THE CASE DATA BASE

Version 1.1.0.0

For Windows 7 and Windows 10

for

Geotechnical Laboratory Testing

by

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Case Western Reserve University
Cleveland, Ohio 44106

THE CASE DATA BASE PROGRAM

For

GEOTECHNICAL LABORATORY TESTING
(1989-1992)

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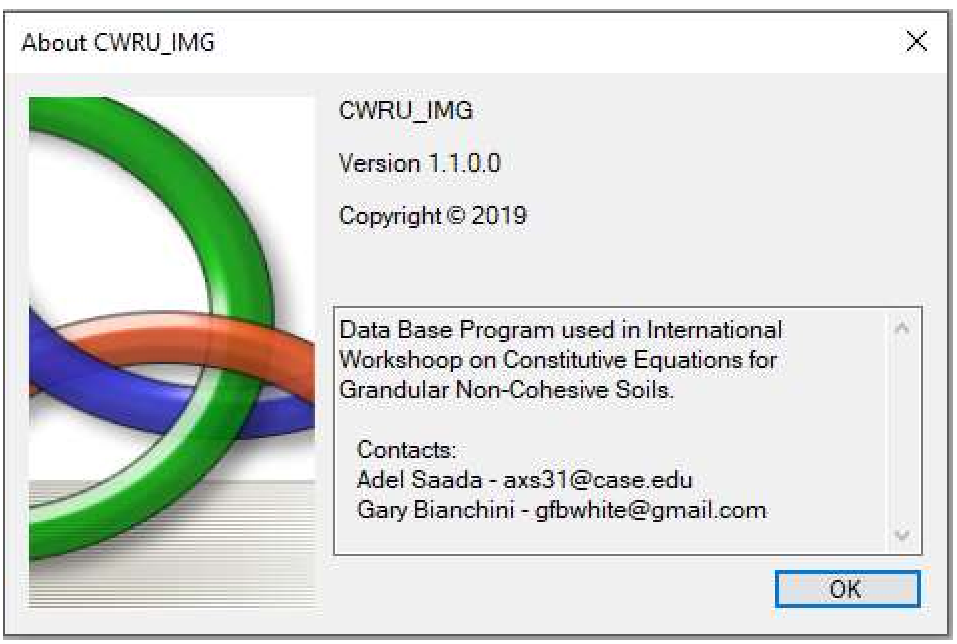

DISCLAIMER

Although both Drs. Bianchini and Saada and some of their colleagues and students have tested the code, it is possible that it may not function properly in environments under which it has not been tested. The programs are provided "as is" and the authors disclaim any and all responsibility for damages resulting from their use or misuse. Sole responsibility for determining the suitability of the code rests with the users.

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

CONTENTS

1 THE USER'S MANUAL

1.1 Introductory demonstration

This demonstration presents an overview and scope of this program. The user can choose either The International System of Units or The US Standard System of Units.

1. **Selecting one or more of the tests that are listed in the Tree View (Figure 1-1). Double click to position a test in the Collection Box.**

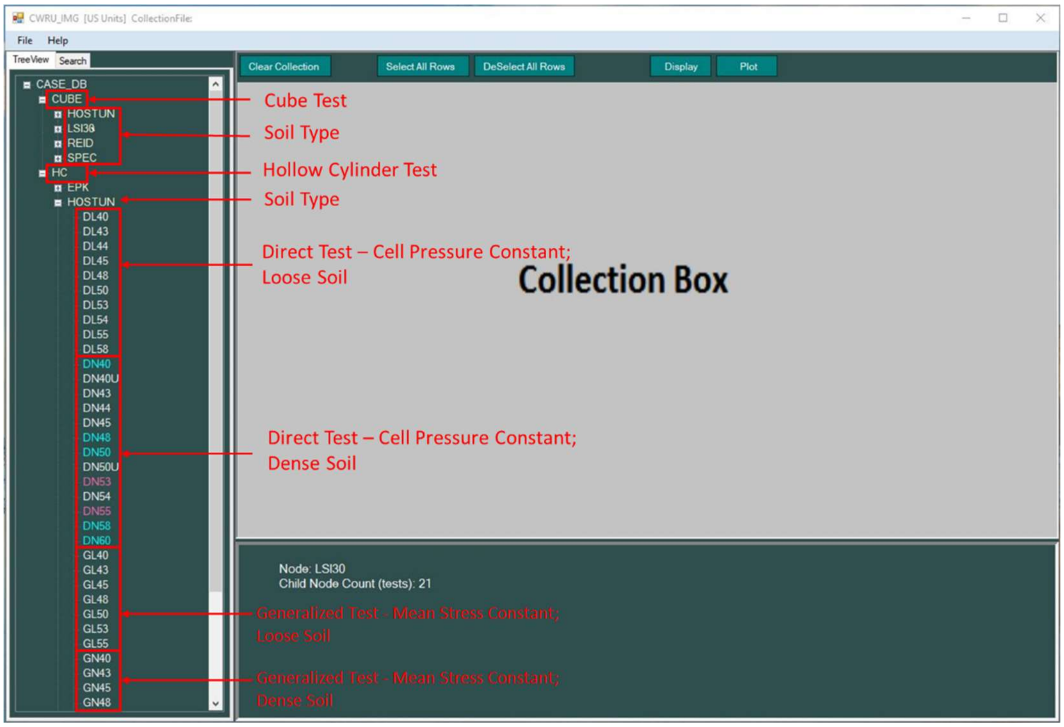


Figure 1-1: Tests in the Tree View

2. Choosing the tests. Only marked tests can be Displayed or Plotted (Figure 1-2).

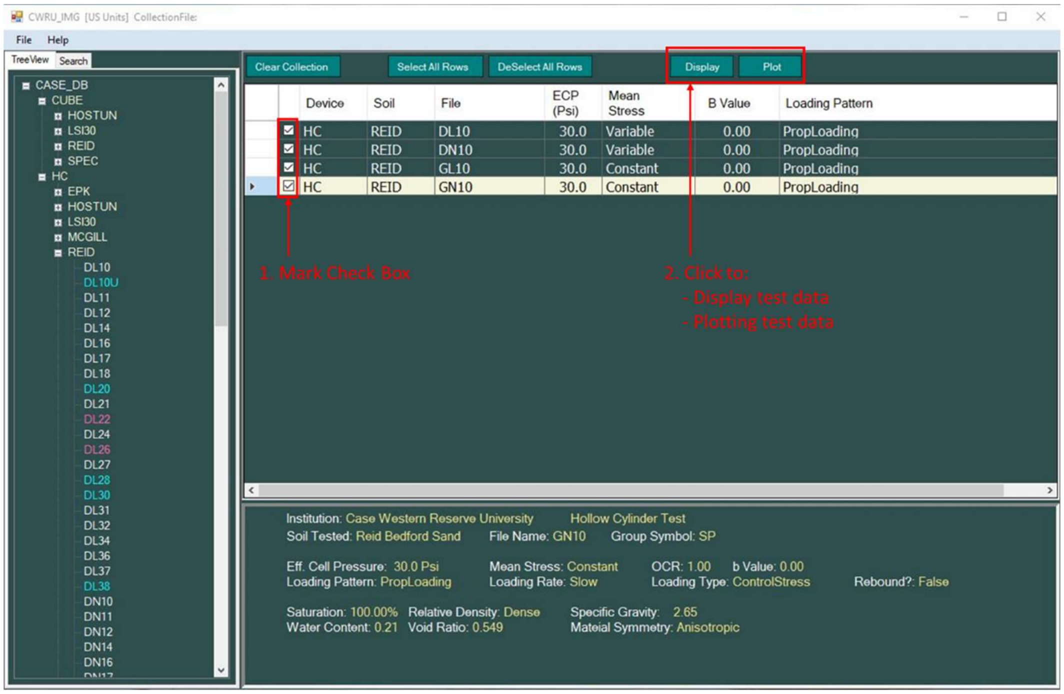


Figure 1-2: Marked tests in the Collection Box

3. Clicking “Display” (Figure 1-2) will result in a new window which lists the input data and computed variables (Figure 1-3).

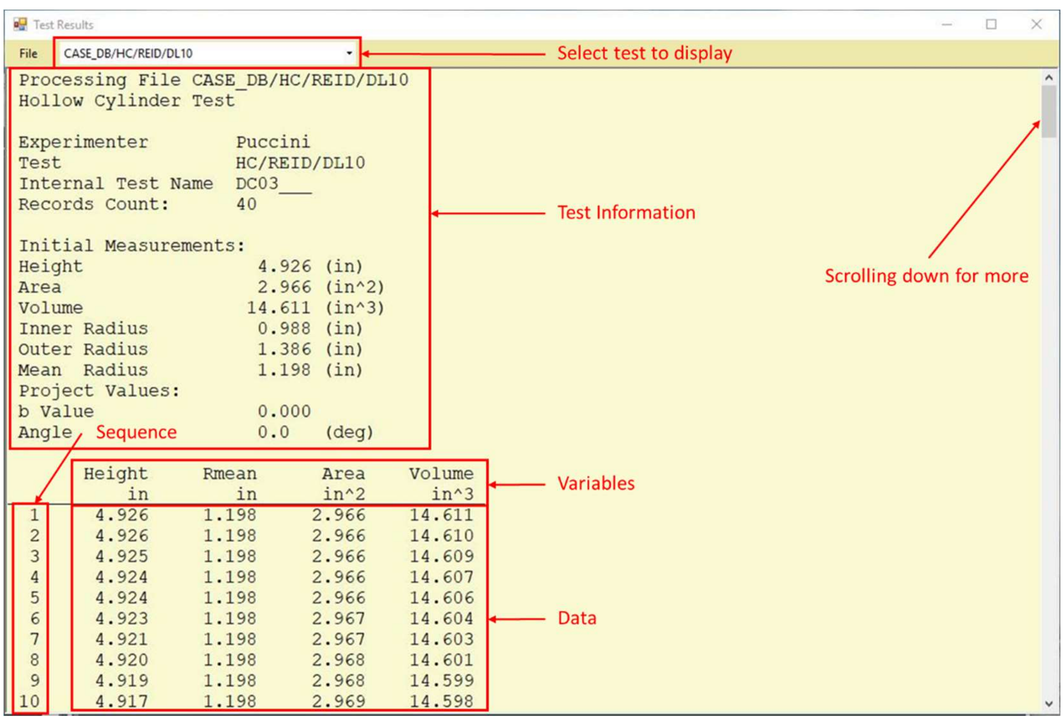


Figure 1-3: Displayed input data and computed variables

4. **Clicking “Plot” (Figure 1-2). Multiple tests can be plotted for comparison.**

   There are two pop-out windows for plotting setup:

   - The first pop-out window (Figure 1-4) allows the user to preset some plotting parameters. Click the “Plot” button to continue.

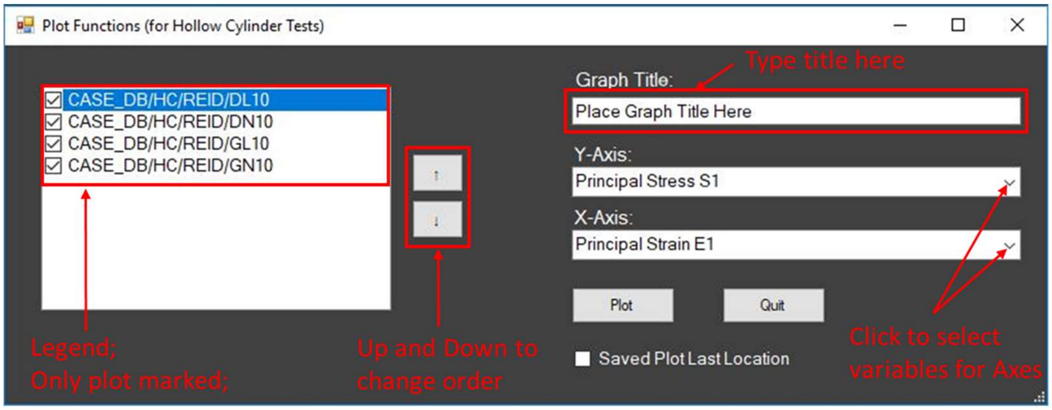


Figure 1-4

   - The 2nd pop-out window (Figure 1-5) allows the user to set the plotting scales. Click the “Plot” button to continue.

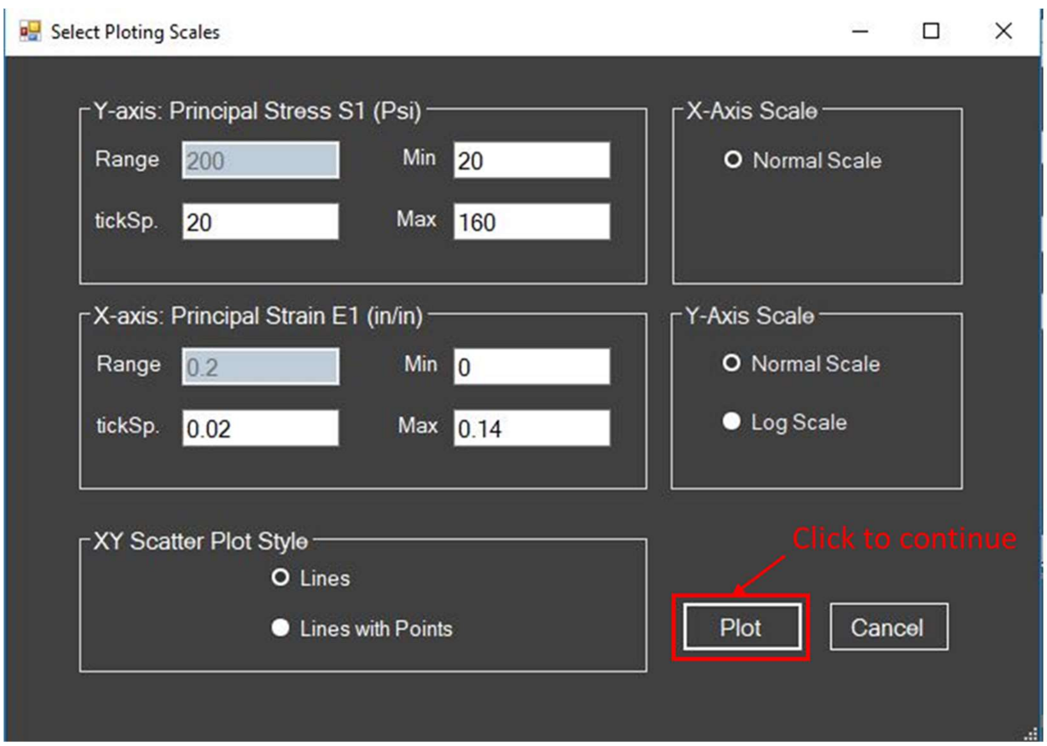


Figure 1-5

Figure 1-6 allows the user to compare different tests and edit the graphs.

