SEMESTER I

Discipline : CIVIL ENGINEERING
Stream : CE3

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-CE3

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
221TCE005	ADVANCED SOIL MECHANICS	PROGRAM CORE 1	3	0	0	3

Preamble: This course intends to bridge the basic soil mechanics concepts with the advanced topics related to soil strength and volume change. This course is ideal for the orientation of geotechnical engineering post-graduate students to modeling geotechnical problems using geo mechanical concepts .

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

CO 1	To analyse soil water interaction problems and assess its effect on soil behaviour
CO 2	To apply the effective stress concept in solving geo mechanical problems
CO 3	To Understand consolidation and swell phenomenon and apply it to various Geotechnical
CO 4	To evaluate the shear strength behavior of cohesion and cohesionless soil
CO 5	To analyse the stress-strain characteristics of soils, failure mechanism
CO6	Toapply the soil response with constitutive relationships.

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	1	1
CO 2	3	1	3	3	3	1	1
CO 3	3	1	3	3	3	1	1
CO 4	3	1	3	3	3	1	1
CO 5	3	1	3	3	3	1	1
CO 6	3	1	3	3	3	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	25
Evaluate	30
Create	15

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 University. 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

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geotechnical and Geoenvironmental Energy
Specialisation: Transportation Engineering
Subject: Advanced Soil Mechanics
Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1. What is meant by 'base exchange capacity'? List the cations in order of their increasing replacement power. What is the significance of cation exchange?

2. Explain a) Radial consolidation and b)Osmotic swell pressure

3.What are the factors affecting shear strength of cohesive and cohesion less soils?

4.What is the stress path ? What is its advantage over Mohr circle

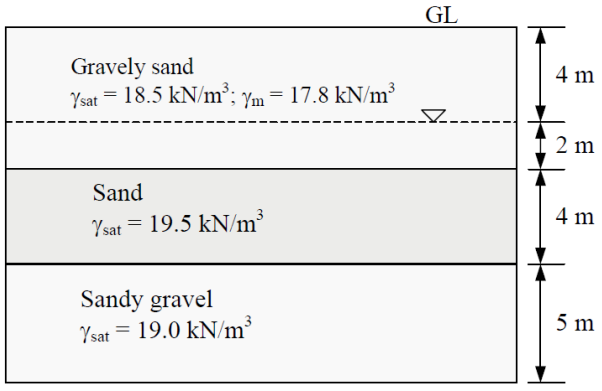
5.Explain about the critical state for over consolidated soil.

(5*5=25)

PART B
(Answer any 5 Questions)

6a)Illustrate the effect of grain size on 'Specific Surface'. How does this influence the engineering behaviour of a soil? **(3)**

6b)Plot the variation of total and effective vertical stresses, and pore water pressure with depth for the soil profile shown below in Fig.1 **(4)**



7a)What is the effect of secondary consolidation on preconsolidation pressure **(4)**

7b)A layer of submerged soil 8m thick is drained at its upper surface but is underlain by an impermeable shale. The sol is subjected to a uniform vertical stress which is produced by the construction of an extensive embankment on the ground surface. If the coefficient of consolidation for the soil is 2 x 10-3 cm2/sec calculate the times when 50% and 90%

respectively of the final settlement will take place. **(3)**

8a).Explain Pore pressure coefficients A and B due to Skempton. What are the effects of overconsolidation on the value of A factor at failure ? Explain briefly the methods of evaluating the value of A and B from laboratory test. **(3)**

8b) In a triaxial test, a soil sample was consolidated under a cell pressure of 700 kN/m^2 and a back pressure of 350 kN/m^2.Thereafter with drainage not allowed, the cell pressure was raised to 800 kN/m^2 resulting in the increased pore water pressure reading of 445 kN/m^2 . The axial load was then increased to give a deviator stress of 575 kN/m^2 (while the cell pressure remained at 800 kN/m^2) and a pore pressure reading of 640 kN/m^2.Calculate pore pressure coefficients. **(4)**

9a). Name the basic stress path used in practice. If the inclination of the p-q plot is 25° to the horizontal, find the value of angle of the shearing resistance of the soil **(4)**

9b)Explain the stress path method of settlement computation **(3)**

10a)Explain the significance of Roscoe and Hvorslev state boundary surface for a critical state **(2)**

10b)Soil sample was isotropic ally consolidated under a cell pressure of 300kPa and unloaded to mean effective stress of 200 kPa. Drained shearing was performed . Determine the principal stress at yield, deviator and mean stress at failure . Initial void ratio is 1.1 .Critical friction angle is 30^0 .Slope of NCL(in e-lnp')(λ) is 0.3 . Slope of unloading line (k)is 0.05. **(5)**

Syllabus and Course Plan		
No	**Topic**	**No. of Lectures**
	Module 1 (8hrs)	
	Soil -Water Interactions	
1.1	Soil structure –Fundamental units: Silica tetrahedron, alumina octahedron, silica sheet, alumina sheet.Types of clay minerals: kaolinite, illite, montmorillonite – classification and identification–Clay mineral identification by XRD	2
1.2	Types of water in soils - soil water – mechanism of soil – water interactions -Its relevance to engineering behavior of soilsFlow of water through soil – Darcy's law – Coefficient of Permeability – Determination of Coefficient of permeability – Factors affecting (Review topics) – Permeability of stratified soil deposits – Field Permeability	2
1.3	Total and Effective stresses, Pore water pressure – various cases(Review topics) Layered soils-	2
1.4	SepageAnalysis :- Seepage force, seepage pressure, quick condition – Liquefaction – Piping resistance of soil Force equilibrium in seepage problems – Effective stress under steady seepage conditions – Two dimensional flow – Laplace's equation – Flownet.	2
	Module 2 (8 hrs)	
	Volume change Behaviour of soils	
2.1	Compressibility of soils: consolidation theory (one, two, and three dimensional consolidation theories), Stress history Pre- consolidation pressure, consolidation in layered soil and consolidation for time dependent loading, secondary compression – Radial consolidation.	5
2.2	Swelling : Problems associated with swelling and shrinkage behaviour of soils –Causes, consequences and mechanisms – factors influencing swell – shrink characteristics – swell potential – osmotic swell pressure – soil suction - measurement of suction and swell.	3
	Module 3 (8 hrs)	
3	**Strength behavior of soils**	
3.1	Shear Strength of soils; Mohr Circle of Stress; UU, CU, CD tests, drained and undrained behavior of sand and clay,	3

3.2	Pore water Pressure :significance of pore pressure parameters; Skempton's pore pressure coefficients	2
3.3	Determination of shear strength of soil, Interpretation of triaxial test results,	3
	Module 4(8 hrs)	
4	**Stress path**	
4.1	Stress path :Drained and un drained stress path	3
4.2	Stress path with respect to different initial state of the soil;	3
4.3	Stress path for different practical situations.	2
	Module 5(8 hrs)	
5	**Critical state soil mechanics**	
5.1	Critical state soil mechanics: Critical state parameters	3
5.2	Critical state for normally consolidated and over consolidated soil	2
5.3	Significance of Roscoe and Hvorslev state boundary surface; drained and undrained plane, Critical void ratio; effect of dilation in sands; different dilation models.	3

Reference Books

1. Braja M. Das, Advanced Soil Mechanics, fifth edition (2019) New York: Taylor & Francis. ISBN 9780815379133

2. Srinath, L. S. Advanced mechanics of solids. Tata McGraw-Hill, 2003.

3. M.E. Harr, Foundations of Theoretical Soil Mechanics., McGraw-Hill, New York, [1966]

4. Holtz, Robert D., William D. Kovacs, and Thomas C. Sheahan. An introduction to geotechnical engineering. Vol. 733. Englewood Cliffs: Prentice-Hall, 1981.

5. Knappett, Jonathan, and Robert F. Craig. Craig's soil mechanics. CRC press, 2019.

6. Smith, Ian. Smith's elements of soil mechanics. John Wiley & Sons, 2021.

7. Atkinson, John. An introduction to the mechanics of soils and foundations: through critical state soil mechanics. McGraw-Hill Book Company (UK) Ltd, 1993.

8. Wood, David Muir. Soil behaviour and critical state soil mechanics. Cambridge university press, 1990.

9. Terzaghi, Karl, Ralph B. Peck, and GholamrezaMesri. Soil mechanics in engineering practice. John Wiley & Sons, 1996.

10. Lambe, T. William, and Robert V. Whitman. Soil mechanics. Vol. 10. John Wiley & Sons, 1991.

11. Mitchell, James Kenneth, and Kenichi Soga. Fundamentals of soil behavior. Vol. 3. New York: John Wiley & Sons, 2005.

12. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.

13. Van Olphen, H. (1977) An Introduction to Clay Colloid Chemistry: For Clay Technologists, Geologists and Soil Scientists. 2nd Edition, Wiley, New York

14. R. E. Grim: Clay Mineralogy. 2nd edition, McGraw-Hill Book Company, New York (1968)

15. Das, Braja M. Principles of geotechnical engineering. Cengage learning, 2021.

16. Donald Coduto, Man-chu Yeung, Man-chu Ronald Yeung, William Kitch. Geotechnical Engineering: Principles & Practices Edition: 2. Pearson City, ISBN: 0132368684

17. McCarthy, David F, Essentials of soil mechanics and foundations: basic geotechnics Edition: 7th, intern. 2014, Pearson City, ISBN: 9781292039398

18. Nagaraj, T. S., and B. R. Srinivasa. Analysis and prediction of soil behaviour. Taylor & Francis, 1994.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE006	FOUNDATION ANALYSIS AND DESIGN	PROGRAM CORE 2	3	0	0	3

Preamble: This Course is designed to provide advanced level knowledge on various type of Foundationsembedded on different type of Soil. By undergoing this course students could acquire detailed information on theoretical methods as well as field tests for computing bearing capacity and settlement of common type of shallow foundations.Apart from this, methods for computing load carrying capacity and settlement of deep foundation structures such as Pile, Caisson, Well and Piled Raft are discussed in this course. Knowledge on Reinforced soil, Machine Foundations and Soil –Structure interaction could also attained by Students after the completion of this Course.

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

CO 1	Compute the bearing capacity of shallow foundations embedded in various type of soils
CO 2	Determine settlement of shallow foundations embedded in various type of soils
CO 3	To compute bearing capacity and safe settlement pressure of Raft foundations constructed in various type of soils
CO 4	Load carrying capacity of pile foundation(individual as well as pile group) constructed in various type of soils
CO 5	To Analyze the well foundations and caissons
CO 6	To get a preliminary knowledge about the Soil- Structure Interaction Studies

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	60%
Analyse	20%
Evaluate	20%
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 University. 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

APJ Abdul Kalam Technological University

First Semester M.Tech Degree Examination

Branch: Civil Engineering

Specialisation: Geotechnical Engg

Subject: FOUNDATION ANALYSIS AND DESIGN

Time: 2.5 Hrs Max. Marks: 60

PART A

(Answer All Questions)

1. Derive Terzaghi's equation for Ultimate bearing capacity for a strip footing

2.What is meant by differential settlement? Explain its significance

3. Describe Piled Raft. What are its advantages and disadvantages?

4. A Concrete pile, 35 cm diameter, is driven in to medium dense sand ($\phi = 35°$; $\gamma = 19$ kN/m^3 ; K = 1.0; tan $\delta = 0.70$) for a depth of 9.0 m. Estimate the safe load, taking a Factor of safety of 3.0. For $\phi = 35°$, De/B = 12.0

5. Explain the following: - (i) Contact Pressure and (ii) Winkler Model

(5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. A footing 1.5 m square is laid at a depth of 1.2 m below the ground surface. Determine the net ultimate bearing capacity using IS Code method. Take $\phi' = 30°$; $\gamma = 18$ kN/m^3 and c' = 0. Assume (i) Water Table at great depth and (ii) Water Table at the level of base and (iii) Water Table is at Ground surface. For $\phi' = 30°$, $N_c = 30.14$; $N_q = 18.4$ and $N_\gamma = 22.4$

7. Determine the allowable bearing capacity of a 1.5 m × 1.5 m square footing founded at a depth of 1.4 m below the ground level in 6.0 m deep stratum of silty clay having the following properties. Unit wt. of soil is 16.0kN/m^3 and 17.5 kN/m^3 respectively above and below the water table. c = 30 kN/m^2; $\varphi = 0$; $C_c = 0.30$; $e_o = 0.70$. The maximum permissible settlement of footing is 6.5 cm. The highest position of the water table at the site is at a depth of 1.8 m below ground level

8. A building is supported on nine columns with square pattern. Columns are supported by individual square column footings. Centre to Centre distance between the columns/column footings are 6.0 m in both directions. The column loads are indicated in the following table.

