Chittagong University of Engineering and Technology

Department of Civil Engineering

Report Title: **Engineering classification of soil**

Sample Collection Area: **Goribullah Shah Housing Society**

Course No: **CE-332**

Course Name: **GEOTECHNICAL ENGINEERING(Sessional-I)**

Course Instructor(s):

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Group No	Group Members
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Introduction:

The engineering classification of soil is an important aspect because the behavior of soil directly influences the stability of the structure as the load directly is transferred to the soil. As part of the sessional course, geotechnical engineering (CE 332), project work was conducted under the guidance of the civil engineering department, and CUET professors. As Chittagong metropolitan area is a rapidly growing urban center in Bangladesh, understanding the soil properties becomes even more crucial due to the unique geological and environmental conditions prevalent in this region. This lab project aims to comprehensively analyze different samples from various locations provided to 26 groups. A range of geotechnical test analyses was done, which will provide valuable insights for civil engineers to help do the engineering classification and also make informed decisions in planning, design, and construction of infrastructures.

Aim of this lab project:

1. Learn how to take samples from a provided area.

2. Choose and conduct the necessary tests needed to do engineering classification.

3. Working in groups will help grow leadership skills, and communicate with local people, and among peers.

4. Practical field negotiations and perseverance.

Advantages:

1. Working on a group project will allow students to apply theoretical concepts learned in the theory of geotechnical engineering course (CE 331).

2. Exposure to real environments and collecting samples without having any prior experience will be challenging and, at the same time, helpful for the students.

3. Students will learn essential laboratory skills and decision-making abilities in soil testing.

4. Analyzing data and handling them accordingly will help in developing critical interpretive skills.

5. Problem-solving skills and communication will also improve.

6. Personal growth can be ensured.

APPLICATION IN REAL LIFE:

1. After entering the job field, this group project will give us prior experience as we will be asked to conduct similar project works. Knowing beforehand how to communicate with local people and how and where the sample should be collected will give us benefits.

2. Working in a team requires leadership, understanding among the members, equal effort, and understanding mentality. This experience will give us confidence so that we can engage and work with a larger group of people.

3. Being able to recognize whether the report results are okay or not is necessary for us. This project work will give us an idea about how to properly analyze test results and give a proper discussion on that.

LOCATION OF THE SITE:

Goribullah Shah Housing Society, Khulshi-1, Chittagong City, Bangladesh.

Specific Location: beside a hillock, in front of a tin shade house (22.3582318, 91.8194207).

TOPOGRAPHY:

1. Near the main road of the society.

2. Two-minute walking distance from the main road.

3. In front of a tin shade house, beside a hillock.

4. High elevation compared to other areas.

WEATHER: Sunny day with high humidity.

According to Google, the temperature on 12th July 2023 was 30 degrees, and humidity was nearly 70%.

SAMPLE COLLECTION:

DATE: 12TH July 2023.

Plan:

1. After finishing our theory classes, group members went to the designated area by CUET bus, around 3 PM.

2. Necessary instruments were borrowed (spade, polythene, bag) from a nearby construction site in CUET beforehand.

3. Took 5 kg amount of sample and went back directly to CUET geotechnical laboratory to measure moisture content around 4:45 PM.

OUTLINE:

The project was completed in the following order:

1. Project order was given on 10th July.

2. Meeting among group members and fixing a date.

3. Collecting necessary instruments for sample collection.

4. Going to the area and reconnaissance the whole area first and finding a suitable area to collect the sample from.

5. A 5KG sample was collected from a 1-meter-deep dug hole beneath the surface.

6. Collect the sample in a plastic bag.

7. Return to the lab as soon as possible and do the necessary steps for measuring moisture content.

8. Appropriate amount of sample was kept for oven drying to do tests.

9. Then samples were ground, and sieve analysis was done.

10. Specific gravity and Atterberg limit tests were done next.

11. Due to a lack of necessary fine particles, hydrometer analysis was not necessary. This experiment was omitted.

12. The lab report was prepared.

13. The lab report was submitted.

EXPERIMENTAL PROCEDURES:

A. Determination of natural moisture content.

1. Moisture can container numbers were recorded.
2. The weight of empty cans was recorded.
3. After that, the can with moist soil sample weight was recorded.
4. Then moisture can containers with moist soil samples were put in the oven at 105 degrees Celsius for 24 hours.
5. After 24 hours, moisture can containers were taken out, and the oven-dried weight with the can was recorded.
6. This test was conducted within 2 to 3 hours of collecting the sample.