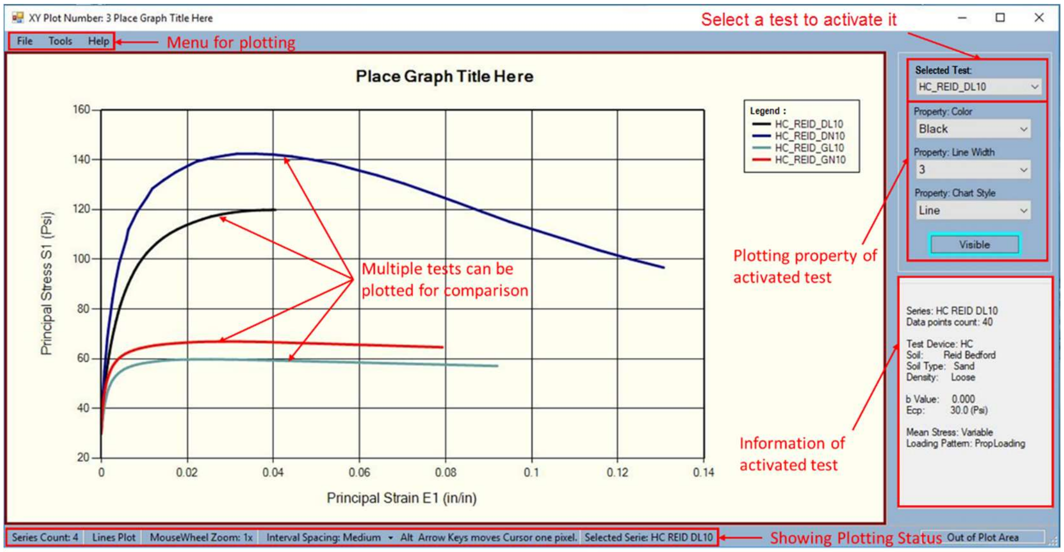


Figure 1-6: Plotted test data

The crosshair help determine the accurate coordinates of the point on the curve as well as the area bellow (Figure 1-7).

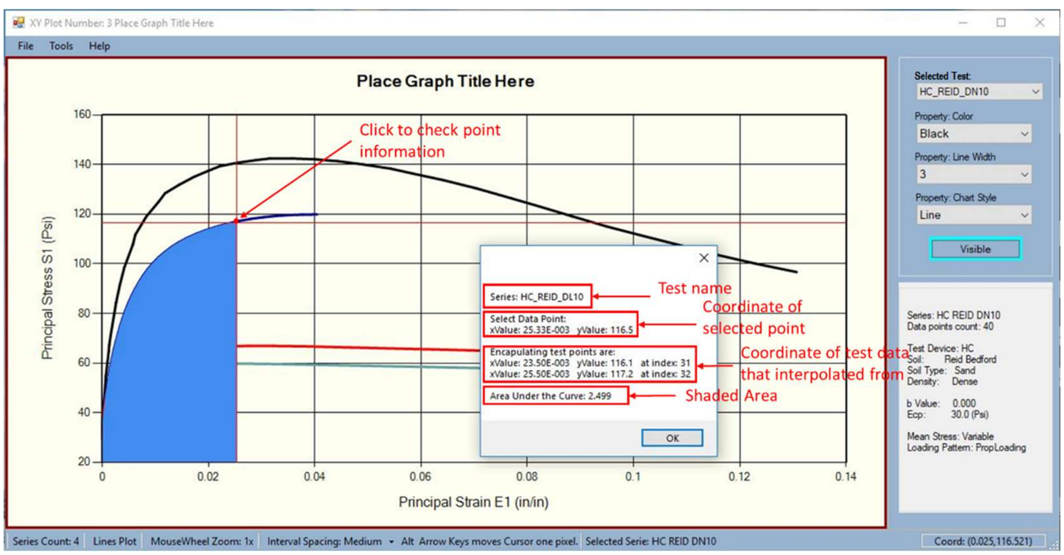


Figure 1-7

Figure 1-8 allows the user to compare the same test conducted in the Hollow Cylinder and in the Cube with the same value of “b”. And click Tools to display the legend.

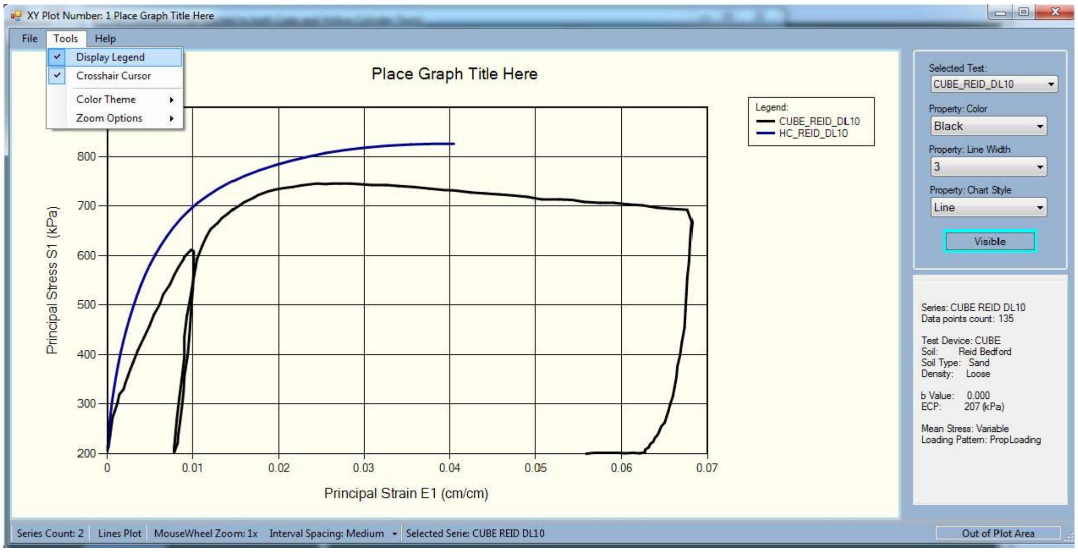


Figure 1-8 Comparison between Hollow Cylender and Cube Test

1.2 Before getting started

The website:

The Case Database and its related information can be downloaded from the following website:

http://engineering.case.edu/eciv/geodatabase/

This hyperlink also can be found at the CWRU Department of Civil Engineering website, at the bottom of the main menu, named "geotechnical database".

All the information that relates to the program can be found on the website, including the program files, raw and computed test data, manual documents, introductory videos, contact information, author's biography, etc.

Getting the program:

The program can be downloaded from the database website (Figure 1-9). To download the program, first, go to the download page by clicking "download" on the main menu, and then click the "Download Program and Manual" button. A program file package named "program_and_manual.zip" will be downloaded to your local computer folder. For most Windows computer, the default download folder could be found at C:\Users\user\Downloads. The downloaded program files were compressed into a zip file, and the user needs to unzip it before using the program.

The manual is in the same folder with the program.

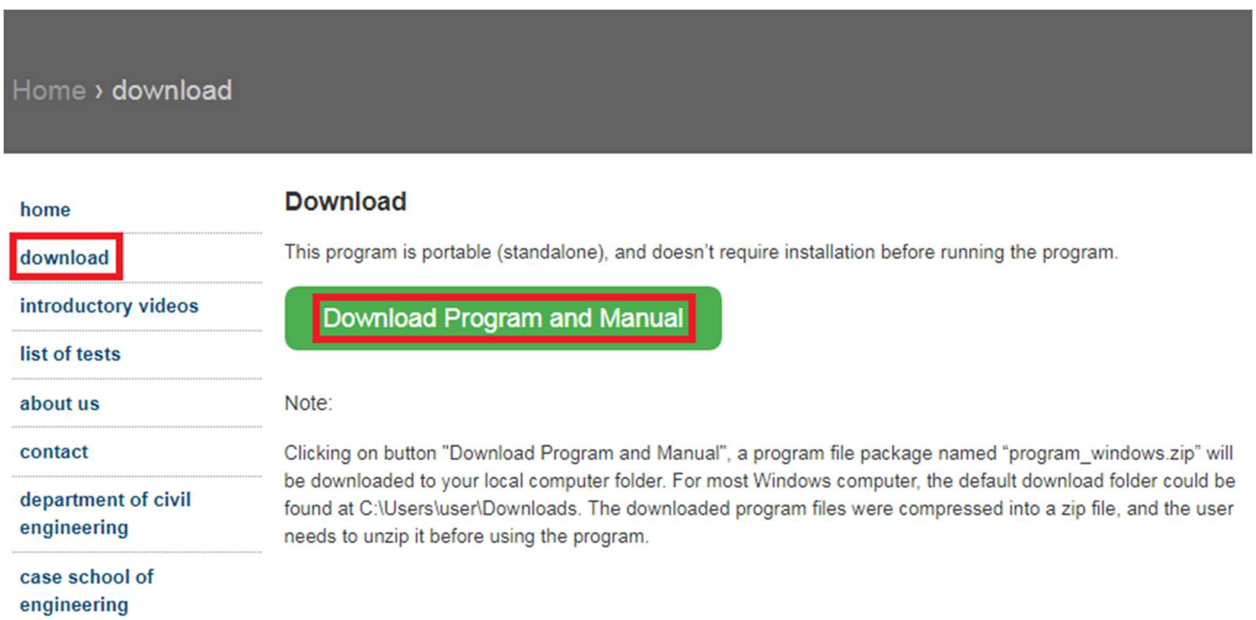


Figure 1-9: Program and manual downloading steps

A physical copy of the program stored in a USB drive is also available in case you have trouble acquiring the program online. The USB drive comes with three folders inside. One of the folders named "Program" contains the unzipped program files which can run directly (see below for running the program). The second folder named "Manual" contains a pdf manual and introduction videos. The third folder named "Information" contains information about the authors and contacts.

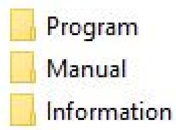


Figure 1-10: Folders in the USB drive

Installation and setup:

This program is portable (standalone), and **does not** require installation before running.

After the program package has been downloaded and unzipped, the user will be able to run the program by double-clicking on the execute file named "CWRU_IMG.exe". Since the program is portable, the user can relocate the program folder to any computer space, including an external drive; however, the files in the Program folder, namely:

must remain in the same folder.

The program obtained on a USB drive, can directly be run by executing the "CWRU_IMG.exe" file. The user also can copy the "Program" folder from the USB drive to any computer space, and then run it.

For convenience, the user can create a shortcut to the desktop by right-clicking on the execute file "CWRU_IMG.exe", selecting "send to", and then clicking on "Desktop (create shortcut)". The program can be executed by directly double-click the shortcut on the desktop.

Note that only one instance of this program is allowed. A warning window (Figure 1-11) will pop up when the user tries to execute the second instance.

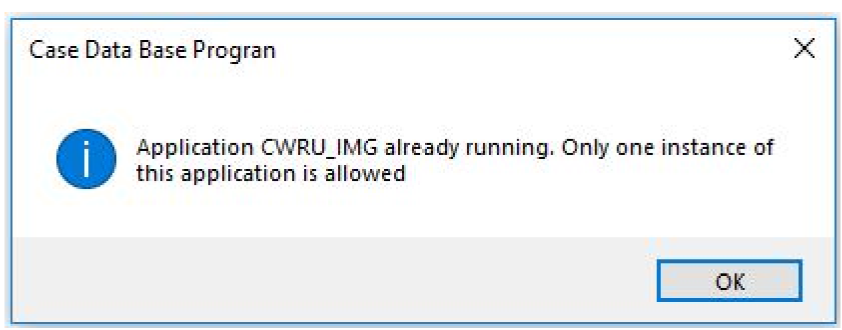


Figure 1-11: A warning pop-up window

Let Us Get Started

1.3 Using the program

1.3.1 Startup

When the program starts running, a marquee describing sponsorship will appear first (Figure 1-12). To continue the program, this marquee must be closed by clicking the cross at the right top corner. The user could avoid this pop-up by clicking on "Help" in the manual bar, selecting "settings" and unchecking the box "Show Marquee".

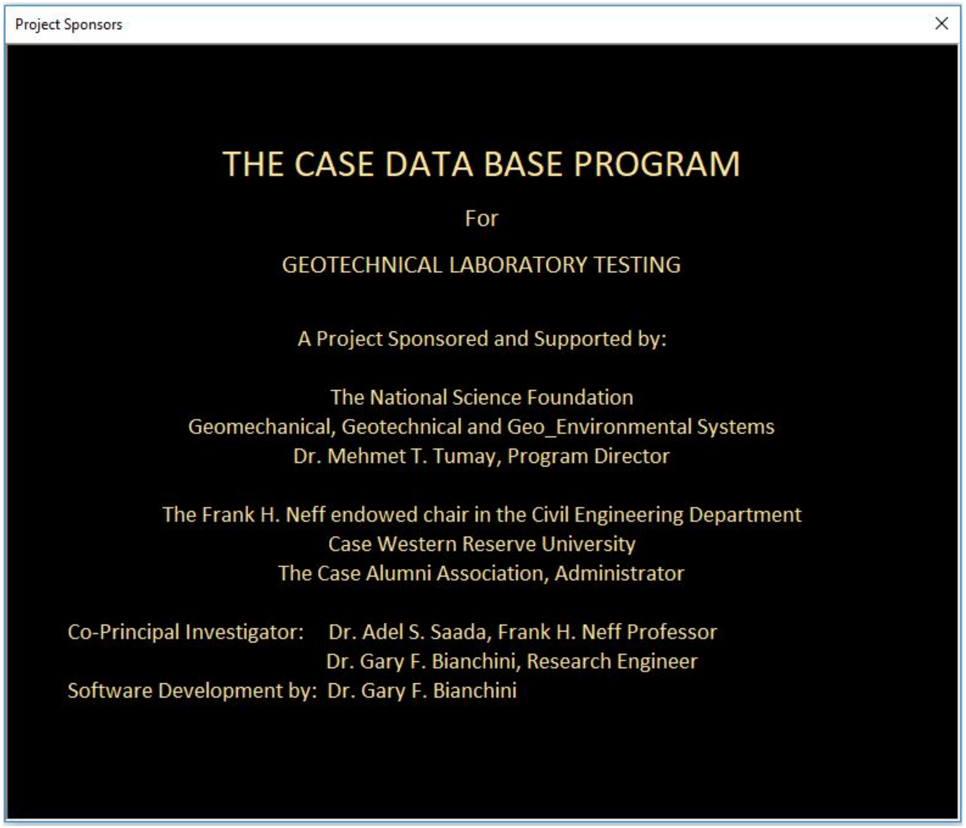


Figure 1-12: Startup window

The user can decide the startup status by checking or unchecking the box in front of each of the options (Figure 1-13).