Column No	1	2	3	4	5	6	7	8	9

Dead Load(kN)	200	370	250	310	600	370	190	370	220
Max Live Load (kN)	175	410	220	310	730	370	130	310	190

Proportion the column footings for equal settlement. At the selected depth of 1.5 m, the allowable bearing capacity is 240 kN/m^2

9. (i) Explain floating foundation

(ii) Explain the different types of Raft Foundation

(ii) Determine the allowable soil pressure for a Raft having 8.5 m × 13.0 m size, if the average blow count over 28 m depth is 15. Use IS Code method

10.(i) Explain Negative skin friction

(ii) A Square Pile group consists of 9 friction piles having 40 cm diameter and 12 m in length driven in clay (C_u = 75 kN/m^2 ; γ = 18.5 kN/m^3). Spacing between the adjacent piles in the group is 0.80 m. Determine the safe load for the group (FS = 4.0 ; α = 0.65)

11. A circular well of 4.1 m external dia and 0.80 m steining thickness is used as a foundation for a bridge pier in a sandy stratum. Submerged unit wt of sand is 9.0 kN/m^3 and ø = 30 °. The well is subjected to horizontal force of 470 kN and a total moment of 4700 kNm at the scour level. Depth of well below scour level is 12.0 m. Assuming the well to be light ,check the lateral stability of the well . If the well is not stable, find the minimum depth of the well, required for lateral stability.

12. Explain the following (i) Eccentrically loaded footings (ii) Bearing capacity of a square footing embedded in cohesionless soil from SPT results (iii) Pnematic Caisson and (iv) Soil-Structure interaction.

(5 x 7 = 35 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 Bearing capacity of Shallow Foundations**	**08 hours**
1.1	Introduction - various type of shallow foundations and Bearing Capacity (Review topics) - Bearing capacity theory proposed by Terzaghi-Effect of water table on bearing capacity	03
1.2	Bearing capacity theories proposed by Meyerhof, Hansen, Vesic and Skempton. Bearing capacity as per IS Code	02
1.3	Loads on Foundation structure- Eccentricity of load on bearing capacity-inclination of load on bearing capacity- Foundations on layered soil, Foundations on sloping ground.	03
2	**Module 2 -Settlement of Shallow Foundations**	**08 hours**
2.1	Importance of settlement analysis- Causes of settlement, immediate and consolidation settlement (Review topics) Elastic formulae for immediate settlement-Consolidation settlement	03
2.2	Load for settlement analysis-Uniform and differential settlement-permissible settlement as per IS Code- Proportioning of footings for equal settlement- Effect of settlement on structures	03
2.3	Other methods for determining bearing capacity and settlement (Review topics)- Bearing capacity from SPT-Safe settlement pressure from SPT-Allowable soil pressure	02
3	**Module 3**	**08 Hours**
3.1	Raft Foundations:-Introduction- Application and types of Raft (Review topics)- Analysis of Raft- Allowable soil pressure for Raft on Cohesion less soil based on SPT –IS specifications- Raft on Clay- Floating foundation-problems to be considered in the design of a floating foundation-Design methods for Raft Foundations-Rigid beam method, Elastic plate method	04
3.2	Piled Raft –Introduction-Necessity- Application- Types- Piled Raft for Settlement reduction- Piled Raft for Load Transmission.	03
3.3	Footings embedded over a Reinforced Soil bed (General features only)	01
4	**Module 4**	**08 hours**
4.1	Pile foundations- Necessity of pile foundation, classification of pile(Review topics) load carrying capacity of individual pile–	02

	Theory and methods - Load transfer mechanism	
4.2	Pile group- Load carrying capacity of pile group- Efficiency of pile group- Settlement of pile group- capacity of piles founded on solid rock- IS specifications for pile foundations Negative skin friction- Under-ReamedPiles-Laterally loaded piles-	04
4.3	Machine Foundations- Types- General Design considerations	02
5	**Module 5**	**08 hours**
5.1	Caisson and Well Foundations- Types-Construction aspects (Review topics)–Scour depth-grip length- thickness of Steining-bottom plug	02
5.2	Forces acting on well-bearing capacity of wells- Bearing capacity of Well Various method of Analysis-Lateral Stability-Terzaghi's method of Analysis- Design aspects- IRC and IS specifications.	03
5.3	Introduction to Soilstructure Interaction studies-Contact Pressure – Modulus of subgrade reaction- Interaction models -Winkler Model	02

Reference Books

1. Nainan P Kurian "Design of Foundation Systems: Principles and Practices" Narosa publish House New Delhi

2. Joseph E. Bowles, "Foundation Analysis and Design" McGraw-Hill.

3 P C Varghese, ".Foundation Engineering " Prentice-Hall of India Pvt Ltd

4. Peck, R.B., Hanson, W.E. and Thornburn, T.H., "Foundation Engineering", 2nd Edition, Wiley Eastern Ltd., New York.

5. Teng, W.C., "Foundation Design", Prentice-Hall of India (Pvt) Ltd., New Delhi.

6. IS: 6403 "Code of Practice for Determination of Bearing Capacity of Shallow Foundations", Bureau of Indian Standards, New Delhi.

7. IS 1904 Design and Construction of Foundations in Soils- General requirements

8. IS: 2911 (Part 1) Section 1 to 4 "Code of Practice for Design and Construction of Pile Foundations", Bureau of Indian Standards, New Delhi.

9. IS: 8009 (Part I & II) "Code of Practice for Calculation of Settlements of deep Foundations",Bureau of Indian Standards, New Delhi.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LCE002	ADVANCED GEOTECHNICAL LABORATORY 1	LABORATORY	0	0	2	1

Preamble: This laboratory course intends to equip the students to analyze the different methods in determining the engineering and index properties of soil. This will in turn orient the prospective geotechnical engineering post-graduate students to get exposed to geotechnical problems with an engineering judgement.

Course Outcomes: To make the students aware of Laboratory Testing of Soils.

After the completion of the course the student will be able to

CO 1	To evaluate specific gravity ,water content ,and consistency limits of soils
CO 2	To analyse grain size distribution and swelling characteristics of fine and coarse grained soils
CO 3	To evaluate permeability and consolidation characteristics of soils
CO 4	To analyse shear strength parameters of soils
CO 5	To evaluate compaction and CBR characteristics of soils
CO 6	To understand the types, applications of geotextiles and properties.

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	1	3	2	2	2
CO 2	2	2	1	2	2	2	2
CO 3	2	2	1	2	2	2	2
CO 4	2	2	1	3	2	2	2
CO 5	2	2	1	3	2	2	2
CO 6	2	2	2	3	2	2	2

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	
Analyse	50%
Evaluate	50%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: TEST I (All Cos) at the end of Semester and credit should be taken for Viva for each Lab session and total credit for Viva marks should be 20 which should be added to TEST I which will be assessed in 80 marks

Split up of 80 marks: (Procedure -10, Working-10, Tabulation (15), Calculations (25), Result (10), Viva (10)

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
1	**Specific gravity, Water content &, Atterbergs limit**
1.1	Specific Gravity & Moisture content
1.2	Liquid limit & Plastic Limit
1.3	Shrinkage limit
2	**Grain size distribution tests and Swelling test**
2.1	Dry and wet Sieve Analysis
2.2	Hydrometer Test
2.3	Swell Test
3	**Permeability Test,Consolidation Test**
3.1	Constant head permeability test
3.2	Variable head permeability test
3.3	Consolidation test
4	**Shear strength Tests**
4.1	Direct Shear test
4.2	Unconfined Compression Test
4.3	Triaxial test
5	**CompactionTest & CBR**
5.1	Light Compaction test (Proctor test)
5.2	Heavy Compaction test (Modified Proctor Test)
5.3	CBR
6	Geotextiles
6.1	Introduction to types, applications and properties of geotextiles

Reference Books

1.K. R. Arora, Soil Mechanics and Foundation Engineering, 7th Edition, New Delhi, Standard Publishers, 2019, ISBN: 13-978-8180141126

2.IS 2720 (Part I to XLI) Methods of tests for soils

SEMESTER I

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE024	GROUND IMPROVEMENT TECHNIQUES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course is designed **to** provide fundamental knowledge on ground modification to students. It enables the students to select and design appropriate ground improvement techniques for specific cases. Also it directs students to refer up-to-date journal articles to study the state of the art in ground improvement.

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

CO 1	Analyze the suitability of a ground improvement technique for a specific case
CO 2	Design a suitable ground improvement technique
CO 3	Analyze the safety of a reinforced soil wall.
CO 4	Explain the stabilization mechanism in each of the 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	2	2	3	3	1	1
CO 2	1	3	1	3	3	1	1
CO 3	1	2	3	3	1	1	1
CO 4	1	1	3	1	1	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10%
Understand	10%
Apply	60%
Analyze	20%
Evaluate	0
Create	0

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Total Marks	Assignments	Test 1	Test 2
40	10	15	15

End Semester Examination Pattern:

There will be two parts; Part A and Part B.
Part A contains 5 questions with 1 question from each module having 2 marks for each question. Students should answer all questions.
Part B contains 2 questions from each Module 10 marks of which student should answer any one question from each Module.

Model Question Paper

Course Code: XXXXX

Course Name: GROUND IMPROVEMENT TECHNIQUES

Max.Marks:60 Duration: 2.5 Hours

PART A

Answer all questions; each question carries 2 marks.

(5×2 marks = 50 marks)

1. Explain the importance of zone of seasonal change in ground improvement.
2. What is the principle of blasting technique for compaction?
3. What are the different types of geo synthetics used in reinforced earth walls?
4. Explain the term groutability.
5. Provide an example of soil stabilisation using cooling.

PART B

Answer one full question from each module (10 × 5 =50 Marks)

Module I

6. (a) Explain the classification of ground stabilisation techniques.
   (b) Suggest a suitable technique for stabilizing a profile with black cotton soil and explain its reason.
7. A Construction site requires an excavation of a rectangular area of size 200 m × 200 to a depth of 12 m, The existing groundwater table is at 4 m. Below the ground surface is a 25 m thick gravel layer with a permeability of 5.0×10^{-5} m/s, which is underlain by bedrock. The groundwater table should be lowered to 2 m below the bottom of the excavation. Deep wells are used to dewater the site. Calculate the total required discharge. If 200 mm diameter deep wells are used, how many deep wells are required?

Module II

8. (a) Explain the principle of vibro compaction method.
   (b) Can we use blasting technique to stabilise a deep clay layer? Substantiate your answer.
9. Explain the design parameters and procedure of dynamic compaction.

Module III

10. A soil nailed wall is needed for an excavation in uniform silty sand. The excavation depth is 8 m. The wall has a batter of 12∘ without a top slope. The soil has cohesion of 3 kPa, friction angle of 30∘, and unit weight of 18kN/m^3. The required global factor of safety is 1.5 and the factor of safety against pullout is 2.0. Determine the layout, length, and size of soil nails. Assume soil nails are placed in spacing of 1.5m in vertical and horizontal directions. (Design chart shall be provided)

11. Explain the design procedure of a reinforced earth wall constructed with the help of geogrids.

Module IV

12. (a) Explain the principle of compaction grouting.
    (b) Describe briefly how lime stabilisation works in clayey soil.
13. A site consists of a loose medium sand (D_{15} = 0.09 mm), which is located at a depth from 4.0 to 5.0 m. The groundwater is at the depth of 2.5 m. The permeability of this sand is 0.0015 m/s. This loose sand has liquefaction potential; therefore, it should be improved. Permeation grouting is selected for this improvement. Design the permeation grouting.

Module V

14. Explain Electro kinetic stabilisation with example.
15. What does the term sustainable ground improvement mean? Detail any one ground improvement technique which can be classified as sustainable.

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

Understanding the need for ground improvement. Identification of challenges in various soil types of soil profiles. Study of different methods including, Drainage and dewatering methods; In-situ densification methods; Grouting; Earth reinforcement; Thermal stabilization; electrokinetic stabilization; Microbial methods.

