

GEOSYSTEM[®] SHEAR

**Axial and Direct Shear Module
for GEOSYSTEM[®] for Windows**

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1. Introduction, Installation and Setup

The GEOSYSTEM Axial & Direct Shear module (SHEAR) is designed to reduce laboratory data from triaxial, direct shear and unconfined compression tests. Following is a list of supported features:

- ⇒ Triaxial pore pressures
- ⇒ Drained test outflow buret readings
- ⇒ Direct shear vertical deformation measurements
- ⇒ Both English and SI (metric) units with automatic unit conversion.
- ⇒ Utilizes the GEOSYSTEM Data Manager program (GDM) for file handling: project information such as the project name and number is entered only once per project. GDM can be used to create printed lists of all of the SHEAR tests performed for a given project.
- ⇒ Supports unconsolidated undrained, consolidated undrained, consolidated undrained with pore pressures, and consolidated drained triaxial tests
- ⇒ 3 triaxial test report formats
- ⇒ Interactively adjust the strength tangent envelope
- ⇒ Plot pore pressure versus strain and the stress path diagram for triaxial tests
- ⇒ Compatible with Corps of Engineers and ASTM procedures
- ⇒ Calculates moisture, density, saturation and void ratio for initial, saturated, and consolidated phases
- ⇒ Staged load ring constants are permitted, as well as separate constants for each specimen
- ⇒ Test reports may list up to four specimens
- ⇒ Printed summary lists all testing data and results
- ⇒ Report export to .EMF (word-processor picture), .DXF (CAD) and .PDF (Acrobat Reader) files.

Since SHEAR utilizes the GEOSYSTEM Data Manager program (GDM) or LD4 package for all file handling, the user should review the GDM or LD4 manuals before proceeding.

1.1 Installation

By itself, SHEAR is not a complete system; the program must be installed into a hard disk or network subdirectory that already contains a copy of the Data Manager or LD4 (Drilling Log) packages. (To enter a new SHEAR test, you must first use the Data Manager or LD4 package to open or create a project file.)

- ⇒ If you haven't licensed the Drilling Log package (LD4), SHEAR requires the GEOSYSTEM for Windows Data Manager (GDM) software, *version 2 or later*. A compatible version is automatically installed when you install SHEAR; after installing, you might want to check the GEOSYSTEM web site (www.geosystemsoftware.com) for any available updates.

Installing SHEAR is simple: place the program's CD into a CD drive. If the installation program doesn't automatically start, double-click on your **My Computer** desktop icon, navigate to your CD drive and double-click on the SETUP program.

- ⇒ If you have already licensed the GEOSYSTEM Drilling Log program or any other GEOSYSTEM Windows programs, you *must* install SHEAR into the same hard disk or network subdirectory.
- ⇒ If you are installing the software onto a network server, please refer to the Networks section in the LD4 manual or the Network Installation section in the Data Manager manual before proceeding with the installation.
- ⇒ If you're adding SHEAR to an existing GEOSYSTEM for Windows installation, you can make sure that SHEAR was installed correctly by starting the GEOSYSTEM for Windows package: SHEAR should be listed next to the **Installed modules:** title on the right side of the opening screen.

1.2 Configuring SHEAR

SHEAR includes support for a few different testing and recording procedures – before typing in your first test set you should make sure that the package is correctly configured. To do this, start up your GEOSYSTEM for Windows package (refer to either the GDM or LD4 manuals for instructions) then select [Options](#) > [SHEAR Setup](#).

⇒ Note that these settings affect every test entered into the current project file.

1.2.1 General

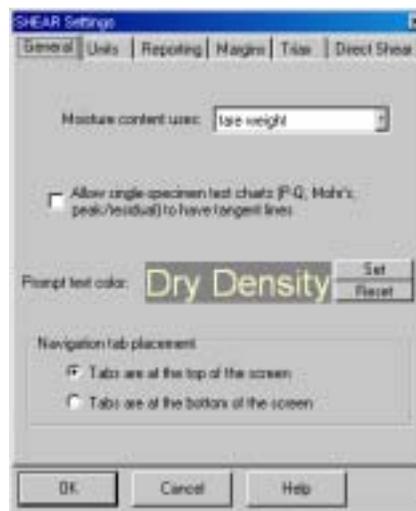


Figure 1.2.1 -- Setup Dialog, General Settings Tab

Moisture content uses

SHEAR can be set up to keep a list of container IDs and associated weights -- when entering moisture content data, instead of entering the container weight you can enter the container ID and the program will look up the associated weight. To do this, select **Tare ID** in this box then enter your list of container IDs and weights into the program's container database ([Options](#) > [Container List](#)).

Allow single-specimen test charts (P-Q, Mohr's, peak/residual) to have tangent lines

When this option is turned off, P-Q, Mohr's and peak/residual stress charts for a single specimen do not show a tangent line.

Prompt text color

Sets the color of the data entry prompts shown on the **Sample Info.** and **Specimen #** tabs. Click **Set** to select a color or **Reset** to restore the program's default color.

Navigation tab placement

Navigation tabs allow you to change from one window to another (for example, between the specimen data entry window and the report preview window). The tabs look like this:



The tabs may be placed at either the top or the bottom of the screen by selecting one of the **Navigation tab placement** options.

1.2.2 Units



Figure 1.2.2 -- Setup Dialog, Units Tab

Data entry:

Specimen weight

Selects the units used to measure the initial specimen weight (grams or lbs.).

Fluid pressure

Specifies the units used to measure pore pressures.

Dimensions

Determines the units used for dial readings, specimen heights, etc.

Reports:

When listing your data on one of the program's chart reports, SHEAR can convert your measurements into different units. This capability allows you to, for example, take all of your data in Imperial units and report in SI units. (The conversion *does not* change the data that you've entered, it merely reports your measurements in different units.) The **Reports** section selects the chart report units: if you do not want to convert your data, make sure that the **Reports** selections match those in the **Data entry** section.

Density

Selects the units used to reporting unit weights.

Stress

Selects the units used for reporting calculated stresses.

Fluid pressure

Pore pressure units: may be different from the **Fluid pressure** units selected in the **Data entry** box in order to report pore pressures in different units than the ones with which they were taken.

Dimension

Determines the length units in which dial readings, specimen diameters and heights, etc. are reported. May be different from the **Dimension** setting in the **Data entry** box in order to report length measurements in different units than the ones with which they were taken.

1.2.3 Reporting



Figure 1.2.3 -- Setup Dialog, Reporting Tab

Rate of strain reported as

Three choices for this selection (**Strain rate, in./min.**, **Time to failure, min.** and **Strain rate, %/min.**) merely determine how the user-entered rate of strain measurement is labeled on reports. The fourth choice, **Strain at peak, %**, causes the program to report the strain calculated at peak stress *instead of rate of strain*.

Load reading and load precision

The program automatically selects the precision to be used for reporting load dial readings and calculated load values. In cases where the dial readings and loads are larger than normal (such as when testing 6 inch diameter and larger specimens), it may be necessary to reduce the precision to avoid having the dial readings and loads overrun their boundaries on the hardcopy printouts.

If printed reports show that load dial readings or loads are overprinting adjacent data, change the **Load reading and load precision** selection to **nearest whole number**; for lighter loads, select **nearest 0.1**.

Report Phi to

Selects the precision used for reporting p-q, Mohr's circles and direct shear tangent angles.

Label specimen numbers

Changes how specimen numbers are labeled on reports: this may be, e.g., **Sample No.** or **Specimen No.** or **Lab. No.**

Include specimen number on stress-strain charts

Checking this option causes the program to label individual curves on stress-strain charts with the number of the specimen used to produce the curve. (Specimens are numbered 1-4 in the order in which they are entered.) Because stress-strain charts include curves from all the specimen entered into the current file, it can be difficult to determine which specimen produced a given curve if the **Include specimen number...** option is not selected.

Additional decimal precision for all testing results

Strengths, cohesions and failure pore pressures are all reported using a commonly accepted number of decimal places for the measurement units being used. To add an extra decimal place to these values, check the **Additional decimal...** box.

Additional decimal precision for reporting dimensions

Diameters and heights are reported using a commonly accepted number of decimal places for the measurement units being used; checking the **Additional decimal precision...** box adds one more decimal place.

Staged tests

Determines how the stress and strain values calculated for staged tests are reported:

- **Restart stress & strain at 0 for each stage**
Each stage's stress and strain values begin with 0 at the start of the stage.
- **Stress & strain accumulates from first stage**
Each stage's stress and strain values begin with the previous stage's final stress and strain.
- **Strains accumulate, stress restarts at 0**
Each stage's strain values begin with the last stage's final strain, but the stress values restart at 0 with the start of each new stage.

Include disclaimer on chart reports

If selected, a disclaimer is printed down the left margin of chart reports. The disclaimer is listed in the **Disclaimer** field directly below the checkbox, and may be modified after checking the **Include disclaimer...** box.

Drop "Tested by" from reports if a name is not entered

The Sample Info. window includes a data entry field titled **Tested by**. This field, along with the **Drop "Tested by" from reports if a name is not entered** checkbox on the program's setup dialog affects the appearance of chart reports:

- If the **Tested by** data entry field is *left blank* and **Drop "Tested by" from reports if a name is not entered** *is not* checked:

"Tested by"; will appear below chart report's bottom margin, along with an area for a signature.
--

- If the **Tested by** data entry field is *left blank* and **Drop "Tested by" from reports if a name is not entered** *is* checked:

"Tested by" will NOT appear below chart report's bottom margin.

- If the **Tested by** data entry field is *filled in*:

"Tested by" will appear below chart report's bottom margin, followed by the name entered into the Tested by field.

Drop "Checked by" from reports if a name is not entered

Is similar to **Drop tested by...**, discussed above. Leaving this box *unchecked*, and leaving the **Checked by** data entry field blank provides an area below chart reports' bottom border for the report's reviewer to sign the page.

1.2.4 Margins

SHEAR features two printed reports: one that summarizes your raw testing data in a tabular format (the *summary report*, shown in Figure 4.2.1) and a second that reports the program’s calculated results and includes charts of stress vs. strain, Mohr’s circles, etc. (the *chart report*, shown in Figure 4.3.1, Figure 4.3.2, Figure 4.3.3, Figure 4.3.4, Figure 4.3.5 and Figure 4.3.6). You can change both report type’s margins (the whitespace between the sides of the page and the borders around the report) by clicking on the **Margins** tab of the Setup dialog.



Figure 1.2.4 -- Setup Dialog, Margins Tab

Select margins for

This drop-down box selects for which of the two report types (summary or chart) the margin changes will apply. Prior to entering new margins, make sure that this box shows the appropriate report style.

Top, Left, Right and Bottom

The measurement units that are used for the report margins (inches or centimeters) are determined by the **Regional Options** in your Windows Control Panel.

1.2.5 Triax



Figure 1.2.5 -- Setup Dialog, Triax Tab

Minimum strain scale range (0.2%-100%)

This setting can be used to ensure that all stress-strain charts produced with the program share the same strain scale: specify the minimum strain scale as the desired strain scale maximum for all the charts. (As long as all of the strain data fit within your selected minimum scale, the program will use your selected strain scale range.)

⇒ To leave the strain scale selection up to the program, enter **0.2** into the field.

Label failure stress as Label ultimate stress as

The terms used on reports to label the deviator stress at failure and ultimate deviator stress may be changed.

⇒ The labels typically used are **Failure Stress** and **Ultimate Stress**, respectively.

Mark failure point on P-Q charts with a circle

Since P-Q charts show the stress path through to the end of the test, the failure point may be indistinct: checking the **Mark failure point...** box causes the program to place a circle at the specimen failure point on P-Q charts.

Mark ultimate point on P-Q charts with a cross

Since P-Q charts show the stress path through to the end of the test, the ultimate point may be indistinct: checking the **Mark ultimate point...** box causes the program to place a cross at the specimen ultimate point on P-Q charts. (Note that the ultimate stress point must be manually selected for each specimen: refer to § 2.2.4 for details.)

Report pore pressures as excess

The pore pressures reported with consolidated/undrained tests can either be absolute or excess. Selecting **Report pore pressures as excess** causes the program to subtract the initial pore pressure from all subsequent readings, so the values reported are the excess pressure from the initial. (This selection also applies to the pore pressure graphs shown on the second page of the triaxial test report.)

Do not summarize ASTM Method B saturated params.

If selected, calculated saturated values (diameter, density, void ratio and saturation) will be omitted from the program's data summary report for ASTM D 4767 Method B tests.

1.2.6 Direct Shear



Figure 1.2.6 -- Setup Dialog, Direct Shear Tab

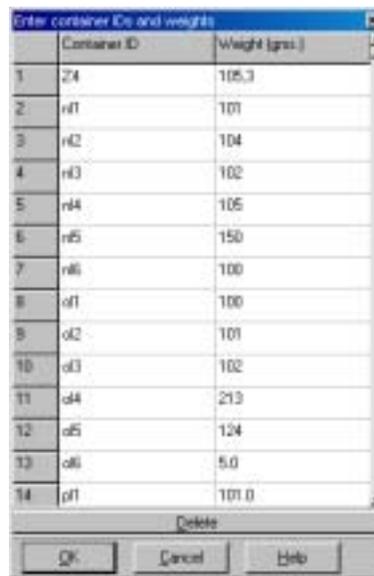
Label failure stress as Label ultimate stress as

The terms used on reports to label the stress at failure/peak and ultimate stress may be changed.