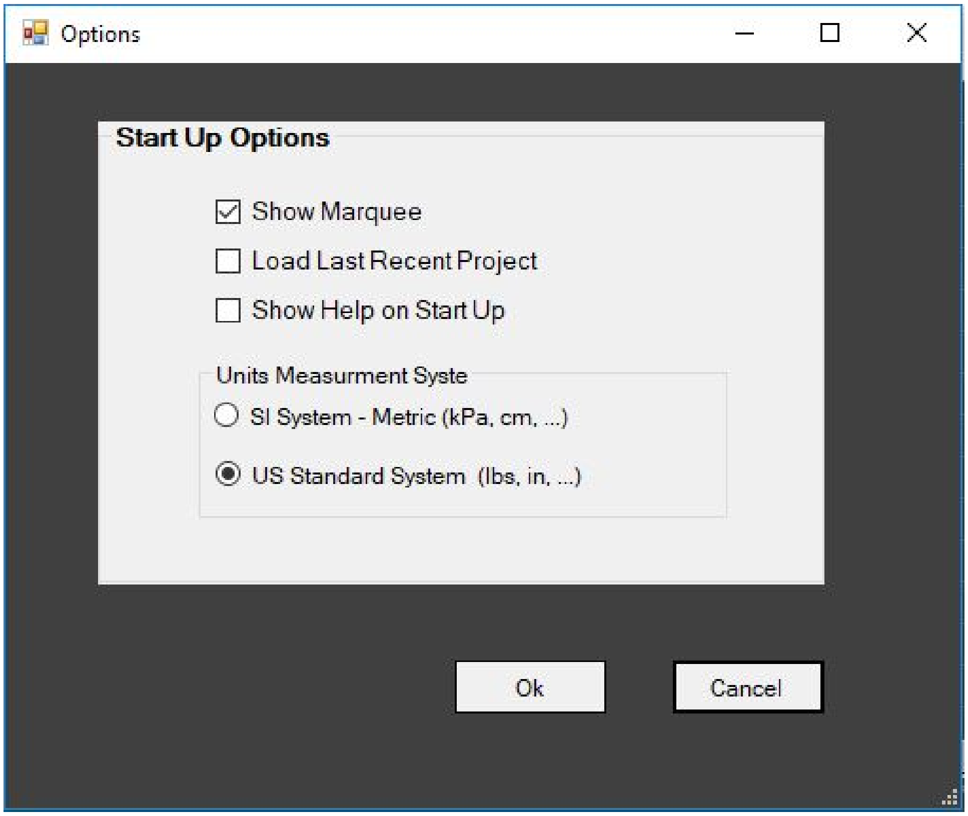


Figure 1-13: Startup options

1.3.2 The interface of the program

The interface of the program consisted of Menu Bar, Tool Bar, Database Panel, Collection Area, and Information Area (Figure 1-14).

The Menu Bar has the options (File, Help) to interface with the user.

The Tool Bar helps select the tests to be displayed or plotted.

The Tree View is the place where the user can select the tests to be placed in the collection box and operated on.

The Search is the place where the user can find a test with a given description (Figure 1-15).

The Collection Box is the place where the test selected for examination are listed. Multiple tests can be listed.

The Information Box is the place where the properties of the material and the kind of test that has been clicked on, either in the Tree View or in the Collection Box, are shown.

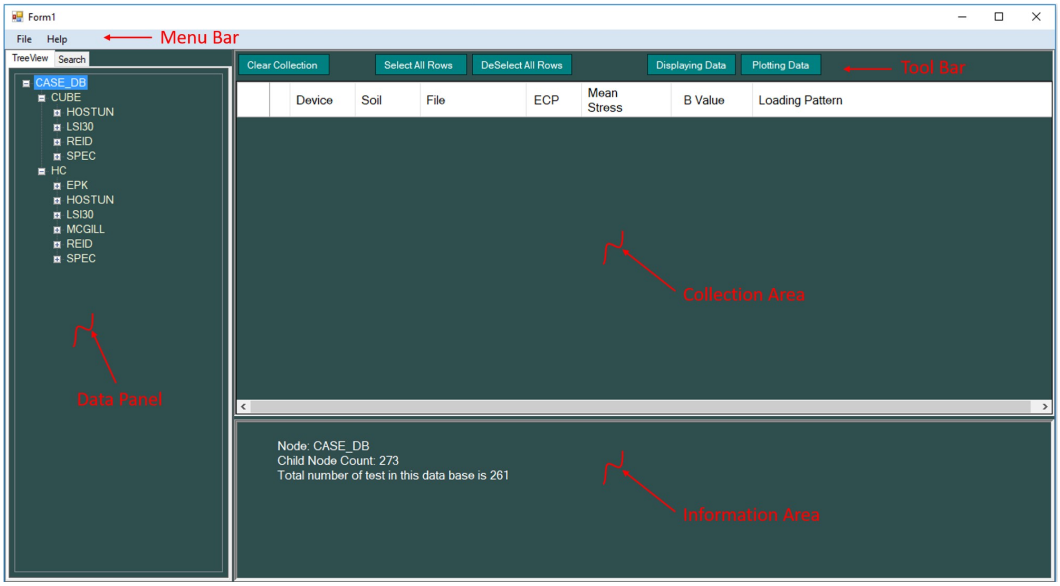


Figure 1-14: Program interface

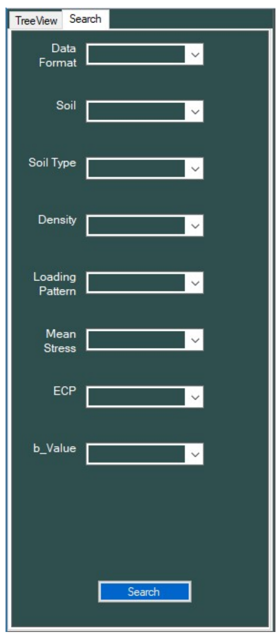


Figure 1-15: Search

1.3.3 Unit systems

This program uses both the International System of Units and the US Customary Units. The current unit system will be shown on the program title on the top left corner.

The user can select their preferred unit system as follows:

1. Click on "Help" on the Menu Bar(Figure 1-16)
2. Click on "Setting"
3. Select the unit system under Unit Measurement System(Figure 1-13)

Once the unit system is selected, it will immediately apply to the program and will be saved for the next run.

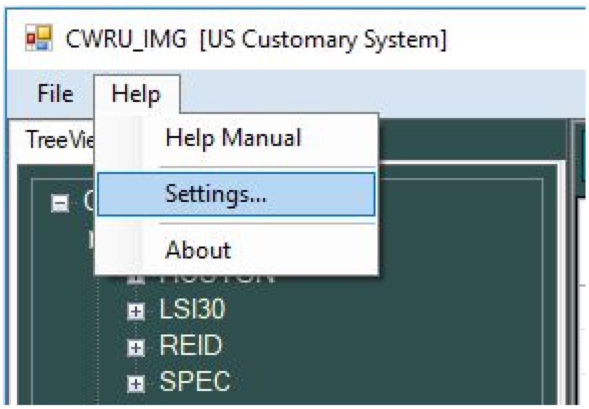


Figure 1-16: Step to the Unit System selection

1.3.4 Selecting the Test whose results are to be examined

The task here is to put desired tests in the Collection Box for further operation (displaying or plotting). Here are three methods that can be used for selecting tests:

<u>Select the tests from Tree View:</u>

All the tests are categorized by the testing method and soil type. The user can click the plus or minus to expand or collapse the test list, respectively.

The test data can be added to the collection box by two ways:

1. Double click on the name of the test
2. Right click on the name of the test, and then click on "Add to Collection"

Multiple tests can be added to the collection box.

<u>Select the tests from Search:</u>

The user can use "Search" to narrow down the tests by giving test descriptions:

1. Go to the Search Panel
2. Clicks on the down arrows to select soil and test descriptions, then press Enter to confirm your choice (Figure 1-17).

3. A search confirm window(Figure 1-18) will pop-out after clicking on the search button. After checking that all the search conditions are correct, the user just click the “OK” button to proceed with the search.
4. The result of the search results will appear in the Collection Box.

The total number of the match count will be shown in the Information Box (Figure 1-19).

Figure 1-17: Search panel

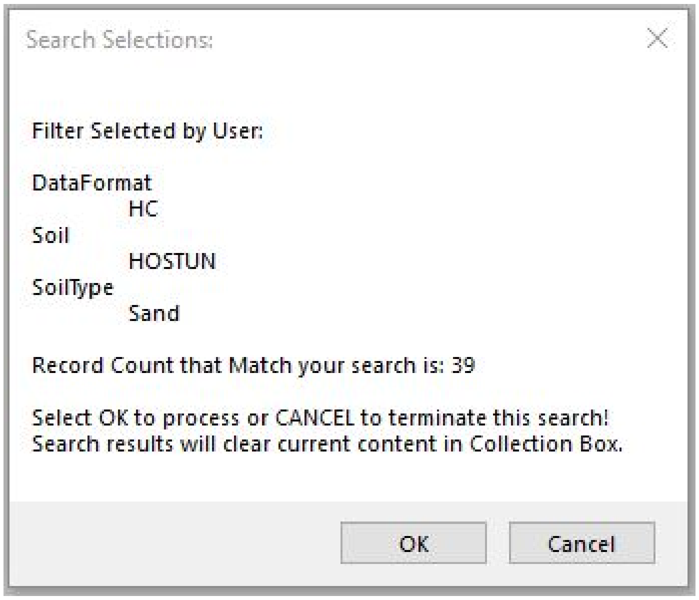


Figure 1-18: Search confirm window

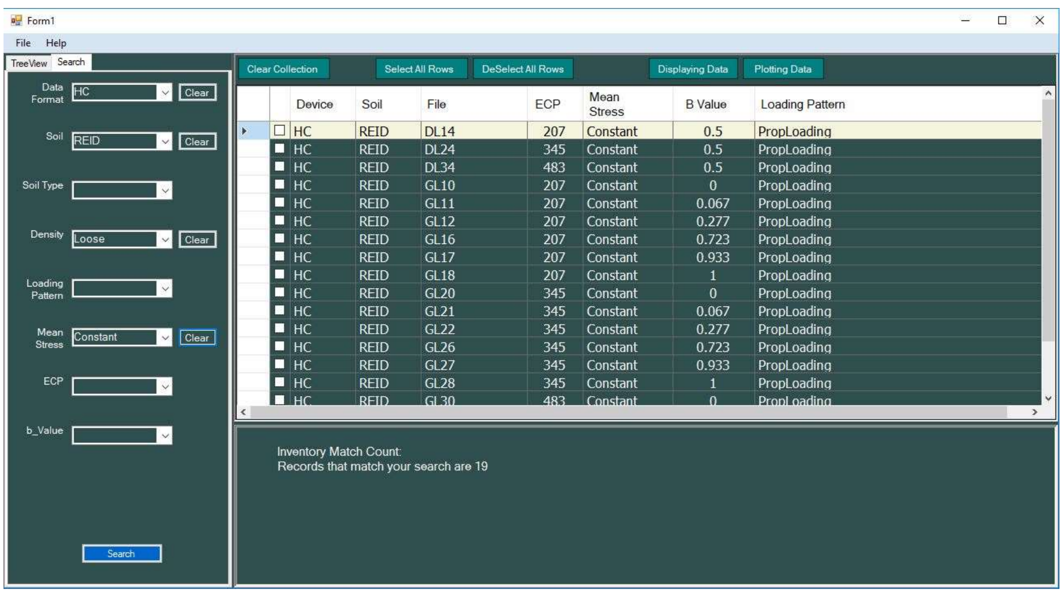


Figure 1-19: Search Results

<u>Input the test list from .Cobo file (Optional):</u>

.Cobo is a file format of this program, and it stores the test information such as test number, test name, testing method, soil type, and check box status.

The user can add the test list to the Collection Box by inputting .Cobo file. There are several operations regarding inputting the .CoBo file:

1. *Save test list:* the user can go to "File" on the Menu Bar, and then clicking on "Save". A saving window will be pop out for choosing the saved location. and then click on save. The status of test list from the Collection Box will be saved into .CoBo file.

"status" means the exact moment of the Collection Box when it was saved, including the selection of the check box in front.

1. *Open test list:* the user can go to "File" on the Menu Bar, and then clicking "Open" to select the desired .Cobo file for the pre-saved test list.
2. *Create or modify .CoBo file*: by modifying the *.CoBo file,* the user can have a test list edited in advance in text format, rather than in visual Collection Box. The user can even create .Cobo file totally new, as long as it follows a certain format.

   The .CoBo file can be created or modified by using text edit software such as Notepad which comes with Windows System.
3. *Recent Collection:* The user can find the recent .Cobo file and direct input it into Collection Box by going to "File", then " Recent Collections", finally selecting the file that desired.
4. The user can close the current test collection by going to "File" on the Menu Bar, and then clicking on "New" or "Close". Note that the program will ask to save the current test collection, when the opened test collection is modified or a totally new test collection is created.

1.3.5 Tools for the Collection Box

After the desired tests have been added into the Collection Box, the Tool Bar (Figure 1-20) is the only place that control test collection.

The first three tools control the tests chosen for display or plotting.

The last two tools are used to display the test data, and plot it.

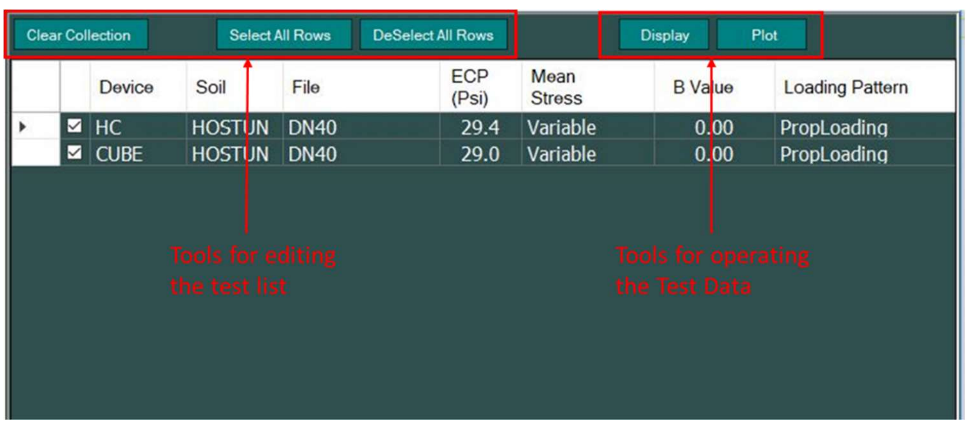


Figure 1-20 Showing tools for the Collection Box

1.3.6 Display of test data

There are two ways of displaying test data.

The first way is by right-clicking on the test name in the Tree View and then selecting "Display Test Data".

