# CE 3121: Geotechnical Engineering Laboratory

## Class 8

## Triaxial Test on Sand
## &
## Unconfined Compression Test

**Sources:**

Soil Mechanics – Laboratory Manual, B.M. DAS (Chapter 16 & 18)
Soil Properties, Testing, Measurement, and Evaluation, C. Liu, J. Evett

# Class Outlines

- Triaxial Shear Test
- Advantages over DST
- Principles of Triaxial Compression Test
- Soil Shear Strength under Drained and Undrained Conditions
- Triaxial Compression Tests
  - Types of tests
  - Differences among test
  - Graphs and results
- Unconfined Compression Test

# Triaxial Shear Test

- Developed by Casagrande in an attempt to overcome some of the serious disadvantages of the direct shear test.
- Advantages over DST
  - More Versatile
  - Drainage can be well controlled
  - There is no rotation of the principal stresses like the direct shear test
  - Also the failure plane can occur anywhere

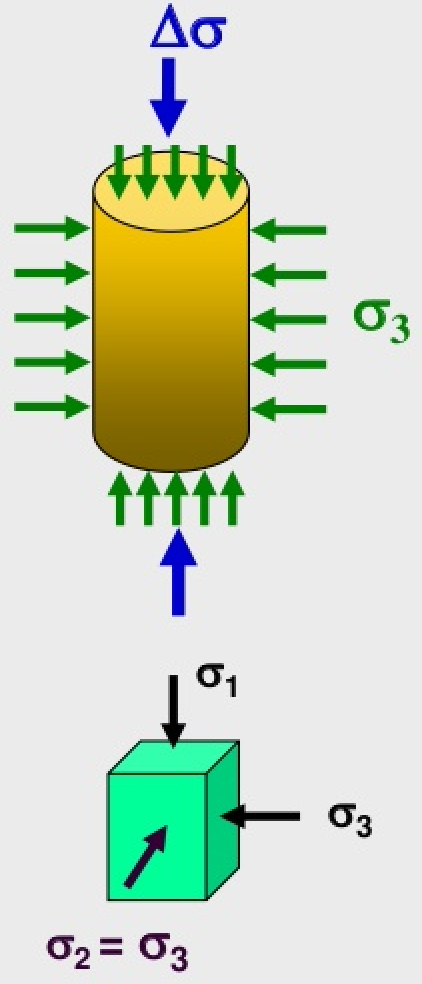
# Principles of the Triaxial Compression (TC) Test

- The triaxial compression test is used to measure the shear strength of a soil under controlled drainage conditions
- A cylindrical specimen of soil is subjected encased in a to a confining fluid/air pressure and then loaded axially to failure.
- The test is called "triaxial" because the three principal stresses are assumed to be known and are controlled.

# Principles of the TC Test

- During shear, the major principal stress, $\sigma_1$ is equal to the applied axial stress ($\Delta\sigma = P/A$) plus the chamber (confining) pressure, $\sigma_3$
- The applied axial stress, $\sigma_1 - \sigma_3$ is termed the "principal stress difference" or sometimes the "deviator stress"
- The intermediate principal stress, $\sigma_2$ and the minor principal stress, $\sigma_3$ are identical in the test, and are equal to the confining or chamber pressure

$\sigma_1 = \Delta\sigma + \sigma 3$



# Soil Shear Strength under Drained and Undrained Conditions ….

- Drained conditions occur when rate at which loads are applied are slow compared to rates at which soil material can drain *(k - dependent)*
- Sands drain fast; therefore under most loading conditions <u>drained conditions exist in sands</u>
- <u>Exceptions:</u> pile driving, earthquake loading in fine sands

# Soil Shear Strength under Drained and Undrained Conditions ….

- In clays, drainage does not occur quickly; therefore excess pore water pressure does not dissipate quickly
- Therefore, <u>in clays</u> the <u>short-term shear strength</u> may correspond to <u>undrained conditions</u>
- Even <u>in clays, long-term shear strength</u> is estimated assuming <u>drained conditions</u>

