NAME(s): ____

INTRODUCTION TO SOILS

GEOTECHNICAL Part 1: Soil Lab Analysis

Purpose: This geotechnical project will introduce you with the concept of using soils as construction materials. *Part I* of this project involves characterizing soils using various laboratory analyses and applying the Unified Soil Classification System in naming the soil. *Part II* of this exercise (next week) will allow you to apply your knowledge of soils and their use in embankments and foundations. For this part of the project you will learn to read site plans and as the onsite soil scientist you will make recommendations on what soil type is best used at the hypothetical construction site.

Directions: You will be divided into groups of 3 to 4 students. For Part I, each group will have their own soil to evaluate. You will be responsible for the following analysis:

1. Soil Description
2. Mass Wetness
3. Grain Size Analysis
4. Grain Size Distribution
5. Atterberg Limits (Plastic and Liquid Limits for the fine fraction of soil)

You will use the United Soil Classification System to classify your soil.

1. Soil Description

Provide a general description of the soil. Use the Munsell color chart to record the color of the soil. Typically the color is determined with the moisture content of the soil as found in the environment.

2. Mass Wetness
Here we will determine the mass of water in our soil sample. As discussed in class, mass wetness (w) equals the mass of water divided by the mass of the solid (M_w/M_s). The following steps will lead you through the procedure for calculating the Mass Wetness trough drying your soil sample in an oven.

A. Collect a sample of soil from the field and place in a ziplock bag or 5 gallon bucket and cover the bucket in order to reduce moisture loss from the soil.

B. Weigh the mass of a drying pan: _______________

C. Add approximately 100 grams of soil to the pan and weight: _______________

D. Place sample in labeled pan into the oven. Oven should be set at 105°C; leave sample in oven for approximately 24 hours.

E. Remove sample from oven and weight: _________________

F. Calculate the mass of water in the soil (C-E): _________________

G. Calculate the mass of the dry soil (E-B): _________________

H. You should now be able to calculate the mass wetness: _____________________

I. Mass wetness is reported in what units? ________________

3. Grain Size Analysis
The purpose of the grain size analysis and distribution is to classify the soil and determine whether the soil can be treated as a coarse grained or fine grained soil and if the soil is well graded or poorly graded. These characteristics influence the soil's integrity as a building material. Sections 3 and 4 outline the procedure for determining the Grain Size Analysis & Distribution.

A. Weigh out approximately 100-200 grams of dry sample on the balance and record the mass in the Excel spreadsheet (see Blackboard or your Professor for spreadsheet). *Make sure your soil has been oven dried for 24 hours at 105℃.* Samples with abundant salts should be washed prior to drying.

B. Use the sieve-shaker to analyze the grain distribution of your sample.

What percent of your soil sample is coarse grained? ________________

What percent of your soil sample is fine grained? ________________

This soil would best be categorized as what (Gravel, Sand, Silt/Clay)? __________________

4. Grain Size Distribution
A. Construct a histogram of your results in Excel (see example).

B. Construct a second plot showing grain size (x-axis) versus cumulative percent (y-axis) in Excel.

C. Use your plots to determine if your sample is **Well Sorted** or **Poorly Sorted**?

5. Liquid and Plastic Limits (Atterberg Limits)
This lab test is performed to determine the plastic and liquid limits of the fine-grained component of the soil. Use the fraction of the soil that passed through a No. 40 sieve for this lab analysis. The Atterberg limits are based on the moisture content of the soil. The plastic limit is the moisture content that defines where the soil changes from a semi-solid to a plastic or flexible state. The liquid limit is the moisture content when the soil integrity changes from plastic to a viscous fluid.

Plastic Limit *(The moisture when soil ribbons crumble at 3.2 mm thickness)*
A. Weigh 3 metal drying cups (or tins) and record measurements.

B. Take a soil sample (approximately the size of your thumb) and add distilled water to the soil until it reaches a consistency where it can be rolled in the hands without sticking to your skin. Add water slowly to avoid adding excess moisture.

C. Form a ball of soil with your hands. Roll the soil between your palm (or fingers) and a glass plate. Use sufficient pressure to roll the mass into uniform thread. If the thread cannot be rolled down to 3.2 mm (diameter of wooden dowel) without breaking then add water to the sample. If thread can be rolled down to 3.2 mm in under 2 minutes without crumbling then break the thread into several pieces. Knead soil back to a ball and re-roll until the thread crumbles when it reaches 3.2 mm in thickness. The kneading process removes moisture from the soil.

D. Quickly collect the sample that crumbled at precisely 3.2 mm, place in a weighted tin, and record the mass of the wet soil + tin. You can now subtract the mass of the tin to calculate the mass of the wet soil.

E. Place wet soil in over at 105°C for 16+ hours to remove moisture.

F. Repeat this process 2 additional times with the remaining soil. (Make sure all members of the team attempt this procedure).

G. After drying: weigh dry soil + tin and calculate the weight of the dry soil. Subtract this from the weight of the wet soil to determine the mass of water for each of the three samples.

H. Compute the water content (mass wetness %) for each of the samples. Calculate the mean. (See AtterbergLimit.pdf on Blackboard for examples and pictures. Portions of this lab or adapted from *Prof. Reddy, UIC*).

Liquid Limit *(The moisture when soil comes in contact at exactly 25 drops)*
A. Weigh 3 metal drying cups (or tins) and record measurements.

B. Take a golf ball size of soil (passed through No. 40 sieve) and place it in dish. Mix soil with small amount of distilled water to create a smooth uniform paste.

C. Adjust the liquid limit apparatus by checking the height drop of the cup. The cup should drop 10 mm. The block on the end of the grooving tool is 10 mm high and can be used to measure the drop. Reset the counter to “0000”.

D. Place a small portion of the mixed soil into the bronze cup at the point where the cup rests on the base. Use the spatula or knife to spread the soil thinly over the cup removing all air pockets. The soil should be 10 mm at its thickest point. The soil should form an approximately horizontal surface.

E. Use the grooving tool to carefully cut a clean straight groove through the center of the soil. The tool should be held perpendicular to the soil; care should be taken to prevent any sliding of the soil on the cup.

F. Clean around the apparatus ensuring no soil is between the bottom of the cup and the platform. Turn the machine on.

G. Watch the soil as the machine is running. Stop the apparatus once the contact at the base of the groove reaches a distance of ½ inch or 13 mm. Record the value in Excel. If the number of hits exceeds 50 then go to step “I”.

H. Take a sample from the center of the pan from side to side. Place it into a tin and immediately weigh the wet sample. Place the sample in the oven to dry at 105°C for 16+ hours.

I. Clean and dry apparatus cup and grooving tool. If the counter is < 25 then add some dry soil. The goal is to get at least one drop count less than 25 and one drop count greater than 25. If the counter is greater than 25 then proceed by adding a few drops of water into the soil to increase the water content so that the number of drops required to close the groove decreases. Remix soil thoroughly.

J. Repeat steps C-I to get values using 3 different moistures.

K. Calculate the Plastic Limit by first calculating the water content (w) for each of the 3 samples after being dried in the oven. Plot the number of cup drops (x axis) versus the water content (w) in Excel. Add a best fit trend line in Excel (straight line). If you disagree with Excel’s interpretation feel free to do this on your own through the 3 points you plotted. Determine the liquid limit (this is the water content at 25 drops).

L. You can now calculate the plasticity index: PI = LL-PL (round to the nearest whole number):

M. Use the Atterberg Plasticity Diagram for fines (see class notes or PowerPoint) to determine if the fines exhibit **Low Plasticity (L)** or **High Plasticity (H).**