DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING CVE 306: SOIL MECHANICS

EXAMINATION FOR SECOND SEMESTER 2018/2019 SESSION

Instructions: Answer Three questions in all, Question 3 is compulsory. Use the Tables supply in the Appendix A where necessary.

Time Allowed: 3 Hrs

3 units

Question 1 - (20 marks)

- a) Explain the following processes of soil formation briefly. You are free to support your answer with diagram(s) where necessary;
 - i. Accumulation of materials
 - Leaching losses and illuviation
- iii. Transformation
- iv. Podsolisation and translocation

(8 marks)

- b) Mention five (5) factors that affect soil formation. Distinguish between mechanical and chemical disintegration of rock in soil formation. (4 marks)
- c) Differentiate between the following terms of soil formation;
 - i. Denudation and Deposition
 - ii. Colluvial and Glacial
- iii. Hydration and carbonation
- iv. Oxidation and reduction

(8 marks)

Question 2- (20 marks)

- a) Soils, as they exist in nature, consist of solid particles (mineral grains, rock fragments) with water and air in the voids between the particles. Explain with the aid of a schematic diagram or diagrams the three-phase system in terms of weight and volume. (3 marks)
- b) i. A soil sample has a unit weight of 16.97kN/m³ and a void ratio of 0.84. The specific gravity of solid is 2.7. Determine the moisture contents, dry unit weight and degree of saturation of the sample.

 (6 marks)
 - ii. An undisturbed sample of soil has a volume of 29 cm³ and weighs 48 g. The dry weight of the sample is 32 g. The value of Gs = 2.66. Determine the
 - (a) natural water content,
 - (b) insitu void ratio.
 - (c) degree of saturation, and
 - (d) saturated unit weight of the soil. (6 marks)
- c) A core cutter cylinder with internal diameter of 100mm and length of 125mm was used to collect soil sample from the site, the following data were obtained;

Mass of soil + cylinder = 3813g

Mass of empty cylinder = 1625g

Mass of dry soil

= 1833g

Gs

=2.71

Determine (i) the bulk and the dry densities, (ii) water content, (iii) void ratio and airvoids content (5 marks)

Question 3 - (20 marks)

- a) Explain briefly what you understand as particle size distribution of a soil? State two methods you can use to measure the distribution of particle sizes in a soil sample?
 Explain sieve analysis in detail. (8 marks)
- b) From the results of a sieve analysis, shown in Table Q3, determine: (a) the percent finer than each sieve and plot a grain-size distribution curve, (b) D_{10} , D_{30} , D_{60} from the grain-size distribution curve, (c) the uniformity coefficient, C_u , and (d) the coefficient of gradation, C_c . (12 marks)

Table Q4: Particle size analysis

| Sieve Number | Diameter (mm) | Mass of soil retained on each sieve (g) |
|--------------|------------------|--|
| 4 | 4.750 | 28 |
| 10 | 2.000 | 42 |
| 20 | 0.850 | 48 |
| 40 | 0.425 | 128 |
| 60 | 0.250 | 221 |
| 100 | 0.150 | 86 |
| 200 | 0.075 | 40 |
| Pan | | 24 |

Question 4- (20 marks)

- a) Explain briefly what you understand as Atterberg limits. How can you determine plastic limit of soil in the laboratory? (8 marks)
- b) The laboratory test on a soil sample gave the following results; $W_n=24\%$, $W_1=62\%$, $W_p=28\%$, percentage of particle less than 2μ is 23%. Using the above results and the tables below, determine;
 - i. Liquidity index
 - ii. Activity
 - iii. Consistency, nature of soil and its classification

(6 marks)

c) A soil with a liquidity index of -20 has a liquid limit of 56% and a plasticity index of 20%. What is its natural content? What is the nature of the soil? (6 marks)

Question 5- (20 marks)

a) The sieve analysis of a given sample of soil gave 57% percent of the particles passing through 75 micron sieve. The liquid and plastic limits of the soil were 62 and 28 percent respectively. Classify the soil per AASTO and the Unified Soil Classification Systems.

(8 marks)

b) For a large project, a soil investigation was carried out. Grain size analysis carried out on the samples gave the following average test results (Table Q5).