No	Topic	No. of Lectures
	Module 1	
1.1	Need for ground improvement, and its area of application.	1
1.2	Classification of ground stabilization techniques	1
1.3	Introduction to problematic soil. Fundamental reasons for the behavior of problematic soils.	2
1.4	Drainage and dewatering: well point system, shallow well system, deep well system, vacuum dewatering.	2
1.5	Electro osmosis	1
	Module 2	
2.1	In situ densification, principle, and applicability. Properties of compacted soil. Intelligent compaction.	1
2.2	Dynamic compaction.	2
2.3	Vibro compaction methods	2
2.4	Blasting technique for compaction	1
2.5	Preloading, and design of vertical drains	2
	Module 3	
3.1	Concepts of reinforced earth.	1
3.2	Geosynthetics classifications and functions.	2
3.3	Construction procedure of reinforced earth structures.	1
3.4	Stability analysis of reinforced earth retaining walls	2
3.5	Soil nailing, design, and construction.	2
	Module 4	
4.1	Introduction to grouting techniques and their applications.	1
4.2	Grouting materials and groutability	2
4.3	particulate grouting, Compaction grouting, penetration grouting, jet grouting, displacement grouting-Procedure-soil suitability-merit and demerit.	3
4.4	Lime stabilization and cement stabilization mechanism and application procedures.	3
	Module 5	
5.1	Thermal methodstabilization by heating or cooling	1
5.2	Electro kinetic stabilization	2

5.3	A sustainable method of ground improvement, Microbial methods	2
5.4	Micro piles design and construction.	2
5.5	Emerging trends in ground improvement and prospects	1

Reference Books

1. P. Purushothama Raj, Ground Improvement Techniques, Laxmi Publications (P) Ltd.

2. Manfred. R. Hausmann, Engineering Principles of Ground Modification, McGraw Hill, 1989

3.M.P. Moseley and K. Kirsch (Edited), Ground improvement, Second edition, Spon Press, Taylor, and Francis group

4. Jie Han, Principles and Practices of Ground Improvement, Wiley, 2015

5. Jeffrey Evans, Daniel Ruffing, David Elton, Fundamentals of Ground Improvement Engineering, CRC Press 2023

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE025	TRANSPORTATION GEOTECHNIQUE	PROGRAM ELECTIVE I	3	0	0	3

Preamble: The course enables the students to design various types of soil structures which are geotechnical components of transportation network using appropriate methods and tools. It introduces the applications of principles of soil mechanics to analyse and design such structures. Specific cases of flexible pavements, reinforced soil retaining walls and embankments are also discussed at length. The course trains the students to design these structures as per codal provisions related to highways, railways and airfields.The design of drainage components is also given importance.

Prerequisite: Courses on soil behaviour and highway engineering

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

CO No.	Description of Course outcome	Knowledge level
221TCE 025.1	**Infer** the soil properties for design of transportation network components	K4 Evaluate
221TCE 025.2	**Plan** and **Judge**the actual construction and monitor the performance of geotechnical aspects of transportation network components	K6 Create
221TCE 025.3	**Design** the main and sub components of geotechnical aspects of transportation network	K6 Create
221TCE 025.4	**Asses** the effect of drainage on the behaviour of pavements	K4 Evaluate

Mapping of course outcomes with program outcomes

Mapping computation matrix

		Independently carry out research/investigation	Communicate effectively	Mastery over specialisation area	Apply knowledge in real life problems	Use of appropriate tools for problem solving	Life-long learning	Management skills
		PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
	KL	6	NA	NA	3	3	NA	6
221TCE025.1	4	-2	NA	NA	-1	1	NA	-2
221TCE025.2	6	0	NA	NA	3	3	NA	0
221TCE025.3	6	0	NA	NA	3	3	NA	0
221TCE025.4	4	-2	NA	NA	-1	1	NA	-2

Mapping matrix

PO No. / CO No.	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
221TCE025.1	2	NA	NA	3	3	NA	2
221TCE025.2	3	NA	NA	3	3	NA	3
221TCE025.3	3	NA	NA	3	3	NA	3
221TCE025.4	2	NA	NA	3	3	NA	2

Assessment Pattern

Bloom's Category	End Semester Examination
Apply K3	24 (5 x 1 + 7 x 2)
Analyse K4	24 (5 x 1 + 7 x 2)
Evaluate K5	12 (5 x 1 + 7 x 1)

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 reviewedOriginal publications (minimum 10publications 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 answerquestions with 1 question from each module, having 5 marks for each question (suchquestions 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 questionsshall be useful in the testing of overall achievement and maturity of the students in acourse, through long answer questions relating to theoretical/practical knowledge,derivations, problem solving and quantitative evaluation), with minimum one questionfrom each module of which student should answer any five. Each question can carry7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed20% over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60%.

Model Question Paper

Slot D

Geotechnical Engineering Stream
Program Elective I
221ECE025 Transportation
Geotechnics Time: 2.5 hours Max. marks: 60

Part A
Answer all questions
Each question carries 5 marks

Qn no.	Question	CO	KL
1.	Explain how the effective modulus/CBR for design is arrived at as per codal provisions?	CO1	K3
2.	a. Compare the desirable CBR for the design of highway and airfield pavements. b. Explain the method of conducting CBR test in the field.	CO1 CO2	K4
3.	Detail the steps involved in the external stability analysis of a reinforced soil wall.	CO3	K5
4.	Give the details of codal specifications for the construction of railway embankments in soft soils.	CO2	K4
5.	Design a geotextile filter surrounding an open graded stone aggregate that in turn surrounds a perforated pipe underdrain. Flow will enter through the stone base from the upper part of the underdrain while soil infiltration will come from the surrounding native soil. The soil is a dense sand silt (ML) with relevant properties of 15% non-plastic fines with C_C = 2,C_U = 5, I_D= 80%, d_{50}= 2.035 mm and k= 1 x 10^{-5} m/s. The geotextile being considered is non-woven needle felt with laboratory tested values of ψ = 1.5 s^{-1} and AOS = 0.212 mm. The cross-sectional dimensions of the drain are 400 mm x 300 mm. There is a stone base course of 450 mm thickness above the drain.	CO3	K4

Part B
Answer any *five* questions
Each question carries 7 marks

Qn no.	Question	CO	KL
6.	An embankment of width 10 metre and side slope 1.5:1 is required to made on ground which is level in a direction transverse to center line. The central height at 20 m intervals are as follows: 0.8, 1.2, 2.25, 2.6, 1.9, 1.4, 0.9. Calculate the volume of the earth work related to the embankment construction using trapezoidal formula.	CO1	K3
7.	Design a bituminous pavement with granular base and sub-base layers using thefollowing input data: (i) Four lane divided carriageway (ii) Initial traffic in the year of completion of construction = 5000 cvpd (two-way) (iii) Traffic growth rate per annum = 6.0 per cent	CO3	K5

	(iv) Design life period = 20 years (v) Vehicle damage factor = 5.2 (taken to be the same for both directions) (vi) Effective CBR of subgrade = 7 % (vii) Marshall mix design carried out on the bituminous mix to be used in the bottom bituminous layer (DBM) for an air void content of 3% resulted in an effectivebitumen content (by volume) of 11.5%.		
8.	Detail the design criteria related to a soil nailed wall.	CO3	K4
9.	Give the details of codal specifications for the construction of railway embankments for high-speed rails.	CO2	K4
10.	Calculate the factor of safety of a 500 gsm needle-punched non-woven geotextile required to train border from behind an 8 metre high concrete cantilever retaining wall if it has an allowable transmissibility of 0.15×10^{-3} m^2/min measured at its maximum design pressure. The soil backfill is silty sand (ML-SW) with $k = 5 \times 10^{-5}$ m/s.	CO2	K5
11.	a. What is the purpose of using Proctor needle in the field? b. How is the calibration chart for Proctor needle prepared in the lab? c. How is the calibration chart for Proctor needle used in the field?	CO1	K3
12.	a. List out and define the design parameters involved in the design of stone columns. b. Explain the concept of replacement ratio in the design of stone columns.	CO1	K3

Reconnaissance, site investigation and evaluation of properties of soil at the site; quantity and cost estimation of earthwork; field densification techniques; design criteria and construction guidelines for construction of flexible pavements, reinforced soil walls, soil nail walls, embankmentsin soils, high embankments and embankments for high-speed rails

Course Plan(For 3 credit courses, the content is for 40 hrs)

No	Topic	No. of Lectures
1	**Module 1:Soil properties**	
1.1	Planning of a sub-surface exploration programme; Site investigation; Soil sampling – undisturbed and undisturbed; Determination of dry density and moisture content – light and heavy compaction, Resilient modulus, Field CBR, Effective Modulus/CBR for design – Determination and IRC specifications, SPT & CPT – correlations and corrections, moisture content – rapid determination, proctor needle	3
1.2	Computation of earthwork – prismoidaland trapezoidal formulae; Cost estimation of pavements and embankments as per IRC and Railway design manual guidelines.	2
1.3	Field densification techniques: Cohesionless soils – deep dynamic compaction - vibro compaction – blasting; Cohesive soils - preloading, sand drains, PVDs, stone columns – design criteria, lime and chemical stabilisation	3
2	**Module 2:Flexible pavements – Design and Construction**	
2.1	General design principles of flexible pavements – geotechnical aspects only - highway and airfield pavements Component layers of flexible pavements; IRC specifications - Pavement Section with Bituminous Layer(s), Granular Base and GSB – IRC specifications – materials, minimum thickness	2
2.2	Factors affecting design and performance of pavements - Traffic Growth Rate, Design Period,Vehicle Damage Factor, Lateral Distribution of Commercial Traffic over the Carriageway, Computation of Design Traffic; Wheel loads -Concept of ESWL for multiple wheel load; Desirable soil properties for highway and airfield pavements, railway embankments	3
2.3	Steps involved in the Pavement Design – as per IRC guidelines - Design of Bituminous Pavement with Granular Base and Sub-base – example; Design of reinforced soil flexible pavement with geotextile as separator; Use of IITPAVE in pavement design	3
3	**Module 3:**Reinforced soil walls – Design and Construction	
3.1	Construction – materials used – specifications	2
3.2	Geosynthetic reinforced soil walls - construction guidelines and Design criteria as per IRC	3

No	Topic	No. of Lectures
3.3	Soil nailed walls – construction guidelines and Design criteria as per FHWA; Salient features of Plaxis 2D software	3
4	**Module 4:**Embankments – Design and Construction	
4.1	High embankments and embankments in soft soils – construction guidelines –design criteria as per Railway design manual	3
4.2	Reinforced soil embankments – basal reinforcement and slope reinforcement - construction guidelines – design criteria for basal reinforcement alone	3
4.3	Embankments for high-speed rails construction guidelines – design criteria; Salient features of GeoStudio software	2
5	**Module 5:**Drainage in pavements, embankments and retaining walls	
5.1	Computation of flow – surface and sub surface flow – permeability, transmissivity	2
5.2	Design of filters and drains – sand and geosynthetic materials - specifications and design	4
5.3	Surface and sub surface drains – specifications as per MoRTH, Railway design manual	2
	Total hours	40

Reference Books

1. Babu, G. L. S.,'Soil Reinforcement and geosythetics', University Press, 2006.
2. GopalRanjan& Rao, A.S.R., 'Basic and Applied Soil Mechanics', 3rd edition, New Age International (P) Limited, New Delhi, 2002
3. Huang, Y. H.,'Pavement Analysis and Design', 2nd edition, Prentice Hall, 2004
4. IRC: 37-2018, "Guidelines for the Design of Flexible Pavements", Third Revision, Indian Roads Congress, New Delhi, 2018.
5. Jayasree, P. K., Balan K. and Rani V., "Practical Civil Engineering", CRC Press, Taylor and Francis, 2021.
6. Koerner, R M., "Designing with Geosynthetics", 6th edition, Prentice Hall Mc Graw Hill, 1986

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE026	WASTE MANAGEMENT AND CONTAINMENT SYSTEMS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: To impart knowledge on waste management and containment systems with emphasis on subsurface flow and transport of contaminants; liner systems, leachate collection, removal systems for landfills and use of geosynthetics

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

CO 1	Identify the composition of wastes and develop idea about hazardous waste management
CO 2	Categorize low permeability liners and drainage materials
CO 3	Compare the use of vertical barriers and geosynthetics in waste management
CO 4	Identify sludge solidification and stabilisation methods
CO 5	Identify energy generation techniques from waste

