SEMESTER I

Discipline : CIVIL ENGINEERING
Stream : CE4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE100	PROBABILITY AND STATISTICS	DISCIPLINE CORE	3	0	0	3

Preamble: The objective of this course is to expose the students to the fundamental concepts of probability and statistics. The course aims to equip the students to find solutions for many real-world civil engineering problems and to understand basic data analysis tools by applying the principles of statistics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	To create an awareness of the concepts of statistics and probability distributions
CO 2	To formulate and test hypotheses for civil engineering problems
CO 3	To apply statistical data analysis tools such as ANOVA and experimental designs
CO 4	To build regression models for civil engineering applications and to identify the principal components
CO5	To apply the concepts of data analysis for a time series

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2		3			2
CO 2	3	2	2	3	3		2
CO 3	3	2	2	3	3		2
CO 4	3	2	2	3	3		2
CO5							

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	5
Create	5

Mark distribution

Total Marks	CIA	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Micro project/Course based project	:	20 marks
Course based task/Seminar/Quiz	:	10 marks
Test paper, 1 no.	:	10 marks

The project shall be done individually. Group projects are not permitted. The project may include the implementation of theoretical computation using software packages.
The test papers hall include a minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Syllabus

Module 1- Introduction to probability distributions

Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence. Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.

Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.

Module 2- Statistical Inference

Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:-Confidence interval for mean and variance.-Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.-Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence

Module 3- Analysis of variance

Analysis of variance. Completely randomized designs and randomized block designs.- Latin square designs -Factorial experiments: Two-factor experiments (overview only)

Module 4- Correlation and regression models

Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient- Multiple linear regression, normal equations -Principal components (brief overview only)

Module 5-Time Series Models

Components of time series. Identifying linear trend: semi averages method and least squares method. Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient. Forecasting, measuring forecasting accuracy

Course Plan

No	Topic	No. of Lectures
1	**Introduction to probability distributions**	
1.1	Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence.	1
1.2	Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.	2
1.3	Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.	5
2	**Statistical Inference**	
2.1	Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:-Confidence interval for mean and variance.	2
2.2	Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.	2

2.3	Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence	4
3	**Analysis of variance**	
3.1	Analysis of variance. Completely randomized designs and randomized block designs.	4
3.2	Latin square designs	2
3.3	Factorial experiments: Two-factor experiments (overview only)	2
4	**Correlation and regression models**	
4.1	Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient	4
4.2	Multiple linear regression, normal equations	2
4.3	Principal components (brief overview only)	2
5	**Time Series Models**	
5.1	Components of time series. Identifying linear trend: semi averages method and least squares method.	2
5.2	Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient.	3
5.3	Forecasting, measuring forecasting accuracy	3
	Total hours	40

Reference Books

1. Gupta. S. C. and Kapoor. V. K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2020
2. Benjamin, Jack.R and Comell.C, Allin, Probability, Statistics and Decision for Civil Engineers, Mc- McGraw-Hill.
3. Johnson RA , Miller I, Freund J. Miller and Freund's Probability and Statistics for Engineers (9th edition) Pearson. 2018.
4. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, 4th EditionRaymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook ISBN: 978-1-118-91601-8 February 2016.
5. Introduction to Time Series Analysis and Forecasting Second Edition, DOUGLAS C. MONTGOMERY, CHERYL L. JENNINGS, MURAT KULAHCI, John Wiley & Sons, 2015.
6. Papoulis A, Pillai SU Probability, Random Variables and Stochastic Processes McGraw Hill 2022
7. Schiller J, Srinivasan RA, Spiegal M Schaum's Outline of Probability and Statistics, 2012 McGraw Hill
8. Ross S Introduction to Probability and Statistics for Engineers and Scientists Elsevier 6th Edition 2021

Model Question Paper CIVIL ENGINEERING-CE4

XXXX PROBABILITY AND STATISTICS

Time: 3 Hrs Max. Marks:60

PART A

(Answer all Questions: Each question carries 5 marks)

1. Explain the concept of mean, median and mode, and its applicability in various contexts with suitable examples.
2. Explain Type I and Type II errors with example.
3. What are the assumptions involved in Analysis of Variance (ANOVA)?
4. Obtain Karl Pearson's correlation coefficient for Stress and Performance.

Observation no.	1	2	3	4	5
Performance	75	80	85	90	95
Stress	80	75	80	60	55

5. Explain briefly the components of time series.

PART B

(Answer any five questions: Each carry 7 marks)

6. The number of products sold by a shop keeper follows Poisson distribution, with a mean of 2 per week. (i) Find the Probability that in the next 4 weeks the shop keeper sells exactly 3 products. (ii) The shop keeper monitors sales in periods of 5 weeks. Find the probability that in the next 15 of these 5-week period, there are exactly 10 periods in which more than 5 products are sold.
7. After conducting series test on ProbabilityandStatistics the following scores were obtained for Batch A and Batch B. Conduct a hypothesis testing for checking the equality of variance in scores of two batchesat a significant level corresponding to a β error probability of 0.9.

A	35	40	42	30	12	50	45	28	26	30
B	20	24	28	26	18	50	50	48	48	09

8. In order to evaluate safety performance of employees across 3 departments, 5 employees across each department were randomly monitored and their safety behaviour on a hundred scale is given below. Do the departments differ in their safety behaviour?

Department	**1**	**2**	**3**	**4**	**5**
A1	68	73	75	65	78
A2	85	85	78	86	79
A3	73	77	72	70	76

9. Develop a Regression Equation between A and Busing Method of Least Square. Consider B as the dependent variable. Explain the significance of estimated slope.

Observation no.	1	2	3	4	5
A	75	80	85	90	95
B	80	75	80	60	55

10. Foodgrain production (in lakh tones) is given below. Find the Trend by using 3-yearly and 4-yearly movingaverage method, tabulate the trend values and predict the production for the year 2022.

Years	**Production**
2008	40
2009	60
2010	45
2011	85
2012	130
2013	135
2014	150
2015	120
2016	200

11. An evaluation of teaching methods shows the following outcomes.

Method of Teaching	No of students	Average marks obtained	Population Standard Deviation
Chalk and Talk Method	32	70	5
PPT and Talk Method	29	65	8

Conduct hypothesis testing for the mean difference of the teaching methods at a significant level corresponding to a Type I error probability of 0.01.

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE007	THEORY OF ELASTICITY	PROGRAM CORE 1	3	0	0	3

Preamble: This course advances students from the one-dimensional and linear solid mechanics problems, conventionally treated in courses of strength of materials, into more general, two and three-dimensional problems. Students will be introduced to rectangular and polar coordinate systems to describe stress and strain in an elastic continuum and also solve various 2D linear elastic problems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply knowledge of mechanics and mathematics to model elastic bodies as continuum.
CO 2	Formulate boundary value problems; and calculate stresses and strains.
CO 3	Comprehend constitutive relations for elastic solids and compatibility constraints.
CO 4	Solve two-dimensional problems (plane stress and plane strain) using the concept of stress function.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	3	3	3	1
CO 2	3	2	3	3	3	3	1
CO 3	3	2	3	3	3	3	1
CO 4	3	2	3	3	3	3	1

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Understand	10	15
Apply	10	15
Analyse	20	30
Evaluate	-	-
Create	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

Max. Marks: 60 Duration: 2.5 Hours

PART A

Answer all questions; each question carries 5 marks

1. A rectangular metal bar of cross-section 30 mm × 25mm is subjected to an axial tensile force of 150 kN. Calculate the normal, shear and resultant stresses on a plane whose normal has the following direction cosines: $l = m = 1/\sqrt{2}$ *and* $n = 0$.

2. Demonstrate the systematic reduction in the number of independent elastic constants from a general anisotropic material to isotropic material.

3. State and explain the principal of stationary potential energy and complementary energy.

4. Show that the function $\phi = A\left(xy^3 - \frac{3}{4}xyh^2\right)$ is an Airy's stress function. Also calculate and define the stress components on a rectangular domain of width *b* and depth *h*.

5. Determine the shear stress induced and the angle of twist per unit length of a hollow shaft of uniform wall thickness 5 mm with cross section dimensions 80 mm (width) × 20 mm (depth), when subjected to a torque of 1kN-m. The modulus of rigidity $G = 1.3\times10^4\ MPa$.

PART B

Answer any five questions; each question carries 7 marks

6. The state of stress at a point in a stressed body is given below:

$$\sigma = \begin{bmatrix} 10 & 4 & 6 \\ 4 & 2 & 8 \\ 6 & 8 & 6 \end{bmatrix} MPa$$

(i) Find the principal planes and principal stresses corresponding to the above stress state. (4 marks)

(ii) Also determine the normal and shear stresses on an octahedral plane. (3 marks)

7. The displacement field in a homogenous isotropic elastic body is given by $u = 1\times10^{-6}\left[\left(3x^2z + 60x\right)i + \left(5z^2 + 10xy\right)j + \left(6z^2 + 2xyz\right)k\right]$.

(i) Determine the strain components. (3 marks)

(ii) If the coordinate axes are rotated about the z-axis through 45° in the anticlockwise direction, determine the new strain components. (4 marks)

8. Derive the Navier equations for 3D elasticity problems. (7 marks)

9. Explain in detail any three failure theories. (7 marks)

10. Using stress function approach, derive an expression for the maximum deflection of a simply supported beam of length *l* and depth '2*c*', if the beam is subjected to a uniformly distributed load of intensity *q*. (7 marks)

11. Derive the expressions for the maximum shear stress in a bar of elliptical cross-section subjected to torque. Also plot the contour lines for displacement. (7 marks)

12. Figure 1 shows a two cell tubular section having one interior web. An external torque of 10,000 N-m is acting in a clockwise direction. Determine the distribution of internal shear flow. The peripheral lengths are as shown I figure. The cell areas are as follows: A_1 = 800 cm^2 and A_2 = 1780 cm^2.