⇒ The labels typically used are **Failure Stress** and **Ultimate Stress**, respectively.

1.3 Container Weight Database

The program may be set up to keep a list of container IDs and weights (this list is shared with other GEOSYSTEM programs, such as the Moisture-Density and Atterberg Limits modules). After setting up the list, you can enter your moisture-content test data with a container ID in place of the tare weight. Selecting Options > Container List displays the container weight editor:



	Container ID	Weight (gms.)
1	Z4	105.3
2	n11	101
3	n12	104
4	n13	102
5	n14	105
6	n15	150
7	n16	100
8	o11	100
9	o12	101
10	o13	102
11	o14	213
12	o15	124
13	o16	5.0
14	p11	101.0

Figure 1.3.1 -- Container List Dialog

Container IDs are what you use when entering moisture content data: they're convenient, *unique* identifiers assigned to the containers holding the moisture content samples. IDs may be any combination of alphabetic and numeric characters; e.g., ACD or 123. IDs that differ only by case (e.g., 3A and 3a) are considered identical.

- ⇒ To add a new container to the list: Click on the first blank row in the list and enter the container ID and container weight.
- ⇒ To remove a container from the list: Click in either the **Container ID** or **Weight** columns of the row you want to delete then click on the **Delete** button.

Note that this list is optional: if you run a moisture content test with a container which is not on your container list, you can skip entering a container ID and instead enter the container's weight. (If you want to use the container list, make sure to select **Tare ID** in the **Data entry requires** Setup field (see § 1.2.1).

1.4 Walkthrough

Before continuing, consider taking the program's 30 minute tutorial:

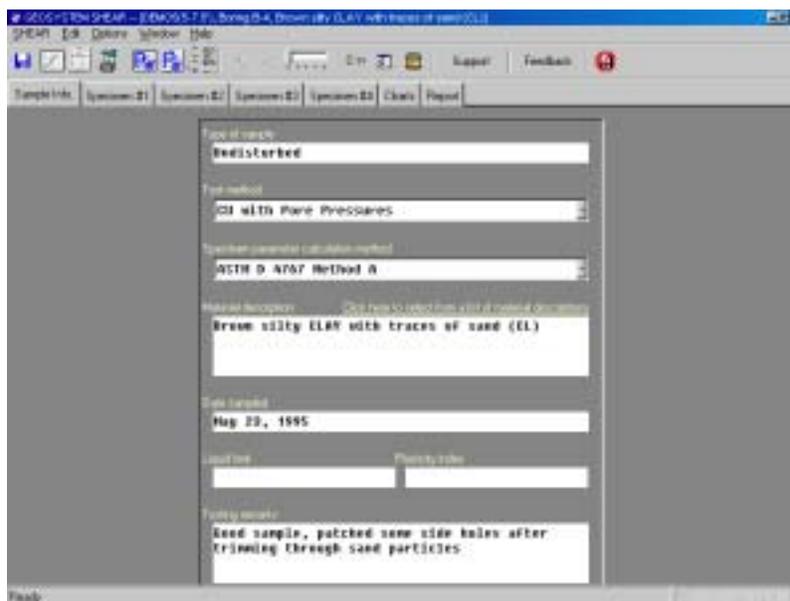
1. Start the GEOSYSTEM for Windows package: If you have a "GEOSYSTEM" shortcut on your desktop, double-click on it (you can also click on your "Start" button and select Programs > GEOSYSTEM > GEOSYSTEM for Windows).
2. On the left side of the program's screen is a directory box: navigate to the directory where the GEOSYSTEM software is installed. (If you've installed the software onto your own hard disk, this will probably be either **C:\GEOSYS** or **C:\PROGRAM FILES\GEOSYS**.)
3. In the program directory, you'll find a file called **DEMO**: double-click on it.
4. The software should display the contents of the DEMO project. On the left side of the screen is a yellow box listing the material sources from which DEMO's testing samples were taken: double-click on **B-4**.
5. On the right side of the screen you should see a list of samples taken from B-4: find the data entry card for sample **S-4** and click on the **SHEAR** link for that card.
6. You should see the SHEAR data entry screen. Select Help > Tutorial: the program will display a series of yellow tutorial cards at the bottom of the data entry window

2. Data Entry

Begin data entry for a SHEAR test by filling in a data entry card on the LD4 or Data Manager screen:

1. Create or open a project file (see Sections 2.1 and 2.2 in the GDM manual or, if you've licensed LD4, Sections 2.3 and 2.4 in the LD4 [User's Guide](#)).
2. Create or open a material source folder (see Sections 2.5 and 2.9 in the GDM manual or Sections 2.7.1 and 2.7.2 in the LD4 [User's Guide](#)).
3. Locate a data entry card for the sample and fill in the sample's identifying information (see Section 2.6 in the GDM manual or Section 2.9 in the LD4 [User's Guide](#)).

Click on the **SHEAR** link at the bottom of the sample's data entry card (see Section 2.7 in the GDM manual or Section 6.1 in the [User's Guide](#)). You should see a display similar to the one shown below:



2.1 Sample Info.

SHEAR's initial data entry window covers basic information about the SHEAR test and the sample tested. (This window can also be reached by clicking on the **Sample Info.** tab at the bottom of your screen.)

- ⇒ Except for **Test method** and **Specimen values calculation method**, any data entry field in this window may be left blank
- ⇒ Entering symbols: to enter a symbol which is not a part of your keyboard (such as the degree symbol), press function key F9.

The following data are requested:

Type of sample

Use this field to indicate whether the tested sample was **Undisturbed** or **Disturbed**.

Test method

SHEAR supports a number of test variants:

- Unconfined Compression
- Direct Shear
- Unconsolidated Undrained
- Consolidated Undrained
- Consolidated Undrained with Pore Pressures
- Consolidated Drained

SHEAR may be licensed with support for unconfined compression, direct shear and/or triaxial shear test methods: if a particular test method is not licensed then that method will not be available for selection in the Test method list. For example, if SHEAR is licensed without support for triaxial tests, then the Unconsolidated Undrained, Consolidated Undrained and Consolidated Drained testing methods will not be available.

Specimen values calculation method

The specimen calculations (moisture content, density, saturation, etc.) for triaxial tests can be performed using several different methods, including:

ASTM D 2850 is the standard ASTM procedure for unconsolidated undrained triaxial tests.

COE - uniform strain is the first method described in Section 7c2 of EM 1110-2-1906 Appendix X.

COE - saturation assumed is the second method described in Section 7c2 of EM 1110-2-1906 Appendix X.

COE - uniform strain & water volume is a variant method which combines the COE - uniform strain and COE - saturation assumed methods.

ASTM D 4767 Method A and **ASTM D 4767 Method B** **D 4767** is the standard ASTM procedure for consolidated undrained triaxial tests. SHEAR supports both methods A and B of the after-consolidation cross-sectional area calculation.

ASTM D 4767 Method B w/ saturation est. is a non-standard variant of the ASTM D 4767 Method B procedure that allows the user employ an estimate of the consolidated specimen saturation rather than assuming 100% saturation. This calculation method is only available for consolidated undrained tests.

- ⇒ The **Specimen values calculation method** selection is not changeable for direct shear and unconfined compression tests because SHEAR only supports a single calculation method for these tests.

Material description

By default, SHEAR uses the material description that you entered into the **Material Description** field on the Data Manager screen (that's the screen where you click on the SHEAR link). However, if you're entering drilling log data, the material description at the depth where you took the SHEAR sample may only be something like **grades to slightly silty**, with the full stratigraphy description taken at some depth above the SHEAR sample. If this is the case, you can either override the default description or click on the link that reads **Click here to select from a list of material descriptions**: this drops down a box listing all of the material descriptions entered into the current source folder. Double-click on one of the descriptions to select it.

Date sampled

Use any date format desired; e.g., mm/dd/yy or dd/mm/yyyy or November 20, 2004.

Liquid limit/Plasticity index

These values are automatically retrieved from the GEOSYSTEM Atterberg Limits program if it has been licensed and if Atterberg testing data are entered prior to entering the SHEAR test data.

- ⇒ If a valid liquid limit and plasticity index are entered, SHEAR will automatically calculate and report the plastic limit on chart reports.

Testing remarks

Use this field to note any deviations from normal sample preparation and testing procedures, testing personnel, etc.

Chart report figure number

This value is printed at the bottom-right corner of the chart reports. Typically, the value will be shown as **Figure No.: xxxxxxx**; to change the title from 'Figure No.' to, e.g., 'Plate No.', exit SHEAR (SHEAR > Save and Exit) then select Options > Setup General Options, click on the **Lab. Modules** tab and enter the new title into the **On reports, "Figure No." is titled:** field.

Page 2 figure no. (if applicable)

This field only applies to triaxial tests: the Corps of Engineers and alternate triaxial test report forms are two page forms (see this page for a sample of the second page): if desired, the second page's figure number may be entered into the **Page 2 figure no.** field.

Skip initial moisture data

As an alternative to taking moisture content data both before and after the test, the entire test specimen can be used post-test to determine the post-test moisture content: the dry weight from the post-test moisture content test and the initial moist weight are used to calculate all specimen values (initial moisture content, density, etc.) without requiring an initial moisture content determination.

Specific gravity is assumed

Check this box if a test was not performed to determine the specific gravity of the sample: SHEAR's chart reports will label the specific gravity value that you enter as *Assumed*.

2.1.1 Additional Sample Information Required for Triaxial Tests

Several additional fields are included on the **Sample Info.** window when entering triaxial test data:

Single specimen staged test

SHEAR supports a triaxial and direct shear test variant where a single soil specimen is used to develop failure data for several different minor effective principal stresses (in other words, a single specimen is subjected to up to 4 different stresses; stages 2 and beyond are assumed to start at exactly the same sample state (i.e., height and area) as when the previous stage completed). If this non-standard procedure was used, check the **Single specimen staged test** box.

⇒ Staged tests require initial specimen data (initial moist weight, moisture content, change in saturated/consolidated water volume, height, etc.) only for the first stage: subsequent stages require only the change in height during consolidation.

- ⇒ When testing staged samples, *do not reset the deformation dial between stages*. The program does not add in the deformation produced by previous stages, so the dial cannot change between changes.
- ⇒ SHEAR does not currently support staged consolidated drained tests.

Membrane correction

Selecting this option applies the ASTM D 4767, Section 10.7 correction for rubber membranes. Note that the correction requires the membrane thickness and the membrane modulus.

Membrane modulus

See ASTM D 4767 Section 10.7.1. (ASTM D 4767, Section 10.7.1 notes that a typical value for latex membranes is about 0.137895.)

Membrane thickness

Enter the thickness of the rubber membrane in cms.

Filter paper correction

Selecting this option applies the ASTM D 4767, Section 10.6 correction for filter paper strips.

Filter paper coefficient

Enter the coefficient for the load carried by the filter paper per unit length of perimeter covered by filter paper. (ASTM D 4767, Section 10.6 notes that a typical value is about 0.0019 kN/cm.)

Filter paper percent coverage

Enter the percent of perimeter covered by filter paper. This value should be entered as a percentage (e.g., fifty percent coverage should be entered as 50 instead of 0.5).

Consolidated Drained Tests Only**Test uses outflow buret**

Select this option when outflow buret readings have been taken.

Buret precision

Select the precision used when reading the outflow buret: normally, divisions as small as 0.1 cc may be read, but large scale testing may involve the use of burets with 1 cc as the minimum readable division).

Reverse buret convention

Selecting this option indicates use of a buret graduated in *increasing* values as the fluid level is increased.

2.1.2 Additional Sample Information Required for Direct Shear Tests

Several additional fields are included on the **Sample Info.** window when entering direct shear test data:

Enter vertical deformation

If vertical deformation readings are taken then they may be entered and shown graphically on the program's chart report if this box is checked.

Use square or rectangular shear box

Select this option if a square or rectangular shear box was used for the test. Leave the option unselected if a circular sample was tested.

Fabric on fabric (no soil) test

Select this option if a geotextile was tested without soil.

⇒ SHEAR only supports fabric on fabric tests when performed in a square or rectangular shear box.

Report deformation as

Deformations can be reported as either displacements or strains.

Single specimen staged test

SHEAR supports a triaxial and direct shear test variant where a single soil specimen is used to develop failure data for several different minor effective principal stresses (in other words, a single specimen is subjected to up to 4 different stresses; stages 2 and beyond are assumed to start at exactly the same sample state (i.e., height and area) as when the previous stage completed). If this non-standard procedure was used, check the **Single specimen staged test** box.

⇒ Staged tests require initial specimen data (initial moist weight, moisture content, change in saturated/consolidated water volume, height, etc.) only for the first stage: subsequent stages require only the change in height during consolidation.

⇒ When testing staged samples, *do not reset the deformation dial between stages*. The program does not add in the deformation produced by previous stages, so the dial cannot change between changes.

EXPERIMENTAL: Correct sample areas based upon strain

The ASTM direct shear test standard (D 3080) specifies that shear stresses are to be calculated by dividing the shear force over the initial sample area. This ignores the effect of shearing on the sample area: as the test proceeds, the area of the sample decreases.

