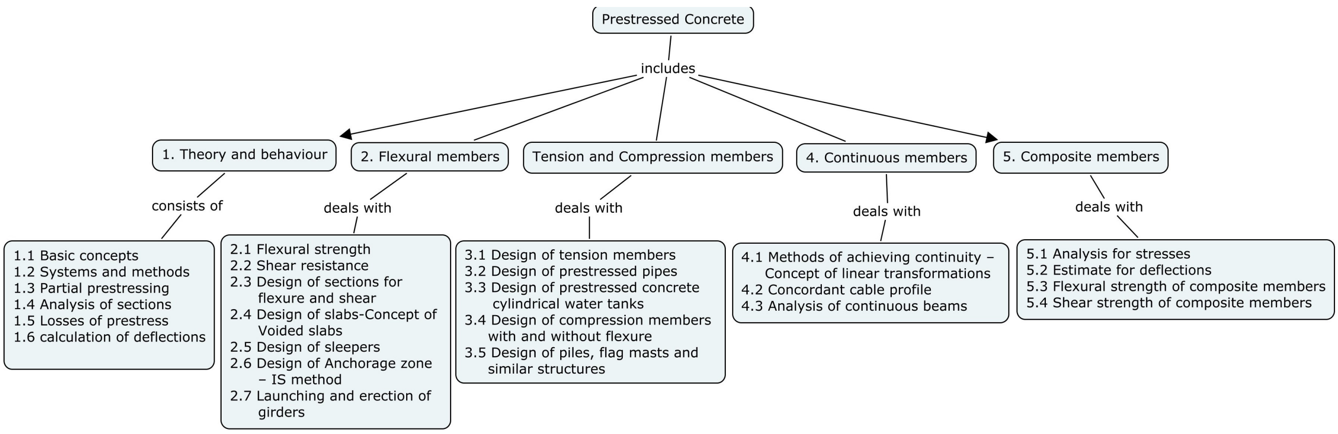
4. Calculate the resultant stress developed in the precast and insitu cast concrete when the beam is propped during the casting of slab. The size of the beam is 125mm x 250mm. Assume the same modulus of elasticity for concrete in precast beam and insitu cast slab. The beam with an effective span of 5m 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.
5. In two equal span prestressed concrete continuous beam ABC, 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. Locate the line of pressure (C-line) due to prestress alone. The prestressing force is 1200 kN. Calculate the extreme stresses in concrete at the section over the middle support. The size of the beam is 300mm x 600mm.
6. A prestressed concrete beam of rectangular section 150mm x 300mm 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. Determine shear resistance of uncracked section at supports and design the shear reinforcement. Take fck=40 Mpa and span=8m.

Create

1. A post tensioned prestressed concrete beam of rectangular section 300mm wide x 700mm deep is prestressed by an effective force of 200 kN acting at an eccentricity of 200mm. At service load conditions, a section of beam is subjected to a bending moment of 220 kN-m and a transverse shear force of 90 kN. If f_{ck} = 40 N/mm^2, f_y = 415 N/mm^2, f_p = 1600 N/mm^2, design suitable shear reinforcement in the section using IS:1343-1980 recommendations. A_p = 250mm^2, f_{pe} = 800MPa
2. A prestressed concrete tank of diameter 10m has to resist an internal pressure head of 4m of water. Design the reinforcement required per metre height and the thickness of concrete required. 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

3. 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.
4. A prestressed concrete beam 250mm wide and 600mm deep 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. Design the reinforcement required in the transmission alone.
5. 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.
6. 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 vertical cables of 12, 5mm dia wires in which the stress at transfer is 900 N/mm^2 and k=0.75.

Concept Map



Course content and Lecture schedule

S.No	TOPICS	PERIODS
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	1
1.5	Losses of prestress	
1.5.1	Losses in pre-tensioning system	2
1.5.2	Losses in post-Tensioning system	1
1.6	Calculation of deflections	
1.6.1	Short term deflection – tendons of various profile – self weight and imposed loads	1
1.6.2	Prediction of long term deflections	2
2. Flexural members		
2.1	Flexural strength	1
2.2	Shear resistance – Web shear crack – Flexure-shear cracks	1
2.3	Design of sections for flexure and shear	1
2.4	Design of slabs – Concept of voided slabs	1
2.5	Design of sleepers	1
2.6	Design of Anchorage zone – IS method	2
2.7	Launching and erection of prestressed girders – introduction	1
3. Tension and Compression members		
3.1	Design of tension members	2
3.2	Design of prestressed pipes	2
3.3	Design of prestressed concrete cylindrical water tanks	2
3.4	Design of compression members with and without flexure	2
3.5	Design of piles, flag masts and similar structures	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	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	2
	Total	**40**

Syllabus

Theory and Behaviour - 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 – Concept of voided 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. T.Y. Lin, & Ned. H. Burns, Design of Prestressed Concrete Structures, John Wiley & Sons, New York, 2010.
2. Arthur H.Nilson, Design of Prestressed Concrete, John Wiley & Sons, New York, 1987.
3. James R.Libby, Modern Prestressed Concrete: Design principles and Construction methods - Van Standard Rainford Co., New York, 1994
4. N. Rajagopalan, Prestressed Concrete, Narosa Publishing House, New Delhi, 2002
5. N. Krishna Raju, Prestressed Concrete, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2003

6. James R.Libby, Modern Prestressed Concrete: Design principles and Construction methods - Van Standard Rainford Co., New York, 1994
7. P. Dayaratnam, Prestressed Concrete Structures, Oxford and IBH, New Delhi, 2003.
8. M.C. Sinha & S.K. Roy, Fundamentals of Prestressed Concrete, S.Chand & Company Ltd, New Delhi, 1999.

IS Codes

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 Part 1 Concrete Pile; Section 3 Driven Precast Concrete Piles
6. IS 2911 (Part 1/Sec 4): 1984 Code of Practice for Design and Construction of Pile Foundation Part 1 Concrete Pile; Section 4 Bored Precast Concrete Piles

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
J16	3	1	-	4

J 16 Computer Aided Design **3:1**

Preamble:

This course provides the essentials of performing computer aided design, from engineering rather than a purely mathematical point of view.

Competencies: At the end of the course, the students will be able to

1. formulate algorithm for solving equations and solve truss problems by matrix approach
2. handle computer aided design of reinforced concrete members
3. understand computer aided design of steel and light gauge steel members
4. develop algorithm for analysis of prestressed concrete members
5. understand computer aided project planning

Assessment pattern

Sl.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	30	30	30
4.	Analyze	-	-	-
5.	Evaluate	50	50	50
6.	Create	-	-	-

Course level learning objectives

Remember

1. List the methods of solving simultaneous equations.
2. Write the equation for obtaining structure stiffness matrix.
3. Draw the stress-strain relationship for mild steel.
4. Define stiffened elements in light gauge sections.
5. Mention the various losses of prestress.
6. List the softwares for analysis and design of structural members.

Understand

1. Explain Gauss Elimination method of solving simultaneous equations.
2. Illustrate with an example the matrix stiffness method of solving a truss.
3. Compare the stress-strain relation for mild steel with that of cold formed steel.
4. Summarise the conditions for providing stiffeners in welded plate girder.
5. Express the equations for analysis of prestressed concrete members due to self weight and prestress.
6. Classify the differents stages of project execution.

Apply

1. Determine the forces in the members of the truss shown in Fig.1 by matrix stiffness method. Take E = 200 GPa.

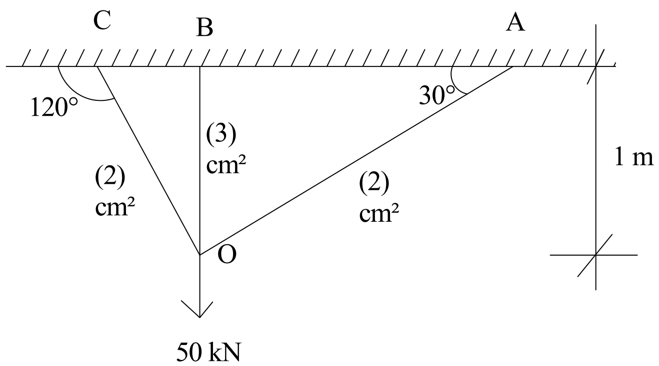


Fig.1

2. A concrete beam 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. Compute the stresses at the central section for
   a.) Prestress + self weight (density of concrete = 24 kN/m^3)
   b.) Prestress + self weight + live load
3. Solve the following system of equations by Gauss elimination method.

$$3x_1 - 4x_2 - x_4 = 2$$

$$x_2 + x_3 + 4x_4 = 3$$

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

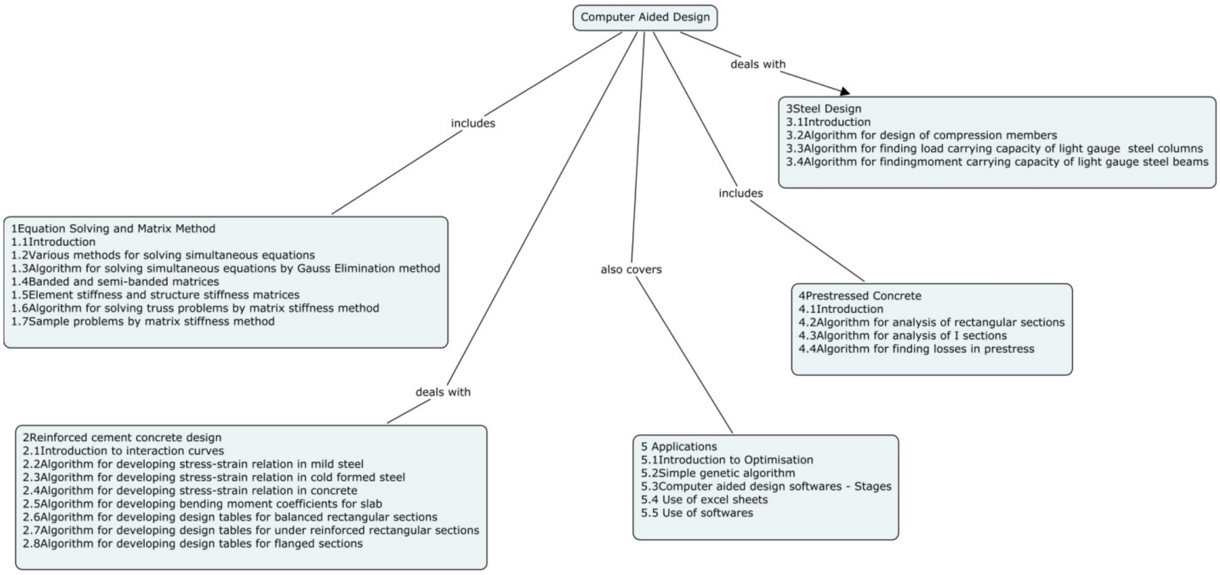
$x_2 + 2x_3 + 3x_4 = -4$

4. 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. Determine the maximum uniformly distributed load inclusive of self weight that can be supported by the beam.
5. A welded plate girder section is to be provided for a hall. The superimposed load exclusive of self weight is 150kN/m. The span of the girder is 20m. Determine the web and flange sections, intermediate and end bearing stiffeners required.
6. Compute the values of design chart for balanced and under reinforced rectangular sections.

Evaluate

1. Generate the algorithm for solving simultaneous equations by Gauss Elimination Method.
2. Write the algorithm for determination of bending moment coefficients for two way simply supported slab
3. Outline the algorithm for analyzing prestressed concrete members.
4. Generate the detailed algorithm for finding load carrying capacity of a light gauge column section.
5. Write the algorithm for analysis and design of single and built up steel beam sections.
6. Write the algorithm for design of web and flange section of a welded plate girder.

Concept Map



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	Sample problems by matrix stiffness method	2
2	**Reinforced cement concrete design**	
2.1	Introduction to interaction curves	1
2.2	Algorithm for developing stress-strain relation in mild steel	1
2.3	Algorithm for developing stress-strain relation in cold formed steel	1
2.4	Algorithm for developing stress-strain relation in concrete	1
2.5	Algorithm for developing bending moment coefficients for slab	1
2.6	Algorithm for developing design tables for balanced rectangular sections	1

2.7	Algorithm for developing design tables for under reinforced rectangular sections	1
2.8	Algorithm for developing design tables for flanged sections	2
3	**Steel Design**	
3.1	Introduction	1
3.2	Algorithm for design of compression members	1
3.3	Algorithm for finding load carrying capacity of light gauge steel columns	2
3.4	Algorithm for finding moment carrying capacity of light gauge steel beams	2
4	**Prestressed Concrete**	
4.1	Introduction	1
4.2	Algorithm for analysis of rectangular sections	1
4.3	Algorithm for analysis of I sections	2
4.4	Algorithm for finding losses in prestress	2
5	**Applications**	
5.1	Introduction to Optimisation	1
5.2	Simple genetic algorithm	2
5.3	Computer Aided Design Softwares – Stages	2
5.4	Use of excel sheets	2
5.4	Use of softwares	2
	Total	**40**

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**– 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**. Applications** Introduction to

Optimisation – Simple Genetic Algorithm. Introduction to computer aided design softwares – Use of excel sheets

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", 2005.

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Sub Code	Lectures	Tutorial	Practical	Credit
J 17	0	0	3	1

J17 CONCRETE TECHNOLOGY & STRUCTURAL ENGINEERING LABORATORY 0:1

(Common to IM17)

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. Determination of material fringe value using Transmission Polariscope
6. Determination of suitability of water for concreting and curing
7. Soil analysis for Safe Bearing Capacity determination
8. Determination of tensile strength of steel plates by coupon test
9. Study of moment curvature characteristics of RCC specimens
10. Calibration of Equipments and interpretation of results
11. Determination of Endurance Limit using Fatigue testing machine
12. Monitoring of corrosion in Reinforced concrete and steel
13. Study of steel frame under seismic effect
14. Design of rigid and flexible pavements using codal provisions
15. Determination of roughness of road surface using Merlin equipment

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Sub code	Lectures	Tutorial	Practical	credit
J21	3	1	0	4

J21 Structural Dynamics **3:1**

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.

Competencies: At the end of the course, the students will be able to

1. Analyse the Response of single degree of freedom undamped systems to initial excitations
2. Analyse the Response of single degree of freedom viscously damped systems to initial excitations
3. Analyse the Response of single degree of freedom systems to harmonic excitations
4. Analyse the Response of two degree of freedom damped systems to initial excitations
5. Analyse the Response of two degree of freedom systems to harmonic excitations
6. Analyse the Response of Multi degree of freedom systems to harmonic excitations

Assessment Pattern:

Sl NO	Bloom's Category	Test 1	Test II	Test III / End Semester
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	40	40	40
4	Analyse	40	40	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives:

Remember

1. State Alembert Principle
2. What is logarithmic decrement?
3. What is displacement transmissibility?
4. What is Quality factor?
5. What is vibration absorber?
6. Write the general form of Lagrange's equation?

Understand

1. What is the use of orthogonality principle?
2. What is the use of Rayleigh method in multi degree of freedom system
3. Why is modal participation is factor involved in dynamics of a buildings?
4. What do you understand by coupled modal equations?
5. Find the natural frequency of the system shown in fig1. The mass of the beam is negligible in comparison to the suspended mass.
   $E = 2x\ 10^5\ N / mm^2$

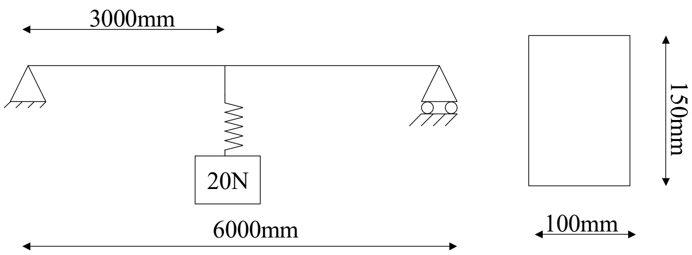
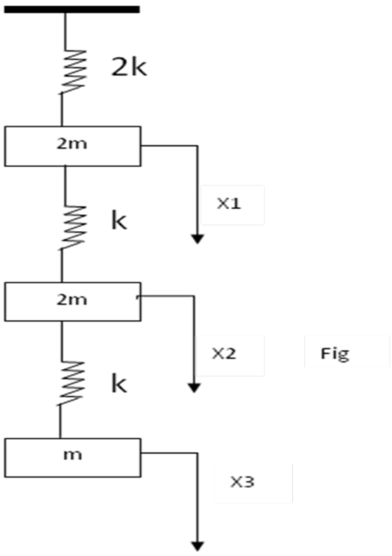


Fig 1

Apply

1. 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
   i. Derive the equation for an angular motion u (t) about O
   ii. Determine natural frequency of the system



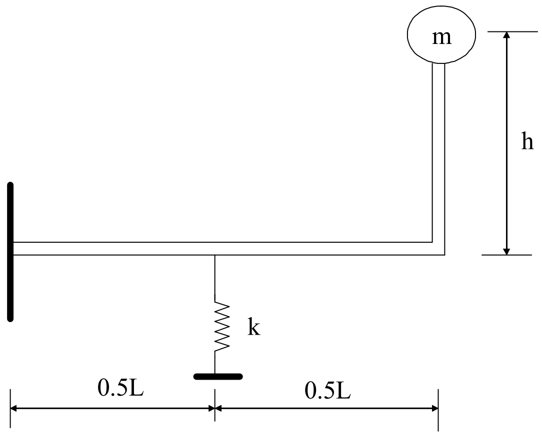


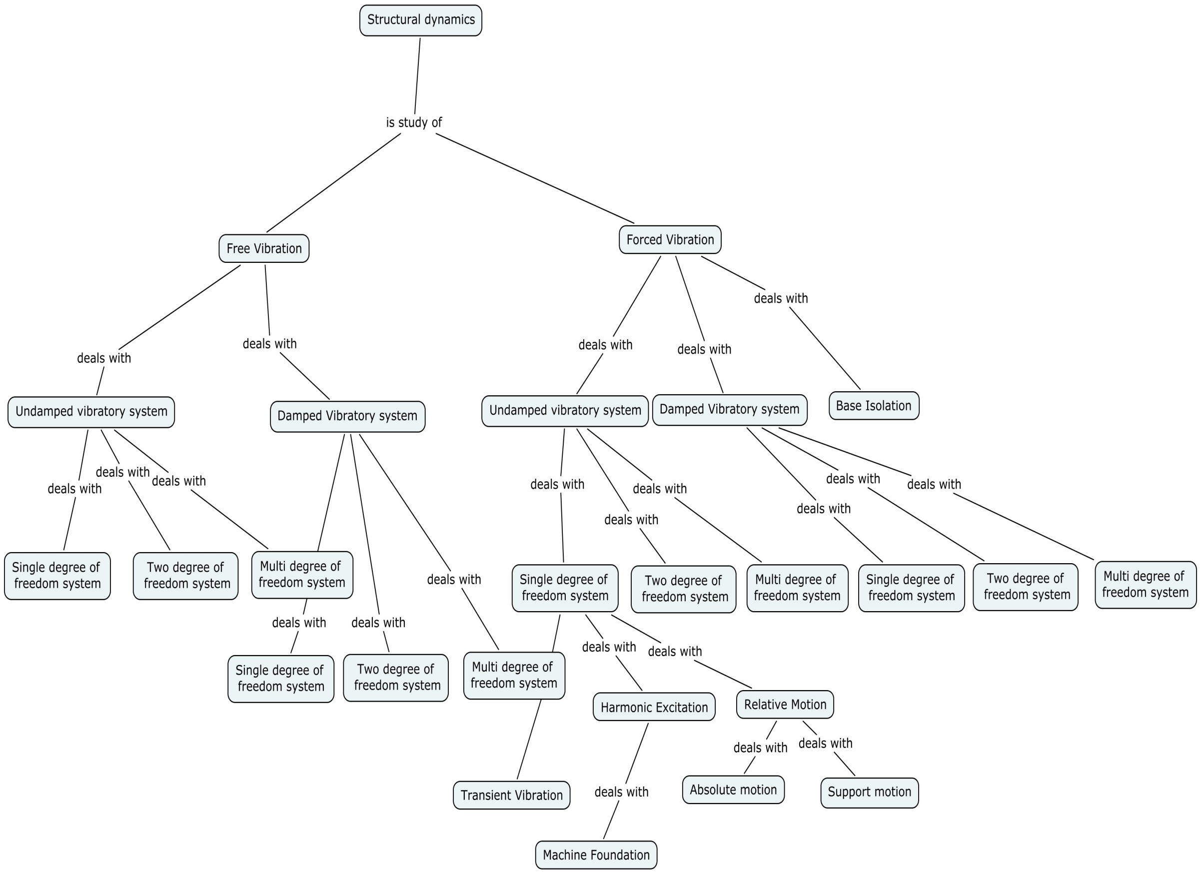
fig1

2. Using matrix method, determine the natural frequencies of the system as shown in fig 2 by Holzer method

Analyse

1. Derive the expression for Logarithmic decrement and prove that $\delta = 2\Pi\xi$ for damped free vibration
2. Find the natural frequency and amplitude ratio of the system for two degree of freedom system of your choice by using Lagrange,s equation
3. Explain coordinate coupling of two degree of freedom system and derive amplitude ratio and frequencies
4. Derive duhamel integral for an arbitrary forcing function
5. Find undamped response of a system which is subjected to a stepped rectangular forcing function
6. Derive the expression for the response of Multi degree of freedom system for free undamped vibration

Concept Map:



Course Content and Lecture Schedule:

Sl No	Topics	Periods
1.Introduction to vibration		
1.1	Simple Harmonic motion	1
1.2	Longitudinal Vibrations Equation of motion, SDOF analysis	1
1.3	Undamped SDOFs- dynamic equation of motion	1
1.4	Newtons law of motion, D'Alemberts principle- equivalent stiffness	1
1.5	Springs 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 and overdamped	2

1.8	Damped SDOFs- critically damped	1
1.9	Logarithmic decrement ,method of determining damping	1
2.Forced vibration of single degree of freedom system		
2.1	Undamped harmonic excitation	1
2.2	Damped harmonic excitation	1
2.3	Evaluation of damping at resonance	1
2.4	Response to support motion	1
2.5	Torsional vibration	1
2.6	Dynamic Magnification Factor	1
2.7	Impulsive loading,	1
2.8	Numerical evaluation of Duhamel's integral for damped system	1
3.Two degrees of freedom		
3.1	Principle modes of vibration and equation of motion for two degree of freedom	1
3.2	Two degrees of freedom for torsional system	1
3.3	Vibrations of undamped Two degrees of freedom	1
3.4	Forced Vibrations	1
3.5	Undamped forced vibration for two degrees of freedom	1
3.6	Orthogonality Principle	1
3.7	Vibration isolation	1
4.Multi degree of freedom system		
4.1	Equation of motion of multi degree of freedom	1
4.2	Stiffness, mass and damping matrices	1
4.3	Influence Coefficient, Eigen vector normalisations, problems	1
4.4	Matrix Method	1
4.5	Holzer Method	1
4.6	Rayleigh Method	1
4.7	Dunkerleys method	1
4.8	Modal analysis – damped undamped free vibration	1

5.Base Isolation and Machine foundation		
5.1	Base Isolation techniques, Types of bearings,	1
5.2	Seismic Instruments	1
5.3	Introduction to Machine Foundation	1
5.4	Forces transmitted to the foundations	1
5.5	Examples on Machine foundation	1
5.6	Structure to soil interaction	1
5.7	Introduction to random vibrations	1
	Total	**40**

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, solution of eigen value problems-Matrix Method –Rayleigh Method – Holzer Method - Dunkerleys method -Natural frequencies and mode shapes-Modal analysis – damped undamped free vibration. **Base Isolation and Machine foundation** Base Isolation – Techniques -case studies on base isolation -Types of bearings – Theory of Machine foundation –Instruments to measure machine vibration - Forces transmitted to the foundations -Structure to soil interaction - Random Vibrations.

