Techno India NJR Institute of Technology

Course File

Geotechnical Engineering (5CE4- 04)

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Syllabus

Year - V Semester: B.Tech. (Civil Engineering

5CE4-04: GEOTECHNICAL ENGINEERING

Credit: 3 **Max. Marks: 100(IA:30, ETE:70)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	1
2	Soil and soil-mass constituents, water content, specific gravity, void ratio, porosity, degree of saturation, air void and air content, unit weights, density index etc. Inter-relationships of the above. Determination of index properties of soil: water content, specific gravity, particle size distribution, sieve and sedimentation analysis, consistency limits, void ratio and density index. Mineral structures, structures of Illite Montmorillonites and kaolinite and their characteristics. Darcy's law of permeability of soil and its determination in laboratory. Stresses in soil mass: total, effective and neutral pressure, calculation of stresses, influence of water table on effective stress, quicksand phenomenon. Classification of soil for general engineering purposes: particle size and I.S. Classification systems.	8
3	Mohr's circle of stress, shearing strength of soil, parameters of shear strength, Coulomb's failure envelope, determination of shear parameters by Direct Shear Box. Tri-axial and unconfined compression test apparatuses. Principles of soil compaction, laboratory compaction tests; Proctor's test, Stresses in Soil under surface loading: Bossinesq's and Westergaard's analysis for vertical pressure and its distribution in a soil mass. Vertical stresses due to concentrated loads, Isobar diagram, Vertical stress distribution on a horizontal plane. Influence diagram, Vertical stresses at a point under circular and rectangular loaded area. Approximate methods of obtaining vertical pressure due to surface loading. Newmark's chart,	8

4	Compressibility and Consolidation: Introduction to consolidation, comparison of compaction and consolidation, Spring Analogy Terzaghis one dimensional consolidation theory, Degree of consolidation, consolidation test, Compressibility parameters, co- efficient of consolidation. Pre-consolidation pressure and its determination. Normally, over and under consolidated soils. Methods of predicting Settlement and its rate. Total and differential Settlement.	**8**
5	Stability of Slopes: Classifications of slopes, Stability analysis of infinite slopes. Stability of finite slopes by Swedish and Friction circle method. Stability analysis by Taylor's stability number , Taylor's stability number curves. . Bishop's method of stability analysis. Earth Pressure: Active, passive and earth pressure at rest. Rankine's and Coulomb's theories. Rebhann's and Culman's graphical methods for active earth pressure for vertical and inclined back retaining walls, horizontal and inclined cohesion less back fill.	**8**
6	Bearing Capacity of Soils: Terminology related to bearing capacity, Common types of foundations. Terzaghi and Meyehoff's theory for bearing capacity. Rankine's method for minimum depth of foundation. Skempton's method. Effect of eccentricity and water table on bearing capacity. IS code method, Plate load and penetration tests for determining bearing capacity. Introduction to pile, Site Investigations: Methods of explorations. Planning of Investigations, Depth of exploration, Number of boreholes, Undisturbed and Disturbed samples. Types of samplers. Brief description of procedures of sampling, Transportation and Storage of samples.	**9**
	TOTAL	**42**

Course Overview:

Geotechnical engineering is the systematic application of techniques which allows construction on, in, or with geo materials, i.e., soil and rock. Every civil engineering structure and construction is related to soil in some way, and subsequently, its design will depend on properties of the soil or rock. Geotechnical operations are of importance with respect to soil sampling, investigating geo materials properties, controlling groundwater level and flow as well as environmental and hydrological interactions. Foundation engineering, excavations and supporting ground structures, underground structures, dams, natural or artificial fills, roads and airports, sub grades and ground structures, and slope stability assessments are examples of geotechnical engineering applications in practice.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Application	Student will be able to Explain different types of soil present on Earth crust.
2	Application	Student will be able to Explain different types of soil properties And their use in engineering fields.
3	Analysis	Students will be able to Analyze engineering properties of soil Like compaction, permeability, and shear strength.
4	Analysis	Students will be able to Analyze engineering properties of soil Like compaction, permeability, shear strength.
5	Design	Students will be able to Compute the lateral thrust due to backfill On the retaining walls.

Prerequisites:

1. Student will be able to explain different types of soil present on earth crust.
2. Student will be able to explain different types of soil properties and their use in engineering fields.
3. Students will be able to Analyze engineering properties of soil like compaction, permeability, and shear strength.
4. Students will be able to analyze engineering properties of soil like compaction, permeability, and shear strength.
5. Students will be able to compute the lateral thrust due to backfill on the retaining walls.