Another way is by adding the test to the Collection Box and then clicking "Display" on the Tool Bar. Note that only one single selected test will be displayed. If multiple tests are selected, only the chosen test will be displayed (Figure 1-21).

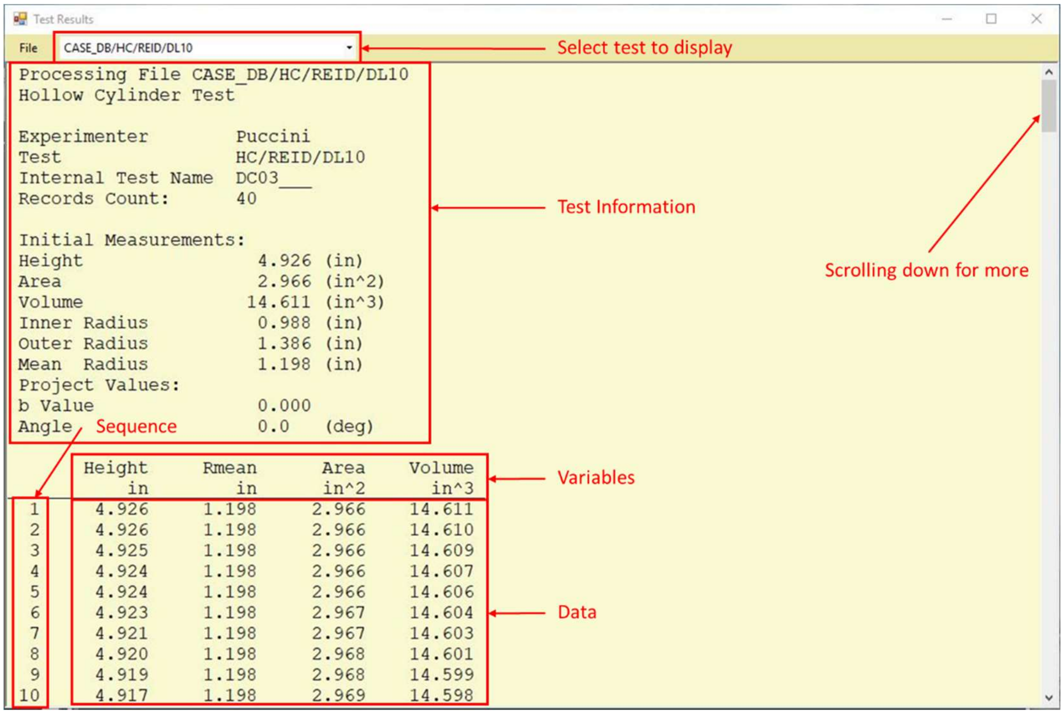


Figure 1-21

1.3.7 Plotting test data

The only way of plotting the test data is by adding the test to the Collection Box and then clicking "Plot" on the Tool Bar.

Multiple tests can be selected and plotted on the same figure. Note that only selected tests will be plotted.

Here are the steps for plotting:

1. Add the test to the collection box. (see 1.3.4 for detail)
2. Click the "Plot" button on the Tool Bar(Figure 1-20)
3. A "Plot Functions" window(Figure 1-22) will pop-out. Check the following items:
    - The left box shows the selected test collection, and the user can click the "up" or "down" arrow to change the order of the test. Only the selected test data will be plotted.
    - Write the Graph Title, or leave it empty.
    - Select the variables of vertical axis and horizontal axis from the drop down menu.
4. Click the "Plot" button to continue

5. A “Select Plotting Scales” window (Figure 1-23) will pop-out. This window gives the user options regarding the scale and the style of the plot. To continue, click on “Plot” button.
6. A graph of the tests will appear in a new window (Figure 1-24). Please refer to the next section for details.

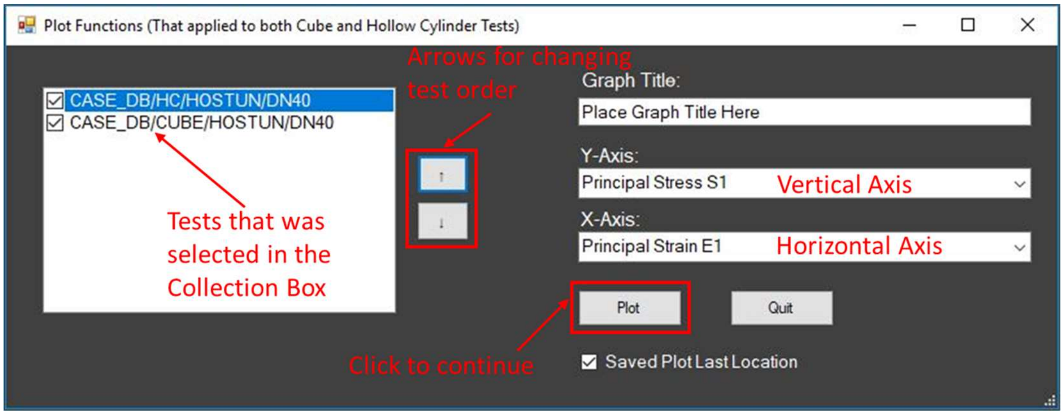


Figure 1-22: Plot Function window

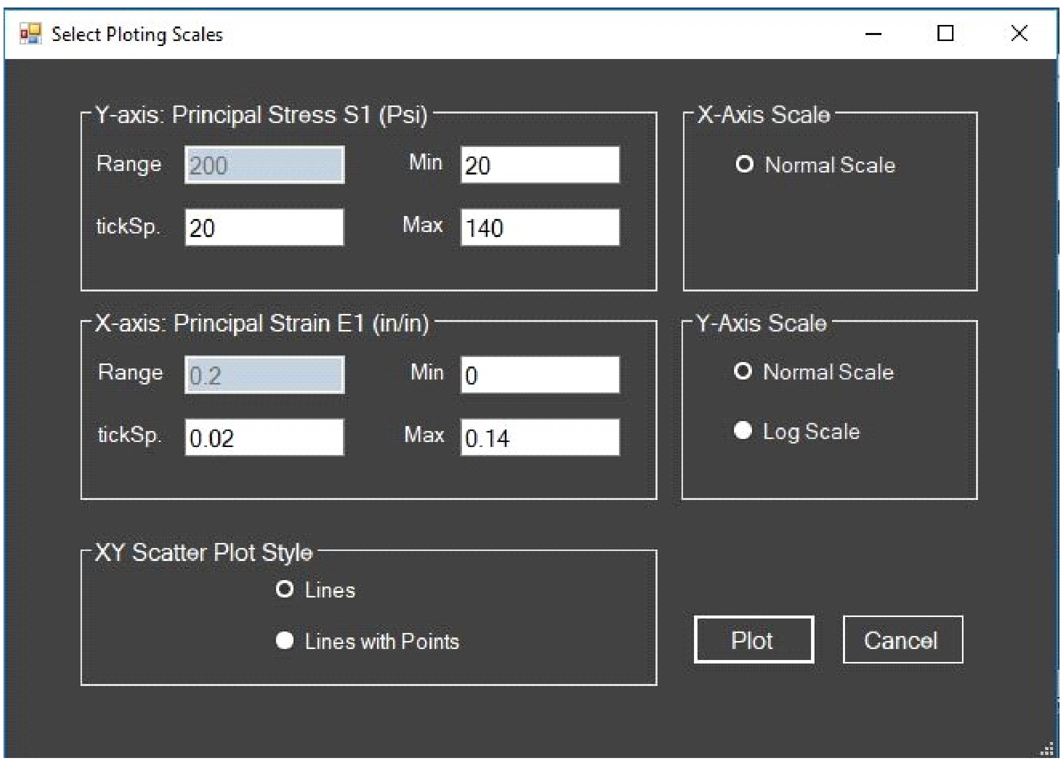


Figure 1-23: Select Plotting Scales window

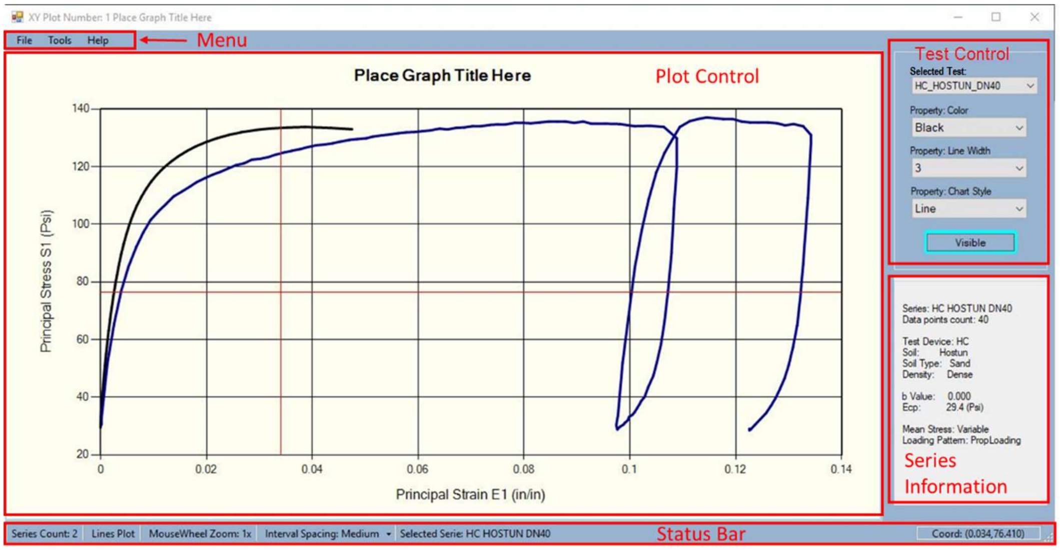


Figure 1-24: Plot window

1.3.8 The final graph

Figure 1-25 contains 5 Regions of interest:

a) Menu - list of options that interface with the user; the Plot Window (Figure 1-24) has its own menu.

b) Graph Area - Where the plot data (series) are plotted.

c) Series Controls - Controls that affects current selected Series (color, line thickness, etc.)

d) Series Information Box - List the Intrinsic Test Information for current selected Series.

e) Status Bar - Shown at the bottom of the window displaying the current Plot Utility Status.

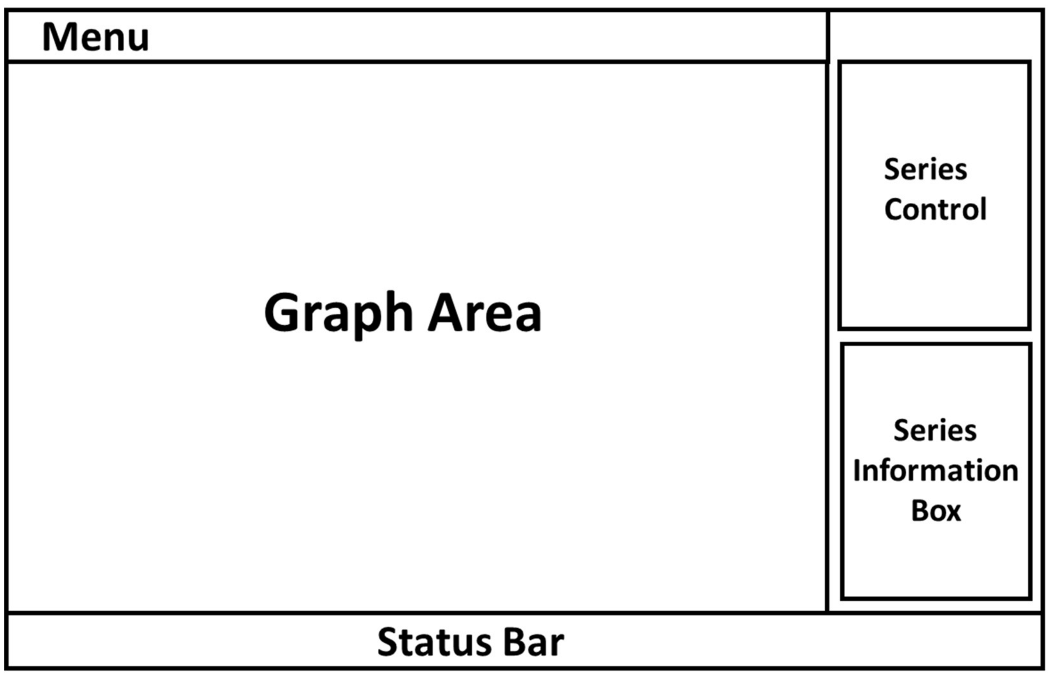


Figure 1-25

a) Menu Options (Figure 1-26 and Figure 1-27):

- Color Theme - Select either the Light or Dark color scheme. The Light Theme is suitable for printing and the Dark Theme is helpful for the visual impaired.
- Display Legend - Select either to display Series Legend in the Plot Control or not.
- Display Cross Hair - Select either to display the crosshair with the mouse pointer or not.
- Save - Save the plot image to a file.
- Print - Print the plot image: it is best to set color theme to Light before printing.

- Zoom - This program offers 2 Mutually Exclusive Methods for changing the plot's scale.
  - Default Mouse Wheel Zoom - Users can expand the plot about the mouse pointer location by a factor of 2 using the mouse wheel. The Zoom factor is displayed in the Status Bar.
  - Chart Control Zoom - Allows users to select X-axis zoom, Y-axis zoom or both. To apply, press and hold the primary mouse button when moving the mouse over the chart area. This action will define the new plot range. You can further modify the plot image by moving the curser.