Reference books

1. Mario Paz, "Structural Dynamics: Theory and Computation", CBS Publications, New Delhi, 1994.

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

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
J22	3	1	-	4

J22 Finite Element Analysis **3:1**

Preamble:

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

Competencies: At the end of the course, the students will be able to

1. Formulate basic energy, weak formulation and weighted residual techniques
2. Differentiate global, local and natural coordinates
3. Handle one dimensional line elements having linear and quadratic shape functions
4. Originate truss elements capable of solving two dimensional truss problems
5. Formulate two dimensional elements (triangular andisobarometric)
6. Understand Gaussian numerical integration technique
7. Understand about Higher order elements, plate and shell elements
8. Employ FEM in Dynamic problems and understand underlying concepts in Error evaluation and adaptive analysis
9. Use softwares to perform FEA

Assessment pattern:

Sl.No.	Bloom's Category	Test 1	Test 2	Test 3 / End semester examination
1.	Remember	10	10	10
2.	Understand	20	20	20
3.	Apply	70	70	70
4.	Analyze	0	0	0
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course level learning objectives:

Remember

1. Explain boundary value and initial value problems with examples.
2. What do you mean by shape function? What are the shape functions of a line element?
3. Write the properties of Global Stiffness Matrix K in case of a one dimensional line element.
4. Write the element body force and element traction force matrices.

5. Give the constitutive matrix in case of a plane strain problem
6. Give the weights and Gauss points in case of one point formula and two point formula

Understand

1. What is the significance of integration by parts?
2. The coordinates of two nodes of a truss element are (0,0) and (7,4). Determine the length and direction cosines.
3. The coordinates of points of a triangular element are (1,2), (3,7) and (5,4). Obtain the Jacobian matrix.
4. Derive the element stiffness matrix and element body force matrices of a line element.
5. Derive the Jacobian of transformation of a triangular element.
6. Compare Remeshing and Mesh Enrichment.

Apply

1. Consider the bar shown in Fig.1. Axial force P=20N is applied as shown. Determine the nodal displacement, stresses in each element and reaction forces.($E=2\times10^5$ N/mm^2)

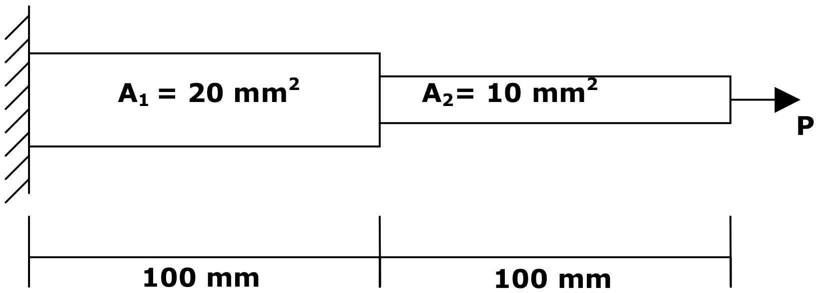


Fig.1

2. Evaluate the integral $\int 3e^x + x^2 + \frac{1}{x+2} dx$ using one point and two point Gauss quadrature formula.
3. Determine the forces in the members of the truss shown in Fig.2 by finite element method. Take E = 200 GPa.

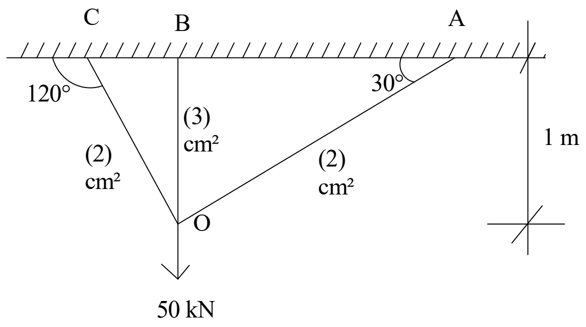


Fig.2

4. For the two-dimensional loaded plate shown in Fig. 3, determine 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.

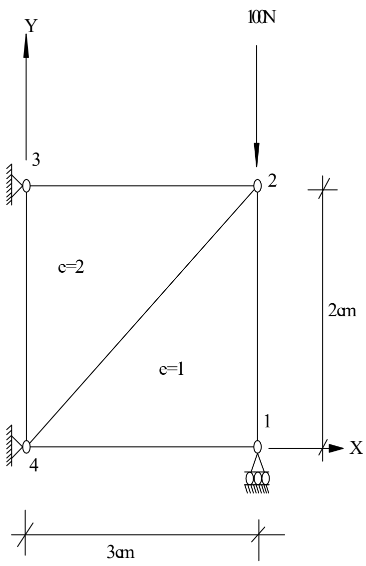


Fig.3

5. If a displacement field is described by

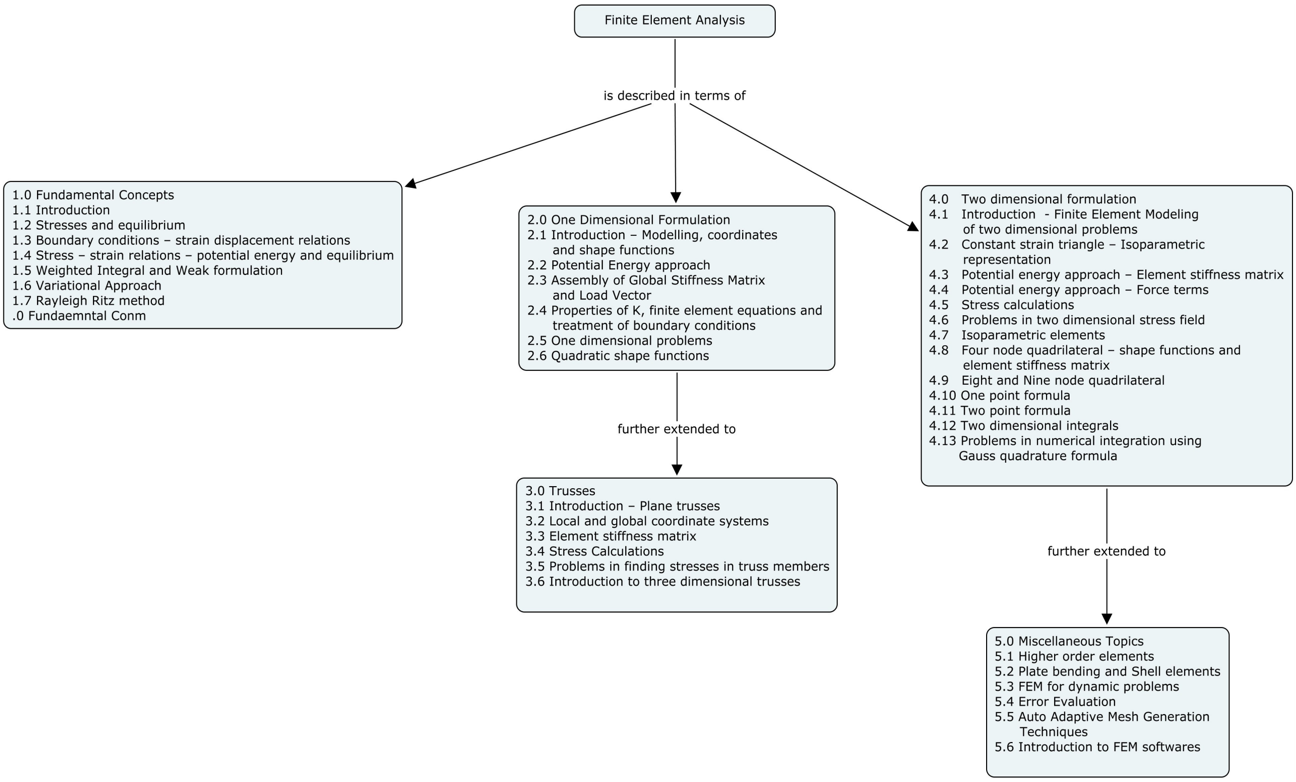
   $u = (-x^2 + 2y^2 + 6xy)\ 10^{-4}$

   $v = (3x + 6y - y^2)\ 10^{-4}$

   determine direct strain at x and y and shear strain at the point x = 1, y=0

6. Explain Super Convergent Patch Recovery used in Error estimation.

Concept Map



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
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	1
2.5	One dimensional problems	2
2.6	Quadratic shape functions	1
3	**Trusses**	
3.1	Introduction – Plane trusses	1
3.2	Local and global coordinate systems	1
3.3	Element stiffness matrix	1
3.4	Stress Calculations	1
3.5	Problems in finding stresses in truss members	2
3.6	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	1
4.3	Potential energy approach – Element stiffness matrix	1
4.4	Potential energy approach – Force terms	1
4.5	Stress calculations	1
4.6	Problems in two dimensional stress field	2
4.7	Isoparametric elements	1
4.8	Four node quadrilateral – shape functions and element stiffness matrix	1
4.9	Eight and Nine node quadrilateral	1
4.10	One & two point formula	1
4.11	Two dimensional integrals	1
4.12	Problems in numerical integration using Gauss quadrature formula	1
5	**Miscellaneous Topics**	
5.1	Higher order elements	1
5.2	Plate bending and Shell elements	1
5.3	FEM for dynamic problems	1
5.4	Error Evaluation	1
5.5	Auto Adaptive Mesh Generation Techniques	1

5.6	Introduction to FEM softwares	1
	Total	**40**

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**. One dimensional formulation** Finite element modeling – coordinates and shape 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. **Miscellaneous topics** Higher order elements- - plate bending and shell elements- FEM for dynamic problems – Error evaluation – Auto and adaptive mesh generation techniques – Introduction to FEM softwares.

Reference Books

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

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Sub Code	Lectures	Tutorial	Practical	Credit
J 31	3	1	0	4

J 31 Design of Steel Concrete Composite Structures 3:1

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 have 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.

Competencies: At the end of the course, the students will be able to

1. Apply the limit state approach to design the steel concrete composite structural elements
2. Design the composite beam with or without the provision of profile decking according to the limit state approach of IS and EURO code respectively
3. Design the composite slab and trusses for the respective limit states
4. Understand the load transferring behaviour of the shear connectors
5. Apply the composite concept by knowing some case studies

Assessment Pattern

	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	-	-	-
6	Create	60	-	60

Course level learning objectives

Remember

1. What is sectional classification?
2. Write two functions of shear connectors?
3. What is slip strain?
4. List any two applications of composite trusses
5. What is second order effect?
6. List the various forces at a composite beam column connection.

Understand

1. How the effective breadth of the composite beam is considered? Why?
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. Why the calculation of effective breadth of flange of a composite beam is needed?
4. What is the effect of shape of profiled deck slab on shear connection with the supporting beam?
5. Why the circular tubular column is better than the other ones?
6. Why column web stiffeners are provided in a beam column connection

Apply

1. 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.
2. 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$\times$425mm, Use 0.5% of gross concrete area Fe 415 as reinforcing steel
3. 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.
4. Check the adequacy of the continuous composite profile deck slab spanning 2m. The cross section of the profiled sheeting is as shown in figure.1. 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

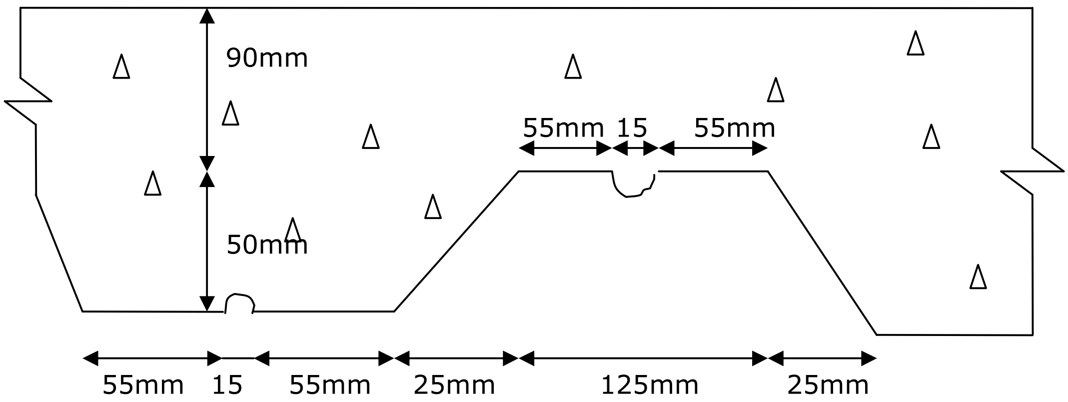


Figure.1

5. Check the adequacy of a concrete encased composite section for uni-axial bending. The details of the section are given as
   i. The height of the column is 3.5m and pinned ended
   ii. The dimension of the column is 400mm $\times$ 400mm
   iii. Use M30 grade of concrete
   iv. Use ISMB 350 RSJ section
   v. Reinforcing steel Fe 415 of 4no, of 14mm diameter bar
   vi. Design axial load is 1500kN
   vii. The design bending moment 125kN-m

6. Discuss in detail about the determination of bending resistance of composite slab with the provision of profile sheeting under the following two cases (i) Full interaction and (ii) Partial interaction.

Create

1. Design a simply supported composite beam of span 10m as shown in the figure.2. 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.

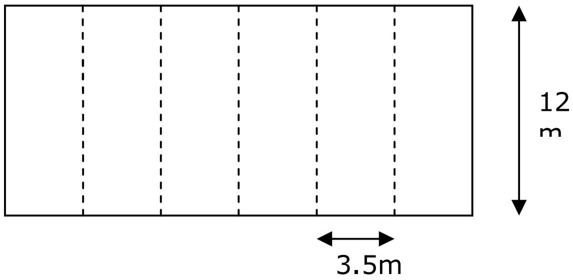


Figure.2

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.
4. A composite truss of span 10 as shown in figure 3 with following data,

i.	Slab thickness	- 130m
ii.	Profile depth	- 80mm
iii.	Self weight of the slab	- 2.81kN/m^2
iv.	Spacing of truss	- 3.25m c/c
v.	Construction load	-1.0kN/m^2
vi.	Live load	- 2.5kN/m^2
vii.	Maximum laterally unstrained length in top chord is 1.5m	
viii.	Grade of concrete is M20	
ix.	Design the top and bottom chord of the composite truss	

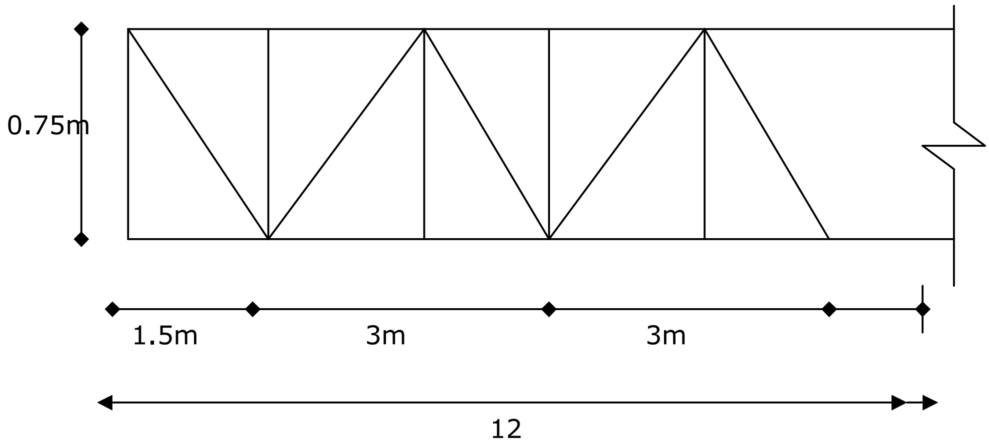
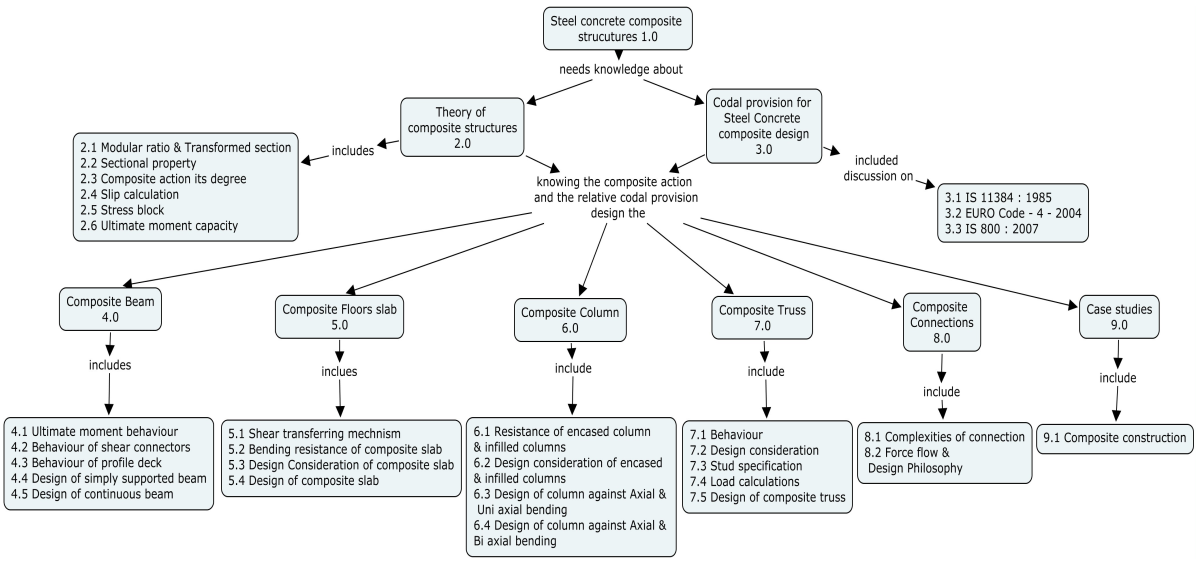


Figure-3

5. Design an encased composite column in M30 concrete. The height of the column is 3.5m and is pinned at one end and fixed at the other end. Assume the reinforcing steel Fe 415 is about 0.5% of gross concrete area.

6. Design an infilled composite circular column, filled with M30 grade concrete to have a plastic capacity of 1200kN. The height of the column is 3m and is fixed at the ends.

Concept Map



Course content and Lecture schedule

S.NO.	TOPICS	PERIODS
1.0	Introduction to Steel Concrete Composite Construction	1
2.0	**Theory of Composite Structures**	
2.1	Modular ratio and Transformed section	1
2.2	Sectional property like moment of inertia	1
2.3	Composite action - No interaction - Full interaction	1
2.4	Slip calculation	1
2.5	Stress block	1
2.6	Ultimate moment capacity	1
3.0	**Codal provisions for steel concrete composites design**	
3.1	Provisions of IS: 11384, Code of practice for composite construction in Structural Steel and Concrete	1
3.2	Provisions of Euro Code-4-2004, Design of composite steel land concrete structures	1
3.3	Provisions of IS 800 : 2007, Code of practice for General construction in Steel	1
3.3.1	Local buckling and section classification	1
3.3.2	Partial Safety Factors	1
3.3.3	Design provisions for tension , compression, bending members and connections	1
4.0	**Composite Beams**	
4.1	Ultimate moment behaviour of Composite beams	2
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	1
4.5	Design of continuous composite beam	2
5.0	**Composite floors**	
5.1	Shear transferring mechanism in profile deck composite floors system	1
5.3	Bending resistance of composite slab	1
5.4	Design consideration of composite floor	1
5.5	Design of Composite floor	2
6.0	**Composite columns**	

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 under	1
6.3	Design of column against axial & uniaxial bending	1
6.4	Design of column against axial & biaxial bending	1
7.0	**Composite trusses**	
7.1	Behaviour and application of composite truss	1
7.2	Design consideration of composite truss	1
7.3	stud specifications	1
7.4	Load calculation	2
7.5	Design of composite truss	2
8.0	**Composite connections**	
8.1	Complexities of composite connections and its design philosophies	1
8.2	Force flow in the joint	1
9.0	**Case studies**	
9.1	Composite constructions	2
	Total	**40**

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

Composite columns - Introduction to composite columns and its applications - Resistance of encased composite column cross section and infilled composite column cross section under compression - Design consideration of both encased and infilled composite column under - axial compression, uniaxial bending and biaxial bending – Problems. **Composite trusses** –Behaviour and application of composite truss - Design consideration – stud specifications – Load calculation - Design of composite truss. **Composite connections** - Complexities of composite connections and its design philosophies - Force flow in the joint. **Case studies** - composite constructions.