B. Grain sixe distribution (Sieve analysis)

1. A few kgs of the sample were put in the oven for oven drying. The oven-dried sample was taken 500 gm in the sieve.
2. In the sieve stack, after closing the top lid, vibrated horizontally for 5 minutes straight without any interruption.
3. Then with the help of a weighing machine, the weight of samples retained on different sieves was measured.
4. Soil retained on the pan was less than 5%. That's why we decided not to conduct the hydrometer analysis test, as it was not necessary.

C. Determination of specific gravity of soil.

1. The pycnometer was cleaned properly and dried, and then the weight of a clean pycnometer was taken.

2. The calibrated temperature and calibrated volume of the pycnometer were noted down.

3. After adding distilled water, the weight of the pycnometer with water was again measured. The temperature of the water was also measured.

4. If the temperature was non-uniform, the thumb was pressed on the open end of the pycnometer and turned upside down.

5. The bottle of water was slightly heated by placing it in a water bath to bring the meniscus down to the calibration mark. The temperature and weight of the pycnometer filled with water were recorded every time.

6. The above steps were repeated to get the calibration curve within the 2-3 degrees range.

7. Then the pycnometer was cleaned.

8. 50 gms of the soil sample was taken and added distilled water to the pycnometer about three fourth of the pycnometer.

9. After 10 minutes of boiling in a water bath, all the air entrapped in the soil was removed. Then the bottle was cooled, and the weight with water was taken. The temperature was also taken.

D. Atterberg limit test

For liquid limit:

1. We took 100gm of the sample that passed through the number 40 sieve.

2. Water was added accordingly so that a moldable paste of the soil sample was ready.

3. After that, the sample was put into the liquid limit device and smoothened out.

4. Then the center of the soil was cut by a growing tool.

5. Then the device's blowing apparatus was rotated till the gap at the center is filled by the soil. The number of blows was recorded each time.

6. Then the soil sample was cut into six equal portions, and the middle two portions were taken into a can. Previously, the can number and empty can weight were taken.

7. The above process is repeated 5 times, and an average liquid limit can be determined.

Plastic limit test:

1. About 15 gm of the soil sample was mixed with water to make roles of the soil sample.

2. But our soil sample broke each time we tried to roll it.

3. Then the soil sample was put in a can, and weight was measured.

4. The average water content i

Location	**Coordinate**	**Moisture Content (%)**	**Grain Size Analysis**				**Specific Gravity**		**Atterberg Limit**		
			Sand (%)	**Fines (%)**	**Silt (%)**	**Clay (%)**	**Experimental**	**Theoretical**	**Liquid Limit (%)**	**Plastic Limit (%)**	**Plasticity Index (%)**
Goribullah Shah Housing Society	(22.3582318,91.8194207)	13.176%					1.35	1.314	0	0	0