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	2	1	1
CO 2	3	3	3	3	2	1	1
CO 3	3	3	3	3	2	1	1
CO 4	3	3	3	3	2	1	1
CO 5	3	3	3	3	2	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70%
Analyse	30%
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 %

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geotechnical and Geoenvironmental Energy
Specialisation: Transportation Engineering
Subject: 221ECE026 WASTE MANAGEMENT AND CONTAINMENT SYSTEMS Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1. Explain the significance of diffusion in contaminant transport through fine grained materials

2. Explain the construction control and quality assurance of low permeability compacted clay liners

3. Explain soil geosynthetic friction tests

4. Explain liquid-solid separation process and biological treatment process

5. What is Briquetting? Describe the environment benefits of biochemical and thermo-chemical conversion. (5 x 5 = 25 marks)

PART B
(Answer any 5 Questions)

6. Describe Geochemical Attenuation with examples. What are the steps involved in quantifying attenuation capacities?
7. Explain the methods for calculating contaminant migration
8. Explain the hydraulic conductivity requirements, chemical compatibility and filter requirements of drainage materials.
9. Explain the types, functions and material properties of geogrids and geosynthetic clay liners in waste containment.
10. Describe the encapsulating agents used in the solidification/stabilisation methods.
11. Define gasification. What are the types of gasifiers? Explain the industrial applications of gasifiers
12. Describe the engineering properties of wastes. (5 x 7 = 35 marks)

No	Topic	No. of Lectures
1	**Waste characterisation and soil-waste interaction**	
1.1	Composition of wastes-chemical and biochemical reactions within and below a waste disposal site-soil-waste interactions-engineering properties of wastes - Contaminant transport in soils-determination of parameters	3
1.2	Methods for calculating contaminant migration-significance of diffusion	2
1.3	Hazardous waste management - impact on environment - control – minimization and recycling – Assessment of hazardous waste sites – disposal Underground storage tank construction – installation – closure	3
2	**Low-permeability liner and drainage materials, lining systems**	
2.1	Hydraulic conductivity-testing-field hydraulic conductivity testing	2
2.2	Low-permeability compacted clay liners- low permeability admixed soil liners- drainage materials	3
2.3	Containment lining systems-cover lining systems - specifications-construction-quality assurance-water balance for landfills-stability of landfills	3
3	**Vertical barriers: slurry walls, geosynthetics**	
3.1	Introduction-Trench-slurry interaction - permeability, compatibility and strength of the barrier walls	3
3.2	Construction-specifications-construction quality control and quality assurance	3
3.3	Geosynthetics in waste containment and cover systems	2
4	**Sludge solidification and stabilisation**	
4.1	Terminology and regulatory requirements-physical and chemical tests for regulatory compliance	3
4.2	Treatment methods-solidification/stabilisation methods-construction methods-safety. quality control and closure	3
4.3	Leachate collection and removal systems	2
5	**Energy Generation from waste**	

5.1	Types - biochemical conversion – sources of energy generation – industrial waste – agro residues – anaerobic digestion – Biogas production – types of biogas plant thermo-chemical conversion	3
5.2	Sources of energy generation – gasification – types of gasifiers - industrial applications of gasifiers –	2
5.3	Briquetting – utilization and advantages of briquetting – environment benefits of biochemical and thermo-chemical conversion	3

Reference Books

1. Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation, Hari P Sharma, Sangeetha P Lewis, Wiley-Interscience; 1st edition (19 September 1994)

2. Geotechnical practice for waste disposal, David E Daniel, Springer-Science + Business media, B.V, 1996

3. Guide to Hazardous materials and waste management , Jon W.Kindschy, Marilyn Kraft, Molly Carpenter, Solano Publishers, 1997

4. Hazardous wastes : sources, pathways, receptors, Richard J Watts, Wiley, 1998

5. Geosynthetic Clay Liners for Waste Containment Facilities, Abdelmalek Bouazza, Jr. Bowders, CRC Press, 2010

6. Geosynthetic Testing for Waste Containment Applications, ASTM Special Publication, 1990

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE027	ENVIRONMENTAL REMEDIATION ENGINEERING	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course details the usual remediation techniques practiced worldwide and provide an understanding of the relevant theoretical concepts.

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

CO 1	Develop understanding of integrated approaches to remediating contaminated sites.
CO 2	Quantify relationships that link contaminant fate and transport with chemical and physical properties of contaminants and contaminated sites.
CO 3	Describe the conditions in contaminated soil and groundwater that influence microbial activity and the success of desired bioremediation strategies.
CO 4	Propose relevant techniques to thermally bioremediate soils in a variety of scenarios involving mixtures of traditional and emerging contaminants.
CO 5	Develop the ability to screen, choose and design electrokinetic appropriate technologies for remediation.

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	
CO 2	3	2	3	3	3	3	
CO 3	3	2	3	3	3	3	
CO 4	3	2	3	3	3	3	
CO 5	3	2	3	3	3	3	
CO 6	3	2	3	3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70 %
Analyse	30 %
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

APJ Abdul Kalam Technological University

M.Tech Degree Examination

Branch: Geotechnical and Geoenvironmental Energy

Subject: ENVIRONMENTAL REMEDIATION ENGINEERING

Time: 2.5 Hrs Max. Marks: 60

PART A

(Answer All Questions)

1. The groundwater of a particular area is contaminated with leachate from a landfill having Arsenic, with the reference dose (3*10-4 mg/kg-day) and a daily intake (DI) (0.3 mg/kg-day). Find out the hazard quotient(HQ)?

2. Explain the characteristics of barrier material

3. Explain the Advantages and limitations of bioremediation

4. The concentration of contaminant before entering PRB is 10 mg/l. However, the concentration is reduced after contaminant transported through PRB to a value of 1 mg/l. The safe limit of the contaminant is 2 mg/l. In this scenario, what would you suggest ?

5. Explain the different types of contaminant transport mechanism involved in electrokinetic remediation. (5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. A solid contaminant is dissolved in an aquifer. The aquifer has a porosity of 0.4. The dissolved volume of contaminant in GW is 500 L. The pumping out of an extraction well is performed at a flow rate of 2 L/day. Calculate the remediation time required for the contaminated site.

7. Explain in detail Permeable Reactive Barriers

8. Discuss the Phtyoremediation technologies for soil decontamination

9. A ground water contaminant that transports through PRB has a retention time of 48 hrs. The discharge rate is observed as 0.05 m^3/hr. The aquifer has a porosity of 0.4. The c/s area through which the flow is occurring is 150 m^2. Evaluate the thickness of PRB?

10. Explain the mechanism involved in soil washing

11. Explain the Electrokinetic technology to remediate heavy metal contaminated soil.

12 . A contaminant is detected in both adsorbed and dissolved phases at a particular site. The partitioning coefficient of adsorbed contaminant is estimated as 3 L/Kg. The porosity and dry density of contaminated soil are 0.4 and 1.6 Kg/L respectively. Calculate the retardation coefficient of the considered contaminant.

(5 x 7 = 35 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
Module I (9 Hours)		
1.1	Introduction to laws, regulations and remediation	2
1.2	Legal concepts	1
1.3	Types of laws, regulations	1
1.4	Laws/Regulations- History & Objectives	1
1.5	Remediation Process	1
1.6	Definition of hazardous waste	1
1.7	Waste classification	1
1.8	Corrective Action	1
Module II (9 Hours)		
2.1	Remedial Options-Ground water & Soil /Sediments	1
2.2	Ground Water-Plume containment	1
2.3	Pump & treat	1
2.4	Permeable Reactive Barriers	1
2.5	Soils/ Sediments-Landfill	1
2.6	Containment- characteristics of barrier material	1
2.7	Solidification, stabilisation	1
2.8	Chemical treatment	1
2.9	Surfactant Extraction	1
Module III (8 Hours)		
3.1	Bioremediation	2
3.2	Introduction	1
3.3	Advantages and limitations of bioremediation	1
3.4	Processes Involved	1
3.5	Types of Bioremediation	1
3.6	Phtyoremediation technologies for soil decontamination	1
3.7	Phtyoremediation mechanism	1
Module IV (7 Hours)		
4.1	Thermal processes	1
4.2	Incineration	1
4.3	Thermal Desorption	1

4.4	Aqueous Oxidation	1
4.5	Soil washing	1
4.6	Process Description	1
4.7	Design considerations	1
Module V (7 Hours)		
5.1	Electrokinetic Remediation	1
5.2	Introduction	1
5.3	Types of contaminant transport mechanism	1
5.4	Physical and chemical processes involved	1
5.5	Technologies Involved	1
5.6	Advantages and Limitations	1
5.7	Electrokinetic technology to remediate heavy metal contaminated soil	1

Reference Books

1. LaGrega, M.D., Buckingham, P.L., Evans, J.C., Hazardous Waste Management, McGraw-Hill, 1994.Haas, C.N.,

2. Vamos, R.J., Hazardous and Industrial Waste Treatment, Prentice Hall, Englewood Cliffs, NJ, 1995.

3. Nathanson & Schneider,Basic Environmental Technology: Water Supply, Waste Management and Pollution Control, 6th Edition,2005.

4. Singh SN Biological Remediation of Explosive Residues, Springer International Publishing, Switzerland,2014.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE028	ADVANCED DESIGN OF CONCRETE STRUCTURES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: To understand and apply the design guidance used in current codes of practice for the designof distinctive R C structural elements suitable for substructures as well as for super structures.

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

CO 1	Calculate short term and long term deflections for RCelements
CO 2	Analyse the flexural and shear capacity of special RCelements.
CO 3	Design special RC structures as per current codes ofpractice.
CO 4	Apply Yield line theory and redistribution of moments in slab design
CO 5	Calculate the ductility of a reinforced concrete section

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	2	
CO 2	3	2	3	3	3	2	
CO 3	3	2	3	3	3	2	
CO 4	3	2	3	3	3	2	
CO 5	3	3	3	3	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	
Create	30%

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 %

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geomechanics and Structures
Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1.Explain short term and long term deflection.
2.State and describe the limits of slenderness laid down for concrete walls.
3.Explain strut and tie method of analysis and its application to design of corbels and deep beams
4. Explain the characteristic features of yield lines.
5. Describe the forces acting on beam-column joints. (5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. A RCC beam 200x400mm (effective) carries a uniformly distribute load of 70kN/m over a clear span of 6m.The beam is reinforced with 1percentage of steel on tension side. Comment on the shear design of the beam. Use M20 concrete and Fe415 steel. Take load factor as 1.5.

7. A rectangular beam section 200mm wide, 450mm depth (overall depth) is reinforced with 3 bars of 16mm dia. At an effective depth 420mm, 2 bars of 12 mm dia. are provided at the compression face. The effective span of the beam is 5m. The beam supports a service load of 10kN/m. If f_{ck} = 20N/Sq. mm and f_y=415N/Sq. mm, compute short term deflection.

8. A RC braced column 300x400mm is subjected to an ultimate load (Pu) of 1500kN and ultimate moments of 60kNm at top and of 8kNm at the bottom. If the column is bent in double curvature, about vertical axis, determine the design moments. Take unsupported length as 8m and effective length as 6m about both the axes. Assume Ka =1.

9. Design a corbel to carry a factored load of 500kN at a distance of 200mm from the face of a column of dimension 300x300mm. Assume M30 concrete and Fe 415 steel.10. Explain the Contaminant transport in sub surface advection , diffusion and dispersion

10. Determine the design moments of an interior panel of size 6mx6m of the flat slab floor system of size 30mx30m supported on 500 x 500mm square columns without drops and without column head. The floor system supports an imposed service load of 4kN/Sqm. Adopt load due to floor finishes as 1kN/Sqm. Use concrete of grade M20 and HYSD steel of grade Fe415.

11.Derive an expression for ultimate load carrying capacity of the Isotropically reinforced square slab fixed on all edges. subjected to udl over the entire surface.