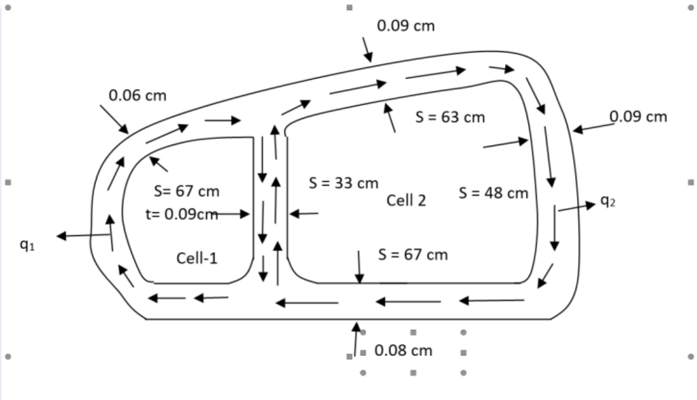


Fig.1

Syllabus and Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
	Review of the topics in the undergraduate course Mechanics of Solids from a slightly advanced point of view.	1 Hr.
1	**Analysis of 3D state of stress**	
1.1	Definition of stress at a point – Notation and sign conventions for stress Stress tensor.	1 Hr.
1.2	Differential equations of equilibrium and numerical examples	1 Hr.
1.3	Stress components on an arbitrary plane – stress transformations.	1 Hr.
1.4	Numerical examples on stress transformations and Traction boundary conditions	1 Hr.
1.5	Principal planes and principal stresses -stress invariants.	1 Hr.
1.6	State of stress referred to the principal coordinate system – stress ellipsoid – octahedral stresses.	1 Hr.
1.7	Maximum shear stress, Hydrostatic and Deviatoric Stress, Numerical examples	1 Hr.
2	**Analysis of 3D state of strain and Constitutive relations**	
2.1	Displacement field and strain field – elementary concept of strain.	1 Hr.
2.2	Strain-displacement relations for small deformations,	1 Hr.
2.3	Compatibility conditions – numerical examples	1 Hr.
2.4	Strain transformations; Principal strains	1 Hr.
2.5	Strain invariants, Octahedral strains, Hydrostatic and deviatoric components of strain.	1 Hr.
2.6	Generalized Hooke's law: Reduction in number of elastic constants: general anisotropy, orthotropy and isotropy.	1 Hr.
3	**Boundary value problems of elasticity, energy theorems and failure theories**	
3.1	Boundary value problems of elasticity- Displacement, Traction and Mixed types.	1 Hr.
3.2	Navier equations and Beltrami-Michell's Equations.	1 Hr.
3.3	St.Venant's principle, Uniqueness of solutions.	1 Hr.
3.3	Energy theorems - Strain energy and Complimentary energy.	1 Hr.
3.4	Principle of stationary potential energy and minimum complementary energy.	1 Hr.
3.5	Principle of virtual work for deformable bodies – illustrative examples	1 Hr.
3.6	Failure theories or Yield criteria: Maximum principle stress theory, Maximum shear stress theory, Maximum normal strain theory.	1 Hr.
3.7	Octahedral shear stress theory, Maximum elastic energy theory, Maximum distortion energy theory.	1 Hr.
4	**Two-Dimensional Problems of Elasticity**	

4.1	Plane stress and plane strain problems	1 Hr.
4.2	Solution of plane problems in rectangular coordinates- stress function approach	1 Hr.
4.3	Airy's stress function and Biharmonic equation in rectangular coordinates; Solution by polynomials – Numerical examples.	1 Hr.
4.4	Elasticity solution for bending of cantilever loaded at free end	1 Hr.
4.5	Elasticity solution for bending of Uniformly loaded simply supported beam.	1 Hr.
4.6	2D problems in polar coordinates - Equations of equilibrium in polar coordinates	1 Hr.
4.7	Strain displacement, compatibility and stress-strain relations in polar coordinates	1 Hr.
4.8	Stress function approach for solution of 2D problems in polar coordinates- Airy's stress function and Biharmonic equations	1 Hr.
4.9	Problems of axisymmetric stress distributions- Thick cylinders subjected to internal and external pressures.	1 Hr.
4.10	Stress concentrations due to circular hole in plates	1 Hr.
5	**Torsion of noncircular bars**	
5.1	St.Venant's Semi-inverse method	1 Hr.
5.2	Prandtl's stress function approach	1 Hr.
5.3	Stress function approach for solution of torsion of bars of elliptical cross section	1 Hr.
5.4	Stress function approach for solution of torsion of bars with triangular cross section	1 Hr.
5.5	Prandtl's membrane analogy.	1 Hr.
5.6	Membrane analogy application to prismatic bars of narrow rectangular cross-section and thin-walled open sections.	1 Hr.
5.7	Torsion of thin-walled single cell hollow closed sections	1 Hr.
5.8	Torsion of thin-walled multiple cell closed sections.	1 Hr.

Reference Books

1. Timoshenko S.P. and J. Goodier, McGraw-Hill.
2. Ugural A. C. and S. K. Fenster, "Advanced Strength and Applied Elasticity", Prentice Hall.
3. Ragab A.R. and S.E. Bayoumi, Engineering Solid Mechanics, Fundamentals and Applications, CRC Press New York.
3. Boresi A.P. and R. J. Shimidt, Advanced Mechanics of Materials, John Wiley & Sons, Pvt. Ltd.
4. Srinath L.S., Advanced Mechanics of Solids, Tata McGraw-Hill publishing company, NewDelhi.
5. Sadd. M., Elasticity: Theory, Applications and Numerics, Elsevier.
6. C. T. Wang, "Applied Elasticity", Mc-Graw Hill Book Company, New York.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE008	STRUCTURAL DYNAMICS	PROGRAM CORE 2	3	0	0	3

Preamble: The course provides the basic concepts of structural dynamics and the theoretical background to perform dynamic analysis of structures. The course focuses on analysis of single and multi-degree of freedom systems. An introduction to distributed parameter system is also included. The course also provides an introduction to earthquake analysis of structures.

Course Outcomes: After the completion of the course on Structural Dynamics, the student will be able to

CO 1	Model single and multi-degree freedom systems for dynamic analysis and develop equations of motion
CO 2	Estimate parameters of dynamic systems
CO 3	Perform dynamic analysis of single degree freedom systems
CO 4	Perform dynamic analysis of multi - degree freedom systems
CO 5	Analyse and design vibration isolation systems
CO 6	Perform dynamic analysis of distributed parameter systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		2				
CO 2	3		2				
CO 3	2		2		1		
CO 4	1		1		1		
CO 5	1		1	1	1		
CO 6	1		1		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	46
Analyse	14
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

The project shall be done individually. Group projects not permitted.

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

QP CODE:

Reg No.:____________________________

Name:______________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION,

MONTH & YEAR

Course Code: 221TCE008

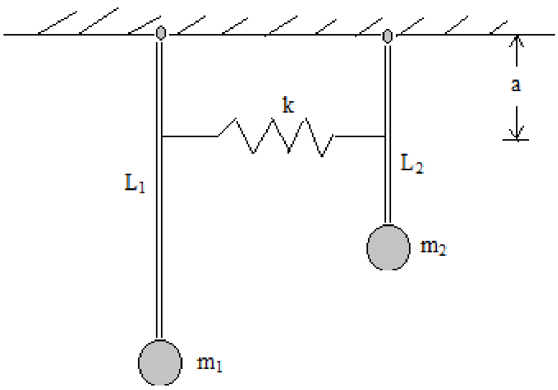
STRUCTURAL DYNAMICS

Max. Marks: 60 Duration: 2.5 hours

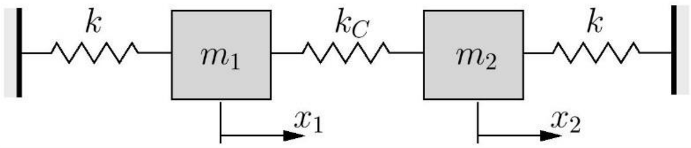
PART A

(Answer ***ALL*** questions; each question carries 5 marks)

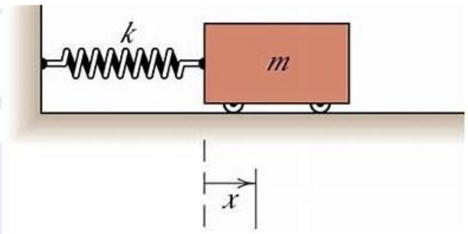
1. Calculate the natural frequency of transverse vibrations of a cantilever beam 40mm diameter circular cross section, carrying a load of 500N at the free end. Span of the cantilever is 800mm. E = 200GPa. If a spring of stiffness 52.75kN/m is introduced between the mass and the beam calculate the change in natural frequency.
2. A sieving machine weighs 2500kg and when operating at full capacity, it exerts a harmonic force of 3kN amplitude at 20Hz on its supports. After mounting the machine on spring type vibration isolators, it was found that the harmonic force exerted on the supports had been reduced to a 250N amplitude. Determine the stiffness of the isolator springs. Take $\zeta = 10\%$.
3. Two pendulum bobs are suspended from the ceiling using massless rigid bars and the bars are connected using a spring as shown in figure. Derive the equation of motion for small oscillations. Write down the mass and stiffness matrices of thesystem. Take $m_1 = 2.0$kg, $m_2 = 1.5$kg, $L_1 = 1.5$m, $L_2 = 1.0$m, a = 0.5m, k = 150N/m.



4. Establish the equation of motion for the frame shown in figure, if it is subjected to a suddenly applied constant acceleration 0.28g at its base. Take m_1 = 10kg, m_2 = 20kg, k = 1500N/m, k_c = 2000N/m.



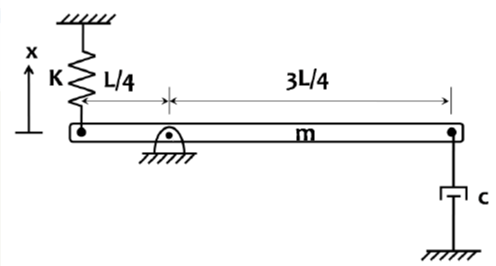
5. Obtain the equation of motion of a SDOF system shown in figure using Lagrange's equation. Take m = 10kg and k = 5000N/m.



PART B

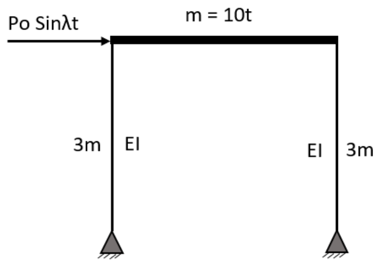
(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Determine the parameters in an equivalent model of the system as shown in the figure when θ, the clockwise angular displacement of the bar from the system's equilibrium position, is used as generalized coordinate. Assume small θ.



7. One of the construction companies hires you to determine the dynamic properties of a frame system for which it has lost the original blue prints. Being a civil engineer, you were assigned to do a free vibration test of the frame system. Supplied with a hydraulic jack, you were able to apply a jacking force to displace the frame. With a jacking force of 134kN, you noted down that the frame has displaced 0.76cm. On the first return swing after release, the frame did not come back to the release point but rather it stopped at 0.64cm towards it. You recorded time between the release and the first return as 2s. Determine the following
    a. Weight of the frame
    b. Natural frequency
    c. Logarithmic decrement
    d. Damping ratio
    e. Damping frequency
    f. Amplitude of the frame after 6 cycles

8. A frame is subjected to harmonic loading as shown in figure. If Po = 20kN, calculate the dynamic amplification factor and amplitude of steady state response for the following cases. (i) λ = 10rad/s, (ii) λ = 15rad/s, (iii) λ = 20rad/s. Comment on the results. Take ζ = 5% and EI = 10^{10}kNmm^2.



9. Derive the expression for the response of a SDOF system subjected to a rectangular impulse of duration t_1 and magnitude P_0.
10. State and prove the orthogonality condition of normal modes in a MDOF system.
11. Explain mode superposition method of analysis.
12. Derive the differential equation governing the flexural vibration of beams. How will you find the undamped free vibration solution? Demonstrate for a simply supported beam of span L having uniform flexural rigidity EI and �mass per unit length.