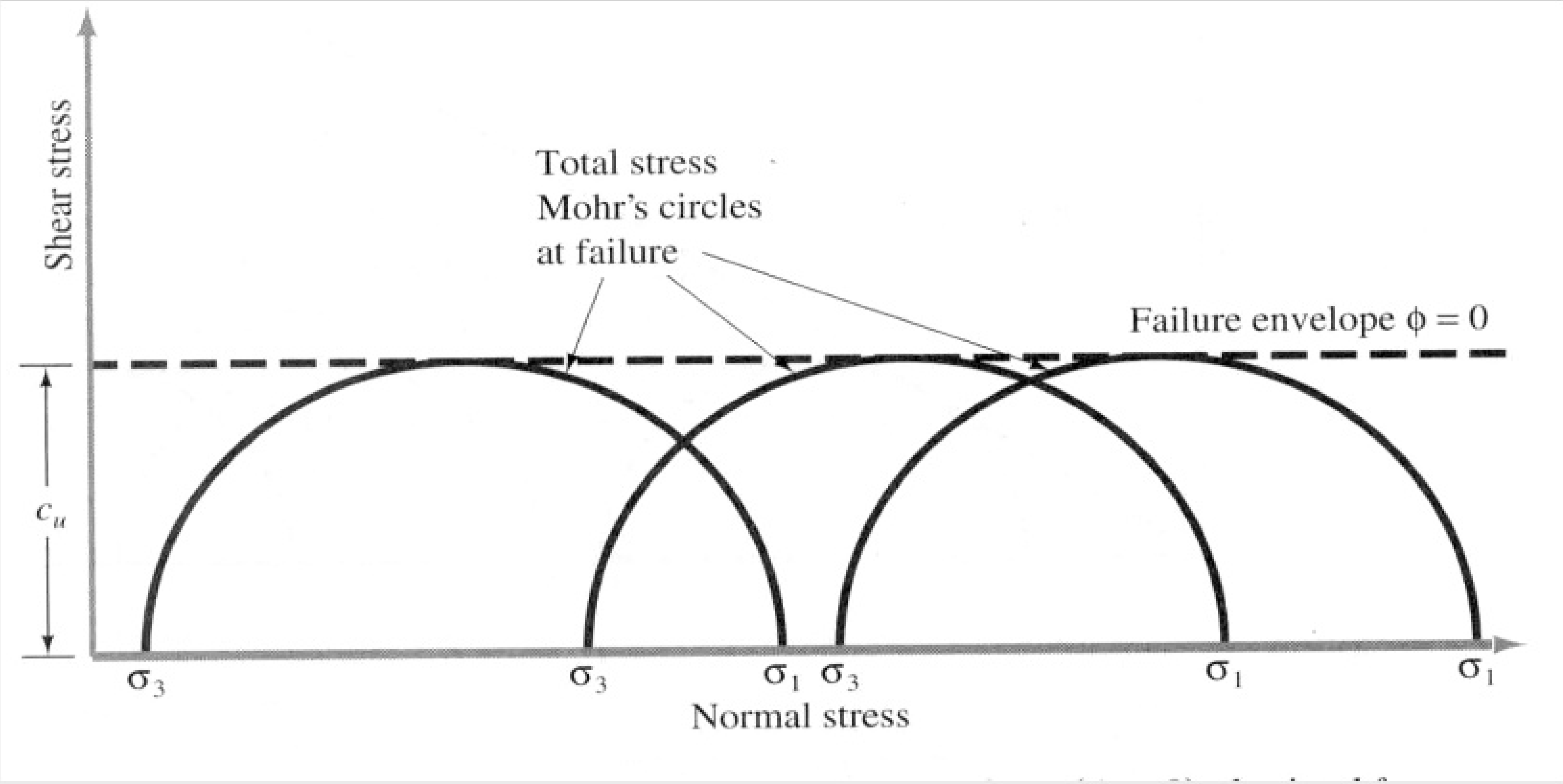
# Types of Tests

- There are three types of tests:
  1. Unconsolidated-undrained (UU or Q) Test
  2. Consolidated-undrained (CU or R) Test
  3. Consolidated-drained (CD or S) Test
  4. Unconfined Compression (UC) Test

# Unconsolidated-undrained Test

- This test is also called the quick test.
- $\sigma_3$ and $\Delta\sigma$ are applied fast so the soil does not have time to settle or consolidate.
- The test is performed with the drain valve closed for all phases of the test.
  (Water is not allowed to drain)
- UU test simulates <u>short term</u> shear strength for cohesive soils.
- For this test, $\phi = \phi' = 0$
- $s = c_u = Su = (\sigma_1 - \sigma_3)/2 = (\sigma'_1 - \sigma'_3)/2$