Reference Books:

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

IS Codes:

1. IS. 11384 -1985, Code of practice for composite construction in Structural Steel and Concrete.
2. IS 800-1974, Code of practice for General construction in Steel.
3. IS 800: 2007, Code of practice for General construction in Steel
4. Euro Code-4-1992, Design of composite steel and concrete structures.
5. IS 875-1987 (Part1-5), Code of practice for design load (other than Earth quake) for building and structures,
6. SP: 6(1)-1964, Handbook for structural Engineers 1-Structural Steel Sections

Website: www.steel-insdag.org

Course Designers

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ACADEMIC COUNCIL MEETING

M.E Degree (Structural Engineering) Program

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2008 certified

Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41

Fax: 0452 2483427

Web: www.tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Structural Engineering) PROGRAM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Approved in BOS Meeting 14.10.11 Academic Council Meeting 12.11.11

Department of Civil Engineering

Graduating Students of M.E program of Structural Engineering will be able to

1. Apply the concept of mechanics both in elastic and plastic states of structural members
2. Analyze structural members under static and dynamic conditions
3. Design Reinforced concrete, prestressed concrete, steel and steel-concrete composite members following the provisions of Indian and international standards using manual and computer aided approach
4. Construct and maintain structures through retrofitting and rehabilitation techniques

Thiagarajar College of Engineering, Madurai-625015

Department of Civil Engineering

M.E Structural Engineering

Scheduling of Courses

Semester	**Theory Courses**						**Practical / Project**	
4th (12)							J41 Project Phase- II 0:12	
3rd (16)	J31 Design of Steel Concrete Composite Structures 3:1	Elective V 4:0	Elective VI 4:0				J34 Project Phase – I 0:4	
2nd (25)	J21 Structural Dynamics 3:1	J22 Finite Element Analysis 3:1	Elective I 4:0	Elective II 4:0	Elective III 4:0	Elective IV 4:0	J27 Seminar 0:1	
1st (25)	J11 Applied Mathematics 3:1	J12 Design of Concrete Structures 3:1	J13Structural Mechanics 3:1	J14 Theory of Elasticity and Plasticity 3:1	J15 Pre stressed concrete 3:1	J16 Computer Aided design 3:1	J17 Concrete Technology & Structural Engineering Laboratory 0:1	

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
J11	Applied Mathematics	BS	3	1	-	4
J12	Design of Concrete Structures	DC	3	1	-	4
J13	Structural Mechanics	Dc	3	1	-	4
J14	Theory of Elasticity and Plasticity	DC	3	1	-	4
J15	Prestressed Concrete	DC	3	1	-	4
J16	Computer Aided Design	DC	3	1	-	4
PRACTICAL						
J17	Concrete Technology & Structural Engineering Laboratory	P	-	-	3	1
Total			**18**	**6**	**3**	**25**

BS : Basic Science
DC : Department Core
DE : Department Elective
GE : General Elective
L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
J21	Structural Dynamics	DC	3	1	-	4
J22	Finite Element Analysis	DC	3	1	-	4
JX	Elective I	DE	4	-	-	4
JX	Elective II	DE	4	-	-	4
JX	Elective III	DE	4	-	-	4
JX	Elective IV	DE	4	-	-	4
PRACTICAL						
J27	Seminar	P	-	-	3	1
	Total		**22**	**2**	**3**	**25**

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
J31	Design of Steel Concrete Composite Structures	DC	3	1	-	4
JX	Elective V	DE	4	-	-	4
JX	Elective VI	DE	4	-	-	4
PRACTICAL						
J 34	Project Phase- I	P	-	-	12	4
	Total		**11**	**1**	**12**	**16**

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	**T**	**P**	
PRACTICAL						
J41	Project Phase- II	P	-	-	36	12
Total			**-**	**-**	**36**	**12**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 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	J11	Applied Mathematics	3	50	50	100	25	50
2	J12	Design of Concrete Structures	3	50	50	100	25	50
3	J13	Structural Mechanics	3	50	50	100	25	50
4	J14	Theory of Elasticity and Plasticity	3	50	50	100	25	50
5	J15	Pre stressed Concrete	3	50	50	100	25	50
6	J16	Computer Aided Design	3	50	50	100	25	50
PRACTICAL								
7	J17	Concrete Technology & Structural Engineering Laboratory	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

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	J21	Structural Dynamics	3	50	50	100	25	50
2	J22	Finite Element Analysis	3	50	50	100	25	50
3	JX	Elective I	3	50	50	100	25	50
4	JX	Elective II	3	50	50	100	25	50
5	JX	Elective III	3	50	50	100	25	50
6	JX	Elective IV	3	50	50	100	25	50
PRACTICAL								
7	J27	Seminar	-	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

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	J31	Design of Steel Concrete Composite Structures	3	50	50	100	25	50
2	JX	Elective V	3	50	50	100	25	50
3	JX	Elective VI	3	50	50	100	25	50
PRACTICAL								
4	J34	Project Phase- I	-	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E DEGREE (Structural Engineering) PROGRAM

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

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	J41	Project Phase- II	-	150	150	300	75	150

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** 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:

1. JA Structural Steel Design
2. JB Design of Bridges
3. JC Experimental Techniques and Instrumentation
4. JD Concrete Technology
5. JE Industrial Structures
6. JF Earthquake Engineering
7. JG Repair and Rehabilitation of Structures
8. JH Disaster Mitigation and Management
9. JJ Shell Structures
10. JK Structural Optimization
11. JL Theory of Plates
12. JM Foundation Design
13. JN Engineering Fracture Mechanics
14. JP Construction Planning, Scheduling and Management

Sub Code	Lectures	Tutorial	Practical	Credit
JA	3	1	-	4

JA - STRUCTURAL STEEL DESIGN 3:1

Preamble

This course deals with limit state design of steel structures. The discussion on the concept of limit state design based on new IS 800:2007, EURO code-3 have been included in this course. The design and detailing of cold formed steel, towers & Masts chimneys and plastic design were dealt in detail. Some case studies have also been included in pre-engineered buildings, tower etc.

Competencies: At the end of the course, the students will be able to

1. Apply the limit state approach to the design of steel structural elements
2. Design the gantry girder and crane columns.
3. Design a towers and masts according to the provision given in the IS:800-2007.
4. Design the connections according to the limit state approach given in IS:800-2007.
5. Design of tubular truss according to its codal provisions
6. Design plastic design of beams and frames
7. Design of cold formed steel elements with the respective limit states

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	40	40	40
4	Analyse	-	-	-
5	Evaluate	-	-	-
6	Create	40	40	40

Course level learning objectives

Remember

1. What is meant by slenderness ratio?
2. Define yielding.
3. What is meant by local buckling?
4. What are the parameters that affect the plastic behaviour of steel member?
5. List the loads acting on the transmission line towers.
6. State the difference between a towers and masts.

Understand

1. Illustrate the action of loads on the gantry girder?
2. write short notes on
    a. Bolted moment end plate connection
    b. Flange angle connection
    c. Split beam T connection
    d. Beam to beam connection
    e. Beam splices
    f. Column splices.
3. How are the sizes of gussets determined?
4. What is a lug angle? Why is it not used in practice?
5. Distinguish between the elastic modulus and plastic modulus of a section.
6. How bracing are designed?

Apply

1. Discuss indetail the analysis and design of transmission line towers.
2. A beam ISLB @ 56.9 kg/m carrying a total udl of 260kN over a span of 7.5m is to be connected to the flange of steel stanchion ISHB 250 @ 51.0kg/m. An ISA 100 x75 x 8mm is used as a top and seat angle in a connection. Use M16 grade 4.6 bolts. Check whether this connection angle is adequate.
3. A portal frame of height L and span L is hinged at the base and is of uniform plastic moment M_p. It carries a single central vertical load

Create

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. An industrial building is shown in figure-1. the frames are at 5m centres and the length of the building is 40m. The purlin spacing of the roof is as shown in figure-1. The Building is situated in Mumbai. Assume live and wind loads as per IS875 (part 2 and Part 3) and the roof is covered with GI sheeting. Design the roof truss using tubular sections. The truss is to be fabricated using welded joints in two parts for transport and assembled at site using bolted joints at A,B and C as shown in figure-1(b).

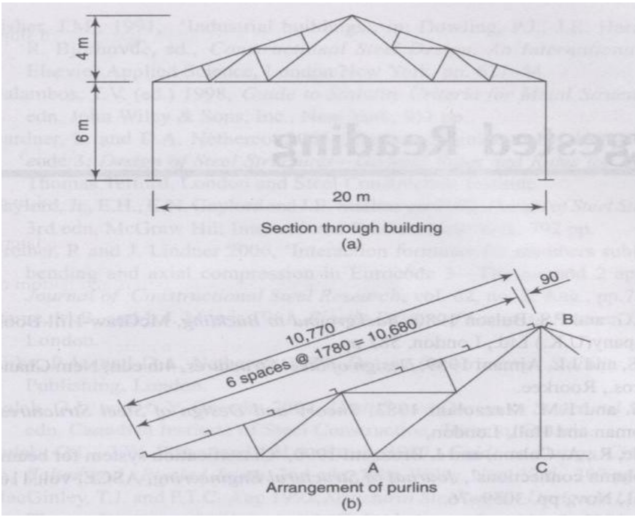


Figure-1

3. Design a seat-angle connection between a beam MB300 and column SE200 for a reaction of beam 100kN using M20 bolts of property class 4.6. Take Fe410 grade steel (fy =250MPa). Refer fig.

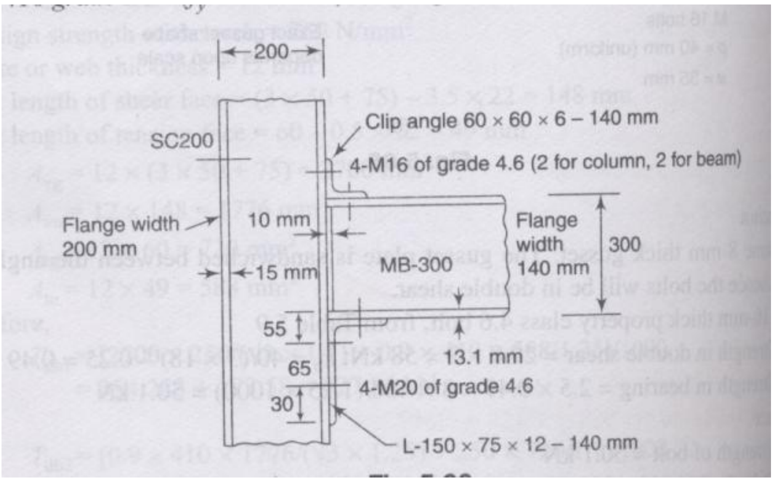
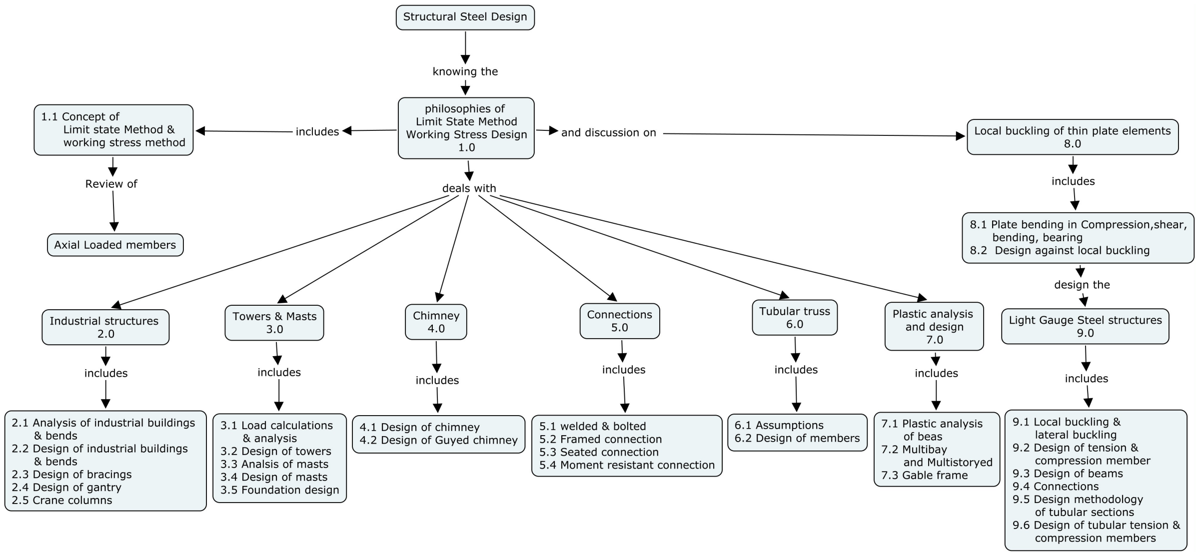


Figure-2

Concept Map



Course content and Lecture schedule

S.NO.	TOPICS	PERIODS
1.0	**Introduction to design methodologies**	
1.1	Concept of design methodologies -Philosophies of Limit State Design, Working stress design – review of axially loaded members	2
2.0	**Industrial structures**	
2.1	Analysis of industrial buildings and bends	2
2.2	Design industrial buildings and bends	2
2.3	Design of bracings	1
2.4	Design of gantry	2
2.5	Crane columns	2
3.0	**Towers and Masts** –.	
3.1	Load calculation and Analysis of steel tower.	2
3.2	Design of Towers	2
3.3	Analysis of masts	2
3.4	Design of masts	2
3.5	Foundation design	2

4.0	**Chimney**	
4.1	Design of self supporting	2
4.2	Design of guyed chimneys	2
5.0	**Connections**	
5.1	Introduction to Welded and bolted connections	2
5.2	Framed connection	2
5.3	Seated connection	2
5.4	Moment resistant connection.	2
6.0	**Tubular truss**	
6.1	Design of tubular sections – assumptions	2
6.2	Design of tension and compression members	2
7.0	**Plastic analysis and Design**	
7.1	Moment distribution and plastic analysis of Continuous beams	2
7.2	Multi bay and Multi storeyed frames	2
7.3	Gable frames	2
8.0	**Local Buckling of Thin Plate Elements**	
8.1	Introduction – plate elements in compression –shear – bending – bending and shear – bearing	2
8.2	Design against local buckling.	2
9.0	**Light Gauge Steel Structures**	
9.1	Types of cross sections – local buckling and lateral buckling	2
9.2	Design of compression and tension members	2
9.3	Design of beams – deflection of beams	2
9.4	Design of connections	2
	TOTAL	**45**

Syllabus

Introduction: Concept of design methodologies -Philosophies of Limit State Design, Working stress design. Review of axially loaded member design. **Industrial structures** – Analysis and design of industrial buildings and bends – Design of bracings – Design of gantry and crane columns. **Towers and Masts** – Analysis an design of steel tower and masts. **Chimney** – Design of self supporting and guyed chimneys. **Connections:** Welded and bolted connections – framed connection – seated connection – moment resistant connection. **Tubular truss** - Design of tubular sections – assumptions – Design of tension and compression members. **Plastic analysis and design** – Moment distribution and plastic analysis of continuous beams - Moment distribution and plastic analysis of Continuous beams **-** Gable frames **- Local Buckling of Thin Plate Elements:** Introduction – plate elements in compression –shear – bending – bending and shear – bearing – design against local buckling. **Light Gauge Steel Structures**: Types of cross sections – local buckling and lateral buckling – Design of compression and tension members – beams – deflection of beams – Design of connections –

REFERENCES:

1. Gaylord E H, Gaylord N C and Stallmeyer J E, "Design of Steel Structures", 3rd edition, McGraw Hill Publications, 1992.
2. 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.
2. Subramanian N," Design of Steel Structures", Oxford University Press, NewDelhi 2008.
3. Englekirk R, "Steel Structures: Controlling Behaviour through Design",John-Wiley & Sons, Inc, 2003.
4. Teaching resource for, "Structural Steel Design," Volume 1,2 & 3, Institute for Steel Development and Growth (INSDAG),2002.

IS Codes:

1. IS 800: 2007, Code of practice for General construction in Steel
2. IS 800-1974, Code of practice for General construction in Steel
3. Euro Code-3-1992, Design of composite steel and concrete structures.
4. IS 875-1987 (Part1-5), Code of practice for design load (other than Earth quake) for building and structures,
5. IS 6533 : Part 2 : 1989 Code of practice for design and construction of steel chimneys Part 2 Structural aspects
6. SP: 6(1)-1964, Handbook for structural Engineers 1-Structural Steel Sections
7. IS 1161 :1998 – Steel tubes for structural purposes – specifications, BIS.
8. IS 806 : 1968 – Code of practice for use of steel tubes in general building construction, BIS

9. IS 808 : 1989 Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
10. IS 801 : 1975 Code of practice for use of cold formed light gauge steel structural members in general building construction

Website: www.steel-insdag.org

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
JB	3	1	-	4

JB DESIGN OF BRIDGES **3:1**

Preamble

This course offers the design of bridges such as RCC bridges, design principles of Steel bridges, design of prestressed concrete bridges, design principles of substructure and design of different types of bearings as per IRC loadings standards, Indian Railway standards bridge rules and MOST codes. It aims at determination of safe as well as economical section using different kinds of material used in construction and maintenance.

Competencies: On completion of this course, the students will be able to

1. Understand the specifications given in IRC codes, IRC manuals.
2. Calculate the shear force and bending moment for wheel loads placing on the bridge at critical conditions.
3. Design the components of super structure of bridges (Deck slab, Longitudinal girders, Cross Girders, Lattice Girder, Articulation etc.,)
4. Design all the components of continuous bridge, cable stayed bridge, balanced cantilever bridge and box Girder Bridge.
5. Design principles of substructures such as pier, Abutments, end bearing pile and caisson foundation.
6. Design of bridge bearings
7. Design the suitable foundation for bridges such as piers, abutments and wing walls.

Assessment_Pattern

S.No	**Blooms Category**	**Test 1**	**Test 2**	**Test 3 / End Exemption**
1	Remember	10	10	10
2	Understand	20	20	20
3	Apply	30	30	30
4	Analyze	-	-	-
5	Evaluate	-	-	-
6	Create	40	40	40

Remember

1. Define Linear waterway.
2. write the Lacey's formula for calculating the Linear water way.
3. What is the minimum width of carriage way for single lane traffic?
4. What are the different classes of IRC loading standards?
5. Draw the position of IRC class 'AA' Tracked vehicle wheel load for getting maximum bending moment.
6. List out any two advantages of balanced cantilever bridge.
7. Write the assumptions made to analyze the fixed arch bridge.
8. Define economic span.
9. Draw typical sketch of different types of pier.
10. What are the advantages of rigid framed bridge?
11. List out the various classification of fixed bearings.
12. What do you mean by afflux?
13. What is the equation for calculating the effective width of deck slab?
14. Write the equation for calculating the scour depth for natural streams in alluvial soil.

Understand:

1. Draw a neat sketch of a bridge and mark all its components, also explain the importance of each component.
2. What are the various classification of bridge according to its materials used in construction briefly?
3. What are the points to be considered while selecting a ideal bridge site? Explain briefly.
4. what is the concept of prestress? Explain briefly the design principle of a post tensioned,prestressed concrete 'I' Girder bridge with neat sketches
5. What are the factors to be considered in selecting a paint for steel bridge?
6. List out the various components of 'T' beam deck slab bridge
7. What is meant by quality assurance for bridge construction
8. What are the various types of Expansion bearing for Girder bridge?
9. What are the factors influencing the selection type of bridges?
10. List out the basic difference between pretensioning and post tensioning.

Apply

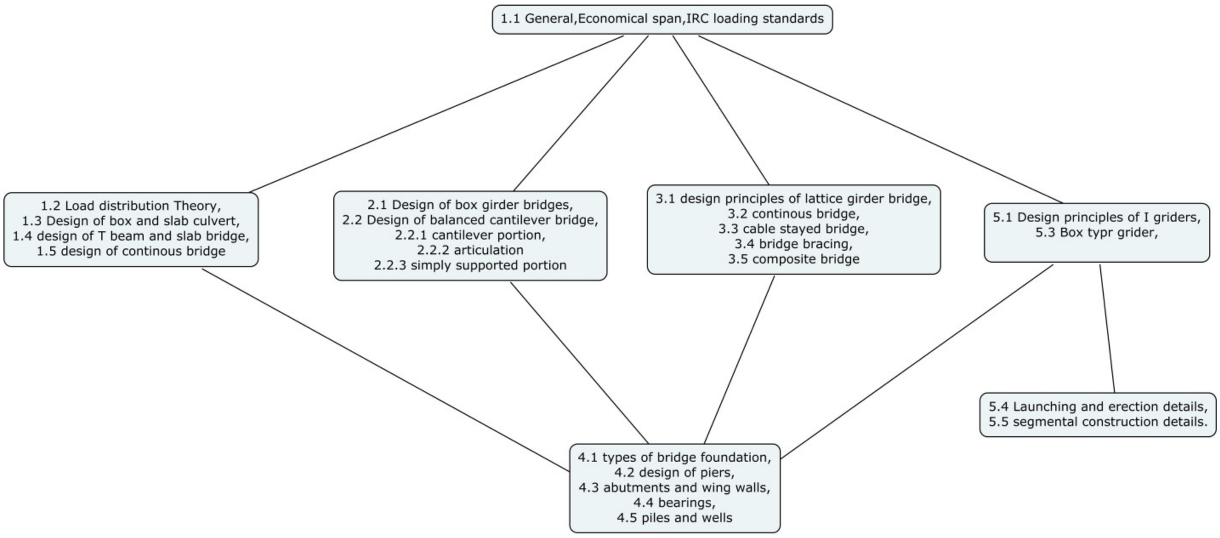
1. Design a R.C rocker bearing to transmit a support reaction of 1000Kn.permissible bearing stress in concrete is 8 Mpa. Use M30 grade concrete and Fe 415 grade steel.

2. Design the articulation of balance cantilever bridge of span 70m, carriage way two lane, loading class 70R tracked vehicle, Materials:M25 grade concrete and Fe 415 steels are used.
3. Explain the design principles pyloyns with neat sketches.

Create

1. Design the reinforced concrete slab 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 (lenth of the bridge)
   Cross girders are provided at 5m c/c
   Loading: IRC class "AA" Wheeled vehicle
   Materials: M25 concrete grade and Fe 415 steel are used.
   Also sketch details of reinforcement in the slab.
2. Design a RC slab culvert for a National Highway to suit the following data:
   Carriageway 2lane,Footpath-1.2m wide, clear span-6m,thickness of wearing coat-80mm,width of bearing -0.4m,Load-class 70R tracked vehicle,M25 concrete and Fe 415 steel.
3. Design the deck slab of a RC slab culvert for following specifications.
   Carriage way=3.5m wide.
   Foot path 0.9m on either side
   Clear span=5m
   Thickness of wearing coat=80mm
   Width of bearing=350mm
   Loading class 'AA' Tracked vehicle.
   Materials:M25 grade concrete and Fe 415 steels are used.