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Syllabus

Module 1

Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion. Undamped and damped free vibration of single degree of freedom system. Measurement of damping from free vibration response - Logarithmic decrement.

Module 2

Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method. Impulse response function, Response of single degree of freedom systems subjected to impulse, periodic and general loading- Duhamel integral. Single degree freedom subjected to support motion. Vibration isolation –Transmissibility.

Module 3

Multi-degree of freedom systems – Equation of motion. Shear building concept and models for dynamic analysis –Evaluation of natural frequencies and mode shapes by solution of characteristic equation. Co-ordinate coupling - Orthogonality of normal modes.

Module 4

Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis. Response of multi degree of freedom systems to support motion.

Module 5

Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods. Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only) –Variational formulation of the equation of motion – Hamilton’s principle - Lagrange’s equation.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Dynamics and Free Vibration of SDOF Systems (9)**	
1.1	Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion.	4
1.2	Undamped and damped free vibration of single degree of freedom system.	4
1.3	Measurement of damping from free vibration response - Logarithmic decrement.	1
2	**Forced Vibration of SDOF Systems (11)**	
2.1	Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method.	3
2.2	Impulse response function, Response of single degree of freedom systems subjected to impulse (rectangular, triangular and half sine wave), periodic and general loading- Duhamel integral.	4
2.3	Single degree freedom subjected to support motion.	2
2.4	Vibration isolation –Transmissibility	2
3	**Free vibration of MDOF Systems (7)**	
3.1	Multi-degree of freedom systems – Equation of motion.	1
3.2	Shear building concept and models for dynamic analysis – Evaluation of natural frequencies and mode shapes by solution of characteristic equation.	5
3.3	Co-ordinate coupling - Orthogonality of normal modes.	1
4	**Forced Vibration of MDOF Systems (7)**	

4.1	Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis.	4
4.2	Response of multi degree of freedom systems to support motion.	3
5	**Distributed Parameter Systems (6)**	
5.1	Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods.	1
5.2	Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only).	4
5.3	Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.	1

Reference Books

1. Clough R W and Penzien J, Dynamics of Structures, McGraw Hill, New Delhi.
2. Biggs J M, Introduction to Structural dynamics, McGraw Hill, New Delhi.
3. Mario Paz, Structural Dynamics – Theory and Computation, CBS Publishers and Distributors, Delhi.
4. Mukhopadhyay M, Structural Dynamics - Vibrations and Systems, Ane Books India, Delhi.
5. Humar J, Dynamics of Structures, CRC Press, Netherlands.
6. Anil K Chopra, Dynamics of Structures- Theory and Application to Earthquake Engineering,
7. Pearson Education, New Delhi.
8. Roy R Craig, Structural Dynamics – An Introduction to Computer Method, John Wiley & Sons, Newyork.
9. Thomson W T, Theory of Vibration with Application, Pearson Education, New Delhi.
10. Weaver W, Timoshenko S P, Young D H, Vibration Problems in Engineering, John Wiley & Sons, USA.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LCE003	ADVANCED STRUCTURAL ENGINEERING LAB	LABORATORY	0	0	2	1

Preamble: To familiarize the students with the different sophisticated instrumentations used in the laboratory and field for measuring/monitoring stress, strain, deflection etc. in structures. New construction materials, their testing and construction practices are introduced. It also provides the students to observe the behaviour of reinforced concrete structural elements and steel sections. It also encompasses to develop a firm foundation for research and practice in Civil Engineering.

General Instructions to Faculty:

1. Any 10 of the 13 experiments included in the list of experiments need to be performed mandatorily. Virtual Lab facility cannot be used to substitute the conduct of these mandatory experiments.

2. The laboratory should have possession of modern testing equipment such as Linear variable differential transducer -Hydraulic jack-load cells-indicators- crack detection microscope - Data logger-Rebound hammer, ultrasonic pulse velocity- rebar locator, core cutter, concrete penetrometer.

3. Periodic maintenance and calibration of various testing instruments needs to be made.

Course Outcomes:

After the completion of the course on Advanced Structural Engineering Lab, the student will be able to:

CO 1	Understand basic test for the materials,
CO 2	Compute the mix proportion for various types of concrete as per IS guidelines.
CO 3	Evaluate the mechanical properties of concrete
CO 4	Analyse the behaviour of reinforced concrete elements.
CO 5	Analyse the behaviour of steel members
CO 6	Familiarise modern instruments.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	2	2	3	2	2	
CO 2	2	2	2	3	2	2	
CO 3	3	3	2	3	3	2	
CO 4	3	3	3	3	3	2	
CO 5	3	3	3	3	3	2	
CO 6	3	3	3	3	3	2	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100	–	–

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Syllabus and Course Plan

Mix design of concrete

Material characterisation-Mix design of normal-fibre reinforced and self-compacting concrete as per IS code guidelines.

Study of instruments

Mechanical strain gauges-Electrical strain gauges - Linear variable differential transducer - Hydraulic jack-load cells-indicators-Data logger- crack detection microscope -Non-destructive testing

Testing of Reinforced concrete elements and Structural steel sections

Behaviour of under-reinforced concrete beams under flexure-shear- Behaviour of short reinforced concrete columns under axial compression-Steel bending tests on steel joists-Buckling of steel angles- Torsion of closed and open sections- Behaviour of bolted connections.

List of Experiments

Expt. No.	Title	Hours Allotted
1	Determination of properties of constituent materials in concrete.	2
2	Study on the mix design of normal and high strength concrete as per IS code. Introduction to fibre reinforced concrete.	2
3	Casting of cubes, beams and cylinders with designed normal strength concrete and fibre reinforced concrete.	2

4	Introduction to self-compacting concrete. Study on the mix design and flow properties of self-compacting concrete as per IS code.	2
5	Study on the working of mechanical strain gauges-Electrical strain gauges - Linear variable differential transducer - Hydraulic jack-load cells-indicators- crack detection microscope -Data logger.	
6	Behaviour of under-reinforced concrete beams under flexure	2
7	Behaviour of reinforced concrete beams under shear	2
8	Bending tests on steel joists	2
9	Behaviour of short reinforced concrete columns under axial compression	2
10	Buckling of steel angles	2
11	Torsion of closed and open sections	2
12	Behaviour of bolted connections	2
13	Non-destructive testing	2

Reference Books/Resources:

1. Pillai S.U &Menon D – Reinforced Concrete Design, Tata McGraw Hill Book Co., 2009.
2. “Concrete Technology”- Neville – Pearson Publishers, 2000
3. Subramanian, N., “Design of Steel Structures”, Oxford University Press.
4. Iyengar, N.G.R., "Elastic Stability of Structural Elements", Macmillan India Ltd., New Delhi, 2007.
5. IS 456:2000, “PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE”, Bureau of Indian Standards New Delhi.
6. IS 10262 : 2019-Concrete Mix Proportioning-Guidelines.
7. IS 800:2007, “GENERAL CONSTRUCTION IN STEEL - CODE OF PRACTICE”, Bureau of Indian Standards New Delhi.
8. SP 6(1) Hand book for structural Engineers.
9. IS 4000 (1992): Code of practice for high strength bolts in steel structures [CED 7: Structural Engineering and structural section.

SEMESTER I

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE036	ADVANCED THEORY AND DESIGN OF CONCRETE STRUCTURES	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Design of an advanced reinforced concrete structures are one of the primary requisites of any structural engineer. Hence the course aims to provide a detailed theoretical background of various design philosophies and their applications using national and international design guidelines. Therefore, at the end of the course the student is expected to analyse and design various special reinforced concrete structures. The students are also able to apply the knowledge in real civil engineering problems and to design new and advanced reinforced concrete structures.

Course Outcomes: After the completion of the course on Advanced Theory and Design of Reinforced Concrete Structures, the student will be able to

CO 1	Understand the behaviour of reinforced concrete and its components.
CO 2	Familiarise the various advanced reinforced concrete structural elements.
CO 3	Analyse the various advanced reinforced concrete structural elements.
CO 4	Design the advanced reinforced concrete structural elements like deep beam, slender column.
CO 5	Design the special reinforced concrete structural elements like corbel and beam column joint.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		2	3	2	1	1
CO 2	1		2	3	2	1	1
CO 3	3	2	3	3	3	2	1
CO 4	3	2	3	3	3	2	1
CO 5	3	2	3	3	3	2	1

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	10
Apply	25
Analyse	15
Evaluate	–
Create	–

Mark Distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper CIVIL ENGINEERING-CE4

Max. Marks: 60 **Duration: 2.5 hours**

PART A

(Answer ALL questions; each question carries 5 marks)

1. (a) Write short notes on
   i) Confined concrete
   ii) Bauschinger effect
2. Draw the design bending moment envelop allowing 30% redistribution for the beam fixed at both ends of span 8m and carrying a udl of 25kN/m.
3. Sketch the strut and tie model for a corbel and describe how the load is carried by corbel.
4. What is the purpose of shear wall? Discuss the classification of shear walls.
5. Explain with a sketch the forces acting on a beam column joint.

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Determine the short-term deflection of a simply supported beam having a span of 6m.and a cross section of 300x600mm. it is subjected to a udl of 30kN/m. The tension reinforcement consists of three 25 mm dia bars and compression reinforcement as two 20mm dia. Bars both at an effective cover of 40 mm. The grade of concrete is M25 and steel used is Fe415.
7. A beam of size 250mmx600mm with 25mm clear cover to steel is reinforced with 3x25mm dia. As tension steel and 3x16mm dia. as compression steel. The section is subjected to a maximum bending moment of 220KN-m. use M20 and Fe415. Determine the maximum probable crack width at the soffit of the beam.
8. A transfer girder carries two square column of size 600mm each with factored load 7500kN located at 1/3rd of the span. The beam has thickness 600mm and total depth 4m. Use fck = 35N/mm2 and fy = 415N/mm2. The girder has a span of 12m. Design the beam for given loads ignoring self-weight Use Strut and Tie.
9. A column of size 400 mm x 600 mm subjected to factored load Pu = 2000 kN, Mux = 160 kNm and Muy = 120 kNm. The unsupported length of column is 4m. Design the reinforcements in the column, assuming M20 concrete and Fe415 steel. Provide 60mm effective cover to reinforcement
10. Design an exterior Type I joint for the following data:
    Column 500 x 500mm with 8 Nos. 25mm longitudinal bars, maximum load on column is 5000 kN.
    Main beam 450 x 500 mm with ultimate capacity 390 kNm and tension steel 4 Nos. 25mm.
    Spandrel beam cross section 450 x 600 mm, Storey height 3 m.
    Assume M20 concrete and Fe 415 steel.
11. How the beam column joints are classified into different categories? Explain with neat sketch each one of them.
12. Explain classical theory of cracking.What are the factors affecting the crack width?

