

# Static triaxial testing at the University of Waikato

Methods strictly adhered to the British Standard 1377 (1990) Part 8: Shear strength tests.

## 1. Preparation

### 1.1 Make sure enough distilled water is available

1.1.1. Always make sure there is enough distilled water because it can take a long time to prepare. Check that distilled water is up to underside of line (marked);

1.1.2. If not, fill up by turning black tap on (press down to right) looking up to see if beaker up the top is filled, wait for water to run into the sink, check for blockages, then turn the switch on. Once up to line, turn off in same order.



### 1.2 De-air the water for the triaxial

1.2.1. Turn on vacuum tap (black tap turned to right)



1.2.2. Turn tap in sink on (top left tap)

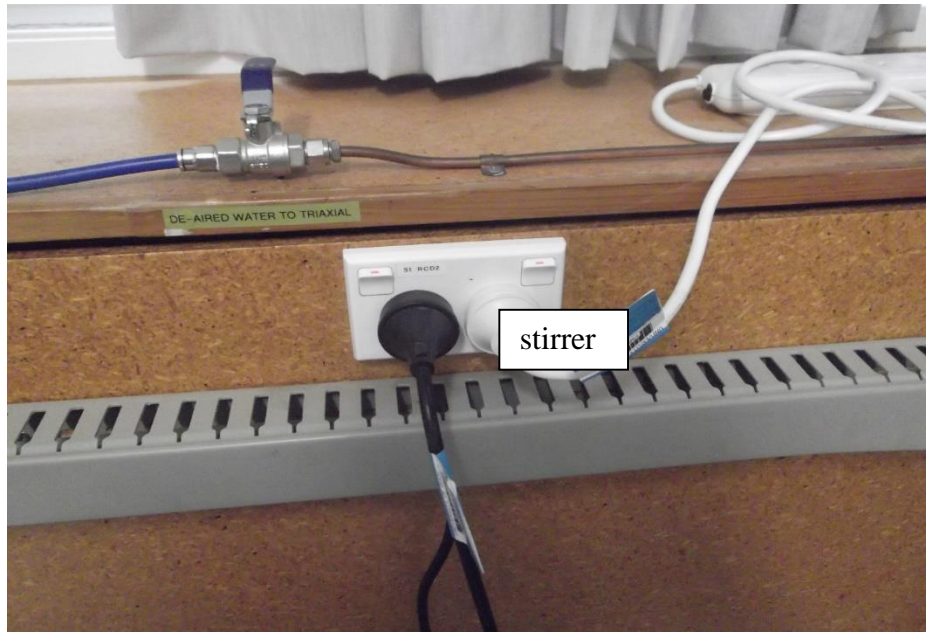


1.2.3. Turn water to de-aerator on



1.2.4. To fill the tank with de-aerated water, turn vacuum release to 90 degrees, to empty turn vacuum release off, turn to left. **Keep an eye on the water otherwise it will overflow.**

1.2.5. When filled to top line, close "water to tank de-aerator" but leave vacuum on (water running), turn on stirrer. **Never leave running or unattended because motor will overheat. Leave motor max half hour running.**



1.2.6. To finish: open vacuum release, turn off stirrer, turn off tap.

### 1.3. *Clean and de-air the porous plates and membrane*

1.3.1. Clean debris off porous plates

1.3.2. Put porous plates and membrane in a beaker, and half fill with water



1.3.3. Put beaker in vacuum chamber, put the lid on, connect pipe up with tap and sink, turn water on so that the water can be de-aerated

1.3.4. Leave on for at least half an hour



#### *1.4. Software setup*

1.4.1. Log in as “instrument” (user) and “generic” (password) on the triaxial computer

1.4.2. Open WINCLISP software;

##### To set up a new jobfile:

- a) Open file > new jobfile > add a folder and save your work there;
- b) Configuration > Reference (e.g. site location) > borehole number if needed > new > type relevant site details and press ok;
- c) Configuration > new test > choose what test you are doing e.g. undrained, consolidated, effective triaxial test;
- d) Assign the cell: Load 06 matches the number on the top of the cell: If you are testing multiple samples, make sure you click how many samples you are testing under specimen > leave everything else as is and press ok;
- e) Leave everything as is (timebase, trigger, stop), make sure controller selection > machine > triaxial > ok.

