# LABORATORY 4:

# SLOPE STABILITY
# AND MASS WASTING

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# 1 Objective

The objective of this lab was to take a look at the ways in which we can characterize the physical properties of sediments in relation to mass wasting and we assessed the stability of the same sedimentary materials on a slope.

# 2 Materials and Methods

Three different samples were used in each part of the experiment. Sample A was a type of gravel, sample B was some sand, and sample C was some very fine clay. In the first experiment, we examined the 3 samples and remarked on their physical properties. For the second experiment, each sample we poured the sedimentary material through a funnel and into a pile to measure the angle it created when forming a hill. The second part of experiment 2 was to take each material and put it on an inclined plane and slowly increase the angle until the sediment started to slip. The angles were measured for the slope of the hill that was formed from the material being poured through a funnel, and the angle in which the material slid on the inclined plane.

# 3 Results and Discussion

The angle data that was collected in this experiment can be found on the attached table.

## 3.1 Experiment 1 - Physical properties of local sediments

In the first experiment, specific questions had to be answered and they are as follows:

**1.** Describe the 'feel' of each sediment using hand texturing.

| Sample A – Gravel | Sample B – Sand | Sample C – Clay |
|---|---|---|
| • Chunky<br>• Cool to touch<br>• Smooth<br>• Separated<br>• Multi-coloured | • Gritty<br>• Rough<br>• Fine | • Like a hard liquid<br>• Soft<br>• Sticky<br>• Dusty |

**2.** Describe the dominant (mean) grain size category.

A. 1.7cm
B. 1.5 micrometer
C. 0.15 micrometer

**3.** Describe the shape and sorting of each sample.

| | Shape | Sorting |
|---|---|---|
| A | Sub rounded | Poorly sorted |

| | | |
|---|---|---|
| B | Very angular | Well sorted |
| C | Sub angular | Very well sorted |

**4.** Explain the environment of deposition for all 3 samples.

A. Mouth of a river, beginning of a delta
B. Point Bars
C. Point Bars

## 3.1 Experiment 2 - Mechanics of Mass Wasting

In the second experiment, specific questions had to be answered and they are as follows:

**5.** To calculate the mean for each part of the collected dataset, each data point must be added and then divided by the number of data points.

The calculated means of the class dataset are very similar to our experimental values in the fact that all of the calculated means fall within our min-max values. (see attached table)

**6.** Describe the differences in the angle of repose between the three samples, and explain whether or not grain size appears to influence the angle of repose.

By examining the means from the class samples, it seems that the mean angle of repose increases as the material particle size decreases. Clay has the smallest particle size and has the steepest angle, whereas the gravel has the largest and has the smallest angle. It appears that the grain size does in fact influence the angle of repose.

**7.** Describe the differences in the angle of sliding friction between the three samples, and explain whether or not grain size appears to influence the angle of sliding friction.

In examining the mean data values for the angle of sliding friction from the class values, it becomes apparent that the angle of sliding friction is affected by the grain size. The influence is obvious as the angle for sample C (clay) was higher by approximately 15 degrees compared to sample A (gravel).

**8.** Compare angles of repose to angles of sliding friction for each of the three samples, and explain any similarities or discrepancies.

The angle of sliding friction was very close to the angle of repose for each of the samples except the Clay as the Clay exhibited sticky characteristics associated with some form of particle cohesion. Something to notice is that each of the angle of reposes for the samples was less than the angles of sliding friction because as more material was added to the mound during the first part of the second experiment, the angle of repose would surpass the angle of sliding friction and create a landslide in order to bring the factor of safety back to within acceptable levels.

**9.** Discuss any other factors or limitations (i.e., experimental procedures, errors, etc.) that may have affected your results.

The Clay sample seemed to exhibit some moist characteristics as because it is made up of such fine particles, the moisture in the air aids with the material's cohesive properties and could have possibly skewed our results for the angle of sliding friction for sample C.

**10.** Moisture affects internal friction by altering the shear strength of sediments. Discuss how the addition of moisture to the sand sample affected the angle of sliding friction for the class dataset for your lab section. Explain how the amount of moisture in natural, sandy sediment may affect its susceptibility to failure from low moisture content to high.

