Sri BVV Sangha's

Basaveshwar Engineering College, (Autonomous)
Bagalkot-587103

Department of Civil Engineering

SYLLABUS FOR POST GRADUATE PROGRAMME
M. Tech.

GEOTECHNICAL ENGINEERING

2019-20

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

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.

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**

Basaveshwar Engineering College, Bagalkot
Department of Civil Engineering

M. Tech. Geotechnical Engineering 2019-20

Scheme of Teaching and Examination

Semester –I

Sl. No	Code	Subject	C	Hours/Week			Exam Marks		
				L	T	P	CIE	SEE	Total
1	PGT 121C	Geomechanics and Engineering	4	3	2	0	50	50	100
2	PGT 122C	Soil Exploration and Field testing	4	3	2	0	50	50	100
3	PGT 133C	Advanced Foundation Engineering	4	3	2	0	50	50	100
4	PGT 00XE	Elective -1	4	3	2	0	50	50	100
5	PGT 00XE	Elective – 2	4	3	2	0	50	50	100
6	PGT 00XE	Elective – 3	3	2	2	0	50	50	100
7	PGT124S	Seminar	1	0	0	2	50	50	100
		Total	**24**	**17**	**12**	**2**	**350**	**350**	**700**

Semester –II

Sl. No	Code	Subject	C	Hours/Week			Exam Marks		
				L	T	P	CIE	SEE	Total
1	PGT 221C	Reinforced Earth Structure and Geosynthetics	4	3	2	0	50	50	100
2	PGT 222C	Dynamics of Soils and Foundation	4	3	2	0	50	50	100
3	PGT 00XE	Elective – 4	3	2	2	0	50	50	100
4	PGT 00XE	Elective – 5	4	3	2	0	50	50	100
5	PGT 00XE	Elective – 6	4	3	2	0	50	50	100
6	PGT 00XE	Elective – 7	4	3	2	0	50	50	100
7	PGT 224T	Term Paper	1	0	0	2	50	50	100
		Total	**24**	**17**	**12**	**2**	**350**	**350**	**700**

Semester –III

Sl. No	Code	Subject	C	Hours/Week			Exam Marks		
				L	T	P	CIE	SEE	Total
1	PGT 00XE	Elective -8	4	3	2	0	50	50	100
2	PGT 321 I	Industrial training	4	0	0	8	50	50	100
3	PGT 312 P	Project phase- 1	10	0	0	20	50	50	100
4	PGT 304L	Geotechnical Engg.Lab	2	0	0	4	50	50	100
		Total	**20**	**3**	**2**	**32**	**200**	**200**	**400**

Semester –IV

Sl. No	Code	Subject	C	Hours/Week			Exam Marks		
				L	T	P	CIE	SEE	Total
1	PGT 431P	Project phase- II	20	0	0	40	50	50	100
		Total	**20**	**0**	**0**	**40**	**50**	**50**	**100**

LIST OF ELECTIVES

Sl No	Subject Code	Subject	Credits
01	PGT 003E	Theory of Elasticity and Plasticity	04
02	PGT 004E	Advanced Pavement Design	04
03	PGT 018E	Numerical Methods for Civil Engineers	04
04	PGT 009E	Finite Element Method	04
05	PGT 023E	Pile foundation Analysis and Design	04
06	PGT015E	Structural Design of Foundations	04
07	PGT016E	Earth and Rock-fill dams	04
08	PGT017E	Soil Structure Interaction Problems	04
09	PGT020E	Design of Earth Retaining Structures	04
10	PGT024E	Critical State Soil Mechanics	04

Sl No	Subject Code	Subject	Credits
1	PGT 008E	Ground Improvement Techniques	03
2	PGT 005E	Environmental Geo-Techniques	03
3	PGT 010E	Construction Management Techniques	03
4	PGT 011E	Design of Machine Foundations	03
5	PGT019E	Remote Sensing and GIS application in Geo-environmental Engineering	03
6	PGT014E	Geotechnical Earthquake Engineering	03