##### To edit a jobfile:

1. Open the job file you have previously been working on > configuration > edit test > select what specimen you are up to > check load, strain, PWP and volume are correct > make sure the test name matches the display on the blue triaxial machine (data logger);
2. Saturation > Initial conditions > check correct specimen is selected.

### 1.5 Sample preparation

The goal is to spend as little time as possible with the sample exposed to air (out of the bins) so that the natural moisture content is maintained. **Be very careful not to drop or bang the sample, because this will change your results.**

1.5.1. Grab sample out of bin and unwrap plastic;

1.5.2. To extrude sample:

- a) Push the non-tapered end of the tube up into the underside of the top, then use levers (to left) to push the stage up to the sample, guiding it in with your fingers;
- b) To make the stage go up: black lever is up then use red lever to pump, to make stage go down: black lever is down and pump red lever;



c) Once sample is extruded, grab it using the sample holder and put it on the glass plate.

1.5.3. Trimming the sample

- a) Straight away, take a sample for moisture content: weigh a container, then add a small amount of sample, dry for 24 hours at 100°, then re weigh sample and container.
- b) Cut sample on chopping board with knife, shaving bits off so that it is the same size as the cylinder or slightly larger **(as long as it is not less, as the height needs to be at least twice the diameter of the sample, which is 48 cm in this case).**



1.5.4. **Weigh the sample**: holding the sample carefully in the sample holder, weigh both together and write this down;



1.5.5. Turn off vacuum which is de-aerating porous stone and filter paper: bend vacuum tube, pull it off, and then turn off the water;

1.5.6. On the triaxial cell place porous stone on, then dip filter paper in de-aerated water from the vacuum chamber. Then carefully place sample over the top, put dipped filter paper then the porous stone on top. Put the sample holder aside for weighing (subtract this from overall sample weight);



1.5.7. Put the membrane in the sample holder;

1.5.8. Connect plastic tube to sample holder at one end and the vacuum tap at the other end;

1.5.9. Turn on the tap so that the membrane is sucked to the inside of the sample holder;

1.5.10. With the tap still on, bend the tube, then turn the tap off with the tube still squeezed so the suction remains;

1.5.11. Fit sample holder with membrane over the sample on the triaxial, then slowly release the bend in the tube to release air;

1.5.12. Roll back the membrane and remove the sample holder;



1.5.13. Put one of the two black rubber rings on smaller steel ring and fit the steel ring over the sample. Then release the black ring over the groove to seal the bottom of the membrane;



1.5.14. Then seal the top off: put the smaller steel ring with the other black rubber ring through the top of the triaxial cap tube, and carefully hold this as close as possible to the top groove. Release the black ring to seal the top of the membrane off;



1.5.15. Check that there is no water in the air line by turning the red handle (in the corner) down until no water is sprayed out. Then push the red handle down to permanently turn the air pressure on. This stays on for the entire triaxial test;



1.5.16. Fit the cell: Carefully lift the cell up and put it over the sample, making sure the white tube connected to the sample cap is not crushed;

