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| **Course Name:** CE363 | **Deadline of Report** 08/12/2014 |
| **Title of Test**  Direct Shear Test | |
| **Year & Section:** 3 & 2 | **Lab. Group:** 1 |
| **Name & Surname of Student:**  **ID:** | |

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# **Introduction**

Direct Shear Test is done to determine strength-deformation characteristics of a dry sand at a specific density.

# **Equipment**

* Direct shear box with two separator bolts and two restraining bolts.
* Top cap (a steel ball is placed on top of the cap in many setups, but here we do not need it)
* Porous stones and ribbed plates
* Direct shear load frame with lever arm and weights
* Shear load measurement device (proving ring)
* Horizontal and vertical displacement measurement devices (dial gages)
* Gauging disc (or block for square specimens)
* Dish, spoon, spatula

# **Methodology**

## General Rules

* The specimen in this test is cohesionless. Cohesionless soils change density, and therefore mechanical properties, when subject to vibrations. Therefore, avoid bumping the table during preparation, shaking the shear box during assembly, or bumping the setup during the test.
* It is important that your preparation procedure is repeatable, and you do not vibrate the specimen in any of the steps after specimen constitution.

## Calibration

1- Note the mechanical advantage of the loading arm. This is used as 10 in this test.

2- Notice the load transmitted by the lever arm to the specimen is not zero when there is no load. Weigh the individual components that will rest on the specimen (i.e. top cap, porous stone, top half of the shear box) to figure out the zero load. (If the loading arm itself is not balanced, a balancing load can be figured out by applying external weights on one side.) For our equipment, the arm is balanced, so zero load on the lever arm corresponds to the total weight of components on the specimen (about 1.5 kg).

3- Note which bolts restrain relative movement of the two halves of the shear box, and which bolts separate the two halves from each other.

4- Determine how many turns of the separator bolts make a gap equal to the maximum grain diameter. This can be done by measuring the thread width on the bolts. The bolts of our setup have 0.8 mm threads.

5- Adjust the separator bolts such that they barely touch the bottom half. Fix the two halves to each other by the restraining bolts.

6- Measure inner diameter or width of the box.

7- Place the lower porous stone into the box.

8- Place the ribbed plate into the box, with ribs facing up and perpendicular to shearing.

9- Measure the depth of the shear box from its top to the ribbed plate.

10- Measure the height of the small diameter (or width) portion of the gauging disc (or block).

11- Calculate specimen volume from the measurements in steps 6, 9 and 10 above.

## Specimen

1- Constitute the specimen in the shear box. This process may vary depending on soil type and desired density.

a) Calculate the mass of sample material to be placed in the shear box, from volume of the shear box and the desired density.

b) Weigh a batch of soil such that it has exactly the required mass.

c) Place the required mass of soil into the box (without spilling any soil outside the box).

d) Smoothen the soil surface by fingers or a spatula.

e) Compact the soil to desired density by pressing and rotating the gauging disc on it.

2- Place the ribbed plate with ribs facing down and perpendicular to shearing

3- Place the top porous stone.

4- Place the top cap (and the steel ball for many other setups).

5- Place and connect the shear box into the frame with minimal vibration.

6- Remove the restraining bolts.

7- Create a gap between two halves of the shear box, equal to the maximum grain size, by rotating the separator bolts by the amount determined in calibration Step 4.

## Test Procedure

1- Affix the measurement devices to the shear box.

2- Take zero readings of the displacement measurement devices.

3- Calculate the normal force you must add (based on calibration step 2) to achieve desired normal stress.

4- Apply the vertical load. The loading lever must remain horizontal – if it does not, adjust by rotating the loading screw.

5- Record vertical settlement.

6- Loosen the separator bolts.

7- Adjust the motor to shear the specimen at about 0.7 mm/min.

8- Start shearing, read the shear force at every 0.1 mm displacement at the beginning. You can widen the interval once the test passes the point of peak shear force. Also record the elapsed time every 5-10 readings, in order to verify the rate of shear displacement.

