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**LABORATORY VANE TEST**

# Purpose of the Test

The purpose of the test is to investigate peak and residual values of undrained shear strength of a soft clay.

# Equipment

* straight edge spatula
* miniature laboratory vane
* water content determination equipment
* chronometer



Figure-1: Laboratory Vane Shear Apparatus

# Preparation

* The blades of the vane must be clean and undamaged.
* Measure and record dimensions (Height and Diameter) of the vane.
* The spring with the correct stiffness must be used, according to the strength of soil. Record spring number and calibration factor. If the calibration factor is not known, it can be determined by applying a known torque and measuring rotation of the spring.
* The rate of loading is rotating the spring by 90° in 10 sec.
* If there isn’t one already, place a mark on the vane shaft, 13mm above the top of the blades.
* Set needle indicators to zero.

# Sample

The sample is prepared by the assistant before the experiment.

# Procedure

* Insert the vane into the sample until the mark touches the soil surface.
* Start rotating the vane at a rate that turns the spring by about 90° in 10 sec. Record measurements of spring and vane rotation indicators at equal intervals of time.
* At failure, the soil in the vane is sheared off from the rest. Take a set of measurements at that point.
* One of the needles on the indicator records the peak value. This corresponds to the peak shear strength.
* Rotate the vane several times.
* Set needle indicators to zero.
* Rotate at the testing rate until the spring measurement reaches a constant value. Record this constant value. This corresponds to the residual shear strength.
* In a real test you would repeat steps 1 to 6 twice more at undisturbed locations of the soil surface, and then take their average. Here, once is enough for instruction purposes.
* Excavate the test location and take that soil for water content determination.

# Calculations

First of all, D and H values in the formula are both given as 1.25 cm. Moreover, the diameter is given as 9.5 mm. That is, radius is 0.475 cm.

Table 1 : The calculation of the applied torque is tabulated below.

|  |  |  |
| --- | --- | --- |
| **Applied Mass(g)** | **Applied Torque(N.cm)** | **Deflection(deg)** |
| **200** | **0.9320** | **2.20** |
| **400** | **1.8639** | **5.40** |
| **600** | **2.7959** | **8.20** |
| **800** | **3.7278** | **10.50** |
| **1000** | **4.6598** | **13.10** |
| **1200** | **5.5917** | **16.90** |
| **1400** | **6.5237** | **20.00** |
| **1600** | **7.4556** | **22.50** |
| **1800** | **8.3876** | **25.40** |
| **2000** | **9.3195** | **28.20** |
| **2200** | **10.2515** | **30.10** |

* T= (200/1000)\*9.81\*0.475=0.9320. This is the calculation of the first row, and the same procedure is applied to the other rows.
* The peak and residual shear strength values are obtained from the graph and the data obained during the lab session.

cresidual =5.212419kPa cpeak= 11.60168kPa

**Sensitivity= cpeak / cresidual = 2.226**. Since sensitivity is in between 1&4. It is said to be an insensitive sample.

* By using the trend line equation that is obtained from the spring deflection&applied torque graph, the torques are calculated shown in Table 2.
* To do so, **y = 0.3267x + 0.172** equation is used. The x value represents the spring deflection.
* For the first and second values, y=0.3267\*0+0.172=0.172 **T1=0.172**

y=0.3267\*1+0.172= 0.4987 **T2=0.4987**

Other torque values are tabulated in Table-2.



Figure 2: The torque formulation

By using the torque formulation shown in Figure-2, the average shear strengths are calculated and they are tabulated in Table-2, in the last column.

As an example, τ= Torque/(π\*D^2\*((H/2)+(D/6))). At t= 50, τ= 7.6084 kPa by means of this formulation. Where D=1.25 cm, H= 1.25 cm. This calculation is done for other values.