1.5.17. Secure the cell with the three bolts, tightening them up equally. Finger tightening is sufficient;



1.5.18. Raise the cell up by pressing and holding the green UP button, until the cell is just below the loading frame.

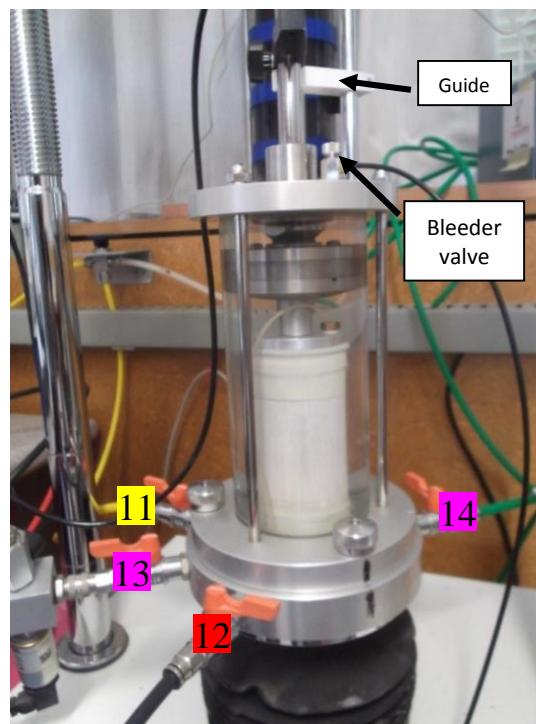
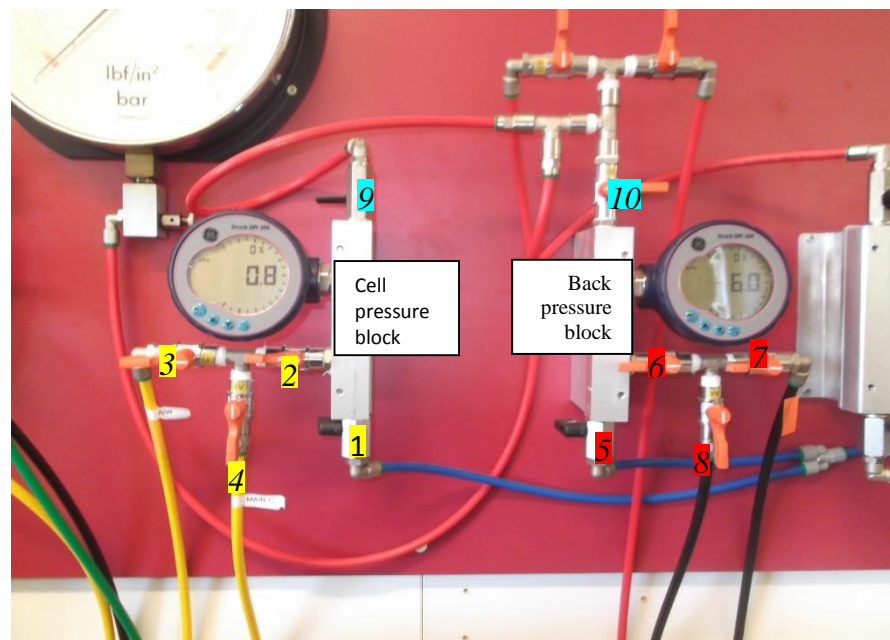
## 2. SATURATION

2.1. Make sure all taps (1-14) are turned off i.e. turned at 90° to the direction of the pipe;

2.2. Turn de-aired water to triaxial on, then turn tap 1 on;

2.3. Turn taps 2 and 4 on, then at the cell, turn tap 11 on;

2.4. Turn on de-aired water to triaxial: the cell should start filling with water. Unscrew the bleeder valve at the top of the cell while filling;



2.5. As the cell is filled, water will run out bleeder into pink bucket. Put a tissue by the bleeder valve to prevent water overflow;

2.6. Once the cell is filled, pick the cell up carefully, with the bleeder valve still open, and shake the cell gently to displace air bubbles trapped inside the cell;

2.7. Turn all water supply and air taps off so the system is closed. Turn off the bleeder, then turn off taps 4 and 11;

2.8. Software: Set up conditions for saturation: Saturation > initial conditions: enter relevant details. The actual moisture content can be added later on;

2.9. Turn triaxial machine and data logger on at wall (black cord);



2.10. On computer: open control > overview > turn sample one on only

2.11. Remove the guide support

2.12. On computer: saturation > data entry

2.13. Make sure de-aired water is filled to the top of both bladders;

a) Open the bleeder of the cell bladder, then open taps 1, 2 and 3, then wait for the cell to fill up gently shaking to remove bubbles. Close the bleeder once bubbles are removed, then close tap 3;