GEOMECHANICS AND ENGINEERING
04 Credits (3-2-0)

Subject Code: **PGT121C** IA Marks: 50
Duration of Exam: 3Hrs Maximum marks: 100

Course outcomes:

1. Students should describe the concept of stress, direction cosines, stress transformation, principal stresses.
2. Students will apply the concept of strain, compatibility conditions and fundamentals of Elasticity including Generalized Hooke's law. The students should understand elastic, elasto plastic and plastic behavior of soils. They must also understand limit equilibrium concept, Mohr – Coulomb failure theory, stress paths and yield criteria as applicable to soils.
3. The students will describe consolidation theory, classification of soils based on stress history, coefficients used in consolidation theory and their significance, determination of Time factor and coefficient of consolidation. Calculation of total and time rate settlements. They should also learn significance of settlement, components of settlement, permissible settlements for various civil engineering structures.
4. The students will describe mechanism of shear strength mobilization, factors influencing shear strength, measurement of shear strength, choice of tests based on drainage conditions.
5. The students will clearly determine shear strength of cohesive and cohesionless soils in drained and undrained conditions and stress paths.

UNIT 1:
Stability analysis of slope; Effective vs Total stress analysis (Approach), shape of slip surface, methods of slices, graphic methods, location of critical slip circle, wegde analysis method, stability during critical condition.

UNIT 2:
Soil behavior- Elastic, Plastic and Elasto-plastic. Mohr's stress circle concept; Limitequilibrium- Mohr coulomb theory; Failure criteria for cohesive and cohesionless soils; Concept of stress paths – Total and Effective stress paths in different spaces; Yield criteria- Tresca, Von mises and Mohr coulomb criteria.

UNIT 3:
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 4:
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.

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. Edward Arnod (Pub) Ltd London(1962).
7. M.E.Harr., “Foundation of Theoretical Soil Mechanics”, McGraw Hill (1966).

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Students should describe the concept of stress, direction cosines, stresstransformation, principal stresses.	1	-	2
2	Students will aplly the concept of strain, compatibility conditions and fundamentals of Elasticity including Generalized Hooke’s law. The students should understand elastic, elasto plastic and plastic behavior of soils. They must also understand limit equilibrium concept, Mohr – Coulomb failure theory, stress paths and yield criteria as applicable to soils.	1	-	2
3	The students will describe consolidation theory, classification of soils based on stress history, coefficients used in consolidation theory and their significance, determination of Time factor and coefficient of consolidation. Calculation of total and time rate settlements. They should also learn. significance of settlement, components of settlement, permissible settlements for various civil engineering structures	2	-	3
4	The students will describe mechanism of shear strength mobilization, factors influencing shear strength, measurement of shear strength, choice. of tests based on drainage conditions.	2	-	3
5	The students will clearly determine shear strength of cohesive and cohesionless soils in drained and undrained conditions and stress paths.	2	-	3
Avg		1.6	-	2.6

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

Subject Code: **PGT 122C** 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 significance of soil exploration and study the various approaches of soil/rock investigation.
2. Select appropriate sampling techniques as per site condition.
3. Interpret the importance of insitu tests and collect data independently, integrate it with remote sensing, GIS and prepare the investigation report.

UNIT 1:

Role of engineer in the systematic exploration of a site; Relevance of geology to civil engineering, Soil profiles of various regions. Rock and soil types and their formation; Basics of structural geology; In-situ state of stress in soils and rocks; In situ permeability; Engineering classification of intact and fissured rocks – RQD.

UNIT 2:

Geological exploration of an engineering site; Field reconnaissance, Applied geophysical surveys; 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 3:

Importance of In-situ testing, performing various In-situ tests: standard penetration test, static and dynamic cone penetration tests, pressure meter test, plate load test and field vane shear test (VST), Ground water exploration, site evaluation and reporting.