Syllabus

Module 1

Stress-strain characteristics of concrete under single and multi- axial stresses- confined concrete--Effect of cyclic loading on concrete and reinforcing steel- Ultimate Deformation and ductility of members with flexure strength and deformation of members under shear--Moment-curvature relationship of RCC flexural members- Tension stiffening effect of concrete in flexural members, and corresponding equivalent moment of inertia-Codal procedures on immediate and long-term deflections in reinforced concrete beam and slab as per IS.

Module 2

Classical theory of cracking-factors affecting crack width-control of cracking- Codal procedures on crack width computation in reinforced concrete beams in flexure as per IS-Inelastic behaviour of reinforced concrete beams – plastic hinge formation-length of plastic hinge-Conditions for moment redistribution-redistribution of moment in reinforced concrete fixed and two span continuous beams (numerical problems).

Module 3

Development- Design methodology- selecting dimensions for struts, tie and nodal zones-compression fans- ACI 318 Provisions- Design of deep beam as per ACI 318 provisions-Design of Corbel as per ACI 318 provisions.

Module 4

Biaxial bending of columns- interaction diagrams-IS method of design-Analysis and Design of slender RCC columns- Types of shear walls-Loads in shear walls-Principle of shear wall analysis-Distribution of lateral loads in uncoupled shear walls- Equivalent Stiffness Method-Shear Wall Frame Interactions.

Module 5

Beam column joint- classification –Type 1 and Type 2 joint- failures in joint-forces acting on joint- Ductile detailing as per IS code- joint shear strength as per ACI 318 code (numerical problem is not required)- Design of an exterior type I beam-column joint.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to behaviour of reinforced concrete structural elements and Limit state of Deflection (9)**	
1.1	Stress-strain characteristics of concrete under single and multi-axial stresses- confined concrete--Effect of cyclic loading on concrete and reinforcing steel	3
1.2	Ultimate Deformation and ductility of members with flexure	2

	strength and deformation of members under shear--Moment-curvature relationship of RCC flexural members.	
1.3	Tension stiffening effect of concrete in flexural members, and corresponding equivalent moment of inertia	1
1.4	Codal procedures on immediate and long-term deflections in reinforced concrete beam as per IS	2
1.5	Codal procedures on immediate and long-term deflections in reinforced concreteslab as per IS.	1
2	**Limit state of crackingand redistribution of moments. (7)**	
2.1	Classical theory of cracking-factors affecting crack width-control of cracking	2
2.2	Codal procedures on crack width computation in reinforced concretebeams in flexure as per IS	2
2.3	Inelastic behaviour of reinforced concrete beams – plastic hinge formation-length of plastic hinge.	1
2.4	Conditions for moment redistribution-redistribution of moment in reinforced concretefixed and two span continuous beams (numerical problems)	2
3	**Strut and Tie Models (8)**	
3.1	Development- Design methodology- selecting dimensions for struts,tie and nodal zones-compression fans	2
3.2	ACI 318 Provisions	1
3.3	Design of deep beam as per ACI 318 provisions	2
3.4	Design of Corbel as per ACI 318 provisions	3
4	**Slender Columns and Shear wall (9)**	
4.1	Biaxial bending of columns- interaction diagrams	2
4.2	IS method of design-Analysis and Design of slender RCC columns.	2
4.3	Types of shear walls-Loads in shear walls-Principle of shear wall analysis- Distribution of lateral loads in uncoupled shear walls	3
4.4	Equivalent Stiffness Method- Shear Wall Frame Interactions.	2
5	**Beam-column joint (7)**	
5.1	Beam column joint- classification –Type 1 and Type 2 joint-failures in joint-forces acting on joint.	3
5.2	Ductile detailing as per IS code- joint shear strength as per ACI 318 code (numerical problem is not required)	2
5.3	Design of an exterior type I beam-column joint	2

Reference Books

1. Varghese P.C, Advanced Reinforced Concrete Design, Prentice Hall of India Pvt Ltd, 2008.
2. Park,R and Paulay T, “Reinforced Concrete Structures”, (John Wiley & Sons, New York).
3. Arthur. H. Nilson, David Darwin and Charles W Dolan, “Design of Concrete Structures”, Tata McGraw Hill, 2004
4. Pillai S.U & Menon D – Reinforced Concrete Design, Tata McGraw Hill Book Co., 2009.
5. Purushothaman.P. “Reinforced Concrete Structural Elements”, Behaviour , Analysis and Design (Tata McGraw Hill 1986)
6. Relevant IS codes (IS 456, IS 13920)
7. ACI 318-11, Building Code Requirements for Structural Concrete and Commentary, ACI Michigan.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE037	**HIGH RISE BUILDINGS**	**PROGRAM ELECTIVE 1**	**3**	**0**	**0**	**3**

Preamble: Due to urbanization and lack of land, it has become inevitable to construct high rise structures. This subject will make the students aware of the various structural systems for high rise structures and the suitability of each towards different varying parameters. The course provides the basic principles involved in the design of high-rise structures. Different types of loads acting on a high-rise building are to be discussed after which the structural system required to take these loads are to be dealt with. The methods of analysis of high-rise structure are also to be discussed.

Course Outcomes: After the completion of the course on High-Rise Structures the student will be able to

CO 1	Describe the design philosophy and design criteria for tall buildings.
CO 2	Identify the characteristics of wind and earthquake loads acting on high rise structure.
CO 3	Choose and apply appropriate structural systems for different sizes and heights of structures
CO 4	Analyse the effect of gravity and lateral loads on structural members of tall structures.
CO 5	Analyse the behaviour of different structural forms and systems to carry lateral loads of high-rise structures
CO 6	Apply modelling and analysis methods for high rise buildings.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2				
CO 2	1		2				
CO 3	1		3	2	1		
CO 4	1		2				
CO 5	1		2				
CO 6	2		3		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (Minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper CIVIL ENGINEERING-CE4

QP CODE:

Reg No.:______________

Name:____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE037

HIGH-RISE BUILDINGS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer *ALL* questions; each question carries 5 marks)

1. Explain the factors affecting the growth, height and structural forms of tall buildings.
2. Discuss the different types of gravity loads and associated parameters to be considered for the analysis and design of a tall building.
3. List with sketches, three floor systems suitable for high rise structures.
4. Explain the behaviour of high-rise structures with braced frames.
5. Discuss the advantages of outrigger braced structure over core structure.

PART B

(Answer *any FIVE* questions; each question carries 7 marks)

6. Discuss the design criteria for high rise structures.
7. Explain the need of wind tunnel test. What are the different types of wind tunnel experiments for high rise buildings.
8. Explain the different performance levels of building considered in Performance based seismic design.
9. A three-span beam each of 4m span carries a dead load of 6 kN/m for all the spans and 4kN/m for the two consecutive spans from right. Determine the support moments for the beams, if it is simply supported through out.
10. Discuss the advantage of a wall frame structure over framed or wall structures.
11. Discuss the different types of modelling for high rise structures.

****

No	Topic	No. of Lectures
Module – 1		
1.1	Definition and need of tall building - Historic background - factors affecting growth	1
1.2	Design Criteria, Design Philosophy of High-Rise structures	2
1.3	Materials	2
2.1	Dead and live load, live load reduction techniques	2
Module – 2		
2.2	Sequential loading, Impact loading	1
2.3	Wind Loading - Wind Characteristics, Static and Dynamic wind effects - Analytical and wind tunnel experimental method	3
2.4	Seismic Loading - Earthquake loading-equivalent lateral force method, modal analysis, Introduction to Performance based seismic design	3
Module – 3		
3.1	Structural form, Floor systems, Rigid frame Structures, rigid frame behaviour	3
3.2	Approximate determination of member forces by gravity loading-two cycle moment distribution	3
3.3	Approximate determination of member forces by lateral loading-Portal method, Cantilever method	2
Module – 4		
4.1	Braced frames- Types of bracings-behaviour of bracings, behaviour of braced bents-method of member force analysis-method of drift analysis	2
4.2	Infilled frames, behaviour of infilled frames-stresses in infill-forces in frame- design of infill and frame (no numerical)-horizontal deflection	2
4.3	Shear wall Structures-behaviour of shear wall structures - proportionate wall systems, non-proportionate wall systems (no analysis required)- horizontal deflection, Coupled shear walls - behaviour of coupled wall structures	2
4.4	Wall frame structures- behaviour of wall frames	2
Module – 5		
5.1	Tubular structures-framed tube structures-bundled tube structures-braced tube structures	1
5.2	Core structures, Outrigger-Braced Structures	1
5.3	Foundations for tall structures-pile foundation-mat foundation	2
5.4	Modelling for analysis for high rise structures – approximate analysis, accurate analysis and reduction technique.	2

5.5	Discussion of various Finite Element Packages for the analysis of High-Rise Structures	

Text Books

1. Bryan Stafford Smith and Alex Coull, Tall Building structures: Analysis and Design, Wiley-Interscience, New York, 1991.

2. Bungale S Taranath, Structural Analysis and Design of Tall Buildings, Tata McGraw Hill,1988.

Reference Books

1. Robert L Wiegel, Earthquake Engineering. Prentice Hall, 1970.

2. Kolousek V, Pimer M, Fischer O and Naprstek J, Wind effects on Civil Engineering Structures. Elsevier Publications, 1984

3. IS 16700:2017, Criteria for Structural Safety for Tall Concrete Buildings, BIS

4. High Rise Building Structures, Wolfgang Schueller, Wiley

5. Designing and installation of services in building complexes and high rise buildings, Jain, V.K., Khanna Publishers, New Delhi.

6. High rise structures; design and constructions practices for middle level cities, Gupta, Y.P., New Age International Publishers, New Delhi.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE038	**EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING**	**PROGRAM ELECTIVE 1**	**3**	**0**	**0**	**3**

Preamble: The proposed course is expected to enhance and strengthen the knowledge on conducting laboratory experiments on structures. Purpose and structure of measurement system, strain gauge types, LVDT, photo elasticity, Nondestructive testing methods, Computer based data acquisition systems, Errors in measurement will be discussed.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand characteristics of a measurement system
CO 2	Understand working and types of strain gauges and force transducers
CO 3	Understand working and types of potentiometers and accelerometers
CO 4	Understand different types of Non destructive testing methods
CO 5	Understand the application of Two-dimensional photoelasticity in analysing stress or strain.
CO 6	Understand working of recording instruments like chart recorders and CROs.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

Model Question Paper CIVIL ENGINEERING-CE4

Pages: 2 **D**

Reg. No……………… Name:…..…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION

STRUCTURAL ENGINEERING

221ECE038: EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING

Max. Marks: 60 Duration: 3 Hours

PART A

Answer all questions. Each question carries 5 marks (5x 5=25Marks)

1. Explain measurement system and its structure with a diagram.
2. Explain terms: Repeatability, Sensitivity and Precision
3. Explain ideal characteristics of a strain gauge.
4. Explain strain gauge construction.
5. Explain the types of potentiometers.