Selecting the **Correct sample areas based upon strain** option causes the program to approximate the sample area at each test reading, and to use the approximated area when calculating the stress at that reading. While this calculation differs from the D 3080 standard, it is roughly allowed for by Note 19, which states: *Factors which incorporate assumptions regarding the actual specimen surface area over which the shear and normal forces act can be applied to the calculated values of shear or normal stress, or both.*

2.2 SHEAR Testing Data

Clicking on the **Specimen #1**, **Specimen #2**, **Specimen #3** or **Specimen #4** tabs at the bottom of the screen displays the testing data entry screen shown below:

	Initial	Saturated	Unconsolidated	Test
Moisture weight (gms.)	177.5			
Specific gravity	2.68			
Density (g/cc)	2.5	2.676	2.676	
Area (sq ft)	4.708	4.707	4.708	
Height (in.)	2	4.991	4.708	
Net distance in height (in.)	---	0.20	0.1	
Net distance to water column (in.)	---	---	0.5	
Moisture content (%)	35.8	33.8	16.4	30.4

Figure 2.2.1 -- Testing Data Window

⇒ Movement through the entry fields is by the Tab and Shift-Tab keys (Enter may also be used to jump from one field to the next).

2.2.1 Moisture Content Data

Initial moisture content

An initial moisture content test is required unless the **Skip initial moisture data** option is selected (see the **Sample Info.** window).

Final moisture content

A post-test moisture content is required for triaxial tests and optional for direct shear tests.

- ⇒ If you've added a list of container IDs and weights to the program's container weight database you can enter a **Container ID** instead of a tare weight (see § 1.3).

2.2.2 Specimen Measurements

Following the moisture content test data you'll be asked for data on the initial sample, and, for some test methods, saturated and/or consolidated data:

Sample values	Initial	Saturated	Consolidated	Test
Moist weight (g)	117.5			
Specific gravity	2.65			
Diameter (in)	2.5	2.475	2.475	
Area (in²)	4.908	4.902	4.928	
Height (in)	5	4.950	4.950	
Net distance to height (in)		0.85	1	
Net distance to water content (in)			2.5	
Moisture content (%)	30.8	33.8	32.4	32.4
Unit density (pcf)	123.7	136.7	136.2	
Dry density (pcf)	132.8	148.2	147.1	
Void ratio	0.5750	0.5207	0.4131	
Porosity (%)	35.1	34.2	28.2	

Figure 2.2.2 -- Specimen Measurements

Moist weight

This is the total moist weight of the specimen. Note that the measurement units used are selectable between grams and pounds: to change the units, select Options > SHEAR Setup, click on the **Units** tab and change the **Specimen weights** setting. (See § 1.2.2.)

Specific gravity

This is the mineral solids specific gravity. The value entered must be a number greater than 1.

- ⇒ If you are assuming a specific gravity value for the samples, make sure to check the **Specific gravity value is assumed** box on the Sample Info. window.

Diameter

and

Height

Sample dimensions may be entered in inches, centimeters or millimeters, depending on the current data entry units setting (§ 1.2.2).

Compression side length

This is the length of the square or rectangular shear box side against which a direct shear sample is compressed. (See § 1.2.2 for information on changing the length measurement units.)

Side 2 length

This is the length of the non-compression side of a square or rectangular shear box.

⇒ See the **Use square or rectangular shear box** Sample Info. setting (§ 2.1.2) for information on choosing between a rectangular or circular direct shear test sample.

Net decrease in height

For direct shear and consolidated triaxial tests, the change in height during consolidation is used to determine the sample volume at the start of the shear test.

Triaxial tests also require the change in height during saturation.

⇒ Change in height should be entered as a positive measurement if the height of the sample decreased; if the sample swelled, the change in height measurement should be a negative number.

Net decrease in water volume

In triaxial tests the change in the volume of pore water may be measured during saturation and, for consolidated tests, during consolidation. The change is entered as a positive number (in cubic centimeters) if the outflow from the sample was greater than the inflow, or as a negative number if the specimen took on water.

The table below lists which specimen values calculation methods require a water volume change measurement during the test saturation and consolidation phases:

<i>Calculation method</i>	<i>Saturated Water Volume Change</i>	<i>Consolidated Water Volume Change</i>
COE uniform strain		
COE saturation assumed	required	required
COE uniform strain & water volume	required	required
ASTM D 4767 Method A		required
ASTM D 4767 Method B		required
ASTM D 4767 Method B with saturation estimate		required

Saturation (%)

ASTM D 4767 Method B w/ saturation est. specimen values calculation method requires an estimation of the consolidated sample's saturation. This value should be entered as a percentage (e.g., 95% should be entered as 95, not 0.95).

⇒ Staged tests require an estimate of the final saturation instead of the consolidated sample's saturation.

2.2.3 Test Parameters

Below the Specimen Measurements panel is the Test Parameters panel:

Figure 2.2.3 -- Test Parameters

Type of readings

SHEAR supports both load ring equipped compression frames as well as digital dial gauge equipped frames. Before you begin entering load readings, you'll need to let SHEAR know how to convert your readings into loads by selecting from the **Type of readings** box:

Load ring constant

Select this option for load ring equipped compression frames. (Note that SHEAR supports both single and double (staged) ring style proving rings.) Load ring constant frames require the following data:

Load ring #1 constant

Load-ring equipped loading frames require a Load Ring Constant (LRC) to convert readings into loads; these conversion factors are specified in terms of pounds per load dial division or kN per load dial division.

- ⇒ LRCs can be visualized as being the slope of the load vs. dial reading line on a ring calibration chart.
- ⇒ When converting a load dial reading to a load, SHEAR subtracts the initial load dial then multiplies the result by the LRC.

Crossover

Staged load rings utilize a secondary LRC which is employed after the second ring makes contact and begins compressing. The **Crossover** field should be filled in with the load dial reading at which the secondary load ring makes contact.

- ⇒ If a single load ring is used, leave the **Crossover** field blank or enter 0.

Load ring #2 constant

This field is the LRC of the secondary proving ring. If a single load ring is used, leave this field blank or enter 0.

Sample LRC calculation, given:

- The frame's LRC is **27030** lbs./inch up to **0.15** inches and **39490** lbs./inch beyond that.
- The initial load dial reading was **0.0025**.
- A subsequent load dial reading of **0.3000** was taken.

The load would be:

$$(0.15 - 0.0025) * 27030 + (0.3000 - 0.15) * 39490 = 5941.68 \text{ pounds}$$

Some notes on using LRCs:

- ⇒ In the above example, **27030** would be entered into the **Load ring #1 constant** field, **39490** would be entered into the **Load ring #2 constant** field and **.15** would be entered into the **Crossover** field.
- ⇒ Optionally, to allow load dial readings to be entered as integers, (assuming that the dial is accurate to .0001), LRC#1 could be entered as **2.7030**, LRC2 as **3.9490** and the Crossover as **1500**. This makes the initial dial reading for the example **25** and the second reading **1995**. Generically, if your LRC is given as X lbs. per inch and your dial is readable to .0001, entering your load ring constant as X*.0001 allows you to enter your dial readings as whole numbers.

"Ax+B ring equation"

This style of reading-to-load conversion is used with load rings that utilize an "Ax+B" linear calibration. This equation requires the following data:

"A" term

The "A" term is specified in either pounds per load dial division or kN per load dial division.

"B" term

"B" term is given in either pounds or kN.

Sample calculation, given:

- The "A" term is 15000 lbs./inch.
- The "B" term is 50 lbs.
- The initial load dial reading was 0.0025.
- A subsequent load dial reading of 0.1000 was taken.

The load would be

$$(0.1 - 0.0025) * 15000 + 50 = 1512.5 \text{ pounds}$$

- ⇒ Optionally, to allow load dial readings to be entered as integers, (assuming that the dial is accurate to .0001), "A" could be entered as **1.5** and "B" as **0.0050**. This makes the initial dial reading for the example **25** and the second reading **1000**. Generically, if your "A" term is given as X lbs. per inch and your dial is readable to .0001, entering your "A" and "B" terms as X*.0001 allows you to enter your dial readings as whole numbers.

Actual loads

This option should be selected when working with data taken from a digital dial gauge (because the gauge reads directly in loads and does not require a conversion factor).

Readings units

Selects the force units represented by the load dial readings. Currently, pounds and kN (kilo Newtons) are supported.

Cell pressure

Back pressure

These two fields are only present when entering triaxial testing data. **Cell pressure** is the total fluid pressure around the sample. **Back pressure** is the pore pressure applied to the sample before the start of the test (typically used to compress air voids and to increase saturation).

- ⇒ To change the units used for entering the cell and back pressures, see the **Fluid pressure** field on the program's configuration dialog ([Options](#) > [SHEAR Setup](#) then click on the **Units** tab).

Normal stress

This field is only present when entering direct shear data, and should be filled in with the total normal stress applied to the specimen before and during shear testing.

Strain rate

Time to failure

SHEAR does not use these fields for any calculations; it's included documentation purposes only.

These fields are shown if you select either **Strain rate, in./min.**, **Strain rate, %/min.** or **Time to failure, min.** from the **Rate of strain reported as** box on the program's configuration dialog (§ 1.2.3).

2.2.4 Test Readings

The last panel on the test data entry screen is the Test Readings panel:

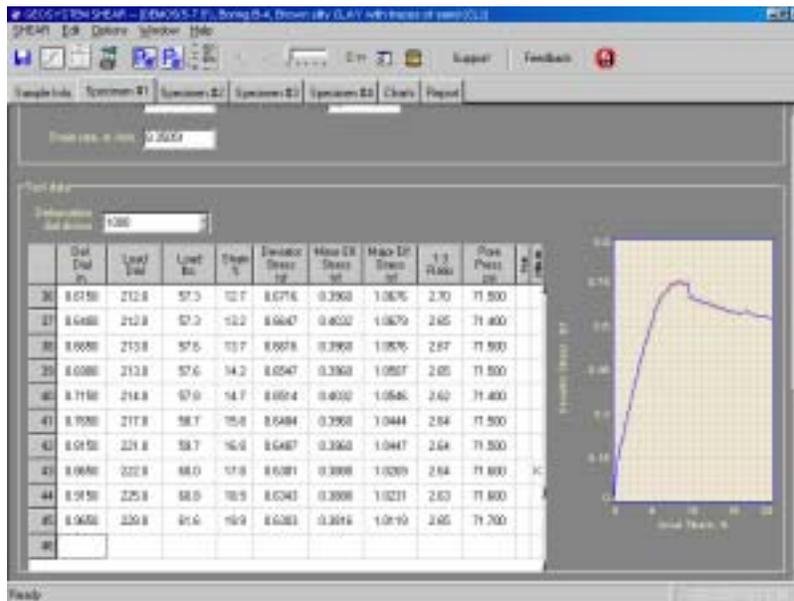


Figure 2.2.4 -- Test Readings

Deformation dial divisor

Vertical def. dial divisor

This selection allows entry of deformation dial readings as whole numbers such as **1950** instead of decimal values like **0.1950**. During data entry, SHEAR accepts your deformation values and divides them by the deformation dial divisor before entering them into the **Def. Dial** column on the test readings grid.

To avoid entering the "0." for each deformation value that you enter, select the dial divisor representing the value that will produce a whole number when multiplied by the smallest deformation readable on your dial. For example, if your smallest readable deformation is .0001, select **10000** as your deformation dial divisor. If you prefer to enter actual deformations, select **1** as your deformation dial divisor.

- ⇒ Once your deformation dial reading is entered into the program, the dial divisor is irrelevant: **1950** entered with a dial divisor of **10000** is the same deformation as **0.195** entered with a dial divisor of **1**. Selecting a different dial divisor has no effect on deformations that you've already entered.

SHEAR supplies a second dial divisor for direct shear tests: the **Vertical def. dial divisor** converts values entered into the **Vertical Def. Dial** column.

Test readings data:

Def.**Dial***or***Horiz.****Def.****Dial**

Is the deformation undergone by the sample, adjusted for the chosen deformation dial divisor. The measurement units used (inches, cms. or mms.) must match the **Dimensions** units chosen for data entry on the **Units** tab of the program's Setup dialog (§ 1.2.2).

Load**Dial**

Is the load dial reading. Be sure to make the correct **Type of readings** selection (§ 2.2.3) before entering load dial readings.

Pore**Press.**

Is the pore pressure measurement. The measurement units used (psi, tsf, etc.) must match the **Fluid pressure** units chosen for data entry on the Units tab of the program's Setup dialog (§ 1.2.2). Pore pressures are entered only if **Consolidated Undrained with Pore Pressures** is the selected test method (§ 2.1).

Buret**Read.**

Is the reading, in CCs, on the outflow buret used for drained triaxial tests. Outflow buret readings are entered only if **Consolidated Drained** is the selected test method (§ 2.1) and **Test uses outflow buret** box is checked (§ 2.1.2).

Vertical**Def.****Dial**

(Direct shear tests only.) Is the vertical deformation dial reading, adjusted for the chosen vertical deformation dial divisor. To enter vertical deformation data, the Enter vertical deformation test settings box must be checked. The measurement units used (inches, cms. or mms.) must match the **Dimensions** units chosen for data entry on the Units tab of the program's Setup dialog (§ 1.2.2).

Peak*and***Ultimate**

An "X" in the **Peak** column indicates the readings row that holds the specimen's peak stress, while an "X" in the **Ultimate** column indicates the readings row that holds the specimen's ultimate stress.