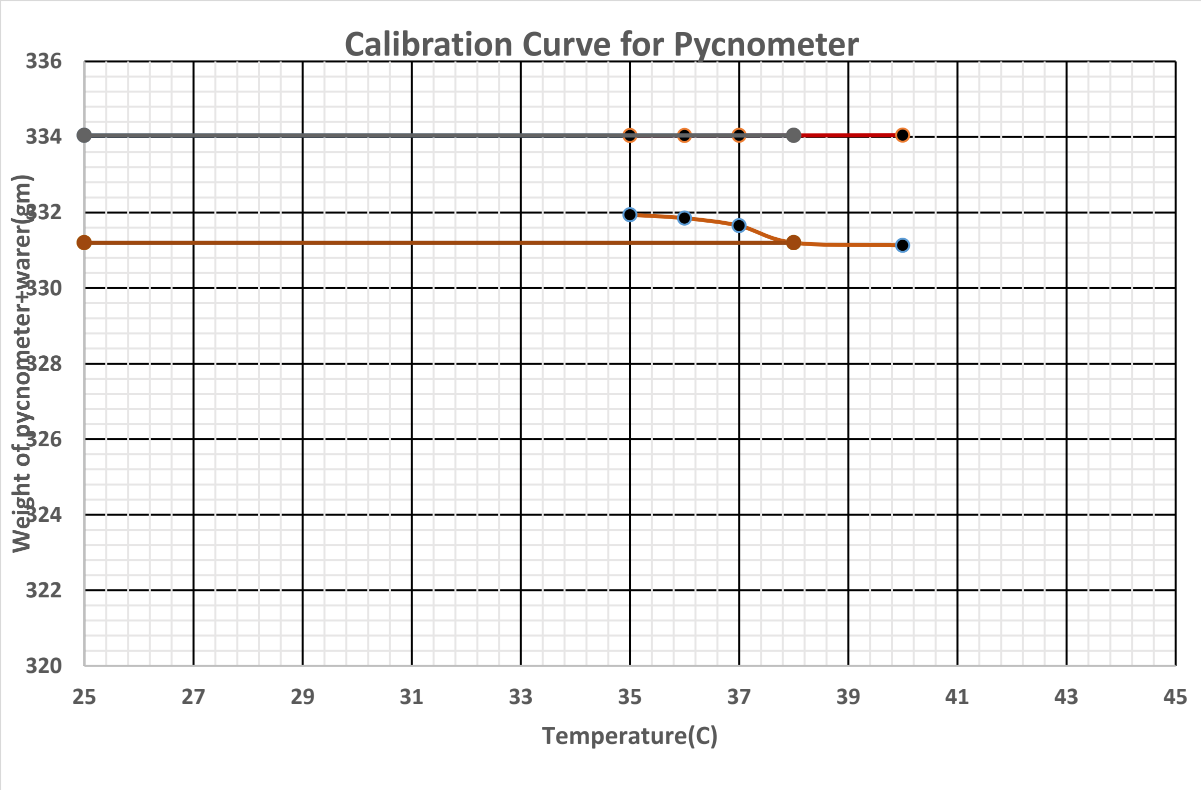
Therefore, the soil class as per ASTM D2487-11/BNBC 2020 is ‘Poorly Graded Sand’.

Data sheet for specific gravity of soil.

Weight of pycnometer (gm):							84.03
Calibrated volume of pycnometer (mL) :							250
Calibrated temp. of pycnometer (°C):							33
ϵ = Thermal coefficient of cubical expansion for Pyrex glass (/°C):							0.00001
γa= Unit Weight of air at T and atmospheric pressure (gm/cm^3):							0.0012

SL No.	**Temperature (°C)**	**Weight of pycnometer + water (gm) Ex.**	**Unit wt. of water at T °C (γT) (gm/cm^3)**	**Weight of pycnometer + water (gm) Th.**
1	35	331.94	0.99408	334.035
2	36	331.85	0.99373	334.037
3	37	331.65	0.99337	334.040
4	38	331.2	0.9993	334.042
5	40	331.13	0.99225	334.047

SL No.	**Temperature (°C)**	**Weight of pycnometer + water +Soil (gm) Ex.**	**Weight of pycnometer + water (gm) (Calibration Curve)-Ex.**	**Weight of pycnometer + water (gm) (Calibration Curve)-Th.**	**Dry weight of soil (gm)**
1	38	369.95	331.2	334.042	150



Calculation:

1. **Determination of specific gravity of soil.**

Calibration of pycnometer (theoretical)

W_2=$W_B + V_B(1 + \Delta T * \in)(\gamma_T - \gamma_a)$

=$W_B + V_B(1 + T - T_C)(\gamma_T - \gamma_a)$

At 35℃,

W_2(35) = 84.03+250(1+(35-33) *0.1*10^{-4})*(0.99408-0.0012)

=332.255

From graph at 38℃,

W_2=334 (theoretical)

W_2=33.25 (Exp)

