Assignment

Geotechnical Engineering (2930603)

B.E. (Part Time)
Semester 3 (Civil)

Directorate of Technical Education
Gandhinagar, Gujarat

Preface

The assignment of Geotechnical Engineering is prepared with reference to the syllabus described by the Gujarat Technological University. Geotechnical engineering is very fundamental subject to study for determination of various soil parameters theoretically and experimentally based on laws of mechanics.

Any civil engineering structure needs strong and stable foundation which depends on proper understanding of soil properties and its behavior, determination of stresses and settlements in soil etc. Knowledge of the geotechnical engineering will prepare students to enter into mutli-disciplinary folds of this subject into various other civil engineering schemes.

The assignments are thus designed so as students at least be aware of basics and fundamentals of the geotechnical Engineering. These assignments are focusing on descriptive questions along with numericals.

The assignments cover not all but major content of the syllabus. It is also important to note that students must not stick the questions given in assignments only, but also require additional reading and practice for the exam and skill development in Geotechnical Engineering.

Course Outcomes

Sr. No.	CO statement
CO-1	Classify the soil and will be able to understand its behaviour and will be able to compute/estimate index parameters.
CO-2	Interpret soil behaviour through learning soil compaction, consolidation, and analyise various theories and calculate parameters needed in design.
CO-3	Compute earth pressure, stress distributions and FOS for slopes using various graphical and analytical tools for various engineering projects/site.
CO-4	Differentiate, compare, formulate, and evaluate soil parameters through performing various tests as per site conditions or project needs ethically and professionally.
CO-5	Suggest suitable type of foundation as per soil type, estimate bearing capacity and demonstrate its socio-economic feasibility.

	Tutorial- I **Type of Soils, Index Properties, Inter-relationships and Soil Characterization**	
1	Define the following term: (a)Void ratio (b)Porosity (d)Degree of saturation (e)Air content (f)Bulk mass density (g)Dry mass density (h)Saturated mass density (i)Mass density of soil (j)bulk unit weight (k)Dry unit weight (l)unit weight of soil solid (m)Specific gravity (n) Water content	CO1
2	Derive the relation between following: (i) Void ratio and Porosity (ii) Porosity and Void ratio (iii)Water content, Void ratio, Specific Gravity and Degree of saturation. (iv)Bulk unit weight (γ_B), Unit weight of water (γ_w), specific gravity of soil solid (G), Water content (w) and void ratio (e). (v)Dry unit weight (γ_d), Unit weight of water (γ_w), Specific gravity(G) of soil Solid and Void ratio (e).	CO1
3	A saturated sample of soil has water content of 35%. Adopting specific gravity G = 2.70 , calculate dry density (γd) , saturated density (γsat) and submerged density (γ')	CO1
4	A sample of soil was prepared by mixing a quantity of dry soil with 10% by mass of water. Find the mass of this wet mixture required to produce a cylindrical, compacted specimen of 15 cm diameter and 12.5 cm deep and having 6% air content. Find also the void ratio and the dry density of the specimen if G=2.68.	CO1
5	A soil deposit to be used for construction of an earth embankment has an average dry density of 1.62 gm/ml. If the compacted embankment is to have an average dry density of 1.72 gm/ml, determine the volume of soil to be excavated for 1000 m^3 of embankment. The water content of the soil in the borrow pit is 10%.	CO1
6	A soil has porosity of 40%, the specific gravity of solid of 2.65 and a water content of 12%. Determine the mass of water required to be added to 100 m^3 of this soil for fully saturation.	CO1
7	The liquid limit of a clay soil is 56% and its plasticity index is 15%. (a) In what state of consistency is this material at a water content of 45%? (b) What is the plastic limit of the soil? (c) The void ratio of this soil at the minimum volume reached on shrinkage, is 0.88.What is the shrinkage limit, if its grain specific gravity is 2.71?	CO1
8	Determine total stress, neutral stress and effective stress at a depth of 16m below ground level for the following condition. Water table is 3 m below ground level. e = 0.72, G = 2.68 average water content of the soil water table is 8%.	CO1