Concept map:



Course content and lecture schedule

Sl No	Topics	Periods
1.	**Analysis and design of short span bridges**	
1.1	Economical span of the bridge – loads on bridges, IRC recommendation	1
1.2	Load distribution theories	1
1.3	Design of slab and box culvert	2
1.4	Design of 'T' beam	2
1.5	Design of slab	1
1.6	Design of continuous bridges	3
2	**Long span girder bridges**	
2.1.	Design of box girder bridges	2
2.2	Analysis of box girder bridge	2
2.2	Design of balanced cantilever bridges	2
2.2.1	Design of cantilever portion	2
2.2.2	Design of articulation	2
2.2.3	Design of simply supported portion	2

3.	**Steel bridges**	
3.1	Design principles Lattice girder bridges	3
3.2	Design principles of continuous bridge	3
3.3	Design principles of composite bridges	2
3.4	Design of bridge bracings	2
4.	**Supporting structures for bridges**	
4.1.	Types of bridge foundation	1
4.2.	Design of piers	2
4.3.	Design of abutments and wing walls	2
4.4.	Design of bearings	2
4.5.	Design principles of piles and wells	3
5.	**Analysis and design of prestressed bridges**	
5.1.	Concept and design principles	2
5.2	Design of I girders	3
5.3	Design of Box type girder	3
5.4	launching and erection details with case studies	2
	Total	**40**

SYLLABUS :

Analysis and design of short span bridges - Economical span of the bridge – loads on bridges, IRC recommendation – load distribution theories – design of slab and box culvert – ‘T’ beam and slab bridge – design principles of continuous bridges **Long span girder bridges –** Design of box girder bridges – design of balanced cantilever bridges. **Steel bridges –** Lattice girder bridges – continuous bridge – cable stayed bridge – bridge bracings. **Supporting structures for bridges –** types of bridge foundation and design – design of piers, abuntments and wing walls, bearings, piles and wells. **Analysis and design of prestressed bridges –** Design of prestressed concrete bridges – I and Box types – launching and erection with case studies – segmental construction principles.

Reference Books:

1. Robinson J.R. (1966), "Piers Abutments and Form work for Bridges", B.I.Publications, Bombay.
2. Rowe R.E. (1962), "Concrete Bridges Design", John willey and Sons – New York, U.S.A.
3. Hayden A.G. & Barron N. (1926), "Rigid Frame Bridge", John willey and Sons – New York, U.S.A.
4. Johnson victor (1984), "Design of Bridges", Oxford and IBH publication.
5. Krishnaraju N (1998) "Design of Bridges", Oxford and IBH Publishing House, New Delhi.
6. Madras Highways Manual – Vol I, II & III – Madras Government Press, Madras.
7. Raina V.K, "Concrete Bridges Handbook", Galgotia publications.
8. Raina V.K. (1991) "Concrete Bridge practice analysis, Design and Economics", Tata McGraw Hill, New Delhi.
9. Launching and erection details (video show Railway CD)

IS Codes:

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.
4. IRC: 24-2000 "Standard specifications & code of practice for steel bridges".
6. IRC: 87-1984, "Guidelines for the Design and Erection of False work for Road Bridges.
7. IS 1343:1980 Code of Practice for Pre Stressed Concrete
8. IRS: 1 1977, Bridge rules.
9. IRS: 2, "Code of practice for plain, reinforced and prestressed concrete for general bridge construction.

10. MOST standard plans for 3.0m to 10m span reinforced cement concrete solid slab superstructure with and without foot paths for highways, (1991).
11. MOST standard plans for highways bridges RCC.T-Beams and slab superstructure – span from 10m to 24m width.
12. 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.
13. MOST standard drawings for road bridges- RCC solid slab superstructure (15° and 30° SKEW) span 4m to 10m (with and without foot paths), 1992.
14. MOST standard drawing for road bridges-RCC solid slab superstructure (22.5°SKEW) span 4m to 10m (with and without foot paths), 1996.
15. IS 2911, 1980 code of practice for pile foundation.

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JC	4	-	-	4

JC EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION 4.0

(Common to IMG)

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.

Competencies: On completion of this course, the students will be able to

1. Understand the working and uses of different types of strain gauges.
2. Understand the principle and design of model analysis.
3. Understand the distress management and control.
4. Understand the working principle of LVDT, seismographs, cathode ray oscilloscope under instrumentation.
5. Understand the different types of non destructing test methods

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	80	80	80
4	Analyze	-	-	-
5	Evaluate	-	-	-
6	Create	-	-	-

Course level learning objectives

Remember

1. What is sensitivity of the strain gauge?

2. What is rosette?

3. What is similitude?

4. What is distress?

5. What is corrosion?

Understand

1. What are the characteristics of ideal strain gauge?

2. Compare static and dynamic strains.

3. State Muller Breslau’s principle.

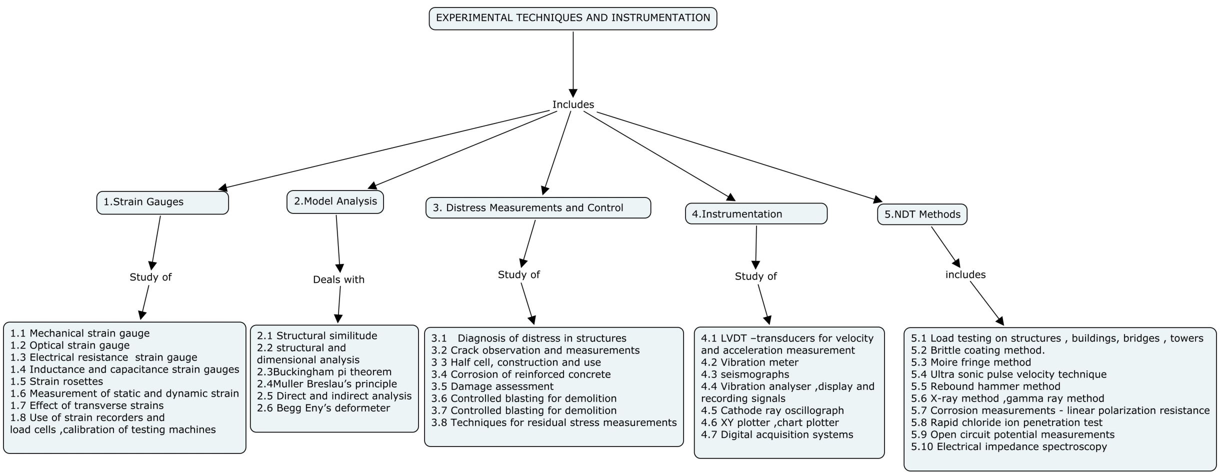
4. What are photo elastic coatings?

5. What is calibration of a machine?

Apply

1. Explain the working of Huggenberger tensometer.
2. Explain the working of moment indicators?
3. Explain the working of Begg Eny’s deformeter
4. How will you conduct test using rebound hammer?
5. How seismograph is working?

Concept Map



Course content and Lecture schedule:

S.No	TOPICS	PERIODS
1	**Strain Gauges**	
1.1	Mechanical strain gauge	2

1.2	Optical strain gauge	2
1.3	Electrical resistance strain gauge	1
1.4	Inductance and capacitance strain gauges	1
1.5	Strain rosettes	2
1.6	Measurement of static and dynamic strain	1
1.7	Effect of transverse strains	1
1.8	Use of strain recorders and load cells ,calibration of testing machines	1
2	**Model Analysis**	
2.1	Structural similitude	1
2.2	Structural and dimensional analysis	1
2.3	Buckingham pi theorem	2
2.4	Muller Breslau's principle	1
2.5	Direct and indirect analysis .	1
2.6	Begg Eny's deformeter	1
2.7	Moment indicators	2
2.8	Design of models for direct and indirect analysis	1
3.	**Distress Measurements and Control**	
3.1	Diagnosis of distress in structures	1
3.2	Crack observation and measurements	1
3.3	Corrosion of reinforced concrete	2
3.4	Half cell, construction and use	2
3.5	Damage assessment	1
3.6	Controlled blasting for demolition	2
3.7	Techniques for residual stress measurements	2
4	**Instrumentation**	
4.1	LVDT(linear variable differential transducer) –transducers for velocity and acceleration measurement	1
4.2	Vibration meter	1
4.3	Seismographs	1
4.4	Vibration analyser ,display and recording signals	1
4.5	Cathode ray oscillograph	1
4.6	XY plotter ,chart plotter	1

4.7	Digital acquisition systems	1
5	**NDT Methods**	
5.1	Load testing on bridges , towers	2
5.2	Brittle coating method	1
5.3	Moire fringe method	1
5.4	Ultra sonic pulse velocity technique	1
5.5	Rebound hammer method	1
5.6	X-ray method, Gamma ray method	1
5.7	Corrosion measurements - linear polarization resistance	1
5.8	Rapid chloride ion penetration test-	1
5.9	Open circuit potential measurements	1
5.10	Electrical impedance spectroscopy	1
	Total	**50**

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. **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 **Distress Measurements and Control** –Diagnosis of distress in structures –crack observation and measurements –corrosion of reinforced concrete –half cell, construction and use –damage assessment –controlled blasting for demolition –techniques for residual stress measurements. **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. **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

Reference Books

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

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
JD	4	-	-	4

JD CONCRETE TECHNOLOGY 4:0

Preamble:

To provide students with advanced knowledge of concrete technology which covers properties of fresh concrete hardened concrete, and the concept of designs of mix proportion. Durability of concrete structures will be discussed in details. New concrete-making materials and recent advancements in concrete technology, namely high-strength concrete, high performance concrete, fiber-reinforced concrete, self-compacting concrete and polymer concrete will also be included as well as special processes and technology for particular types of structure also discussed.

Competencies: At the end of the course, the students will able to

1. Have knowledge about cement types and their properties, pozzolanic activities and properties of the binder phase.
2. Identify the properties of aggregates and their influence in concrete and also use of admixtures in concrete.
3. Understand the importance of durability and workability of concrete
4. Design concrete mix proportions by using various methods like IS method, ACI and DOE method.
5. Test concrete members for compressive, tensile and flexural strength.
6. Identify the important properties of fresh and hardened concrete
7. Have knowledge about special concretes and special process of construction works.

Assessment Pattern

S.No	**Bloom's category**	**Test 1**	**Test 2**	**Test 3 / End semester examination**
1.	Remember	20	20	20
2.	Understand	50	50	50
3.	Apply	30	30	30
4.	Analyse	0	0	0
5.	Evaluate	0	0	0
6.	create	0	0	0

Course level learning objectives

Remember

1. Define 'Alkali aggregate reaction'.
2. Write short notes on 'accelerators'.
3. What is transition zone?
4. What causes segregation in concrete?
5. Mention the various methods of designing concrete mix.
6. Define self compacting concrete.
7. Differentiate HSC and HPC.
8. How will you control freezing and thawing effect on concrete?
9. List the different types of fibres used in concrete.
10. What is polymer concrete?

Understand

1. Explain different types of vibrators used for compaction of concrete.
2. What is high strength concrete? Explain the methods of making high strength concrete.
3. List different types of cement? Explain any three types of cement and its uses.
4. How will you determine compressive and tensile strength of concrete? Explain each test with neat sketch.
5. Enumerate different methods of curing and explain any two types of curing elaborately.

Apply

1. Identify the admixture which can be used to control freezing and thawing effect and also state the influence of admixtures in concrete.
2. Design a concrete mix M40 by IS method for the following details

   Specified 28-day works cube strength = 40 MPa

   Very good degree of control; control factor = 0.85

   Degree of workability = very low

   Type of cement = ordinary Portland cement

   Type of coarse aggregate = crushed granite (angular) of maximum size 20mm.

   Type of fine aggregate = natural sand

   Specific gravity of sand = 2.56

   Specific gravity of cement = 3.11

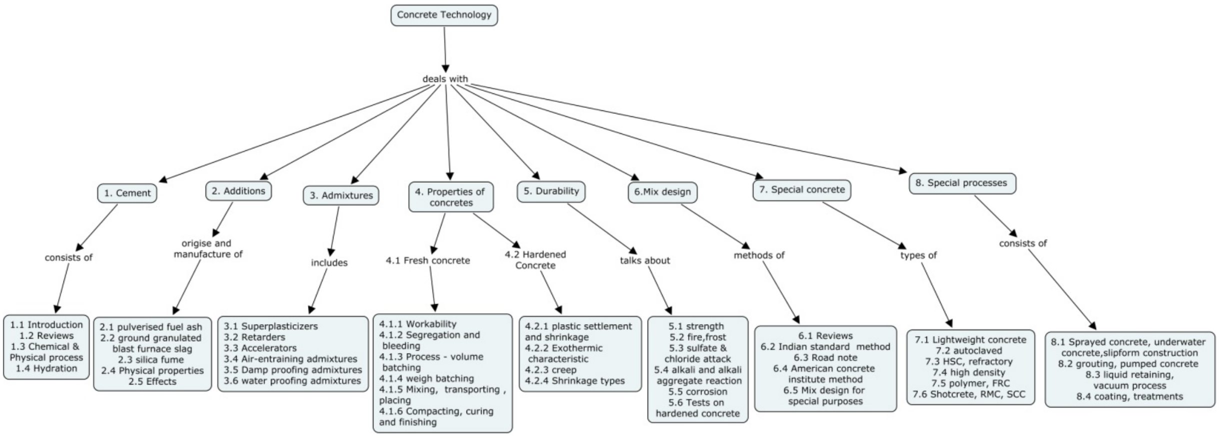
   Specific gravity of coarse aggregates = 2.79

3. Design a concrete mix M40 for the following details
   Specified 28-day works cube strength = 20 MPa
   Very good degree of control; control factor = 0.95
   Degree of workability = high
   Type of cement = OPC 43
   Type of coarse aggregate = crushed of size 20mm.
   Specific gravity of sand = 2.41
   Specific gravity of cement = 3.01
   Specific gravity of coarse aggregates = 2.75
   Fine and coarse aggregates contain 5 and 1 percent moisture respectively and have grading characteristics as detailed as follows:

IS sieve size	**Percentage Passing**	
	Coarse aggregate	**Fine aggregate**
20mm	100	-
10mm	96	100
4.75mm	8	92
2.36mm	-	78
1.18mm	-	61
600 micron	-	45
300 micron		18
150 micron	-	0

4. How chemical attacks are affecting concrete? Explain the methods of controlling various chemical attacks.

Concept Map



Course content and Lecture schedule

S.No	Topics	No. of lectures
1.0	**Cement**	
1.1	Introduction- manufacturing process	1
1.2	Review of cements including blended cements,	1
1.3	chemical composition, chemical and physical processes of hydration	1
1.4	water requirement for hydration	1
2.0	**Additive to Concrete**	
2.1	Origins and manufacture of pulverised fuel ash in concrete	1
2.2	Origins and manufacture of ground granulated blast furnace slag	1
2.3	Origins and manufacture of silica fume	1
2.4	Physical process of hydration and interaction	1
2.5	Effect of waste materials in concrete	1
3.0	**Admixtures**	
3.1	Introduction – effect of admixtures in concrete	1
3.2	Superplasticizers	1
3.3	Factors affecting workability, site problems	1
3.4	Retarders	1
3.5	Accelerators	1
3.6	Air-entraining admixtures, types and uses	1
3.7	Damp proofing admixtures	1
3.8	water proofing admixtures	1

4.0	**Properties of Fresh and hardened concrete**	
4.1	**Properties of Fresh concrete**	
4.1.1	Workability- Measurements and factors affecting workability	1
4.1.2	Segregation and bleeding effect of concrete	1
4.2	**Preparation and Properties of hardened concrete**	
4.2.1	Volume batching, weigh batching, mixing, transporting	2
4.2.2	Placing, compacting, curing and finishing	2
4.2.3	Plastic settlement and plastic shrinkage of hardened concrete	1
4.2.4	Exothermic characteristics, deformation under load, Elastic properties	1
4.2.5	Creep- measurements and effects	1
4.2.6	Shrinkage – types and other volume changes	1
5.0	**Durability of concrete**	
5.1	Strength and durability relationships	1
5.2	Fire resistance; frost damage	1
5.3	Sulfate attack & chloride attack	1
5.4	Alkali silica reaction, alkali aggregate reaction	1
5.5	Corrosion of steel & corrosion control methods	1
5.6	Tests on hardened concrete- compressive strength	1
5.7	Split tensile strength and flexural strength.	1
6.0	**Mix design**	
6.1	Review of methods and philosophies	1
6.2	Indian standard method,	1
6.3	Road note number 4 method (DOE method)	1
6.4	American concrete institute method	1
6.5	Mix design for special purposes	1
7.0	**Special concrete**	
7.1	Lightweight concrete: natural and artificial	1
7.2	autoclaved aerated concrete, no-fines concrete	1
7.3	High strength concrete; refractory concrete	1
7.4	high density and radiation-shielding concrete;	1
7.5	polymer concrete; fibre-reinforced concrete;	1
7.6	Shotcrete, Readymix concrete, self compacting concrete.	1
7.7	Self healing concrete, Geo-polymer concrete, roller compacted	1

	concrete	
8.0	**Special processes and technology for particular types of structure**	
8.1	Sprayed concrete; underwater concrete; slipform construction	1
8.2	grouting and grouted concrete, mass concrete , pumped concrete	1
8.3	concrete for liquid retaining structures; vacuum process	1
8.4	concrete coatings and surface treatments	1
	Total	**50**

Syllabus

Cement- Introduction- manufacture, Review of cements including blended cements, chemical composition, chemical and physical processes of hydration and water requirement for hydration. **Additives -** Review of types, pulverised fuel ash, ground granulated blast furnace slag, quarry sand and silica fume; origins and manufacture; chemical composition; physical characteristics; physical processes of hydration and interaction; effects on properties of concretes. **Admixtures** - Types of admixtures- Superplasticizers- factors affecting workability; site problems, Retarders, Accelerators, Air-entraining admixtures, damp proofing and water proofing admixtures - effects on properties of concretes. **Properties of Fresh and hardened concrete Fresh concrete -** Workability; Measurements, factors affecting workability Segregation and bleeding effect of concrete, Process of manufacture of concrete- volume and weigh batching. Mixing; transporting; placing; compacting; curing and finishing. **Hardened concrete -** Plastic settlement and plastic shrinkage; exothermic characteristics, deformation under load; elasticity; creep-measurement and effects; shrinkage- types and other volume changes. **Durability of concrete-** Durability of concrete- strength and durability relationships- fire resistance; frost damage; sulfate attack; chloride attack; alkali silica reaction; alkali aggregate reaction; corrosion of steel; corrosion control methods; tests on hardened concrete-compressive strength, split tensile strength and flexural strength. **Mix design**- Review of methods and philosophies; IS method, Road note method, ACI method; mix design for special purposes. **Special concrete -** Lightweight concrete: natural and artificial light weight aggregate concrete; autoclaved aerated concrete, no-fines concrete, High strength concrete; refractory concrete, high density and radiation-shielding concrete; polymer concrete; fibre-reinforced concrete; Shotcrete; Readymix concrete, self compacting concrete, self healing concrete, reactive powder concrete, roller compacted concrete and

Geo-polymer concrete. **Special processes and technology for particular types of structure -** Sprayed concrete; underwater concrete; grouts, grouting and grouted concrete; mass concrete; slip form construction; pumped concrete; concrete for liquid retaining structures; vacuum process; concrete coatings and surface treatments.

Reference Books

1. Nevile A.M., "Properties of concrete", 4th edition, Longman, 1995.
2. Gambhir, " Concrete Technology", TMH Publications, 1986.
3. Aitkens, " High Performance Concrete", McGraw Hill Book Co., 1999.
4. Shetty M.S., "Concrete Technology", S.Chand and company limited, 2004.
5. Mehta P.K, " Concrete ", 1990.
6. Santha Kumar A.R, " Concrete Technology", Oxford university Press, 2006.

IS Codes

1. IS: 10262-1982, recommended guidelines for Concrete Mix Design.
2. SP: 23-1982, Handbook on concrete mixes

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
JE	3	1	0	4

JE Industrial Structures **3:1**

Preamble

This course offers planning and functional requirement of industrial structures and design of criteria of single storeyed industrial structures. This also includes handling systems such as gantry and conveyor system etc. Design concepts of storage systems and environmental control structures are also dealt in detail.

Competencies

At the end of the course, the students will be able to

1. Plan the functional requirements of an industrial structure.
2. Design a single storey industrial roof truss using the IS800-2007 Provisions
3. Design the material handling system such as gantry girder, conveyor system etc.
4. Design a bunkers and silos
5. Design environmental control structures and chimneys etc.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test 3 / End Semester Examination**
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	30	30	30
4	Analyse	-	-	-
5	Evaluate	-	-	-
6	Create	50	50	50

Course level learning objectives

Remember

1. List the items that are to be considered while planning and designing and industrial building.
2. List the items to be considered while selecting a cladding system.
3. State the difference between a purlin and girt.
4. What is the economic range of spacing of a truss?
5. What is the main purpose of a gantry girder?
6. List a few types of cranes.

Understand

1. How is the spacing of purlins fixed?
2. Why is it necessary to provide connections that will allow movement in the supports of trusses?
3. Draw the different profiles of cross sections which are used for gantry girders.
4. What ate the possible ways to reinforce the compression flange of a I beam to resist the lateral loads.
5. State the difference between through fastened roofing and standing-seam roofing.
6. Is it necessary to provide bracings in a portal frame? Why?
7. When are bending moments to be considered in the design of the top chord of trusses?

Apply

1. A fink roof truss is proposed to be constructed at chennai. The pitch of the roof is ¼ and the span is 12m. The trusses are spaced at 4.5m c/c. use G.I sheeting. The height of the roof above the ground level is 10m. The configuration of the girder is given in figure-1. Assume that ISMC75@71.4kg/m is used as purlins and placed on the nodal point. Determine the dead, live and wind loads acting on the roof .