UNIT 4:

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 Engineering Purposes", Waterways Experiment station, Missisippi, 1949
2. Hunt R.E. "Geotechnical Engineering: Analysis and Evaluation" McGraw Hill Book Company 1986
3. H. F. Winterkorn and H Y Fang, Foundation Engineering Hand Book, Galgotia Booksource.
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 Freeman and 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
1	Apply the significance of soil exploration and study the various approaches of soil/rock investigation.	-	1	1
2	Select appropriate sampling techniques as per site condition.	-	-	2
3	Interpret the importance of in-situ tests and collect data independently, integrate it with remote sensing, GIS and also prepare the investigation report.	2	2	3
Avg	Avg	2	1	2

ADVANCED FOUNDATION ENGINEERING
04 Credits (3-2-0)

Subject Code: **PGT133C** 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. Judge the appropriate shallow foundation type, depth and required design.
2. Design required type of deep foundations.
3. 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 footings and Rafts.

Pile Foundations – Analysis and Conventional Design of pile foundations for vertical and lateral loads 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 and Retaining structures", K. A. Rastogi Prakashan, Meerut, India.
4. Jain, G.R. S., "Hand Book on Underreamed and Bored Compaction Pile Foundations", Published by G. S. Jain Associates, Roorkee.
5. Das, B. M., "Principles of Foundation Engineering", Cengage Learning (2011)
6. Tomlinson, "Foundation Design and Construction", ELBS, Longman Group Ltd.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Judge the appropriate shallow foundation type, depth and required design.	-	-	2
2	Design required type of deep foundations	-	-	3
3	Analyze and suggest remedial measures against foundation failures.	-	-	3
	Avg	-	-	2.6

REINFORCED EARTH STRUCTURES AND GEOSYNTHETICS
04 Credits (3-2-0)

Subject Code: **PGT 221C** 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. Identify and select different geosynthetics for intended purpose.
2. Evaluate properties of geosynthetics and design reinforced soil structures to fulfill various functions.
3. 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 using synthetic 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
1	Identify and select different geosynthetics for intended purpose.	1	-	2
2	Evaluate properties of geosynthetics and design reinforced soilstructures to fulfill various functions	-	-	2
3	Apply geocomposite systems to solve contemporary geotechnicalproblems.	1	-	2
	Avg	1	-	2

DYNAMICS OF SOILS AND FOUNDATION
04 Credits (3-2-0)

Subject Code: **PGT 222C** 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. Identify Free and Forced vibration analysis with and without damping, Resonance condition, Flexural vibration of Beam with different end condition, Response spectrum seismic analysis, dynamic soil property, Wave propagation through soil media, Machine foundation classification.
2. Analysis of machine foundation, permissible limit of vibration, seismic analysis of chimney and building. Seismic analysis of earthen structure. Vibration isolation.
3. Analyze Machine foundation, seismic analysis of structure. P, S, R, L-wave.

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 to R 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 equipments for dynamic soil tests; In-situ measurements and field tests for evaluation of 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
1	Identify Free and Forced vibration analysis with and without damping, Resonance condition, Flexural vibration of Beam with different end condition, Response spectrum seismic analysis, dynamic soil property, Wave propagation through soil media, Machine foundation classification.	2	-	3
2	Analysis of machine foundation, permissible limit of vibration, seismic analysis of chimney and building. Seismic analysis of earthen structure. Vibration isolation.	2	-	3
3	Analyze Machine foundation, seismic analysis of structure. P, S, R, L-wave.	2	-	3
	Avg	2	-	3

THEORY OF ELASTICITY AND PLASTICITY
04 Credits (3-2-0)

Subject Code: **PGT 003E** 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. Find and apply the essential facts, concepts, theories and principles underlying elasticity and plasticity theory, and how the two fields are underpinned by mathematics and physics.
2. Apply wider multidisciplinary context of the underlying theory, including applications of both elasticity and plasticity to engineering design.
3. Demonstrate creative and innovative ability in the synthesis of theoretical solutions and linking them to the design of real-world structures.

UNIT 1:

Definition of stress components of stress at a point, Cartesian and polar co-ordinates, Equilibrium equations, Transformation of stress, Principal stresses, invariants of stress, hydrostatic and deviatric stress.

