Techno India NJR Institute of Technology

Course File

Geotechnical Engineering (5CE4- 04)

Jitendra Choubisa
(Assistant Professor)
Department of CE

5CE4-04: GEOTECHNICAL ENGINEERING

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
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 geomaterials, 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 geomaterials 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, shear strength.
5. Students will be able to Compute the lateral thrust due to backfill on the retaining walls.

For Techno India NJR Institute of Technology
पंकज पोरवाल
Dr. Pankaj Kumar Porwa
(Principal)

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	2	2
CO354.2	2	2	1	1	1	2	1	1	2	2	2	1	1	2	2
CO354.3	3	2	2	2	2	1	1	1	2	1	1	2	2	2	2
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	1.6	1.6

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 are the composition of soil? B. What are the main purpose of soil testing? C. In a shrinkage limit test, the volume and mass of a dry soil pat are found to be 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 behaves as *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 of water as 1 gm/cm^3, the void ratio is _ B. A uniformaly 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 a certain load intensity is 100 kN/m^2. What will 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 400 kPa. 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-3

A. Effective stress
Video Tutorials: https://youtu.be/9FsJRKrnZAE
Theory concepts: https://civilengineeringnotes.com/effective-stress-concept-in-soil-mechanics/
Sample Quiz: https://edurev.in/course/quiz/attempt/-1_Test-Slope-Deflection-Level-2/576771f9-7384-4f14-9a98-56f877cce30c

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

B. 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/

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पंकज पोरवाल
Dr. Pankaj Kumar Porwal
(Principal)

Previous Year Question Paper:

5E5063

Roll No. 15ECTCE049 [Total No. of Pages : 2

5E5063

B.Tech. V Semester (Main/Back) Examination, Nov./Dec. - 2017

Civil Engineering

5CE3A Geotechnical Engineering - I

Time : 3 Hours

Maximum Marks : 80

Min. Passing Marks : 26

Instructions to Candidates :

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Unit - I

1. a) Explain the Hydrometer test in detail with stretches. **(8)**

   b) A soil has a porosity of 40%, The specific gravity of solids 2.65 and a water content of 12%. Determine the weight of water required to be added to 100 m^3 of this soil for full saturation. **(8)**

OR

1. a) Write about the is classification system of soil in detail. **(8)**

   b) Explain the liquid limit, plastic limit and shrinkage limit with fig and methods to find shrinkage limit. **(8)**

Unit - II

2. a) What are the different types of soil structures which can occur in nature. Describe in detail. **(8)**

   b) Discuss the characteristics and construction of montmorillonite' and Illite mineral groups. **(8)**

OR

2. a) What are different methods for determination of the co-efficient of permeability in laboratory. Discuss their limitations. **(8)**

   b) Explain permeability of stratified soil mosses. **(8)**

5E5063/20 7 (1) [Contd....

Unit - III

3. a) What is quick sand? How would you calculate hydraulic gradient required to create quick sand conditions in a sample of sand? **(8)**

   b) Define total stress, neutral stress and effective stress. What is importance of effective stress. **(8)**

OR

3. a) Explain the term piping and uplift pressure. **(8)**

   b) Explain the method of constructing a flow net in an earth dam consisting of two different zones. **(8)**

Unit - IV

4. a) Describe direct shear test. What are its merits and demerits. **(8)**

   b) Explain unconfined compression test with fig. What is advantage over triaxial test. **(8)**

OR

4. a) A cylindrical specimen of saturated clay, 4 cm in diameter and 9 cm in overall length is tested in unconfined compression tester. The length of specimen after failures is 8 cm. Find the unconfined compressive strength of clay, if the specimen foils under and axial load of 46.5 N. **(8)**

   b) What is Mohr's strength theory for soils stretch typical strength Envelop for a clean sand. **(8)**

Unit - V

5. a) Describe standard proctor test and Modified proctor tests. **(8)**

   b) What are the factors that effect compaction? Discuss in brief. **(8)**

OR

5. a) What are the different methods of compaction in field. How would you select the type of roller. **(8)**

   b) What is mechanical stabilization. What are factors that affect the mechanical stability of mixed soil. **(8)**