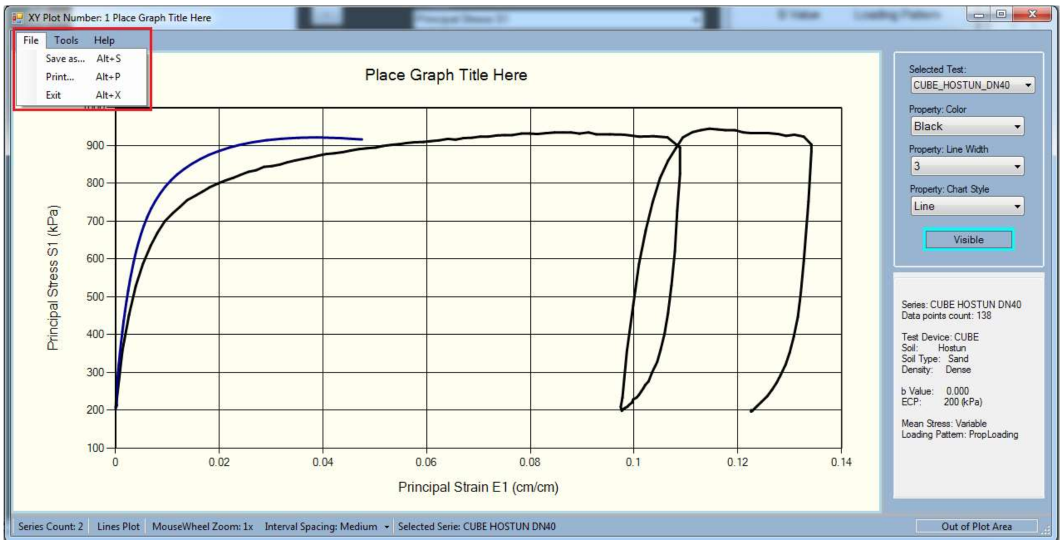


Figure 1-26

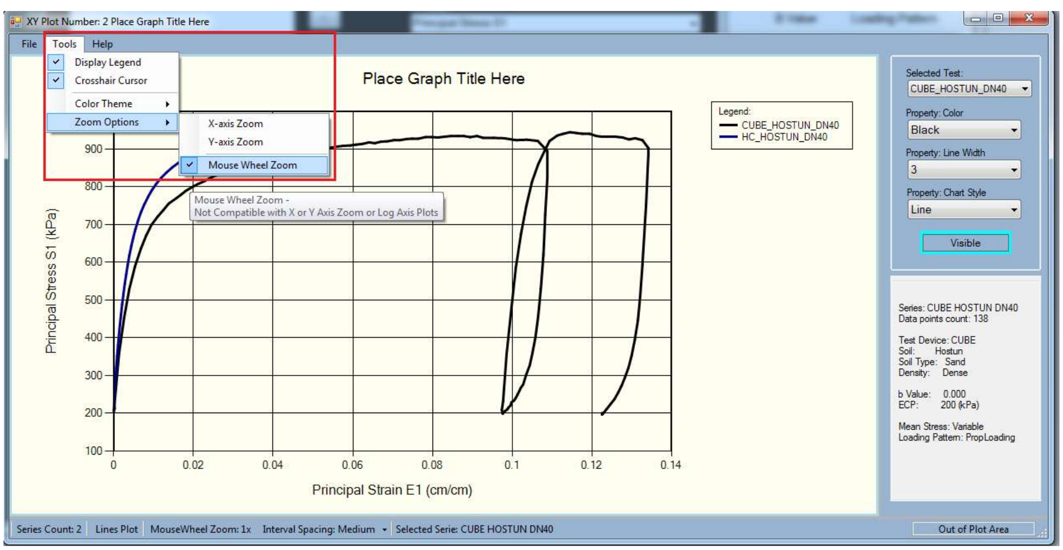


Figure 1-27

b) Graph Area (Figure 1-28):

Using the crosshair and clicking on a point on a curve, give the coordinate of the point as well as the area under the curve.

Note that the calculation of the area under the curve results from the accumulation of the elementary areas.

<u>Key Board Input:</u>

For the Graph Area in Figure 1-25 to accept keyboard input, it must be activated. One can use the “Tab” key or a click of the mouse while it is on the “Graph Area” to activate it. When the Graph Area is activated, the frame in Figure 1-28 turns from blue to red. Under those conditions, the following keyboard inputs are operational:

- Ctrl & Arrow Keys - Shift or translate the plot in the direction of the selected arrow key. You can change the size of the interval spacing by using the Interval Spacing Label in the Status Bar. The options are Course, Medium and Fine.
- Alt & Arrow Keys - Move the mouse pointer one pixel in the direction of the selected arrow key.

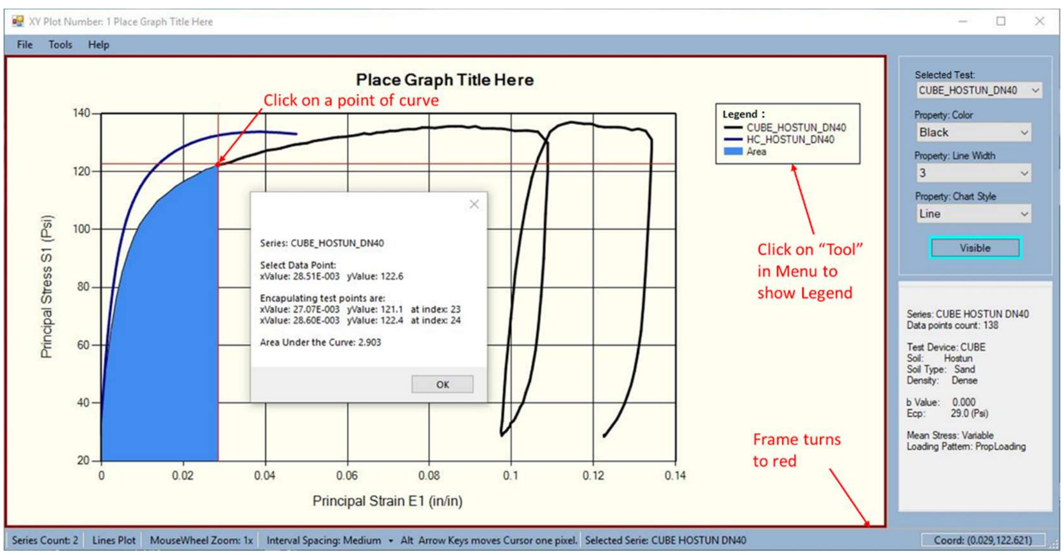


Figure 1-28

c) **Series Control Area (where the graph properties can be changed) (Figure 1-29):**

- Select a test – select the test whose properties are to be changed from the drop down menu under “series” (or click on the test in the legend frame). The Series Information Box will also be updated.
- Color - decide the color of the curve.
- Line Width – decide the thickness of the curve.
- Chart Style – from the drop down menu, choose the desired line style (Line, Spline, Area or Points). Note that there is little difference between Line and Spline options.
- By click on the “Visible” button the user can hide the selected test.

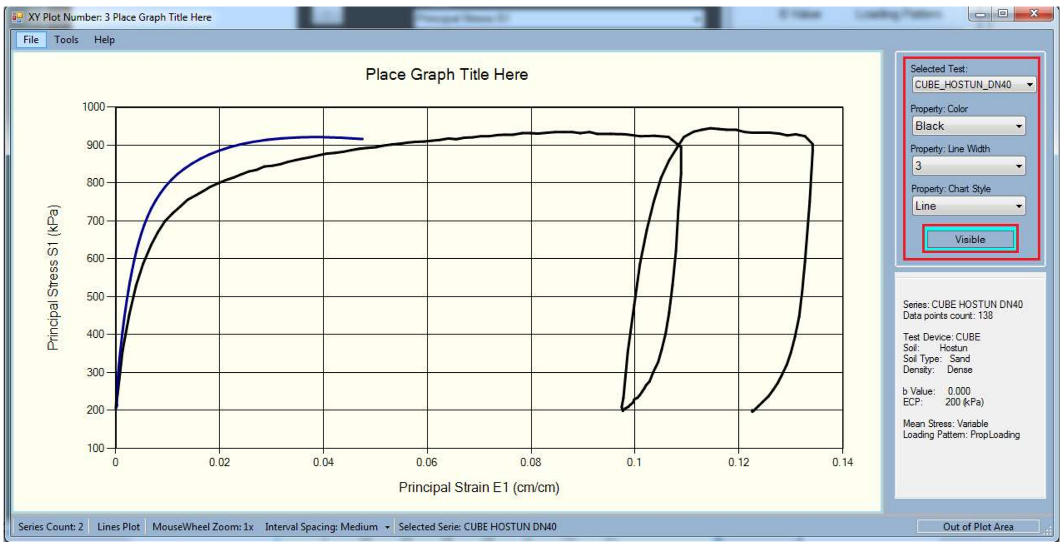


Figure 1-29

1.3.9 Examples

1.3.9.1 Example 1: Choosing a test for constitutive modeling

1. From Figure 1-30, choose the soil whose granulometry is the closest to your requirements (same as Figure 3-1).

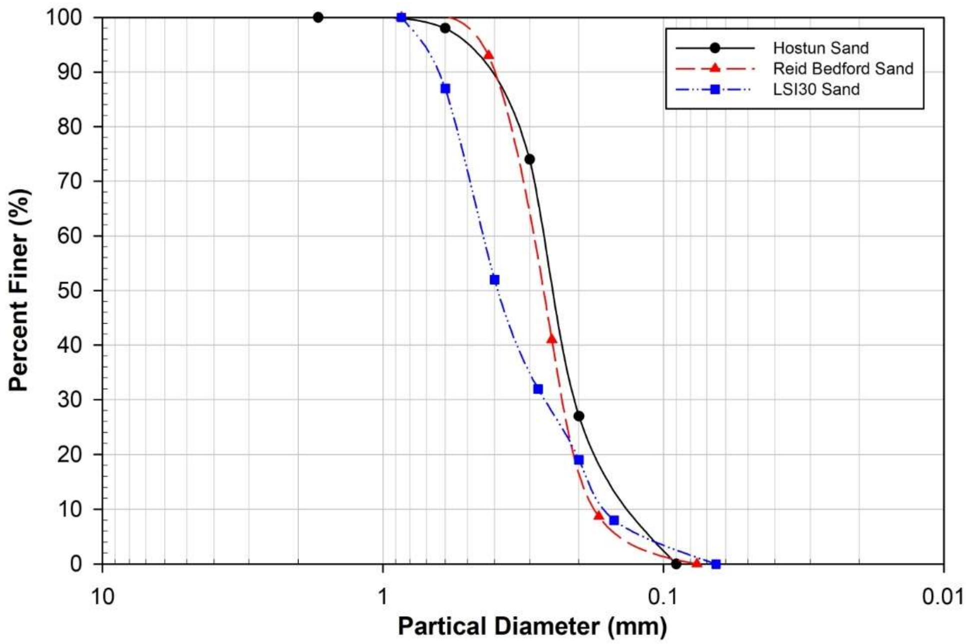


Figure 1-30: Grain Size Distribution

2. For the chosen soil, find the desired tests from the Tree View. The tests name follow a certain format which is shown in Figure 1-31 and in Table 1. Please refer to Chapter 7 for more details.

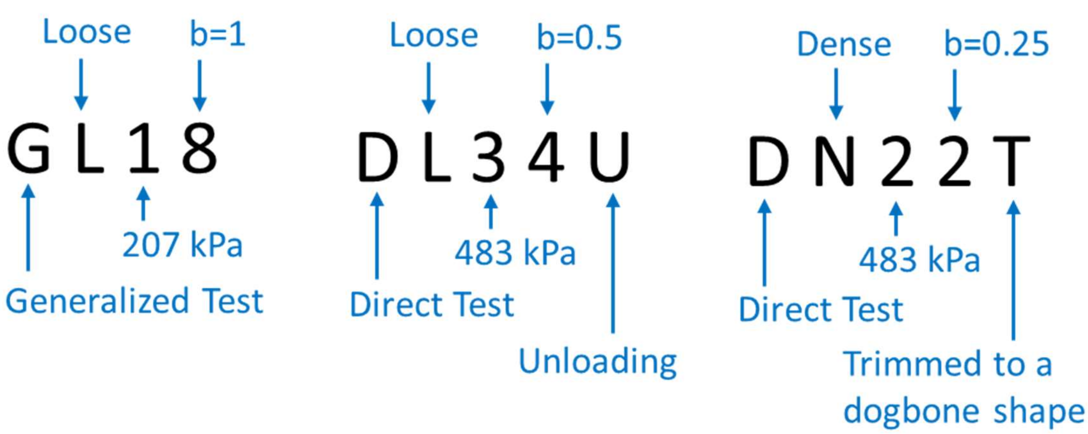


Figure 1-31: Test name notation

Table 1:

Nomenclature	ECP (psi,bar)	ECP (kPa)
1:	30 psi	(206.85 kPa)
2:	50 psi	(344.75 kPa)
3:	70 psi	(482.65 kPa)
4:	2 bar	(200.00 kPa)
5:	5 bar	(500.00 kPa)
6:	3.5 bar	(350.00 kPa)

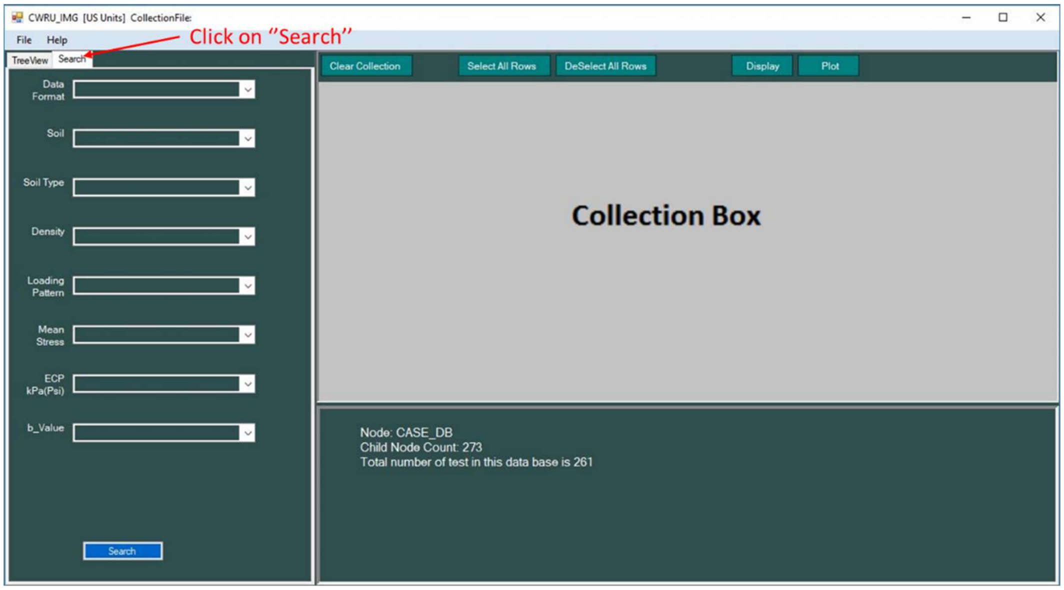
Nomenclature	**β**	**b**
0:	0	0
1:	15	0.067
2:	31.75	0.277
3:	32.33	0.286
4:	45	0.5
5:	54.69	0.666
6:	58.25	0.723
7:	75	0.933
8:	90	1