9- Stop beyond the observation of peak shear force, or at 3mm shear displacement.

10- Repeat steps 2 to 9 at twice the vertical load. (In a real test, a new specimen is prepared and the test is restarted at each normal load. But in this lab session, due to time constraints, the same specimen will be used, and shearing will continue from the final shear deformation reading of the first loading.)

# **Results**

All measurements of the experiment and results are on the data sheet that I prepared on Excel, related graphs are at the end of the report.

# **Calculations**

I have prepared an Excel file for the data sheet and in order to calculate the asked values. And I showed all values in the tables.

* Density of the specimen

**ρ = M/V = 100 / (3166.921744\*20.5)=1.54\*10-3 g/mm3 =1.54 g/cm3**

* u, δ and v values are converted from division to mm as follows:

**u = (u\*)\*0.01**

**v = (v\*)\*0.01**

**δ = (δ\*)\*0.01**

* Initial area and corrected area of the specimen

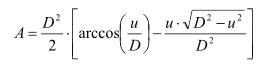


Figure 1: Provided Formula to calculate corrected area

For circular box, where D is specimen diameter and u is the shear displacement.

Initial area of the specimen is **A0 = pi\*(63.5)^2/4 =3166,921744 mm2**

Area after shear displacement is calculated via formula given above. D is 63,5 mm and shear displacement data were recorded during the experiment.

For u\* is 10 u becomes 0,1, by substituting necessary quantities to the provided formula we obtain the corrected area for that shear displacement.

**A=(63,5^2/2)\*(ACOS(0,1/63,5)-(0,1\*SQRT(63,5^2-0,1^2))/(63,5^2))= 3160,571747 mm2**

For each row on the data sheet same calculation is done in order to obtain corrected area with the help of the Excel.

* Shear stress is also asked to calculate by provided formula as follows:

**τ = ( Cp\*δ ) / A**

For the third row of the data sheet,

**τ3=(0.142 \* 0,39)/ 3160,571747 = 0,000171892 kPa**

I made the same calculations for each row with the help of the Excel.

* **τ = C + tan(φ)** by assuming C=0 .

As it can be seen from the data sheet that prepared on Excel that our φ values do not change much. The average value is found by drawing best line to the points. φ=0.0057 radians for first load which weighs 21.5 kg. as shown in the Figure 2.

Figure 2: best line for 21,5 kg load

Our 2nd φ = 0.0069 radians for the 2nd load which weighs 41.5 kg as shown in the Figure 3.