Definition of strain, components of strain at a point, Cartesian and polar co-ordinates, Equilibrium equations, transformation of strain, principal strain, invariant of strain, spherical and deviatoric strains, maximum shear strain, compatibility equations.

UNIT 2:

Compatibility equations, stress strain relations, constitutive relations- plane stress and plane strain. Problems in polar coordinates (2D)

Problems in rectangular coordinates (2D) – boundary conditions Airy's stress function approach to 2-D problems of elasticity, simple problems on bending of beams. Solution of axi-symmetric problems, stress concentration due to the presence of a circular hole in plates.

UNIT 3:

3D problems: Elementary problems of elasticity in three dimensions, stretching of a prismatical bar by its own weight, twist of circular shafts.

Torsion: torsion of non-circular sections.

UNIT 4:

Theory of plasticity: Plastic stress – strain relations, Failure theories, Criterion of yielding, Theories of plastic flow, Plastic deformation

Bending of prismatic beams, residual stresses, Plastic torsion.

References

1. Timoshenko & Goodier, "Theory of Elasticity", McGraw Hill
2. Sadhu Singh, "Theory of Elasticity", Khanna Publishers
3. Chenn W.P and Hendry D.J, "Plasticity for Structural Engineers", Springer Verlag
4. Sadhu Singh, "Applied Stress Analysis", Khanna Publishers
5. Srinath L.S. Advanced Mechanics of Solids, Third Edition, Tata McGraw Hill publishing company. New Delhi, 1994.
6. Valliappan S. "Continuum Mechanics Fundamentals" (1982), Oxford IBH, N D. New Delhi.
7. T.G. Sitharam and L. Govinda Raju, "Applied Elasticity" – Interline Publishing, 2005.
8. Chakrabarthy J, Theory of Plasticity, McGraw Hill.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Find and apply the essential facts, concepts, theories, and principles underlying elasticity and plasticity theory, and how the two fields are underpinned by mathematics and physics	-	-	3
2	Apply wider multidisciplinary context of the underlying theory, including applications of both elasticity and plasticity to engineeringdesign	1	-	3
3	Demonstrate creative and innovative ability in the synthesis of theoretical solutions, and linking them to the design of real-world structures	3	-	2
	Avg	2	-	2.6

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

Subject Code: **PGT 004E** 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. Summarize the importance of sub grade soil properties on pavement performance.
2. Design of flexible pavements and rigid pavements using different methods.
3. Recognize the behavior 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
1	Summarize the importance of sub grade soil properties on pavement performance.	-	-	1
2	Design of flexible pavements and rigid pavements using differentmethods.	-	2	3
3	Recognize the understanding of behavior of the stresses and deflections at different loading and soil conditions	-	-	2
	Avg	-	2	2

ENVIRONMENTAL GEOTECHNIQUES
03 Credits (3-0-0)

Subject Code: PGT005E 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. Identify possible susceptibility of soil properties to environmental effects.
2. Identify contaminant transport mechanisms in soils.
3. Apply various techniques or remedial measures for polluted zones and reuse of various waste materials engineering constructions
4. Analyze the stability of various components of a landfill, load bearing capacity of compacted landfill, stability of liquid waste disposal system.
5. Apply environmental changes to soil stabilization and landfill engineering.

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
1	Identify possible susceptibility of soil properties to environmental effects.	-	-	3
2	Identify contaminant transport mechanisms in soils	-	-	3
3	Apply various techniques or remedial measures for polluted zones and reuse of various waste materials engineering constructions	1	-	3
4	Analyze the stability of various components of a landfill, load bearing capacity of compacted landfill, stability of liquid waste disposal system.	1	-	3
5	Apply environmental changes to soil stabilization and landfill engineering	1	-	3
	Avg	1	-	3

GROUND IMPROVEMENT TECHNIQUES
3 Credits (2-2-0)

Subject Code: PGT008E 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. Recognize the underlined concepts, facts, and principles of ground improvement techniques.
2. Identify different ground improvement techniques based on assessment of soil properties.
3. Propose Site specific method of improvement and its design.