SHEAR's chart reports show the maximum deviator stress (i.e., *peak* or *failure* stress) encountered by each specimen. SHEAR automatically determines this value; however, you can override the program's selection:

1. On the grid holding the test readings values, locate the row containing your maximum deviator stress value.
2. On the maximum deviator stress row, click the left mouse button in the column titled **Peak**: you should see an "X" appear.

Chart reports also show the ultimate stress reached by each specimen. *Unlike the peak stress, this value is not automatically determined*: the ultimate stress point must be manually selected for each specimen. To specify the ultimate stress point:

1. On the grid holding the test readings values, locate the row containing your ultimate stress value.
2. On the ultimate stress row, click the left mouse button in the column titled **Ultimate**: you should see an "X" appear.

⇒ You can remove your peak or ultimate stress selection by clicking on the "X" in the **Peak** or **Ultimate** columns: clicking in the "X" should make it disappear. Removing your peak stress selection causes the program to automatically determine the specimen's peak stress, while removing the ultimate stress selection prevents any ultimate stress data from appearing on the chart reports.

2.3 Copying and Pasting SHEAR Data

If you have two SHEAR tests with similar testing data, you may want to copy the first test entered piecemeal. To do this:

1. Open the test and select Edit > Copy Test.
2. Start the next test (from the Data Manager screen, enter the test's sample data then click on the SHEAR link) then select Edit > Paste Test.

2.4 Deleting a SHEAR Test

To remove all of the data that you've entered for a test, refer to Section 2.8 in the GDM manual or Section 6.2 in the LD4 [User's Guide](#).

2.5 Importing Data Files Created with the DOS SHEAR Program

SHEAR can import individual data files entered with GEOSYSTEM's original DOS version of the program. To do this:

1. From the Data Manager screen, find a blank sample card and enter the sample number, depth, etc. of the sample that you want to import.
2. Click on the underlined [SHEAR](#) shown at the bottom of the data entry card.
3. Select [SHEAR > Import DOS SHEAR File](#).
4. Navigate to the hard disk subdirectory where your DOS SHEAR program was installed (typically, this will be C:\SHEAR).
5. Locate the data file that you're trying to import (DOS SHEAR data file names end in **.SDT**) and double-click on it.

3. Curve Display

The **Charts** tab (Window > Charts) displays charts of triaxial Mohr's circles and p-q stress paths, direct shear peak vs. normal stress and unconfined compression stress vs. strain curves. The Mohr's circles, P-Q and direct shear charts feature adjustable tangent line constructions.

3.1 Mohr's Circles Chart Display

To display a chart of a triaxial test's Mohr's circles, select Window > Charts then click on the **Mohr's** toolbar button.

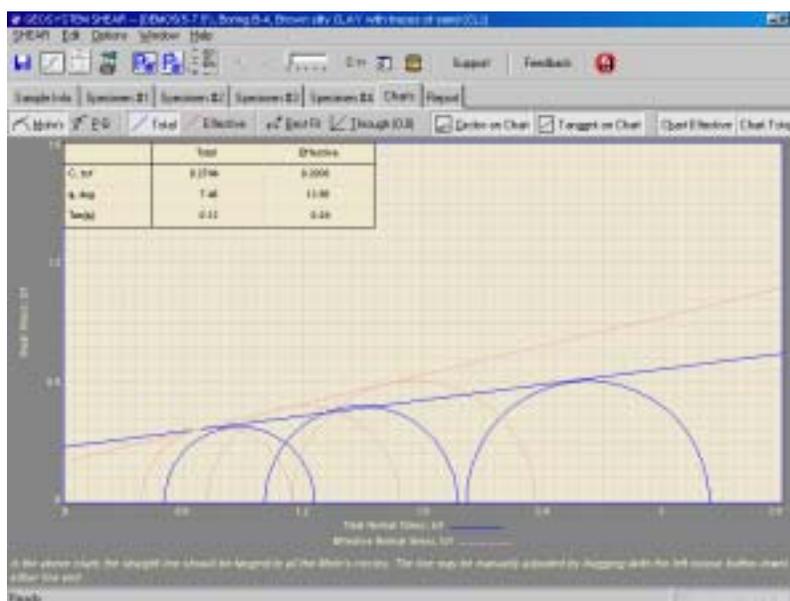


Figure 3.1.1 -- Mohr's Circles Chart Display

⇒ If pore pressure measurements were taken, SHEAR will display two sets of Mohr's circles, representing the total and effective stresses: The total stress Mohr's circles are shown in red and the effective stress circles are shown in blue.

The chart also displays one or two lines that should ideally be tangent to *all* the Mohr's circles of the same color. (I.e., the blue line should be tangent to all the blue Mohr's circles.) SHEAR attempts to automatically adjust these lines for a best-fit. The lines may also be manually adjusted:

1. If pore pressures were taken, begin by clicking on the **Effective** or **Total** buttons.
2. Drag (with the left mouse button down) the end of the line to be adjusted.

There are also several toolbar buttons designed to help with the adjustment:

Best Fit

This button returns the tangent line to the program's automatically selected alignment.

Through (0,0)

This button forces the left end of the tangent line to pass through the lower-left corner of the chart; i.e., through (0,0).

Two toolbar buttons determine how the chart appears on the chart report:

Circles on Chart

When this button is in the up position the Mohr's circles are omitted from the report's chart.

Tangent on Chart

When this button is in the up position Mohr's circles tangent lines are omitted from the report's chart.

⇒ Check the effect of selecting or deselecting these options by selecting Window > Report Preview.

Chart Effective

CU with pore pressures only: When this button is in the up position the effective p-q paths are omitted from the report's chart.

Chart Total

CU with pore pressures only: When this button is in the up position the total stress p-q paths are omitted from the report's chart.

3.2 P-Q Chart Display

To display a chart of a triaxial test's p-q values, select Window > Charts then click on the **P-Q** toolbar button.

⇒ If pore pressure measurements were taken, SHEAR will display two sets of p-q values, representing the total and effective stresses: The total stress p-q values are shown in red and the effective stress values are shown in blue.

The chart also displays one or two lines that should ideally connect all the same colored failure stress points. (I.e., the blue line connects the failure points on the blue p-q chart.) SHEAR attempts to automatically adjust these lines for a best-fit; The lines may also be manually adjusted:

1. If pore pressures were taken, begin by clicking on the **Effective** or **Total** buttons.

2. Drag (with the left mouse button down) the end of the line to be adjusted.

There are also several toolbar buttons designed to help with the adjustment:

Best Fit

This button returns the tangent line to the program's automatically selected alignment.

Through (0,0)

This button forces the left end of the tangent line to pass through the lower-left corner of the chart; i.e., through (0,0).

Get Tan from Mohr's

This forces the best-fit line to correlate with orientation of the Mohr's circles tangent line. (The correlation is useful because the intersection of the Mohr's circles tangent with a specimen's Mohr's circle represents the specimen's peak stress point.)

Several toolbar buttons determine how the chart appears on the chart report:

Points on Chart

When this button is in the up position the p-q stress paths are omitted from the report's chart.

Best-fit lines on Chart

When this button is in the up position the lines connecting the p-q peak stress points are not shown on the report's chart.

⇒ Check the effect of selecting or deselecting these options by selecting Window > Report Preview.

Chart Effective

CU with pore pressures only: When this button is in the up position the effective p-q paths are omitted from the report's chart.

Chart Total

CU with pore pressures only: When this button is in the up position the total stress p-q paths are omitted from the report's chart.

3.3 Direct Shear Chart Display

For direct shear tests, selecting Window > Charts displays a plot of:

⇒ Peak vs. normal stress

- ⇒ If ultimate stress points have been selected the chart also plots ultimate vs. normal stress

The blue line should connect the "O" markers representing the peak stress points, while the red line (if shown) should connect the "X" markers. SHEAR attempts to automatically adjust these lines for a best-fit. The lines may also be manually adjusted:

1. Click on the **Peak** button to adjust the line connecting the peak stress points, or click on the **Ultimate** button to adjust the ultimate stress points line.
2. Drag (with the left mouse button down) the end of the line to be adjusted.

There are also several toolbar buttons designed to help with the adjustment:

Best Fit

This button returns the line to the program's automatically selected alignment.

Through (0,0)

This button forces the left end of the line to pass through the lower-left corner of the chart; i.e., through (0,0).

Two toolbar buttons determine how the chart appears on the chart report:

Points on Chart

When this button is in the up position the peak and ultimate stress points are omitted from the report's chart.

Best-fit Lines on Chart

When this button is in the up position the lines connecting the peak and ultimate stress points are omitted from the report's chart.

- ⇒ Check the effect of selecting or deselecting these options by selecting Window > Report Preview.

4. Reporting Your Data

SHEAR features three main report styles, discussed in the following sections.

4.1 XML Files

SHEAR's XML files are small files that list all of your raw SHEAR testing data, along with the program's calculated values (e.g., stress, strain, etc.). XML files are saved on-disk and may be viewed by a web browser or by versions of Microsoft Excel newer than Excel2000. This is an ideal format for e-mailing testing data and results to your clients in a format that incorporates both a means of presentation (through a web browser) as well as a means of manipulating the raw data (through a spreadsheet).

XML files are generated by selecting SHEAR > Export XML File. Once exported, a SHEAR XML file may be saved to a web site or e-mailed directly to your clients.

A portion of a SHEAR XML file, as viewed with Internet Explorer, is shown below:

Specimen #2			
	Initial	Mid	Final
Moisture content: Moist soil+tax, gms.	831.8		918.8
Moisture content: Dry soil+tax, gms.	714.6		790.2
Moisture content: Tax, gms.	117.2		128.6
Moisture, %	12.7		16.6
Moist specimen weight, gms.	824.8		
Diameter, in.	2.5		
Area, in. ²	4.909	4.909	4.942
Height, in.	3.25		
Def decrease in height, in.		0	8.22
Def decrease in water volume, cc.		0	33.2
Dry weight, pct	104.8	104.8	100.8
Void ratio	1.5788	0.3790	1.4202
Saturation, %	71.9	90.3	89.2

Feeding to load converter* load ring constant: LRC1=0.2703 LRC2=0 Crossover= units: lbs.									
No.	Def Dial	Def.	Load Dial	Load	Strain %	Stress	Minor Stress	Major Stress	Pore Press
0	0	0.0000	0	0.0	0.0	0.0000	1.0000	1.0000	70
1	0.015	0.0150	53	14.3	0.3	0.2124	1.0000	1.2122	70.1
2	0.03	0.0300	78	21.3	0.6	0.2826	0.9996	1.2862	70.2
3	0.045	0.0450	102	27.6	0.9	0.3777	0.9996	1.3713	70.2
4	0.06	0.0600	115	31.3	1.2	0.4396	0.9864	1.4151	70.3

Figure 4.1.1 -- SHEAR XML File Viewed in Internet Explorer

4.2 Data Summary Reports

Data summary reports list the raw data taken from a SHEAR test (e.g., specimen weights and dimensions, test readings, etc.); the reports may be sent to a printer or saved on disk. Data summary reports are generated by selecting SHEAR > Output Data Summary Report.

TRIAxIAL COMPRESSION TEST				
Cl with Fine Fillers				
				02/01/04
				2:32 PM
Date:	May 21, 1997			
Client:	Kochelot Paving and Restoration Department			
Project:	Kochelot Road and South Entrance			
Location:	Hwy 88-1			
Depth:	3.2 ft			
Quantity:	Down a city CLAY with trace of sand (L)			
Remarks:	Good sample, packed some side holes after winnowing through sand particles			
Type of Sample:	Undisturbed			
Assumed Specific Gravity:	2.65	LL*	PL*	PI*
Test Method:	ASTM D 2922 Method A			
Parameters for Specimen No. 1				
Specimen Parameters:	Initial	Subsided	Consolidated	Final
Moisture content: Wet soil-tare, gms.	68.500			876.800
Moisture content: Dry soil-tare, gms.	61.200			786.800
Moisture content: Tare, gms.	12.600			71.700
Moisture, %	15.9			16.4
Moist specimen weight, gms.	777.900			
Diameter, in.	2.500	2.475	2.406	
Area, in ²	4.909	4.839	4.558	
Height, in.	3.000	2.900	2.800	
Net decrease in height, in.		0.100	0.200	
Net decrease in water volume, cc.		0.488	0.900	
Wet Density, pcf	129.7	136.7	156.5	
Dry density, pcf	105.0	89.2	117.1	
Void ratio	0.5759	0.3261	0.4111	
Subsidence, %	3.33	33.33	33.33	
Test Readings for Specimen No. 1				
Load ring constant = 0.2760 lb./psi ring size				
Membrane modulus = 0.12488 lb./in ²				
Membrane thickness = 0.01 in.				
Filter paper coefficient = 0.00126 lb./in				
Filter paper coverage = 10%				
Consolidation cell pressure = 77.000 psi (5.348 tonf)				
Consolidation back pressure = 79.800 psi (5.660 tonf)				
Consolidation effective confining stress = 0.5988 tonf				
Strain rate, in./min. = 0.011				
Fail. Stress = 0.7550 tonf at reading no. 26				
Ult. Stress = 0.6381 tonf at reading no. 45				

Figure 4.2.1 -- First Page of a Sample Summary Report

- ⇒ **To preview the testing data summary:** right-click on the **SHEAR** link at the bottom of your sample's data entry card from the Data Manager or LD4 screens (see Section 2.7 in the GDM manual or Chapter 6 in the LD4 manual) and select Summary Preview.