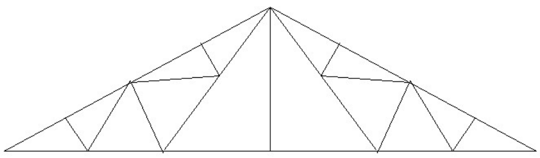


Figure-1

2. Check the adequacy of the channel ISMC125 @12.7kg/m as purlin for a rolled steel truss under dead load and live load combinations and use the following conditions

i.	Spacing of roof truss	-	4m
ii.	Spacing of purlin along the sloping length	-	1.65m
iii.	Pitch of the roof	-	¼ of the span
iv.	Weight of sheeting	-	0.129kN/m^2
v.	wind intensity normal to roof	-	1.2 kN/m^2

3. Determine the load carrying capacity the top chord member made of two angles of ISA 75x75x6mm of a rolled steel truss. The maximum factored compression and tension are 120kN and 90kN respectively. The unsupported length of the member is 1.3m

Create

1. Design a gantry girder for a mill building to carry an electric overhead traveling crane with the following data
   a. Centre to centre distance between columns - 6m
   b. Centre to centre distance between gantry girders - 12m
   c. Crane capacity - 50kN
   d. Self weight of crab alone - 10kN
   e. Self weight of crane - 40kN
   f. Allowable approach of crane hook from the vertical axis to the gantry girder is 1.0m
   g. Distance between centre of wheels moving on the gantry girder and supporting the crane girder is 3.0m
   h. Weight of rail section attached on the top of the gantry girder 0.1kN/m
2. A fink type tubular truss is proposed to be constructed at chennai. The pitch of the roof is 1/5 and the span is 20m. The trusses are spaced at 4.5m c/c. use G.I sheeting. The height of the roof above the ground level is 10m. The configuration of the girder is given in figure-1. Design a tubular purlin for the truss and also design the top and bottom chord of a tubular truss subjected a maximum factored load as given in table-1.

Table-1

MEMBER SPECIFICATION	UNSUPPORTED LENGTH OF THE MEMBER IN M	MAX. COMPRESSIVE FORCE IN KN	MAX. TENSILE FORCE IN KN
Top chord member	1.45	102.6	76.5
Bottom chord member			
a) Member having a length of 4.2m		40.5	41.78
b) Member having a length of 2.9m		87.73	70.43

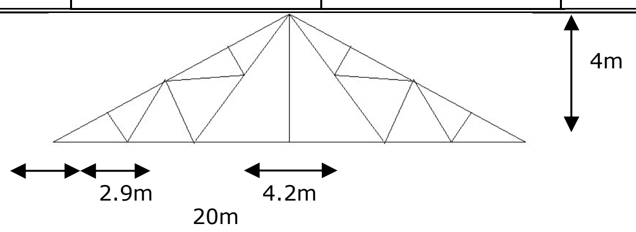
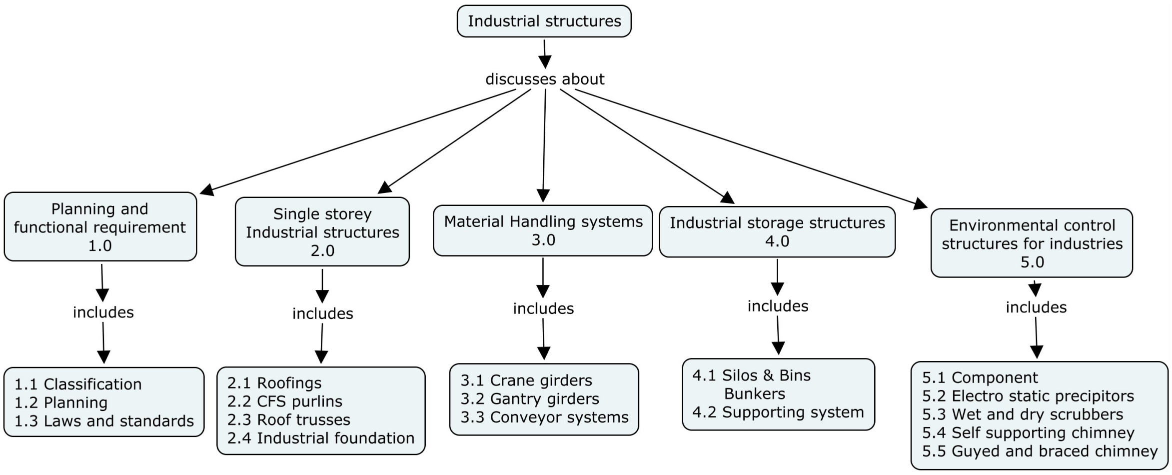


Figure-2

Concept Map



Course content and Lecture schedule

S.NO.	TOPICS	PERIODS
1.0	**Planning and Functional Requirements**	
1.1	Classification of Industries and Industrial Structures	1
1.2	Planning for layout requirements regarding lighting, ventilation and fire safety & protection against noise and vibration	3
1.3	Guidelines from factories act – material handling systems - structural loads.	3
2.0	**Single Storey Industrial Structures**	
2.1	Types of roofing and roofing sheets	2
2.2	Design of purlins – light gauge sections	4
2.3	Built-up sections for roof trusses – Design methodology of pre-engineered structures.	3
2.4	Foundations for industrial structures	1
3.0	**Material Handling Systems**	
3.1	Cranes – Types design of EOT over head travelling cranes,	2

	zib cranes etc.	
3.2	Design of Gantry girders for over head cranes	2
3.3	Conveyor systems – Supports for conveyor systems.	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 and bunkers	2
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	Design of Design of Self supporting Chimneys	2
5.5	Guyed and Braced chimneys	3
	Total	**45**

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 – material handling systems - structural loads. **Single Storey Industrial Structures:** Types of roofing – roofing sheets – purlins – light gauge sections – built-up sections – roof trusses – pre-engineered structures. Foundations for industrial structures **Material Handling Systems:** Cranes – Types design of EOT over head travelling cranes, zib cranes. Design of Gantry girders for over head cranes - Conveyor systems – Supports for conveyor systems **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 – Chimneys – Self supporting, Guyed and Braced chimneys.

References:

1. Alexander Newman, "Metal Building Systems – Design and Specifictions", second Edition Mc Graw Hill, NewDelhi, 2004.
2. Gaylord E H, Gaylord N C and Stallmeyer J E, "Design of Steel Structures", 3rd edition, McGraw Hill Publications, 1992.

3. National building code – 2005, BIS, New Delhi.
4. Teaching Resource for Structural Steel Design, Vol. 1,2,3 (2000), INSDAG- Institute for Steel Development and Growth, Kolkatta.
5. Subramanian, N., (2008), Design of Steel Structures, oxford university press, USA.

Indian Standard Codes

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

Course Designers

S.Arul Mary samciv@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
JF	3	1	-	4

JF Earthquake Engineering 3:1

Preamble

One of the major destructive forces that damage the Infra structure is earthquake. Therefore the structures in earthquake prone areas need to be designed to resist this unpredictable natural force. Earthquake-resistant design of structures has grown into a true multi disciplinary field of engineering wherein many exciting developments are possible in the near future. This subject introduces the concepts of seismic-resistant design and provides minimum standards for use in building design to maintain public safety in an extreme earthquake. Further methods of analysis and determinant internal forces in structural members due to earthquake the approximate design, detailing are introduced

Competencies: At the end of the course, the students will be able to

1. Describe the causes of seismicity in the world, both inter-plate and intra-plate.
2. Identify hazards to buildings caused by earthquakes.
3. Interpret response spectra presented in different formats, including the Acceleration-Displacement Response Spectrum (ADRS) diagram, and hence to quantify the potential ground motion hazards on the building.
4. Analyze the RCC structure using static and dynamic analysis
5. Understand the concepts of soil-structure interaction
6. Design the masonry structures according to seismic resistant design
7. Assess seismic performance of non-structural components, building contents and identify effective measures to mitigate potential damage.

Assessment Pattern

S.No	Bloom's category	Test 1	Test 2	Test 3 / End semester examination
1.	Remember	20	20	20
2.	Understand	20	20	20
3.	Apply	60	60	60
4.	Analyse	0	0	0
5.	Evaluate	0	0	0
6.	create	0	0	0

Course level learning objectives

Remember

1. Define centre of mass and Centre of rigidity.
2. What is meant by 'torsional effect' on buildings?
3. What is meant by Soil friction?
4. Write short notes on passive earth pressure.
5. Define modal mass and modal participation factor.
6. Differentiate foreshocks and aftershocks.
7. Define liquefaction.
8. Write short notes on soil-structure interaction
9. What are the types of bands normally used for masonry structures?
10. Define ductility.

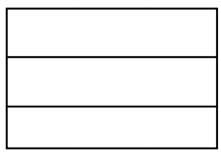
Understand

1. Explain the concepts and types of Response spectrum. Write step by step procedure of constructing response spectrum diagrams with neat sketch.
2. Explain the factors affecting ductility of RCC members.

Apply

1. An industrial multi-storeyed building 25m high is to be designed in Assam. Compute the a. Seismic force by static method b. modal mass and modal participation factors for the following details. (T=0.820)
   - Live load 250kg/m2
   - Beam size 25 x 35 mm
   - Column size 30 x 40mm
   - Slab thickness 18mm
   - Wall thickness 15mm

3 x 3@6.5m



5@25m

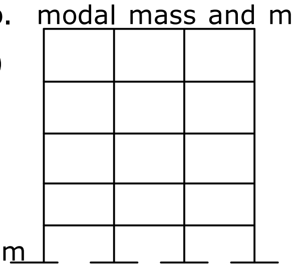


Fig.1.a PLAN fig.1.b ELEVATION

(or)

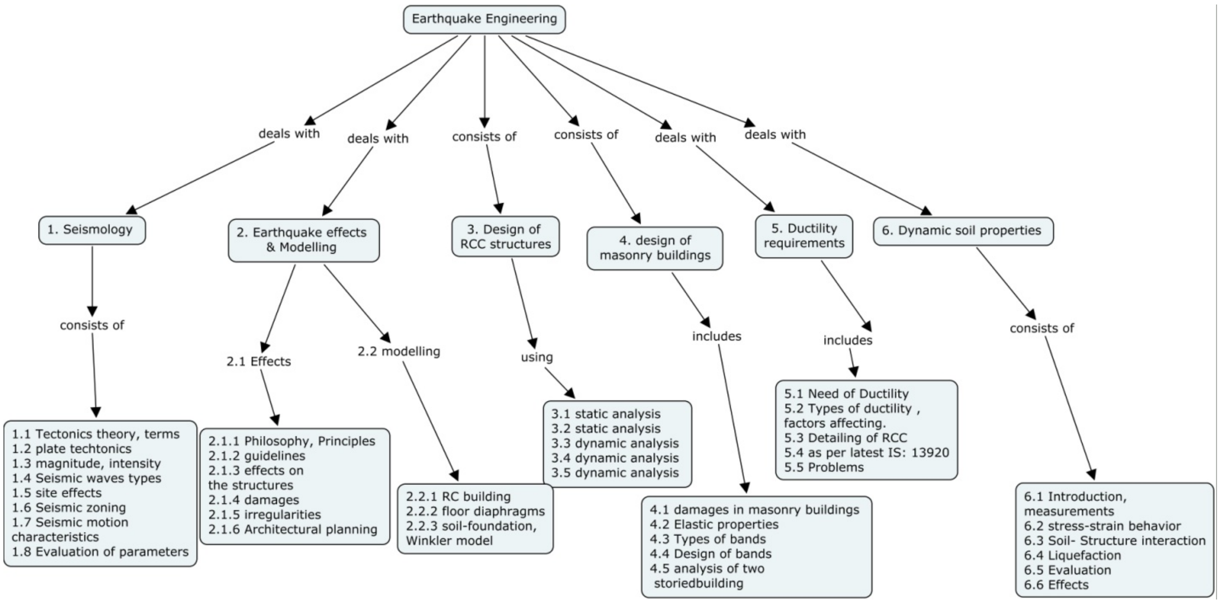
2. Design fig 1.a & 1.b by using Response spectrum method . The Free Vibration Properties of the building for vibration in the X-Direction is shown below

	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

3. Analyze 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.
4. 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.

Concept Map



Course content and Lecture schedule:

S.No	Topic	No.of Periods
1.0	**Introduction to Engineering Seismology**	1
1.1	Tectonics theory , basic terms in earthquake	1
1.2	Plate margins and earthquake occurrences	1
1.3	Earthquake magnitude, intensity of earthquake	1
1.4	Seismic waves , types of seismic waves	1
1.5	Local site effects due to earthquake, Seismic zoning map of India	1
1.6	Characteristics of strong motion	1
1.8	Evaluation of seismic design parameters.	1
2.0	**Earthquake effects & Modelling Of RCC**	
2.1	**Effect of Earthquakes**	
2.1.1	Philosophy, Principle of Earthquake Resistant Design	1
2.1.2	Guidelines for Earthquake Resistant Design	1
2.1.3	Earthquake effects on the structures, Effect of irregularities	1
2.1.4	Seismic damages during past earthquakes	1

2.1.6	Architectural planning on the performance of RC structures.	1
2.2	**Modeling of RCC structures**	
2.2.1	Mathematical modeling of multistoried RC buildings	1
2.2.2	Modeling of floor diaphragms, Soil-foundation model, Winkler model	1
3.0	**Design of RCC structures**	
3.1	Design of multi-story RC structure as per latest IS: 1893:2000 by Equivalent static method	1
3.2	Problems-static analysis	1
3.3	Design of multi-story RC structure as per latest IS: 1893:2000 by dynamic analysis method	1
3.4	Problems- Response spectrum method	1
3.5	Problems – Frame analysis-response spectrum method	1
3.6	Introduction to time-history method, Capacity based design	1
3.7	Soft story concept, Base isolation, types of dampers	1
3.8	Design of shear walls	1
4.0	**Earth quake resistant design of masonry buildings**	
4.1	Identification of damages in masonry buildings from past earthquakes	1
4.2	Elastic properties of structural masonry	1
4.3	Types of bands- Lintel band, Roof band, plinth band and gable band.	1
4.4	Design of lintel and roof bands	1
4.5	Lateral load analysis of two storied masonry building.	2
5.0	**DUCTILITY REQUIREMENTS**	
5.1	Need of Ductility requirements in RC buildings	1
5.2	Types of ductility , factors affecting ductility	1
5.3	Detailing of RCC structures	1
5.4	Ductile detailing as per latest IS: 13920:1993	1
5.5	Problems on ductility	1
6.0	**DYNAMIC SOIL PROPERTIES**	
6.1	Introduction- measurement of dynamic soil properties	1
6.2	Stress-strain behavior of cyclically loaded soils	1
6.3	Soil- Structure interaction. Local site conditions on ground	1

	motion.	
6.4	Liquefaction- initiation of liquefaction hazards,	1
6.5	Evaluation of liquefaction	1
6.6	Effects of liquefaction	1
	Total	**40**

Syllabus

SEISMOLOGY- Introduction to engineering Seismology – basic terms- plate tectonics theory- plate margins and earthquake occurrences - Earthquake magnitude, intensity of earthquake – Seismic waves –local site effects. Seismic zoning map of India – Characteristics of strong motion- evaluation of seismic design parameters. **EARTHQUAKE EFFECTS & MODELLING OF RCC-** Philosophy, Principle and guidelines for Earthquake Resistant Design, classification of loads, seismic design methods Earthquake effects on the structures, Seismic damages during past earthquakes and effect of irregularities and building architecture on the performance of RC structures. Mathematical modeling of multistoried RC buildings with modeling of floor diaphragms and soil-foundation, Winkler model.**DESIGN OF RCC STRUCTURES-** Design of multi-story RC structure as per latest IS: 1893:2000 by Equivalent static lateral load method and Response Spectrum Method. Introduction to Time history method. Capacity based design of soft story RC building, Base isolation, types of dampers, design of Shear Walls. **DESIGN OF MASONRY STRUCTURES-** Identification of damages in masonry buildings from past earthquakes, Elastic properties of structural masonry. Types of bands- Lintel band, Roof band, plinth band and gable band. Design of lintel and roof bands. Lateral load analysis and design of two storied masonry buildings.**DUCTILITY REQUIREMENT-** Ductility requirements in RC buildings, Types of ductility, factors affecting ductility. Ductile detailing as per latest IS:13920:1993. **DYNAMIC SOIL PROPERTIES-** Introduction- measurement of dynamic soil properties, stress-strain behavior of cyclically loaded soils, Soil- Structure interaction. Local site conditions on ground motion. Liquefaction- evaluation of liquefaction hazards, Initiation of liquefaction, effects of liquefaction.

Reference Books

1. Pankaj Agarwal, Manish Shrikhande , "Earthquake resistant design of structures", Prentice Hall, India, 2006.
2. James Ambrose and Demitry Vergun, "Earthquake retaining structures", John willey & sons 2001.

3. Hemant Kumar Sharma, & Giridharilal Agarwal, "Earthquake Resistant Building construction", Vedha publications New Delhi. 2001.
4. Polyahov S., "Design of Earthquake Resistant Structures", John willey & sons, 1993.
5. Green, "Earthquake Resistant Building Design", John willey & sons
6. Alan Williams, Ph.D. Williams Alan, "Siesmic Design of Buildings and Bridges: For Civil and Structural Engineers".
7. Website- www.nicee.org

IS Code:

1. IS: 13920:1993, "Code of Practice for ductile detailing of Reinforce Concrete-Structures subjected to Seismic forces",
2. IS 4326:1993 Code of Practice for "Earthquake Resistant Design and Construction of Buildings.
3. IS: 1893: 2000 – Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.
4. IS: 13828: 1993 – Improving Earthquake Resistance of Low Strength Masonry Buildings.
5. IS: 13827: 1993. - Improving Earthquake Resistance of Earthen Buildings,1993.

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JG	4	-	-	4

JG Repair and Rehabilitation of Structures 4:0
(Common to IMA)

Preamble:

To impart knowledge for understanding the properties of concrete, causes of its failure, effects and measures to repair and rehabilitate it.

Competencies: At the end of the course, the students will be able to:

1. Know the factors affecting the durability of concrete structures such as permeability, strength, suphate attack, fire resistance, action of sewage, thermal properties of concrete and resistance to freeze and thaw
2. Understand the causes and effects of distress in concrete structures namely; effect to climate, temperature, chemicals, wear and erosion, design and construction errors, corrosion mechanism, effects of cover thickness and cracking
3. Know the maintenance and repair strategies, diagnosis of distress of concrete structure
4. Understand the concept of quality assurance in structures, basic mechanisms by which quality assurance schemes may be developed and operated
5. Know the materials for repair namely; special concretes and mortars, special cements for accelerated strength gain, expansive cement, polymer concrete, sulphur infiltrated concrete, ferro-cement, FRC, self healing concrete, formed concrete, methods of corrosion protection- inhibitors, resisting steels, coatings, cathodic protection
6. Know the techniques of repair namely; rust eliminators and polymer coating for rebars, FRP, foamed concrete, mortar and dry pack, prepack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks
7. Know about case studies on distress concrete structures and type of treatment done

Assessment Pattern

S. No.	Bloom's Category	Test 1	Test 2	Test 3/ End -semester Examination
1.	Remember	20	20	20
2.	Understand	50	50	50
3.	Apply	30	30	30
4.	Analyze	0	0	0
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course Level Learning Objectives:

Remember:

1. Define the term permeability. List the factors affecting permeability of concrete
2. Mention two measures by which freeze & thaw resistance of concrete can be improved
3. Define the term quality assurance and mention its need
4. Name two NDT tests of assessing quality of concrete
5. What is meant by dry pack? Mention the situations of its use
6. What is meant by economical appraisal of structures? Write its need

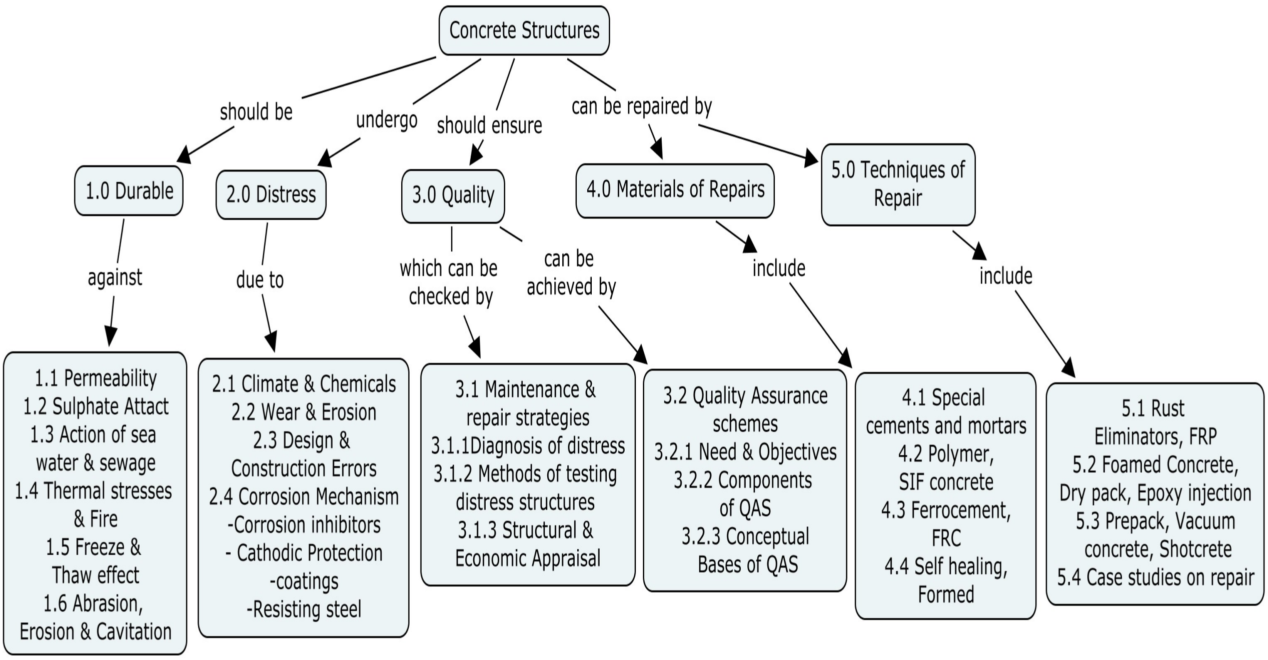
Understand:

1. Discuss the phenomenon of sulphate attack on concrete mentioning the methods to minimize the same
2. Discuss the mechanism of corrosion in rebars and discuss the influencing factors
3. By means of a flow chart discuss the method of diagnosing distress in concrete structures
4. Differentiate between the terms Repair, Rehabilitation and Retrofitting
5. Explain with a sketch the procedure of vacuum dewatering technique giving its applications
6. Discuss the various methods of corrosion protection of rebars

Apply:

1. What is the concreting technique you would recommend for a marine bridge pier construction? Justify and discuss its salient features
2. Is corrosion of rebars influenced by cover thickness? How? Mention the cover thickness to be provided for the following situations: Underwater concreting structure, Normal exposure concrete
3. Which special concrete you would recommend for a concrete structure to be constructed in freezing climatic conditions and why? Also discuss the properties of such a concrete
4. Which is the special concrete you would recommend for a concrete water tank and why? Discuss its features
5. How do you make concrete buried under polluted ground resistant to corrosion? Discuss the various methods
6. Discuss a method of strengthening of a concrete beam. Discuss the properties of the materials used in the strengthening method

Concept Map:



Course Content and Lecture Schedule:

S. No.	**Topic**	**No. of Lectures**
1.	**Durability of Concrete Structures**	
1.1	Permeability of concrete- factors influencing, methods of improving impermeable characteristics	2
1.2	Sulphate attack – influencing factors & methods of control	2
1.3	Durability of concrete in sea water- action of sewage – influencing factors	2
1.4	Thermal properties of concrete – fire resistance - factors influencing	2
1.5	Resistance to freezing and thawing- influencing factors	1
1.6	Resistance to abrasion, erosion and cavitation – influencing factors	1
2.	**Distress in concrete structures- causes, effects and remedial measures**	
2.1	Effects due to climate, temperature, chemicals - causes, effects and remedial measure	2
2.2	Wear and erosion- causes, effects and remedial measure	1
2.3	Design and construction errors –causes, effects and remedial measure	2
2.4	Corrosion mechanism, types of corrosion, effects of cover thickness and cracking- influencing factors. Methods of corrosion protection, inhibitors, resistant steels, coatings, cathodic protection	3
3.0	**Quality of Concrete Structures**	
3.1	**Maintenance and Repair Strategies**	
3.1.1	Inspection, types of maintenance, structural appraisal, economic appraisal Diagnosis of distress – Procedure	3
3.1.2	Methods of assessing the quality of concrete – NDT and DT tests	2
3.1.3	Structural Appraisal & Economic Appraisal	1
3.2	**Quality assurance**	
3.2.1	Need and Objectives- people benefited by QAS	2
3.2.2	Components, Conceptual bases of quality assurance schemes	2
3.2.3	Basic methods of development and operation of QAS	2
4.0	**Materials for Repair**	
4.1	Special concretes and mortars, special cements for accelerated strength gain, expansive cement – properties, methods of manufacture and applications	2
4.2	Polymer concrete, sulphur infiltrated concrete- properties, methods of	3

	manufacture and applications	
4.3	Ferro-cement, fibre reinforced concrete- properties, methods of manufacture and applications	2
4.4	Self healing concrete, formed concrete, Fibre reinforced Polymers - properties, methods of manufacture and applications	2
5.0	**Techniques of Repair**	
5.1	Rust eliminators and polymer coating for rebars during repair	2
5.2	Foamed concrete, mortar and dry pack, epoxy injection, mortar repair for cracks	2
5.3	Prepack, vacuum concrete, gunite and shotcrete – procedure and applications	3
5.4	Case studies on distress concrete structures and type of treatment done Forensic investigations – case studies	4
	Total Periods	**50**

Syllabus:

Durability of Concrete Structures - Permeability of concrete- Sulphate attack – methods of control – durability of concrete in sea water- action of sewage – thermal properties of concrete – fire resistance – resistance to freezing and thawing – resistance to abrasion, erosion and cavitation. **Distress in concrete structures- causes, effects and remedial measures**- effects due to climate, temperature, chemicals, wear and erosion, design and construction errors, corrosion mechanism, effects of cover thickness and cracking, methods of corrosion protection, inhibitors, resistant steels, coatings, cathodic protection. **Maintenance and Repair Strategies -** Inspection, structural appraisal, economic appraisal- Diagnosis of distress – Procedure. **Quality assurance** – need- components- conceptual bases of quality assurance schemes. **Materials for Repair –** Special concretes and mortars, special cements for accelerated strength gain, expansive cement, polymer concrete, sulphur infiltrated concrete, ferro-cement, fibre reinforced concrete, self healing concrete, formed concrete, Fibre reinforced Polymers. **Techniques of Repair –** Rust eliminators and polymer coating for rebars during repair, foamed concrete, mortar and dry pack, prepack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks – case studies on distress concrete structures and type of treatment done.

References:

1. Shetty. M.S., "Concrete Technology – Theory and Practice", S.Chand Company, New Delhi, 2010

2. Dension Campbell, Allen and Harold Roper, " Concrete Structures, Materials, Maintenance and Repair", Longman Scientific and Technical Publications, UK, 1991'
3. Gambhir. M.L. " Concrete Technology", Tata McGraw Hill Publishing Co., New Delhi, 1998.
4. ACCE(I), Madurai Centre, "Workshop on cracks, corrosion and leaks", July 2003
5. Allen R.T. and Edwards. S.C., "Repairs of Concrete Structures", Blakie and Sons, UK, 1997.
6. Raikar R.N., " Learning from failures", Structwel Designers & Consultants, New Delhi, 1987.
7. Lecture notes on "Workshop on Repairs & Rehabilitation of Structures", Organized by Dept. of Civil Engg., Anna University, Chennai 29-30 October, 1999

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JH	4	-	-	4

JH Disaster Mitigation and Management 4:0

(Common to IMF)

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.

Competencies: At the end of the course the student will be able to

1. 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.
2. To identify the potential deficiencies of existing buildings for Earthquake disaster and suggest suitable remedial measures.
3. Derive the guide lines for the precautionary measures and rehabilitation measures for Earthquake disaster.
4. Derive the protection measures against floods, cyclone, land slides
5. Understand the effects of disasters on built structures
6. Understand the hazard Assessment procedure

Assessment Pattern:

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End semester Examination
1	Remember	20	20	20
2	Understand	80	60	60
3	Apply	0	20	20
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember:

1. What is Richter Magnitude?
2. What is Peak ground Acceleration?
3. What is meant by *hazard mitigation*?
4. What is a Local Hazard Mitigation Plan?
5. List the different types of droughts and highlight its various causes.
6. Define community Contingency Plan

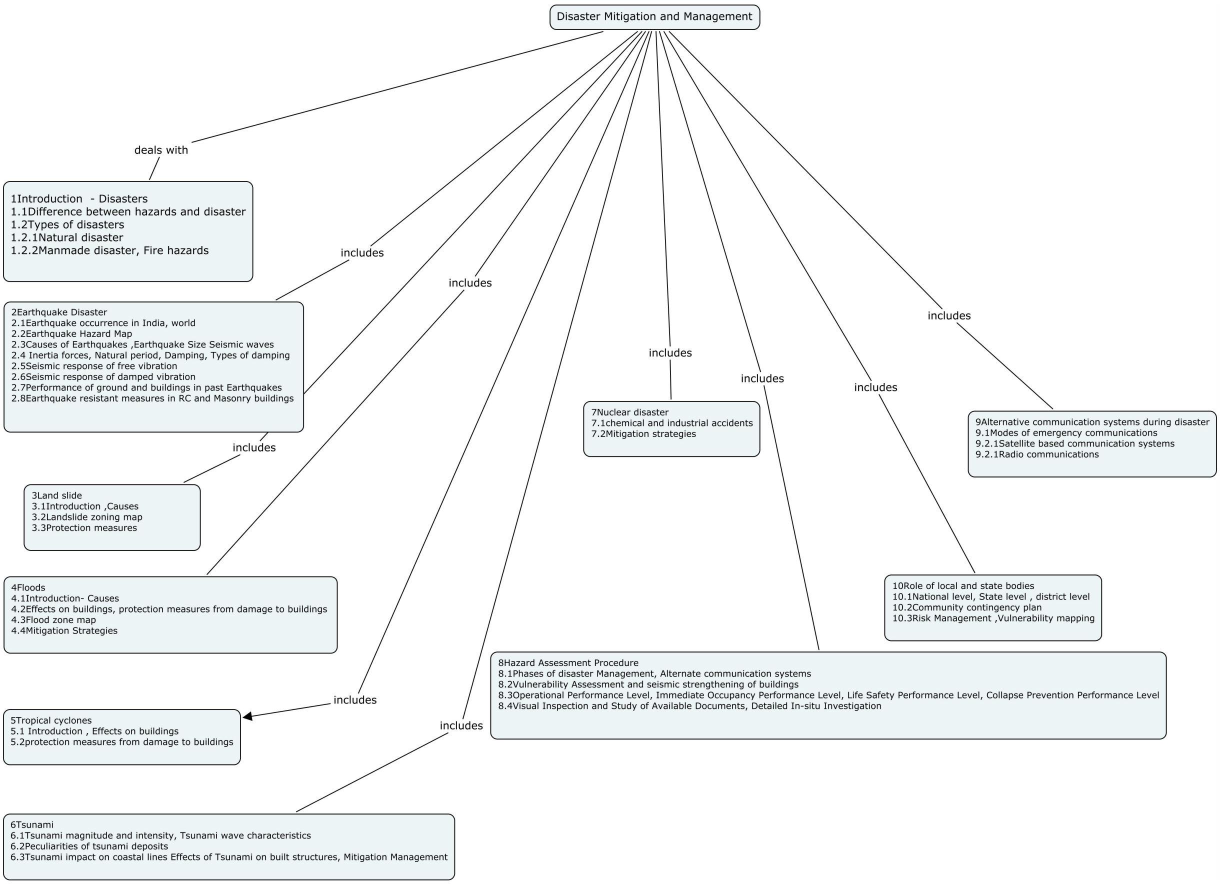
Understand:

1. How does the site soil affect the EQ response of structures?
2. Explain the classification and causes of landslides indicating the places where they could occur in India.
3. Explain the plan, Mass and Geometric irregularities in the RC buildings. How these irregularities adversely affect the performance of the RC buildings during Earthquake
4. Discuss the various types of natural disasters and highlight the specific efforts to mitigate disasters in India
5. Describe various types of hazards and impacts associated with earthquakes and highlight the lessons learnt
6. Briefly explain the components of follow-up activities in psychological rehabilitation of disaster affected people.

Apply

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. Do you think disaster risk can be reduced through community participation? Discuss
4. 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
5. Explain the role of central Government in responding to disasters
6. Describe suitable mitigation and preparedness measures that the community should take in advance to guard a EQ disaster occurring again.

Concept Map



Course Content and Lecture Schedule

Sl No	Topics	Periods
1	**Introduction - Disasters**	
1.1	Difference between hazards and disaster	1
1.2	Types of disasters	1
1.2.1	Natural disaster	1
1.2.2	Manmade disaster, Fire hazards	1
2	**Earthquake Disaster**	
2.1	Earthquake occurrence in India, world	1
2.2	Earthquake Hazard Map	1
2.3	Causes of Earthquakes ,Earthquake Size Seismic waves	1
2.4	Inertia forces, Natural period, Damping, Types of damping	1

2.5	Seismic response of free vibration	1
2.6	Seismic response of damped vibration	1
2.7	Performance of ground and buildings in past Earthquakes	1
2.8	Earthquake resistant measures in RC and Masonry buildings	1
3	**Land slide**	
3.1	Introduction ,Causes	1
3.2	Landslide zoning map	1
3.3	Protection measures	1
4	**Floods**	
4.1	Introduction- Causes	1
4.2	Effects on buildings, protection measures from damage to buildings	1
4.3	Flood zone map	1
4.4	Mitigation Strategies	1
5	**Tropical cyclones**	
5.1	Introduction , Effects on buildings	1
5.2	protection measures from damage to buildings	2
6	**Tsunami**	
6.1	Tsunami magnitude and intensity, Tsunami wave	1
6.2	Peculiarities of tsunami deposits	2
6.3	Tsunami impact on coastal lines Effects of Tsunami on built structures, Mitigation Management	2
7	**Nuclear disaster**	
7.1	chemical and industrial accidents	2
7.2	Mitigation strategies	1
8	**Hazard Assessment Procedure**	
8.1	Phases of disaster Management, Alternate communication systems	1
8.2	Vulnerability Assessment and seismic strengthening of	1

8.3	Operational Performance Level, Immediate Occupancy Performance Level, Life Safety Performance Level, Collapse Prevention Performance Level	2
8.4	Visual Inspection and Study of Available Documents, Detailed In-situ Investigation	1
9	**Alternative communication systems during disaster**	
9.1	Modes of emergency communications	1
9.2.1	Satellite based communication systems	1
9.2.1	Radio communications	1
10	**Role of local and state bodies**	1
10.1	National level, State level , district level	1
10.2	Community contingency plan	1
10.3	Risk Management ,Vulnerability mapping	1
	Total	**50**

Syllabus

Introduction -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 hazards **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 **Landslides –** 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 – Mitigation Management **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- **Alternative communication systems during disaster-** Modes of emergency communications-Satellite based communication systems -Radio communications **Role of local and state bodies** Natioanal level,State level , district level -Community contingency plan –Risk Management - Vulnerabilty mapping.

Reference Books:

1. Ray.N.Glough, Joseph Penzein, (1996), "Dynamics of Structures", McGraw Hill International Ltd.
2. Jaikrishna & A.R.Chandrasekaran, (1996) "Elements of Earthquake Engineering",Sarita Prakashan, Meerut.
3. Berg.GV (1982), "Seismic Design codes and procedures", EERI, CA.
4. Booth, Edmund (1994), "Concrete Structures in earthquake regions; Design and Analysis", Longman.
5. Dowrick. D.J (1987), "Earthquake resistant design for Engineers and Architects",John Wiley & Sons, Second Edition.
6. G.K. Ghosh (1993) "Disaster Management" A.P.H. Publishing Corporation, New Delhi
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8. Ayaz Ahmad(1990) Disaster Management: Through the New Millennium By Anmol Publications, New Delhi
9. Goel, S. L. (1991) "Encyclopaedia of Disaster Management" Deep & Deep Publications Pvt Ltd, New Delhi

IS Codes:

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 Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
JJ	4	-	-	4

JJ Shell Structures **4:0**

Preamble

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.

Competencies: At the end of the course, the students will be able to

1. State the basis of the analysis of shell structures.
2. Understand the structural behaviour of shell under different loading conditions and the analysis techniques.
3. Understand the analytical solution for various types of shells using different methods.
4. Determine the deflection, moment and stress in shells.
5. Analyse the strength, stability and vibrations of different types of technically important shell structures.
6. Understand the concepts of design.
7. Prepare fabrication sketches of the designed components of shell structures.

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	64	64	64
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	16	16	16

Course level learning objectives

Remember

1. Define the term: Shells of translation
2. Draw the view of North light shell.

3. Give the codal provision of depth of shells.
4. Write the IS specification for minimum reinforcement as per IS specifications.
5. Define the terms long and short shells as per codal provisions.

Understand

1. What do you mean by shell?
2. What are the loads acting on the shell roof structures?
3. Discuss the limitations of the membrane theory of shells.
4. Differentiate between membrane shells and flexible shells.
5. What are funicular shells?

Apply

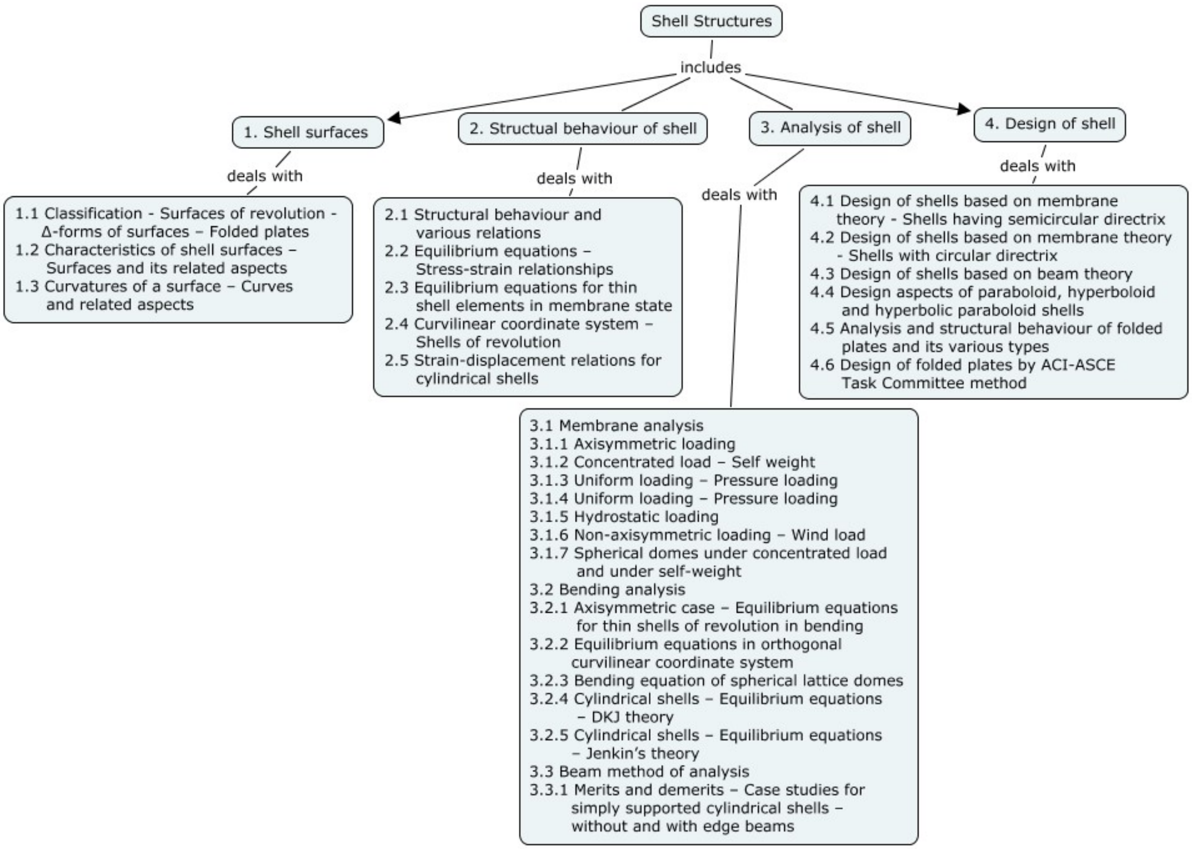
1. Derive the second fundamental magnitudes and hence expressions for curvature for shells of revolution.
2. Derive the equations of equilibrium of a shell element.
3. Determine the stress resultants in a spherical dome subjected to a uniformly distributed load over the plan of the shell.
4. Analyse a spherical dome supporting a light skylight structure or lantern and subjected to its own weight.
5. Derive the equations of equilibrium for cylindrical shells in terms of displacement components u, v and w.
6. Derive the governing equations for a cylindrical shell subjected to axially symmetric loads.
7. 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.
8. A hinged immovable shell of subjected to its own weight. Analyse the shell.
9. Explain the beam theory of analysis of shell with neat sketches.

Create

1. A circular cylindrical 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. 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.

3. 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 materals.

Concept Map



Course content 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	1
1.3	Curvatures of a surface – Curves and related aspects	1
2.	**Structural behaviour of shell**	
2.1	Structural behaviour and various relations	2
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	2
3.	**Analysis of shells**	
3.1	**Membrane analysis**	
3.1.1	Axisymmetric loading	2
3.1.2	Concentrated load – Self weight	2
3.1.3	Uniform loading – Pressure loading	2
3.1.4	Hydrostatic loading	2
3.1.5	Non-axisymmetric loading – Wind load	2
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	2
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	2

4.6	Design of folded plates by ACI-ASCE Task Committee method	2
	Total periods	**50**

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. G.S. Ramasamy, "Design and Construction of Concrete shell roofs," McGraw hill Book Company, New York, 2002.
2. S. Timoshenko and S.W. Kruger, "Theory of Plates and Shells," McGraw Hill Book Company, New York, 2008.
3. ASCE Manual of Engineering Practice No.3, "Design of Cylindrical concrete shell roofs," ASCE, New York, 1952.
4. Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.
5. B.K. Chatterjee, "Theory and Design of concrete shells," Oxford IBH, India, 1990.
6. Arthur. W. Leissa, "Vibration of Shells," Acoustical Society of America Publications on Acoustics, USA, 1993.

7. E. Ventsel and T. Krauthammer, "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001
8. J.N. Reddy, "Theory and Analysis of Elastic Plates and Shells", McGraw Hill Book Company, 2006.

IS codes

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 Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JK	3	1	-	4

JK Structural Optimization **3:1**

Preamble

Structural Design is an iterative process. Iterative implies analyzing several trial designs one after another until an acceptable design is obtained. In structural optimization process, the trial design is analyzed to determine if it is not just acceptable but the best design. Structural design can be formulated as problems of optimization in which a measure of performance is to be optimized while satisfying all constraints. This course covers concepts, fundamental principles, and basic techniques of structural design optimization.

Competencies: At the end of the course, the students will be able to:

1. Understand the elements of structural optimization problems.
2. Formulate problems mathematically using the concept of Linear Programming (LP)
3. Solve LP problems by graphical method, and identify special cases in obtained solution
4. Solve LP problems by Simplex method and Artificial variable techniques, and identify special cases in the solutions and Understand the concept of duality
5. Apply Non-Linear Programming methods in design optimization problems.
6. Understand optimization using Genetic Algorithms.
7. Understand application of ANN in Structural optimization.

Assessment Pattern

S. No.	**Bloom's Category**	**Test 1**	**Test 2**	**End -semester Examination**
1.	Remember	20	20	20
2.	Understand	20	20	20
3.	Apply	60	60	60
4.	Analyze	0	0	0
5.	Evaluation	0	0	0
6.	Create	0	0	0

Course Level Learning Objectives:

Remember:

1. What is the purpose of Slack variables in Simplex method?

2. Write the standard form of a LPP
3. What is meant by a system? Give examples
4. Define the term optimization with examples
5. What is Sensitivity Analysis?
6. List few Selection procedures in GA.
7. What is an evolutionary algorithm?

Understand:

1. Discuss the elements of optimization problem.
2. Explain Kuhn Tucker necessary conditions.
3. Discuss the special cases in Simplex method of solution of LPP
4. List the various criteria in which decision making can be done
5. Explain in detail about Reproduction, Crossover, Mutation in GA.
6. Explain Artificial Neural Networks using an Application.

Apply:

1. Design a circular tank closed at both ends to have a volume of $250m^3$. The fabrication cost is proportional to the surface area of the sheet metal and is Rs.$400/m^2$. The tank is to be housed in a shed with a sloping roof. Therefore, height *H* of the tank is limited by the relation $H \leq 10 - D/2$, where *D* is the diameter of the tank. Formulate the minimum cost design problem. Use Graphical method.