12. Discuss the requirements of special confining reinforcement in columns as per IS 13920-1993. (5 x 7 = 35 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(8 hours)**	
1.1	REVIEW -Limit state design of beams, slabs and columns according to IS Codes.	1
1.2	Calculation of deflection of beams according to IS 456-2000-	1
1.3	Short term and long term deflection of Cantilevers, continuous beams, slabs etc,	2
1.4	Measures for reducing deflection.	1
1.5	Crack width-Factors affecting crack width in beams	1
1.6	Mechanism of flexural cracking	1
1.7	Estimation of crack width in beams by IS 456 method.	1
2	**Module 2(8hours)**	
2.1	SPECIAL RC ELEMENTS - Slender columns -Slenderness limits for columns, methods of design of slender columns	1
2.2	Design of braced and unbraced slender columns.	2
2.3	RC walls – Design of plain concrete walls carrying axial load and horizontal loads.	1
2.4	Shear walls –Classification of shear walls-Principle of shear wall analysis	1
2.5	Design considerations-Design of rectangular and flanged shear walls.	1
2.6	Deep beams- IS 456 and ACI recommendations- Design of RC deep beams	2
3	**Module 3(8hours)**	
3.1	Corbels or brackets- Strut and tie method of analysis -Design of corbels	2
3.2	FLAT SLABS –Components of flat slab construction-Recommendations according to IS 456-2000	2
3.2	Direct Design method and Equivalent frame method, Shear in flat slab	1
3.3	Effect of openings in flat slab-Comparison of flat slab with two way slabs.	2
3.4	Design of spandrel beams	1
4	**Module 4(8 hours)**	
4.1	YIELD LINE THEORY AND DESIGN OF SLABS-	1
4.2	Characteristic features of yield lines-Moment capacity along an yield line	1

4.3	Analysis by virtual work method and Equilibrium method	2
4.4	REDISTRIBUTION OF MOMENTS-Limit analysis	1
4.5	Moment curvature relationship-Recommendations of IS 456-2000 –Bending moment envelope-	1
4.6	Application to continuous beams	1
4.4	Application to one way continuous slabs.	1
5	**Module 5(8 hours)**	
5.1	CAST IN-SITU BEAM-COLUMN JOINTS-Types of cast in-situ joints,	2
5.2	Forces acting on joints-Design of joints for strength	1
5.3	Anchorage- Confinement of core of joint-Corner or kneejoints	1
5.4	DUCTILE DETAILING OF RC FRAMES FOR SEISMIC FORCES- General Principles-	1
5.5	Factors increasing ductility-	1
5.6	Requirements for ductile detailing of beams, coulmns and frame members.	2

Text books

1.Unnikrishna Pillai and Devdas Menon “Reinforced concrete Design’, Tata McGraw Hill Publishers Company Ltd., New Delhi,2006.
2.Varghese, P.C, “Advanced Reinforced Concrete Design”, Prentice Hall of India, 2005.
3.. Purushothaman, P, “Reinforced Concrete Structural Elements : Behaviour Analysis and Design”, Tata McGraw Hill,1986
4.Dr.B.C.Punmia,Ashok Kumar Jain,Arun Kumar Jain,”Limit State Design of Reinforced Concrete,Laxmi Publications PvtLtd,2010

Reference Books

1. Varghese, P.C., “Limit State Design of Reinforced Concrete”, Prentice Hall of India,2007.
2. .Park.R & Paulay T, "Reinforced Concrete Design", John Wiley & Sons, NewYork,1975
3. M.L Gambir , "Design of Reinforced Concrete Structures",PHI LearningPvt.Ltd,Delhi

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE029	PRESTRESSED CONCRETE STRUCTURES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course intends to expose the students to the basic principle of behaviour of prestressed structural members under flexure, shear, and torsion. The course equips the post graduate students to analys and design various structural components employing the prestressed principle.

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

CO 1	Analyse prestressed concrete member, estimate the stresses, losses, deflection by applying fundamental principles
CO 2	Design a prestressed concrete member for flexure, shear and torsion
CO 3	Analyse and design indeterminate structures using basic principles
CO 4	Design end blocks of a prestressed concrete member
CO 5	Analyse and design composite prestressed concrete members

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	2	1	3	1	
CO 2	3	3	3	3	2	2	
CO 3	2	2	2	2	2	2	
CO 4	1	2	1	1	1	2	
CO 5	2	1	1	2	2	2	

Assessment Pattern

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

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 %

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geomechanics and Structures
Subject: Prestressed Concrete Structures
Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1. What are the systems of prestressing
2. Derive the expression for evaluating the moment carrying capacity of a T beam with its neutral axis outside the flange.
3. How is the secondary moment evaluated in a prestressed continuous beam?
4. Sketch the stress flow/distribution diagram near the end block for a single anchorage system
5. What are the advantages of using composite construction with prestressed and insitu concrete in structural members? (5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. A simply supported concrete beam of span 8m and rectangular cross section, 150mm wide and 300mm deep is prestressed by a single cable in which the total tensile force is 250kN. The centre line of the cable is parallel to the axis of the beam and 75mm above the soffit over the middle third of the span and is curved upward in a parabola over the outer third of the span to a distance of 175mm above the soffit at the supports. If the modulus of elasticity of concrete is 36kN/mm2 and the density of the concrete is 24kN/m3, calculate the upward deflection at mid-span due to prestress alone, the deflection when the beam is supporting its own weight. Also calculate the magnitude of concentrated load Q placed at the third point of the span, which would result in a limiting short-term deflection of span/500
7. A prestressed concrete beam of rectangular cross section 250mm wide and 500mm deep is prestressed by 5 numbers of 8mm high tensile wires at 500 mm from top and 15 numbers of 8mm high tensile wires at 83mm from the soffit. The initial stress in the wires is 1200N/mm2. Estimate the loss of stress in wires due to elastic shortening of concrete. Assume modular ratio=6.
8. A pre-tensioned prestressed concrete T section having a flange width of 1200mm and thickness of flange 125mm, the thickness of web being 300mm is prestressed by 4700mm2 of high tensile steel located at an effective depth of 1500mm. if fck=40N/mm2, fp=1600N/mm2, estimate the ultimate moment capacity of the pre-tensioned T section
9. A post tensioned prestressed concrete girder of a bridge spans over 30m and is made up of an unsymmetrical I section with the top flange 1200mm wide and 250mm deep, web 200mm thick, bottom flange 500mm wide and 400mm deep. It has an overall depth of 1800mm. the section has to support a dead load bending moment of

4261kNm and a live load bending moment of 2074kNm. If fct= 18N/mm2 and ftw=0 and loss ratio is 15%, compute the prestressing force required assuming an effective cover of 200mm for the cables. Also check the adequacy of the section.

10. A continuous concrete beam ABC (AB=BC) has a uniform cross section throughout its length. The beam is prestressed by a straight cable carrying an effective force P. The cable has an eccentricity e towards the soffit at end supports A and C and e/2 towards the top fibre at the central support B. Show that the cable is concordant.
11. The end block of a post-tensioned prestressed concrete bridge is of rectangular cross section 450mm wide by 1350mm deep. Freyssinet anchorages of 7K-15 type comprising anchor plates of size 250mm x 250mm are used. Three anchorages are provided spaced at 450 mm centres. The jacking force in each anchorage is 1500kN. Design suitable anchorage zone reinforcement in the end block.
12. A rectangular pretensioned concrete beam has a breadth of 100mm and depth of 230mm, and the prestress after all the losses have incurred is 12N/mm2 at the soffit and zero at the top. The beam is incorporated in a composite I beam by casting a top and of breadth 300mm and depth 50mm. Calculate the maximum uniformly distributed live load that can be supported on a simply supported span of 4.5m, without any tensile stresses occurring,

    a. If the slab is externally supported while casting and

    b. If the pretensioned beam supports the weight of the slab while casting

(5 x 7 = 35 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	**Basic concept of Prestressing,Systems of Prestressing**	
1.1	Analysis of prestress and bending stress	3
1.2	Losses of Prestress	3
1.3	Deflection of beams	3
2	**Elastic Design**	
2.1	Flexural Strength, Shear and Torsional Resistance of PSC members	3
2.2	Design of Pretensioned and Post-Tensioned Flexural Members	3
2.3	Design of sections for Shear and torsion	3
3	**Prestressing of statically indeterminate structures**	
3.1	Primary, secondary and resultant moments	3
3.2	Pressure line	2
3.3	Guyon's theorem, Concordant cable profile	2
4	**End Blocks**	
4.1	Stress distribution in end blocks	2
4.2	Methods of investigation of end blocks	2
4.3	Design of end blocks	3
5	**Composite construction of Prestressed and in situ Concrete**	
5.1	Analysis of stresses, Differential Shrinkage	3
5.2	Flexural strength and Shear strength of composite prestressed structural elements	3
5.3	Design of composite section	2

Reference Books

1. N. Krishna Raju, "Prestressed concrete", Tata McGraw Hill Publishing Co.Ltd.
2. N. Rajagopal, "Prestressed Concrete", Narosa Publishing House, New Delhi.
3. S. Ramamrutham, "Prestressed Concrete", DhanpatRai Publishing Company (P)Ltd., New Delhi.
4. Y. Guyon, "Prestressed Concrete", C. R. Books Ltd., London

SEMESTER I

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE030	REINFORCED EARTH AND GEOSYNTHETICS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: This course is designed to provide knowledge on applications of various Geosynthetic materials in Geotechnical Engg field. It helps the students to study the methods for analyzing, designing and construction of Reinforced Earth Retaining Walls, Reinforced Soil Embankments and Reinforced soil bed for footings. Further application of Geosynthetic materials in Highways, Rural Roads and Railways could be understand for Students. More over by undergoing this course, Students could acquire the applications of of Geosynthetic materials for controlling drainage and filter problems on conventional type of retaining walls, Roads Railways etc. Application of Geosynthetic materials in Land fill, Ling of Canals, Ponds, and Erosion Control could be studied by undergoing this course. Since the syllabai of this course is framed and designed by incorporating casehistories and hence students could understand the field problems likely to be faced

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

CO 1	To identify the application areas and also to evaluate the properties of Geosynthetics in the GeotechnicalEngineering field
CO 2	To analyze and design Reinforced Earth Retaining Walls
CO 3	To design a Reinforced Soil Embankments and Reinforced Soil bed for Footings.
CO 4	To assess the functions of Geosynthetics as a filter and drainage material.
CO 5	To evaluate the benefits of using Geosynthetic materials in Rural roads , Highways and Railways
CO 6	To assess the use of Geosynthetics in Environmental applications

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	1	1
CO 2	2	1	3	2	3	2	1
CO 3	3	2	2	2	2	2	1
CO 4	2	1	2	2	2	1	1
CO 5	2	2	2	3	3	2	1
CO 6	3	1	3	3	3	1	1

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	30
Analyse	25
Evaluate	30
Create	15

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

APJ Abdul Kalam Technological University
First Semester M.Tech Degree Examination
Branch: Geotechnical Engineering
Specialization:
Subject: REINFORCED EARTH AND GEOSYNTHETICS
Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1. Explain the principle of reinforced soil
2.Explain the design considerations of reinforced soil bed for footings
3. Describe briefly the application of geosynthetic materials in highways
4.Explain the design considerations of Gabion walls.
5. Write explanatory notes on application of geosynthetic materials for erosion control purposes

(5 x 5 = 25 marks)

PART B
Answer any 5 Questions;
Assume suitable data's for numerical questions, if needed

6.An 8.0 m high vertical embankment is to be built using Geogrids in the back filling. The facing units are of suitable interlocking concrete blocks. Assume the soil properties ($\phi = 30^{\circ}$ $\gamma = 18$ kN/m^3). The friction between the reinforcement and the soil, δ can be taken as 24°. Find the length of the reinforcement needed (provide uniform length). Total number of layers = 8; First layer may be placed at 0.5 m from the top surface and the last layer is at 0.5 m above original ground level. Vertical spacing between all other grids are 1.0 m.

7. (a) Describe the procedure for determining CBR puncture strength of Geotextiles
(b) Explain a method for determining Factor of safety of a Reinforced soil Embankment

8.Compute the factor of safety for the following cases for in plane drainage of seepage water behind a 6.3 m high retaining wall where a geosynthetic is placed along the back of the wall. From the flow net for heavy rainfall, it has been determined that the number of flow paths, n_f is 5 and the number of equipotential drops, n_d is 6. Head causing flow is equal to the height of the wall. The soil is clayey sand with $k = 0.85 \times 10^{-5}$ m/sec.
(i) Case A: Non-woven geotextiles (820 gem) with θ allowable = 2.6×10^{-5} m^2 /sec.
(ii) Case B; 6.7 mm thick geonet sandwiched between wall surface and a geotextile with θ allowable = 1.15×10^{-3} m^2 /sec

9. For a 13 m high zoned embankment, the seepage estimated using a flow net is 13.0×10^{-7} m 2 /sec for k of 5.5×10^{-8} m/sec for the core. It is proposed to provide a non-woven geotextile to act as a filter between the shell and the core. The geotextile is a 10 mm thick, 2050 gsm geosynthetic with an allowable permittivity of 0.05 sec^{-1} and O_{95} of 0.04 mm. The

soil of the core is clayey silt with D_{85} of 0.03mm. Will the geosynthetic will be satisfactory as a filter?

