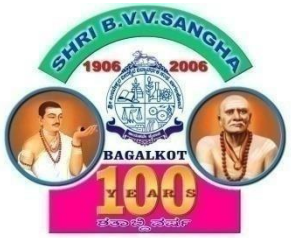
Shri BVV Sangha's

Basaveshwar Engineering College, Bagalkote-587102

Department of Civil Engineering



SYLLABUS FOR POST GRADUATE PROGRAMME

M. Tech.

GEOTECHNICAL ENGINEERING

2022-2023

Vision of the Institution

To be recognized as the premier technical institute committed to developing exemplary professionals offering research based innovative solutions and inspiring inventions for holisticsocioeconomic developments.

Mission of the Institution

- To pursue excellence through student centric dynamic teaching-learning processes,encouraging freedom of inquiry and openness to change.
- To carry out innovative cutting-edge research and transfer technology for industrial andsocietal needs.
- To imbibe moral and ethical values and develop compassionate, humane professionals.

Vision of the Department

To be a center of excellence of higher learning and research in civil engineeringencompassing ethical environmental and economical aspect of the society.

Mission of the Department

- The department of Civil Engineering is committed to prepare globally competent engineers in response to rapid economic and technological growth, through a dynamic process of teaching-learning, research and sharing professional experiences for the betterment of the community.
- To provide knowledge base and consultancy services to the community in all the area of Civil Engineering

Program Educational Objectives (PEOs)

PEO - 1. Graduates of the program will become effective Geotechnical Engineers in Government, industry, or other organizations, designing, improving and implementing efficient, sustainable Geotechnical engineering practices.

PEO - 2. Graduates of the program will provide solutions to Geotechnical Engineering problems that account for economical, societal, ethical, as well as with standards both as individuals and in team environments, by applying acquired engineering knowledge.

PEO - 3. Graduates of the program will continue their lifelong learning to remain effective professionals to maintain and enhance technical and professional growth.

Program Outcomes 2022 - 23

PO - 1. An ability to independently carry out research /investigation and development work to solve practical problems.

PO - 2. An ability to write and present a substantial technical report/document.

PO - 3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO - 4. Apply concepts of geotechnical engineering through the use of analytical techniques, experiments, computer-based methods, and other modern engineering tools in the analysis and design of a variety of geotechnical structures and their components effectively

PO - 5. Solve geotechnical engineering problems and evaluate alternative solutions considering the economy, quality, safety, environmental and sustainability aspects.

PO - 6. Use recent developments in the geotechnical engineering field for updating and life-long learning and imbibe ethical practices and social responsibilities for capacity building in upcoming areas of geotechnical engineering.

Mapping of Institution Vision with Department Vision statements

Institution vision / Department Vision	To be recognized as the premier technical institute committed to developing exemplary professionals offering research based innovative solutions	Inspiring inventions for holistic socioeconomic Development
To be center of excellence of higher learning and research in civil engineering	**3**	**3**
To encompass the graduates ethical, environmental and economical aspect of the society.	**2**	**2**

Mapping of Institution Mission with Department Mission statements

Institution Mission / Department Mission	To pursue excellence through student centric dynamic teaching-learning processes, encouraging freedom of inquiry and openness to change	To carry out innovative cutting-edge research and transfer technology for industrial and societal needs.	To imbibe moral and ethical values and develop compassionate, humane professionals
M1: The department of Civil Engineering is committed to prepare globally competent engineers in response to rapid economic and technological growth, through a dynamic process of teaching-learning, research and sharing professional experiences for the betterment of the community.	**3**	**3**	**2**
M2: To provide knowledge base and consultancy services to the community in all the areas of Civil Engineering	**2**	**2**	**3**

GEOTECHNICAL ENGINEERING (CGT)											
Scheme of Teaching and Examinations – 2022											
M.Tech., Choice Based Credit System (CBCS) and Outcome-Based Education (OBE)											
I SEMESTER											
Sl. No	**Course**	**Course Code**	**Course Title**	**Teaching Hours per Week**			**Examination**				**Credits**
				Theory	**Practical/Seminar**	**Tutorial/ Skill Development Activities**	**Duration in hours**	**CIE Marks**	**SEE Marks**	**Total Marks**	
				L	P	T/ SDA					
1	BSC	22PGT11	Advanced Computational Methods	3	0	0	3	50	50	100	3
2	IPCC	22PGT12	Soil Exploration and Field Testing	3	0	2	3	50	50	100	4
3	PCC	22PGT13	Geomechanics	3	0	2	3	50	50	100	4
4	PCC	22PGT14	Advanced Foundation Engineering	3	0	0	3	50	50	100	3
5	PCC	22PGT15	Ground Improvement Techniques	3	0	0	3	50	50	100	3
6	MCC	22RMI16	Research Methodology and IPR	3	0	0	3	50	50	100	3
7	PCL	22PGT17	Geotechnical Engineering Laboratory	0	4	0	3	50	50	100	2
8	AUD /AEC	22AUD18 /22AEC18	Any SWAYAM/ NPTEL Geotechnical/Interdiscplinary engineering related ONLINE courses (conducting during current semester), whose lecture hours are not less than 8 weeks.	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL				**18**	**4**	**4**	**21**	**350**	**350**	**700**	**22**

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC-Mandatory Credit Course,

Integrated Professional Core Course (IPCC): **Integrated Professional Core Course (IPCC)**: Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper.

Audit Courses /Ability Enhancement Courses Suggested by BOS (ONLINE courses): Audit Courses: These are prerequisite courses suggested by the concerned Board of Studies. Ability Enhancement Courses will be suggested by the BoS if prerequisite courses are not required for the programs. **Ability Enhancement Courses**:

- These courses are prescribed to help students to enhance their skills in in fields connected to the field of specialisation as well allied fields that leads to employable skills. Involving in learning such courses are impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of Studies.
- Registration to Audit /Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Audit Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

Skill development activities: Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis,fiscal expertise, etc.

Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhancetheir skill. The prepared report shall be evaluated for CIE marks.

GEOTECHNICAL ENGINEERING (CGT)											
Scheme of Teaching and Examinations – 2022											
M.Tech., Choice Based Credit System (CBCS) and Outcome-Based Education (OBE)											
II SEMESTER											
Sl. No	**Course**	**Course Code**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Practical/ Seminar**	**Tutorial/ Skill Development Activities**	**Duration in hours**	**CIE Marks**	**SEE Marks**	**Total Marks**	
				L	P	T/SDA					
1	IPCC	22PGT21	Finite Element Method	3	0	2	3	50	50	100	4
2	PCC	22PGT22	Critical State Soil Mechanics	3	0	2	3	50	50	100	4
3	PEC	22PGT23X	Professional Elective-I	3	0	0	3	50	50	100	3
4	PEC	22PGT24X	Professional Elective-II	3	0	0	3	50	50	100	3
5	OEC	22PGT25X	Open Elective	3	0	0	3	50	50	100	3
6	MPS	22PGT26	Mini Project with Seminar	0	6	0	3	100	--	100	2
7	PCL	22 PGT L27	Computational Laboratory	0	4	0	3	50	50	100	3
8	AUD/AEC	22AUD28	Any SWAYAM/ NPTEL Geotechnical/ Inter-discplinary engineering related ONLINE courses (conducting during current semester), whose lecture hours are	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL				**15**	**10**	**4**	**21**	**400**	**300**	**700**	**22**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities(Hours are for Interaction between faculty and students)

Professional Elective 1		Professional Elective 2	
Course Code under 22XXX23X	**Course title**	**Course Code under 22XXX24X**	**Course title**
22PGT 231	Dynamics of Soils and Foundations	22 PGT 241	Pile foundation Analysis and Design
22 PGT 232	Soil Structure Interaction Problems	22 PGT 242	Design of Earth Retaining Structures
22 PGT 233	Geotechnical Earthquake Engineering	22 PGT 243	Numerical Methods for Civil Engineers
22 PGT 234	Earth and Rock-fill dams	22 PGT 244	Design of Machine Foundations
22 PGT 235	Construction Management Techniques	22 PGT 245	Remote Sensing and GIS Application

Open Elective 1	
Course Code under 22XXX25X	**Course title**
22PGT01N	Ecology and Environmental Impact Assessment
22PGT01N	Repair and Rehabilitation of Structures
22PGT01N	Green Buildings

1. **Mini Project with Seminar:** This may be hands-on practice, survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analyzing and authenticating, case studies, etc.
   CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini project. Participation in the seminar by all postgraduate students of the program shall be mandatory.
   The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question-and-Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester. There is no SEE for this course.
2. **Internship:** All the students shall have to undergo a mandatory internship of 06 weeks during the vacation of II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. The internship shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in the internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

GEOTECHNICAL ENGINEERING (CGT)											
Scheme of Teaching and Examinations – 2022											
M.Tech., Choice Based Credit System (CBCS) and Outcome-Based Education (OBE)											
III SEMESTER											
Sl. No	**Course**	**Course Code**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Practical/ Mini–Project/ Internship**	**Tutorial/ Skill Development Activities**	**Duration in hours**	**CIE Marks**	**SEE Marks**		
				L	P	SDA					
1	PCC	22PGT31	Reinforced Earth Structure and Geosynthetics	3	0	0	3	50	50	100	3
2	PEC	22 PGT32X	Professional Elective-3	3	0	0	3	50	50	100	3
3	SP	22 PGT33	Societal Project	0	6	0	3	50	50	100	3
4	INT	22 PGT34	Internship	0	12	0	3	100	--	100	6
				(06 weeks Internship Completed during the intervening vacation of II and III semesters)							
5	PROJ	22PGT35	Project Work (Phase-I)	0	6	0	--	100	--	100	3
TOTAL				**6**	**24**	**0**	**12**	**350**	**150**	**500**	**18**