Course Outcome Mapping with Program Outcome:

GEOTECHNICAL ENGINEERING															
Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO354.1	3	2	2	2	2	1	1	1	2	1	1	2	2	1	1
CO354.2	2	2	1	1	1	2	1	1	2	2	2	1	1	1	1
CO354.3	3	2	2	2	2	1	1	1	2	1	1	2	2	1	1
CO354.4	2	2	2	1	2	2	2	2	1	1	2	1	1	1	1
CO354.5	2	2	2	2	1	1	0	0	0	1	0	0	1	1	1
CO354 (AVG)	2.4	2	1.8	1.6	1.6	1.4	1	1	1.4	1.2	1.2	1.2	1.4	1	1

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	**INTRODUCTION:** Objective, scope and outcome of the course
2	**2**	Student should be able to understand about SOIL AND SOIL-MASS CONSTITUENTS, water content
3	2	Student should be able to understand about Specific gravity, void ratio, porosity, degree of saturation
4	2	Student should be able to understand about Air void and air content, unit weights, density index
5	2	Student should be able to compute Inter-relationships between different properties of soil.
6	2	Student should be able to Determine of index properties of soil: water content, specific gravity
7	2	Student should be able to understand Particle size distribution, sieve and sedimentation analysis, consistency limits, voidratio and density index
8	2	Student should be able to understand Mineral structures, structures of Illite Montmorillonites and kaolinite and theircharacteristics
9	2	Student should be able to understand about Darcy's law of permeability of soil and its determination in laboratory
10	2	Student should be able to understand about Stresses in soil mass: total, effective and neutral pressure, calculation of stresses, influence of water table on effective stress
11	2	Student should be able to understand about Quicksand phenomenon. Classification of soil for general engineering purposes
12	3	Student should be able to understand about MOHR'S CIRCLE OF STRESS, shearing strength of soil, parameters of shear Strength, Coulomb's failure envelope

13	3	Student should be able to Determine shear parameters by Direct Shear Box
14	3	Student should be able to understand about Tri-axial and unconfined compression test apparatuses
15	3	Student should be able to understand Principles of soil compaction, laboratory compaction tests; Proctor's test
16	3	Student should be able to understand about Stresses in Soil under surface loading: Bossinesq's and Westergaard's analysis for vertical pressure and its distribution in a soil mass
17	3	Student should be able to understand about Vertical stresses due to concentrated loads, Isobar diagram
18	3	Student should be able to understand about Vertical stress distribution on a horizontal plane. Influence diagram
19	3	Student should be able to understand about Vertical stresses at a point under circular and rectangular loaded area
20	3	Student should be able to understand about Approximate methods of obtaining vertical pressure due to surface loading. Newmark's chart
21	4	Student should be able to understand about COMPRESSIBILITY AND CONSOLIDATION: Introduction to consolidation, comparison of compaction and consolidation,
22	4	Student should be able to understand about Spring Analogy Terzaghis one dimensional consolidation theory
23	4	Student should be able to understand about Degree of consolidation, consolidation test, Compressibility parameters
24	4	Student should be able to understand about Degree of consolidation, consolidation test, Compressibility parameters
25	4	Student should be able to understand about Coefficient of consolidation. Pre-consolidation pressure and its determination
26	4	Student should be able to understand about Normally, over and under consolidated soils
27	4	Student should be able to understand about Methods of predicting Settlement and its rate
28	4	Student should be able to understand about Total and differential Settlement
29	5	Student should be able to understand about STABILITY OF SLOPES: Classifications of slopes
30	5	Student should be able to understand about Stability of infinite slopes. Stability of finite slopes by Swedish and Friction circle method
31	5	Student should be able to understand Stability analysis of infinite slopes. Stability of finite slopes by Swedish and Friction circle method
32	5	Student should be able to understand about Stability analysis by Taylor's stability number , Taylor's stability number curves
33	5	Student should be able to understand about Stability analysis by Taylor's stability number , Taylor's stability number curves
34	5	Student should be able to understand about Bishop's method of stability analysis
35	5	Student should be able to understand about Earth Pressure: Active, passive and earth pressure at rest