3. For displaying and plotting test data, please refer to Example 3 and Example 4, respectively.

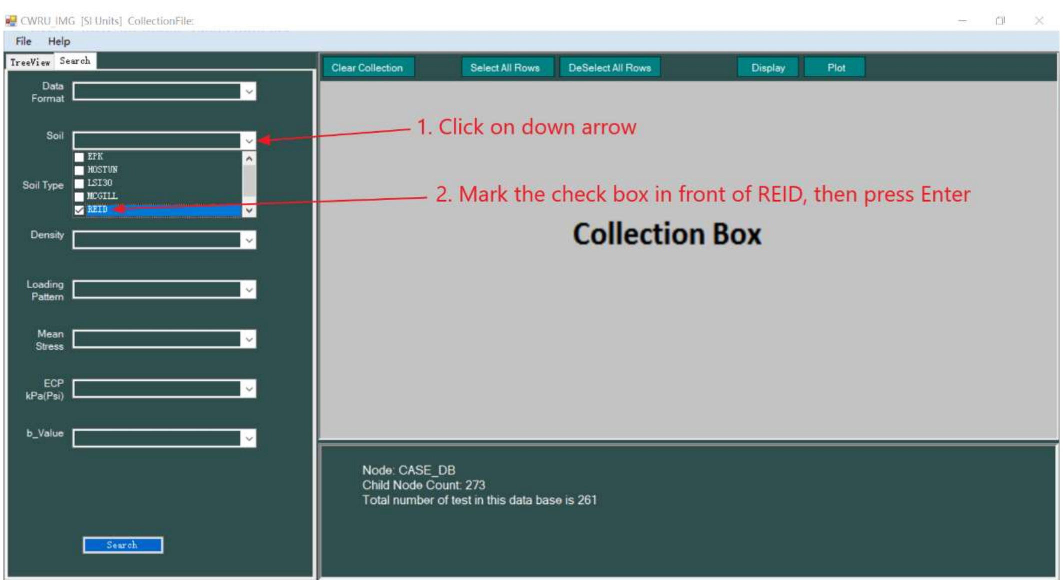
1.3.9.2 Example 2: Searching for tests satisfying specific conditions

Assume the user found that Reid Bedford sand, in a dense condition, adequately represents the soil to be modeled:

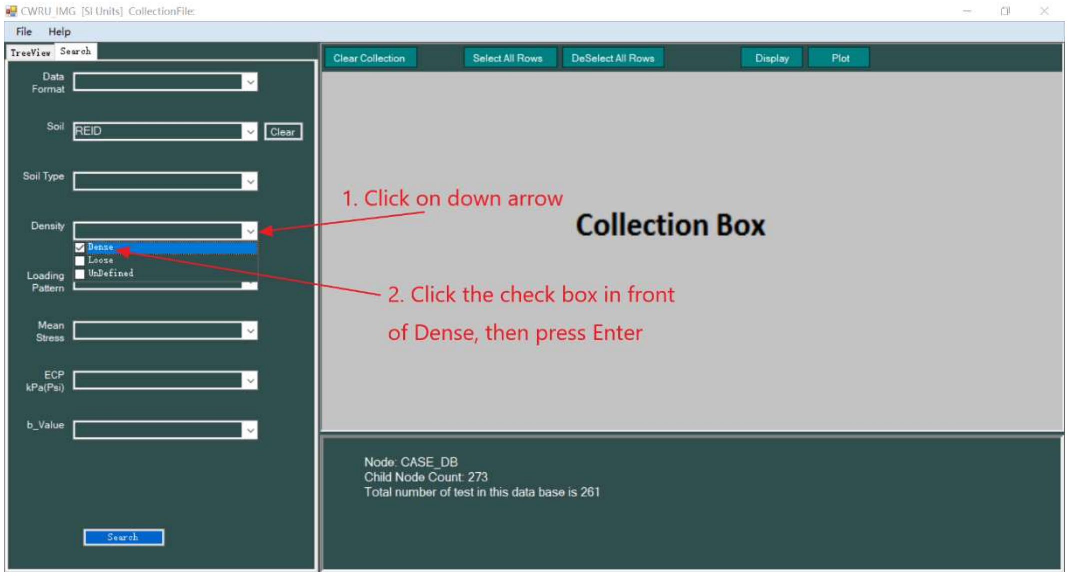
1. Click on “Search” at the top of the left hand panel.



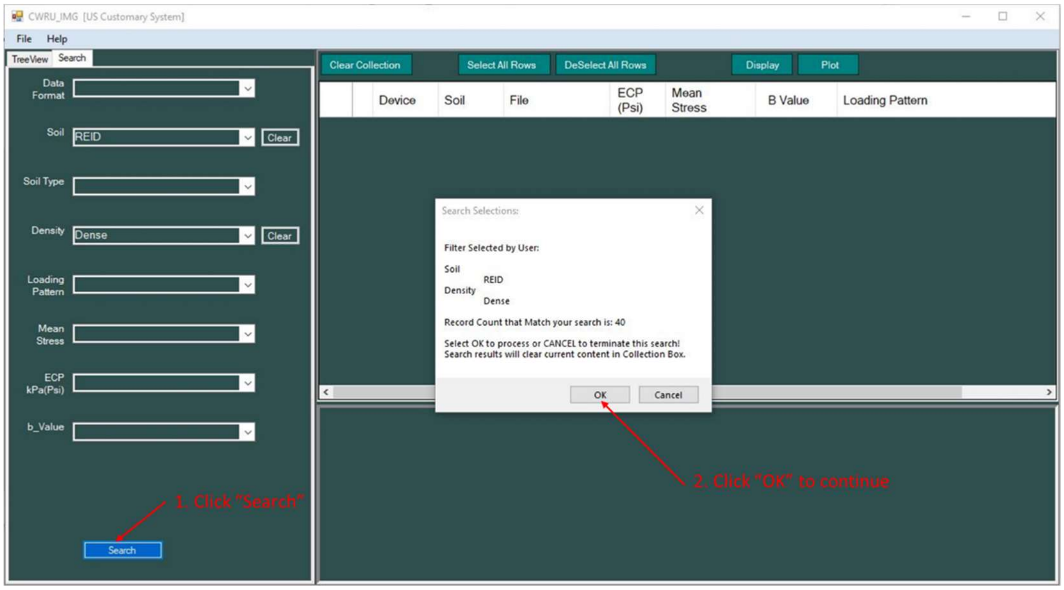
2. Select soil.



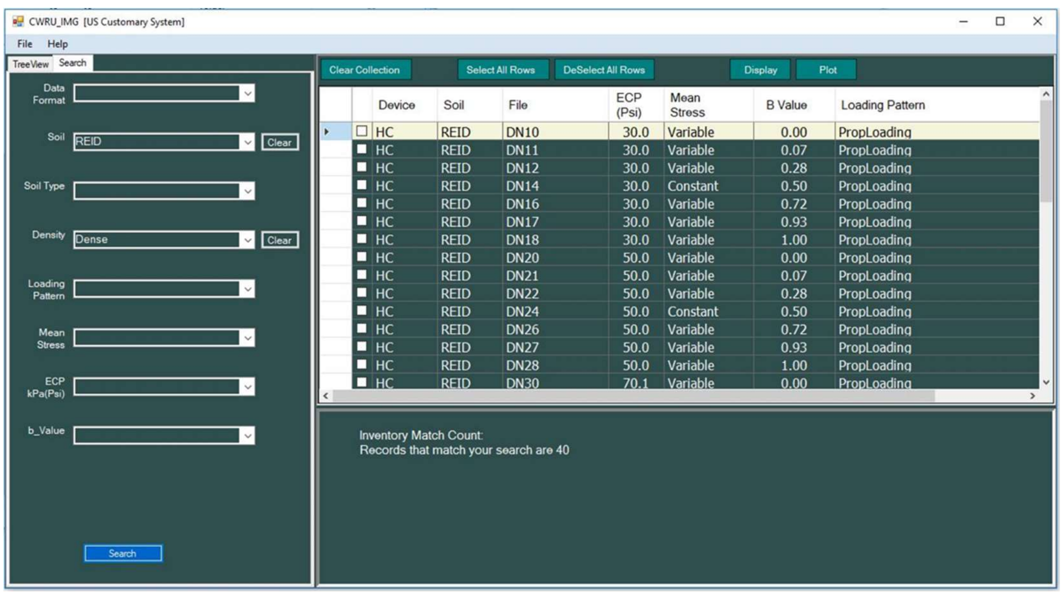
3. Select soil density.



4. Search



5. The search results

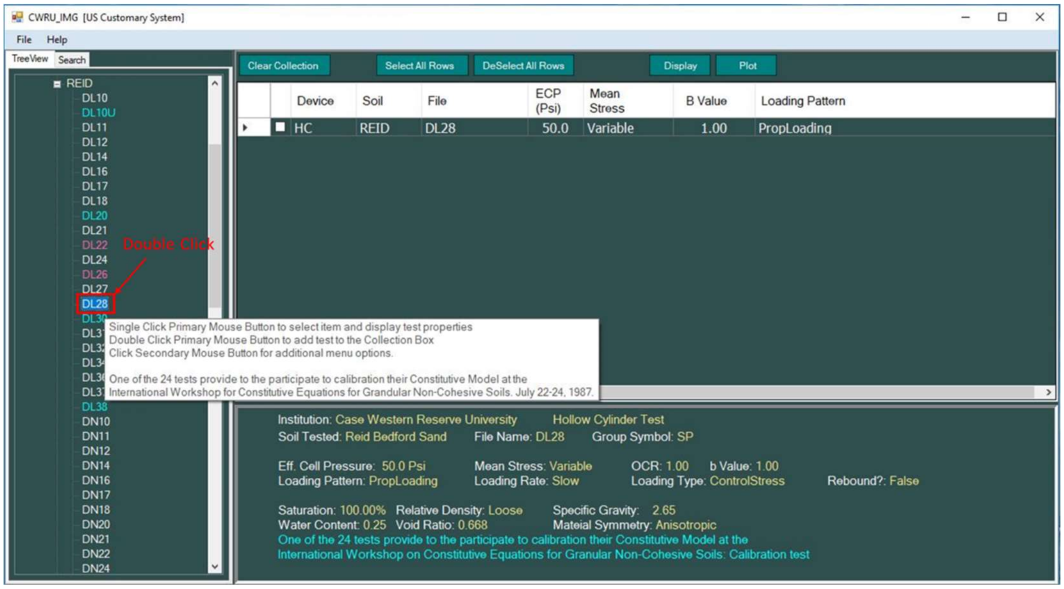


6. For displaying and plotting test data, please refer to sections 1.3.6 and 1.3.7, respectively.

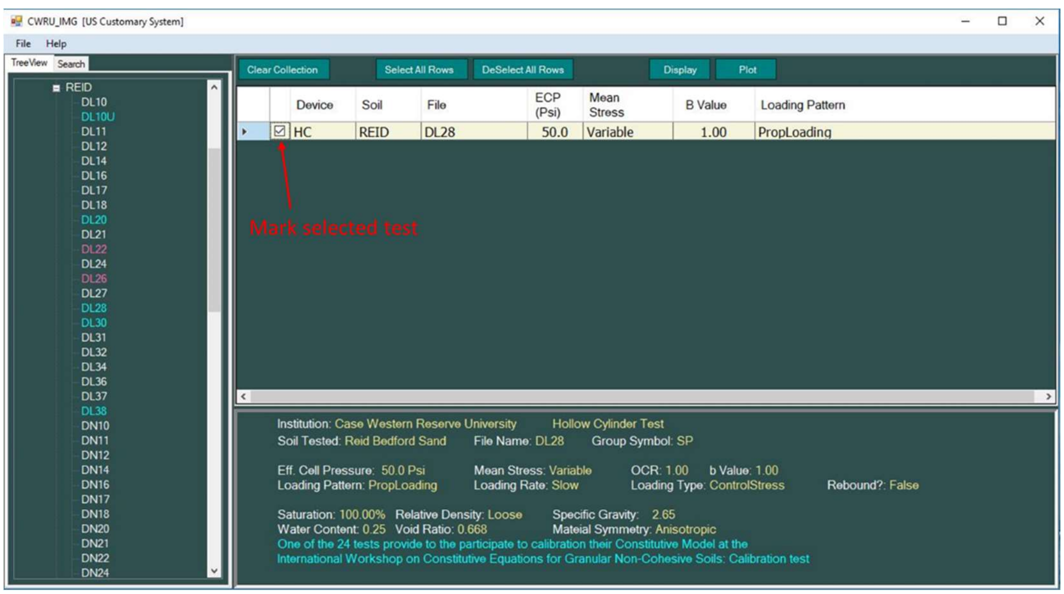
1.3.9.3 Example 3: Displaying data

Let us choose Hollow Cylinder Test, Reid Bedford, DL28

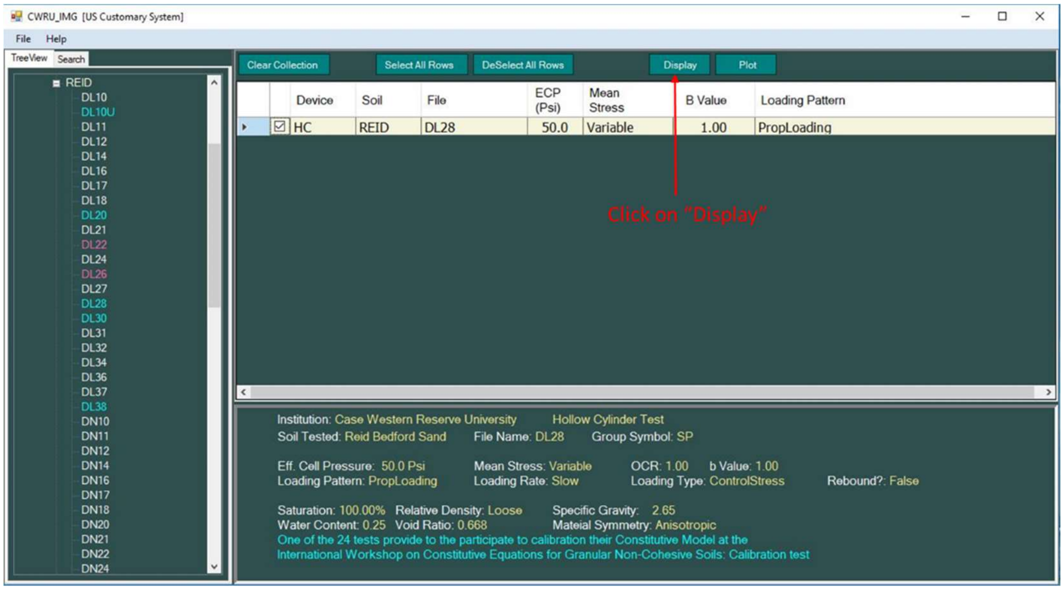
1. From Tree View, click on “plus” to expand REID; double click on DL 28