UNIT 1:
Principles and objectives of ground improvement; History of ground improvement developments. 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.

UNIT 2:
Field compaction – Dead weight surcharge for compaction;; Equipment for field compaction: smooth wheel rollers, pneumatic rollers, sheep foot rollers, grid rollers, Power rammers. Role of vibrations in dynamic compaction; Dynamic Field Compaction Equipment: Impact type of compaction, Vibratory rollers, Vibratory pneumatic tyre, compaction piles, vibroflotation, vibratory probes, compaction sand columns and sand piles, underground blasts.
Hyd. Modification: Preloading by lowering ground water table, Filters, Control of ground water seepage, Sand drains and wick drains, Well point system, Vertical drains, Electrosmosis and its application in ground improvement.

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:
Applications of Geosynthetics for ground improvement;
Miscellaneous: 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"., McGraw Hill Pub Co New York.
3. Hausmann, M R (1990) "Engineering Principles of Ground Modifications", McGraw Hill Pub Co New York.
4. Ingles O G and Metcalf J B., "Soil Stabilization: Principles and practice", Butterworths, London, 1972
5. Nelson J D and Miller D J., "Expansive soils", John Wiley and sons. Inc new

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

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Recognize the underlined concepts, facts and principles of ground improvement techniques	1	-	3
2	Identify different ground improvement techniques based	1	-	3
3	Propose Site specific method of improvement and its design	2	2	3
	Avg	1.33	2	3

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

Subject Code: **PGT009E** 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 essential facts, concepts, theories and principles underlying various finite element methods and analysis.
2. Generate the governing FE equations and models for the evaluation of different displacement models for 1-D, 2-D and 3-D elements with isoparametric concepts in the analysis of plane stress and plane strain problems.
3. Determine the behaviors and analyze various structures by adopting basic principals of FEM.

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
1	Apply the essential facts, concepts, theories and principles underlying various finite element methods and analysis.	2	-	3
2	Generate the governing FE equations and models for the evaluation of different displacement models for 1-D, 2-D and 3-D elements with iso-parametric concepts in the analysis of plane stress and plane strain problems.	2	-	3
3	Determine the behaviors and analyze various structures by adoptingbasic principles of FEM	3	2	3
	Avg	2.33	2	3

CONSTRUCTION MANAGEMENT
03 Credits (2-2-0)

Subject Code: **PGT010E** 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 independently ISO standards in quality and safety for construction.
2. Prepare feasible report for a construction project.
3. Demonstrate the skills with inventory management techniques.

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 checklists for 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
1	Apply independently ISO standards in quality and safety for construction	1	3	1
2	Prepare feasible report for a construction project.	-	3	2
3	Demonstrate the skills with inventory management techniques.	1	-	3
	Avg	1	3	2

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

Subject Code: **PGT011E** 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 theory of vibration of single and two degree of freedom systems 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
1	Describe the theory of vibration of single and two degree of freedom systems with and without damping.	1	-	3
2	Analyze the dynamic response of block foundation	1	-	3
3	Design Machine Foundations using Spring Mass dashpotidealization and elastic half space method.	2	-	3
4	Design framed foundations, vibration control and isolation, use of IScodes provision	2	-	3
	Avg	1.5	-	3

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

Subject Code: **PGT014E** 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 Engineering seismology and dynamic behavior of the soil.
2. Analyze and design slopes, embankments, foundations, and earth retaining structures forseismic conditions.
3. 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. Liquefaction phenomena and analysis of pore pressure development.