Professional elective 3	
Course Code under 22PGT32X	**Course title**
22PGT321	Advanced Pavement Design
22PGT322	Environmental Geo-Techniques
22PGT323	Structural Design of Foundations

Note:

1. **Project Work Phase-1:** The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.
   Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.
   CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report,Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.
2. **Societal Project:** Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology toworkout/proposing viable solutions for societal problems.
   CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.
   Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.
3. **Internship:** Those, who have not pursued /completed the internship, shall be declared as fail in the internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.
   CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

GEOTECHNICAL ENGINEERING (CGT)											
Scheme of Teaching and Examinations – 2022											
M.Tech., Choice Based Credit System (CBCS) and Outcome-Based Education (OBE)											
IV SEMESTER											
Sl. No	**Course**	**Course Code**	**Course Title**	**Teaching Hours /Week**			**CIE Marks**	**SEE Marks Viva voce**	**Total Marks**	**Credits**	
				Theory	**Practical/ Field work**	**Examination Duration in**					
1	Project	22PGT41	Project Work (Phase-II)	--	36	3	100	100	200	18	
TOTAL				--	**36**	**3**	**100**	**100**	**200**	**18**	

1. Project Work Phase-2:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Total Credits 22+22+18+18 =**80**

ADVANCED COMPUTATIONAL METHODS
Credits: 03 (3-0-0)

Subject Code: 22PGT011 **IA marks: 50**
Duration of Exam: 3 h **Maximum marks: 100**

Unit-I

Statistics: Frequency Distribution – Characteristics of Distributions: Central tendency and dispersion. Methods of least square and regression, multiple regression, Solutions of regression analysis problems Analysis of Variance.

Probability: Concept of probability, Random Variables, Binomial, Poisson and Normal distribution – applications, Chi- squared test, F test, t-test. Applications to respective fields in Civil Engineering.

Unit-II

Matrix operation: Matrix operation Eigen value and Eigen vector by iterative methods. Diagonalisation and square matrix. Applications to respective fields in Civil Engineering.

Unit-III

Ordinary Differential Equation: Second order homogeneous equation, Euler-Cauchy's equation, non-homogeneous linear equation. Partial differential equation: wave equation – one and two dimensions. Applications to respective fields in Civil Engineering

Unit-IV

Numerical methods: Development of simultaneous equation using Gaussian elimination method, Gauss- Jordan matrix inversion method, Gauss-Siedel method, Cholesky decomposition method. Applications torespective fields in Civil Engineering.

BOOKS FOR REFERENCE

1. Rao, S.S. (1996), "Optimization: Theory and applications", Wiley Eastern Ltd. Publications
2. Grewal. B.S., and Grewal. J.S., "Numerical methods in Engineering and Science", Khanna Publishers, 9th Edition, New Delhi.
3. S S Sastry- Introductory Methods of Numerical Analysis, 5th edition, PHI,New Delhi , 2012.
4. E Balagurusamy- Numerical Methods, Tata Mc Graw Hill, 2017.
5. H C Saxena- Examples in Finite Differences and Numerical Analysis, S Chand & Co. New Delhi, 1975.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Apply the concept of probability to find the physical significance of various distribution phenomena.	3	2	-			
2	Make use of matrix theory to compute eigenvalues and eigenvectors.	3	2	0			
3	Analyse the solution of differential equations.	3	2	-			
4	Able to apply numerical method to solve systems of equations.	3	2	-			

SOIL EXPLORATION AND FIELD TESTING
04 Credits (3-2-0)

Subject Code: 22 PGT12 IA marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Select suitable site investigation methods and its extent for variety of structures including preliminary investigations.
2. Identify suitable geophysical investigation method for soil exploration.
3. Identify suitable in-situ tests and Appraise codal provisions for different soil conditions
4. Describe the basics of photogrammetry and remote sensing application in geotechnical exploration.

UNIT 1

Introduction to Exploration-

Role of engineer in the systematic exploration of a site; Need and Objectives; Rock and soil types and their formation; Soil profiles of various regions.; Field reconnaissance, Extent of Investigation for different types of structures (buildings, towers, industries, road, embankment, reservoir, Dams, retaining wall, etc.)

Basic of Exploration-

Drilling and accessible explorations; Sampling methods and equipments; Factors considering in selection sampler, Factors affecting sample quality, Sample disturbance, Spacing and Depth of boring, Handling, preservation, and transportation of samples.

UNIT 2

Geological exploration-

Relevance of geology to civil engineering, Basics of structural geology, Geological exploration of an engineering site; Engineering classification of intact and fissured rocks – RQD.

Geophysical methods-

Applied geophysical surveys, electrical conductivity, electrical resistivity, seismic reflection and seismic refraction methods, magnetic survey, surface wave method, Gravity survey In-situ state of stress in soils and rocks; In situ permeability; Importance of In-situ testing, Ground water exploration, site evaluation and reporting.

UNIT 3

In-situ Tests, Result interpretations and Codal provisions-

Plate load test (Theory and perform), pile load test, SPT test (Theory and perform), CPT test, flat dilatometer test, DCPT test, Vane shear test, pressure meter test, field CBR test, core cutter (lab), sand replacement test (lab), nuclear probe method, block shear test. Soil profiling, interpretation of exploration data and report preparation, various standards for soil investigations. Codal provisions.

UNIT 4

Photogrammetry and remote sensing in soil exploration-

Importance of photogrammetry and remote sensing in geological and geotechnical investigations. Photo interpretation– Basic elements in photo interpretation, Interpretation of rock forms and bed rocks. Basic concepts of remote sensing, remote sensing system, energy interaction mechanism on ground, Earth's emission, spectral response and spectral signature and spectra of rock and soils.

References

1. Hvorslev M J., "Subsurface Exploration and Sampling of Soil for Civil EngineeringPurposes", Waterways Experiment station, Missisippi, 1949
2. Hunt R.E. "Geotechnical Engineering: Analysis and Evaluation" McGraw Hill BookCompany 1986
3. H. F. Winterkorn and H Y Fang, Foundation Engineering Hand Book, GalgotiaBooksource.
4. McLean A.C. and Gribble C.D., "Geology for Civil Engineering's" Unwin Hyman,London,

1988.
5. Floyd F Sabins Jr., "Remote Sensing – Principles of Interpretation", 2nd Ed. W H Freemanand Co.
6. Michael Hord R., "Remote Sensing – Methods and Applications", John Wiley and Sons,New York.
7. Ravi P Gupta., "Remote Sensing Geology", Springer Verlog.
8. Wolf P R., "Photogrammetry"., McGraw Hill Publication New York.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Apply the basics of site investigation methods and its extent for variety of structures including preliminary investigations.	2	-	2	2	-	-
2	Identify suitable geophysical investigation method for soil exploration.	3	-	2	2	1	-
3	Identify suitable in-situ tests and appraise codal provisions for different soil conditions	3	3	2	2	3	-
4	Apply the basics photogrammetry and remote sensing application in geotechnical exploration.	2	-	2	-	1	3
	Average	2.5	3	2	2	1.67	3

GEOMECHANICS
04 Credits (3-2-0)

Subject Code: 22PGT13 **IA Marks:** 50
Duration of Exam: 3 h **Maximum marks:** 100

Course outcomes: At the end of the course the student will be able to

1. Explain the concept of stress, direction cosines, stress transformation,principal stresses.
2. Describe the concept of strain, compatibility conditions and fundamentals of elasticity elastoplastic and plastic behavior of soils by using Hooke's law, limit equilibrium concept, Mohr – Coulomb failure theory, stress paths and yield criteria as applicable to soils.
3. Evaluate the total and time rate of settlement by applying the concepts of consolidation theory.
4. Select the type of shear tests of soil tests based on drainage conditions and also understand the mechanism of shear strength mobilization, factors influencingshear strength, measurement of shear strength.
5. Analyse the shear strength of cohesive and cohesionless soils indrained and un-drained conditions by interpreting the stress paths of soils.

UNIT 1

Introduction to geomechanics; basics of consolidation theory; Soil classification based on stress theory, Estimation of compression index, preconsolidation pressure; Settlement analysis- Components of Settlement, Calculation of total settlements, time rate settlement; Total and differential settlements, permissible settlements.

UNIT 2

Shear strength – Physical components, Factors influencing shear strength, Mohr-Coulomb strength theory, Mechanism of shear strength mobilization, Measurement of shear strength, Drainage conditions, Pore pressure parameters, Choice of test conditions, Shear strength of cohesionless soils, Shear strength of saturated cohesive soils, Determination of Insitu shear strength and Stress paths for drained and undrained shear tests.

UNIT 3

Soil behavior- Elastic, Plastic and Elasto-plastic. Mohr's stress circle concept; Limit equilibrium-Mohr coulomb theory; Failure criteria for cohesive and cohesionless soils; Concept of stress paths – Total and Effective stress paths in different spaces; Yield criteriaTresca, Von mises and Mohr coulomb criteria.

UNIT 4

Stability analysis of slope; Effective vs Total stress analysis (Approach), shape of slip surface, methods of slices, graphic methods, location of critical slip circle, wedge analysis method, stability during critical condition.

References

1. Scott R F., “Theoretical soil mechanics” Prentice Hall, New Jersy (1965).
2. Lambe and Whitman. “Soil Mechanics”, Wiley Eastern Pvt Ltd., New Delhi (3rdEd ,1979).
3. Mitchell J K., “Principles of Soil Behaviour”, John Willey and sons (1976).
4. Leornards G A., “Foundation Engineering “, McGraw Hills, New York, (1962).
5. Yong R N., Warkentin B P., “Soil Properties and Behaviour”, Elsevier Publication (1975).
6. Bishop A W., and Henkal D J., “Measurement of Soil Properties in Triaxial Test. EdwardArnod (Pub) Ltd London(1962).
7. M.E.Harr., “Foundation of Theoretical Soil Mechanics”, McGraw Hill (1966).