The addition of moisture to the sand sample dramatically increased the angle of sliding friction of the moist sand. By increasing the cohesive properties of the sand by adding water, the moist sand was not only able to adhere to itself quite well, but also to the attached surface of the inclined plane. With no moisture, the cohesive properties of the base material are not changed, but the addition of a small amount of water (less than the point of saturation) was able to increase the cohesive forces of the fine-grain sedimentary material. If too much water is added and the material becomes fully saturated, there is too much of a distance between the particles to allow for the bonus cohesive forces of the water to take effect and the base cohesive forces of the sedimentary material are lost.

**11.** The Factor of Safety for a 1m wide column can be estimated using the following formula:

$$F_S = \frac{c' + [(\gamma_d z_d + \gamma_{sat} z_w - \gamma_w z_w) \cos\theta * \tan\phi]}{(\gamma_d z_d + \gamma_{sat} z_w) \sin\theta}$$

a) Define each of **c**, $\gamma$, $\theta$ and $\phi$. This will require some research on your part, and you must cite your sources.

**C** = *cohesive force:* the property of like molecules to stick together. [1]

$\gamma$ = *specific weight:* defined as the weight per unit volume. [2]

$\theta$ = *slope angle (in degrees):* measured incline of the plane.

$\phi$ = *internal friction angle:* the angle at which shear failure occurs (measured). [3]

b) Describe what happens to $\mathbf{F_S}$ when $\phi$ is set to **40**deg, but $\theta$ goes from **20**deg to **45**deg (requires two calculations). Identify which scenario is more stable and discuss why this change occurs based on your definitions.

The scenario when $\mathbf{F_s}$ is between 20-40deg is more stable because the slope angle is less than or equal to the internal friction angle. As long as the slope angle remains less than the internal friction angle, the chance of a landslide is significantly diminished. There is a very large range on the slope angle due to the internal friction angle of the slope material being fairly high.

c) Describe what happens to $\mathbf{F_s}$ when $\phi$ is set to **30**deg, but $\theta$ goes from **25**deg to **45**deg (requires two calculations). Identify which scenario is more stable and discuss why this change occurs based on your definitions.

The scenario when $\mathbf{F_s}$ is between 25-30deg is more stable because the slope angle is less than or equal to the internal friction angle. As long as the slope angle remains less than the internal friction angle, the chance of a landslide is significantly diminished. The range in which the slope is safe is much less due to the significant decrease in the internal friction angle of the slope material.

d) Discuss what might happen to $\mathbf{F_s}$ if $\mathbf{Z_d}$ decreased to 0m and $\mathbf{Z_w}$ increased to 3.0m and all other variables are controlled and **c** = 0.

The ratio would change from 32.68/42.5 = 0.769 to 30.57/60 = 0.510. Therefore, $\mathbf{F_s}$ would decrease by approximately a factor of 1/3.

e) Discuss what might happen to $\mathbf{F_s}$ if **c** increased and all other variables are controlled.

$\mathbf{F_s}$ would increase dramatically! Because **c** is normally equal to zero, the addition of a positive cohesive force would increase the factor of safety of the material because it means that the material is now bonding with itself with a greater force.

# 4 Summary and Conclusion

The results obtained from the two experiments were expected. There were no surprising outcomes and all tests went smoothly. The experiment was able to aptly illustrate the effects that grain size has on the slope angle and the internal friction angle of certain sedimentary materials. We also were able to observe the effects that moisture had on the internal friction angle when added to a high grain sedimentary material. The experiment was able to shed light on the importance of understanding the properties of soil materials in order to predict the effects that weather has on surrounding landscapes, and provide insight into possible associated dangers.

# 5 References

[1] http://www.diffen.com/difference/Adhesion_vs_Cohesion

[2] http://www.engineeringtoolbox.com/density-specific-weight-gravity-d_290.html

[3] http://www.geotechnicalinfo.com/angle_of_internal_friction.html