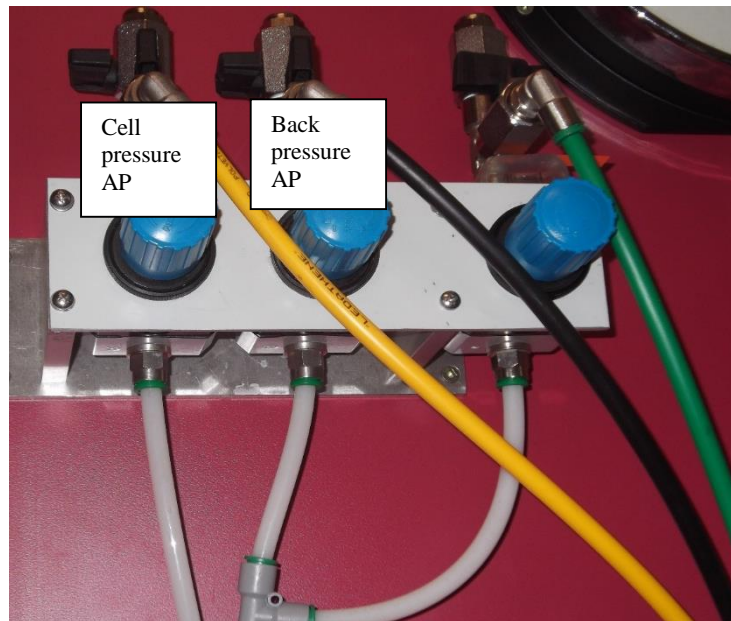
b) Open 5, 6, 7 and 8.

c) Fill the back pressure bladder as above. Once fill, close tap 7, then taps 1 & 5, then close de-aired water to triaxial.

2.14. Turn air on: turn red lever down



2.15. Turn on cell and back air pressure (AP) on for main cell and back pressure;



2.16. SLOWLY turn cell pressure nozzle so that it stabilises around 5-6 kPa, then do the same for back pressure;

2.17. Open taps 11, 12 and 13;

2.18. On computer: saturation > data entry > click cell pressure, then enter data from screen, after waiting 5 mins or so for numbers to settle (if clayey sample this will take longer);

2.18. Close tap 12: only 11 and 13 should be open;

**NOTE:** The following saturation process should not be rushed – pressure distribution throughout the sample needs time to equalise between each change, so that pwp can equilibrate before pressure is increased again.

2.19. Very slowly increase cell pressure (AP) to 50 kPa. On the computer, monitor PWP (test overview tab) over time until it reaches a uniform value;

2.20. Turn back pressure AP SLOWLY to 40 kPa (leaving cell pressure 50 kPa)

2.21. Open tap 12. Wait PWP and volume change to equilibrate to a uniform value over time.

2.22. Once PWP and volume are at a steady value, enter values into the data sheet.

**NOTE:** Back pressure is always 10 kPa less than cell pressure. If greater than cell pressure this may cause failure or deformation in the sample.

2.23. Close tap 12.

2.24. Increase cell pressure AP to 100 kPa. Wait for pwp to equalise as above;

2.25. Double check that tap 12 is closed;

2.26. Increase back pressure AP to 90 kPa, then turn tap 12 on;

2.27. Wait for pwp to equalise with time as above then record data then close tap 12;

2.28. Repeat these steps, incrementally increasing cell and back pressure until a B value of > 95% is reached. Both cell and back pressure MUST be greater than 300 kPa, even if the B value is greater than 0.95 before this. This is because 300 kPa is the pressure at which air dissolves into water.

**NOTE:** If PWP continues to rise and exceeds cell pressure increment – leakage. After the first cell increment: If the PWP transducer reading is close or equal to the cell pressure, there is probably a pressure lock (open valves to the big dial gauge to release the lock) or there could be a membrane leakage

2.29. After saturation reached, close tap 12, and proceed to consolidation.

### 3. CONSOLIDATION

*Effective stress in brief:*

When the sample was removed from the outcrop, so were the natural forces above and around the soil sample. These forces include the weight of the soil (overburden pressure) above where it was sampled from, and also the water pressures from the water table, if present. The combined forces of the soil overburden pressure (positive stress) of the soil and the pore water pressure effects of the water table (negative stress) are called the *effective stress*.

This is calculated by the equation:

$$\sigma' = \sigma - u$$

(bulk density of soil \* depth of soil) – (depth of water table \* unit weight of water)

The bulk density of each soil layer above the sampling site must be taken into account, as clay for example has a very different bulk density to sand.

The estimated effective stress must be reapplied to the sample in the triaxial, to replicate *in situ* conditions as much as possible. This is achieved by increasing the cell pressure so that the difference between the back and cell pressure equals the effective stress. The back pressure is then opened so that PWP can equilibrate.