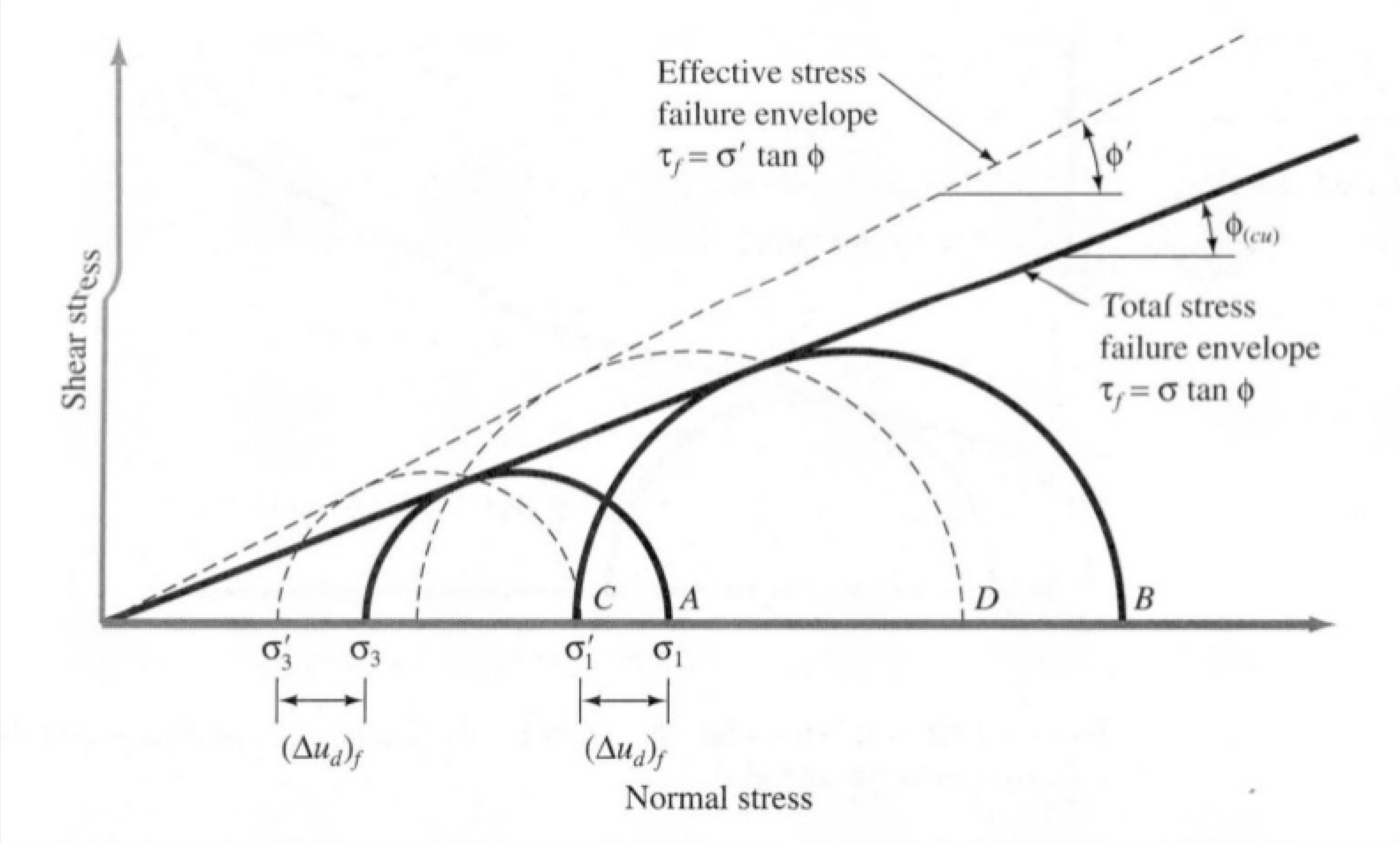
# UU Test Results



# Consolidated-undrained Test

- Apply $\sigma_3$ and wait until the soil consolidates
- Drainage valves open during consolidation phase but closed during the shearing phase
  (Drainage and consolidation is allowed to take place during the application of the confining pressure $\sigma_3$)
- Loading does not commence until the sample ceases to drain (or consolidate).
- This test can simulates long term as well as short term shear strength for cohesive soils if pore water pressure is measured during the shearing phase
- For this Test, $c_T \neq c'$ and $\phi_T = \phi'$
- From this test we obtain;
  - $c'$, $\phi'$ and $u$ (Effective stress)
  - $c_T$, $\phi_T$ (Total stress)