10. It is proposed to construct 4.5 m high and 10 m wide road embankment of over a soft soil of 7.0 m depth using geogrids. In situ vane shear test results indicate that undrained shear strength of soft soil is 16 kPa and is constant with depth. The embankment needs to be constructed rapidly in one stage. It is estimated from consolidation test results that if geogrids are used the index strength need to be corrected for time periods of three years which corresponds to 90 % consolidation and the corresponding reduction factor is 0.52. Granular soil is available in the nearby area and has a bulk density of 17.0kN/m^3; φ_{cu} = 25° Targeted factor of safety is 1.7. Arrive the required tensile strength assuming partial mobilization of inward stress with geogrid reinforcement (α=0.52) Assume any data necessary.

11. Explain the use of Geosynthetic materials in Railway applications as Reinforcement, Separator, Drainage and filter

12 Explain the following (i) Single composite liner system for MSW landfill (ii) Double composite linersystem for MSW landfill. (iii) Stability analysis for sliding of geomembrane over clay in liner system

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).

No	Topic	No. of Lectures
1	**Module 1**	08 hours
1.1	Introduction-Meaning- Materials- Principles and Mechanism- Tension failure-Pull out failure.-Advantages	02
1.2	Classification of Materials – Application- Functions-Types-Properties and Testing, Natural Geotextiles –IS Code provisions	02
1.3	Reinforced Earth Retaining walls –Applications- Analysis-Design-Construction	03
1.4	Any one case study	01
2	**Module 2**	08 hours
2.1	Reinforced Soil Embankments- Use- Analysis-Design-Construction	02
2.2	Reinforced Soil bed for Footings-Application-Theory-Design-Constuction	02
2.3	Geosynthetic materials as filter/ drainage in Retaining walls and Earth Dams-Mechanism- Cross plane and in plane permeability	03
2.4	Any one case study	01
3	**Module 3**	08 hours
3.1	Geosynthetic applications in Rural Roads-Applications-mechanism -Construction Analysis and Design aspects.	02
3.2	Geosynthetic applications in various components of Highways-mechanism -Construction Analysis and Design aspects.	03
3.3	Geosynthetic materials for Embankments over Soft Soil-Stress and force equilibrium-Internal stability-Foundation stability-overall stability-Foundation of uniform strength	02
3.4	Any one case study	01
4	**Module 4**	08 hours
4.1	Geosynthetic materials in Railway -Geosynthetic materials in Railway applications as Reinforcement,Mechanism-Construction ,Analysis and Design aspects.	03
4.2	Use ofGeogrid in Indian Railways - Guide lines	01
4.3	Gabions –Gabion walls- Gabion faced Reinforced Soil Retaining Structures.–Applications-Analysis, Design and construction	03
4.4	Any one case study	01
5	**Module 5**	08 hours
5.1	Geosynthetics for Ponds, Reservoir and Canals-function-Mechanism, construction, analysis- design aspects	02
5.2	Geosynthetics for land fill applications-Waste management-Waste contamination-Liner-Cover- MSW- Construction, Analysis and Design aspects-Stability considerations.	03

5.3	Application of Geosyntheics in Erosion control- – Stability considerations, Construction and design aspects	02
5.4	Any one case study	01

Reference Books

1. Robert M. Koerner, “Designing with Geosynthetics”, Prentice Hall, Englewood Cliffs.
2. Venkatappa Rao G., Surry Narayana Raju G.V.S., “Engineering with Geosynthetics”, Tata McGraw - Hill Publishing Company Ltd, New Delhi
3. Ingold, T.S, “Reinforced Earth”, Thomas Telford Ltd, London.
4. Mandal, J.N., “Reinforced Soil and Geotextiles”, Oxford and IBH Publishers Co. Pvt. Ltd, New Delhi.
5. P C Varghese, “.Foundation Engineering “Prentice-Hall of India Pvt. Ltd
6. S K Gulhati and Manoj Dutta, “ Geotechnical Engineering” Tata Macgraw hill
7. IS 13162 Geotextiles- Methods of Tests- Part 1-6
8. IRC SP 59 Guide lines for use of Geosynthetics in Road pavements and Associated works
9. IRC SP 102 Guide lines for Design and Construction of Reinforced Soil Walls

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE031	GROUND MONITORING TECHNIQUES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The course enables the students to have the basic cognisance on the current and established techniques on ground monitoring. It introduces the applications of methods and instrument on slope stability monitoring, vaious load testing methods in the field, samplin of soil and geophysical methods.

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

CO	Description	KL
CO 1	Take various steps leading to planning Investigation Programmes, **criticallyanalyse** the necessities, **interpret** the situations and **develop** a robust investigation programme.	5
CO 2	**Choose** the appropriate exploration method, in-situ tests and sampling techniqueafter **evaluating** various site, structure and environment factors and perform the exploration, in-situ tests and sampling.	5
CO 3	**Formulate** quality control scheme and monitor the quality of earthwork construction, **estimate** the performance of constructed structures on consolidating deposits, monitor and **analyse** their post construction behaviour.	6
CO 4	**Evaluate** the requirements and **decide** the necessary instrumentation needed to monitor the behaviour of constructed earth structures, unstable slopes, **interpret** the observed behaviour and **recommend** remedial measures if any required.	6

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	3
CO 2	3	2	3	3	3	3	3
CO 3	3	2	3	3	3	3	3
CO 4	2	1	2	2	3	2	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	20%
Create	10%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	3 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewedOriginal publications (minimum 10publications 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 answerquestions with 1 question from each module, having 4 marks for each question (suchquestions 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 questionsshall be useful in the testing of overall achievement and maturity of the students in acourse, through long answer questions relating to theoretical/practical knowledge,derivations, problem solving and quantitative evaluation), with minimum one questionfrom each module of which student should answer any five. Each question can carry7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed20% over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60%.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION, JANUARY 2023

Branch: Civil Engineering

Stream(s):CE3

(Geomechanics andStructures, Geotechnical andEnvironmental Energy,

Geotechnical Engineering)

221TCE031 GROUND MONITORING TECHNIQUES

Answer all questions from Part A. Each question in Part A carries 5 marks. Answer any five questions from Part B. Each question in Part B carries 7 marks.

Limit answers to the required points.

Max. Marks: 60 Duration: 150 minutes

PART A

1.	a.	Explain the significance of site reconnaissance.	2
	b.	What are the features to be onbserved during site reconnaissance	2
2.	a.	A thick walled sampling tube has the following dimensions. I D of the shoe 35mm. OD of the shoe 52mm. ID of the sampling tube 38mm. OD of the sampling tube 50 mm. Compute the area ratio, inside clearance ratio and outside clearance ratio. Comment on the quality of sample obtained from this sampler.	4
3.	a.	Explain the corrections to be applied to the Standard Penetration Test (SPT) N values as per the IS code?	2
	b.	At a site, N value of 19 was obtained at a depth of 8m below the existing ground level. The subsoil comprises of silty sand layer of unit weight of 15 kN/m3. Ground water table is at a depth of 4m below the existing ground level. What is the corrected N value?	2
4.	a.	List various types of pile load tests	1
	b.	Why cyclic pile load test is preferred?	1
	c.	State the criteria of finding ultimate load from a pile load test on group of piles as per the IS 2911 Part I Section 2.	2
5.	a.	Justify the purpose of using inclinometers. List various types of inclinometers.	2
	b.	Explain the principle of vibrating wire inclinometers	2

PART B

6	a.	Differentiate between preliminary and detailed investigation.	3
	b.	Explain wash boring with a sketch	4

7. a. Explain how block samples are obtained from the field. What are the advantages and disadvantages of block samples? 3

   b. Explain with the help of sketches sampling using piston sampler. 4

8. a. Explain how sampling is done in rock? What are the tools used for the same. 2

   b. Justify the use of drilling mud during drilling and sampling. 2

   c. List the potential sources of errors in SPT. What are the precautions to be taken to avoid errors. 3

9. A pumping out test was conducted in a well of diameter 40 cm drilled down to an impermeable stratum. The depth of water above the impermeable stratum was 8 m. The yield from the well was 4 m3/min at a steady drawdown of 4.2 m.Determine the hydraulic conductivity of the soil in m/day if the observed radius of influence was 120m. 7

10. Compare Spectral Analysis of Surface Waves (SASW), Multi-channel Analysis of Surface Waves (MASW). 7

11. A 15m long concrete pile having 45 cm diameter was subjected to cyclic pile load test. The following data was obtained from the test. Separate the skin friction and end bearing components of load carrying capacity using graphical procedure. M35 mix was used for the concrete. 7

Load on the pile top (t)	0	10	20	40	60	80	100	120
Total settlement (mm)	0	1.7	4	9.5	16.5	25	40.5	70
Net settlement (mm)	0	1.2	2.5	5	8.5	13	19.5	30

12. a. Explain the application of remote sensing in monitoring slopes. 2

    c. Detail the instrumentation required while constructing an embankment on soft soil. 5

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).

Syllabus:

Geotechnical investigations for ground characterisation, site reconnaissance, planning of investigations, methods of investigation, methods of boring, sampling. In-situ tests. Monitoring of field compaction and settlement of built earth structures. Monitoring lateral and vertical deformations, monitoring water pressures, need for the same and the various instrumentations needed. Basic concepts of automated remote data logging. Instrumentation for unstable slopes.

Course Plan

No	Topic	No. of Lectures
1	Geotechnical investigations	6
1.1	Planning of geotechnical investigations, Site reconnaissance, features to be observed, Objectives of investigation	2
1.2	Details to be obtained from investigation, Methods of investigation, Preliminary and detailed investigation,Depth, spacing and number of boreholes	2
1.3	Methods of boring- auger boring, wash boring, rotary drilling, percussion drilling,	2
2	Sampling	6
2.1	Sampling –various methods – disturbed and un-disturbed samples, causes of disturbance, precautions to be taken.	2
2.2	Block sampling, tube samplers with design features, numerical problems, scraper bucket sampler,	2
2.3	piston sampler, sampling operations, preservation and transport of samples, sampling in rock.	2
3	In-situ tests	
3.1	Standard Penetration Test, Static cone penetration test,	2
3.2	Dynamic cone penetration test, Vane shear test, field permeability test- pumping in test, pumping out test, packer test,	2
3.3	Geophysical methods, basic concepts of block vibration test, Spectral Analysis of Surface Waves (SASW), Multi-channel Analysis of Surface Waves (MASW)	2
4	Monitoring of field behaviour	6
4.1	Pile load test – various types, maintained load test and cyclic pile load test, separation of end bearing and skin friction from cyclic pile load test, basic information about pullout and lateral load tests.	3
4.2	Monitoring field compaction - Compaction control.	1
4.3	Monitoring consolidation settlement - vertical drains – numerical	2

	problems, prediction and performance.	
5	Monitoring of deformations and water pressure	8
5.1	Monitoring lateral and vertical deformations – reasons for and instruments used. traversing and in place inclinometers, inclinometer casings, tiltmeters, extensometers, settlement gauges, installation.	2
5.2	Monitoring pore water pressure – reasons for, instruments used - water levels, piezometers – vibrating wire piezometers, choosing piezometers (guide to instrumentation)	3
5.3	Monitoring unstable slopes and early warning system for landslides . Applications of remote sensing, Terrestrial LiDAR , Photogrammetric techniques and Ground-based geodetic techniques for landslide monitoring, concepts of applications of global Positioning System, use of drones in ground monitoring.	3
6	Other ground monitoring techniques	8
6.1	Automated and remote data logging, standard softwares. Real time monitoring of infiltration and evaporation – Schematic diagram of typical set up and explanation of components	4
6.2	Use of tensiometers, time-domain reflectometry (TDR), soil temperature sensors, and weather stations Autonomous monitoring using micro-electro-mechanical systems (MEMS) based system and Shape Accel Array (SAA). Acoustic emission method	4

Reference Books

1.Dunnicliff, J. and Green, G.E. (1993). Geotechnical Instrumentation for Monitoring Field Performance. Wiley-Interscience.