PART B

Answer any five questions (5x7=35Marks)

6. Explain any seven static performance characteristics of a measurement system.
7. Explain electrical resistance strain gauges- it's working with figure, advantages and disadvantages.
8. Explain Vibrating wire resistance strain gauges- it's working with figure, advantages and disadvantages.
9. Explain Piezo electricaccelerometers - it's working with figure, advantages and disadvantages.
10. Explain the principle, working, advantages and disadvantages of LVDT with a figure.
11. Explain principle, working, correlation with quality of concrete, advantages and disadvantages of Rebound hammer method with a figure.
12. Explain principle, components and working of Cathode ray oscilloscope with a figure.

…………………….

No	Topic	No. of Lectures
1	**Measurement system**	
1.1	measurement system – structure , purpose, components	1
1.2	Static Characteristics - Accuracy, Precision, Repeatability / Reproducibility , Threshold,	1
1.3	Static Characteristics - Resolution, Sensitivity, Discrimination, Static error ,Tolerance	1
1.4	Static Characteristics - Span, Range, Dead space, Hysteresis, Drift, Linearity	1
1.5	Dynamic Characteristics – Fidelity, Dynamic error, speed of response, measuring lag.	1
1.6	zero order, first order and second order instruments, Calibration – Standards and evaluation	1
2	**Measurement of Strain and Force transducers**	
2.1	Strain gauge – Ideal characteristics – Types: Mechanical, Electrical resistance, Optical gauges;	1
2.2	Electrical resistance strain gauges: working and types.	1
2.3	Gauge materials: foils, backing, adhesives. Gauge construction – gauge factor;	1
2.4	Vibrating wire strain gauges- working.	1
2.5	Strain gauge bridges – Potentiometric and Wheatstone bridge – strain sensitivity; forms of wheat stone bridge.	1
2.6	Strain gauge Rosette – two elements, three elements – rectangular, star- delta.	1
2.7	Force transducers: working principle – Load cells: different types.	1
2.8	Pressure transducer: working- types.	1
3	**Measurement of displacement and acceleration**	
3.1	Potentiometers – principle, working, different types- linear, rotary;	1
3.2	Linear variable differential transformer – principle, working, advantages	1
3.3	Accelerometers – Application- Characteristics of Accelerometers	1
3.4	Working of Piezo electric and Piezo resistive accelerometer	1
3.5	Working of Capacitive accelerometer	1

3.6	Working of LVDT Type accelerometer	1
3.7	Working of potentiometric accelerometer	1
3.8	Calibration techniques.	1
4	**Non Destructive Testing Methods and Statistical Analysis**	
4.1	uses- advantages and disadvantages of NDT methods –	1
4.2	Ultrasonic pulse velocity Method- principle, working, advantages and disadvantages, correlation of each method with quality of concrete:	1
4.3	Hardness methods - Rebound Hammer - principle, working, advantages and disadvantages, correlation of each method with quality of concrete	1
4.4	Core sampling technique- principle, working, advantages and disadvantages, correlation of each method with quality of concrete	1
4.5	Pullout experiment - principle, working, advantages and disadvantages	1
4.6	Detection of embedded reinforcement – acoustic emission and electromagnetic method- principle, advantages, Limitations, application.	2
4.7	- Errors in measurement: Systematic and Random;	1
4.8	Uncertainties in measurement- Types; Normal Distribution	1
4.9	Confidence level- determination.	1
5	**Photo elasticity and Indicating & recording elements**	
5.1	uses of polarised light - Maxwell's stress optic law – Two-dimensional photo elasticity.	1
5.2	polariscopes – use, components, working and Types.	1
5.3	Photo elastic model materials- properties; Isoclinics and Iso chromatics – properties.	1
5.4	Moire fringe method of stress or strain analysis- techniques and its use. Advantages and disadvantages of Moire fringe method.	2
5.5	Chart recorders – Types, working.	1
5.6	Cathode ray oscilloscope – principle, components, working.	1
5.7	Computer based data acquisition systems – structure and	1

	components, working.

Reference Books

1. Bently JP - Principles of Measurement Systems – Longman, 1995
2. Nakra B. C. &Chaudhry - Instrumentation Measurement & Analysis - Tata McCraw Hill, 2004
3. Adams L F - Engineering Measurements and Instrumentation – English University Press, 1975
4. Doebelin E O - Measurement Systems Application & Design - McGraw Hill, 2003
5. Dally JW & Riley WF – Experimental stress Analysis - McGraw Hill, 1991

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE039	STRUCTURAL OPTIMIZATION AND RELIABILITY OF STRUCTURES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Uncertainty is inherent in the design of structural systems, whether it be on the loading front or be on the material strength front or even on the analysis model. Optimization and Reliability techniques help engineers arrive at an optimal design solution for engineering structures in an uncertain environment. This course is designed to introduce structural optimization and structural reliability methods to graduate students. The course, through first two modules introduces conventional techniques as well as genetic algorithm methods for structural optimization application. Modules III & IV covers the elementary probability theory, random variables and univariate and bivariate distributions. Level 2 reliability methods and simulation techniques are introduced in Module V.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Formulate optimization problems in structural engineering
CO 2	Apply appropriate algorithms for the solution of optimization problems in structural engineering
CO 3	Identify the various sources of uncertainty in variables encountered in structural design / assessment and apply the mathematical theory of probability for modelling uncertainties encountered in engineering systems.
CO 4	Evaluate the probability of failure / reliability of structural elements and simple structural components using level 2 reliability methods as well as simulation techniques.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	1	3	3	3	2	3
CO 2	3	1	3	3	3	2	3
CO 3	3	1	3	3	3	2	3
CO 4	3	1	3	3	3	2	3

Assessment Pattern

Bloom's Category	Continuous Assessment Test	End Semester Examination
Understand		10
Apply		25
Analyse		15
Evaluate		10
Create		-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 70% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

PART A

Answer all questions.

All Questions carry equal (5) marks

1. A contractor is considering two general pits from which he may purchase materials to supply for a project. The unit cost to load and deliver the material to project site is Rs 500/m^3 from pit 1 and Rs 300/m^3 from pit 2. He must deliver a minimum of 10,000 $m^3$to the site. The mix that he delivers must consist of at least 50% sand, not more than 60% gravel, not more than 8% silt. The material at pit 1 consists of 30% sand and 70 % gravel. The material at pit 2 consists of 60% sand, 30% gravel and 10% silt. Formulate a minimum cost model.

2. Explain the solution procedure of an unconstrained Geometric programming problem using differential calculus. Illustration should be based on the standard form of a geometric programming problem.

3. A building may fail by excessive settlement of the foundation or by collapse of the superstructure. Over the life of the building, the probability of excessive settlement of the foundation is estimated to be 0.10, whereas the probability of collapse of the superstructure is 0.05. Also, if there is excessive settlement of the foundation, the probability of superstructure collapse will be increased to 0.20.

   (a) What is the probability that building failure will occur over its life ?.

   (b) If the building failure should occur during its life, what is the probability that the failure is due to superstructure collapse?

4. If X is maximum annual wind speed with the probability density function

$$f_X(x) = \lambda . e^{-\lambda x}; x \geq 0$$

   Where, λ is the parameter of the distribution. The wind record shows that the probability of the maximum annual wind velocity less than 70 mph is 0.9. Determine the parameter λ. Also determine the mean, standard deviation.

5. The axial load carrying capacity of a column *R*, is normally distributed with $\mu_R = 1000kN$ and $\delta_R = 0.2$. The column is subjected to an axial load *S*, which is normally distributed with $\mu_S = 700kN$ and $\delta_S = 0.43$. Calculate the probability of failure of the column assuming *R* and *S* to be independent.

PART B

Answer any FIVE questions

6. Find the ultimate plastic moment capacities M_b and M_c of the steel frame ABCD for minimum weight. The weight of the frame may be assumed to vary linearly with the plastic moment capacity. Column AB and CD are identical. AB=CD=4m, BC=6m. At midspan of beam BC, 140 KN load acts downwards. A lateral load of 70 KN load acts at joint B towards right. Assume supports A and D as fixed.

7. Solve the geometric programming problem

Minimize $z = \frac{1}{x_1 x_2 x_3} + 2x_2x_3 + 3x_1x_3 + 4x_1x_2$

Subject to the condition that all variables have positive values.

8. The problem of finding the equilibrium configuration of a two bar pendulum subjected to horizontal force is coined as an optimization problem involving minimization of potential energy. The problem is proposed to be solved using Genetic Algorithm. The inclinations of the bars to the vertical (α_1 and α_2) are treated as the decision variables. The integer values assigned to the different possible angles are listed in table 1.

TABLE 1

Sl.no:	Angle	Integer	Sl. no:	Angle	Integer
1	0	0	9	48	8
2	6	1	10	54	9
3	12	2	11	60	10
4	18	3	12	66	11
5	24	4	13	72	12
6	30	5	14	78	13
7	36	6	15	84	14
8	42	7	16	90	15

An initial population of variables (α_1 and α_2) was randomly generated as given in table 2. Tabulate its binary encoding (8 bit string with 2 substrings of 4 bit each representing each variable). The fitness of the individual strings are also given in table 2. Calculate the expected count. Based on the expected count, judiciously create a mating pool after reproduction.

TABLE 2

Population No:	Angles		Fitness
	α_1	α_2	
1	0	0	1
2	12	18	1.8
3	84	72	1.92
4	36	60	4.58
5	6	30	3.01
6	42	72	4.6
7	84	60	1.92
8	12	6	2.11

9. a. Write a note on the common probability distributions used in modelling uncertainties in the context of structural reliability analysis. (3 marks)

b. A bridge can be damaged by failure in foundation (F) or in the superstructure (S). The corresponding failure probabilities for a particular bridge are estimated to be 0.05 and 0.01 respectively. Also, if there is a foundation failure, then the probability that the superstructure will also suffer some damage is 0.50.

(i) find the probability of damage to the bridge

(ii) If the events F and S are statistically independent, what is the probability of damage to the bridge. (4 marks)

10. a. What are joint probability distributions? Develop expressions for absolute and central moments related to continuous joint distributions. (3 marks)

b. Given $f_{XY}(x,y) = A.x\,;\quad for\ 0 \le y \le x \le 1.0.$

find (i) the constant A, (ii) the marginal density functions $f_X(x)$ and $f_Y(y)$ and

(iii)The conditional densities $f_{X|Y}(x|y)$ and $f_{Y|X}(y|x)$ (4 marks)

11. a. Derive the exact solution for the probability of failure when the demand and capacity variables (*R* and *S*) and uncorrelated and lognormally distributed. (3 marks)

b. The buckling strength of a column is given by

$$R = \frac{\pi^2 EI}{l^2}$$

Where, *E* is the Young's modulus, *I* the moment of Inertia and *l* the length of the column.

The column is subjected to a load Q. The mean and coefficient of variations of all the random variables are given below.

$$\mu_E = 2.03 \times 10^5\ N/mm^2;\ \delta_E = 0.1;\ \ \mu_I = 12.5 \times 10^6\ mm^4;\ \ \delta_I = 0.05$$

$$\mu_l = 5000mm;\ \ \delta_l = 0.05;\ \mu_Q = 700\ kN;\ \ \delta_Q = 0.3$$

If all the variables are lognormally distributed and uncorrelated, define a suitable performance function and hence determine the probability of failure of the column.