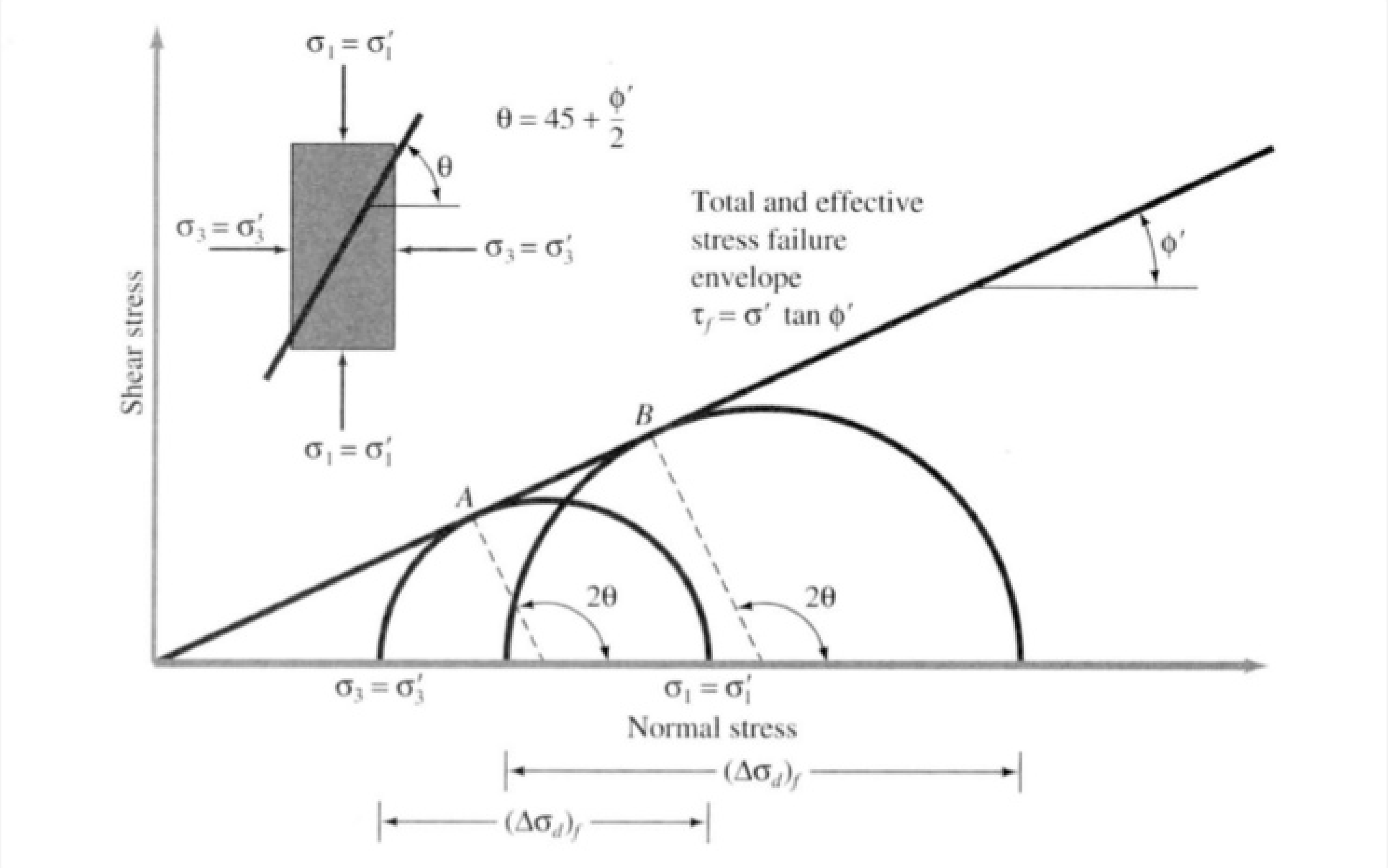
# CU Test Results



# Consolidated-drained Test

- Also called slow test.
- Drainage valves OPEN during consolidation as well as shearing phases.
- Complete sample drainage is achieved prior to application of the vertical load.
- The load is applied at such a slow strain rate that particle readjustments in the specimen do not induce any excess pore pressure. (can take up to 2 weeks)
- Since there is no excess pore pressure total stresses will equal effective stresses.
- This test simulates long term shear strength for cohesive soils.