2. Hunt, R.E. (2019). Geotechnical Investigation Methods: A Field Guide for Geotechnical Engineers, CRC Press.

3. Arora, K.R. (2019). Soil Mechanics and Foundation Engineering. Standard Publishers, New Delhi

4.Gopal Ranjan and Rao, A.S.R. (1991). Basic and Applied Soil Mechanics. New Age international publishers, New Delhi.

5. Sinha, R. S. (1989. Underground structures : design and instrumentation.Elsevier

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE032	GEO ENVIRONMENTAL ENGINEERING	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To impart in-depth knowledge of the modern skills and tools related to Environmental Geotechnical engineering so as to enable them to address the environmental aspects and sustainable issues related to infrastructure development of the country.

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

CO 1	To understand soil –pollutant interaction and the governing mechanisms
CO 2	To conduct characterization of contaminated soils.
CO 3	To assess the fate and transport of contaminants in soils and evaluate its effects on geotechnical performances.
CO 4	To evaluate the environmental impacts of various geo environmental problems
CO 5	To assess the methods of stabilization of different types of wastes and to suggest the possible use of different wastes for civil engineering applications
CO 6	To evaluate the potential methods and risks in remediation of contaminated soils and ground water.

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	2	3	
CO 2	3	2	3	3	2	3	
CO 3	3	2	3	3	2	3	
CO 4	3	2	3	3	2	3	
CO 5	3	2	3	3	2	3	
CO 6	3	2	3	3	2	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70%
Analyse	30%
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 %

APJ Abdul Kalam Technological University

M.Tech Degree Examination

Branch: Geotechnical and Geoenvironmental Energy

Subject: GEO ENVIRONMENTAL ENGINEERING

Time: 2.5 Hrs Max. Marks: 60

PART A

(Answer All Questions)

1. Geo environmental engineering is multidisciplinary. Justify your answer

2. Explain the characterization of Contaminated site

3. What factors to be considered for the selection of site for landfill?

4. What are the impacts of waste dump and its remedial measures?

5.Explain Waste stabilization and disposal Hazardous waste. (5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. Explain the Effects of subsurface contamination

7. Interpret the failures of foundations due to pollutants

8. Discuss the different techniques of Soil characterization

9. Explain the significance of soil sorption behaviour in waste management.

10. Explain the Contaminant transport in sub surface advection , diffusion and dispersion

11. Explain the dynamic response of soil under environmental stress

12. Explain the Control and storage system involved in the stabilisation of solid waste.

(5 x 7 = 35 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
Module I (9 hours)		
1.1	Introduction to Geo-Environmental Engineering	1
1.2	Sources, production and classification of waste	1
1.3	Effects of subsurface contamination	1
1.4	Factors governing soil-pollutant interaction	1
1.5	Failures of foundations due to pollutants –	1
1.6	Waste characteristics; Soil-water-waste interactions	1
1.7	Physical and chemical properties of soil	1
1.8	Retention behavior	1
1.9	Governing factors, sorption characteristics	1
Module II (8 hours)		
2.1	Soil characterization techniques	1
2.2	Volumetric water content	1
2.3	Gas permeation in soil	1
2.4	Electrical and thermal properties	1
2.5	Pore-size distribution	1
2.6	Contaminant analysis	1
2.7	Contaminated site characterization	1
2.8	Risk Assessment and Strategy	1
Module III (8 hours)		
3.1	Transport of Contaminants	1
3.2	Contaminant transport in sub surface – advection – diffusion – dispersion	1
3.3	Governing equations – sorption	1
3.4	Contaminant transformation	1
3.5	Biodegradation	1
3.6	Ion exchange – precipitation	1
3.7	Hydrological consideration in land fill	1
3.8	Ground water pollution	1
Module IV (7 hours)		
4.1	Impact of Environmental Issues	1
4.2	Environmental effects caused by pile driving and their control	1
4.3	Dynamic response of soil under environmental stress	1
4.4	Contribution of environmental stress such as hazardous waste	1
4.5	Acid rain, tree cutting to mechanism of landslides	1
4.6	Remediation of contaminated soils	1
4.7	Rational approach to evaluate and remediate contaminated sites	1
Module V (8 hours)		
5.1	Waste stabilization and disposal Hazardous waste-	1
5.2	Control and storage system	1

5.3	Stabilization/ solidification of wastes	1
5.4	Micro and macro encapsulation	1
5.5	Absorption, adsorption, precipitation, detoxification	1
5.6	Mechanism of stabilization	1
5.7	Organic and inorganic stabilization	1
5.8	Utilization of solid waste for soil improvement.	1

Reference Books

1. Daniel D.E., Geotechnical Practice for Waste Disposal, Chapman and Hall, London, 1993.

2. Koerner R.M., Designing with Geosynthetics, Fifth Edition. Prentice Hall, New Jersey, 2005.

3. Reddi L.N and Inyang HI Geo environmental Engineering: Principles and Applications, Marcel Dekker Inc Publication, 2000.

4. R. N. Yong Geo environmental Engineering: Contaminated Soils, Pollutant Fate ,Mitigation Lewis Publication, 2000.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE033	ENVIRONMENTAL SYSTEM ANALYSIS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To describe current views and state-of-the-practice of LCA, to address specific LCA methodological issues including creating life cycle inventory, life cycle impact assessment, and capturing ecosystems services

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

CO 1	Develop an understanding on the thermodynamics of living systems
CO 2	Examine the principle of Life Cycle Analysis
CO 3	Examine the principle of Life Cycle Inventory Analysis
CO 4	Examine Life Cycle Impact Assessment and Interpretation
CO 5	Categorize the methodological issues in Life Cycle Analysis

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70%
Analyse	30%
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 %

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geotechnical and Geoenvironmental Energy
Specialisation: Geotechnical Engineering
Subject: ENVIRONMENTAL SYSTEM ANALYSIS
Time: 2.5 Hrs Max. Marks: 60

PART A
(Answer All Questions)

1. Describe the Thermodynamics of living systems.
2. What are the phases of Life Cycle Analysis?
3. Describe open loop recycling.
4. What are the existing methods in Life Cycle Impact Assessment ?
5. Describe the economic input-output framework of Life Cycle Analysis. (5 x 5 = 25 marks)

PART B
(Answer any 5 Questions)

6. Explain complex system behaviour in detail.
7. Explain the types of Life Cycle Analysis in detail.
8. Describe the first stage of Life Cycle Analysis.
9. Describe Life Cycle Inventory Analysis in detail.
10. What are the impact categories in Life Cycle Impact Assessment? Explain in detail.
11. Describe the fourth stage of Life Cycle Analysis.
12. Describe the methodological issues of Life Cycle Analysis in detail.

(5 x 7 = 35 marks)

No	Topic	No. of Lectures
1	**Introduction and General Systems Theory and Thermodynamics**	
1.1	Types of systems-properties of systems-complex system behaviour	2
1.2	Thermodynamics-first law-second law-environmental change-resources far from equilibrium	3
1.3	Thermodynamics of living systems	1
2	**Introduction to LCA**	
2.1	Life Cycle Analysis- Uses - Stages – phases – types – Life cycle cost – social LCA	3
2.2	Goal and scope of stage 1 - Product system & purpose - Initial flowchart - Functional unit - Choice and justification for impact categories	3
2.3	Method of impact assessment - Type of LCA - System boundary - Data quality - Assumptions & limitations	3
3	**Lifecycle inventory (LCI) analysis**	
3.1	Multiple product systems - Physical problem - Computational problem - Solutions	3
3.2	Open-loop recycling – computational structure of LCA - Basics of matrix math - Heijungs and Suh matrix methodology -	3
3.3	LCA software	2
4	**Lifecycle impact assessment (LCIA) and Interpretation**	
4.1	Impact categories (midpoints) - Global warming potential (GWP) - Abiotic depletion potential (ADP) - Acidification potential (AP) - Eutrophication potential (EP) - Ozone depletion potential (ODP) - Human toxicity potential (HTP) –	3
4.2	Existing methods – seven steps	3
4.3	Identification of significant issues - Evaluation of study – Conclusions – Limitations – Recommendations	2
5	**Methodological issues in LCA**	
5.1	Goal and scope definition - Life cycle inventory analysis - Life cycle impact assessment - Life cycle interpretation	3

5.2	Economic input-output LCA & Systems of environmental - economic accounts (SEEA) - Input-output (IO) framework - Leontief method - Make-use tables - Extending IO method to environmental flows - Energy IO – EIOLCA	4
5.3	Hybrid LCA - Full monetary analysis - Mixed unit analysis	2

Reference Books

1. Life Cycle Assessment (LCA): A Guide to Best Practice, Walter Klöpffer, Birgit Grahl, Wiley-VCH; 1st edition (2 April 2014)

2. Life Cycle Assessment (LCA) of Environmental and Energy Systems, Fabrizio Passarini and Luca Ciacci, Energies, 2021

3. Assessing and Measuring Environmental Impact and Sustainability, Klemes, Jiri J, Oxford: Elsevier Science & Technology, 2015

4.Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products, Mary Ann Curran, Wiley-Scrivener; 1st edition (2 November 2012)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE034	ADVANCED CONCRETE TECHNOLOGY	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To impart in-depth knowledge on properties of concrete-making materials such as cement, aggregates and admixtures, design mix for special concretes and to get adequate knowledge about the special concretes and their applications in the diverse constructionfield.

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

CO 1	Describe the characteristics of cement, aggregates, admixtures and fibres and its influence on the properties of concrete
CO 2	Describe the rheological behaviour of fresh concrete andthe behaviour of concrete under various stress state
CO 3	Decide the best suited special concrete in terms of materials, mix proportioning, and properties depending upon the field requirement and siteconditions
CO 4	Describe behaviour of concrete under various exposure conditions and the performance-based specifications for durable concrete
CO 5	Execute mix proportioning of high performance and high strength concrete and describe how the strength of concrete can be modified by changing theproportions.

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	3	3	
CO 2	2	2	2	2	2	2	
CO 3	3	3	3	3	3	3	
CO 4	3	3	3	3	3	3	
CO 5	3	3	3	3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	
Create	30%

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 a 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 a minimum of 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

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geomechanics and Structures
Advanced Concrete Technology

Time: 2.5 Hrs **Max. Marks: 60**

PART A
(Answer All Questions)

1. List any 3 characteristics of concrete aggregate and describe their influence on fresh and hardened concrete properties.

2. Define creep. Explain the factors affecting creep in concrete.

3. Describe the features of geopolymer concrete.

4.Explain the behaviour of concrete exposed to marine environment.

5.Descrbe the factors affecting the choice of mix proportions. (5 x 5 = 25 marks)

PART B

(Answer any 5 Questions)

6. Explain the principal advantage of using fiber-reinforced concrete. Explain how concrete acquires this property.

7. Discuss the admixtures suitable for concreting in (i) hot weather,

(ii) cold weather. Justify the answer with reason.

8.Explain the significance of interfacial transition zone on the properties of concrete.

9. Explain the microstructure of aggregate phase

10. Explain the materials and mix proportioning criteria, properties and applications of Self compacting concrete

11. Explain the behaviour of concrete exposed to sulphate attack, and suggest performance based specification of concrete durable to sulphate attack.

12. Arrive amix proportioning suitable for a concrete of M70 grade using silica fume and fly ash. Type of cement- OPC 53 grade, silica fume conforming to IS 15388, maximum nominal size of aggregate-20mm,exposure condition-severe(for R C C), workability-120mm(slump),type of aggregate-crushed angular aggregate, maximum cement content-450kg/m^3,chemical admixture type-superplasticizer.