UNIT 3:
Analysis and design of slopes, embankments, foundation and earth retaining structures 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
1	Describe Engineering seismology and dynamic behavior of the soil	1	-	3
2	Analyze and design slopes, embankments, foundations, and earth retaining structures for seismic conditions.	1	1	3
3	Interpret the case histories, mitigation techniques and computer aided analysis.	2	3	3
	Avg	1.33	2	3

STRUCTURAL DESIGN OF FOUNDATIONS

03 **Credits (3-2-0)**

Subject Code: **PGT015E** 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. Acquire 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 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
1	Acquire the knowledge about the principles of designing foundations.	2		2
2	Design and detail the shallow foundations according to codal provisions.	2	2	3
3	Design foundation for retaining walls and deep foundations	2	1	3
4	Design and detail the foundation for special structure like Chimneys, power plants and towers.	2	1	3
	Avg	2	1.33	2.75

EARTH AND ROCK FILL DAMS
04 Credits (4-0-0)

Subject Code: **PGT016E** 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, materials and equipment for construction of earth/rockfill dams.
2. Analyze the stability of Earth and Rockfill Dams and design.
3. Analyze seepage through a given earth/rockfill dam section and select effective seepagecontrol 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
1	Describe the importance of earth – rock fill dams and select a suitable site, materials and equipment for construction of earth/rockfill dams.	1	1	3
2	Analyze the stability of Earth and Rockfill Dams and design	2	-	3
3	Analyze seepage through a given earth/rockfill dam section and select effective seepage control measures for the prevailing site conditions.	2	-	3
	Avg	1.33	1	3

SOIL STRUCTURE INTERACTION
04 Credits (3-2-0)

Subject Code: **PGT017E** 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. Analyze the behavior of the soil under elastic and plastic condition and demonstrate the understanding of Elastic and Elasto plastic analysis of footing and Raft foundations.
2. Predict the behavior of the pile under static and dynamic loads.

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, Behavior 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 Wiley and 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
1	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.	1	-	3
2	Predict the behaviour of the pile under static and dynamic loads.	2	-	3

NUMERICAL METHODS FOR CIVIL ENGINEERS
04 Credits (3-2-**0)**

Subject Code: **PGT018E** 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 eams, 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 4^{th} 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 determinate indeterminate 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, New Delhi, 1997
4. Ghosh Pallab., Numerical methods in computer programs in C++ , Prentice Hall of India Private 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
1	Apply the solution of linear system of equations to civil engineering. problems, construction planning, slope deflection method applied toframes and truss analysis.	2	1	3
2	Apply numerical integration for solving simple beam problems and application of finite difference technique in structural mechanics.	2	-	3
3	Apply New-Marks method for computation of slopes and deflections instatically determinate beams.	2	-	3
4	Develop algorithm and application of solution of ordinary differential equation to civil engineering problems by Eulers method and Runge Kutta 4th order method.	2	-	3
	Avg	2	1	3

REMOTE SENSING AND GIS APPLICATION IN GEO-ENVIRONMENTAL ENGINEERING
3 Credits(2-2-0)

Subject Code: **PGT019E** 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 RemoteSensing.
2. Apply available Remote Sensing technologies and be able to match these to particular kinds of Geoenvironmental engineering problem.
3. Develop a critical awareness of the strengths and limitations of monitoring using RemoteSensing and the wider monitoring.

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 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
1	Develop a sound understanding of the nature, purpose, and underlying principles of Remote Sensing.	-	-	1
2	Apply available Remote Sensing technologies and be able to match these to particular kinds of Geo-environmental engineering problem.	2	-	1
3	Develop a critical awareness of the strengths and limitations ofmonitoring using Remote Sensing and the wider monitoring.	3	-	1
	Avg	2.5	-	1

DESIGN OF EARTH RETAINING STRUCTURES
3 Credits (3-2-0)

Subject Code: **PGT020E** 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 underlined concepts, facts and principles ofearth retaining structures practically.
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.

UNIT 1:
Importance of retaining structures in geotechnical engineering; Lateral earth pressures and earth pressure coefficients; Variation of lateral earth pressure at a certain depth.
Lateral earth pressure at rest; Classical theory of earth pressure proposed by Rankine; Rankine active pressure: Derivation and Problems; Rankine passive pressure; Rankine passive pressure: Vertical back face and inclined backfill; Coulomb's active earth pressure; Coulomb's passive earth pressure; Active earth pressure due to surcharge-Line load and Strip load.