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Explain the concept of stress, direction cosines, stress transformation, principal stresses.	1	-	2	2	-	-
2	Describe the concept of strain, compatibility conditions and fundamentals of elasticity elasto plastic and plastic behavior of soils by using Hooke’s law, limit equilibrium concept, Mohr – Coulomb failure theory, stress paths and yield criteria as applicable to soils.	1	-	2	1	-	-
3	Evaluate the total and time rate of settlement by applying the concepts of consolidation theory	2	-	3	-	-	-
4	Select the type of shear tests of soil tests based on drainage conditions and also understand the mechanism of shear strength mobilization, factors influencing shear strength, measurement of shear strength	2	-	3	-	-	-
5	Analyse the shear strength of cohesive and cohesionless soils in drained and un-drained conditions by interpreting the stress paths of soils.	2	-	3	-	-	-
	Average	1.6	-	2.6	0.6	-	-

ADVANCED FOUNDATION ENGINEERING
03 Credits (3-0-0)

Subject Code: 22PGT14 IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Estimate the settlement of soil by assessing the different loads on the foundation.
2. Design the structural and geotechnical aspects of shallow foundations.
3. Design the deep foundations for different loads and type of soils.
4. Analyze and suggest remedial measures against foundation failures.

UNIT 1

Assessment of foundation loads for Engineering structures – Dead load, Live load, wind and seismic load combinations for the Design, Code requirements. Bearing Capacity Settlement analysis, immediate settlements, Consolidation settlements, Total settlements, Relative settlements, various methods of estimation.

UNIT 2

Shallow Foundations - Conventional structural design of Individual footings, combined footingsand Rafts.

Pile Foundations – Analysis and Conventional Design of pile foundations for vertical and lateralloads including design of pile cap.

UNIT 3

Piers and Well Foundations: Analysis and design of pier and well foundations. Caissons.Foundations on expansive soils, under reamed piles.

UNIT 4

Special foundations. Design of Sheet piles

Foundation Failures - Types and causes of failures, Remedial measures, Shoring and Underpinning.

References

1. Bowels J E. "Foundation Analysis and design", McGraw Hill Book Co., New York.
2. Winterkorn and Fang, "Foundation Engineering Hand book"-Von Nostrand Reinhold Co
3. Shamsher Prakash, Gopal Ranjan and Swami Saran "Analysis and design of Foundation andRetaining structures", K. A. Rastogi Prakashan, Meerut, India. Jain, G.R. S., "Hand Book on Underreamed and Bored Compaction PileFoundations",Published by G. S. Jain Associates, Roorkee.
4. Das, B. M., "Principles of Foundation Engineering", Cengage Learning (2011)
5. Tomlinson, "Foundation Design and Construction", ELBS, Longman Group Ltd.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Estimate the settlement of soil by assessing the different loads on the foundation.	-	-	2	1	-	-
2	Design the structural and geotechnical aspects of shallow foundations	-	-	3	1	2	-
3	Design the deep foundations for different loads and type of soils.	-	-	3	1	2	-
4	Analyze and suggest remedial measures against foundation failures.	-	-	3	-	1	-
	Avg	-	-	2.6	1	1.67	-

GROUND IPROVEMENT TECHNIQUES
03 Credits (3-0-0)

Subject Code: 22PGT15 IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of the course the student will be able to
1. Select the type of mechanical modification for shallow and deep compaction of soils.
2. Select the type of hydraulic modification required for cohesive and cohesionless soil
3. Choose the stabilization of soils using various admixture and various grouting techniques.
4. Choose the site specific method of soil improvement by inclusion and miscellaneous methods.

UNIT-1

Principles and objectives of ground improvement; Classification of ground improvement techniques. Factors affecting ground improvement.

Mechanical modification method of ground improvement; Theory of compaction, moisture-density relationship, optimum moisture content and maximum dry density; Laboratory compaction test using Proctor's mould and modified Proctor Mould, Factors affecting compaction

Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro-floatation, Blasting, Dynamic consolidation, Pre-compression and compaction piles, Field compaction control, Specifications for field compaction

UNIT 2

Hydraulic Modification: Preloading by lowering ground water table, Filters, Control of ground water seepage, Sand drains and wick drains, open sumps and ditches, Well point system, Electro-osmosis, Vacuum dewatering wells, Vertical drains, and its application in ground improvement, pre-loading without and with sand drains, Design of vertical drains

UNIT 3

Chemical Modification: Factors affecting chemical modification, Lime stabilization, Cement stabilization, Bitumen stabilization, Chemical Stabilization, Methods of construction- mix in place method, traveling plant and stationary plant methods.

Grouting: Factors affecting grouting, Groutability, Grouting materials and their properties, Pressure grouting, Compaction grouting, Grouting procedures, Applications of grouting

UNIT -4

Modification by Inclusion and Confinement: Applications of Geosynthetics for ground improvement;Ground Anchors: Types of ground anchors and their suitability, Uplift capacity of anchors.

Soil Confinement Systems: Concept of confinement, Gabion walls, Crib walls, Sand bags, Evergreen systems and fabric form work.

Miscellaneous Techniques: Expansive Soil Problems and Foundation Techniques, Construction andapplications of stone columns in soft clays, Rock cutting, anchoring, heating, soil nailing

References

1. Manfired R.H. (1990) "Engineering Principles of Ground Modification", McGraw-Hill Pub.
2. Koerner R M. (1985) "Construction and Geotechnical Methods in Foundation Engineering"., McGrawHill Pub Co New York.
3. Hausmann, M R (1990) "Engineering Principles of Ground Modifications", McGraw Hill Pub Co NewYork.
4. Ingles O G and Metcalf J B., "Soil Stabilisation: Principles and practice", Butterworths, London, 1972
5. Nelson J D and Miller D J., "Expansive soils", John Wiley and sons. Inc new

P. Purushothama Raj., " Ground Improvement Techniques", Laxmi Publications Pvt Ltd

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Select the type of mechanical modification for shallow and deep compaction of soils.	1	1	1	-	-	2
2	Select the type of hydraulic modification required for cohesive and cohesionless soil	2	2	2	-	-	-
3	Choose the stabilization of soils using various admixture and various grouting techniques	2	1	2	-	-	-
4	Choose the site specific method of soil improvement by inclusion and miscellaneous methods	2	2	2	-	-	1
	Average	1.75	1.5	1.75	-	-	1.5

RESEARCH METHODOLOGY AND IPR

3 Credits

(3-0-0)

Subject Code: 22RMI16 IA marks: 50

Duration of Exam: 3 h Maximum marks: 100

On completion of the course, students should be able to:

1. Describe need for research design.
2. Assess and review steps in sampling design.
3. Study and understand statistics in research.
4. Apply research paper and IPR.

UNIT 1

Introduction to Research Methodology:

Meaning, Objective of research, Motivation in research, Type of research, research approaches, significance of research, Research methods versus Methodology, Research and scientific method , importance of knowing how research is done, research process, criteria of good research, problem encountered by research in India.

Defining the Research Problem:

What is research problem, Selecting the problem, necessity of defining the problem, technique involved in defining a problem, meaning of research design, need for research design, features of a good design, importance concepts relating to research design , different research design, basic principal of experimental design .

UNIT 2:

Sampling Design:

Census and sample survey, Implications of a sample design , steps in sampling design, criteria of selecting a Sampling procedure, characteristics of a good sample design, different type of sample designs, how to select a random sample, Radom sample from an infinite universe , complex random sampling designs.

Method of data collection:

Collection of primary data, observation method, interview method, collection of data through questionnaires, collection of data through schedules, different between questionnaires and schedules, some other method of data collection, collection of secondary data, selection of appropriate methodfor data collection ,case study method.

UNIT 3

Processing and analysis of data:

Processing operation, some problem in processing, elements of analysis, statistics in research , measures of central tendency, measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationship, simple regression analysis , multiple correlation and regression ,partial correlation, association in case of attributes, other measures.

Testing of Hypothesis-I:

Hypothesis, Basic concept concerning testing of hypothesis ,procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, test of hypotheses, important parametric tests, hypothesis testing of mean, hypothesis testing for different between means, hypothesis testing for comparing two related samples.

UNIT 4

Interpretation and Report Writing:

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports,Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research report.

Nature of Intellectual Property:

Patents, Designs, Trade Mark and Copyright. Process of Patenting and Development: technological research, innovation, patenting & development. Procedure for grants of patents.

Text-books:

1. Kothari C.R."Research Methodology "Methods & Techniques", Wishwa prakashan, A Division of New Age International Pvt. Ltd.
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

Reference books:

1. RanjitKumar , " Research Methodology", Sage Publication , London, New Delhi,1999.
2. Meenakshi Raman & Sangeeta Sharma. "Technical Communication-Principles and Practice"Oxford University press,Jai Singh Road, New Delhi.
3. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
4. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO3	PO4	PO6
1	Describe need for research design	2	1	3	2	1	3
2	Assess and review steps in sampling design.	3	1	3	3	1	3
3	Study and understand statistics in research	2	3	2	2	3	2
4	Apply research paper and IPR	2	3	2	2	3	2
	Average	2.25	2	2.5	2.25	2	2.5

Geotechnical Engineering Laboratory
02 Credits
(0-0-4)

Subject code- 22PGT17 **IA Marks- 50**
Duration of exam: 02 h **SEE Marks-100**

Course outcomes: At the end of the course students will be able to

1. Evaluate the gradation of soil by using dry and wet analysis.
2. Estimate the shear strength and penetration resistance of soil.
3. Evaluate the consolidation properties of soil.
4. Interpret geotechnical report and develop an appreciation the use of field tests in the engineering of civil infrastructure.