12. a. Explain the procedure for generation of samples of a random variable following an arbitrary distribution. (2 marks)

b. Estimate the Hasofer-Lind reliability index corresponding to shear mode of failure a simply supported steel I beam. The beam is subjected to a point load Q at midspan. The following statistics are known about the load and resistance variables.

$$\mu_Q = 4000\ N;\ \ \sigma_Q = 1000\ N;\ \mu_F = 95\ Mpa;\ \ \sigma_F = 10\ MPa$$

$$\mu_D = 50\ mm;\ \ \sigma_D = 2.5\ mm$$

Web thickness, t_w = 1.25 mm (deterministic)

Where D is the overall depth of beam and *F* is the shear strength of material. Q, F and D are uncorrelated normal random variables.

NB: Two cycles of iterations alone expected. (5 marks)

Syllabus and Course Plan

(For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Engineering application of Optimization- statement of an optimization problem-Design vector, design constraints, objective function-classification of optimization problems.	1 Hr.
1.2	Classification of optimization problem based on nature of objective function- linear and nonlinear programming problems-standard form of linear programming problems.	1 Hr.
1.3	Simplex algorithm-identifying an optimal point	1 Hr.
1.4	Duality in linear programming, symmetric primal-dual relation.	1 Hr.
1.5	Primal dual relation when the primal is in standard form-degeneracy	1 Hr.
1.6	Application of linear programming in Civil Engineering	1 Hr.
1.7	Linear programming problem examples on design of tubular column	1 Hr.
1.8	Limit design of steel portal frames-graphical method of solution	1 Hr.
2	**Module II**	
2.1	Dynamic programming-multistage decision process-conversion of a numerical system in to a serial system	1 Hr.
2.2	Concept of sub optimization and the principle of optimality	1 Hr.
2.3	Computational procedure in dynamic programming	1 Hr.
2.4	Unconstrained minimization problem-solution of an unconstrained geometric programming problem using differential calculus	1 Hr.
2.5	History and development of genetic algorithm-basic concepts-biological background	1 Hr.
2.6	Genetic modelling-Representation of design variables, objective function and constraints. Creation of off springs-search space-binary encoding-fitness function	1 Hr.
2.7	Genetic operators-reproduction-roulette wheel selection-cross over-mutation	1 Hr.
2.8	Convergence of genetic algorithm. Comparison of Genetic algorithm with other metaheuristic approaches	1 Hr.
2.9	Solution of constrained optimization problems using genetic	1 Hr.

	algorithm	
	Numerical example using genetic algorithm	1 Hr.
3	**Module III**	
3.1	Uncertainties in engineering design- sources; Need for reliability analysis; **Review of fundamental theory of probability**- events & associated probability; Combination of events; De Morgan's rule; Axioms of probability, conditional probability, statistical independence and total probability theorem Note: examples related to structural engineering for illustration to be given as hand out and discussion on the solved example.	1 Hr.
3.2	Random events and random variables- Probability structure of discrete & continuous random variables	1 Hr.
3.3	Main descriptors of random variables; Moments of random variables	1Hr.
3.4	Common continuous probability distributions (Continuous & Discrete) - Binomial, Poisson, Exponential, Gamma, Uniform, Normal and lognormal distributions- Note: examples related to structural engineering for illustration to be given as hand out and discussion on the solved example.	2Hr.
4	**Module IV**	
4.1	Joint probability distributions– Discrete random variables (bivariate case) – Marginals and conditional distributions - illustrative examples from structural engineering.	1 Hr
4.2	Joint probability distributions– Continuous random variables (bivariate case) Marginal and conditional distributions- illustrative examples from structural engineering.	1 Hr
4.3	Correlation and correlation coefficients - discrete and continuous RV case	1 Hr.
4.4	Functions of random variables- one linear function of multiple random variables – second moment statistics - illustrative examples from structural engineering.	2 Hr
4.5	Nonlinear function of multiple random variables- second moment statistics - illustrative examples from structural engineering.	1 Hr
`5	**Module V**	
5.1	Basics of structural reliability- concept of limit states/ performance functions; Space of state variables.	1 Hr.
5.2	Probability failure for performance function involving normally distributed random variables and lognormally distributed random variables.	1 Hr.
5.3	Definition of reliability in standard Normal space (Cornell's reliability index).	1 Hr.
5.4	FORM for linear performance functions.	1 Hr.
5.5	MVFOSM for non-linear performance functions.	1 Hr.
5.6	Hasofer-Lind's definition of reliability.	1 Hr.
5.7	Rackwitz-Feissler algorithm.	1 Hr.

5.8	Second order reliability methods.	1 Hrs
5.9	Simulation based reliability estimation-Monte-Carlo Methods-simulation of random numbers with arbitrary distributions – estimation of failure probability.	2 Hrs

Reference Books

1. Singiresu S. Rao, “Engineering Optimization (Theory and Practice)” 3rd Edition, New Age International (P) Ltd.
2. Kirsch U., “Optimum Structural Design”, McGraw Hill
3. Fox R.L., “Optimization Methods for Engineering Design”, Addison Wesley
4. Goldberg D.E., “Genetic Algorithms in Search, Optimisation and Machine Learning”,Addison Wesley Publishing Company.
5. Rajasekaran, S. & Vijayalakshmi, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Private Ltd, 2012
6. Krishnamoorthy E.V. and Sen S.K., “Numerical Algorithms”, Affiliated East West Press
7. Haldar A & Mahadevan S. Probability, Reliability and Statistical Methods in Engineering Design, John Wiley & Sons, Inc. NewYork, 2000
8. Haldar A & Mahadevan S. Reliability Assessment Using Stochastic Finite Element Analysis, John- Wiely & Sons Inc., New York, USA, 2000
9. Ayyub B M, McCuen R H. Probability, Statistics and Reliability for Engineers and Scientists, Chapman & Hall, Florida, USA, 2000.
10. Ang A H S & Tang W H. Probability Concepts in Engineering Planning and Design, Vol I, John Wiley, New York, 1984
11. Nowak A.S. and Collins K.R. Reliability of Structures, McGraw-Hill International Editions, USA, 2000.
12. Papoulis A. Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York, USA, 1991.
13. Ranganathan R. Structural Reliability Analysis & Design. Jaico Publishing House, Mumbai, India, 1999.
14. Melchers R E. Structural Reliability: Analysis and Prediction, John Wiley, Chichester, 1999

SEMESTER I

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE042	ADVANCED DESIGN OF STEEL STRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The proposed course is expected to enhance and strengthen the knowledge on detailed design methods for steel structures, in compliance with Indian and International codes. Analysis and design of bolted and welded connections, Design of steel members under special loads like fire and blast loads, design of industrial structures with gantry girders and design of light gauge structures will be discussed.

Course Outcomes; After the completion of the course the student will be able to

CO 1	Design bolted joints
CO 2	Design of welded joints
CO 3	Design light gauge columns, beams, and tension members
CO 4	Understand fire and blast loads
CO 5	Understand various elements in an industrial building and Design gantry girders
CO 6	Draw structural details of bolted and welded joints, light gauge sections and gantry girder.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

Model Question Paper CIVIL ENGINEERING-CE4

Pages: 2 **E**

Reg. No……………… Name:…..…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

ADVANCED DESIGN OF STEEL STRUCTURES

Max. Marks: 60 Duration: 3 Hours

PART A

Answer all questions. Each question carries 5 marks (5× 5=25Marks)

1. Why are HSFG bolts preferred in joints subjected to fatigue?What do you mean by Prying action?
2. Discuss the advantages and disadvantages of welded connections over bolted connections.
3. What is local buckling of thin elements and what do you mean by post buckling strength of light gauge steel members?
4. Draw a plot showing the stress-strain relationships of structural steel marking salient points.
5. Explain sway and non-sway frames. Include at least two examples of each type using appropriate figures.

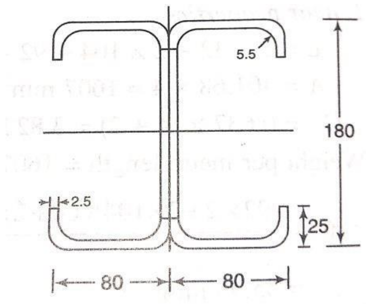
PART B

Answer any five questions (5×7=35Marks)

6. Design a seat connection for a factored beam end reaction of 110kN. The beam section is ISMB 250 @ 36.6 kg/m connected to the flange of column section ISHB 200 @ 36.6 kg/m. Use Fe 410 grade steel and bolt 4.6 grade.

7. Design a welded stiffened seat and clip connection for an ISMB 350 @ 51.4 kg/m to transmit a factored end reaction 320 kN to a column ISHB 300 @ 57.6 kg/m. Steel Fe 410 grade and use fillet weld of required size.

8. Two channels of 180 mm x 80 mm section with bent lips as shown in figure 1 are connected with webs to act as beam. The thickness of the plate is 2.5 mm and the depth of the lip is 25mm. The beam has an effective span of 4.1 m. Determine the allowable load per m run on the beam. The dimensions in the figure 2 are in mm. Use fy = 235 N/mm^2 .



9. A light gauge rectangular box- section with overall cross-sectional dimensions of 200 mm x150 mm (out- to-out), thickness 2.5 mm and fillets of radius 2.5 mm at each of the 4 inside corners, is being employed as a column over an effective length of 3.2 m. Compute the safe load on the column is steel used is having yield stress of 2400 kg/cm^2.

10. Explain the design principles for design of structures against fire, blast and impact loads.

11. Explain the knees and valleys in the steel structures with neat figures.

12. A hand operated 50 kN overhead crane is provided in a workshop. The details are given below: i) Centre to centre between gantry girders = 16 m (ii) Span of the gantry girder = 6 m (iii) Weight of the crane = 40 kN Gantry (iv) Wheel spacing = 3 m (v) Weight of the crab = 10 kN (vi) Maximum edge distance = 1 m. Design a simply supported gantry girder, assuming the flange is laterally supported.

Syllabus

Module 1

Bolted Connections: Classification (Simple, Rigid, Semi rigid)–Moment rotation Characteristics–Failure modes of a joint Types of bolts–Bearing and High strength bolts–Prying force–Beam to Column connections–Design of seat angle–Unstiffened–Design of seat angle–StiffenedWeb angle & end plate connections, Beam and column bolted splices–Design of framed beam connection–continuous beam to beam connection.

Module 2

Welded Connections: Structure and properties of weld metal. Beam to-column connections–Angle seatStiffened beam seat connection–Web angle and end plate connections–Beam and column welded splicesTubular connections–Parameters of an in plane joint Welds in tubular joints–Curved weld length at intersection of tubes–SHS and RHS tubes–design parameters–Weld defects.