3.1. With tap 11 & 13 open, increase cell air pressure so that the difference between cell pressure and back pressure is the effective stress;

3.2 Set the timer up and simultaneously open back pressure and start the timer;

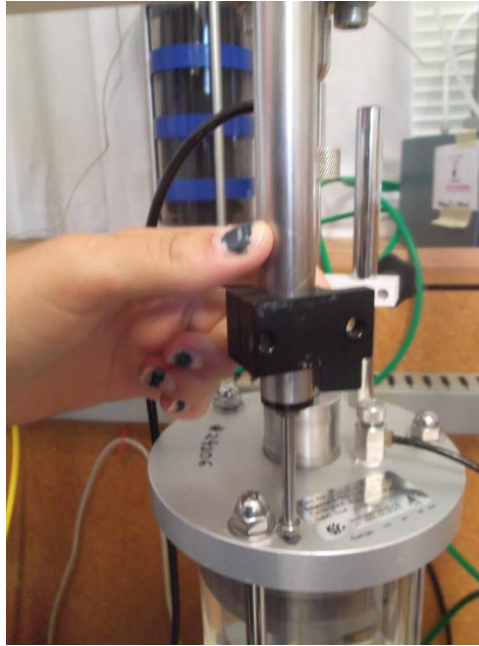
3.3. Record the change in PWP and volume change over time; Take lots of readings in the first 30 minutes – 1 hr, as this is when consolidation is most rapid. Then take readings every 1-2 hours, until PWP and volume change have reached constant values.

### 4. Compression

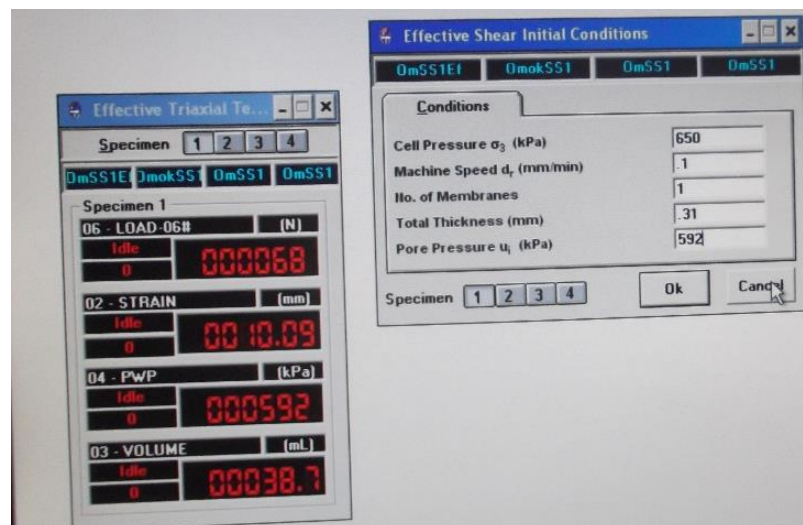
4.1. Enter details of consolidation and sample into excel worksheet (ask Vicki), to obtain the test rate;

4.2. Raise sample just prior to testing so that it is nearly touching with the green up button. Check the load while on the screen, ideal is 0 but it jumps easily to 50-60.

4.3. Attach the strain transducer to the top of the cell with the nut and screwdriver, so that it is touching the top of the cell and has enough room to move in both directions.



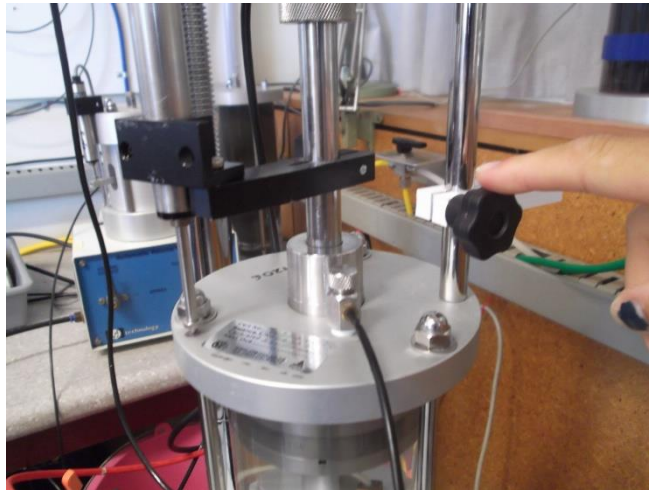
4.4. On computer: Shear > initial conditions > check that you have the right specimen selected > enter cell pressure from gauge > enter test rate), number of membranes (1), membrane thickness (0.31), enter PWP final reading on screen.