List of experiments

1. Grain size analysis of soil: wet and dry analysis.
2. Determination of relative density.
3. Shear tests on soil: Unconfined compression test, Direct Shear Test and Triaxial Test.
4. Determination of California Bearing Ratio (CBR).
5. Electrical Resistivity
6. Standard Penetration Test (SPT)
7. Determination of compression index and coefficient of consolidation.
8. Determination of dynamic properties of soil.
9. Geotechnical investigation report.

Reference books:

1. I.S. Code of Practice (2720): Relevant Parts, as amended from time to time
2. Lambe T.W.,- Wiley Eastern Ltd., Soil testing for engineers-New delhi
3. Head K.H., (1986)-Vol. I, II, III Manual soil laboratory testing-Princeton press, London.
4. Bowels J.E., (1988)- Engineering properties of soil & their measurements McGraw Hill Book Co. New York.

Laboratory Assessment:

1. Each laboratory subject is evaluated for 100 marks (50 CIE & 50 SEE)
2. Allocation of 50 marks for CIE

- Performance & journal write up: Marks for each experiment =30/ No. of proposed experiment
- One Practical test for 20marks. (5 write up, 10 conduction, calculation, results etc., 5 Viva-voce
- Allocation of 50 for SEE-25 % write up, 50% conduction, calculation, results etc., 25% viva-voce.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Evaluate the gradation of soil by using dry and wet analysis.	-	2	1	-	-	2
2	Estimate the shear strength and penetration resistance of soil.	1	2	-	-	-	2
3	Evaluate the consolidation properties of soil.	1	2	2	-	-	2
4	Interpret geotechnical report and develop an appreciation the use of field tests in the engineeringof civil infrastructure.	-	3	2	-	-	2
	Average	1	2.25	1.25	-	-	2

BOS Recommended Online Courses

Subject code: 22AUD18/22AEC18

FINITE ELEMENT METHOD
4 Credits (3-2-0)

Subject Code: **22PGT21** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Describe the essential facts, concepts, theories andprinciples underlying various finite element methods and analysis.
2. Evaluate shape functions, nodal displacements using generalized and natural coordinates generalized for 1-D, 2-D and 3-D elements.
3. Develop stiffness matrix, strain-displacement matrix by using jacobian matrix for isoparametric elements.
4. Apply the concepts of FEM to solve 1-D and 2-D structures for plane stress, plane strain and axis-symmetric problems.

UNIT 1:

Basic concepts of elasticity – kinematic and static variables, approximate methods of structural analysis: Rayleigh-Ritz method, finite difference method, finite element method. Principles of finite element method, advantages and disadvantages, finite element procedure.
Discretization of structures:Finite elements used for one, two and three dimensional problems, element aspect ratio, mesh refinement versus higher order elements, numbering of nodes to minimize band width.

UNIT 2:

Displacement Model: Nodal displacement parameters, convergence criterion, compatibility requirements, geometric invariance, shape function, polynomial form of displacement function. generalized and natural coordinates, Lagrangian interpolation function, shape functions for one, two and three dimensional elements.

UNIT 3:

Concept of Isoperimetric Elements: Internal nodes and higher order elements, serendipity and Lagrangian family of finite elements, sub parametric and super parametric elements, condensation of internal nodes, Jacobian transformation matrix, variation method and minimization of energy approach of element formulation (development of strain – displacement matrix and stiffness matrix) consistent load vector, numerical integration.

UNIT 4:

Application of finite element method for the analysis of one and two dimensional problems:Analysis of simple beams and plane trusses, application to plane stress, strain and axi-symmetric problems using CST and quadrilateral elements. Application to plates and shells – Choice of displacement function (C^o, C^1, C^2 type), techniques for nonlinear analysis.

References

1. Bathe K J, Finite Element Procedures in Engineering Analysis, Prentice Hall
2. Cook R D, Malkan D S & Plesta M.E, Concepts and Application of Finite Element Analysis,3rd Edition, John Wiley and Sons Inc., 1989
3. Daryl L.Logan, Finite Element Method, Thomson Brooks/Cole, 2007
4. Krishnamoorthy C S, Finite Element Analysis, Tata McGraw Hill, 1995
5. Rajasekaran. S, Finite Element Analysis in Engineering Design, Wheeler Publishing, 1993 .

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Describe the essential facts, concepts, theories and principles underlying various finite element methods and analysis.	-	-	3	-	-	-
2	Evaluate shape functions, nodal displacements using generalized and natural coordinates generalized for 1-D, 2-D and 3-D elements.	1	-	3	-	-	2
3	Develop stiffness matrix, strain-displacement matrix by using jacobian matrix for isoparametric elements	2	-	3	2	-	2
4	Apply the concepts of FEM to solve 1-D and 2-D structures for plane stress, plane strain and axis-symmetric problems.	3	-	3	2	-	2
	Average	2	-	3	2	-	2

CRITICAL STATE SOIL MECHANICS
04 Credits (4-0-0)

Subject Code: **22PGT22** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of the course students will be able to

1. Describe the basic concepts of elasticity, plasticity, stress paths, stress invariants, total and effective stress.
2. Discuss the flow of water and volume change through soils by using Darcy's law, Laplace and consolidation theories for cohesionless and cohesive soils.
3. Investigate the behaviour of soils subjected to various loading and drainage conditions within unified framework of critical state soil mechanics.
4. Describe the basic elasto-plastic models based on critical state soil mechanics like Cam-Clay and Granta Gravel.

UNIT 1:

Stress and strain in a continuum, elasticity and plasticity in soils, principle of effective stress and its significance, increment of stress and strain in soils. Principle stresses and principle planes, Mohr circle of total and effective stress, Normal and shear strain. invariants of stresses, Stress paths, Representation of stress paths in different spaces, invariants of strain and strain paths.

UNIT 2:

Darcy's law, Discharge and Seepage velocity, Hydraulic gradient and critical hydraulic gradient, Laplace theory for seepage problems, Flow nets and their applications; Compression and Consolidation – Isotropic compression test, isotropic compression of clay and sands, possible and impossible states.

UNIT 3:

Introduction to critical state concept, Families of undrained and drained shear tests, Representation of critical state lines, Drained and undrained planes in 2 and 3 dimensional spaces. Roscoe surface, Roscoe surface as state boundary surface. Drained test for O.C soils. Hvorslev's surface, critical state lines for O.C soils and complete state boundary surface.

UNIT 4:

Elastic and plastic deformation, calculation of elastic and plastic strains, essentials plasticity theory, Yield surface, Cam clay model. Mohr coulomb failure criteria, general stress states.

References

1 Schofield, A.N. and Wroth, C.P., Critical state soil mechanics, McGraw-Hill, 1968
2 Wood, D.M., Soil behaviour and critical state soil mechanics, Cambridge University Press
3 Atkinson, J.H., An introduction to the mechanics of soils and foundations, McGraw-Hill,
4 Atkinson, J.H. and Bransby, P.L., The mechanics of soils: an introduction to critical state soil mechanics, McGraw-Hill, 1978.
5 Potts, D.M. and Zdravkovic, L., Finite element analysis in geotechnical engineering, Vol. 1: Theory, Thomas Telford, 1999.
6 Muir Wood, D., Geotechnical Modelling, Spon Press, 2004.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO5	PO6	PO7
1	Describe the basic concepts of elasticity, plasticity, stress paths, stress invariants, total and effective stress.	-	-	3	-	-	-
2	Discuss the flow of water and volume change through soils by using Darcy's law, Laplace and consolidation theories for cohesionless and cohesive soils	1	-	3	2	-	-
3	Investigate the behaviour of soils subjected to various loading and drainage conditions within unified framework of critical state soil mechanics.	2	-	3	1	-	-
4	Describe the basic elasto-plastic models based on critical state soil mechanics like Cam-Clay and Granta Gravel.	2	-	3	-	-	-
	Average	1.25	-	3	0.75	-	-

DYNAMICS OF SOILS AND FOUNDATION
Credits (3-0-0)

Subject Code: **22PGT231** IA Marks: 50
Duration of Exam: 3 h **Maximum marks: 100**

Course outcomes - At the end of the course the student will be able to:

1. Interpret the concept of dynamics in Geotechnical Engineering
2. Evaluate the dynamic properties of soils using laboratory and field tests.
3. Analyze liquefaction susceptibility of a site and suggest mitigation.
4. Investigate various isolation methods and classify the earthquake region.

UNIT 1:

Types of dynamic loads encountered in civil engineering. Occurrence of earthquakes, seismic waves generated by earthquakes and their properties. Types of surface waves and their uses in subsoil exploration, effect of depth below ground level on amplitudes of ground vibrations due toR waves. Free and forced Vibration of single degree of freedom system with and without damping. Coulomb (friction) damping, viscous (proportional) damping, radiational (geometric) damping. Two degree of freedom systems with and without damping. Natural frequency and resonance and its effects.

UNIT 2:

Propagation of shear waves through layered media. Dynamic stress-strain characteristics of cohesionless soils, cohesive soils and c-ϕ soils.
Laboratory equipment for dynamic soil tests; In-situ measurements and field tests for evaluationof seismic wave velocity: SASW, MASW, cross bore hole, down-hole, etc.

UNIT 3:

Liquefaction of soils: Occurrence of liquefaction and its significance in geotechnical engineering; examples of liquefaction under field conditions due to seismic vibrations; factors affecting liquefaction; liquefaction analysis; measures for reducing the damage to structures due to liquefaction. Site characterization using seismic consideration, Numerical evaluation of wave amplification for 2 and 3 layer soils, determination of liquefaction. Potential of sites.

UNIT 4:

Vibration isolation and measures for vibration isolation.
Special topics in Geotechnical Engineering: Microzonation and base isolation.