	Tutorial- II **Permeability and Seepage**	
1	Define: (i) Permeability (ii) Seepage (iii) Hydraulic Gradient (iv) Critical Hydraulic Gradient (v)Discharge velocity (vi) Seepage velocity (vii) Seepage pressure (viii)Uplift pressures (ix) Darcy's law (x) Equipotential lines (xi) Flow net (xii) Phreatic Line/Seepage Line	CO1
2	Discuss the factors affecting the permeability of soil.	CO1
3	A sand sample of 30 cm^2 cross sectional area and 20 cm long was tested in a constant head permeameter. Under a head of 60 cm, the discharge was 120 ml in 6 min. The dry weight of sand used for the test was 1120 g, and Gs= 2.68. Determine (a) the hydraulic conductivity in cm/sec, (b) discharge velocity (c) seepage velocity.	CO1
4	The data given below relate to two falling head permeameter tests performed on two different soil samples: (a) stand pipe area = 4 cm^2, (b) sample area = 28 cm^2, (c) sample height = 5 cm, (d) initial head in the stand pipe =100 cm, (e) final head = 20 cm, (f) time required for the fall of water level in test 1, t = 500 sec, (g) for test 2, t = 15 sec. Determine the values of k for each of the samples. If these two types of soils form adjacent layers in a natural state with flow (a) in the horizontal direction, and (b) flow in the vertical direction, determine the equivalent permeability for both the cases by assuming that the thickness of each layer is equal to 150 cm.	CO1
5	A concentrated load 10 kN acts on the surface of a soil mass. Using Boussinesq analysis find the vertical stress at points. (i) 3 m below the surface on the axis of loading and (ii) At radial distance of 2 m from axis of loading but at same depth of 3 m.	CO1
6	Two railway wagon lines in a harbour yard are located 6 m centre to centre. The average load per meter run in the lines are 100 kN/m and 80 kN/m. Find the vertical stress induce by the loading at a depth of 2 m beneath each loading and half way between them.	CO1
7	Calculate the stress in a soil mass below the centre of a uniformly loaded circular area of radius 1.5 m with a pressure of 60 kN/m^2 and obtain the exact depth at which the stress reduces to 10% of the applied stress.	CO1
8	For a homogeneous earth dam 52 m high and 2 m free board, a flow net was constructed and following results were obtained: Number of potential drops = 25 Number of flow channels = 4 The dam has a horizontal filter of 40 m length at its downstream end. Calculate the discharge per meter length of the dam if the coefficient of permeability of the dam material is $3x\ 10^{-3}$ cm/sec.	CO1

	Tutorial- III **Compaction & Consolidation of soil**	
1	Differentiate between compaction and consolidation	CO2
2	Explain Terzaghi's "Spring analogy" for consolidation of soil.	CO2
3	Define the following: Compression index, expansion index, Coefficient of volume compressibility, Coefficient of consolidation.	CO2
4	A laboratory compaction test on soil having g=2.68 have a dry density 1.8gm/cc and water content 14%. Determine the degree of saturation, air content and % air voids at maximum dry density. What could be theoretical maximum dry density corresponding to zero air voids at optimum moisture content.	CO2
5	An Oedometer test is performed on a 2 cm thick clay sample. After 8 minutes, 50% consolidation is reached. After how long a time would the same degree of consolidation is achieved in the field where the clay layer is 4.50 m thick? Assume the sample and the clay layer has the same drainage boundary conditions (double drainage).	CO2
6	The thickness of saturated specimen of clay under a consolidation pressure of 100 kN/m^2 is 22.12mm and its water content is 14%. On increase of the consolidation pressure to 200 kN/m^2, the specimen thickness decreases by 1.28mm. Determine the compression index for the soil. Take G = 2.70.	CO2

	Tutorial – IV **Stress Distribution**	
1	Differentiate between the Boussinesq's theory & Westergaard's theory of stress distribution in soils.	CO3
2	Explain briefly New-mark's influence chart.	CO3
3	Explain pressure bulb.	CO3
4	A concentrated load of 50kN acts on the surface of a homogeneous soil mass of large extent. Find the stress intensity at a depth of 5m and a) Directly under the load, and b) At a horizontal dist of 5m. Use Boussinesq's equation.	CO3
5	A rectangular footing of 2.6 m x 2.1 m carries a uniformly distributed load of 400 kN/m². Find the intensity of vertical pressure at a depth of 5 m below the centre of the footing.	CO3
6	A square footing 3m x 3m carries a uniformly distributed load of 450 kN/m². Find the intensity of vertical pressure at a depth of 6 m below a point 0.75 m inside each of the two adjacent side of footing.	CO3
7	An elevated structure with a total weight of 10000 kN is supported on a tower with four legs. The legs rest on piers located at the corners of a square 6 meter on a side. What is the vertical stress increment due to this loading at a point 7 meter beneath the centre of the structure?	CO3