Specific gravity

For theoretical, $G_s = \frac{W_s * G_T}{W_s - W_1 + W_2}$

$= \frac{150*0.9993}{150-369.95+334.042}$

$= 1.314$

For Experimental,

$G_s = \frac{W_s * G_T}{W_s - W_1 + W_2}$

$= \frac{150*0.9993}{150-369.95+334}$

$=1.35$

Avg. Specific gravity,

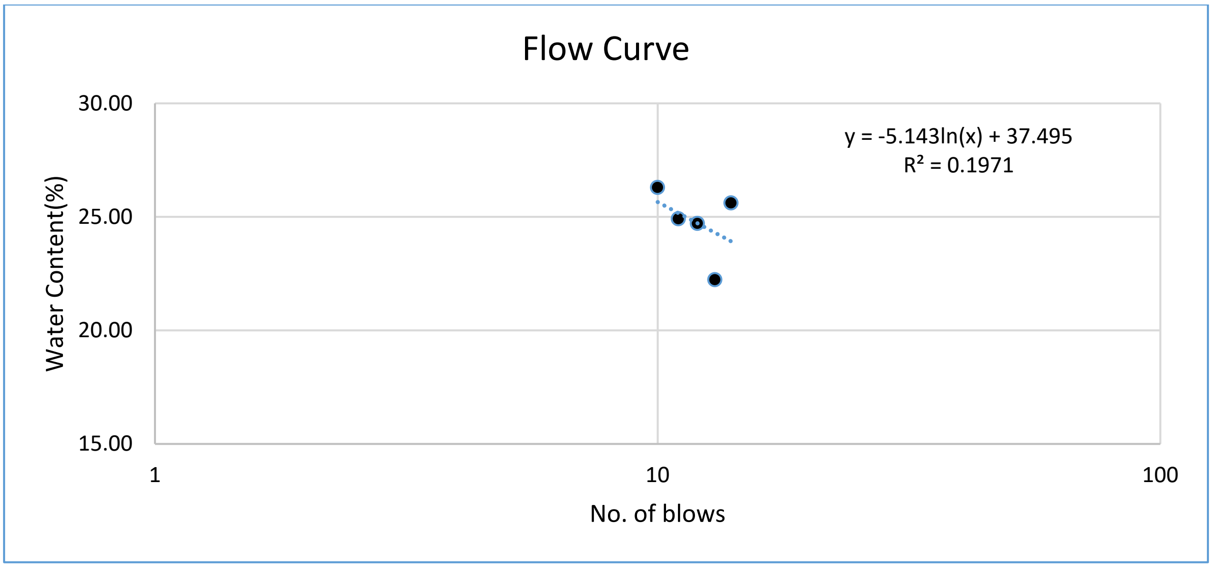
$G = \frac{1.35+1.314}{2}$

$=1.332$

2. Atterberg limit test.

For Liquid Limit

Sl No	**No. of blow**	**Can No**	**Wt of Can**	**Wt of Can + wet sample**	**Wt of Can + dry sample**	**Wt of Water**	**Wt of dry soil**	**Water Content**
			(gm)	**(gm)**	**(gm)**	**(gm)**	**(gm)**	**(%)**
1	12	0	22.11	39.32	35.91	3.41	13.8	24.71
2	11	87	20.76	35.65	32.68	2.97	11.92	24.92
3	10	83	22.33	40.92	37.05	3.87	14.72	26.29
4	13	91	22.48	37.05	34.4	2.65	11.92	22.23
5	14	114	22.87	39.25	35.91	3.34	13.04	25.61



Calculation:

Liquid limit:

For can No. 0

Water content = $\frac{39.32-35.91}{35.91-22.11} * 100\%$

=24.71%

Similarly , water content is calculated in excel for remaining part.