Table Q5: Grain size analysis

| Sieve No. | Percentage finer |
|-----------|------------------|
| | |
| 4 | 96 |
| . 10 | 60 |
| 20 | 18 |
| 40 | 12 |
| 60 | 7 |
| 100 | 4 |
| 200 | 2 |

Classify the soil by using the Unified Soil Classification System assuming the soil is non-plastic.

(6 marks)

c) Soil samples collected from the field gave the following laboratory test results:

Percentage passing No. 4 sieve 100
Percentage passing No. 200 sieve 76
Liquid limit 65
Plastic Limit 30

Classify the soil using the Unified soil classification System. (6 marks)

Appendix A: Necessary and useful Tables

Unified Classification System Table

| Major | T | Group Group | | | Classification criteria for coarse-grained sorts | | | | | | | |
|-------------------------------------|--|---|--|--|--|---|-------------------------------|--|---|---|--|---|
| divisions | | symb GW | 01 | Well-graded gravels, gravel-sand | C. 24 | | | | | | | |
| ose fracti | (more than half of course triver is larger than No. 4 sieve size is larger than No. 4 sieve size (gravels with fines (lettle or (uppreciable (lettle or amount of fines) | GP | | Poorly graded gravels, gravel- | Non-monation all province | ion requitements C; > 3) | | | | | | |
| Coards Half of cou | | GM | d | Silty gravets, gravet-sand-silt mixture | Anorberg limits below A line or $l_p < 4$ | Above A line with $4 < I_a < 7$ are borderline cases requiring use of dual | | | | | | |
| (more than | | Œ | | Cłayey grawełs, grawel-sand-clay maxture | Atterberg limits above A line with $I_p > 7$ | symbols | | | | | | |
| 5 T | <u> </u> | sw | | Well-graded sands, gravelly sands, linte or no fines | C, 26 1 S C, S 3 | | | | | | | |
| siews | | SP | | Poorly graded sands, gravelly sands, little or no times | Not neeting all gradation requirements for SW $\{C_k < 6 \text{ or } 1 > C_c > 3\}$ | | | | | | | |
| Sands n haif of co | Tarks Critical | SM | du | Sitry sands, sand-silt máxture | Atterberg funds below A line or I _g < 4 | Above A line with 4 5 l, 5 7 are bordering cases requiring use of dual | | | | | | |
| (mon the | Sandk Sand W | sc | , | Clayey sands, sand-silt mixture | Atterberg limits above A line with $I_3 > 7$ | symbols | | | | | | |
| | Silts and chys input limit < 50) | | | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity | 2. Depending on per (fraction smaller) coarse-grained so | Seze curve. | | | | | | |
| Silts and ch | | | SE S | | Sirs and Charles | | Silts and Chipped Funds | | | Inorganic clays of very low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | Less than 5%-GW, GP, SW, 3 More than 12%-GM, GC, SN 5 to 12%-Borderline cases to dual symbols | IM. GC. SM. SC |
| | | Or | | Organic silts and organic silty clays of low plasticity | | | | | | | | |
| | Sitts and clays (laqued limit > 50) | | 1 | Inorganic silts, micaceous or di- atomaceous fine sandy or silty soils, clastic silts | C _s : | $= \frac{D_{s_0}}{D_{10}}$ | | | | | | |
| | | | Sits and el (tsqued limit | | Sitts and of (Equid limit | | Sitts and ci (topuid limit | | | leorganic clays or high plasticity, far clays | <i>c</i> , = | $= \frac{D_{i0}}{D_{ik}}$ $= \frac{D_{i0}^{l}}{D_{i0}D_{i0}}$ |
| (mkwe li | | | | | | | | | l | Organic clays of medium to high plasticity, organic silts | | |
| Peat and other highly organic soils | | | | | | | | | | | | |
| | Sands Sands (more than half of course fraction is larger than No. 4 serve size) is smaller than No. 4 sieve size) | Sints and clays Silts | Siths and clays. Siths and cl | Site and clays Site and clays Site and clays (hquid limit > 50) Sands (more than half of coarse fraction is larger than No. 4 serve size) Site and clays (hquid limit > 50) Sands with fixes (Tean sands (Gravels with fixes (Inte or no (uppercrabble (Inte) or no (uppercrabble (Int) or no (upp | Symbol S | Major Maj | | | | | | |