Module 3

Design of Light Gauge Structures: Design of light gauge steel structures: Introduction–Types of cross sections–Materials Local and post buckling of thin elements–Stiffened and multiple stiffened compression elements–Tension members– Beams and deflection of beams–Combined stresses and connections.

Module 4

Design of Blast, Impact, Snow and Fire-resistant structures: Blast loads–impact loads–Ice-infested loads on structures–Fire loads–Fire-resistant design–Simple problems in Fire loads calculations.

Module 5

Design of Industrial buildings and Gantry girders: Design of members subjected to lateral loads and axial loads–Sway and non-sway frames, bracings, and bents–Rigid frame joints–Knees for rectangular frames andpitched roofs - Knees with curved flanges–Valley joints - Rigid joints in multistorey buildings–Vierendeel girders–Design of gantry girders–Introduction–Loading consideration–Selection of gantry girder–Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection–Design of gantry girders.

Course Plan

No	Topic	No. of Lectures
1	**Bolted Connections (9)**	
1.1	Classification (Simple, Rigid, semi rigid)–Moment rotation Characteristics–Failure modes of a joint.	1
1.2	Types of bolts - Bearing and High strength bolts- Prying force–Beam to Column connections.	1
1.3	Design of seat angle – Unstiffened.	1
1.4	Design of seat angle – Stiffened.	1
1.5	Web angle and end plate connections.	1
1.6	Beam and column bolted splices.	1
1.7	Design of framed beam connection – continuous beam to beamconnection.	1
2	**Welded Connections (8)**	
2.1	Structure and properties of weld metal–Beam to-column connections–Angle seat.	2
2.2	Stiffened beam seat connection.	1
2.3	Web angle and end plate connections.	2
2.4	Beam and column welded splices.	1
2.5	Tubular connections - Parameters of an in plane joint Welds in tubular joints.	1
2.6	- Curved weld length at intersection of tubes – SHS and RHS tubes - design parameters- Weld defects.	1
3	**Design of Light Gauge Structures (9)**	
3.1	Design of light gauge steel structures: Introduction – Types of crosssections – Materials.	1
3.2	Local and post buckling of thin elements.	1
3.3	Stiffened and multiple stiffened compression elements.	2
3.4	Tension members.	2
3.5	Beams and deflection of beams.	2
3.6	Combined stresses and connections.	1
4	**Design of Blast, Impact, Snow and Fire-resistant structures (7)**	
4.1	Blast loads - impact loads.	1
4.2	Ice-infested loads on structures.	1
4.3	Fire loads.	1
4.4	Fire-resistant design.	2
4.5	Simple problems in Fire loads calculations.	2
5	**Design of Industrial buildings and Gantry girders (7)**	
5.1	Design of members subjected to lateral loads and axial loads.	1
5.2	Swayand non-sway frames, bracings, and bents.	1
5.3	Rigid frame joints - Knees for rectangular frames and pitched roofs - Knees with curved flanges.	1

5.4	Valley joints - Rigid joints in multistorey buildings - Vierendeel girders.	1
5.5	Design of gantry girders - Introduction - Loading consideration- Selection of gantry girder.	1
5.6	Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection.	1
5.7	Design of gantry girders.	1

Reference Books

1. Gaylord, Design of steel structures, McGraw Hill, New York.
2. Duggal.S.K., Limit state design of steel structures, McGraw-Hill.
3. Subramanian.N, Design of steel structures, Oxford.
4. Wie-Wen Yu.,Cold-Formed Steel Structures, McGraw Hill Book Company.
5. Hetherington John and Smith P. D., Blast, and ballistic loading of structures.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE043	FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The proposed course is expected to enhance and strengthen the knowledge on role and responsibility of a forensic engineer, different cause of deterioration in structures and its prevention, the uses of different NDT equipment's, awareness regarding the structural health monitoring, knowledge in Different modern techniques of retrofitting will be discussed.

Course Outcomes: After the completion of the course the student will be able to

CO 1	To understand role and responsibility of a forensic engineer
CO 2	To understand different cause of deterioration in structures and its prevention
CO 3	To gain adequate knowledge for the uses of different NDT equipments
CO 4	To get awareness regarding the structural health monitoring
CO 5	To gain adequate knowledge in Different modern techniques of retrofitting

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

Pages: 2 **E**

Reg. No……………… Name: …...…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION

STRUCTURAL ENGINEERING

221ECE043 FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

Maximum Marks: 60 **Duration : 3 Hours**

PART A

Answer all questions. Each question carries 5 marks (5 × 5=25 Marks)

1 Give the qualities expected for a Forensic Engineer.

2 Give a classified list of common causes of deterioration of concrete structures.

3 What are non-destructive tests? Discuss the usefulness and significance of NDT.

4 Explain the needs and benefits of Structural Health Monitoring.

5 Explain how cracking is treated by external pre-stressing.

PART B

Answer any five questions (5 × 7=35 Marks)

6 i) What are the duties and responsibilities of a Forensic Engineer?

ii) In the context of construction industry, explain the terms responsibility and accountability.

7 i) Discuss the errors in design and mistakes in construction those may lead to the premature failure of concrete structures.

ii) How does i) acid attack and ii) freezing and thawing affect the health of reinforced concrete structures?

8 i) What are the different types of maintenances? Discuss the importance of each one.

ii) Give a classified list of environmental factors causing deterioration in concrete structures.

9 i) What is meant by acid attack? How does it occur? What are its effects on concrete structures?

ii) Describe the principle, procedure, advantages and limitations of ultrasonic pulse velocity test.

10 i) Explain Fibre Optic method for prediction of structural weakness.

ii) Give a list of methods for repair of concrete structures.

11 i) As a forensic engineer, how will you select a method for your client?

ii) Explain how cracking is treated by external pre-stressing.

………………………………….

Syllabus and Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Syllabus:

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability– Causes of distress in structural members– Design and material deficiencies – over loading. Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment– Preventive measures, maintenance and inspection. Diagnosis and Assessment of Distress: Visual inspection – non-destructive tests – ultrasonic pulse velocity method– Rebound hammer technique – pull-out tests – Windsor probe test– Crack detection techniques. Structural Health Monitoring: Introduction – Needs and Benefits of Structural Health Monitoring– Fibre Optic method for prediction of structural weakness –Methods of repair of cracks Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair–Strengthening by prestressing. Repair of steel structures.

Course Plan:

No	Topic	No. of Lectures
1	**Failure of Structures**	
1.1	Review of the construction theory – performance problems – responsibility and accountability	4
1.2	Causes of distress in structural members	3
1.3	Design and material deficiencies – over loading	4
2	**Environmental Problems and Natural Hazards**	
2.1	Effect of corrosive, chemical and marine environment	4
2.2	Preventive measures, maintenance and inspection	3
3	**Diagnosis and Assessment of Distress**	
3.1	Visual inspection – non-destructive tests – ultrasonic pulse velocity method	4
3.2	Rebound hammer technique – pull-out tests – Windsor probe test	3

3.3	Crack detection techniques	2
4	**Structural Health Monitoring**	
4.1	Introduction – Needs and Benefits of Structural Health Monitoring	2
4.2	Fibre Optic method for prediction of structural weakness – Methods of repair of cracks	4
5	**Modern Techniques of Retrofitting**	
5.1	Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair	4
5.2	Strengthening by prestressing. Repair of steel structures.	3

Reference Books

1. Sidney M Johnson, Deterioration, Maintenance and Repairs of Structures, Mc Graw Hill Book Company, New York

2. Dovkaminetzky, Design and Construction Failures, Galgotia Publication., NewDelhi

3. Jacob Field and Kennenth L Carper, Structural Failures, Wiley Europe

4. Design and Construction Failures, Dovkaminetzky, Galgotia Publication, New Delhi, 2009.

5.Concrete – Building Pathology, Macdonald S, John Wiley and Sons, 2002.

6.Forensic Structural Engineering Handbook, Robert. T Ratay, Mc Graw Hill, 2009.

7.Understanding Building Failures, James Douglas and Bill Ransom, Taylor and Francis Group, 2007.

8.Concrete Repair and Maintenance, Peter H Emmons, Galgotia Publications, 2010.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE044	DESIGN OF OFFSHORE STRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The course aims to provide a basic understating of the theory and concepts of analysis and design of Offshore Structures. After the completion of the subject the student is expected to apply the knowledge to design Jacket Platforms which is most relevant for Indian Offshore Region.

Course outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics of wave mechanics and estimate the wave kinematics for regular and random waves
CO 2	Estimate the functional and environmental loads acting on offshore structures.
CO 3	Apply theoretical principles and analytical models in the design of offshore structures conforming to code provisions
CO 4	Design tubular members and joints following API specifications
CO 5	Evaluate the fatigue life of Tubular joints of Jacket Platforms
CO 6	Practice the profession of Structural engineering with adequate proficiency in analysis and design of Offshore Structures

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			3	3	3	3	
CO 2			3	3	3	3	
CO 3			3	3	3	3	
CO 4			3	3	3	3	
CO 5			3	3	3	3	
CO 6			3	3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	10
Evaluate	20
Create	20

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40 + 20 = 60 %.

Model Question Paper CIVIL ENGINEERING-CE4

PART A

(Answer all questions-Each question carries 5 marks)

1. What is a non-linear wave theory? How are they classified? Differentiate with small- amplitude wave theory.

2. Explain the procedure for estimating wind force on an offshore structure.

3. What are the methods of estimating maximum global wave forces on a jacket structure, Explain

4. Why tubular members are commonly used in offshore structures? What are the important factors affecting the strength of a tubular structure?

5. What is stress concentration? Describe the methods for reducing it in tubular joints?

PART B

(Answer any Five questions-Each question carries 7 marks)

1. (a) Explain the classification of offshore structures with sketches.
   (b) A wave flume is filled with fresh water to a depth of 5 m. A wave of height 1 m and period 4 s is generated. Calculate the celerity, group celerity, energy and power.

2. If a pressure sensing instrument is set up at 5 m below SWL in a water depth of 20 m, determine the phase distribution of pressure head. Determine the maximum dynamic pressure. The wave height is 3 m and period is 8s and γ= 10 kN/m3. Also determine the above for a wave with period 4 s.

3. A pile of diameter 0.75m is to be installed in a water depth of 100m. The wave height and wave period are 6m and 10s respectively with Cd = 1 and Cm= 2. Compute the maximum drag force per unit length at a depth of 20m below SWL.

4. Describe the linear diffraction theory. What are the assumptions and boundary conditions?

5. Main leg member of a jacket platform is 1500mm OD x 25mm thick. Effective length of the member is 18m. If the actual axial load is 75% of the maximum permissible axial load, find the additional bending moment that can be resisted by it. Take Fy=250MPa, E=200GPa

6. Tubular member of an offshore structure is subjected to nominal stresses,corresponding number of cycles per year is given below. S_f for member is

found to be 2.9. determine the fatigue life of the member. The S-N curve is represented by logN = 12.164 - 3logS where S is the hot spot stress range in

Nominal stress (N/mm^2)	59	50	40	28	10
Cycles per year	6	150	3340	64050	1142800

N/mm^2.