UNIT 2:
Dynamic earth pressures, Monopole-Okabe method; Active earth pressure for seismic conditions; Passive pressure for seismic conditions; Active earth pressure for wall rotation about top: Braced cut; Active earth pressure for translation of retaining wall – Granular backfill; Influence of wall friction on the shape of the surface of sliding.

UNIT 3:
Types of retaining walls; Proportioning of retaining walls; Application of lateral earth pressure theories to design; Stability of retaining walls; Check for sliding along the base; Check for overturning; Check for bearing capacity failure; Construction joints and drainage from backfill; Design problems of cantilever and gravity retaining walls.

UNIT 4:
Mechanically Stabilized retaining walls – Basic concepts and step by step design procedure for stabilized reinforced and metallic strip reinforced retaining walls; Analysis of sheet pile walls in uniform soil; Analysis of sheet pile walls in mixed soil; Analysis of cantilever sheet pile wall; Analysis of anchored sheet pile wall; Braced Excavation; Other types of retaining walls – Modular gravity walls, Insitu reinforced walls, Chemically stabilized retaining walls; Design problems on MSE walls.

References

1.Terzaghi, K and Peck, 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", CRC press (2014).

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Apply underlined concepts, facts and principles of earth retaining structures practically.	1	-	3
2	Analyze and determine earth pressures based on various methodsand field conditions.	1	1	3
3	Analyze and design different earth retaining structures by adoptingbasic principles.	1	1	3
	Avg	1	1	3

PILE FOUNDATION ANALYSIS AND DESIGN
04 Credits (3-2-0)

Subject Code: **PGT023E** 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. Apply underlined concept, facts and principles ofpile foundation.
2. Analyze bearing capacity, settlement of foundations and also design pile foundation. Performpile testing.
3. Analyze and Design of deep foundations subjected to different types of loads. Analyze andsuggest 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-situ piles, case studies on failure of piles
Pile testing: Integrity of piles, corrosion resistance, durability, damage protection to 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
1	Apply underlined concept, facts and principles of pile foundation	3	3	3
2	Analyze bearing capacity, settlement of foundations and also designpile foundation. Perform pile testing.	3	2	3
3	Analyze and Design of deep foundations subjected to different types of loads. Analyze and suggest remedial measures against foundation failures.	3	2	3
	Avg	3	2.33	3

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

Subject Code: PGT024E 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. Relate behaviour of soils subjected to various loading and drainage conditions within unifiedframework of critical state soil mechanics.
2. Apply theory of elasticity and plasticity to characterize the stress-strain behavior of soils. 3.Describe basic elsato 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
1	Relate behaviour of soils subjected to various loading and drainageconditions within unified framework of critical state soil mechanics.	2	1	3
2	Apply theory of elasticity and plasticity to characterize the stress-strain behavior of soils.	2	1	3
3	Describe basic elsato plastic models based oncritical state soil mechanics like Cam-Clay and Granta Gravel.	3	2	3
	Avg	2.33	1.33	3

SEMINAR
01 Credit (0-0-2)

Subject Code: **PGT 124S** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 50

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

1. Reach across diverse disciplines to apply theories,methods and knowledge bases from multiple fields to a single question or problem.
2. Show competence in identifying relevant information,defining and explaining topics underdiscussion.
3. Evaluate, synthesize information and use and apply relevant theories.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Reach across diverse disciplines to apply theories, methods and knowledge bases from multiple fields to a single question or problem.	-	3	3
2	Show competence in identifying relevant information, defining andexplaining topics under discussion.	-	3	3
3	Evaluate, synthesize information and use and apply relevant theories.	-	3	3
	Avg	-	3	3

TERM PAPER
01 Credit (0-0-2)

Subject Code: **PGT 224T** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 50

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

1. Make extensive literature survey in a specific topic.
2. Identify specific research area of interest.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Make extensive literature survey in a specific topic	-	3	3
2	Identify specific research area of interest.	-	3	3
	Avg	-	3	3

GEOTECHNICAL ENGINEERING LABORATORY
01 Credit (0-0-2)

Subject Code: **PGT 304L** IA Marks: 50
Duration of Exam: 3 Hrs Maximum marks: 50

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

1. Specify the appropriate test and drainage conditions for different geotechnical condition.
2. Determine engineering properties of soils.
3. Conduct experiments analyze and interpret results for geotechnical engineering design. Develop an appreciation the use of field tests in the engineering of civil infrastructure
4. Prepare geotechnical report.