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| Percentage finer |
|------------------|
| |
| 96 |
| 60 |
| 18 |
| 12 |
| 7 |
| 4 |
| 2 |
| |

Classify the soil by using the Unified Soil Classification System assuming the soil is non-(6 marks) plastic.

c) Soil samples collected from the field gave the following laboratory test results:

| Boil ballpres comments | 400 |
|----------------------------------|---------|
| Percentage passing No. 4 sieve | 100 |
| Percentage passing No. 200 sieve | 76 |
| Liquid limit | 65 |
| Plastic Limit | 30 |
| Flashe Limit | ficatio |

(6 marks) Classify the soil using the Unified soil classification System.

Appendix A: Necessary and useful Tables

| Inifie | ed Class | sificatio | on Sy | stei | n Table | The same | on enteria for |
|--|--|--|-----------------|---|--|--|--|
| Major divisions | | | Greup symbol | | Typical names | Classification criteria for course-grained sorts | |
| Course grained scats (more than No. 200) | T T | | GW | | Well-graded gravels, gravel-sand mixtures, little or no fines | C, ≥ 4 1 ≤ C, ≤ 3 | |
| | rse fract | Clean gravels (little or no fines) | GP | | Poorly graded gravels, gravel- sand mextures, futle or no fines | Not meeting all gradation requirements for GW $(C_r < 4 \text{ or } 1 > C_r > 3)$ | |
| | Gravels (more than half of course fraction is larger than No. 4 serve size) | Cravels with fines (approxishle amount of fines) | GM | d u | Silty gravels, gravel-sand-silt | Anserberg limits below A line or $I_{\mu} < 4$ | Above A line with 4 < 1 < 7 are bonderline cases requiring use of dual |
| | Part of the Property of the Pr | | cc | | Cłayey gruwek, grawei-sand-clay maxture | Atterborg limits above A line with $I_p > 7$ | symbols |
| Course grained scals (of muserial is larger | | Care 8 8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | SW | | Well-graded sands, gravelly sands, little or no fines | C, 26 1 s C, s 3 | |
| Not to | sieve sip | | SP | | Poorly graded sands, gravelly sands, little or no lines | Not neeting all gradation requirements for SW $\{C_n < 6 \text{ or } 1 > C_n > 3\}$ | |
| mean aream | Sands (more than half of coarse fraction is smaller than No. 4 sieve size) | Sands with fines (appreciable amount of fines) | SM | d u | Sity sands, sand-silt mixture | Atterberg firmsts below A line or I, < 4 | Above A line with 4 5 1, 5 7 are bordering cases requiring use of dual |
| | | | SC | | Clayey sands, saod-silt mixture | Atterberg firests above A line with 1, > 7 | symbols |
| than No. 200) | Silts and Carys (Riquid limit < 50) | | MIL. | | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity | 1. Determane percentages of sand and gravel from grain-size curve. 2. Depending on percentages of fines (fraction smaller than 200 sieve size), coarse-grained soils are classified as follows: Less than 5%-GW, GP, SW, SP More than 12%-GM, GC, SM, SC 5 to 12%-Borderline cases requiring dual symbols | |
| | | | CL. | | Inorganic clays of very low to medium plasticity, gravelly clays, vandy clays, silty clays, lean clays | | |
| d souts | | | OL | | Organic silts and organic silty clays of low plasticity | | |
| Fure-grained soils (move than half of material is smaller | Ŕ | | ми | | Inorganic silts, micaceous or di- atomaceous fine sandy or silty soils, clastic silts | $C_s = \frac{D_{s_0}}{D_{s_0}}$ | |
| | | Sitts and clays (Injust limit > 50) | | | legorganic clays or high plasticity. | C, = | $\frac{D_{i\phi}}{D_{i\psi}}$ $\frac{D_{i\phi}^2}{D_{i\psi}D_{i\phi}}$ |
| | C T | | OH | <u> </u> | Organic clays of medium to high plasticity, organic silts | - Y Y | |
| - | | | Fr | *************************************** | Pess and other highly organic soils | | |

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| 10 | 60 |
| 20 40 | 12 |
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| 100 | 2 |

Classify the soil by using the Unified Soil Classification System assuming the soil is non-

c) Soil samples collected from the field gave the following laboratory test results:

100 Percentage passing No. 4 sieve 76 Percentage passing No. 200 sieve 65 Liquid limit Plastic Limit

(6 marks) Classify the soil using the Unified soil classification System.