36	5	Student should be able to understand about Rankine's and Coulomb's theories
37	5	Student should be able to understand about Rebhann's and Culman's graphical methods For active earth pressure for vertical and inclined back retaining Walls, horizontal and inclined cohesion less back fill
38	5	Student should be able to understand about Rebhann's and Culman's graphical methods For active earth pressure for vertical and inclined back retaining Walls, horizontal and inclined cohesion less back fill
39	6	Student should be able to understand about BEARING CAPACITY OF SOILS: Terminology related to bearing capacity, Common types of foundations
40	6	Student should be able to understand about Terzaghi and Meyehoff's theory for bearing capacity. Rankine's method for minimum depth of foundation. Skempton's method
41	6	Student should be able to understand about Effect of eccentricity and water table on bearing capacity
42	6	Student should be able to study on IS code method, Plate load and penetration tests for determining bearing capacity

TEXT/REFERENCE BOOKS

1. Basic and applied Civil Mechanics by Ranjan & Rao, NewAge International Publishers.
2. Soil Mechanics & Foundation Engineering by Arora K.R, StandardPublishers and Distributers, Delhi.
3. Soil Engineering in Theory & Practice by Alam Singh, CBS Publishersand Distributers, Delhi.

Course Level Problems (Test Items):

CO.NO.	Problem description
1	A. What is the composition of soil? B. What is the main purpose of soil testing? C. In a shrinkage limit test, the volume and mass of a dry soil pat are found tobe 50 cm^3 and 88 g, respectively. The specific gravity of the soil solids is 2.71 And the density of water is 1 g/cc. The shrinkage limit (in %, up to two decimal places) is_____.
2	A. The laboratory tests on a soil sample yields the following results: natural moisture content = 18%, liquid limit =60%, plastic limit = 25%, percentage of clay sized fraction =25%. The liquidity index and activity (as per the expression proposed by Skempton) of the soil, respectively, are B. The porosity (n) and the degree of saturation (S) of a soil sample are 0.7 and 40%, respectively. In a 100 m^3 volume of the soil, the volume (expressed in m^3) of air is _____ C. A fine-grained soil has 60% (by weight) silt content. The soil behavesas *semi-solid* when water content is between 15% and 28%. The soil behaves *fluid-like* when the water content is more than 40%. The '*Activity*' of the soil is
3	A. A 588 cm^3 volume of moist sand weighs 1010 gm. Its dry weight is 918 gm and specific gravity of solids, G is 2.67. Assuming density ofwater as 1 gm/cm^3, the void ratio is _ B. A uniformly distribute line load of 500 kN/m is acting on the ground surface. Based on Boussinesq's theory the ratio of vertical stress at a depth 2 m to that at 4 m, right below the line of loading is A footing 2 m × 1 m exerts a uniform pressure of 150 kN/m^2 on the soil. Assuming a load dispersion of 2 vertical to 1 horizontal, the average vertical stress (kN/m^2) at 1.0 m below the footing is

4	A. The vertical stress at some depth below the corner of a 2m×3m rectangular footing due to certain load intensity is 100 kN/m^2. Whatwill be the vertical stress in kN/m^2 below the centre of a 4m×6m rectangular footing at the same depth and same load intensity?. B. A conventional drained triaxial compression test was conducted on a normally consolidated clay sample under an effective confining pressure of 200 kPa. The deviator stress at failure was found to be 400kPa. An identical specimen of the same clay sample is isotropically consolidated to a confining pressure of 200 kPa and subjected to standard undrained triaxial compression test. If the deviator stress at failure is 150 kPa, the pore pressure developed (in kPa, up to one decimal place) is _____
	C. In an unconsolidated undrained triaxial test, it is observed that an increase in cell pressure from 150 kPa to 250 kPa leads to a pore pressure increase of 80 kPa. It is further observed that, an increase of 50 kPa in deviatoric stress results in an increase of 25 kPa in the pore Pressure. The value of Skemptons's pore pressure parameter B is:
5	A. Stress path equation for tri-axial test upon application of deviatoric stress is, q=103√+0.5 pq=103+0.5 p. The respective values of cohesion, c (in kPa) and angle of internal friction, ϕϕ are : B. The effective stress friction angle of a saturated, cohesionless soil is 38°°. The ratio of shear stress to normal effective stress on the failure plane is C. For a sample of dry, cohesionless soil with friction angle ϕϕ, the failure plane will be inclined tothe major principal plane by an angle equal to

Assessment Methodology:

1. Practical exam in lab where they have to analyze problem statement. (Once in a week)
2. Assignments one from each unit.
3. Midterm subjective paper based on topics as mentioned in the modules. (Twice during the semester)
4. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

INTRODUCTION: Objective, scope and outcome of the course.

Video Tutorials: https://youtu.be/fGdf_7hUD0o

Theory concepts: https://www.sciencedirect.com/topics/engineering/geotechnical-engineering#:~:text=Geotechnical%20engineering%20is%20the%20systematic,of%20the%20soil%20or%20rock.