# CD Test Results



# Triaxial Test on Sand

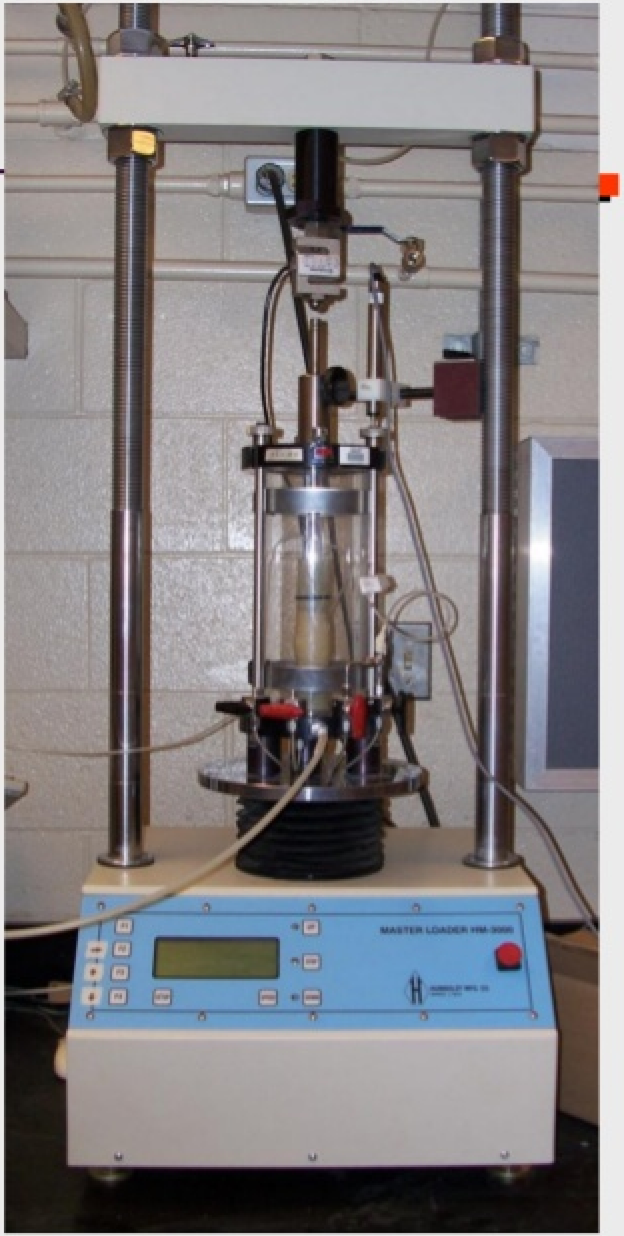
- You will conduct a CD test on sand.
- Soil specimens will be loaded to failure under 3 different confining pressures; 15, 30 and 45 psi
- Failure will be defined as the peak or 3 maximum value of principal stress difference reached.
- ASTM D 2850

# Triaxial Test Equipment

The Cell (Chamber)

Loading Frame


Control Panel



# Procedure

- Follow steps numbers 1 through 31 in the lab manual.
- Soil sample size 140 g
- Rate of loading 0.1 in/min
- Record axial deformation and deviator load at different time intervals
  (every 15 seconds for 2 minutes then every 30 s for the remaining time)
- Stop test after load peaks and drops down about 20%