References

1. Prakash, S. (1981) “Soil Dynamics”, McGraw Hill Book Co., New York.
2. Kramer, S. L. (1996)”Geotechnical Earthquake Engineering”, Prentice Hall International Series.
3. Okamoto, S.(1973), “Introduction to Earthquake Engineering”, John Wiley & Sons, New York.
4. Richarts, F. E., Hall Jr., J. R. and Woods, R. D. (1970) “Vibrations of Soils and Foundations”, Prentice Hall International Series.
5. Barkan, D. D. (1962) “Dynamics of Bases and Foundations”, McGraw Hill Book Co., New York.
6. Kameshwar Rao, (1998) “Vibration Analysis and Foundation Dynamics”, Wheeler Publishing

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Interpret the concept of dynamics in Geotechnical Engineering	1	-	2	-	-	-
2	Evaluate the dynamic properties of soils using laboratory and field tests.	2	-	3	1	1	-
3	Analyze liquefaction susceptibility of a site and suggest mitigation	2	-	3	1	2	1
4	Investigate various isolation methods and classify the earthquake region	3	-	3	2	2	-
	Average	2		2.75	1.33	1.67	0.5

SOIL STRUCTURE INTERACTION
03 Credits (3-0-0)

Subject Code: **22PGT232** IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Describe the concepts of elasticity and plasticity in soils.
2. Analyse the behaviour of the soil under elastic and plastic condition and demonstrate the understanding of Elastic and Elasto plastic analysis of footing and Raft foundations.
3. Evaluate the behaviour of the pile under static and dynamic loads.
4. Design the dynamics of foundations embedded in half-space and analyse the soil-structure in time domain.

UNIT 1:

Introduction to linear algebra, Mathematical modelling, Differential equations in solid mechanics and soil mechanics, Fundamentals of continuum mechanics, Stresses and displacements in soils, solids and structures, Constitutive relations, Fundamentals of soil plasticity, Mechanics of soil- structure interaction, Methods of analysis – FDM, FEM, BEM, DEM.

UNIT 2:

Beams and plates on elastic foundation, Elastic and elasto-plastic analyses of footings and raft foundations. Interaction analysis of pavements.
Static interaction analysis of structures founded on shallow and deep foundations.

UNIT 3:

Analysis of axially and laterally loaded single pile and pile groups, Pile-cap-pile-soil interaction, Behaviour of piled-raft foundations.

UNIT 4:

Dynamics of foundations: Foundation input motion, Foundation embedded in a layered half- space, Seismic soil-structure interaction analysis in time domain for buildings and bridges.
Examples and Case studies.

References

1. Wolf, J. P. and Deeks, A. J. (2004). Foundation Vibration Analysis: A Strength-of-Materials Approach, Elsevier, Amsterdam.
2. Wolf, J. P. (1988). Soil-Structure-Interaction Analysis in Time Domain, Prentice-Hall, New Jersey.
3. Wolf, J. P. and Song, C. (1996). Finite Element Modelling of Unbounded Media, John Wileyand Sons, New York.
4. Zaman, M., Gioda, G. and Booker, J. (2001). Modelling in Geomechanics, John Wiley and Sons, New York.
5. Maekawa, K., Pimanmas, A. and Okamura, H. (2003). Nonlinear Mechanics of Reinforced Concrete, Spon Press, London.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Describe the concepts of elasticity and plasticity in soils.	-	-	3	-	-	-
2	Analyse the behaviour of the soil under elastic and plastic condition and demonstrate the understanding of Elastic and Elasto plastic analysis of footing and Raft foundations.	2	-	3	1	1	1
3	Evaluate the behaviour of the pile under static and dynamic loads	2	-	3	2	-	2
4	Design the dynamics of foundations embedded in half-space and analyse the soil-structure in time domain.	3	-	3	2	-	2
	Average	2.33	-	3	1.67	1	1.67

GEOTECHNICAL EARTHQUAKE ENGINEERING
03 Credits (3-0-0)

Subject Code: **22PGT233** IA Marks: 50
Duration of Exam: 3 Hrs **Maximum marks: 100**

Course outcomes: At the end of the course the student will be able to

1. Demonstrate the understanding of Engineering seismology and dynamic behavior of the soil.
2. Analyze liquefaction susceptibility of a site.
3. Analyze and design slopes, embankments, foundations and earth retaining structures for seismic conditions.
4. Interpret the case histories, mitigation techniques and computer aided analysis.

UNIT 1:

Introduction to Engineering seismology, plate tectonic, Earthquake magnitude.Ground motion and Effect of local soil condition on Ground motion.

UNIT 2:

Dynamic behavior of soils. Analysis of seismic site response. Liquefactionphenomena and analysis of pore pressure development.

UNIT 3:

Analysis and design of slopes, embankments, foundation and earth retainingstructures for seismic loading.

UNIT 4:

Case histories. Mitigation techniques and computer-aided analysis.

References

1. Kramer, S. L. (1996)"Geotechnical Earthquake Engineering", Prentice Hall International Series.
2. Okamoto, S.(1973), "Introduction to Earthquake Engineering", John Wiley & Sons, New York.
3. Richards, F. E., Hall Jr., J. R. and Woods, R. D. (1970) "Vibrations of Soils and Foundations", Prentice Hall International Series.
4. Day, Handbook of Earthquake Geotechnical engineering.
5. Geotechnical Earthquake Engineering Handbook, McGraw Hill, New York, 2002.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Demonstrate the understanding of Engineering seismology and dynamic behavior of the soil	1	-	-	-	-	-
2	Analyze liquefaction susceptibility of a site	2	-	2	1	1	1
3	Analyze and design slopes, embankments, foundations and earth retaining structures for seismic conditions.	3	1	3	2	2	2
4	Interpret the case histories, mitigation techniques and computer aided analysis.	2	2	3	2	2	2
	Average	2	1.5	2.67	1.67	1.67	1.67

EARTH AND ROCK FILL DAMS
03 Credits (3-0-0)

Subject Code: **22PGT235** IA Marks: 50
Duration of Exam: 3 Hrs **Maximum marks: 100**

Course outcomes: At the end of the course the student will be able to

1. Describe the importance of earth–rock fill dams and select a suitable site.
2. Select the materials and equipment required for the construction of earth/rockfill dams .
3. Analyze and design the stability of Earth and Rockfill Dams.
4. Analyze seepage through a given earth/rockfill dam section and select effective seepage control measures for the prevailing site conditions.

UNIT 1:

Introduction: Why earth and Earth-Rock fill dams. Homogeneous earth dams zoned earth, earth – rock fill dams. Typical embankment, dam sections

Site selection and exploration: Influence of topography and subsoil conditions on location and alignment of the dam. Sub surface exploration and studies on embankment construction material.

UNIT 2:

Factors influencing design: Material available for embankment construction, character of foundation, climate, shape and size of the valley, river diversion, and probable wave action time available for construction function of reservoir and earthquake activity.

Design details: Material, location and inclination of earth core and shell materials, embankment side slopes, free board and crest width. Filter zones, design provisions, draw down pore pressures. Berms, upstream and downstream slope protection. Internal drainage systems.

UNIT 3:

Stability analysis: Zones of planes of weakness in foundation, stability analysis of embankment by Taylor's method, Swedish' method including side forces between slices, simplified method suggested by Sherard et. al.; Morgenstern-price method, wedge method, stability during construction, full reservoir and drawdown, settlement and horizontal movements. Special design problems and details.

UNIT 4:

Earth dams on pervious soil foundation: Methods of foundation treatment, preventing under seepage with complete vertical barriers and grouting, Reducing under seepage with partial vertical cutoffs and horizontal upstream impervious blankets, controlling under seepage by regulation of leaks and relief wells.

Embankment construction: Equipments for excavating, hauling spreading, blending, compacting and separating over sized rocks and cobbles, construction procedures and quality control of impervious and semi pervious embankments sections, handling dry and wet materials. Construction procedures and quality control of pervious embankment sections, construction problems caused by fines, construction procedures of hard and soft rockfill embankments, field test on rockfill embankments, slope treatment and riprap.

References

1. Sherard J.C. Woodward. R.J, Gizienski, S.F and Clevenger W.A "Earth and Earth- Rock Dams", John Wiley, Inc. New York.
2. Sowers. G.P and Sally, H.L earth and Rockfill "Dam Engineering" Asia Publishing house,

3. Ereager. W.P., Justin, J.D and Hinds. J “Engineering for Dams” John Wiley, London
4. Stage W.L., “Indian storage resources with earthen dams”, Rand F.N. Spon Ltd.., London.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Describe the importance of earth–rock fill dams and select a suitable site.	-	-	1	-	-	-
2	Select the materials and equipment required for the construction of earth/rockfill dams .	1	-	1	-	1	1
3	Analyze and design the stability of Earth and Rockfill Dams.	2	1	2	2	2	-
4	Analyze seepage through a given earth/rockfill dam section and select effective seepagecontrol measures for the prevailing site conditions.	2	1	2	2	2	2
	Average	1.67	1	1.5	2	1.67	2

CONSTRUCTION MANAGEMENT
03 Credits (3-0-0)

Subject Code: **22PGT235** IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Apply independently ISO standards in quality and safety for construction.
2. Prepare feasible report for a construction project.
3. Apply inventory management techniques.
4. Apply quality management concepts and techniques in construction projects.

UNIT 1:

Stages of construction - estimating, tendering, pricing and contracting, equipment planning and waiting line situations, inventory management.
Engineering economics and Economic feasibility – budget, break-even analysis, Balance sheets, cost benefit analysis, discounted cash flow, Life cycle costing, cost control optimization.

UNIT 2:

Principles and practice of project management; work breakdown structures, critical path networks, PERT, resource charts, cost charts, S-curves,
Performance ratios updating of plans - purpose, frequency and methods of updating, common causes of time and cost overruns and corrective measures.

UNIT 3:

Design tree and decision analysis, construction simulation and simulation models, Appraisal of public investment projects, techno-economics of projects project investment analysis and decisions.