4.5. If test is undrained, close tap 12;

4.6. Make sure support is clear of cell (otherwise it will break when test starts)

4.7. **MAKE SURE SUPPORT IS CLEAR OF CELL:** otherwise it will bend as test



starts.

4.8. On computer: control > run > path selection is shear > ok;

4.9. Identify: everything should be how it was – click ok > overview box should go green to start;

4.10. To view how the test is going click control > overview > select specimen;

4.11. The test will run until 20% strain is reached, unless specified otherwise.

## 5. Test close down

5.1. Lower the cell (down button) and raise the piston into resting position by adjusting the guide

5.2. Reduce the cell AP to about 9 kPa and back pressure to 5 – 6 kPa;

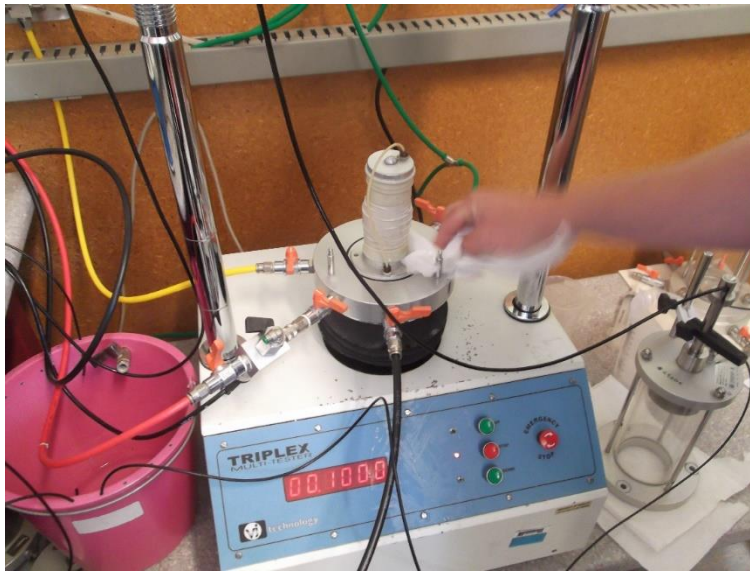
5.3. Close taps 11, 12 and 13;

5.4. Drain the cell: open cell bleed valve, switch taps on wall and by sink to drain cell, turn on tap in sink to a low level;

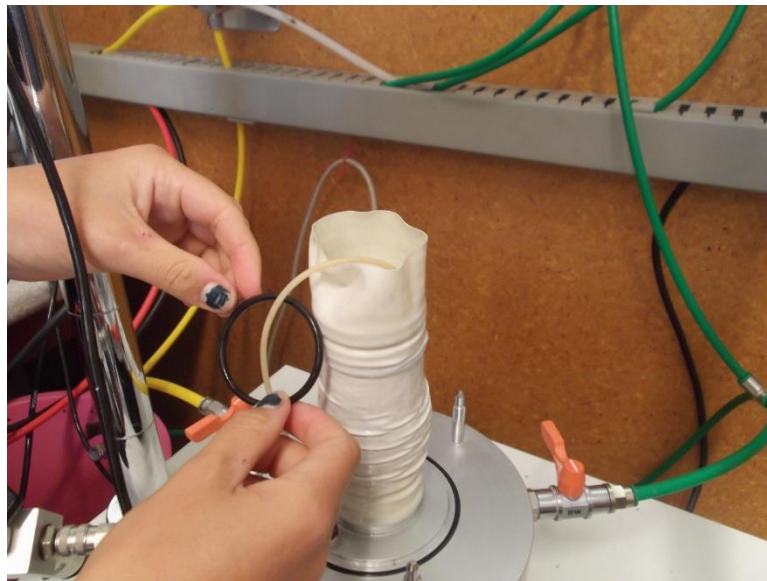


5.5. Turn off all the valves

5.6. Unscrew bolts equally and take off cell



5.7. Carefully remove first the top rubber o-ring then the top plate, then remove the bottom o-ring from its groove;



5.8. Place the membrane with sample inside on the glass plate and carefully roll the membrane off;

5.9. Photograph the sample and sketch if necessary, making sure to include a scale (a ruler) placed immediately adjacent the sample in the photos.

5.10. Clean all equipment thoroughly.