4.3 Chart Reports

Chart reports show SHEAR's interpretation of your testing data: depending upon the test method you used, a SHEAR chart report can include graphs of stress vs. strain, Mohr's circles, p-q stress paths, vertical deformation, etc. Most often these are the reports that are submitted to testing clients. Chart reports are generated by selecting SHEAR > Output Chart Report and clicking on the **Output** button.

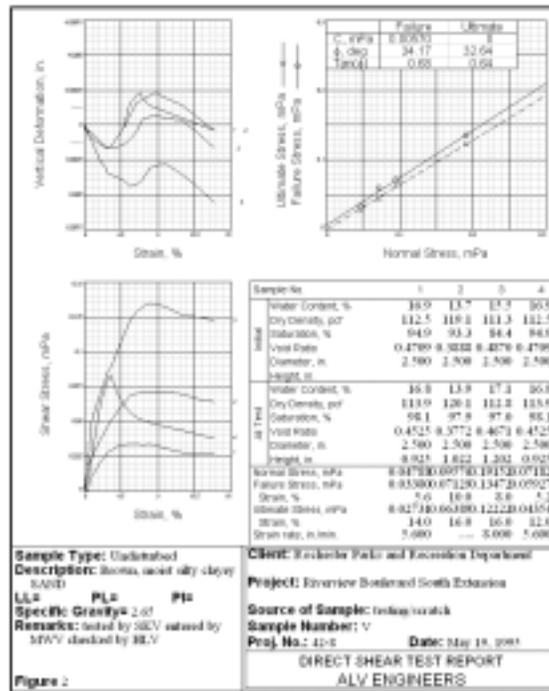


Figure 4.3.1 -- Direct Shear Chart Report

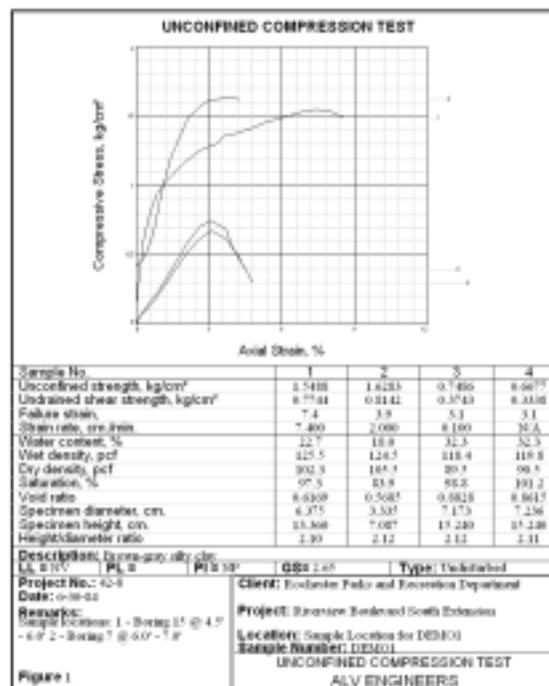


Figure 4.3.2 -- Unconfined Compression Sample Report

SHEAR features three different reporting formats for triaxial data, shown in the following three figures.

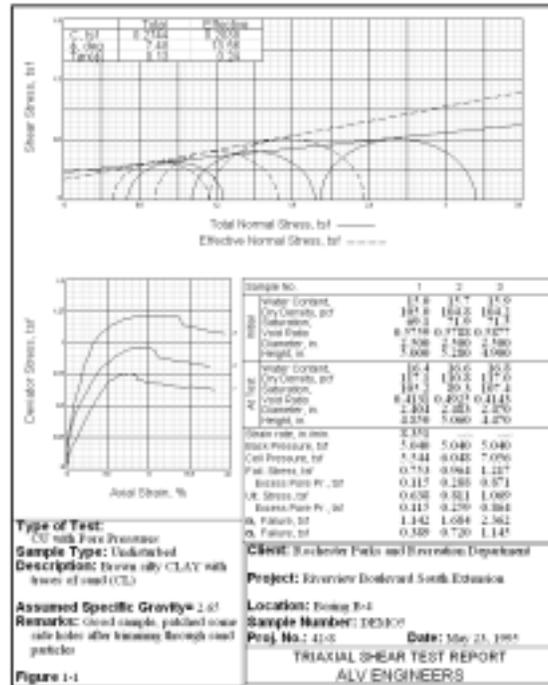


Figure 4.3.3 -- Corps of Engineers Sample Report

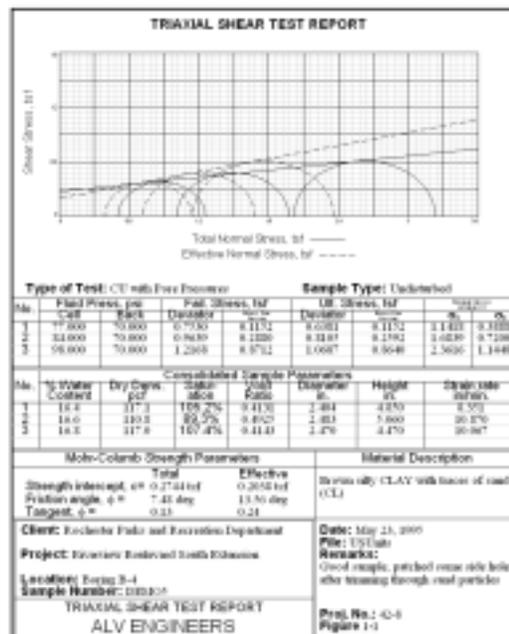


Figure 4.3.4 -- Alternate Report Format Sample

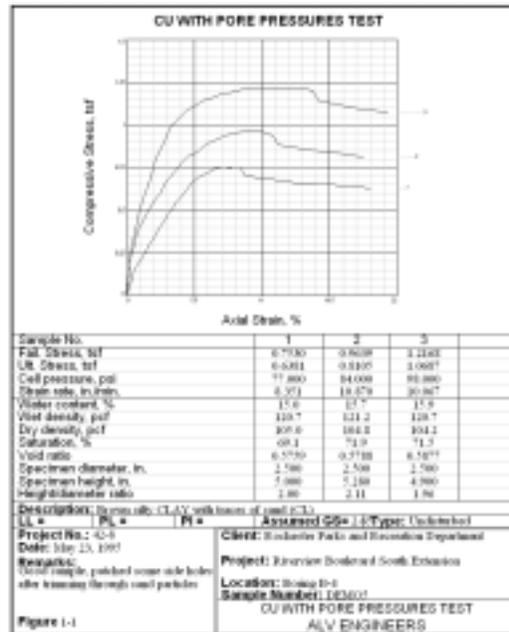


Figure 4.3.5 -- UCC Report Format used with Triaxial Test Data

You can select between the three formats by selecting **Window > Report Preview**, then changing the report format selection:

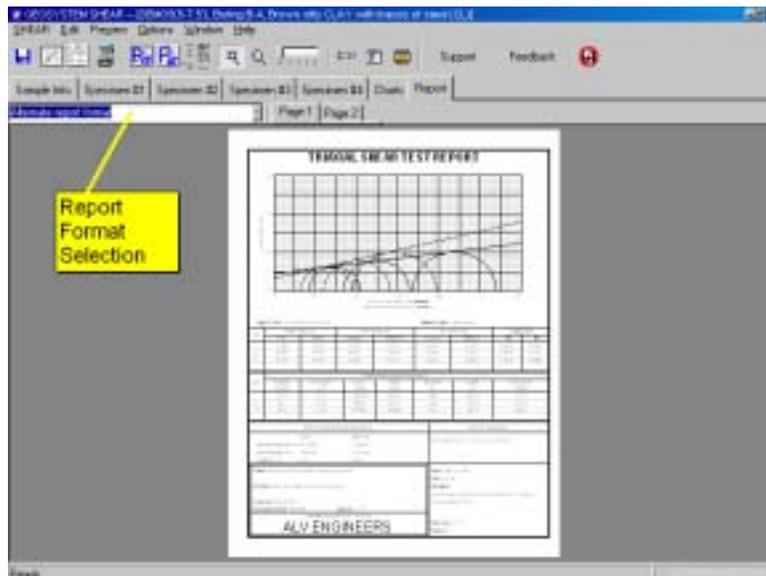


Figure 4.3.6 -- Triaxial Report Format Selection

To preview the testing chart report you can either: right-click on the **SHEAR** link at the bottom of your sample's data entry card from the Data Manager Screen and select Report Preview, or you can click on the **Report** tab at the bottom of the SHEAR data entry screen, or select Window > Report. To print the chart report: select SHEAR > Output Chart Report then click on the **Output** button.

4.3.1 Report Preview Display

Selecting Window > Report Preview displays a preview of the current test's chart report, as shown in Figure 4.3.6.

- ⇒ The display may be magnified by either moving the mouse over the report (which magnifies a portion of the report) or by adjusting the left toolbar slider control, which

looks like this: 

Note: On slower computers and/or higher-resolution displays, the circular magnifier may be unusably slow. Select **Preview** > **Square Magnifier** for a faster magnifier. *(On very slow computers, SHEAR automatically disables the circular magnifier button.)*

- ⇒ There are several selections on the triaxial chart preview and direct shear chart preview screens that control the appearance of the report display.

4.4 Exporting Reports to Files

SHEAR's testing data summary and chart reports may be exported to files that may be posted to a web server or e-mailed to clients. To do this, begin by selecting either SHEAR > Output Data Summary Report or SHEAR > Output Chart Report. You should see the dialog shown in the previous section.

Output to: allows you to choose between sending your report to the printer and sending your report to a disk file in one of several formats:

Adobe Acrobat .PDF

.PDF is a near-universal format for Internet document distribution. Viewing requires the Adobe Reader program that may be downloaded at no charge from Adobe's web site.

AutoCAD .DXF

.DXF is designed for interchange among CAD programs.

Windows Metafile (.EMF)

.EMF files may be inserted as a picture into a word processing document or manipulated with a vector drawing program such as Adobe Illustrator.

Drop down the **Output to:** box and select either “Adobe Acrobat .PDF File”, “Windows Metafile (.EMF)” or “AutoCAD .DXF File”. If you select one of the first two options, you’ll see the following dialog:

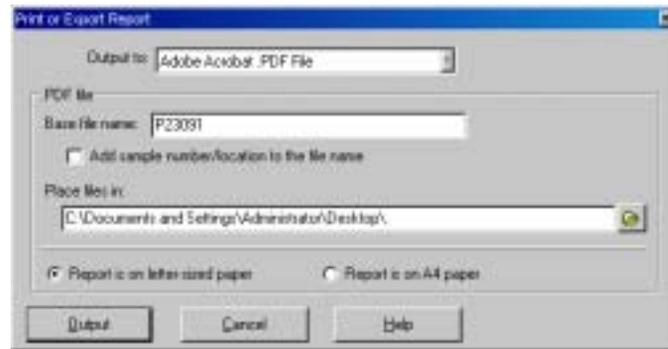


Figure 4.4.1 -- PDF Export Dialog

.DXF files are somewhat more complicated and have more options available:

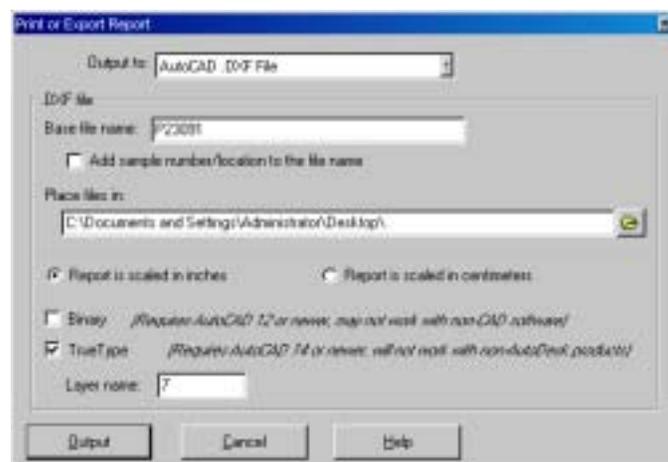


Figure 4.4.2 -- DXF Export Dialog

There are a number of different options available for selecting where and how the reports are exported:

Base file name

When the program creates a .DXF, .PDF or .EMF file of your report, the file's name will start with whatever is entered into this field.

Add sample number/location to the file name

Without this option, the names of the .DXF, .PDF or .EMF files created for exporting a report will be whatever you have selected as the Base file name, plus something like **page 1** at the end. (For example, if the **Base file name** is **P92321**, if the **Add sample number/location to the file name** option was not checked, the first .PDF report file created would be named **P92321 page 1.PDF**, the second report would be named **P92321 page 2.PDF** and on. A client looking at a list of submitted .PDF files would have no way of telling which file corresponds to which tested sample.

Checking the **Add sample number/location to the file name** box alters how the program names the report files: the sample number and/or sampling location is added to the Base file name. Using our previous example, with the box checked the program would create, for example, PDF files named

```
P92321 Sample S-4_Boring B-3.PDF
P92321 Sample S-1_Test Pit TP-2.PDF
etc.
```

⇒ With **Base file name** and **Add sample number/location to the file name** you can come up with some useful file naming variations. For example, you could leave **Add sample number/location to the file name** unchecked and enter the sample number/location as part of the **Base file name** -- of course, this means that when you export the next report, you'd have to change the **Base file name** to reflect the new sample number.