UNIT 4:

Quality control - concept of quality, quality of constructed structure, use of manuals and checklistsfor quality control, role of inspection, basics of statistical quality control, ISO standards.
Safety and health on project sites - accidents; their causes and effects, costs of accidents,occupational health problems in construction, organizing for safety and health, ISO standards.

References

1. Varma, M., “Construction planning and management through system techniques: Metropolitian Book Company , New Delhi 1983.
2. Kumar Neeraj Jha, “Construction Project Management”,
3. Punmia B. C., Khandelwal K. K., “Project Planning and Control with CPM and PERT”, Laxmi Publication Private Ltd., New Delhi, 2004
4. Shrivastva U. K., “Construction Planning and Management”, Galgotia Publications Pvt. Ltd.,New Delhi, 2010
5. Peurifoy R. J., “Construction planning, equipment and methods, McGraw Hill Book company, New York, 2006.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Apply independently ISO standards in quality and safety for construction.	-	1	2	-	2	2
2	Prepare feasible report for a construction project.	1	3	2	-	1	2
3	Apply inventory management techniques.	2	-	2	-	1	2
4	Apply quality management concepts and techniques in construction projects.	1	-	2	-	1	2
	Average	1.33	1	2	0.0	1.25	2

PILE FOUNDATION ANALYSIS AND DESIGN
03 Credits (3-0-0)

Subject Code: **22PGT241** IA Marks: 50
Duration of Exam: 3 Hrs **Maximum marks: 100**

Course outcomes: At the end of the course the students will be able to
1. Demonstrate the understanding and knowledge of underlined concept, facts and principles of pile foundation.
2. Design of pile groups and laterally loaded piles under static and seismic conditions.
3. Design pile cap and under-reamed piles for cohesive soils.
4. Analyze and suggest remedial measures against foundation failures.

UNIT 1:
Shallow v/s deep foundations, classification, economics and capacity of a pileSingle pile: analysis and design

UNIT 2:
Pile group: Problems related to load on each pile Battered piles: Laterally loaded(seismic).

UNIT 3:
Pile cap design; Under reamed piles

UNIT 4:
Pile sinking by vibroflotation, Construction equipments: Bored and cast-in-situpiles, case studies on failure of piles
Pile testing: Integrity of piles, corrosion resistance, durability, damage protectionto wooden and concrete piles.

References

1. Tomlinson M j., "Foundation design and construction"-sir IsacPirman& sons Ltd. London (1963) 1st edition
2. Poulos and Davis. "Pile foundation analysis and design"- Elastic solution for soil & Rock Mechanics. John Wiley sons. (1974)
3. Chellis R.D., " Pile foundation – Theory – Design – Practice"- McGraw Hill (1963)
4. Bowels J.E., "Analytical and computer methods in foundation engineering"(1974)
5. Willkern and Fang., "Foundation engineering Hand Book"-Von No strand and remhold Co(1975)
6. Tomlinson, M. J. and Woodward, J. (2007). Pile Design and Construction Practice, Taylor and Francis, London.
7. Fleming, K., Weltman, A., Randolph, M. and Elson, K. (2009). *Piling Engineering*, Taylor and Francis, London.
8. Prakash, S. and Sharma, H. D. (1990). Pile Foundations in Engineering Practice, John Wiley and Sons, New York.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Demonstrate the understanding and knowledge of underlined concept, facts and principles of pile foundation	1	-	1	-	-	-
2	Design of pile groups and laterally loaded piles under static and seismic conditions.	2	-	3	2	2	2
3	Design pile cap and under-reamed piles for cohesive soils.	2	-	3	2	2	2
4	Analyze and suggest remedial measures against foundation failures.	2	1	3	1	2	2
	Average	1.75	1	2.5	1.67	2	2

DESIGN OF EARTH RETAINING STRUCTURES
3 Credits (3-0-0)

Subject Code: 22PGT242 IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Demonstrate the understanding and knowledge of underlined concepts, facts and principles of earth retaining structures.
2. Analyze and determine earth pressures based on various methods and field conditions.
3. Analyze and design different earth retaining structures by adopting basic principles.
4. Design the braced walls and coffer dams.

UNIT–I

Rankine's and Coulomb's earth pressure theories – concepts and drawbacks – earth pressure models – graphical methods and their interpretations Introduction to earth pressure – basic concepts – active, passive and at rest earth pressures

UNIT–II

Retaining walls – types – Design specifications and pressure distribution variations, Types of earth retaining structures – classifications – specifications

UNIT-3

Sheet Piles and Bulkheads in Granular and Cohesive Soils - Materials Used for Sheet Piles – Free Earth and Fixed earth Support Methods

UNIT-4

Braced Excavations: Arching in soils-soil pressures on braced walls and their design.Coffer dams, types and their design.

References

1. Terzaghi, KandPeck, R. B. and Mesri G (1996), "Soil Mechanics in Engineering Practice", 3rd Edition,John Wiley.
2. Das, B. M. (2011), "Principals of Foundation Engineering", 7th Edition, Cengage Learning
3. Budhu, M. (1981), "Soil Mechanics and Foundations", 3rd Edition John Wiley and Sons.
4. Lambe, T. W. and Whitman, R. V. (1969), "Soil Mechanics", John Wiley.
5. Clayton, Woods and Bond, "Earth pressure and Earth retaining structure", C R C press(2014)

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Demonstrate the understanding and knowledge of underlined concepts,facts and principles of earth retaining structures	-	-	1	1	-	-
2	Analyze and determine earth pressures based on various methods and field conditions.	1	1	1	2	2	1
3	Analyze and design different earth retaining structures by adopting basic principles.	2	1	2	2	2	2
4	Design the braced walls and coffer dams	2	1	3	2	2	2
	Average	1.57	1	1.75	1.75	2	1.67

NUMERICAL METHODS FOR CIVIL ENGINEERS
Credits (3-0-**0)**

Subject Code: **22PGT243** IA Marks: 50
Duration of Exam: 3 Hrs **Maximum marks: 100**

Course outcomes: At the end of the course the student will be able to

1. Apply the solution of linear system of equations to civil engineering problems, construction planning, slope deflection method applied to beams, frames and truss analysis.
2. Apply numerical integration for solving simple beam problems and application of finite difference technique in structural mechanics.
3. Apply New-Marks method for computation of slopes and deflections in statically determinate beams.
4. Develop algorithm and application of solution of ordinary differential equation to civil engineering problems by Eulers method and Runge Kutta 4^{th} order method.

UNIT 1

Introduction: Historical development of Numerical techniques, role in investigations, research and design in the field of civil engineering.
Development of algorithm/ flow charts for following methods for solution of linear Simultaneous equation: a) Gaussian elimination method b) Gauss-Jordan matrix inversion method c) Gauss- Siedel method d) Factorization method

UNIT 2

Application of root finding to civil engineering problems: Development of algorithm for Bisection method and Newton-Raphson method and its applications for solution of non linear algebraic and transcendental equations from problems in hydraulics, irrigation engineering, structural engineering and environmental engineering.
Application of numerical integration for solving simple beam problems: Development of algorithm for Trapezoidal rule and Simpson's one third rule and its application for computation of area of BMD drawn for statically determinate beams.

UNIT 3

New Marks method for computation of slopes and deflections in statically determinate beams. Development of algorithm and application of solution of ordinary differential equation to civil engineering problems by Euler's method and Runge Kutta 4th order method .

UNIT 4

Application of finite difference technique in structural mechanics:

i. Introduction, expression of derivatives by finite difference: backward differences, forward differences and central differences.

ii. Application of finite difference method for analysis of statically determinateindeterminate beams

Application of Finite difference technique in structural mechanics (Contd..): Buckling of columns and Beams on elastic foundation

References

1. Chapra S.C. &Canale R.P., Numerical Methods for Engineers, McGraw Hill, 1990.
2. Krishna Raju N, Muthu K.U., Numerical methods in Engineering Problem, McMillan Indian Limited, 1990.

3. Iqbal H.Khan, Q. Hassan, Numerical methods for Engineers and Scientists, Galgotia,NewDelhi, 1997
4. Ghosh Pallab., Numerical methods in computer programs in C++ , Prentice Hall ofIndiaPrivate Limited, New Delhi,2006.
5. Numerical methods for engineers using MATLAB and C – I Edition SCHILLING "Thomson Publications"

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Apply the solution of linear system of equations to civil engineering problems, construction planning, slope deflection method applied to beams, frames and truss analysis.	1	-	2	1	-	-
2	Apply numerical integration for solving simple beam problems and application of finite difference technique in structural mechanics.	2	-	2	2	-	2
3	Apply New-Marks method for computation of slopes and deflections in statically determinate beams.	1	-	2	1	-	1
4	Develop algorithm and application of solution of ordinary differential equation to civil engineering problems by Eulers method and Runge Kutta 4^{th} order method.	2	-	2	2	-	2
	Average	1.5	-	2	1.5		1.67

DESIGN OF MACHINE FOUNDATIONS
02 Credits (3-0-0)

Subject Code: **22PGT244** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Demonstrate the understanding of theory of vibration single and two degree of freedomsystems with and without damping.
2. Analyze the dynamic response of block foundation
3. Design Machine Foundations using Spring Mass dashpot idealization and elastic half space method
4. Design framed foundations, vibration control and isolation, use of IS codes provision

UNIT 1

Introduction – Consideration in the design of machine foundation – Dynamic loads, Types of machine foundations. Single and Two degree of freedom systems with and without damping. Natural frequency and resonance and its effects.

UNIT 2

Dynamic response of block foundation subjected to vertical, horizontal, rocking and torsional modes of vibrations of vibrations. Dynamic elastic constants and their evaluation in the field. Methods of evaluation of damping in soils.
Permissible amplitudes of machine vibrations, factors affecting resonant frequency and amplitudes of vibrations.