7. K- joint with the chord and brace details shown below is subjected to axial in plane and out of plane BM. Neglect the stress in the chord member. Yield strength of the connection shall be taken as 345Mpa. Check the safety of the joint.

Data :

Brace 1 d1 = 508 mm t1 = 15.88 mm θ1 = 45°

Brace 2 d2 = 406 mm t2 = 12.7 mm θ2 = 30°

Chord D= 762mm T= 19mm

Gap between braces g = 50mm

Brace 1 P= 900 kN Mip = 275 kNm Mop = 125 kNm

Brace 2 P= 1275 kN Mip = 225 kNm Mop = 145 kNm

Syllabus

Module -I

Basics of Wave Mechanics – Introduction to Offshore structures-classification-fixed, compliant-floating platforms-examples- Wave Theories: Basics of wave motion- Small amplitude wave theory- velocity potential- dispersion relationship- wave kinematics-Pressure under wave-wave energy and power (Numerical exercises to be done)- Finite amplitude waves- classification- Random waves-Wave spectral density-Mathematical spectrum models- Design Wave Method-Spectral Method.

Module -II

Loads on Offshore Structures- Loads on Off shore Structures: Functional loads-Environmental loads-Wave, Wind, and Current Forces- Estimation as per API recommendations - Morison equation- force on vertical and inclined piles- Numerical examples -Wave forces on large structures-linear diffraction theory.

Module- III

Analysis and Design Concepts of Jacket Platforms- Concepts of Fixed Platform Jacket: Components and Funcions, Design Wave Method-Spectral Method- Extreme and Operating Conditions -Estimation of Maximum Wave forces and Moments Maximum Base Shear Method- In-service and Pre-service loads- Principles of Static and dynamic analyses of fixed platforms-In-Place Analysis-Analytical modelling of jacket platforms-deck, jacket and foundation

Module- IV

Steel Tubular Member Design- Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors API specifications for steel-allowable stresses-Design procedure Tubular Members, Slenderness effects; Column Buckling- Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples- Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples.

Module- V

Fatigue in Tubular Joints - Tubular Joints-Classification-Analysis of Joints- Stress Concentration in Tubular joints, S-N curves-Cumulative damage ratio-Fatigue analysis methods- Palmgren- Miner rule- evaluation of Fatigue life of components-numerical examples

Course Plan

No	Topic	No. of Lectures 40
1	**Basics of Wave Mechanics** **9**	
1.1	Introduction to Offshore structures-classification-fixed, compliant-floating platforms-examples	2
1.2	Wave Theories: Basics of wave motion- Small amplitude wave theory- velocity potential- dispersion relationship- wave kinematics- Pressure under wave-wave energy and power (Numerical exercises to be done)- Finite amplitude waves- Classification	4
1.3	Random waves-Wave spectral density-Mathematical spectrum models- Design Wave Method-Spectral Method	3
2	**Loads on Offshore Structures** **7**	
2.1	Loads on Off shore Structures: Functional loads- Environmental loads-Wave, Wind, and Current Forces- Estimation as per API recommendations	3
2.2	Morison equation- force on vertical and inclined piles- Numerical examples	3

2.3	Wave forces on large structures-linear diffraction theory	1
3	**Analysis and Design Concepts of Jacket Platforms**	**8**
3.1	Concepts of Fixed Platform Jacket: Components and Funcions, Design Wave Method-Spectral Method- Extreme and Operating Conditions -Estimation of Maximum Wave forces and Moments Maximum Base Shear Method	3
3.2	In-service and Pre-service loads- Principles of Static and dynamic analyses of fixed platforms-In-Place Analysis	2
3.3	Analytical modelling of jacket platforms-deck, jacket and foundation	3
4	**Steel Tubular Member Design**	**8**
4-1	Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors API specifications for steel-allowable stresses	2
4.2	Design-procedure Tubular Members, Slenderness effects; Column Buckling.	3
4.3	Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples	3
5	**Fatigue in Tubular Joints**	**8**
5.1	Tubular Joints-Classification-Analysis of Joints	2
5.2	Stress Concentration in Tubular joints, S-N curves-Cumulative damage ratio-Fatigue analysis methods	3
5.3	Palmgren- Miner rule- evaluation of Fatigue life of components-numerical examples	3

Reference Books

1. Dr. Sundar V.," Ocean Wave Mechanics -Applications in Marine Structures" John Wiley and Sons Ltd

2. Chakrabarti,S.K., "Hydrodynamics of Offshore Structures", Computational Mechanics Publications, Southampton, Boston

3. Sreenivasan Chandrasekharan," Dynamic Analysis and Design of Offshore Structures" Second Edition, Springer

4. API-Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms.API-RP2A-WSD (2014)-API-RP2A-LRFD (1993)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE045	ANALYSIS AND DESIGN OF SUBSTRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Goal of this course is to expose the students to the concepts of soil structure interaction and design of various sub structures. By the completion of this course the students will be able to analyse and design different types of substructures and thereby develop solutions for real world problems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the soil-structure interaction
CO 2	Analyse and Design shallow foundation
CO 3	Design Pile foundation and Pile cap
CO 4	Analyse and Design Retaining walls
CO5	Design various components of Well foundation
CO6	Analysis and Design Machine foundation

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1			3	1	2	
CO 2	2			3	3	3	
CO 3	3			3	3	3	
CO 4	3			3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination (Marks)
Understand	20
Apply	20
Analyse	10
Evaluate	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum10 publications shall be referred) : 15 marks

Course based task/Seminar/Datacollection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

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Model Question Paper CIVIL ENGINEERING-CE4

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION, Month & Year

221ECE045: Analysis and Design of Substructures

Maximum: 60marks Time 2.5 hrs

PART A (*Answer all questions: Each question carries 5 marks*)

1. Draw the contact stress distribution below a rigid circular footing and explain

2. What is a pile cap. Specify the functions of a pile cap.

3. Explain the different types of retaining walls

4. Define scour depth and grip length

5. Explain vibration isolation

PART B (Answer any 5 questions: Each question carries 7 marks)

6. Design the strap footing to carry two column loads of 1100kN and 2020kN. The columns are 6m between the centres . The sizes of the columns are 500 x 500 mm and 600 x 600 mm respectively. The footing areas under the columns are respectively 1.2 mx3m and 3m x 3m connected by the suitable strap. The safe bearing capacity of the soil is 205 kN/m2, use M20 concrete and Fe 415 steel

7. Design a reinforced concrete combined rectangular footing for two columns located 3m apart. The overall size of the column are 40 x 40 cm and 60 x 60 cm and the loads on them are 120 tones and 160 tones respectively. The space available for the width of the footing is restricted to 10cm. The safe bearing capacity of the soil is 30 tones per m2. Use M15 concrete and Mild steel for reinforcement.

8. The foundation of a structure consist of 16 piles. It carry a total load of 10,000 kN. The piles are 400 mm x 400 mm size and are 8m long. They are spaced at 1m centre to centre. Design one of the piles. Use M20 concrete and Fe 415 steel.

9. Design a pile cap for a column size 500 mm x 500 mm carrying a load of 3000kN supported by 4 piles. The size of the piles may be taken as 300 mm x 300 mm. The c/c distance between the piles is 1.5m. Use M20 concrete and Fe 415 steel

10. The stem of the cantilever retaining wall is 4.5 m, retains soil of specific weight 20000 N/m3 and having angle of repose of 30° Top surface of the retained soil is level. Design the retaining wall. The safe bearing of the soil is 200kN/m2. Use M20 concrete and Fe 415 steel.

11. Design the outside well diameter of a caisson to be sunk through 40m of sand and water bed rock if the allowable bearing capacity is 2200 kN/m2. The caisson receives a load of 5000kN from the super structure. The mantle friction is 32kN/m2. Test the feasibility of sinking. Also calculate the thickness of seal.

12. The exciting force in a constant force amplitude excitation is 100 kN. The natural frequency of the machine foundation is 3 Hz. The damping factor is 0.30. Evaluate the magnification factor and the transmitted force at an operating frequency of 6 Hz

Syllabus

Module 1

Soil-structure interaction: Introduction to soil-structure interaction - Soil-structure interaction problems. Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath raft. Selection of foundation .
Shallow foundations: Structural design of spread footing, combined footing and raft foundation.

Module 2

Pile foundation: Introduction- load carrying capacity -Settlement of single pile-Laterally loaded piles-Borm’s method-Ultimate lateral resistance of piles- Structural Design of straight Piles and Structural Design of pile cap

Module 3

Retaining walls: Types-Stability analysis of cantilever retaining wall against overturning and sliding-Bearing capacity considerations-structural design of retaining walls.

Module 4

Well foundation: Introduction to well foundations-Types-Elements of well foundations-Grip length- depth of scour-load carrying capacity-Design of well cap, well steining, well curb, cutting edge and bottom plug.

Module 5

Machine foundation: Types of machine foundation-Basic principles of design of machine foundation-Dynamic properties of soil-vibration analysis of machine foundation-Design of foundation for reciprocating machines and impact machines-Vibration isolation

Course Plan

No	Topic	No. of Lectures
1	**Soil-structure interaction and Shallow foundations**	
1.1	Introduction to soil-structure interaction - Soil-structure interaction problems.	2
1.2	Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath raft.	3
1.3	Types and Selection of foundation. Structural design of spread footing, combined footing and raft foundation.	3
2	**Pile foundation**	
2.1	Pile foundation: Introduction- load carrying capacity - Settlement of single pile-	2
2.2	Laterally loaded piles-Borm's method-Ultimate lateral resistance of piles-	3
2.3	Structural Design of straight Piles and Structural Design of pile cap	4
3	**Retaining walls**	
3.1	Retaining walls-Types-Stability analysis of cantilever retaining wall against overturning and sliding	3
3.2	Bearing capacity considerations-structural design of retaining walls	4
4.	**Well foundation**	
4.1	Well foundation: Introduction to well foundations-Types-Elements of well foundations-	2
4.2	Grip length- depth of scour-load carrying capacity-	2
4.3	Design of well cap,well steining,well curb,cutting edge and bottom plug	4
5	**Machine foundation**	
5.1	Machine foundation: Types of machine foundation-Basic principles of design of machine foundation	2
5.2	Dynamic properties of soil-vibration analysis of machine foundation-	3
5.3	Design of foundation for reciprocating machines and impact machines-vibration isolation	3

Total hours-8+9+7+8+8=40 hrs

Reference Books

1. Bowles. J.E., " Foundation Analysis and Design", McGraww Hill Publishing co., New York, 1997.

2. Swamy Saran, Analysis and Design of substructures, Oxford and IBH Publishing Co. Pvt.Ltd., 2006.

3.Tomilson.M.J, “Foundation Design and Construction”, Longman, Sixth Edition, Ne Delhi-2009
4. Varghese.P.C, “Design of Reinforced Concrete Foundations”-PHI learning private limited, New Delhi-2009