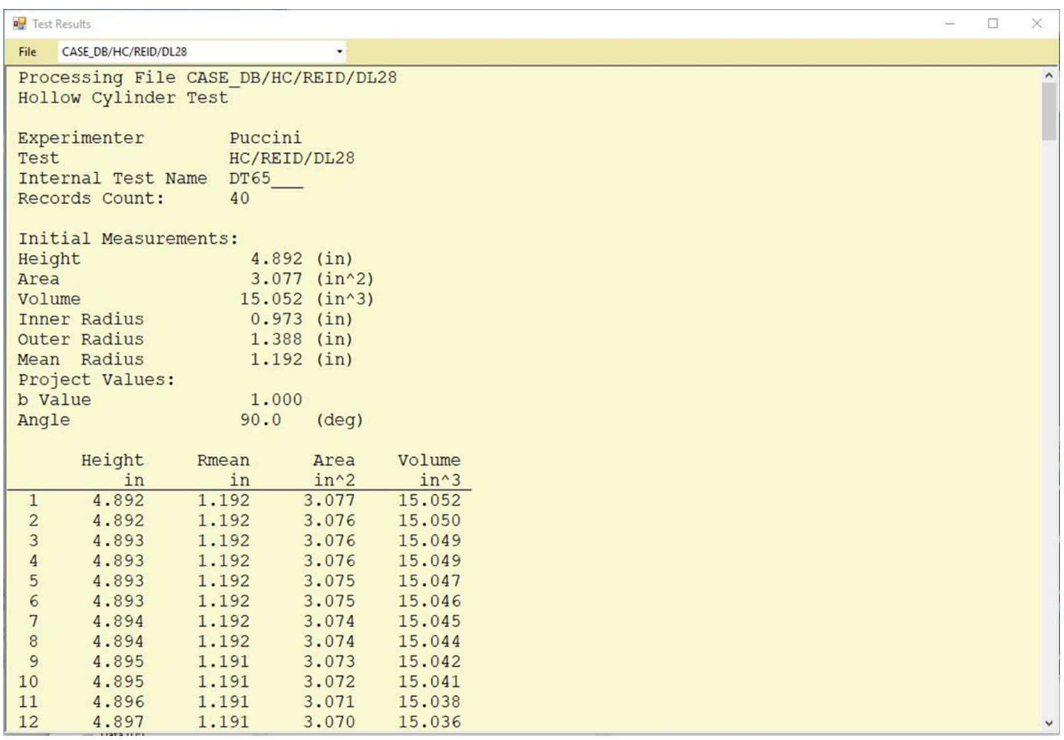
2. Mark the selected test in the Collection Box



3. Click on “Display”



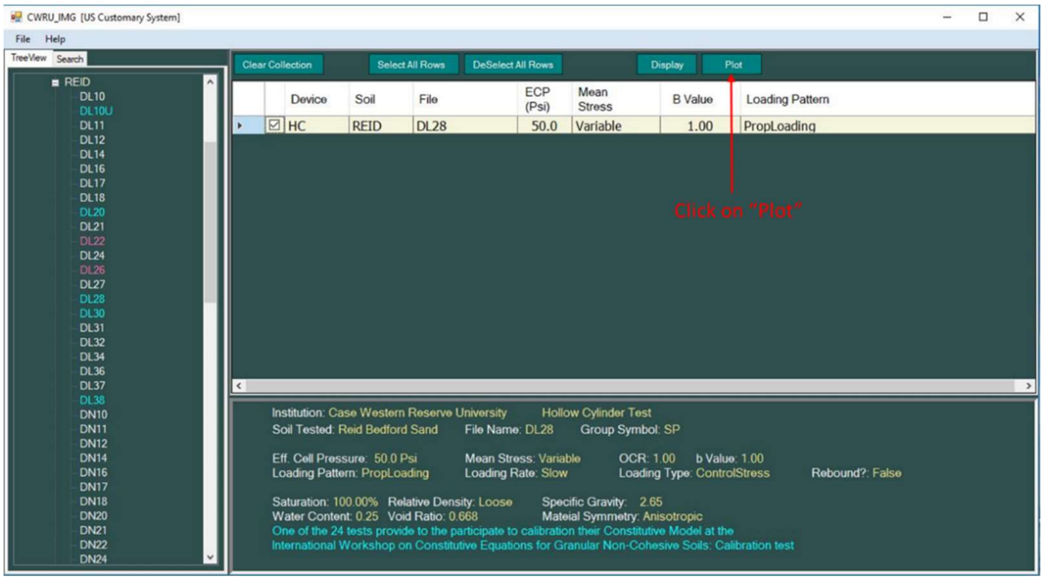
4. Resulting window



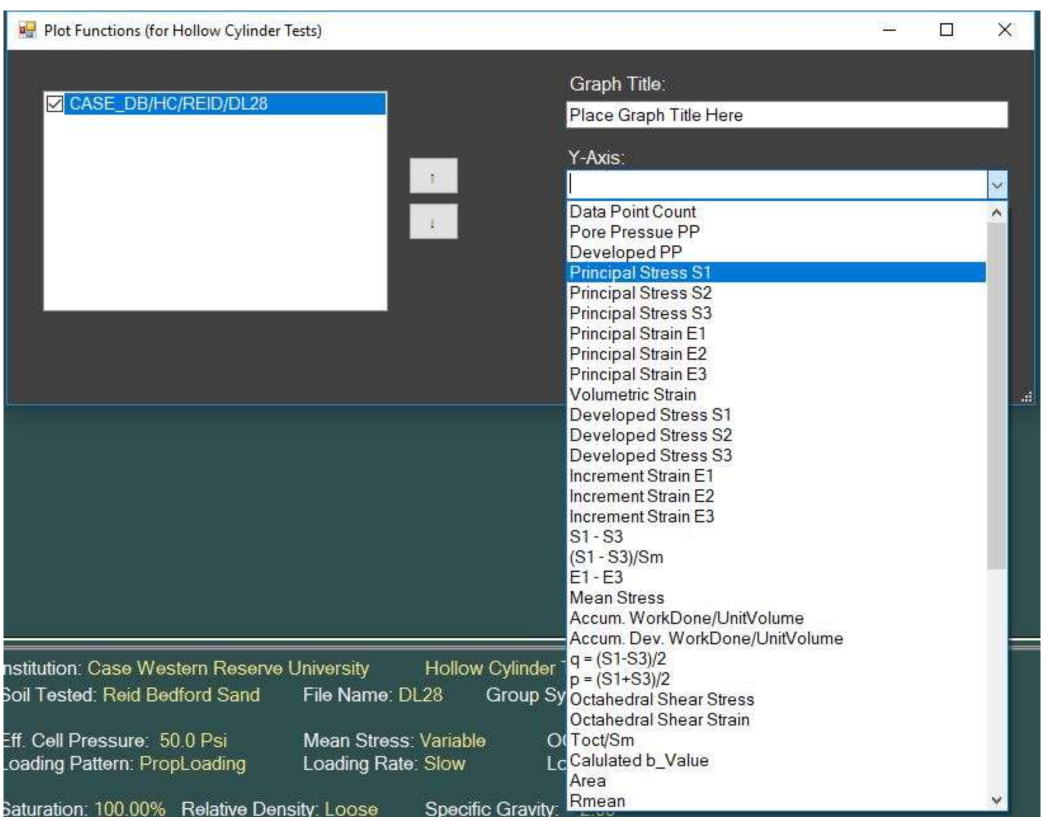
1.3.9.4 Example 4: Plotting data

Plotting test data for Hollow Cylinder Test, Reid Bedford, DL28

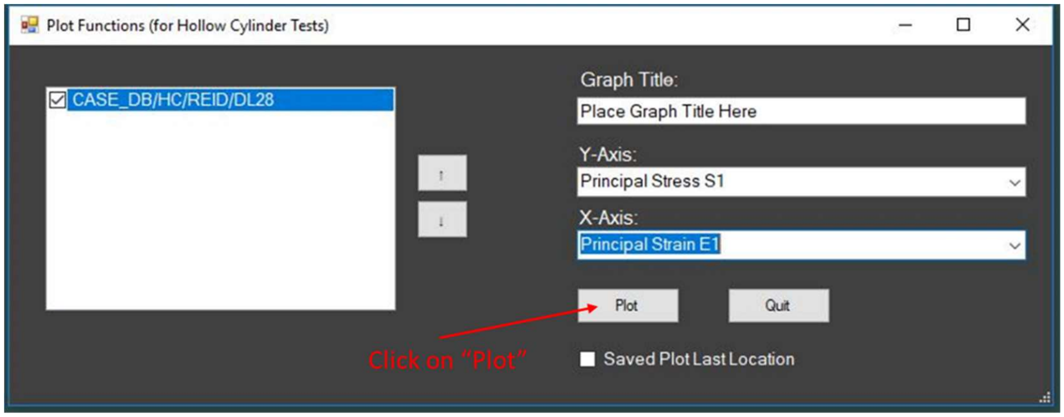
1. Repeat the first two steps from Example 3
2. Click on "Plot"



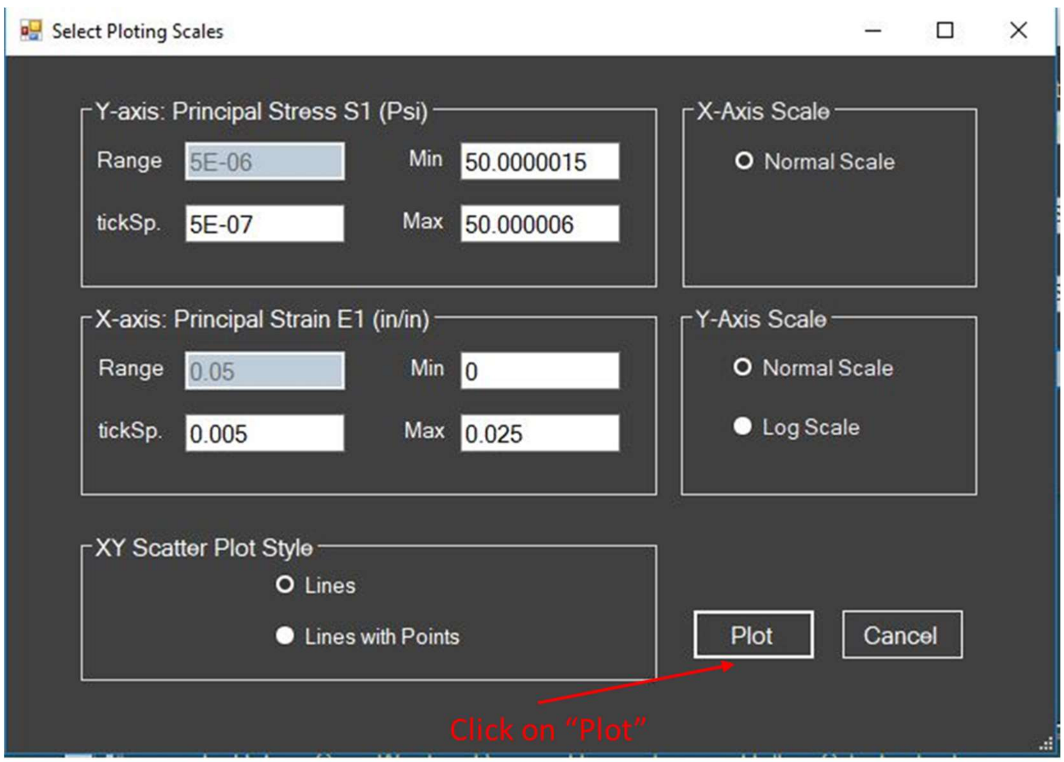
3. Select variables for Y-Axis and X-Axis (for this example: principal stress and strain)



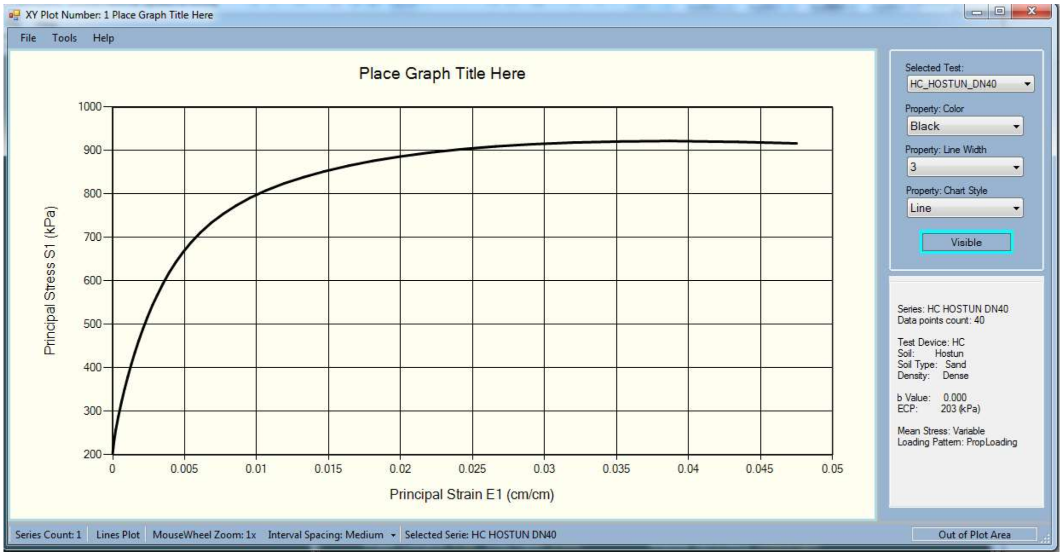
4. Click on “Plot” to continue



5. Click on “Plot” to continue



6. Final graph



To The User!

BEGIN WITH THE ENCLOSED VIDEO!

For detailed explanations,
please read the rest of this manual.

2 INTRODUCTION

The idea of creating a Data Base for the validation of Dynamic and Static Constitutive Relations for soils has been haunting the engineering and scientific communities for years. A succession of conferences and workshops held in the U.S. and Europe have emphasized the importance of having a trustworthy set of data to be used by civil engineers and researchers all over the world.

Over the years, research conducted at Case Western Reserve University on the mechanical behavior of soils under Dynamic and Static loading has resulted in a wealth of data. In the eighties a joint research program on constitutive equations supported by the National Science Foundation was started in cooperation with the University of Grenoble, France. The research resulted in substantial advances in the art of modeling, the techniques of testing and the intricacies of data acquisition and processing. It all led to the present data base which researchers can use to validate their constitutive relations. It contains over 234 tests conducted on three different sands with a wide variety of stress paths. More than half of the tests are on hollow cylinders, the rest on cubical samples. In addition, the data base contains the results of 18 tests on Edga Plastic Kaolin clay and the results of 8 tests on Hydrite121 clay; both series conducted on thin hollow cylinders.

The hollow cylinder tests are all conducted with the same pressure inside and outside the cylinder. Axial and torsional stresses are applied such that the result is a radial path with different values of $b = (\sigma_2-\sigma_3)/(\sigma_1-\sigma_3)$where σ_1, σ_2 and σ_3 are the principal stresses. The same radial stress paths (i.e. the same b) were duplicated in the cube tests; in addition to others, such as circular path tests, that can only be conducted in the cube device.

The references and the four papers cited in Appendix 1 give complete information on the tests conducted as well as details on the sizes of the specimen and the testing equipment. Such information can also be found in the data base for each test. The references will help answer most of the questions about the hollow cylinder and cube testing.

Advances in computer technology and software have necessitated the rewriting of the program and of the user's manual.