2. Solve the following LPP by 2–phase technique.
   Minimize $Z = -3X_1+X_2$
   Subject to: $2X_1 + X_2 \geq 2$; $X_1 + 3X_2 \leq 2$; $X_2 \leq 4$; & $X_1, X_2 \geq 0$.
3. Using Simplex Method

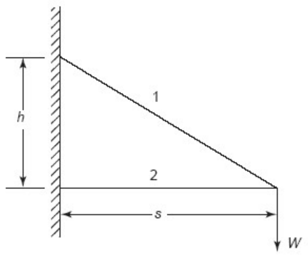
   Maximize $Z= X_1+2X_2-X_3$
   Subject to: $2X_1+X_2+X_3 \leq 14$, $4X_1+2X_2+3X_3 \leq 28$, $2X_1+5X_2+5X_3 \leq 30$,
   $X_1 \geq 0$; $X_2 \geq 0$; X_3 is unrestricted in sign

4. The problem of minimum weight design of the symmetric three-bar truss is formulated as follows: minimize $f(x_1, x_2) = 2x_1 + x_2$ subject to the constraints,
   $g_1 = (Pu/x_1)+Pv/(x_1+0.4x_2)-20000 \leq 0$
   $g_2 = 0.4Pv/(x_1+0.4x_2)-20000 \leq 0$
   $g_3 = -x_1 \leq 0$; $g_4 = -x_2 \leq 0$

where x_1 is the cross-sectional area of members 1 and 3 (symmetric structure) and x_2 is the cross-sectional area of member 2, $Pu = P \cos\theta$, $Pv = P \sin\theta$ .Consider the case of Kuhn Tucker conditions with g_1 as the only active constraint. Solve the conditions for optimum solution and determine the range for the load angle θ for which the solution is valid.

5. A beam of rectangular cross section is subjected to a maximum bending moment of M and a maximum shear of V. The allowable bending and shearing stresses are σ_a and τ_a, respectively. It is also desired that the depth of the beam shall not exceed twice its width. Formulate the design problem for minimum cross-sectional area using the following data: M = 140kNm, V =24 kN, σ_a = 165 MPa, τ_a = 50MPa.

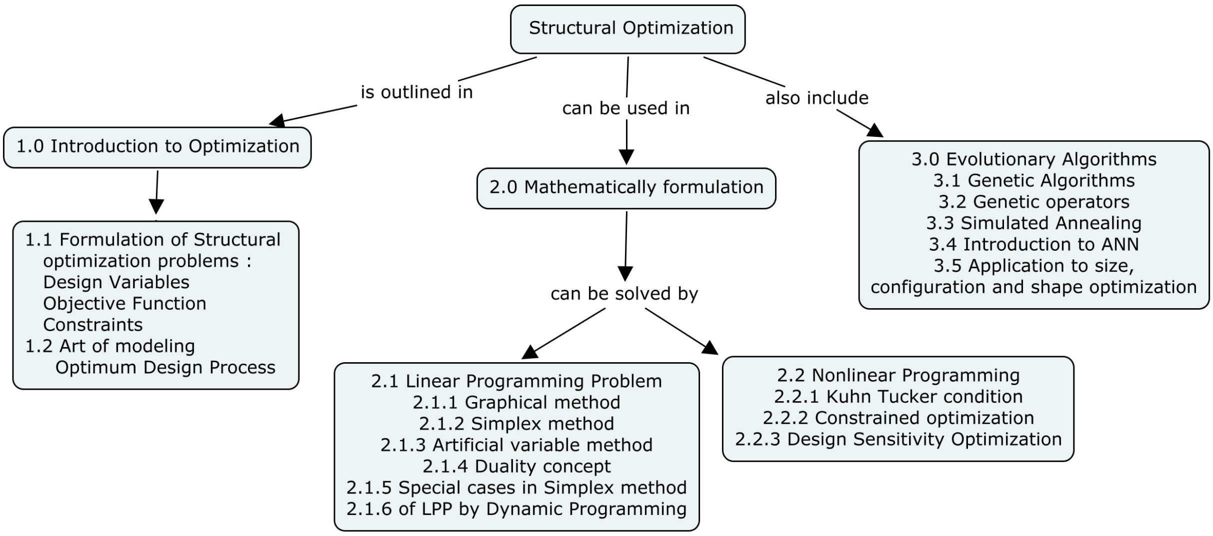
6. The wall bracket shown in Figure - 1 is to be designed to support a load of W = 1.2MN. The material for the bracket should not fail under the action of forces in the bars. Apply Kuhn Tucker necessary conditions. These are expressed as the following stress constraints: $\sigma_1 \leq \sigma_a$; $\sigma_2 \leq \sigma_a$



h = 30cm, s = 40cm, and W = 1.2MN.

Figure 1

Concept Map



Course Content and Lecture Schedule:

No.	Topic	No. of Lectures
1.0	**Introduction to Optimization**	
1.1	Formulation of Structural optimization problems : Design Variables – Objective Function - Constraints	3
1.2	Art of modeling – Optimum Design Process	2
2.0	**Mathematical Formulation**	
2.1	**Linear Programming Problem-** Definition and properties of Linear Programming Problem, Standard form	2
2.1.1	Graphical solution of two variable problems- Special cases	2
2.1.2	Simplex method - computational procedure & Problems	2
2.1.3	Artificial variable Technique– M technique- procedure & problems	2
2.1.3	Artificial variable Technique -Two phase technique- procedure & problems	2
2.1.4	Duality concept- Primal & dual properties, Conversion of primal to dual problems	2
2.1.5	Special cases in Simplex method – Degeneracy, Alternative optima, Un-bonded solution, infeasible solution	2

2.1.6	Solution of Linear Programming Problem by Dynamic Programming – problems	2
2.2	**Non linear programming**	
2.2.1	Non linear programming – Kuhn Tucker Condition - Linearization techniques	2
2.2.2	Single variable search – Multivariable search - Constrained optimization	3
2.2.3	Design Sensitivity optimization of steel and concrete structures	3
3.0	**Evolutionary Algorithms**	
3.1	Genetic Algorithms – comparison with traditional methods	2
3.2	Genetic operators – Simple Genetic Algorithm	3
3.4	Simulated Annealing	2
3.5	Introduction to Artificial Neural Networks	2
3.6	Applications to Size, configuration and Shape Optimization	2
	Total Periods	**40**

Syllabus:

Introduction to Optimization: Formulation of Structural optimization problems : Design Variables – Objective Function - Constraints **-** Art of modeling – Optimum Design Process. **Mathematical Formulation: Linear Programming Problem:** Definition and properties of Linear Programming Problem, Standard form- Graphical solution of two variable problems, special cases. Simplex method - computational procedure & problems. Artificial variables - Big M and two phase Techniques, Special cases in Simplex method. Solution of Linear Programming Problem by Dynamic Programming – problems**. Linear Programming Applications:** Duality concept, primal & dual properties - **Non linear programming** – Non linear programming - Kuhn Tucker condition – linearization techniques – Single variable search – multivariable search – constrained optimization. Design Sensitivity optimization of steel and concrete structures**. Evolutionary Algorithms:** Genetic Algorithms – comparison with traditional methods - Genetic operators – Simple Genetic Algorithm - Simulated Annealing - Introduction to Artificial Neural Networks - Applications to Size, configuration and Shape Optimization

References:

1. S.S. Rao, "Optimization- Theory and Applications", New Age International (P) Ltd., Publishers 2001

2. J.S.Arora, "Introduction to Optimum Design", Second Edition, Elsevier Academic Press, 2004

3. Raphael T.Haftzka, "Elements of Structural Optimization", KluwerPublications

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
JL	4	-	-	4

JL Theory of Plates **4:0**

Preamble

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 like structures in engineering.

Competencies: At the end of the course, the students will be able to

1. State the basis of the analysis of plate like structures.
2. Understand the behaviour of thin plates under different loading conditions and the analysis techniques including analysis for large deflection of plates.
3. Understand the analytical solution for various sizes of plates using classical methods.
4. Determine the deflection, moment and stress in plates.
5. Understand the concepts of design.
6. Prepare fabrication sketches of the designed components of plate like structures.

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	80	80	80
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Write the relationship between bending moments and curvature in pure bending of plates.
2. Give the expressions for the slope and curvature of slightly bent rectangular plates.
3. List various numerical methods for analysis of plates.
4. Give the general expression for deflection of fixed supported circular plate subjected to uniformly distributed load.
5. Write the equation for M_r for a circular plate with loading q (r, θ) in terms of deflection.

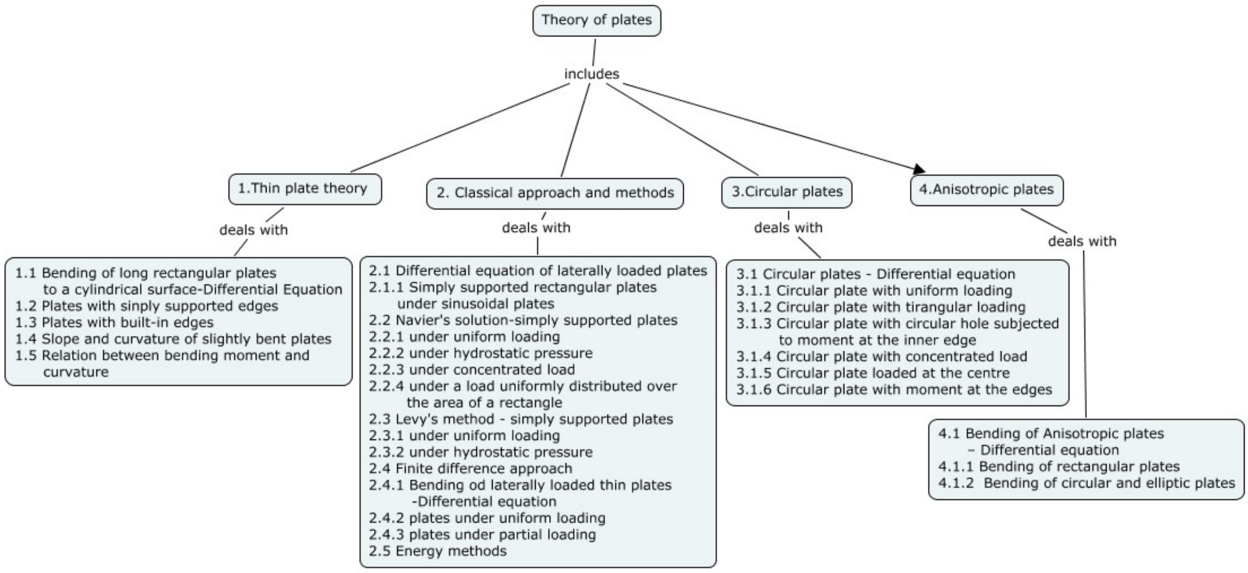
Understand

1. What are the basic assumptions made in the theory of thin plates with small deflections?
2. What are the conditions to be satisfied for applying Levy's method?
3. What are the advantages of finite difference method over classical methods?
4. State the basic difference between Navier's solution and Levy's method.
5. What are the relationships between Cartesian and Polar coordinates in the circular plates?

Apply

1. A square plate of size 6m x 6m is clamped along the opposite edges and simply supported at the other edges. The plate supports a UDL of $60kN/m^2$. Thickness of plate = 40mm; μ = 0.25; E = $2x10^5$ N/mm^2. Using a grid interval of h = a/4, estimate the maximum deflection in the plate.
2. Analyse the cylindrical bending of simply supported and uniformly loaded rectangular plate and determine the maximum deflection.
3. Derive the governing differential equation for the laterally loaded plates by considering the twisting moments and shear in addition to the moments.
4. Analyse a simply supported rectangular plate subjected to uniformly distributed load of P find the expression for deflection and also find the maximum deflection. Apply Navier's solution method.
5. Derive the governing differential equation for symmetrical bending of laterally loaded circular plates.
6. Determine the maximum deflection and maximum bending moment for a clamped circular plate of radius 'a' subjected to uniform loading of intensity 'P'.
7. 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.
8. Analyse a simply supported and uniformly loaded rectangular plate of size a x 2a find the expression for deflection and also find maximum deflection. Apply Navier's solution method.
9. A rectangular plate of size 2m x 4m is simply supported on all the four sides and supports a UDL of intensity $150kN/m^2$ over the right half of the plate. Estimate the deflections at the pivotal points of the plate assuming t = 40mm, Poisson's ratio μ = 0.25 and E = $2x10^5$ N/mm^2.
10. Analyse a simply supported rectangular plate subjected to uniformly varying load which varies from zero at one end to maximum 'P' at other end. Also find the expression for bending moment. Apply Navier's solution method.

Concept Map



Course content and Lecture schedule

S.No	TOPICS	PERIODS
1. Thin plate theory		
1.1	Cylindrical bending of long rectangular plates - Differential equation	2
1.1.1	Plates with simply supported edges	2
1.1.2	Plates with built-in edges	2
1.2	Slope and curvature of slightly bent plates	1
1.3	Relation between bending moment and curvature	1
2. Classical approach and methods		
2.1	Small deflections of laterally loaded plates – Differential equation	2
2.1.1	Simply supported rectangular plates under sinusoidal loading	2
2.2	**Navier's solution**	
2.2.1	Simply supported rectangular plates under uniform loading	2
2.2.2	Simply supported rectangular plates under hydrostatic pressure	2
2.2.3	Simply supported rectangular plates under concentrated load	2

2.2.4	Simply supported rectangular plates under uniform loading over an area of a rectangle	2
2.3	**Levy's method**	
2.3.1	Simply supported rectangular plates under uniform loading	2
2.3.2	Simply supported rectangular plates under hydrostatic pressure	2
2.4	**Finite difference approach**	
2.4.1	Bending of laterally loaded thin plates – Differential equation	2
2.4.2	Simply supported and fixed square and rectangular plates under uniform loading	2
2.4.3	Simply supported and fixed square and rectangular plates under partial loading	2
2.4.4	Simply supported and fixed square and rectangular plates under triangular loading	2
2.4.5	Simply supported and fixed square and rectangular plates under trapezoidal loading	2
2.5	Energy methods - Principle of virtual work- Principle of minimum potential energy	2
3. circular plates		
3.1	Symmetrical bending of laterally loaded circular plates – Differential equation	2
3.1.1	circular plates with uniform loading	1
3.1.2	Circular plate with triangular loading	1
3.1.3	Circular plate with circular hole subjected to moment at the inner edge	1
3.1.4	Circular plate with concentrated load	1
3.1.5	Circular plate loaded at the centre	1
3.1.6	Circular plates with moments at the edges	1
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
	Total periods	**50**

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 - **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 - **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 - **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. S. Timoshenko and S. W. Kruger, "Theory of Plates and Shells," McGraw Hill Book Company, New York, 2008.
2. R. Szilard, "Theory and Analysis of Plates, Classical and Numerical methods" Prentice Hall, USA, 1975.
3. R. Szilard, "Theories and Application of Plate Analysis: Classical, Numerical and Engineering methods" Prentice Hall, USA, 2004
4. Ansel. C. Ugural, "Stresses in Plates and Shells," McGraw Hill Book Company, New York, 1999.
5. Ansel. C. Ugural, "Stresses in Beams, Plates and Shells," CRC Press, 2009.
6. N. K. Bairagi, "A text book of Plate Analysis," Khanna Publishers, New Delhi, 1996
7. E. Ventsel and T. Krauthammer, "Thin Plates and Shells: Theory, Analysis and applications," CRC Press, 2001

8. J.N. Reddy, "Theory and Analysis of Elastic Plates and Shells", McGraw Hill Book Company, 2006.
9. K. Chandrashekahara, "Theory of Plates," University Press (India) Ltd., Hyderabad, 2001.

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JM	3	1	-	4

JM FOUNDATION DESIGN 3:1

Preamble:

Construction of major bridges, ports, Industrial buildings, high rise and earthquake resistant structures require the use of special foundations like Sheet piles, Raft foundations, laterally loaded piles, Batter piles, Pile groups and Machine foundations. This course addresses the methods of analysis and design of such special foundations.

Competencies: At the end of the course the student will be able to,

1. Analyze cantilever and anchored sheet pile walls and determine their depth of embedment.
2. Determine allowable bearing capacity of Raft Foundations in cohesive and cohesionless soils.
3. Design Raft Foundation using conventional method.
4. Design Driven and Under reamed piles.
5. Estimate the lateral load resistance of single vertical pile.
6. Analyze Pile group and design pile caps.
7. Design Foundations for Rotary Machines and Machines producing impact loads.

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	80	80	80
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember:

1. What is the necessity for Sheet Pile walls?
2. Define Modulus of Subgrade reaction.
3. What is negative skin friction in piles?
4. Define efficiency of a pile group.
5. What are the different types of machine foundations?
6. Define resonance.

Understand:

1. Explain equivalent beam method of analysis of Anchored sheet piles.
2. Describe the procedure for Raft analysis using winkler model.
3. Explain the various types of mat foundations and the conditions in which they are adopted?
4. Explain Culmann method of analysis of batter piles.
5. Describe the method of computing settlement of end bearing and friction pile groups.
6. Describe the various methods of vibration isolation techniques.

Apply:

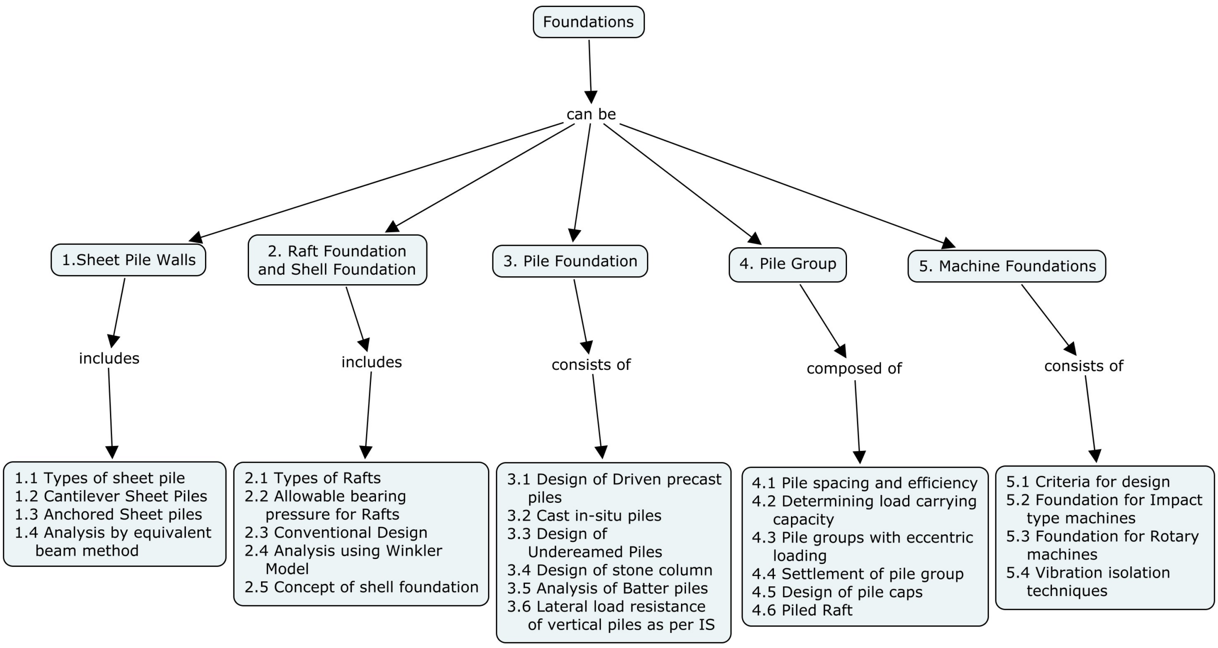
1. A cantilever sheet pile is penetrating a granular soil with the following properties: wet unit weight = 15.9 kN/m^3, saturated unit weight = 19.33 kN/m^3 and ø = 32^0. The height of the sheet pile above the dredge line is 5m and the water table is located at a depth of 2m below the top of the wall.
   (i) Determine the theoretical depth of embedment.
   (ii) Draw the net pressure distribution diagram.
2. Determine the safe bearing capacity of a raft in sand of unit weight 20 kN/m^3 with an average corrected SPT value of 18. Assume the depth of the foundation is 1.5m and the breadth is 6m. A maximum settlement of 40mm can be allowed for the raft. Assume water table level is 3m below the ground level.
3. A precast pile 300mm square in size is driven for a length of 10m at a site. Detail the reinforcement assuming that the full structural capacity in compression of the pile can be mobilized by the bearing stratum. Assume pile passes through clay with cohesion more than 10 kN/m^2.
4. Design the size and steel reinforcement for a bored cast in-situ pile of structural capacity 750 kN, using M30 concrete and Fe415 steel.
5. A 300mm square wooden pile is driven 5m below ground level in a preloaded clay. The load to be applied is 1m above the ground. Determine the ultimate load that can

be applied on the pile with M_u = 100 kNm. Assume K_h = 15 MN/ m^2 and cohesion of clay = 1 kg/cm^2.

6. Make a dynamic analysis of a hammer foundation with the following data:

   Weight of tup = 3.4t
   Weight of anvil = 75t
   Weight of foundation = 163.2t
   Weight of frame = 38.35t (assumed to be resting on foundation)
   Base provided = 7.1m x 4.7m
   Coefficient of rigidity of pad under anvil = 18.02 X 10^5 t/m
   Coefficient of rigidity of base of foundation = 3.8 x 10^3 t/ m^3
   Area of anvil = 8.32 m^2

Concept Map:



Course content and Lecture schedule:

No	Topic	No. of Lectures
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 - Fixed Earth Support Method	2
1.4	Equivalent Beam Method	2
2.	**RAFT AND SHELL 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	2
2.4	Mat Analysis using Winkler Model	1
2.5	Concept of Shell Foundation	2
3.	**PILE FOUNDATION**	
3.1	Structural design of Precast Piles	2
3.2	Design of cast in-situ piles	1
3.3	Design of Under reamed Pile Foundation	1
3.4	Design of Stone columns	2
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	2
4.	**PILE GROUP**	
4.1	Pile Spacing – Efficiency of Pile Group	2
4.2	Load Carrying Capacity	2
4.3	Pile Group subjected to eccentric Vertical Load	2
4.4	Settlement of Pile Group	1
4.5	Design of Pile Cap	2
4.6	Concept of Piled Raft	1
5.	**MACHINE FOUNDATION**	
5.1	Types of machine foundations	1
5.2	Design Criteria for Machine Foundations	1
5.3	Machine Foundation Subjected to Impact Loads - Rotary machines	2
5.4	Vibration Isolation Technique	1
	Total	**40**

Syllabus:

SHEET PILE WALLS: Types of Sheet Piles – Design principles of Cantilever Sheet Pile Wall - Anchored Sheet Pile wall - Fixed Earth Support Method – Equivalent Beam Method. **RAFT AND SHELL FOUNDATION:** Types of Raft Foundation – Allowable pressures for raft in cohesive and cohesionless soils - Conventional Design of Raft Foundation – Mat Analysis using Winkler Model – Concept of Shell Foundation. **PILE FOUNDATION:** Structural design of Precast Piles – Cast in-situ Piles - Design of Under reamed Pile Foundation – 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 – Efficiency of Pile Group – Load Carrying Capacity – Pile Group subjected to eccentric Vertical Load – Settlement of Pile Group – Design of Pile Cap - Concept of Piled Raft. **MACHINE FOUNDATION:** Types of machine foundations – Design Criteria for Machine Foundations - Machine Foundation Subjected to Impact Loads - Rotary machines – Vibration Isolation Technique.