Sample Quiz: https://www.docsity.com/en/quiz-1-with-solution-introduction-to-geotechnical-engineering-civl-2630/6266761/

Unit-2

Darcy law for permeability.
Video Tutorials: https://youtu.be/xj7TnAeMLC4

Theory concepts:
https://www.cityofvancouver.us/sites/default/files/fileattachments/public_works/page/18517/soil_permeability.pdf
Sample ppt: https://edurev.in/course/quiz/attempt/-1_Test-Darcy%E2%80%99s-Law/79ac8189-c718-4230-aa1b-429973772be2

Unit-4

Quick sand condition
Video Tutorials: https://youtu.be/-4RdIc3j2Y0
Theory concepts: https://en.wikipedia.org/wiki/Quicksand
Sample Quiz: https://quizizz.com/admin/quiz/5b92fff93be4a20019cc4391/quicksand

A. Flow Net
Video Tutorials: https://youtu.be/FRuci0wQ0CI
Theory concepts: https://en.wikipedia.org/wiki/Flow_net
Sample Quiz: https://www.sanfoundry.com/geotechnical-engineering-questions-answers-application-flow-net/

Previous Year Question Paper:

5E1344

Roll No. _____ Total No of Pages: 3

5E1344

B. Tech. V - Sem. (Main / Back) Exam., Feb.-March – 2021

PCC/PEC Civil Engineering

5CE4 – 04 Geotechnical Engineering

Time: 2 Hours **[To be converted as per scheme]**

Max. Marks: 82

Min. Marks: 29

Instructions to Candidates:

Attempt all ten questions from Part A, four questions out of seven questions from Part B and two questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 What do you mean by the term Thixotropy of soil?

Q.2 What is normally consolidated soil?

Q.3 What do you understand by the term sensitivity of soil?

Q.4 Define the terms –

(a) Net ultimate bearing capacity

(b) Allowable bearing pressure

Q.5 What is normally consolidated and over consolidated soil?

Q.6 Define the term permeability.

Q.7 What is pre-consolidation ratio?

Q.8 What do you mean by disturbed and undisturbed sample of soil?

Q.9 What is an Isobar Diagram?

Q.10 Give any four differences between compaction and consolidation.

PART – B

(Analytical/Problem solving questions) **[4×8=32]**

Attempt any four questions

Q.1 A partially saturated sample from a borrow pit has a natural moisture content of 15 percent and bulk unit weight of 1.9 g/cc, the specific gravity of solids is 2.70. Determine the degree of saturation and void ratio.

Q.2 What is quick sand condition? Derive the relation for critical hydraulic gradient, $i_{cr} = \frac{G-1}{1+e}$

Q.3 What are the factors affecting permeability of soil?

Q.4 What are the disadvantages of direct shear test?

Q.5 Find the intensity of vertical pressure at a point 4 m directly below a 20 kN point load acting at a horizontal surface. What will be the vertical pressure 2 m horizontally away from the axis of loading? Solve according to Bossinesq theory.

Q.6 Derive relation for vertical stress under a circular loading.

Q.7 Derive relation for permeability for falling head method.

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) [2×15=3

Attempt any two questions

Q.1 Write soil IS soil classification system with symbol and their names.

Q.2 Determine the ultimate bearing capacity of a strip footing 2 m in width with its base at a depth of 1.5 m below ground surface and resting on a dry sand stratum with the following properties:

$\Phi = 38°$, $N_q = 60$; $N_\gamma = 75$. Use Terzaghi's theory. Determine the change in bearing capacity of soil when water table is at the base of footing.

Q.3 An infinite slope is to be constructed of clay soil at a slope angle of 30°. The ground water table is at ground itself, with seepage parallel to the ground. The soil properties are:

$C = 15kN/m^3$; $\Phi = 22°$, $\gamma_{sat} = 20kN/m^3$

What is the factor of safety against movement along a parallel to the ground surface at depth of 4m and 5.5m?

Q.4 A clay soil, tested in a consolidometer, showed decrease in void ratio from 1.20 to 1.10 when pressure was increased from 0.25 to 0.50 kgf/cm^2. Calculate coefficient of compressibility (a_v) and coefficient of volume compressibility (m_v). If coefficient of consolidation (C_v)=$10m^2$/year, calculate coefficient of permeability in cm/s.

Q.5 Explain the procedure to calculate vertical stress under a given loading using Newmarks influence chart.