Figure 3: best line for the load 41,5 kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Shear disp(u\*) | u(mm) | vertical def(v\*) | v(mm) | proving ring (δ\*) | δ | Corrected Area(A)(mm2) | shear stress(kPa) | sigma1 | phi(rad) | phi(degree) |
| 0 | 0 | 0 | 0 | 0 | 0 | 3166,9217 | 0,000000 | 0 |  |  |
| 0 | 0 | 30 | 0,3 | 0 | 0 | 3166,9217 | 0,000000 | 0,066599 |  |  |
| 10 | 0,1 | 33 | 0,33 | 39 | 0,39 | 3160,5717 | 0,000172 | 0,066733 | 0,002576 | 0,073791 |
| 20 | 0,2 | 35 | 0,35 | 58 | 0,58 | 3154,2218 | 0,000256 | 0,066868 | 0,003831 | 0,109741 |
| 30 | 0,3 | 37 | 0,37 | 67 | 0,67 | 3147,8718 | 0,000296 | 0,067002 | 0,004425 | 0,126769 |
| 40 | 0,4 | 39 | 0,39 | 75 | 0,75 | 3141,5219 | 0,000333 | 0,067138 | 0,004953 | 0,141906 |
| 50 | 0,5 | 39 | 0,39 | 84 | 0,84 | 3135,1721 | 0,000373 | 0,067274 | 0,005548 | 0,158934 |
| 60 | 0,6 | 42 | 0,42 | 89 | 0,89 | 3128,8223 | 0,000396 | 0,067410 | 0,005878 | 0,168394 |
| 70 | 0,7 | 43 | 0,43 | 96 | 0,96 | 3122,4726 | 0,000428 | 0,067547 | 0,00634 | 0,181639 |
| 80 | 0,8 | 48 | 0,48 | 104 | 1,04 | 3116,1231 | 0,000465 | 0,067685 | 0,006869 | 0,196775 |
| 90 | 0,9 | 48 | 0,48 | 108 | 1,08 | 3109,7737 | 0,000484 | 0,067823 | 0,007133 | 0,204343 |
| 100 | 1 | 48 | 0,48 | 109 | 1,09 | 3103,4244 | 0,000489 | 0,067962 | 0,007199 | 0,206235 |
| 110 | 1,1 | 48 | 0,48 | 112 | 1,12 | 3097,0752 | 0,000504 | 0,068101 | 0,007397 | 0,211911 |
| 120 | 1,2 | 47 | 0,47 | 115 | 1,15 | 3090,7263 | 0,000518 | 0,068241 | 0,007595 | 0,217587 |
| 130 | 1,3 | 46 | 0,46 | 117 | 1,17 | 3084,3775 | 0,000528 | 0,068382 | 0,007727 | 0,221370 |
| 140 | 1,4 | 46 | 0,46 | 119 | 1,19 | 3078,0289 | 0,000539 | 0,068523 | 0,007859 | 0,225154 |
| 140 | 1,4 | 46 | 0,46 | 119 | 1,19 | 3078,0289 | 0,000539 | 0,132265 | 0,004072 | 0,116648 |
| 150 | 1,5 | 53 | 0,53 | 119 | 1,19 | 3071,6806 | 0,000540 | 0,132538 | 0,004072 | 0,116648 |
| 160 | 1,6 | 55 | 0,55 | 198 | 1,98 | 3065,3325 | 0,000900 | 0,132813 | 0,006775 | 0,194085 |
| 170 | 1,7 | 55 | 0,55 | 215 | 2,15 | 3058,9846 | 0,000979 | 0,133088 | 0,007356 | 0,210748 |
| 180 | 1,8 | 55 | 0,55 | 220 | 2,2 | 3052,6371 | 0,001004 | 0,133365 | 0,007528 | 0,215649 |
| 190 | 1,9 | 54 | 0,54 | 222 | 2,22 | 3046,2897 | 0,001015 | 0,133643 | 0,007596 | 0,217609 |
| 200 | 2 | 54 | 0,54 | 224 | 2,24 | 3039,9427 | 0,001026 | 0,133922 | 0,007664 | 0,219570 |
| 210 | 2,1 | 53 | 0,53 | 224 | 2,24 | 3033,5961 | 0,001029 | 0,134202 | 0,007664 | 0,219570 |
| 220 | 2,2 | 53 | 0,53 | 224 | 2,24 | 3027,2497 | 0,001031 | 0,134483 | 0,007664 | 0,219570 |
| 230 | 2,3 | 52 | 0,52 | 222 | 2,22 | 3020,9037 | 0,001024 | 0,134766 | 0,007596 | 0,217609 |
| 240 | 2,4 | 52 | 0,52 | 222 | 2,22 | 3014,5580 | 0,001026 | 0,135050 | 0,007596 | 0,217609 |

Figure 4: Data Sheet with recorded and calculated values

* Hatched row represents the time where 41,5 kg load is applied. And following rows include the data of 41,5 kg load.

# **Conclusion**

In this experiment, our purpose was to obtain strength-deformation characteristics of a dry sand at a specified density. We are supposed to calculate shear displacement, vertical deflection, corrected area and shear stress for two different loads. How to calculate the asked values is shown in the calculation part. Required graphs are as follows;

Figure 5: Shear Stress vs Shear Displacement Graph

Figure 6: Vertical Displacement vs Shear Displacement Graph

Figure 7: Shear Stress vs Normal Stress Graph