Equation is, y= -5.1426ln x+37.4951

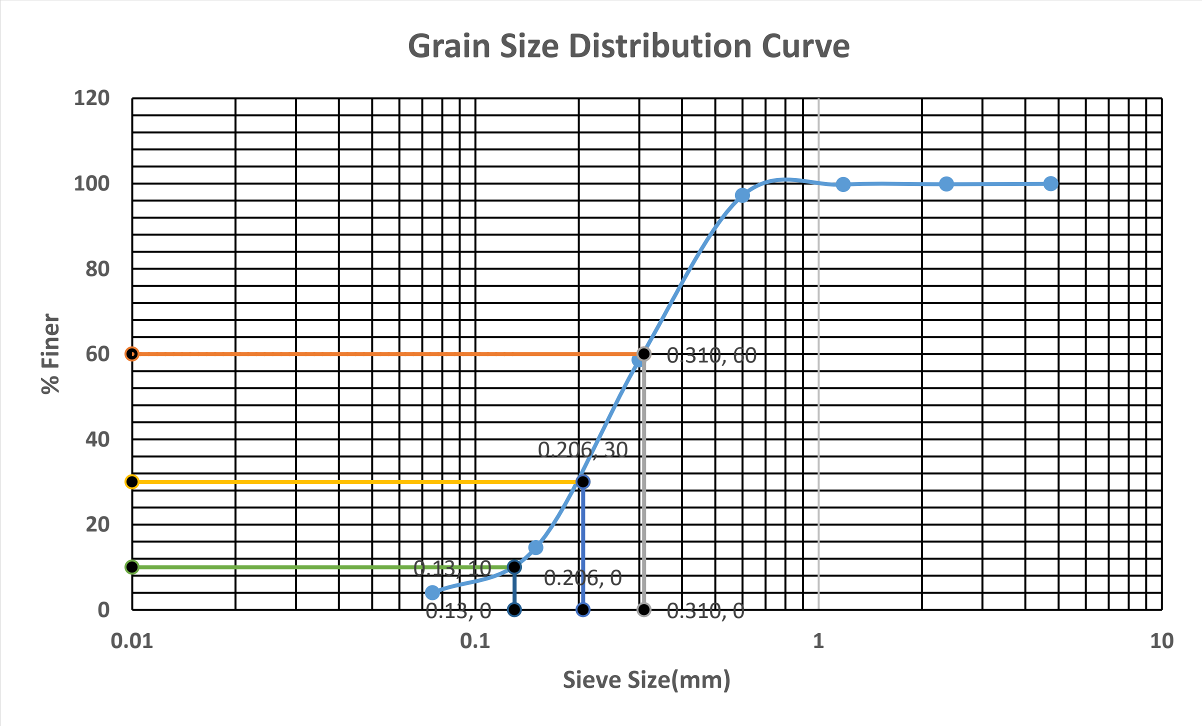
For x=25, y= -5.1426ln 25+37.4951

=20.94%

3. Grain size distribution (Seive analysis)

Data Sheet for Sieve Analysis

Sieve No.	Sieve Size(mm)	Weight of Retained Sample(gm)	% Retained	Cumulative % Retained	% Finer
#4	4.75	0.33	0.066	0.066	99.934
#8	2.36	0.47	0.094	0.16	99.84
#16	1.18	0.44	0.088	0.248	99.752
#30	0.6	12.8	2.56	2.808	97.192
#50	0.3	193.03	38.606	41.414	58.586
#100	0.15	220.03	44.006	85.42	14.58
#200	0.075	53.06	10.612	96.032	3.968
Pan		19.84	3.968	100	0
Total		500			



Calculation:

From the GSD curve ,

D(10) that means, 10% of finer particle size = 0.13 mm

D(30) ; 30% of finer particle size = 0.206mm

D(60); 60% finer particle size = 0.310 mm

Co-efficient of uniformity, $C_u = \frac{D_{60}}{D_{10}} = \frac{0.310}{0.13} = 2.385$

So, Co-efficient of curvature, $C_c = \frac{D(30)*D(30)}{D_{10}*D_{60}} = \frac{0.206*0.206}{0.13*0.310}$

$= 1.053$

For well graded,

$$1 \leq C_c \leq 3$$

So our sample is well graded

And $C_u = 2.385$ we know, if soils $C_u < 4$ is poor graded.

So our soil is poor graded.

4. Determination of moisture content.

Data Sheet for Natural Moisture Content of soil

SL No.	Can No.	Wt. of can(gm)	Wt. of can+wet sample(gm)	Wt. of can+dry sample(gm)	Wt. of soil solids(gm)	Wt. of water(gm)	Moisture content(%)
1	31	22.51	39.27	37.4	14.89	1.87	12.56
2	73	22.21	39.79	37.85	15.64	1.94	12.40
3	71	22.74	37.78	36.22	13.48	1.56	11.57

Calculation:

Can No: 31

Water content $= \frac{39.27-37.4}{37.4-22.51} * 100\% = 15.56\%$

Can No: 73

Water content$= \frac{39.79-37.85}{37.85-22.21} * 100\% = 11.57\%$

Can No: 71,

$$\text{water content} = \frac{37.78-36.22}{36.22-22.74} * 100\% = 13.176$$

$$\text{Average} = \frac{15.56+11.57+13.176}{3} = 13.176$$

Discussion:

The engineering classification of soil is an essential process in geotechnical engineering, as it helps to understand the properties and behavior of soils for various construction applications. In this lab experiment, we conducted a series of tests to classify a soil sample based on its specific gravity, Atterberg limits, sieve analysis and natural moisture content.