As another example, if you have created a hard disk subdirectory just to hold .PDF files from a certain project, you may not need to include the project number as part of each .PDF file name: instead of being called, for example,

```
P92321 Sample S-4_Boring B-3.PDF
```

(P92321 being the project number), by leaving the Base file name field blank you can get export files with names like **Sample S-4_Boring B-3.PDF**

Place files in

Gives the directory where your exported .PDF, .DXF or .EMF file will be placed.

Report is scaled in

Reports exported as .DXF, .EMF or .PDF measure either 10 units vertically (when scaled in inches) or 25.4 units vertically (when scaled in centimeters). This selection does not affect the report's appearance; rather, it affects the coordinates given to each line and piece of text on the report. As such, the selection is only important when the exported report is to be edited by an illustration or CAD program.

Binary (*.DXF files only*)

Binary .DXF files are smaller (by 25 to 50 percent) and are read by AutoCAD faster, however, reports will appear the same when viewed in a CAD program no matter if this option is selected or not. Note that few illustration programs will read binary .DXF report files.

TrueType (*.DXF files only*)

If this option is unselected, .DXF report files use a monospaced font (similar to this) for everything on the form, meaning that .DXF reports are less attractive than their printed counterparts. The TrueType option allows you to generate .DXF files that look exactly like the printed versions -- however, TrueType .DXF files are only supported on AutoCAD versions 14 and newer; additionally, many other drawing and CAD programs do not support TrueType files.

Layer name (*.DXF files only*)

Specifies the name of the CAD drawing layer on which your report will be drawn. Layer names may be any combination of alphabetic and numeric characters -- however, many CAD programs cannot handle layer names that include spaces. (**MYLAYER** is OK, **MY LAYER** is not.) Since your chosen layer name will be repeated throughout the .DXF report files, the shorter you make the name the smaller in size your .DXF files will become.

After selecting the desired export options, click on the **Output** button to create the file(s) (data summary reports will be exported as two files if you've chosen the .DXF or .EMF file format).

4.5 Copying Reports to the Windows Clipboard

If you're creating a word processing document which incorporates your SHEAR reports, you can skip the process of exporting the report to a file then inserting the file as a picture into your word processing document: instead, open the SHEAR test and select Edit > Copy Data. This places a copy of the SHEAR chart report on the Windows clipboard. To paste the report into your word processing document, start the word processor, open the document and select Edit > Paste.

4.6 Listing Results from Multiple SHEAR Tests

The Data Summary and Export tool discussed in Chapter 4 of the GDM manual and Appendix C of the LD4 User's Guide may be used to summarize the results of multiple SHEAR tests. The configuration file, called **TXSMRY1.LFG**, can be used by selection Tools > Data Summary and Export from the GDM or LD4 menu, then selecting File > Recall Existing Configuration and double-clicking on **TXSMRY1.LFG**.

- ⇒ If you've purchased LD4, you can use **TXSMRY1.LFG** to view an on-screen list of the triaxial tests performed for a project: From the LD4 screen, select Project > Browse and choose **TXSMRY1**.

- ⇒ See § 5.17 for a list of calculated shear testing values that may be summarized or exported.

5. TECHNICAL DOCUMENTATION

The calculations used in the program are presented in the following sections. For purposes of simplification, the units are omitted.

5.1 Initial Specimen Parameters

The initial specimen parameters are the following:

MC_i	= moisture content, percent
γ_{wi}	= wet density
γ_{di}	= dry density
S_i	= saturation, percent
e_i	= void ratio

These initial parameters are calculated using the formulas presented in the following sections.

5.1.1 Initial Moisture Content

$$MC_i = \frac{W_{wt} - W_{dt}}{W_{dt} - W_t}$$

where: MC_i	= initial moisture content (decimal)
W_{wt}	= wet weight and tare
W_{dt}	= dry weight and tare
W_t	= tare weight

5.1.2 Calculating Initial Moisture Content without Initial Moisture Content Data

If the **Skip initial moisture data** selection is chosen (§ 2.1), SHEAR calculates the initial moisture content as follows:

$$MC_i = \frac{W_i - (W_{dt} - W_t)}{W_{dt} - W_t}$$

where: MC_i	= initial moisture content (decimal)
---------------	--------------------------------------

W_i = initial specimen weight
 W_{dt} = final moisture content test: dry weight and tare
 W_t = final moisture content test: tare weight

5.1.3 Initial Wet Density

$$\gamma_{wi} = \frac{W_i}{V_i}$$

where: γ_{wi} = initial wet density
 W_i = initial specimen weight
 V_i = initial volume

5.1.4 Initial Volume

$$V_i = A_i \times H_i$$

where: V_i = initial volume
 A_i = initial cross-sectional area
 H_i = initial height

5.1.5 Initial Cross-Sectional Area for Round Specimen

$$A_i = \frac{\Pi \times D^2}{4}$$

where: A_i = initial cross-sectional area
 D = diameter

5.1.6 Initial Cross-Sectional Area for Square (DS) Specimen

$$A_i = S \times S$$

where: A_i = initial cross-sectional area
 S = side length

5.1.8 Initial Dry Density

$$\gamma_{di} = \frac{\gamma_{wi}}{1 + MC_i}$$

where: γ_{di} = initial dry density

5.1.9 Initial Saturation

$$S_i = \frac{MC_i \times 100}{\frac{UW_w}{\gamma_{di}} - \frac{1}{G_{ms}}}$$

where: S_i = initial sample saturation, %
 UW_w = unit weight of water (62.428 pcf)
 G_{ms} = specific gravity of mineral solids

5.1.10 Initial Void Ratio

$$e_i = \frac{UW_w \times G_{ms}}{\gamma_{di}} - 1$$

where: e_i = initial void ratio

5.2 Corps of Engineers Uniform Strain Calculations

Saturated and consolidated specimen parameters in triaxial tests may change during the saturation or consolidation phase. This is due to changes in height or in volume of pore fluids. This section explains methods of calculating the saturated and consolidated parameters using the Corps of Engineers uniform strain methods. The uniform strain method is the first method presented in § 7.c.2 of the Corps of Engineers lab manual EM 110-2-1906 Appendix X.

5.2.1 Saturated Moisture Content

$$MC_s = \frac{W_{ws}}{W_{ms}}$$

where: MC_s = saturated moisture content (decimal)
 W_{ws} = weight of pore water, saturated
 W_{ms} = weight of mineral solids

Weight of pore water:

$$W_{ws} = (V_s - V_{ms}) \times UW_w$$

where: V_s = saturated volume
 V_{ms} = volume of mineral solids
 UW_w = unit weight of water

Saturated volume:

$$V_s = (H_i - \Delta H_s) \times A_i \times \frac{H_i - 2 \times \Delta H_s}{H_i}$$

where: V_s = saturated volume
 ΔH_s = change in height during saturation
 A_i = initial area

Weight of mineral solids:

$$W_{ms} = \frac{W_i}{1 + MC_i}$$

Volume of mineral solids:

$$V_{ms} = \frac{W_{ms}}{UW_{ms}}$$

where: UW_{ms} = unit weight of mineral solids

5.2.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_{ms}}$$

where: γ_{ds} = saturated dry density

5.2.3 Saturated Saturation

By definition, the saturated saturation in a Corps of Engineers, uniform strain method test is 100%.

5.2.4 Consolidated Moisture Content

$$MC_c = \frac{W_{wc}}{W_{ms}}$$

where: MC_c = consolidated moisture content (decimal)
 W_{wc} = weight of pore water, consolidated

Weight of pore water:

$$W_{wc} = (V_c - V_{ms}) \times UW_w$$

where: V_c = consolidated volume

Consolidated volume:

$$V_c = (H_i - DH_s - DH_c) \times A_i \times \frac{H_i - 2 \times (DH_s + DH_c)}{H_i}$$

where: V_c = consolidated volume
 ΔH_c = change in height during consolidation

5.2.5 Consolidated Dry Density

$$\gamma_{dc} = \frac{W_{ms}}{V_c}$$

where: γ_{dc} = consolidated dry density

5.2.6 Consolidated Saturation

By definition, the consolidated saturation in a Corps of Engineers, uniform strain method test is 100%.

5.2.7 Consolidated Area

$$A_c = A_i \times \frac{H_i - 2 \times (\Delta H_s + \Delta H_c)}{H_i}$$

where: A_i = initial area
 H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.3 Corps of Engineers (Saturation Assumed) Calculations

Saturated and consolidated specimen parameters in triaxial tests may change during the saturation or consolidation phase due to changes in height or in volume of pore fluids. This section explains methods of calculating the saturated and consolidated parameters using the Corps of Engineers saturation assumed methods. The saturation assumed method is the second method presented in § 7.c.2 of the Corps of Engineers lab manual EM 110-2-1906 Appendix X.

5.3.1 Saturated Moisture Content

$$MC_s = \frac{W_{ws}}{W_{ms}}$$

where: MC_s = saturated moisture content (decimal)
 W_{ws} = weight of pore water, saturated
 W_{ms} = weight of mineral solids

Weight of pore water:

$$W_{ws} = W_{wi} + (\Delta V_{ws} \times UW_w)$$

where: ΔV_{ws} = change in volume of water during saturation
 W_{wi} = initial weight of water

Initial weight of water:

$$W_{wi} = \frac{W_i}{1 + \frac{1}{MC_i}}$$

where: W_i = initial sample weight

Weight of mineral solids:

$$W_{ms} = W_i - W_{wi}$$

5.3.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_s}$$

where: γ_{ds} = saturated dry density
 V_s = saturated volume

Saturated volume:

$$V_s = V_{ms} + V_{wi} - \Delta V_s$$

where: V_s = saturated volume
 V_{ms} = volume of mineral solids
 V_{wi} = initial volume of water
 ΔV_s = change in water volume during saturation

Volume of mineral solids:

$$V_{ms} = \frac{W_{ms}}{UW_{ms}}$$

where: UW_{ms} = unit weight of mineral solids

Initial volume of water:

$$V_{wi} = \frac{W_{wi}}{UW_w}$$

where: UW_w = unit weight of water

5.3.3 Saturated Saturation

By definition, the saturated saturation in a Corps of Engineers, saturation assumed method test is 100%.

5.3.4 Consolidated Moisture Content

$$MC_c = \frac{W_{wc}}{W_{ms}}$$

where: MC_c = consolidated moisture content (decimal)
 W_{wc} = weight of pore water, consolidated

Weight of pore water:

$$W_{wc} = W_{ws} + (\Delta V_{wc} \times UW_w)$$

where: ΔV_{wc} = change in volume of water during consolidation
 W_{wi} = initial weight of water

5.3.5 Consolidated Dry Density

$$\gamma_{dc} = \frac{W_{ms}}{V_c}$$

where: γ_{dc} = consolidated dry density
 V_c = consolidated volume

Consolidated volume:

$$V_c = V_s - \Delta V_{wc}$$

where: V_c = consolidated volume
 V_s = saturated volume
 ΔV_{wc} = change in water volume during consolidation

5.3.6 Consolidated Saturation

By definition, the consolidated saturation in a Corps of Engineers, saturation assumed method test is 100%.

5.3.7 Consolidated Area

$$A_c = \frac{V_c}{H_c}$$

where: V_c = consolidated volume
 H_c = consolidated sample height

Consolidated sample height:

$$H_c = H_i - \Delta H_s - \Delta H_c$$

where: H_c = consolidated height
 H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.4 ASTM D 4767 Method A Calculations

Saturated and consolidated specimen parameters in triaxial tests may change during the saturation or consolidation phase due to changes in height or in volume of pore fluids. This section explains methods of calculating the saturated and consolidated parameters using the ASTM Method A.

5.4.1 Saturated Moisture Content

Saturated moisture content, based on final moisture, adjusted for change in pore water volume during consolidation:

$$MC_s = MC_f + \frac{\Delta V_{wc} \times UW_w}{W_{ms}}$$

where: MC_s = saturated moisture content (decimal)
 MC_f = final moisture content
 ΔV_{wc} = change in volume of water during consolidation
 W_{ms} = weight of mineral solids
 UW_w = unit weight of water

Weight of mineral solids:

$$W_{ms} = \frac{W_i}{1 + MC_i}$$

where: W_i = initial sample weight
 MC_i = initial moisture content

5.4.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_s}$$

where: γ_{ds} = saturated dry density
 V_s = saturated volume

Saturated volume:

$$V_s = A_s \times H_s$$

where: A_s = saturated area
 H_s = saturated height

Saturated area:

$$A_s = A_i \times \frac{H_s - 2 \times \Delta H_s}{H_s}$$

where: A_i = initial area
 H_s = saturated height
 ΔH_s = change in height during saturation

Saturated height:

$$H_s = H_i - \Delta H_s$$

where: H_s = saturated height
 H_i = initial height
 ΔH_s = change in height during saturation

5.4.3 Saturated Saturation

$$S_s = \frac{MC_s}{\frac{UW_w}{\gamma_{ds}} - \frac{1}{G_{ms}}} * 100$$

where: S_s = saturated sample saturation, %
 UW_w = unit weight of water (62.428 pcf)
 G_{ms} = specific gravity of mineral solids

5.4.4 Consolidated Moisture Content

ASTM Method A uses the final moisture content as the consolidated moisture content.