Reference Books:

1. Varghese P.C. (2007), "Foundation Engineering", Prentice Hall of India Pvt., Ltd., New Delhi.
2. Bowles J.E. (1975), "Foundation Analysis & Design", Tata McGraw Hill, New Delhi,1984.
3. Das, B.M. (2007), "Principles of Foundation Engineering", Sixth Edition (India), Thomson.
4. Tomilinson M.J.(1975), "Foundation Engineering", ELBS London.
5. Purushothaman P. (1984), "Reinforced Concrete Structural Elements". Behaviour and Design, Tata McGraw Hill Co., Ltd., New Delhi.

IS Codes:

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 Precast Concrete Piles.
3. IS: 2911 Part3-1980 Code of practice for Design and construction of Pile foundation. Part III- Underreamed Piles.
4. IS:1892 – 1979, Code of practice for subsurface investigation for foundations
5. IS:2950 (Part I) – 1981, code of practice for Design and construction of raft foundation .

Course Designer:

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Sub Code	Lectures	Tutorial	Practical	Credit
JN	3	1	-	4

JN ENGINEERING FRACTURE MECHANICS 3:1

Preamble:

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

Competencies: At the end of the course the student will be able to

1. Understand the various theories of failures of structural materials with pre existing cracks
2. Understand the principles of Linear Elastic Fracture Mechanic and Elastic Plastic Fracture Mechanics
3. Analyse the LEFM and EPFM problems for the safe design of structures which contains pre existing cracks in micro as well as macro level in the materials used in engineering services.

Assessment Pattern:

S.No.	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3/End semester Examination**
1	Remember	10	10	10
2	Understand	30	30	30
3	Apply	60	60	60
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is fracture toughness of a material?

2. What are the modes of fracture?
3. Draw the standard test specimen for KIC testing
4. What is critical stress intensity factor?
5. What is j integral?
6. What is cracktip plastic zone?

Understand

1. Discuss the situation under which "K" approach becomes inapplicable.
2. Determine the energy release rate of DCB specimen through the change in strain energy approach for constant load.
3. Discuss elastic and Visco elastic behavior of steel and explain plastic deformation process of steel.
4. Draw a neat sketch of CT and SENB specimen as per ASTM Standard and explain the method of precracking in these specimens.
5. What are the requirements for the crack to advance by R curve concept?
6. Explain J integral and Crack growth Resistance curves for ductile and brittle materials
7. Why does the Compliance of the component increases with the growth of a crack?

Apply

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

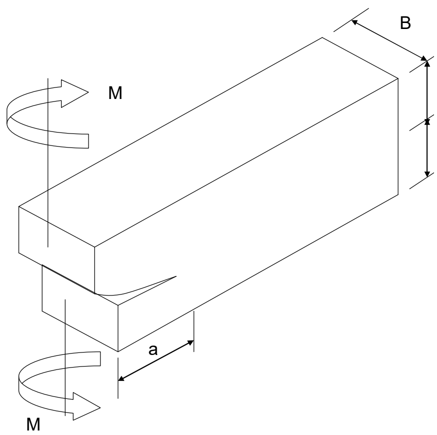
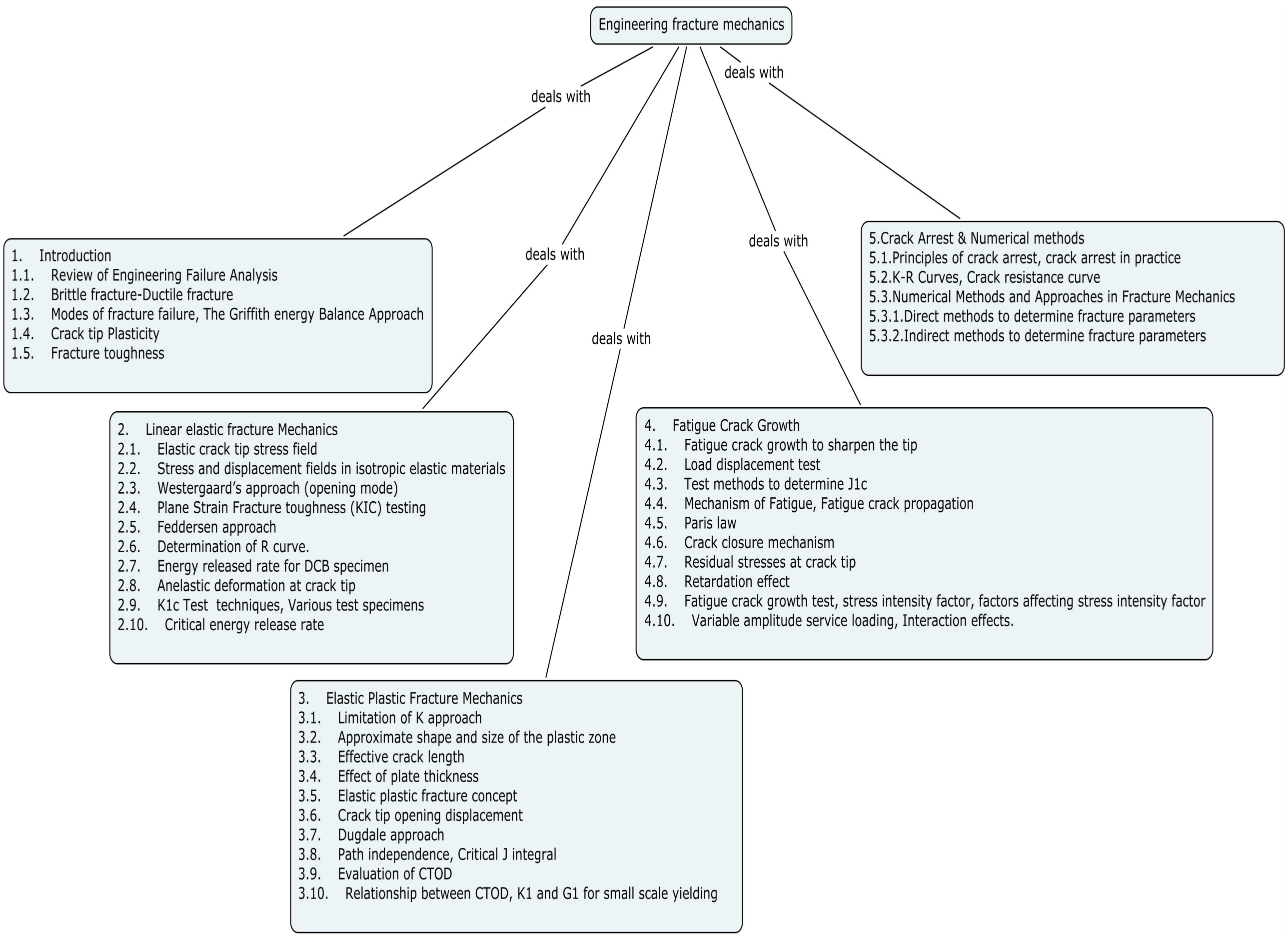


Figure 1

2. By using Westergaard approach evaluate the stresses in the vicinity of crack tip.
3. Explain how is the small scale yielding at the crack tip is taken care by Irwin. Illustrate its physical significance.
4. Discuss the Stresses due to elliptical hole in a plate.
5. Explain Brittle to ductile transition in steel

6. Explain Load interaction and retardation in fatigue crack growth.

Concept Map



Course Content and Lecture Schedule:

S.NO.	Topics	Periods
1.	**Introduction**	
1.1	Review of Engineering Failure Analysis	2
1.2	Brittle fracture-Ductile fracture	1
1.3	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	Westerguard's approach (opening mode)	2
2.4	Plane Strain Fracture toughness (KIC) testing	2
2.5	Feddersen approach	1
2.6	Determination of R curve.	1
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	2
2.1	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	2
3.3	Effective crack length	1
3.4	Effect of plate thickness	1
3.5	Elastic plastic fracture concept	1
3.6	Crack tip opening displacement	1
3.7	Dugdale approach	2
3.8	Path independence ,Critical J integral	1
3.9	Evaluation of CTOD	1
3.1	Relationship between CTOD, K_1 and G_1 for small scale yielding	1
4	**Fatigue Crack Growth**	
4.1	Fatigue crack growth to sharpen the tip, SN curve	1
4.2	Load displacement test	1
4.3	Test methods to determine J_{1c}	2
4.4	Mechanism of fatigue , Fatigue crack propagation	1
4.5	Paris law	1
4.6	Crack closure mechanism	2
4.7	Residual stresses at crack tip	1
4.8	Retardation effect	1

4.9	Fatigue crack growth test, stress intensity factor, factors affecting stress intensity factor	1
4.1	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, Eutectic process	2
5.3	Numerical Methods and Approaches in Fracture Mechanics	1
5.3.1	Direct methods to determine fracture parameters	1
5.3.2	Indirect methods to determine fracture parameters	1
	Total	**50**

Syllabus

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

Reference Books:

1. John M. Barson & Stanely T. Rolfe, "Fracture and Fatigue Control in Structure," Prentice Hall Inc, USA,1987.

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

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
JP	3	1	-	4

JP CONSTRUCTION PLANNING, SCHEDULING AND MANAGEMENT 3:1

(Common to IM22)

Preamble:

Complex research and development projects can be managed effectively if the project managers have the means to plan and control the schedules and costs of the work required to achieve their technical performance objectives. When the planning of a project is undertaken, questions such as how should the project be accomplished? What resources will be needed? How long will it take? How much will it cost? The answers to all these questions can be found by adopting the modern techniques of project management.

Competencies: At the end of the course, the students will be able to:

1. Know about the importance and objectives of project management
2. Understand the functions of project management
3. Understand the concept of Work break down structure of projects and divide a project into smaller manageable units
4. Understand and apply Gantt's approach (knowing its merits and limitations) for analyzing a project
5. Draw network diagrams for projects using Fulkerson's rules
6. Analyze repetitive type of projects using CPM and draw square network diagrams
7. Analyze one time projects using PERT and determine critical path and associated probability
8. Balance resource requirements of projects so as to avoid idling of resources
9. Update projects and determine revised schedule of activities and critical path if any
10. Crash projects to determine its optimum time- minimum cost relationships

Assessment Pattern:

S. No.	Bloom's Category	Test 1	Test 2	Test 3/ End - semester Examination
1.	Remember	20	20	20
2.	Understand	40	20	20
3.	Apply	40	60	60
4.	Analyze	0	0	0
5.	Evaluation	0	0	0
6.	Create	0	0	0

Course Level Learning Objectives:

Remember

1. Define the term free float. Mention its importance
2. Define optimistic time. How is it obtained for an activity
3. List the techniques of controlling cost in projects
4. What is meant direct cost? Give examples
5. Mention the necessity for crashing of project
6. What is the need for updating of projects

Understanding

1. Discuss the objectives of project management
2. Explain the functions of project management
3. Discuss the merits and limitations of bar chart technique
4. Discuss the Fulkerson's rules for drawing of network diagrams
5. Differentiate between CPM and PERT
6. What is meant by resource balancing? Discuss its objectives with examples
7. Summarize the benefits of cost control in projects

Apply

1. A project consists of 12 activities. The time required for each activity is given in the table below. Use the following logical relationships and draw a network diagram for the project and determine the critical path and duration required for completion of the project.

- Activity A,D and H can be performed concurrently and represent the start of the project
- B succeeds A

- C and G follow H
- D,C and B precede F
- L follows A
- M comes after G
- K is preceded by L
- X cannot start until K, F and M are completed
- Z succeeds G
- X and Z are last operations

Activity	A	B	C	D	F	G	H	K	L	M	X	Z
Duration (days)	4	3	2	4	7	3	2	4	8	3	2	1

2. The following table gives data related to activities in a project. Crash the project to minimum project duration and determine the minimum cost and optimum time of completion. Assume indirect cost as Rs.1400/ week.

Activity	Normal		Crash	
	Time (days)	Cost (Rs.)	Time (days)	Cost (Rs.)
0-1	1	5000	1	5000
1-2	3	5000	2	12000
1-3	7	11000	4	17000
2-3	5	10000	3	12000
2-4	8	8500	6	12500
3-4	4	8600	2	16500
4-5	1	5000	1	5000

3. The following table gives the manpower requirements for each activity in a project:

i) Draw the network diagram of the project

ii) Rearrange the activities suitably for reducing the existing total manpower requirement

iii) Also determine the % reduction in peak demand for the resources

Activity (i-j)	0-1	1-2	1-3	2-4	3-5	3-6	4-7	5-7	6-8	7-9	8-9
Duration (days)	2	3	4	2	4	5	6	5	3	4	4
Manpower demand	4	3	2	5	3	4	4	6	2	2	8

4. A project consists of 10 activities. Conduct PERT network analysis

Activity (i-j)	1-2	1-3	2-3	2-4	3-4	3-5	4-6	4-7	7-8	6-8	5-6
Optimistic time (days)	3	6	8	10	6	4	7	6	1	2	0
Most likely time (days)	6	7	13	12	8	7	9	8	2	5	0
Pessimistic time (days)	10	12	18	14	12	10	12	12	3	10	0

a) Compute the expected time of completion of the project
b) Determine the probability of completing the project two days earlier than the target
c) Find the probability of not completing the project one day later
d) What date has 75% chance of being met?
e) Determine the % utilization of resources for a critical and a non-critical activity

5. The following table shows the activities of a project with their durations of completion. The following conditions exist at the end of 11 days.

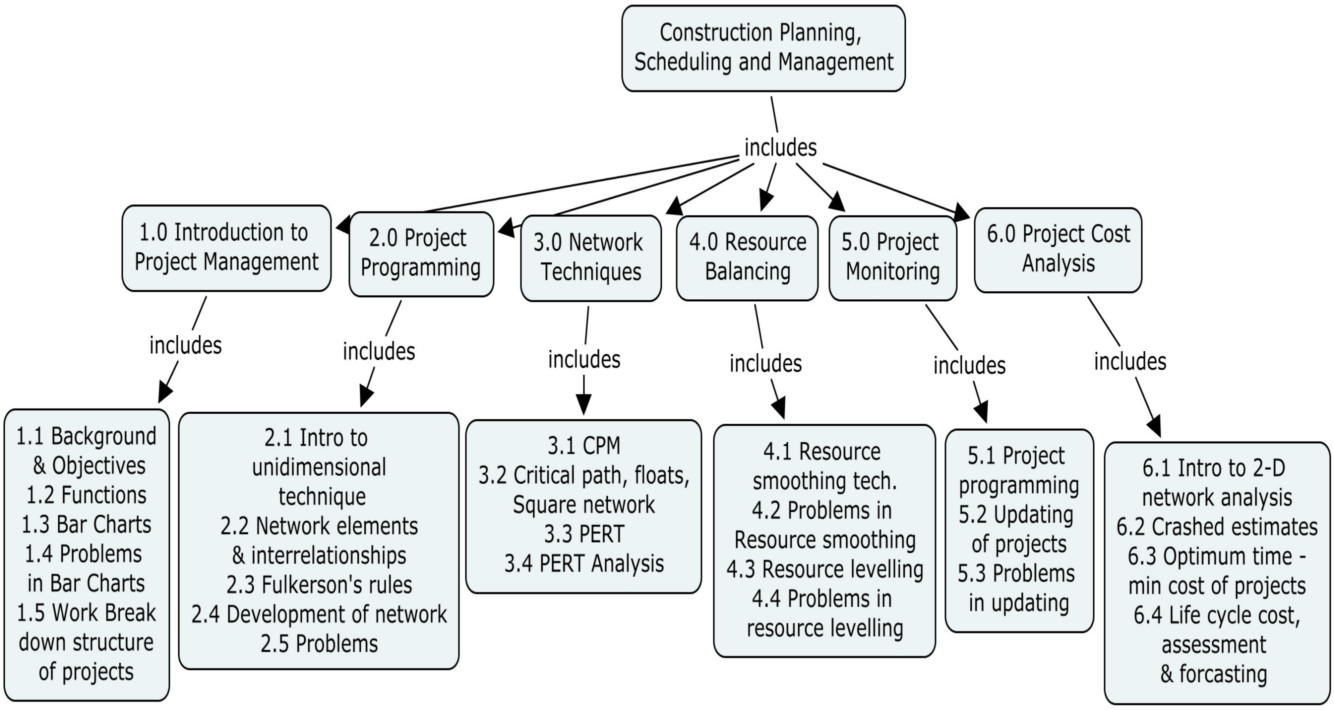
Activity (i-j)	1-2	1-3	1-4	2-5	4-6	3-5	3-6	3-7	5-7	6-7
Duration (days)	2	3	5	3	3	5	4	3	2	7

i) Activities 1-2,1-3 and 1-4 have been completed as originally planned
ii) Activity 3-5 is in progress and will require two more days for completion
iii) Activity 3-6 is in progress and will require three more days for completion
iv) Activity 4-6 is in progress and will be completed in five days
v) All other activity are yet to start and their predicted durations will hold good except 6-7 which will require only 5 days instead of 7 days originally planned

Update the project and determine the critical path of the updated network. What is the revised project completion time? Also show the details on a bar chart

6. Compare the behaviour of direct and indirect cost of a project with respect to time and draw its relationship. If there is a loss encountered in a project during its execution, what would be it's impact on the total cost of the project?

Concept Map:



Course content and lecture schedule:

No.	**Topic**	**No. of Lectures**
1.0	**Introduction to Project Management**	
1.1	Introduction to project management concept, background of management, purpose, objectives	1
1.2	Characteristics of projects and Functions of management	1
1.3	Traditional management systems – Gantt approach, progress-chart, Bar-chart- Merits and limitations	2
1.4	Problems in Bar-chart	1
1.5	Work study, work break down structure, time estimate	1
2.0	**Project Programming**	
2.1	Introduction to modern management concepts, uni-dimensional management techniques	1

2.2	Introduction to network concepts, network elements and inter-relationships	1
2.3	Network techniques, network logic- inter- relationships activity information, data sheets	1
2.4	Development of network based on Fulkerson's rules	2
2.5	Problems in development of network	2
3.0	**Network Techniques**	
3.1	Critical Path Method (CPM) for management, CPM network analysis	2
3.2	Identification of critical path, floats, square network diagrams-problems	2
3.3	Programme Evaluation and Review Technique (PERT) network-introduction to theory of probability and statistics, probabilistic time estimation for activities	2
3.4	Analysis of PERT network – problems, Delta Charts – concept and applications	2
4.0	**Resource Balancing**	
4.1	Resource balancing- objectives, resource smoothing technique – concept and procedure	2
4.2	Problems using resource smoothing technique	2
4.3	Resource Levelling technique - concept and procedure	1
4.4	Problems using Resource Levelling technique	2
5.0	**Project Control and Monitoring**	
5.1	Project programming, phasing of activities programmes, scheduling project control	1
5.2	Reviewing, updating and monitoring – concept	2
5.3	Problems in updating of projects – determination of revised critical path	2
6.0	**Project Cost**	
6.1	Introduction to two-dimensional network analysis – activity cost information, cost –time relationship	1
6.2	Crashed estimates for the activities, compression potential, cost slope, utility data sheet, project direct and indirect cost	2
6.3	Crashed programmes, network compression, least cost solution,	2

	least time solution and optimum time solution-Problems	
6.4	Life cycle assessment- impacts and economical assessment, Life cycle cost- maintenance and operation, life cycle forcasting – concept and applications, Time value of money	2
	Total Periods	**40**

Syllabus:

Introduction to Project Management: Introduction to Project Management concepts - Background of management, purpose and objectives, Characteristics of projects and different functions of management. Traditional management system, Gantt's Approach, progress-chart, bar-chart merits and limitations. Work study, work breakdown structure, time estimates. **Project Programming:** Introduction to modern management concepts, uni-dimensional management techniques- Introduction to network concepts, network elements and inter-relationships. Network techniques, network logic- inter- relationships activity information, data sheets and development of network based on Fulkerson's rules. **Network Techniques:**CPM for management, CPM network analysis, identification of critical path, floats, square network diagrams. PERT network, introduction to the theory of probability and statistics, probabilistic time estimation for the activities, analysis of PERT network, Delta charts. **Resource Balancing:** Resource balancing- objectives, resource smoothing and resource leveling techniques. **Project Control and Monitoring:** Project programming, phasing of activities programmes, scheduling project control, reviewing, updating and monitoring. **Project Cost:** Introduction to two dimensional network analysis, activity cost information, cost time relationship, crashed estimates for the activities, compression potential, cost slope, utility data sheet, project direct and indirect costs. Crashed programmes, network compression least cost solution, least time solution and optimum time solution. Life cycle assessment- impacts and economical assessments, life cycle cost- maintenance and operation, life cycle forecasting- Time value of money.

References:

1. B.C. Punmiya and K.K. Khandelwal, "Project Planning and Control with PERT/CPM", Laxmi publications, New Delhi, 2000
2. Jerome D. Wiest and Ferdinand K. Levy, "A Management Guide to PERT /CPM", Prentice Hall of India Publishers Ltd., New Delhi, 1982

3. B.L. Gupta and Amit Gupta, "Construction Planning and Accounts", Standard Publishers Distributors, Delhi, 1997
4. P.S. Gahlot and B.M. Dhir, "Construction Planning and Managemernt", New Age International Limited, Publishers, 1996
5. V.N. Vazirani and S.P. Chandola, "Construction Management and Accounts", Khanna Publishers, New Delhi, 1986
6. S. Sangareddi and P.L. Meiyappan, "Construction Management", Kumaran Publications, Coimbatore, 2000

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