UNIT 3

Design of Machine foundations using spring-mass-dashpot idealization; Static and dynamic design criteria, Foundations subjected to reciprocating loads;
Hammer Foundations, classification, natural frequencies and amplitudes of foundation vibrations, Design Principles, permissible amplitudes.

UNIT 4

Framed Foundations: Their advantages for high speed machines, permissible amplitudes, design principles. Design of TG foundations.IS Code of Practice and Critical review of IS Code provisions.Structural Design, General Principles of design and construction.
Use of vibration isolators for machines, vibration absorber.
Special topics in Geotechnical Engineering: Microzonation and base isolation.

References

1. Barkan, D. D. (1962) “Dynamics of Bases and Foundations”, McGraw Hill Book Co., New York.
2. Richart, F. E. Jr, Hall, J. R. and Woods, R. D. (1970) “Vibrations of Soils and Foundations”, Prentice Hall Inc, New York.
3. Shamsher Prakash (1980) “Soil Dynamics”, McGraw Hill Book Co., New York.
4. Rao, Kameshwar (1998) “Vibration Analysis and Foundation Dynamics”, Wheeler Publishing.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Demonstrate the understanding of theory of vibration single and two degree of freedom systems with and without damping.	1	-	3	1	-	-
2	Analyze the dynamic response of block foundation	1	-	3	1	1	-
3	Design Machine Foundations using Spring Mass dashpot idealization and elastic half space method.	2	-	3	2	2	1
4	Design framed foundations, vibration control and isolation, use of IS codes provision	2	-	3	2	2	2
	Average	1.5	-	3	1.5	1.67	1.5

REMOTE SENSING AND GIS
03 Credits(3-0-0)

Subject Code: **22PGT245** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 100

Course outcomes: At the end of course students will be able to

1. Develop a sound understanding of the nature, purpose and underlying principles of Remote Sensing.
2. Develop a critical awareness of the strengths and limitations of monitoring using Remote Sensing and the wider monitoring
3. Understand vector-based and raster-based data data analysis
4. Apply available Remote Sensing technologies and be able to match these to particular kinds of Geo-environmental and Geotechnical engineering problem.

UNIT 1

Basics: Fundamentals of Remote Sensing, Electromagnetic Spectrum, Process of remote sensing, Black Body Radiation, Energy Interactions with earth atmosphere and surface features, spectral reflectance curves-For Vegetation, soil & water.
Sensors: Definition, Types (Typical Sensor used in optical remote sensing, Thermal sensor, Synthetic Aperture Radar) Classification.
Plat Forms: Definition & Types: Airborne & Space Borne platforms, Plat form characteristics. Indian Remote Sensing Programme: Definition, Objectives, Data Products of Launch Program Satellite Specifications for IRS-1C, 1D, P4, CARTOSAT-1 & CARTOSAT-2.

UNIT 2

Visual Image Interpretation: Definition, Objectives, Keys & Elements of Visual Image interpretation.
Digital Image Processing (DIP): Definition, Need, Stages of DIP-Image rectification & restoration, Image Enhancement-Contrast Manipulation-Grey Level Thresholding, Classification-Brief discussion of classification procedure for Supervised & Unsupervised Classification Techniques.
GIS: Definition, Components, concept, Data acquisition for GIS input-Spatial (Vector, Raster & Surface data) & Non spatial data, rectification, processing, verification & Data Editing, Application. GIS functions, brief procedure of integrating and remote sensing data into GIS.

UNIT 3

GIS Advanced Concepts: Network Analysis & Virtual GIS. Modeling problems for demonstrating use of GIS functions for civil applications – Site selection for urban development, development of business center and wild life Sanctuary Park.
Computer Concepts of GIS: Coding of attribute data in computer (Binary system & Hexadecimal System), Coding of vector & Raster data in GIS, File Listing & Data Access, Raster data compression techniques, Data Base Structures.
Basics of Photogrammetry: Acquisition of Arial photographs, Aerial Camera, Flight Planning, and Photograph processing & feature extraction. (Brief Discussion Only)
Application of GIS in Geotechnical Engineering:-Introduction, Remote Sensing & GIS assisted geotechnical investigations, Determination of volumetric shrinkage of expansive soils, 3D mapping for sub surface stratum.

UNIT 4

Advanced Applications GIS assisted seismic hazard studies, study of soil drainage characteristics assisted with remote sensing, study of ground water prospects, soil mapping, and rock spectra for mineral identification- Relevant case studies

Applications In Environmental Engineering: Solid waste collection & transport, water quality assessment, water resource management, mapping of ground water portability status, GIS based master plan for water supply project, Ground water Vulnerability assessment, GIS based master plan for sewage collection & transport system.

References

1. Pater A Burraugh Rachal A Mc Donnas "Principle of GIS" (Oxford)
2. Christopher Jones "GIS and Computer Cartography"publication Prentice-Hall(2009)
3. Lilly Sand, "Remote sensing and Image interpretation, John Willey and Sons, New York 1999.
4. S. Kumar,"Basics of Remote sensing and GIS" 1st Edition, 2001
5. BasudebBhatta,"Remote sensing and GIS", Oxford, 2nd Edition, 2011.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Develop a sound understanding of the nature, purpose and underlying principles of Remote Sensing.	-	-	3	-	-	-
2	Develop a critical awareness of the strengths and limitations of monitoring using Remote Sensing and the wider monitoring.	2	-	3	1	-	-
3	Understand vector-based and raster-based data analysis.	2	-	3	1	-	-
4	Apply available Remote Sensing technologies and be able to match these to particular kinds of Geo-environmental and Geotechnical engineering problem.	2	-	3	2	1	2
	Average	2	-	3	1.33	1	2

Computational Laboratory
02 Credits (0-0-4)

Subject Code: 22 PGT L27 IA Marks: 50
Duration of Exam: 2 Hrs Maximum marks: 100

Course Outcomes-At the end of the course the student will be able to:

1. Understand the concept of software based numerical modeling.
2. Apply different soil models in solving geotechnical engineering problems
3. Analyse stability of slopes, retaining walls, tunnels, shallow and deep foundations under differentloading conditions using FEM/FDM packages
4. Carry out seismic hazard analysis and ground response analysis using CRISIS and EDUSHAKE seismosoft, deep soil and opensees.

Course Content

Engineering aspect of finite element method - Basic tools of the design software – Different soil models – modelling of substructure and under different loading conditions – analysis of the response of the shallow and deep foundations, slope stability analysis, Retaining walls, reinforced earth structures, tunnelling using geotechnical software packages
Seismic hazard analysis and ground response analysis.

References

1. C. S., Desai and J. T., Christian, Numerical Methods in Geotechnical Engineering, Mc. Graw Hill, 1977.
2. D. J., Naylor and G. N., Pande, "Finite Elements in Geotechnical Engineering", Pineridge Press Ltd., U.K.
3. S. L., Kramer, "Geotechnical Earthquake Engineering", Pearson Education, 2004
4. PLAXIS 2D & 3D manuals
5. FLAC3D User guide
6. GeoStudio software user manual
7. GEO5 Manuals

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	To understand the concept of software based numerical modeling.	-	3	3	-	1	1
2	Apply different soil models in solving geotechnical engineering problems	1	3	3	1	1	1
3	Analyse stability of slopes, retaining walls, tunnels, shallow and deep foundations under different loading conditions using FEM/FDM packages.	2	3	2	2	2	2
4	Carry out seismic hazard analysis and ground response analysis using CRISIS and EDUSHAKE seismosoft, deep soil and opensees.	2	3	2	2	2	2
	Average	1.67	3	2.5	1.67	1.5	1.5

REINFORCED EARTH STRUCTURES AND GEOSYNTHETICS
04 Credits (4--0)

Subject Code: **22PGT31** IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Discuss basic principles and mechanics of reinforced earth structures.
2. Identify and select different geosynthetics for intended purpose.
3. Evaluate properties of geosynthetics and design reinforced soil structures to fulfill variousfunctions.
4. Apply geocomposite systems to solve contemporary geotechnical problems.

UNIT 1

Historical background – Introduction to reinforced soil structures; Need for Geosynthetics; Comparison with reinforced cement concrete structures, Principles, Concepts and Mechanisms of reinforced earth.

UNIT 2

Material properties, laboratory testing and manufacturing details of Geosynthetics; Metallic strips, Metallic grids, Geotextiles, Geogrids, Geonet, Geomembranes, Geocell, Geocomposites, PVD's, GCL, Geofoam - Functions and Design principles.

UNIT 3

Application of reinforced soil structures in the design of pavements, Embankments, Slopes and Foundations; Reinforced soil structures for soil erosion control problems.

UNIT 4

Design of MSE Wall using Geotextile and Geogrid; Applications of Geosynthetics in Geoenvironmental engineering; Application of Geosynthetics in various Civil Engineering projects; Case studies on Application of Geosynthetics.

References

1. Koerner R M., "Designing with geosythetics", Prenetice- Hall pub 1994
2. Jones C.J.E P., "Earth Reinforcement and soil structures", Butterworth's, London,1996.
3. Koerner R.M., and Welsh. J P., " Construction and Geotechinical Engineering usingsynthetic Fabric", Wiley Inteterseince, New York, 1980
4. Hidetoshi Ochiai, Shigenori Hayshi and jun Otani, "Earth Reinforecement Practice, Vol.I A.A. Balkema, Rotterdam, 1992
5. Bell F G., " Ground Engineer's reference Book", Butterworths, London 1987
6. Ingod T S., " Reinforced Earth", Thomas Telford publications, London
7. S K Shukla., "Fundamentals of Geosynthetics", Taylor and Francis Group, UK
8. R W Sarsby., "Geosynthetics in Civil Engineering", Woodhead Publishing, CRC Press.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Discuss basic principles and mechanics of reinforced earth structures.	1	-	1	-	-	-
2	Identify and select different geosynthetics for intended purpose.	1	1	3	-	2	1
3	Evaluate properties of geosynthetics and design reinforced soil structures to fulfill various functions	2	2	3	2	2	1
4	Apply geocomposite systems to solve contemporary geotechnical problems.	2	2	3	1	2	1
	Average	1.5	1.67	2.5	1.5	2	1

ADVANCED PAVEMENT DESIGN
04 Credits (4-0-0)

Subject Code: **22PGT321** IA Marks: 50
Duration of Exam: 3 h Maximum Marks: 100

Course outcomes: At the end of the course the student will be able to

1. Demonstrate the importance of sub grade soil properties on pavement performance.
2. Design of flexible pavements for roadways and airport pavements using different methods.
3. Analysis and design of rigid pavements using different methods.
4. Demonstrate the understanding of behaviour of the stresses and deflections at different loading and soil conditions.