5.4.5 Consolidated Dry Density

The ASTM Method A consolidated dry density calculation is identical to the COE, saturation assumed dry density calculation covered in § 5.3.5.

5.4.6 Consolidated Saturation

$$S_c = \frac{MC_c}{\frac{UW_w}{\gamma_{dc}} - \frac{1}{G_{ms}}} * 100$$

where: S_c = consolidated sample saturation, %
 UW_w = unit weight of water (62.428 pcf)
 G_{ms} = specific gravity of mineral solids

5.4.7 Consolidated Area

$$A_c = \frac{V_i - \Delta V_s - \Delta V_c}{H_c}$$

where: A_c = consolidated area
 V_i = initial volume
 ΔV_s = change in volume during saturation
 ΔV_c = change in volume during consolidation
 H_c = consolidated sample height

Change in volume during saturation:

$$\Delta V_s = 3 \times V_i \times (\Delta H_s / H_i)$$

where: ΔH_s = change in height during saturation
 H_i = initial height

Consolidated height:

$$H_c = H_i - \Delta H_s - \Delta H_c$$

where: H_c = consolidated height
 H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.5 ASTM D 4767 Method B Calculations

Saturated and consolidated specimen parameters in triaxial tests may change during the saturation or consolidation phase due to changes in height or in volume of pore fluids. This section explains methods of calculating the saturated and consolidated parameters using the ASTM Method B methods.

5.5.1 Saturated Moisture Content

The ASTM Method B saturated moisture content calculation is identical to the Method A calculation documented in § 5.4.1.

5.5.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_s}$$

where: γ_{ds} = saturated dry density
 V_s = saturated volume

Saturated volume:

$$V_s = V_{wf} + V_{ms} + \Delta V_{wc}$$

where: V_{wf} = final volume water
 V_{ms} = volume of mineral solids
 ΔV_{wc} = change in water volume during consolidation

Volume of mineral solids:

$$V_{ms} = \frac{W_i}{(1 + MC_i) \times G_s}$$

where: W_i = initial sample weight
 MC_i = initial moisture content
 G_s = specific gravity of mineral solids

Final volume of water:

$$V_{wf} = \frac{W_{ms} \times MC_f}{UW_w}$$

where: W_{ms} = weight of mineral solids
 MC_f = final moisture content
 UW_w = unit weight of water (1 gm/cc)

5.5.3 Saturated Saturation

By definition, the saturated saturation in an ASTM Method B test is 100%.

5.5.4 Consolidated Moisture Content

ASTM Method B uses the final moisture content as the consolidated moisture content.

5.5.5 Consolidated Dry Density

$$\gamma_{dc} = \frac{W_{ms}}{V_c}$$

where: γ_{dc} = consolidated dry density
 V_c = consolidated volume

Consolidated volume:

$$V_c = V_{ms} + V_{wf}$$

where: V_c = consolidated volume
 V_{ms} = volume of mineral solids
 V_{wf} = final pore water volume

5.5.6 Consolidated Saturation

By definition, the consolidated saturation in an ASTM Method B test is 100%.

5.5.7 Consolidated Area

$$A_c = \frac{V_c}{H_c}$$

where: A_c = consolidated area
 V_c = consolidated volume
 H_c = consolidated sample height

Consolidated volume:

$$V_c = V_{wf} + V_{ms}$$

where: V_{wf} = final volume water
 V_{ms} = volume of mineral solids

Consolidated height:

$$H_c = H_i - \Delta H_s - \Delta H_c$$

where: H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.6 ASTM D 4767 Method B with Saturation Estimate Calculations

A variation of ASTM Method B allows the user to employ an estimate of the consolidated specimen saturation rather than assuming 100%. It is available only for CU tests. This section explains methods of calculating the saturated and consolidated parameters using this variation of ASTM Method B.

5.6.1 Saturated Moisture Content

This calculation is identical to the one covered in § 5.4.1.

5.6.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_s}$$

where: γ_{ds} = saturated dry density
 V_s = saturated volume

Saturated volume:

$$V_s = V_{ms} + V_{vf} + \Delta V_c$$

where: V_{ms} = volume of mineral solids
 V_{vf} = final volume voids
 ΔV_c = change in water volume during consolidation

Volume of mineral solids:

$$V_{ms} = \frac{W_i}{(1 + MC_i) \times G_s}$$

where: W_i = initial sample weight
 MC_i = initial moisture content
 G_s = specific gravity of mineral solids

Final volume of voids:

$$V_{vf} = \frac{W_{ms} \times MC_f}{S_c \times UW_w}$$

where: W_{ms} = weight of mineral solids
 $MC_f\%$ = final moisture content (%)
 S_c = estimated consolidated (final) saturation
 UW_w = unit weight of water (1 gm/cc)

5.6.3 Saturated Saturation

This calculation is identical to the ASTM Method A saturated saturation calculation covered in § 5.4.3.

5.6.4 Consolidated Moisture Content

ASTM Method B, Sat. Est. uses the final moisture content as the consolidated moisture content.

5.6.5 Consolidated Dry Density

$$\gamma_{dc} = \frac{W_{ms}}{V_c}$$

where: γ_{dc} = consolidated dry density
 V_c = consolidated volume

Consolidated volume:

$$V_c = V_{ms} + V_{vf}$$

where: V_c = consolidated volume
 V_{ms} = volume of mineral solids
 V_{vf} = final volume of voids

5.6.6 Consolidated Saturation

The consolidated saturation is the value entered as the estimated consolidated saturation.

5.6.7 Consolidated Area

$$A_c = \frac{V_c}{H_c}$$

where: A_c = consolidated area
 V_c = consolidated volume
 H_c = consolidated sample height

Consolidated volume:

$$V_c = V_{ms} + V_{vf}$$

where: V_{ms} = volume of mineral solids
 V_{vf} = final volume of voids

Consolidated height:

$$H_c = H_i - \Delta H_s - \Delta H_c$$

where: H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.7 Corps of Engineers Uniform Strain with Water Volume Measurements

This method is a variant of the Corps of Engineers uniform strain method. The uniform strain method is the first method presented in § 7.c.2 of the Corps of Engineers lab manual EM 110-2-1906 Appendix X. This variant does not assume 100% saturation, but rather calculates saturations based on water volume changes. Specimen volume changes are based on the uniform strain equations like the COE Uniform Strain method. However, if the resulting saturation is greater than 100%, the calculations revert to the COE Saturation Assumed method (100% saturation assumed.)

5.7.1 Saturated Moisture Content

$$MC_s = MC_i - \frac{\Delta V_{ws} \times UW_w}{W_{ms}}$$

where: MC_s = saturated moisture content (decimal)
 MC_i = initial moisture content (decimal)
 ΔV_{ws} = change in volume of water during saturation
 W_{ms} = weight of mineral solids
 UW_w = unit weight of water (1 gm/cc)

Weight of mineral solids:

$$W_{ms} = \frac{W_i}{1 + MC_i}$$

where: W_i = initial sample weight

5.7.2 Saturated Dry Density

$$\gamma_{ds} = \frac{W_{ms}}{V_s}$$

where: γ_{ds} = saturated dry density
 V_s = saturated volume

Saturated volume:

$$V_s = (H_i - \Delta H_s) \times A_i \times \frac{H_i - 2 \times \Delta H_s}{H_i}$$

where: V_s = saturated volume
 ΔH_s = change in height during saturation
 A_i = initial area

Minimum allowable saturated volume:

$$V_{s(\min)} = V_{ms} + V_{wi} - \Delta V_s$$

where: $V_{s(\min)}$ = saturated volume
 V_{ms} = volume of mineral solids
 V_{wi} = initial volume of water
 ΔV_s = change in water volume during saturation

Initial volume of water:

$$V_{wi} = \frac{W_{wi}}{UW_w}$$

where: W_{wi} = initial weight of water (as documented in § 5.3.1)
 UW_w = unit weight of water (1gm/cc)

5.7.3 Saturated Saturation

The saturated saturation will either be 100%, if the minimum volume criteria was used, or be calculated as documented in § 5.4.3.

5.7.4 Consolidated Moisture Content

$$MC_c = MC_s - \frac{\Delta V_{wc} \times UW_w}{W_{ms}}$$

where: MC_s = saturated moisture content (decimal)
 MC_c = consolidated moisture content (decimal)
 W_{wc} = weight of pore water, consolidated

5.7.5 Consolidated Dry Density

$$\gamma_{dc} = \frac{W_{ms}}{V_c}$$

where: γ_{dc} = consolidated dry density
 V_c = consolidated volume

Consolidated volume:

$$V_c = (H_i - \Delta H_s - \Delta H_c) \times A_i \times \frac{H_i - 2 \times (\Delta H_s + \Delta H_c)}{H_i}$$

where: V_c = consolidated volume
 ΔH_c = change in height during consolidation

Minimum consolidated volume:

$$V_{c(\min)} = V_{s(\min)} - \Delta V_c$$

where: $V_{c(\min)}$ = minimum consolidated volume
 $V_{s(\min)}$ = minimum saturated volume
 ΔV_c = change in water volume during consolidation

$\Rightarrow V_{c(\min)}$ will always be used if $V_{s(\min)}$ was used.

5.7.6 Consolidated Saturation

The consolidated saturation will either be 100%, if the minimum volume criteria was used, or calculated as documented in § 5.4.6.

5.7.7 Consolidated Area

$$A_c = \frac{V_c}{H_c}$$

where: V_c = consolidated volume, from either the uniform strain calculation or the 100% saturation calculation
 H_c = consolidated sample height

Consolidated height:

$$H_c = H_i - \Delta H_s - \Delta H_c$$

where: H_c = consolidated height
 H_i = initial height
 ΔH_s = change in height during saturation
 ΔH_c = change in height during consolidation

5.8 Saturated Void Ratio

The saturated void ratio calculation is identical for all triaxial methods:

$$e_s = \frac{UW_w \times G_s}{\gamma_{ds}} - 1$$

where: e_s = saturated void ratio
 γ_{ds} = saturated dry density

5.9 Consolidated Void Ratio

The consolidated void ratio calculation is identical for all triaxial methods:

$$e_c = \frac{UW_w \times G_s}{\gamma_{dc}} - 1$$

where: e_c = consolidated void ratio
 γ_{dc} = consolidated dry density

5.10 Final Moisture Content

The final moisture content is calculated using the same method as the initial. Refer to § 5.1.1 for details.

5.11 Stress and Strain Calculations - TX and UCC

Stress and strain calculations for triaxial and unconfined compression tests are very similar. Triaxial tests differ in that they may include corrections for filter paper and rubber membrane strengths. Additionally, consolidated drained (CD) tests may have volumetric change readings that enter into the calculation of the cross-sectional area. The following sections explain the methods used in these calculations.

5.11.1 Strain Calculations - TX and UCC

The sample strain at any given reading is the ratio of the change in sample height to the initial sample height. It is usually expressed as a percentage.

⇒ **Note:** When entering deformation data for a staged test the initial dial reading should not be entered as 0 unless the dial gauge (digital display) is actually reset. It is necessary that the strain at the initial reading for all specimens is 0 when entering readings for staged tests.

Strain:

$$\varepsilon = \frac{\Delta H_n}{H_c}$$

where: ε = strain (decimal)
 ΔH_n = change in height at reading n
 H_c = consolidated (TX) or initial (UCC) specimen height

$$\Delta H_n = (DD_n - DD_i) \times DDC$$

where: DD_n = deformation dial reading in user units at dial reading n
 DD_i = initial reading, user units
 DDC = dial constant converting input units to actual units of length

5.11.2 Deviator Stress Calculations - Triaxial and Unconfined Compression

Deviator stresses are calculated from the axial load and the specimen area. Triaxial deviator stresses may optionally be adjusted for filter paper and/or rubber membrane strengths. Drained triaxial tests may alternatively use effluent volume measurements for determining volume changes, area changes, and volumetric strain.

Deviator stress:

$$\Delta\sigma_n = \frac{P_n}{A_n} - \sigma_{fp} - \sigma_{rm}$$

Where: $\Delta\sigma_n$ = deviator stress
 P_n = applied load
 A_n = area at reading n
 σ_{fp} = strength contribution of the filter paper (TX only)
 σ_{rm} = strength contribution of the rubber membrane (TX only)

If using proving rings, the load P is:

$P_n = (LDR_n - LDR_i) \times LRC_1$ for single stage rings and 2 stage rings up to the crossover reading
 $P_n = (LDCR - LDR_i) \times LRC_1 + (LDR_n - LDCR) \times LRC_2$ for double stage rings past the crossover
 $P_n = A \times LDR_n + B$ for Ax + B type rings

where: LRC_1 = primary load ring constant
 LRC_2 = secondary load ring constant
 $LRCR$ = load ring crossover reading
 A = reading coefficient with Ax+B rings
 B = ordinal intercept with Ax+B rings

Area at reading n (UCC and undrained TX):

$$A_n = \frac{A_c}{1 - \epsilon_n}$$

where: A_c = consolidated area of the sample
 ϵ_n = strain (decimal) at reading n

Area at reading n (drained TX):

$$A_n = \frac{V_n}{H_n}$$

where: V_n = specimen volume at reading n
 H_n = specimen height at reading n

$$V_n = V_c - \Delta V_n$$

where: V_c = consolidated specimen volume
 ΔV_n = change in volume from effluent measurements at reading n

$$H_n = H_c - \Delta H_n$$

where: H_c = consolidated specimen height
 ΔH_n = change in height at reading n

σ_{fp} at reading n ($\epsilon_n < 0.02$):

$$\sigma_{fp} = 50 \times \epsilon_n \times \frac{K_{fp} \times P_{fp}}{A_c}$$

σ_{fp} at reading n ($\epsilon_n \geq 0.02$):

$$\sigma_{fp} = \frac{K_{fp} \times P_{fp}}{A_c}$$

where: σ_{fp} = theoretical strength contribution of the filter paper
 K_{fp} = load carried by the filter paper strip per unit length of perimeter
 P_{fp} = length of perimeter covered by filter paper
 A_c = consolidated area of specimen

$$P_{fp} = \frac{\pi \times D_i \times C_{fp}}{100\%}$$

where: π = mathematical pi, 3.14159...
 D_i = initial specimen diameter
 $C_{fp}\%$ = percent of the perimeter covered by filter paper

σ_{rm} at reading n:

$$\sigma_{rm} = \frac{4 \times E_{rm} \times t_{rm} \times \epsilon_n}{D_c}$$

where: σ_{rm} = theoretical strength contribution of the rubber membrane
 E_{rm} = modulus of elasticity of the rubber membrane
 t_{rm} = thickness of the rubber membrane
 ϵ_n = strain at reading n (decimal)
 D_c = consolidated diameter of specimen

⇒ If $\sigma_{rm} / \Delta\sigma_n$ is less than 5%, the effect of the membrane is ignored.