$e = 0.01$

$e = \frac{w_s \gamma_w}{\gamma_d} - 1,$

$0.01 + 1 = 2.70 \left(\gamma_w/\gamma_d\right)$

$\frac{\gamma_w}{\gamma_d} = 0.374, \quad w_s = \frac{\gamma_w}{\gamma_d} - \frac{1}{d}$

$= 0.374 - \frac{1}{2.70}$

$= 0.37\%$

College copy
5/12/2015

5E5063

Roll No. _____ Total No of Pages: 3

5E5063

B. Tech V Sem. (Main/Back) Exam. Nov-Dec. 2015
Civil Engineering
5CE3A Geotechnical Engineering-I

Time: 3 Hours

Maximum Marks: 80
Min. Passing Marks Main: 26
Min. Passing Marks Back: 24

Instructions to Candidates:

*Attempt any **five questions,** selecting **one question** from **each unit.** All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

1. NIL 2. NIL

UNIT-I

Q.1 (a) A 10cm dia, 30cm long sample was extracted from ground weighs 4125gm. A moist specimen of the sample weighing 12.7gm was oven dried and its weight was found 9.2gm. If specific gravity of soil in 2.65 find - [10]

(i) Water content
(ii) Bulk Density
(iii) Dry Density
(iv) Void ratio
(v) Degree of saturation

(b) What do you understand by following classification of soils [6]

(i) CL
(ii) SW
(iii) MH

OR

Q.1 (a) Explain the IS Classification of soils. [10]

(b) The bulks unit weight of soil is 19.10kN/m^2 and water content is 12.5%, specific gravity of soil is 2.67, Determine - [6]

(i) Void ratio

(ii) Porosity

(iii) Degrees of saturation

UNIT-II

Q.2 (a) Explain the structure of cohesive soils. [8]

(b) Explain the structure of montmorillonite mineral. What makes it different from other minerals? [8]

OR

Q.2 (a) What do you understand by permeability of soil. Explain Darcy's law to compute rate of flow through soil. [8]

(b) A soil sample has length of 3.5m and cross-sectional area of 2m^2. If water flows through such soil sample and fluid energy lost is 1650Nm for every cubic meter flow of water, estimate Darcy's velocity and permeability. The time of flow for 1m^3 of water is 26 hours. [8]

UNIT-III

Q.3 (a) Explain total and effective stress taking example of dry and saturated soils. Show the variation of total stress, effective stress and pore water pressure for soil deposit having water table at ground surface. [8]

(b) In the process of an excavation for a wall footing, the water table was lowered from depth of 1.5m to a depth of 4.5m in claying sand deposit. Considering the soil above water table remains saturated at water content 30%, compute the following - [8]

(i) The effective stress at 4m after lowerly water table, take G=2.68.

(ii) Increase in effective stress at depth 5m.

OR

Q.3 (a) What do you understand by 'Piping'? Why it occurs in dams and how it can be prevented? [8]

(b) Show a flow net through an earthen dam and explain the applications of flow net. [8]

UNIT-IV

Q.4 (a) What different drainage conditions are considered in shear strength test of soil. Explain their relevance for actual site conditions. [8]

(b) A specimen of dry sand when subjected to triaxial test, failed at deviator stress 400kN/m^2. It failed with a pronounced failure plane with an angle 24° to the axis of the sample. Compute the lateral pressure which has caused the failure. [8]

OR

Q.4 (a) Explain Mohr-Coulomb shear strength theory. [8]

(b) In a triaxial test on dry sand the sample failed wren major and minor principal stresses were 980kN/m^2 and 280kN/m^2 respectively. What would be shear strength of same sample when tested in direct shear test under a normal stress of 300kN/m^2. [8]

UNIT-V

Q.5 (a) Enumerate the factors affecting compaction and explain how they affect the compaction. [8]

(b) If a proctor mould which has diameter 125mm and height 130.4mm is used for compaction, what would be the number blows to each layer if rammer is used is same as used in standard proctor and compaction is done in three layers. [8]

OR

Q.5 (a) What is a Proctor Needle? How it is used in compaction control in the field? [8]

(b) What do you understand by mechanical stabilization? For what type of soil it will be suitable? [8]