UNIT 1

Introduction – Desirable characteristics of Pavement; Types of Pavements;Pavement Components;Comparision of Rigid,semirigid and Flexible Pavements;Points of difference between Highway and Airfield Pavements; Functions of Pavement components;Factors influencing design and Performance of Pavements

Fundamentals of Pavement Design – Soil as highway material; Desirable properties;soil classificatiom- HRB classification system and FAA classification system; soil compaction;Subgrade soil strength ;Evaluation of soil strength by Direct shear and Triaxial shear tests,Plate load test and CBR tests.

UNIT 2

Stresses and Deflections in Flexible Pavements – Vertical stress determination using Boussinesq's single layer theory ,assumptions and limitations; Solution to the problem using single layer theory ;Burmister's two layer theory, assumptions and limitations; problems solving using two layer theory ;Introducing concept of multilayer theory for calculation of stresses and deflections.

Design of flexible highway pavements- Triaxial and Kansas method; Burmister method; CBR method; California R Value method

Design of flexible Airport Pavements-FAA method and McLeod method

UNIT 3

Stresses in Rigid Pavements- Types of joints in cement concrete (CC) pavements; Reinforcements in CC pavements; Factors affecting design and performance of rigid pavements; Determination of ESWL for Rigid pavements for dual wheels and Tandom axles-LCN and FAA methods; Critical Locations for wheel loads placements; Calculation of wheel load stresses using Westergaard's Analysis; Modified Westergaard's equations; Temperature stresses –warping stresses and Frictional stresses; combined stresses.

Design of Rigid Highway Pavements- Design of slab thickness of CC Pavements; Design of Joints- Design of spacings of Expansion and Contraction joints; Design of reinforcements in CC Pavements – Design of Dowel bars and Tie Bars-Design steps as per IRC Guidelines

UNIT 4

Pavement Failure – Types of failures of flexible and rigid pavements; Causes for failures and remedial measures for the same.

Maintenance of Pavements – Condition and evaluation survey. Functional evaluation – uneveness measurements, serviceability index; Structural evaluation of pavements; Objectives and types of Maintenance works; Types of overlays ; Overlay design by Benkleman beam deflection method; Falling weight deflectometer method.

References

1. Yoder E.J. and Witezok M.W., "Principles of pavement design" Wiley international (1975).
2. Yang , "Design of Functional Pavements"- McGraw Hill.
3. Khanna and Justo "Highway Engineering", Nem Chand & Bros; 10th Edition (2015).
4. Huang H Y , "Pavement Analysis and Design" Pearson , New Delhi (2008).

5. Mallick R, El-Korchi Tahar " Pavement Engineering: Principles and Practice (2009).
6. R Srinivas Kumar "Pavement Evaluation and Maintenance Mangement System" University Press (2014).
7. IRC Publication, "Guidelines for Design of Flexible pavement for Highways" (2012).

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Demonstrate the importance of sub grade soil properties on pavement performance.	-	-	1	-	-	-
2	Design of flexible pavements for roadways and airport pavements using different methods.	2	-	2	2	1	1
3	Analysis and design of rigid pavements using different methods.	2	-	2	2	1	1
4	Demonstrate the understanding of behaviour of the stresses and deflections at differentloading and soil conditions	1	-	2	2	-	-
	Average	1.67	-	1.75	2	0.67	0.67

ENVIRONMENTAL GEOTECHNIQUES
03 Credits (3-0-0)

Subject Code: **22PGT322** IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Assess the Physical-chemical and biological Interaction in soil and study the effects of contaminants on the properties of soil.
2. Design the landfill, liner system and understand the contaminant containment structures.
3. Design the barrier systems and assess the subsurface contaminant transport mechanics.
4. Apply various techniques or remedial measures for polluted zones and reuse of various wastematerials engineering constructions

UNIT 1

Introduction to Environmental Geotechnology; Source, Production and Classification of Wastes; Soil Pollution Processes Physical-chemical and Biological Interaction in Soil, Effects on geotechnical Properties.

UNIT 2

Disposal and Containment of Solid waste- Landfill design, Liner systems etc.; Surface Impoundments, Slurry Walls, etc.

UNIT 3

Barrier systems-Basic concepts, design and construction, stability, compatibility and performance; Contaminant Transport in subsurface, Monitoring sub surface contamination.

UNIT 4

Soil Remediation Techniques- Stabilization/Solidification, Soil Washing, Bioremediation etc.; Additional Aspects-Beneficial Reuse of waste Materials.

References

1. Daniel, D.E. Geotechnical practice for Waste Disposal, Chapman and Hall, London, 1993
2. Rowe, R.K. Quigley R.M. and Booker, Clay Barrier systems for waste disposal facilities, J.R.E. & FN Spon, London, 1995.
3. Reddi, L.N. and lnyang, H.F. Geo environmental Engineering-Principles and Applications Marcel Dekker, Inc. 2000.
4. Bagchi, A. Design, Construction and Monitoring of Landfills, John Wiley & Sons, Inc. New York, 1994.
5. Sharma H.D. and Lewis, S.P. Waste Containment systems, Waste stabilization and landfills: Design and evaluation, John Wiley & sons, Inc. New York, 1994.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Assess the Physical-chemical and biological Interaction in soil and study the effects of contaminants on the properties of soil.	-	-	3	-	-	-
2	Design the landfill, liner system and understand the contaminant containment structures	1	-	3	1	2	1
3	Design the barrier systems and assess the subsurface contaminant transport mechanics.	2	-	3	1	2	2
4	Apply various techniques or remedial measures for polluted zones and reuse of various waste materials engineering constructions	1	-	3	-	2	1
	Average	1.33	-	3	0.67	2	1.33

STRUCTURAL DESIGN OF FOUNDATIONS
Credits (4-0-0)

Subject Code: **22PGT323** IA Marks: 50
Duration of Exam: 3 h Maximum marks: 100

Course outcomes: At the end of the course the student will be able to

1. Describe the knowledge about the principles of designing foundations.
2. Design and detail the shallow foundations according to codal provisions.
3. Design foundation for retaining walls and also deep foundations
4. Design and detail the foundation for special structure like Chimneys, Power plants and towers.

UNIT 1

Introduction to Engineering Design: Concepts, Principles and Applications. Fundamentals of Geotechnical and Structural Design: Concepts and Principles.

UNIT 2

Introduction to RC Design - Codal provisions: A review and A few examples. Shallow Foundations: Geotechnical and Structural Design of Individual footings, Combined footings, Rafts, Ring foundations, etc. Detailing, Examples and Case Studies. Beams and Plates on Elastic Foundation.

UNIT 3

Deep Foundations: Geotechnical and Structural Design of Piles and Pile groups, Piers and Caissons. Detailing, Examples and Case Studies.
Foundations for Retaining Structures: Examples and Case Studies.

UNIT 4

Special Foundations: Towers, Chimneys, High-Rise Buildings, Power Plants, etc. Earthquake Resistant Design of Foundations – A few Examples and Case Studies. Usage of Softwares.

References

1. Peck, R. B., Hanson, W. E. and Thornburg, T. H. (1974). *Foundation Engineering*, John Wiley and Sons, New York.
2. Bowles, J. E. (1996). *Foundation Analysis and Design*, McGraw-Hill, New York
3. Hemsley, J. A. (1998). *Elastic Analysis of Raft Foundations*, Thomas Telford, London.
4. Hemsley, J. A. (Ed.), (2000). *Design Applications of Raft Foundations*, Thomas Telford, London.
5. Murthy, V. N. S. (2007). *Advanced Foundation Engineering*, CBS Publishers and Distributors, Poulos, H. G. and Davis, E. H. (1980). *Pile Foundation Analysis and Design*, John Wiley and Sons, New York.
6. Prakash, S. and Puri, V. K. (1988). *Foundation for Machines Analysis and Design*, John Wiley and Sons, New York.
7. Wight, J. K. and MacGregor, J. G. (2008). *Reinforced Concrete Mechanics and Design*, Prentice-Hall, New Jersey.
8. McCormac, J. C. and Brown, R. (2008). *Design of Reinforced Concrete*, John Wiley and Sons,
9. Reynolds, C. E., Steedman, J. C. and Threlfall, A. J. (2008). *Reynolds's Reinforced Concrete Designer's Handbook*, Taylor and Francis, London.
10. Day, D. W. (2010). *Foundation Engineering Handbook*, McGraw-Hill, New York.

11. Fang, H.-Y. (1990). *Foundation Engineering Handbook*, Kluwer Academic, Dordrecht.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6
1	Describe the knowledge about the principles of designing foundations.	-	-	1	-	-	1
2	Design and detail the shallow foundations according to codal provisions.	1	-	2	1	2	2
3	Design foundation for retaining walls and also deep foundations	2	-	2	1	2	-
4	Design and detail the foundation for special structure like Chimneys, power plants and towers.	2	-	2	1	2	-
	Average	1.67	-	1.75	1	2	0.75