(5 x 7 = 35 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
Module I (8 hours)		
1.1	**Cement:** Hydration of Portland Cement, Heat of hydration,	1
1.2	Effect of cement characteristics on strength and heat of hydration.	1
1.3	Special Hydraulic Cements, Introduction to Calcium sulpho aluminate cement.	1
1.4	**Aggregates:** Types of aggregates used in concrete, characteristics and significance.	1
1.5	**Admixtures:** Chemical and Mineral Admixtures-Types, Mechanism of action and applications.	2
1.6	**Fibres:** Types, Influence on the properties of concrete, Applications.	2
Module II (8 hours)		
2.1	**Fresh Concrete:** Rheological behaviour of fresh concrete	1
2.2	**Hardened Concrete:** Microstructure of aggregate phase, hydrated cement paste,	2
2.3	Interfacial transition zone.	1
2.4	Failure modes in concrete,	1
2.5	Behaviour of concrete under various stress states.	1
2.6	Elastic Behaviour of concrete,	1
2.7	Drying shrinkage and creep.	1
Module III (8 hours)		
3.1	**Special concretes:**Materials and mix proportioning criteria, properties and applications of Structural light weight concrete,	1
3.2	… of High strength concrete	1
3.3	…of High Performance Concrete,	1
3.4	…of Concrete containing polymers	2
3.5	… of Self compacting concrete,	1
3.6	…of Fibre reinforced concrete,	1
3.7	… of Geopolymer concrete etc.	1
Module IV (8 hours)		

4.1	**Durability of concrete:** Behaviour of concrete exposed to sulphate attack,	1
4.2	alkali aggregate reaction, carbonation,	2
4.3	high temperature,	1
4.4	marine environment, corrosion– control measures,	2
4.5	performance based specification for durable concrete.	2
Module V (8 hours)		
5.1	**Mix design:** Methods of Concrete mix design,	2
5.2	High performance concrete mixture proportioning as per IS Code.	3
5.3	High strength concrete mixture proportioning as per IS Code.	3

Text books

1. Metha, P.K. and Monteiro, P.J.M, "*Concrete, Microstructure, Properties and Materials*", Fourth Edition, Tata McGraw- Hill Publishing company Limited, New Delhi, 2006.
2. Neville, A.M. and Brooks, J.J., "*Concrete Technology*", Pearson Education India, 2008.
3. Santhakumar, A.R., "*Concrete Technology*", First edition, Oxford University Press India, 2006.S. Mindess and J.F. Young ,"Concrete", Prentice-Hall, USA, 198

Reference Books

1. S. N. Ghosh , Cement and Concrete: v. 1, Pt. 2: Science and Technology (Progress in Cement & Concrete)
2. EFNARC, "The European Guidelines for Self-Compacting Concrete, Specification, Production and Use" EFNARC-2005, UK.
3. IS 10262-2019, Recommended guidelines for concrete mix design.
4. NPTEL course on Advanced Concrete Technology
5. NPTEL course on Advanced Topics in the Science and Technology of Concrete

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE035	EARTHQUAKE RESISTANT DESIGN	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To deal with the basic concepts involved in achieving appropriate earthquake resistance of RCC and masonry buildings. To evaluate the earthquake excitation and the structure response to this excitation at a particular site to provide a structural system that will not collapse, that may prevent loss of life and will limit economic loss during an earthquake. Preventive measures to improve seismic resistance of buildings as per design guidelines.

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

CO 1	Explain the basic concepts of earthquakes.
CO 2	Evaluate the elementary criteria for earthquake-resistant design.
CO 3	Design the RCC building as per ductile detailing of reinforced concrete structures.
CO 4	Formulate the appropriate repair techniques for RCC structures.
CO 5	Assess the damaging effects of the earthquake on buildings and structures.
CO 6	Develop preventive measures for improving the seismic performance of RCC 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	2	3	1	1	1
CO 2	2	2	3	3	-	2	-
CO 3	2	1	3	3	1	3	1
CO 4	2	2	2	3	3	1	2
CO 5	3	3	1	1	1	2	2
CO 6	2	1	1	3	3	2	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	-
Analyse	-
Evaluate	50%
Create	50%

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:

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. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

APJ Abdul Kalam Technological University
M.Tech Degree Examination
Branch: Geomechanics and Structures
Course Code &Name :221ECE035
EARTHQUAKE RESISTANT DESIGN

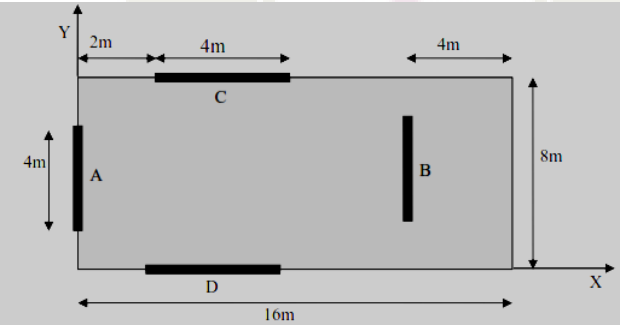
Time: 2.5 Hrs Max. Marks: 60

PART A
Answer All Questions
Each question carries 5 marks

1. Describe the process of liquefaction and its causes.
2. Explain the Response Spectra and its characteristics.
3. Explain torsional coupled and uncoupled systems.
4. Write note on special confining reinforcement and its significance including the provisions for the same in IS: 13920-1993.
5. Discuss the strong column weak beam philosophy.

PART B
Answer any 5 Questions

6. Explain retrofitting and its various techniques in detail. (7marks)
7. Define the shear wall and its classification? Describe the structural behavior of shear wall? (7marks)
8. Discuss the philosophy behind earthquake resistant design of structures. (7marks)
9. Consider a simple one-storey building having two shear walls in each direction. All four walls are in M25 grade concrete, 200 thick and 4 m long. Storey height is 4.5 m. Floor consists of cast-in-situ reinforced concrete. Design shear force on the building is 100 kN in X direction. Compute design lateral forces on different shear walls using the torsional provisions provided in IS1893 (Part 1): 2002. (7marks)



10. What is meant by rocking of masonry piers? How it is eliminated? (7marks)
11. Explain base isolation in buildings in detail. (7marks)
12. What is meant by pounding of building? Explain in detail. (7marks)

Syllabus

Module 1: Seismic hazards and the Earthquake (10 Hours)

Seismic Hazards:- Need of special emphasis to earthquake engineering, Ground shaking, structural hazards, Liquefaction, Lateral spreading, Landslides, Life line hazards, Tsunami and Seiche hazards.

The Earth And its Interior: - The Circulation, Continental drift, Plate tectonics, Plate boundaries, Faults and its geometry. The Earthquake: - Elastic rebound theory, Terminology like hypocentre, epicentre and related distances.

Seismic Waves: - Terminology, Body waves: - P- waves and S- waves, Surface waves: – Love waves and Rayleigh waves. Calculation of wave, velocity, measuring instruments, locating epicentre of earthquakes numerically from traces and wave velocity.

Earthquake Size: - Intensity – RF, MMI, JMA and MSK. Comparison of above. Magnitude – Local magnitude, Calculation (Analytically and graphically), Limitations, Surface wave magnitudes, Moment magnitudes and its Calculation, Saturation of magnitude scales

Module 2: Concept of Earthquake Resistant Design (5 Hours)

Earthquake Ground Motion: - Parameters: - Amplitude, Frequency and duration. Calculation of duration from traces and energy. Response Spectra: - Concept, Design Spectra and normalized spectra, Attenuation and Earthquake Occurrence. Guttenberg- Richter Law.

Concept of Earthquake Resistant Design: - Objectives, Design Philosophy, Limit states, Inertia forces in Structure. Response of Structures – Effect of deformations in structure, Lateral Strength, Stiffness, Damping and ductility. Floor diaphragms: - Flexible and rigid, Effect of inplane and out of plane loading, Numerical example for lateral load distribution

Module 3: Torsional Effects due to Earthquake (7 Hours)

Torsion and Twists in Buildings: - Causes, Effects, Centre of mass and rigidity. Torsional coupled and uncoupled system, Lateral load distribution, Numerical example based on IS code recommendation. Building Configurations: - Size of Building, Horizontal and Vertical layout, Vertical irregularities, Adjacency of Building, Open-ground

Module 4: Ductile design and detailing of structural elements in RCC buildings (10 Hours)

R.C.C for Earthquake Resistant Structures: - How to make buildings ductile, Concept of capacity design, Strong Column weak beam, Soft Storey. Ductile design and detailing of beams and shear walls. Calculation of Base shear and its distribution by using codel provision. Detailing of columns and Beam joints. Performance of R.C.C. Building.

Ductile detailing:-Study of IS: 13920-1993.Repair: - Methods, Materials and retrofitting techniques.

Module 5: Seismic code provisions and reduction of earthquake effects (8 Hours)

Earthquakes in India: - Past earthquakes in India an overview, Behaviour of buildings and structures during past earthquakes and lessons learnt from that. Seismic Code: - Provisions of IS: 1893-2002. Masonry Buildings:- Performance during earthquakes, Methods of improving performance of masonry walls, box action, influence of openings, role of horizontal and vertical bands, rocking of masonry piers. Reduction of Earthquake Effects: - Base Isolation and dampers; Do's and Don'ts During and after Earthquake.

Course Plan

No	Topic	No. of Lectures
1	**Seismic hazards and the Earthquake**	**(10Hours)**
1.1	Seismic Hazards: - Need of special emphasis to earthquake engineering, Ground shaking, structural hazards, Liquefaction, Lateral spreading, Landslides, Life line hazards, Tsunami and Seiche hazards	2
1.2	The Earth And its Interior: - The Circulation, Continental drift, Plate tectonics, Plate boundaries, Faults and its geometry	1
1.3	The Earthquake: - Elastic rebound theory, Terminology like hypocentre, epicentre and related distances	1
1.4	Seismic Waves: - Terminology, Body waves: - P- waves and S-waves, Surface waves: – Love waves and Rayleigh waves. Calculation of wave velocity	2
1.5	Measuring instruments, locating epicentre of earthquakes numerically from traces and wave velocity.	1
1.6	Earthquake Size: - Intensity – RF, MMI, JMA and MSK. Comparison of above.	1
1.7	Magnitude – Local magnitude, Calculation (Analytically and graphically), Limitations, Surface wave magnitudes, Moment magnitudes and its Calculation, Saturation of magnitude scales	2
2	**Concept of Earthquake Resistant Design**	**(5 Hours)**
	Earthquake Ground Motion: - Parameters: - Amplitude, Frequency and duration. Calculation of duration from traces and energy.	1
2.2	Response Spectra: - Concept, Design Spectra and normalized spectra, Attenuation and Earthquake Occurrence. Guttenberg-Richter Law.	1
2.3	Concept of Earthquake Resistant Design: - Objectives, Design Philosophy, Limit states, Inertia forces in Structure. Response of Structures – Effect of deformations in structure, Lateral Strength, Stiffness, Damping and ductility	2
2.4	Floor diaphragms: - Flexible and rigid, Effect of inplane and out of plane loading, Numerical example for lateral load distribution	1

3	**Torsional Effects due to Earthquake**	**(5 hours)**
3.1	Torsion and Twists in Buildings: - Causes, Effects, Centre of mass and rigidity.	2
3.2	Torsionally coupled and uncoupled system, Lateral load distributionNumerical example based on IS code recommendation.	3
3.3	Building Configurations: - Size of Building, Horizontal and Vertical layout, Vertical irregularities, Adjacency of Building, Open-ground	2
4	**Ductile design and detailing of structural elements in RCC buildings (10 Hours)**	
4.1	R.C.C for Earthquake Resistant Structures: - How to make buildings ductile, Concept of capacity design, Strong Column weak beam, Soft Storey.	2
4.2	Ductile design and detailing of beams and shear walls. Calculation of Base shear and its distribution by using codal provision.	3
4.3	Detailing of columns and Beam joints. Performance of R.C.C. Building. Ductile detailing: -Study of IS: 13920-1993	3
4.4	Repair: - Methods, Materials and retrofitting techniques.	2
5	**Seismic code provisions and reduction of earthquake effects**	**(10 Hours)**
5.1	Earthquakes in India: - Past earthquakes in India an overview, Behaviour of buildings and structures during past earthquakes and lessons learnt from that. Seismic Code: - Provisions of IS: 1893-2002.	3
5.2	Masonry Buildings: - Performance during earthquakes, Methods of improving performance of masonry walls, box action	3
5.3	Influence of openings, role of horizontal and vertical bands, rocking of masonry piers.	2
5.4	Reduction of Earthquake Effects: - Base Isolation and dampers; Do's and Don'ts During and after Earthquake.	2

Reference Books

1. Bruce A. Bolt, "Earth quakes", W.H. Freeman and Company, New York

2. Pankaj Agarwal and Manish Shrikhande, "Earthquake Resistant Design of Structures", Prentice Hall of India Private Limited, New Delhi, India.

3. Steven L. Kramer, "Geotechnical Earthquake Engineering", Pearson Education, India.

4. S. K. Duggal, "Earthquake Resistant Design of Structures", Oxford University Press, New Delhi.

5. Anil K. Chopra, "Dynamics of Structures", Pearson Education, India.