Table 2: Data sheet that is arranged by using Microsoft Excel and calculated torque is written in the middle column.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Time(sec)** | **Spring Deflection** | | **Torque(N.cm)** | **Vane Rotation** | | **τ(kPa)** |
|  | **Reading** | **Deflection** |  | **Reading** | **Deflection** |  |
| 0 | 10.00 | 0.00 | 0.1720 | 3.00 | 0.00 | 0.4205 |
| 10 | 11.00 | 1.00 | 0.4987 | 6.00 | 3.00 | 1.2191 |
| 20 | 13.00 | 3.00 | 1.1521 | 7.00 | 4.00 | 2.8164 |
| 30 | 15.00 | 5.00 | 1.8055 | 8.00 | 5.00 | 4.4138 |
| 40 | 17.00 | 7.00 | 2.4589 | 8.50 | 5.50 | 6.0111 |
| 50 | 19.00 | 9.00 | 3.1123 | 9.50 | 6.50 | 7.6084 |
| 60 | 20.00 | 10.00 | 3.4390 | 11.00 | 8.00 | 8.4070 |
| 70 | 21.00 | 11.00 | 3.7657 | 13.00 | 10.00 | 9.2057 |
| 80 | 22.00 | 12.00 | 4.0924 | 15.00 | 12.00 | 10.0044 |
| 90 | 23.00 | 13.00 | 4.4191 | 17.50 | 14.50 | 10.8030 |
| 100 | 23.50 | 13.50 | 4.5825 | 20.00 | 17.00 | 11.2023 |
| 110 | 24.00 | 14.00 | 4.7458 | 23.00 | 20.00 | 11.6017 |
| 120 | 24.00 | 14.00 | 4.7458 | 26.00 | 23.00 | 11.6017 |
| **Residual** | | | | | | |
| t=0 | 9.00 | 0.00 | 0.1720 | 5.00 | 0.00 | 0.4205 |
|  | 11.00 | 2.00 | 0.8254 | 6.00 | 1.00 | 2.0178 |
|  | 13.00 | 4.00 | 1.4788 | 7.00 | 2.00 | 3.6151 |
|  | 15.00 | 6.00 | 2.1322 | 9.00 | 4.00 | 5.2124 |
|  | 15.00 | 6.00 | 2.1322 | 11.00 | 6.00 | 5.2124 |
|  | 15.00 | 6.00 | 2.1322 | 14.00 | 9.00 | 5.2124 |

# Discussion of Results

The graphs that are obtained are as followings. By using Spring Deflection&Applied Torque Graph, the torque is calculated, shown in calculation part. In this laboratory, the undrained shear strengths of a soil sample are determined, and the peak value is 11.6017 kPa. The residual shear strength value is found as 5.2124 kPa. According to these values, the sensitivity of the soil is determined that it is an insensitive soil.

There are definitely some errors in this experiment because of the human factors during the experiment. To exemplify, when applying torque to the specimen, it is difficult to adjust time and rotation of the vane. Owing to some calibration errors, the results that are obtained are affected. In the laboratory session, the torque applied to the vane is not measured and the tabulated form of the applied mass (g) & deflection (deg) is given by the assistant. Then, the graph of the spring deflection and applied torque is plotted (see Figure-2) by means of the data given by the assistant. Moreover, the trend line of the graph is obtained and by using the equation of the trend line, the corresponding torque values are calculated, which is shown in calculation part. Because of the small round off error in this trend line, the results are of course affected. The most prominent thing is that the used soil sample actually used before in the other experiments which means this sample is disturbed, and results in errors.

Figure-2: Spring Deflection&Applied Torque Graph and its trend line with its trend line equation shown in the figure

Figure-3: Vane Rotation&Average Shear Strength Graph

# Conclusion

In the light of this experiment, it is comprehended how to find peak and residual strength of an undrained soil sample (soft clay) by means of laboratory vane test and with the guidance of Makbule Ilgaç. The vane operation is observed and the importance of the experiment is to measure the shear strength of a soft clay.