1. Determination of specific gravity of soil.

The theoretical specific gravity of the soil sample was calculated to be 1.314, while the graphical method yielded a value of 1.35. The values obtained from both methods were relatively close, indicating the accuracy and consistency of the measurements.

The average specific gravity was found to be 1.332, suggests that the soil is composed of relatively light particles.Specific gravity lower than 2 indicates the soil sample was organic sand.

Organic matter can make construction processes more challenging. For example, it can hinder proper compaction efforts, leading to uneven and cracked surfaces.

As our sample was cohesionless, we use 150 gm of soil sample. During the calibration of pycnometer, some error might be occurred. It could be more or less deflected while taking weight at the increasing and decreasing process of temperature. But we tried our best to perform this experiment with minimum error.

Measures should be taken to either remove the organic matter or opt for alternative materials that meet the required engineering standards.

2.Atterberg limit test.

In liquid limit test, the highest number of blows achieved during the test was 14. Generally The standard procedure involves conducting the test until a certain number of blows are reached, typically 25 blows. But it wasn't possible with our sample.If we use equation,then this limit would be 20.94 % at 25 blows which is an approximate and imaginary value. Therefore we are considering no liquid limit for our soil sample in practical.

In plastic limit test, it was not possible to roll the soil sample. So we couldn't conduct plastic limit test. The results represents that both the liquid limit and plastic limit were 0 actually, indicating that the soil does not possess any plasticity and will remain in a solid state even at high moisture contents. Consequently, the soil sample was cohesionless and will not develop strength upon drying. So we can consider the soil sample as sand.

3. Grain size distribution test (Sieve analysis)

Sieve analysis of soil is a fundamental and necessary test in geotechnical engineering and construction for particle size distribution & classification of soil.The coefficient of uniformity, which measures the particle size distribution, was calculated to be 2.385. It suggests that the soil has a wide range of particle sizes (fine and medium grained soil,not coarse grained) which could lead to poor compaction and reduced stability in engineering applications. Coefficient of uniformity less than 4 indicates poorly graded soil. The coefficient of curvature, representing the shape of the gradation curve, was found to be 1.053 indicates a moderately well-graded soil as it lies between 1 and 3. As the two coefficient gives a contradictory result,we will depend on other test result to classify the soil. 0% finer present in pan indicates there wasn't any loss of soil during experiment. Though it could be happen the sieve wasn't properly cleaned. Because of a relatively small percent passing through No. 200 sieve sizes(lower than 50gm) is obtained from the sieve analysis, hydrometer analysis isn't necessary to conduct.

4. Determination of natural moisture content.

Moisture content of soil is the amount of water available in unsaturated zone. The natural moisture content of the soil sample was determined to be 13.176% in average. It indicates the soil was not wet,rather almost dry which is beneficial for construction purposes. It was determined by weighing a fresh soil sample and then drying it in an oven. We had to collect the sample at noon because of our scheduled class in morning,so we couldn't reach the lab before closing time. Hence we performed the test at the next morning as early as possible. That's why some moisture content may vary. Though we had kept the sample in sealed bag, temperature and wind might affected the result.If we ignore these limitations, the result could be considered approximately accurate. In terms of moisture content, we can classify our soil sample as fine sand.

Summary:

Overall our soil sample was 'Poorly graded sand', as it follows the following sequence :
More than 50% retained on No. 200 sieve--Sands--Clean sands--Cu<6--SP--Poorly Graded Sand
Poorly graded sand is generally not considered ideal for most construction applications. It has a wide range of particle sizes with insufficient representation of all particle sizes in the soil. This can lead to various engineering

challenges and potential issues during construction such as lack of uniformity, settlement issues, drainage problems, low shear strength, compaction challenges etc.

So it is crucial to consider the specific requirements of the project and conduct appropriate geotechnical testing to ensure the chosen soil meets the necessary engineering standards and criteria.