# Test Results and Calculations

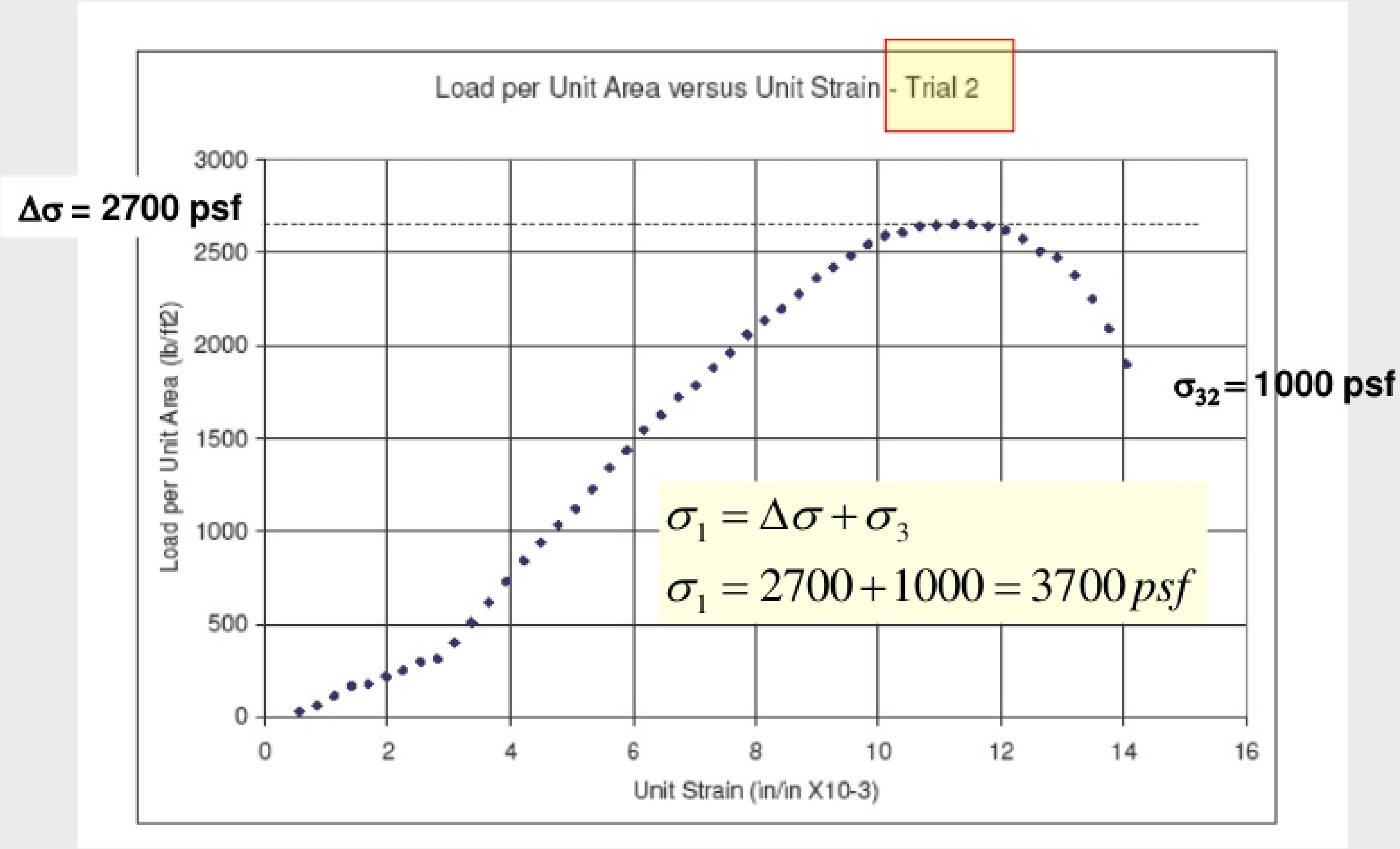
| vertical | | | | | | |
|---|---|---|---|---|---|---|
| deflection | ε | ε | | Load | Area | P/A |
| mm | in/in | in/in X 10-3 | | lbs | ft^2 | lb/ft^2 |
| 0.02 | 0.000 | 0.28 | | 1.81 | 0.0097 | 186.0 |
| 0.04 | 0.001 | 0.56 | | 2.43 | 0.0097 | 250.4 |
| 0.06 | 0.001 | 0.84 | | 3.06 | 0.0097 | 314.7 |
| 0.08 | 0.001 | 1.12 | | 5.57 | 0.0097 | 572.3 |
| 0.1 | 0.001 | 1.40 | | 6.82 | 0.0097 | 701.0 |
| 0.12 | 0.002 | 1.69 | | 8.70 | 0.0097 | 893.9 |
| 0.14 | 0.002 | 1.97 | | 9.95 | 0.0097 | 1022.4 |
| 0.16 | 0.002 | 2.25 | | 11.21 | 0.0097 | 1150.8 |
| 0.18 | 0.003 | 2.53 | | 12.46 | 0.0097 | 1279.2 |
| 0.2 | 0.003 | 2.81 | | 13.40 | 0.0097 | 1375.3 |
| 0.22 | 0.003 | 3.09 | | 15.28 | 0.0097 | 1567.8 |
| 0.24 | 0.003 | 3.37 | | 15.91 | 0.0097 | 1631.6 |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] |

$$\varepsilon = \frac{\Delta l}{l_0}$$

$$A_c = \frac{A_0}{(1-\varepsilon)}$$

$$\sigma = \frac{P}{A_c}$$

# Determining $\sigma_1$




$$\sigma_1 = \Delta\sigma + \sigma_3$$

$$\sigma_1 = 2700 + 1000 = 3700\,psf$$