	Tutorial – V **Shear Strength of Soil**	
1	What is Mohr's strength theory for soil? Sketch the typical envelop for clean sand.	CO4
2	Explain modified Mohr-coulomb theory.	CO4
3	A sample of cohesion less sand is direct shear test fails under a shear stress of 160kN/m^2, when normal stress is 140kN/m^2. Find the angle of shearing resistance & principal stress at failure.	CO4
4	If the major and minor principal stress through a specimen of failure are 600kN/m^2 & 200kN/m^2 respectively. Calculate the values of normal & shear stress on plane making an angle of 30^o with the direction of minor principal stress by graphically.	CO4
5	A soil specimen having c=80kN/m^2 and ϕ=25 is tested in triaxial test apparatus. Estimate a) deviator stress at which sample fails when cell pressure is 55 kN/m^2. b) the cell pressure of sample if fail at major principal stress of 880kN/m^2.	CO4

	Tutorial – VI **Earth Pressure & Stability of Slopes**	
1	Define earth pressure at rest. Show the earth pressure distribution on a retaining wall, assuming the soil is dry.	CO3
2	Enlist the assumptions of Rankine's theory. Derive the expression for active pressure and passive pressure.	CO3
3	Discuss Culmann's method for determination of active earth pressure.	CO3
4	Define stability number. Discuss its utility in the analysis of stability of slopes.	CO3
5	Discuss the method for checking the stability of an infinite slope in a cohesive soil.	CO3
6	Enlist different types of slope failures.	CO3
7	A vertical cut is made through a homogeneous soil mass(c= 30 kN/m^2,Φ= 20°,γ=16.5 kN/m^3).Using Culmann's method, determine the safe depth of the cut, taking factor of safety of 2.0	CO3
8	A cut of depth 10m is made in a cohesive soil deposit (c=20 kN/m^2, Φ=0, γ= 17 kN/m^3). There is a hard stratum under the cohesive soil at a depth of 12 m below the original ground surface. If required factor of safety 1.50, determine the safe slope.	CO3
9	Mention whether the following statements are "True" or "false". (i) The friction circle method can be used for non-homogeneous soil mass. (ii) Culmann's method assumes that failure surface is a plane. (iii)The total stress analysis can be used for stability of slopes. (iv)The active earth pressure is minimum pressure which develops when the wall moves away from the fill. (v) Coulomb's theory always gives conservative results The basement walls are generally designed for at-rest pressure.	CO3

	Tutorial – VII **Introduction to Foundations and Bearing Capacity**	
1	Define the following terms: I. Foundation II. Bearing Capacity III. Gross Bearing Capacity IV. Ultimate bearing capacity V. Net ultimate bearing capacity VI. Safe baring capacity VII. Net Safe bearing capacity VIII. Allowable bearing pressure	CO5
2	Differentiate between shallow foundation and deep foundation.	CO5
3	Enlist the assumptions made in the derivation of Terzaghi's bearing capacity theory. Also derive the equation for calculating ultimate bearing capacity of soil?	CO5
4	Mention the conditions where pile foundation is more suitable than shallow foundation.	CO5
5	A strip footing 2m wide carries a load intensity of 400 kN/m^2 at a depth of 1.2 m in sand. The saturated unit weight of sand is 19.5 kN/m^3 and unit weight above water table is 16.8 kN/m^3, and having angle of shearing resistance is 35˚.Determine the factor of safety with respect to shear failure for the following cases of location of water table: i. Water table is 4m below G.L ii. Water table is 1.2 m below G.L iii. Water table is 2.5 m below G.L iv. Water table is 0.5 m below G.L v. Water table is at G.L itself. Use Terzaghi's theory.(N_q=41.4, N_γ=42.4)	CO5
6	A rectangular footing has a size of 1.8m *3m has to transmit the load of a column at a depth of 1.5m. Calculate the safe load which the footing can carry at a factor of safety of 3 against shear failure. Use IS code method. The soil has following properties: n=40%, G=2.67, w=15%, c=8 kN/m^2, ϕ=32.5˚.(use IS 6403)	CO5
7	A 30 cm diameter concrete pile is driven into homogeneous consolidated clay deposit (c= 40 kN/m^2, α=0.7). If the embedded length is 10m , estimate the safe load(F.S.= 2.5).	CO5