Appendix A: Necessary and useful Tables

Unified Classification System Table

| | Major divisions | | | (0x | Typical names | Classification criteria for coarse-grained sorts | | | | | | | | |
|--|--|---|--------------------|-----------------------|--|---|--|---------------------------|--|---|--|--|----------------------|--|
| | raction size) | (more than half of course fraction is larger than No. 4 serve size) Gravels with fines Clean gravels (approviable (little or to amount of fines) | gravels (ce ex) | gravels (ce ex) | gravels (ce ex) | gavels (ce eo | gravels (G to) | gravels (ce no nes) | gravels (ce no ics) | GW | | Well-graded gravels, gravel-sand nuxtures, little or no fines | C, ≥ 4 1 ≤ C, ≤ 3 | |
| 200) | cls coarse (4 serve | | GP | | Poorly graded gravels, gravel- sand mixtures, little or no fines | Not meeting all grads for GW (C, < 4 or 1 > | tion requirements C, > 3) | | | | | | | |
| Coarse-grained sorts more than No. 200) | Gravels than half of co yer than No 4 | | GM | d is | Silty gravels, gravel-sand-silt mixture | Atterberg limits below A line or $I_{\mu} \in 4$ | Above A line with $4 < I_n < 7$ are borderline cases requiring use of dual | | | | | | | |
| Coarse-grained soils f of material is larger | (more in langer) | | СС | | Clayey gravels, gravel-sand-clay maxture | Atterberg limits above A line with $I_p > 7$ | symbols | | | | | | | |
| Course-g | raction : size) | Clean sands (Sittle or no fines) | sw | | Well-graded sands, gravelly sands, little or no fines | $C_s \ge 6$ $1 \le C_c \le 3$ Not meeting all gradation requirements for SW $\{C_s < 6 \text{ or } 1 > C_c > 3\}$ | | | | | | | | |
| than that | ts coarse f x 4 siew | | SP | | Poorly graded sands, gravelly sands, little or no tines | | | | | | | | | |
| (more | Sands (more than half of coarse fraction is smaller than No. 4 sieve size) | Sands with fines (appreciable amount of fines) | SM | d x | Sitty sands, sand-silt mixture | below A line or $I_p < 4$ | Above A line with 4 5 1, 5 7 are borderine cases | | | | | | | |
| | (more 6 is small | | sc | | Clayey sands, sand-silt maxture | Atterberg fittists above A line with $I_p > 7$ | requiring use of dual symbols | | | | | | | |
| 300 | , in | Silts and chays (liquid limit < 50) | | | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or elayey silts with slight plasticity | 1. Determine percentages of sand and gravel from grain-size curve. 2. Depending on percentages of fines (fraction smaller than 200 sieve size), coarse-grained soils are classified as follows. Less than 5%-GW, GP, SW, SP More than 12%-GM, GC, SM, SC 5 to 12%-Borderline cases requiring dual symbols. | | | | | | | | |
| Fine-grained scals of material is smaller than No. 2000 |) - Per 215 | | | | Inorganic clays of very low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | | | | | | | | | |
| ined son | | | | | Organic silts and organic silty clays of low plasticity | | | | | | | | | |
| Fine-grained sorts if of material is small | 1 | Silts and clays (Equid limit > 50) | | | Inorganic silts, micacecous or di- atomacecous fine sandy or silty soils, elastic siles | $C_s = \frac{D_{\infty}}{D_{10}}$ | | | | | | | | |
| (move than half | Sifts and | | | Silts and quid lim | | one still CH | | | Inorganic clays or high plasticity, fat clays | $C_{i} = \frac{D_{ii}^{2}}{D_{ii}D_{ii}}$ | | | | |
| (Boar) | | | ОН | | Organic clays of medium to high plannetty, organic silts | $=$ $\mathcal{D}_{10}\mathcal{D}_{90}$ | | | | | | | | |
| | Highly | Highty organic xoils | | | Peat and other highly organic soils | | | | | | | | | |