List of experiments

1. Grain size analysis of soil: wet and dry analysis.
2. Determination of relative density.
3. Triaxial test: UU, CU and CD.
4. Determination of compression index and coefficient of consolidation.
5. Determination of Swelling Pressure.
6. Determination of California Bearing Ratio(CBR).
7. Electrical Resistivity
8. Standard Penetration Test (SPT)
9. Static Cone Penetration test (SCPT).
10. Plate load test.
11. Determination of dynamic properties and damping coefficient.
12. Geotechnical investigation report.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Specify the appropriate test and drainage conditions for differentgeotechnical condition.	2	3	1
2	Determine engineering properties of soils.	2	3	2
3	Conduct experiments analyze and interpret results for geotechnical engineering design. Develop an appreciation the use of field tests in the engineering of civil infrastructure	2	3	3
4	Prepare geotechnical report.	2	3	-
	Avg	2	3	2

INDUSTRIAL TRAINING
04 Credits (0-0-8)

Subject Code: **PGT321I** CIE Marks: 50
Contact hours/week: 08

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

1. Identify, formulate and model problems and find engineering solution based on a systemapproach and conduct research in their respective field of specialization.
2. Develop skills with good technical knowledge, management, leadership, and entrepreneurship skills.
3. Become master in one's specialized technology and update with all the latest changes intechnological world.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Identify, formulate, and model problems and find engineering solution based on a system approach and conduct research in their respective field of specialization.	1	3	3
2	Develop skills with good technical knowledge, management, leadership, and entrepreneurship skills.	1	3	3
3	Become master in one's specialized technology and update with allthe latest changes in technological world.	1	3	3
	Avg	1	3	3

PROJECT PHASE-I
10 Credits (0-0-20)

Subject Code: PGT312P CIE Marks: 50
SEE Marks: 100 Contact Hours – hours/week:20

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

1. Show competence in identifying relevant information, defining and explaining thesis statement under consideration.
2. Demonstrate and identify complexity, insight, cogency, independent thought, relevance, and persuasiveness of the thesis statement.
3. Show competence in working with a methodology, structuring their work, and synthesizinginformation.
4. Demonstrate skills and ability in identifying the strength of their thesis statement, and develop their topic with appropriate signposting.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Show competence in identifying relevant information, defining and explaining thesis statement under consideration.	3	3	3
2	Demonstrate and identify complexity, insight, cogency, independent thought, relevance, and persuasiveness of the thesis statement.	3	3	3
3	Show competence in working with a methodology, structuring their work, and synthesizing information.	3	3	3
4	Demonstrate skills and ability in identifying the strength of their thesis statement, and develop their topic with appropriate signposting.	3	3	3
	Avg	3	3	3

PROJECT PHASE-II
20 Credits(0-0-40)

Subject Code: PGT431P CIE Marks: 50
SEE Marks: 100 Contact Hours – hours/week:40

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

1. Evaluate information and use and apply relevant theories.
2. Develop skill to present information in a compelling, well-structured, and logical sequence and show depth of knowledge of complex subjects, and also ability to synthesize, evaluate and reflect on information.
3. Demonstrate problem-solving skills and apply theoretical knowledge.

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3
1	Evaluate information and use and apply relevant theories.	3	3	3
2	Develop skill to present information in a compelling, well-structured, and logical sequence and show depth of knowledge of complex subjects, and ability to synthesize, evaluate and reflect on inform ation.	3	3	3
3	Demonstrate problem-solving skills and apply theoretical knowledge.	3	3	3
	Avg	3	3	3