5.11.3 Unconfined Compression Undrained Shear Strength

The undrained shear strength of a soil, as determined in an unconfined compression test, is defined as:

$$s = \frac{q_u}{s}$$

where: s = undrained shear strength
 q_u = unconfined compressive strength

5.11.4 Triaxial Principal Stresses and Stress Paths

For triaxial tests, the major and minor principal stresses (σ_1 and σ_3) are determined as follows:

$$\sigma_3 = CPP - U$$

where: CPP = cell pressure
 U = pore pressure

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

where: $\Delta\sigma$ = deviator stress

For strengths based on total stresses, U is 0.

5.12 Direct Shear Stress and Deformation Calculations

The stress and deformation values for direct shear tests are calculated using the formulas in the following sections.

5.12.1 Deformation Calculations

$$\delta_h = (DD_n - DD_i) \times DDC$$

where: δ_h = horizontal deformation
 DD_n = deformation dial reading, user units
 DD_i = initial reading, user units
 DDC = dial constant, units per input unit

5.12.2 Direct Shear Stress Calculations

$$\tau_n = \frac{T_n}{A_n}$$

where: τ_n = shear stress
 T_n = shear force
 A_n = area

When using proving rings, the shear force T is:

$T_n = (LDR_n - LDR_i) \times LRC_1$ for single stage rings and 2 stage rings up to the crossover reading

$T_n = (LDCR - LDR_i) \times LRC_1 + (LDR_n - LDCR) \times LRC_2$ for double stage rings past the crossover

$T_n = A \times LDR_n + B$ for Ax + B type rings

where: LRC_1 = primary load ring constant
 LRC_2 = secondary load ring constant
 $LRCR$ = load ring crossover reading
 A = reading coefficient with Ax+B rings
 B = ordinal intercept with Ax+B rings

For normal calculations using constant area:

$$A_n = A_i$$

When using the area adjustment formulas with square cross sectional areas:

$$A_n = A_i - (S \times \delta_h)$$

Where: A_n = area of a square specimen at reading n, adjusted for strain
 A_i = initial sample area
 S = side length
 δ_h = horizontal deformation

When using the area adjustment formulas with circular cross sectional areas:

$$A_n = \pi \times \frac{D_i^2}{4.0} \times \frac{(\Theta - \sin(\Theta))}{\pi}$$

where: A_n = area of a round specimen, adjusted for strain
 D_i = initial diameter
 θ = $2 \times \arccos\left(\frac{\delta_h}{D_i}\right)$

5.13 Triaxial Mohr's Circles and Tangent Envelope Calculations

Mohr's circle based on stresses at failure is plotted on a graph of shear stress versus normal stress. The circle starts at σ_3 for the left side of the circle and ends at σ_1 for the right side of the circle. In terms of the parameters p and q , associated with stress paths, the center of the circle is at p and the radius is length q where:

$$p = \frac{\sigma_1 + \sigma_3}{2}$$

and

$$q = \frac{\sigma_1 - \sigma_3}{2}$$

The program's placement of the tangent envelope is based on a linear regression fit of the p and q values, resulting in an equation of the form:

$$p = a + \alpha \times q$$

A tangent line is then drawn on the Mohr's circle plots using the equation:

$$\tau = c + \sigma \times \tan(\phi)$$

Where: τ = shear stress
 σ = normal stress
 Φ = friction angle
 c = cohesion (shear stress intercept)
 a = $\arcsin(\tan \alpha)$
 c = $\frac{a}{\cos(\phi)}$

5.14 Direct Shear Tangent Line Calculations

The direct shear tangent line is determined using a linear least squares correlation routine. The failure shear stress points for each of the test's normal loads are fit with a line of the form:

$$\tau = c + \sigma \times \tan(\phi)$$

where: τ = shear stress
 σ = normal stress
 Φ = friction angle
 c = cohesion (shear stress intercept)

5.15 Calculation Differences for Staged Tests

A staged test, one where a single specimen is used for multiple shear runs at different normal or confining stresses, has its constitutive parameters handled differently. Since only one specimen is tested, there is only one set of initial specimen parameters. Likewise, since the sample need only be subjected to a single saturation cycle, those constitutive values need only be determined once.

In triaxial tests, stages subsequent to the first begin at the state where the last state ended. At that point the volume is assumed to be the same as when the previous consolidation cycle ended, but the height and area have changed. The specimen is then subjected to another consolidation cycle at a higher normal or confining stress. When there are measurements taken of pore water volume changes, these values are used to determine the constitutive parameters. For example, if ASTM Method B is used, the consolidated volume at the end of the first stage can be calculated by working back from the final stage:

$$V_c = V_{ms} + V_{vf} + \Delta V_{vw3} + \Delta V_{vw2}$$

where: V_{ms} = volume of mineral solids
 V_{vf} = final volume of voids
 ΔV_{vw3} = change in water volume during 3rd stage consolidation
 ΔV_{vw2} = change in water volume during 2nd stage consolidation

Other methods similarly adapt to staged tests. Contact GEOSYSTEM Software for additional technical documentation if desired.

5.16 Online Testing Sets

If you have Internet Explorer version 6.0 or later, or Mozilla 1.0 or later or Netscape 7.0 or later, you can view examples of the test sets used to verify the program's calculations at:

<http://www.geosystemsoftware.com/products/shearv4/testing/>

These examples include extensive annotations documenting our manual verification of the program's results.

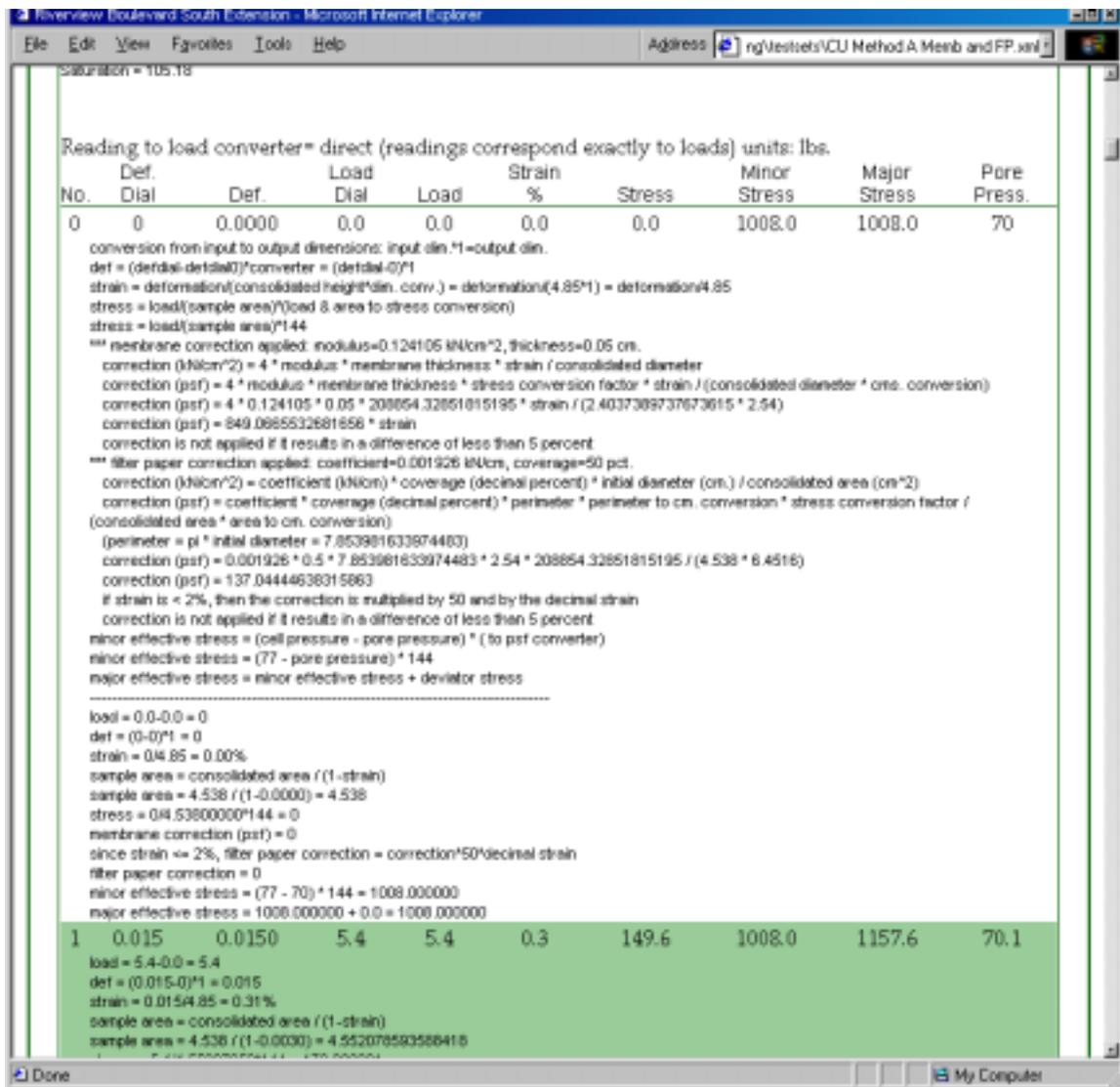


Figure 5.16.1 -- Sample SHEAR Test Set with Annotations

5.17 Values Available for Data Summaries

For each entered test, SHEAR calculates several different values that may be used on data summaries created by the GDM "Data Summary and Export" tool (see Chapter 4 in the Data Manager manual or Appendix C in the LD4 User's Guide). The following table lists the names and a short description of all the calculated values provided by SHEAR:

Item Name	Description
SHSMP1PEAKSTRESS, SHSMP2PEAKSTRESS, SHSMP3PEAKSTRESS, SHSMP4PEAKSTRESS	Peak stress encountered by each of the four SHEAR test specimens
SHSMP1PEAKSTRAIN, SHSMP2PEAKSTRAIN, SHSMP3PEAKSTRAIN, SHSMP4PEAKSTRAIN	Strain at peak stress encountered
SHSMP1ULTSTRESS, SHSMP2ULTSTRESS, SHSMP3ULTSTRESS, SHSMP4ULTSTRESS	Ultimate stress encountered by each of the four SHEAR test specimens. <i>Not</i> an automatic selection: see the <i>ultimate stress selection</i> discussion in § 2.2.4.
SHSMP1ULTSTRAIN, SHSMP2ULTSTRAIN, SHSMP3ULTSTRAIN, SHSMP4ULTSTRAIN	Strain at ultimate stress encountered
SHSMP1CELLPRESS, SHSMP2CELLPRESS, SHSMP3CELLPRESS, SHSMP4CELLPRESS	Triaxial tests only: chamber cell pressure
SHSMP1BACKPRESS, SHSMP2BACKPRESS, SHSMP3BACKPRESS, SHSMP4BACKPRESS	Triaxial tests only: back pressure
SHSMP1NORMLSTRESS, SHSMP2NORMLSTRESS, SHSMP3NORMLSTRESS, SHSMP4NORMLSTRESS	Direct shear tests only: is the normal stress for each of the four samples
SHSMP1STRAINRATE, SHSMP2STRAINRATE,	Rate of strain used during the test

SHSMP3STRAINRATE, SHSMP4STRAINRATE	
COHESION, FRICTION_ANGLE	Resistance at 0 normal stress and friction angle
EFF_COHESION, EFF_FRICTION_ANGLE	Resistance at 0 normal effective stress and effective stress friction angle
PQ_A, PQ_ALPHA	P-q stress path tangent q intercept and tangent angle
EFF_PQ_A, EFF_PQ_ALPHA	P-q effective stress path tangent q intercept and tangent angle
ULT_COHESION	Direct shear resistance @ 0 normal ultimate stress
DIDTX, DIDDS, DIDUCC	DIDTX, DIDDS and DIDUCC are initialized to Y for any samples for which a triaxial, direct shear or unconfined test was performed (respectively) – can be used to count the number of tests performed for a given project.

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