3 SOILS INCLUDED IN THE DATA BASE

The tests whose results are included in the data base were conducted on both clay and sand materials. Two types of clays are involved, namely, Edgar Plastic Kaolin (EPK) and McGill clay(Hydrite121) which is also a Kaolinitic type of clay. Three types of sand are involved, namely, Reid Bedford sand, Hostun sand, and LSI30 sand. The hollow cylinder configuration was used with both sands and clays. The cube configuration was used with sands alone. All the hollow cylinder data was generated at Case Western Reserve; all the cube data was generated at the University of Grenoble.

The user can choose either the SI Units System (Meter, Kilogram, Second) or the US Standard System (Feet, Pound, Second).

The notation is as close as possible to the conventional one. The letters used are defined and listed within the User's Manual. They are also exhibited whenever display or plotting of the data is desired.

It is appropriate at this stage to give a brief description of the soils used in the data base. However, more complete details are given when one brings up to the screen a particular test.

For the three sands used we have:

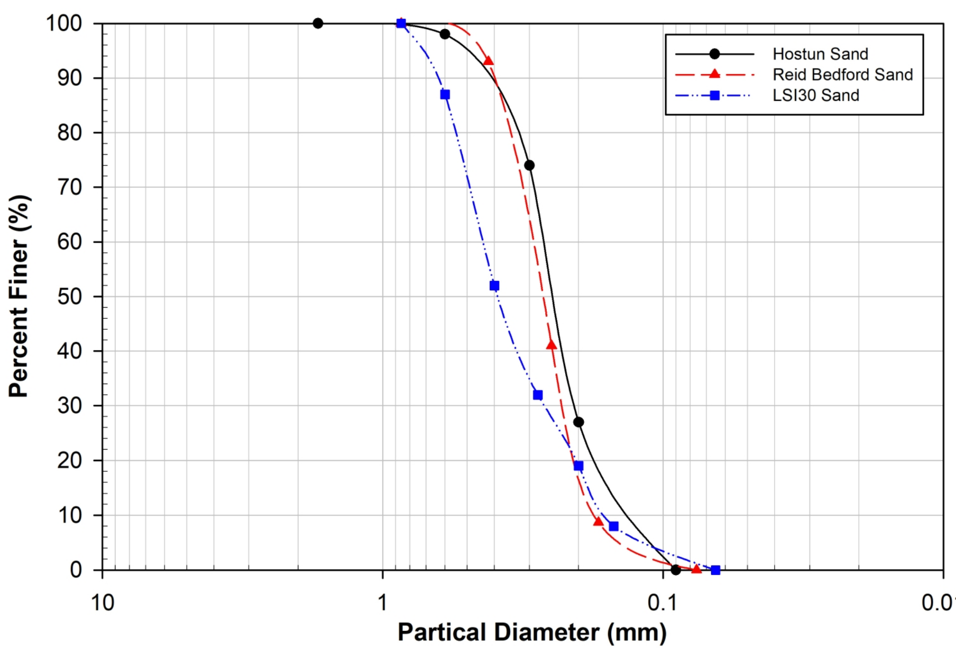


Figure 3-1: Grain Size Distribution

	Hostun Sand	**Reid Bedford Sand**	**LSI30 Sand**
USGS Group	SP	SP	SP
Specific Gravity	2.667	2.65	2.66
e_{max} or γ_{min}	1.66 (grs./cm^3)	0.85	0.83
e_{min} or γ_{max}	1.35 (grs./cm^3)	0.58	0.52

D_{50}	0.35mm	0.26mm	0.39mm

For the clays used we have:

	Edga Plastic Kaolin	**McGill Clay (Hydrite 121)**
Liquid Limit (LL)	56.3	49.6
Plastic Limit (PL)	37.3	37.9
G_s	2.61	2.61

4 ABOUT THE TESTS IN THE DATA BASE

4.1 Introduction and preliminary information

This data base has at present 260 tests conducted at Case Western Reserve University and the University of Grenoble. Those tests were conducted on hollow cylinders and cubes; using both sands and clays. The information in this chapter will help the reader familiarize himself rapidly with the content of this data base so that it can be put to use without undue effort. Figure 4-1 is just a reminder. The notation is familiar to all workers in soil mechanics.

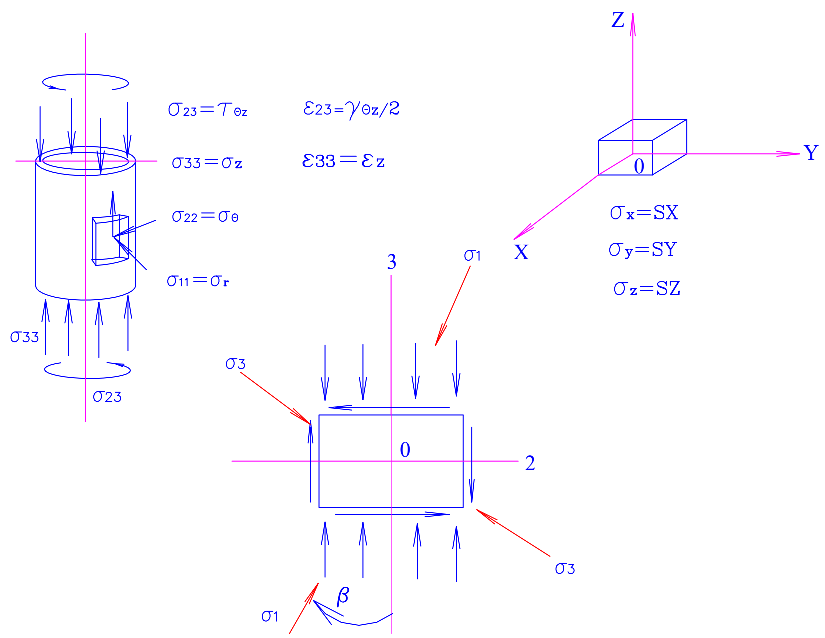


Figure 4-1

4.2 Basic information

All the tests conducted on sands were:

1. Normally consolidated hydrostatically, with no rebound (OCR=1.0);
2. Drained;
3. Slowly loaded;
4. Described as anisotropic because of the deposition process during the specimen's preparation

All the tests conducted on clays (EPK and McGill) were:

1. On hollow cylinders;
2. One dimensionally consolidated (This was followed by a release of the axial load and a period of equilibrium at the cell pressure. The result is a mean over-consolidation ratio of 1.3 making the specimen "nearly" normally consolidated but anisotropic);
3. Undrained with pore pressure measurements;
4. Slowly loaded;
5. Described as anisotropic because of the preparation and consolidation process.

All the tests in the cubical device were conducted on dry sands.

All the tests in the hollow cylinder device were conducted on saturated sands and clays. This, allowing for the measurement of the volume change when testing sands and the measurement of the developed pore water pressure where testing clay. To ensure saturation, back pressure was used with all the tests in the hollow cylinder device.

An important feature of this work is that the results are stored in a raw format and not in a processed one. Whenever a user wishes to examine or plot the results of a test, the variables that are needed are instantaneously calculated and displayed.

5 SIGN CONVENTION AND NOTATION

Throughout, the notations of soil mechanics and engineering mechanics are used to describe many of the variables; so are the traditional letters of the Greek alphabet. When they are not, as is often the case when dealing with graphs coordinates, the names are fully spelled. The user can choose the international system of units or its American equivalent.

5.1 Sign convention

Stress	kPa	or	psi
Length and Deformation	cm & mm	or	inch & feet
Strain	In Decimals	(Not Percent)	

In all tests and predictions, compression is positive and extension (as well as expansion) is negative. The following sketches illustrate the convention:

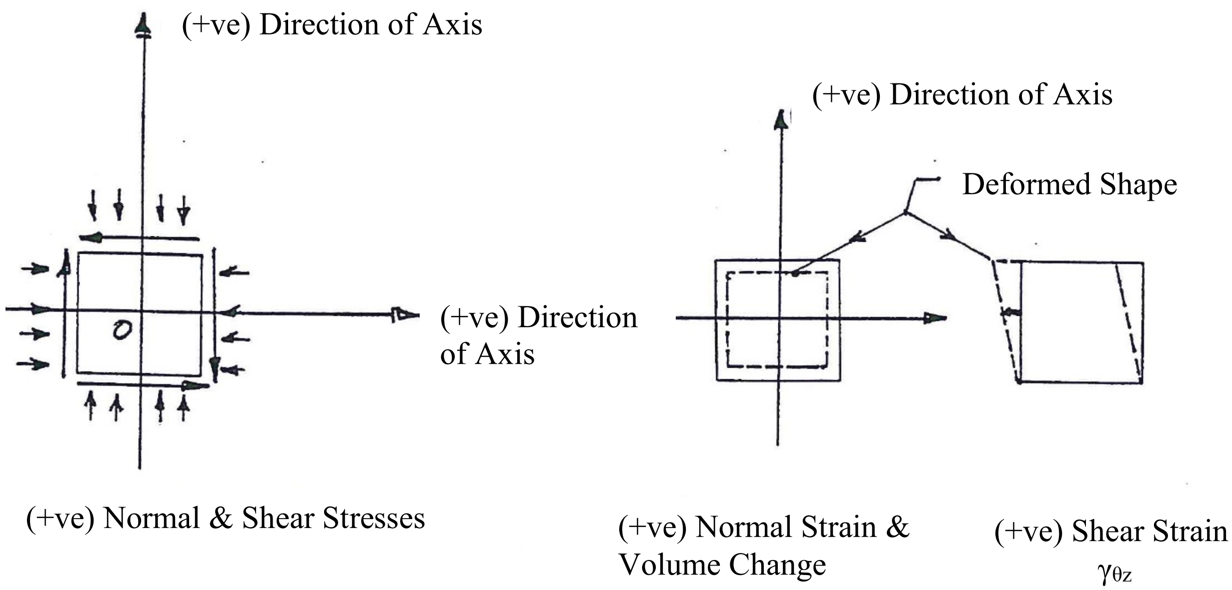


Figure 5-1 Sign convention

5.2 Notation

Observed and measured data:

AL = axial load

AD = axial deformation

CP = cell pressure

PP = pore water pressure

VC = volume change

T = applied torque

R = angle of rotation

Processed data:

σ_1 = major principal stress

σ_2 = intermediate principal stress

σ_3 = minor principal stress

q = $(\sigma_1 - \sigma_3)/2$

p = $(\sigma_1 + \sigma_3)/2$

σ_r = radial stress in the hollow cylinder

σ_θ = circumferential stress in the hollow cylinder

$\sigma_{\theta z}$ = applied shear stress in the hollow cylinder

σ_c = confining cell pressure in hollow cylinder

σ_z = axial stress in the hollow cylinder. Vertical stress in the cube configuration

σ_y = lateral stress in the cube configuration

σ_x = lateral stress in the cube configuration

σ_m = mean effective stress

τ_{oct} = octahedral shear stress

$\tau_{\theta z}$ = shear stress in the hollow cylinder

SD_2 = function of second invariant of the stress tensor

ε_1 = major principal strain

ε_2 = intermediate principal strain

ε_3 = minor principal strain

$\gamma_{\theta z}$ = Shear strain in the hollow cylinder

γ_{oct} = octahedral shear strain

ε_v = volumetric strain

ε_r = radial strain in the hollow cylinder = ε_2

ε_θ = circumferential strain in the hollow cylinder = ε_3

ε_z = vertical strain

ε_x = lateral strain in the cube

ε_y = lateral strain in the cube

ϕ_σ = stress phase angle in the π·plane

ϕ_ε = strain phase angle in the π plane

ID_2 = function of the second invariant of the strain tensor

b = $(\sigma_2 - \sigma_3) / (\sigma_1 - \sigma_3) = \sin^2\beta$

β = inclination of the principal stresses

6 APPARATUS AND TESTING PROCEDURES

6.1 The Hollow Cylinder

The hollow cylinder apparatus used at CASE is a triaxial cell apparatus that can apply axial, torsional, internal and external pressures on thin hollow cylindrical specimens. The device allows the control of internal and external poressures independently; also the axial and torsional stresses can be varied at will. For all the test conducted for this data base, the inner and outer pressures were equal. The stress paths were controlled so as to induce a condition of proportional loading between the axial and the torsional stress; thus keeping the inclination of the principal stress constant with respect to the axis of symmetry of the specmen (See Figure 6-2, Figure 6-3, and Figure 6-1).

The parameter b which locates the position of the intermediate principal stress is given by:

$$b = \frac{(\sigma 2 - \sigma 3)}{(\sigma 1 - \sigma 3)} = \sin^2 \beta$$

Where β is this inclination.

Ref: A. Saada and P. Puccini 1989 " The development of a data base using the Case Hollow Cylinder Apparatus", Constitutive Equations for Granular Non-Cohesive Soils, A.A. Balkema, 1988.

6.1.1 Specimen preparation and testing with the hollow cylinder

Special moulds hold the inner and outer membranes (thickness 0.28 mm) in place while the sand is dry-pluviated in successive layers. Vibration or tamping are applied after each layer has been placed, to reach a desired density. Hostun sand samples were always tamped. Reid Bedford sand samples were always vibrated.

With a small vacuum applied, the moulds were removed, the sample placed dry in the cell and subjected to a small hydrostatic pressure. It was then saturated using the CO_2 technique and left to reach equilibrium overnight under its final cell pressure and backpressure.

The membranes have an average thickness of 0.28 mm and a Young's modulus of about 1800 kpa.

The preparation of the clay soils, namely Edgar Plastic Kaolin (EPK) and McGill Clay (Hydrite 121) was more complex: Slurries of clay were mixed under vacuum and one dimensionally consolidated in a large consolidometer. From the resulting large blocks, 7.1 cm (2.8 in) cylinders were wire cut. A core of 5.18 cm (2.0 in) was removed from the center of each cylinder as illustrated in published references. With the membranes on, the hollow cylinders were one dimensionally consolidated in a large triaxial cell, then tested under axial, and torsional stresses. Both sand and clay specimens had nominal sizes of 7.1 cm (2.8 in.) O.D., 5.08 cm (2.0 in) I.D. and a length of 12.7 cm (5 in.).

In all the tests the same pressure acts on the inner and outer surfaces of the hollow cylinder. This means that the cell pressure is always equal to the inner pressure P_i and to the outer pressure P_0. (See Figure 6-1, Figure 6-2, and Figure 6-3)

If a test starts from a spherical state of stress, one has at the beginning

$$\sigma_c = p_i = p_0 = \sigma_r = \sigma_\theta = \sigma_z$$

During the test, σ_r is always the intermediate principal stress. σ_r is always equal to σ_θ and both are equal to the pressure in the cell. If there is backpressure, which is the case in all our tests, this backpressure must be subtracted from all the normal stresses to give the effective values. For example, the effective cell pressure σ'_c is the applied cell pressure σ_c minus the backpressure; the same applies to σ_r, σ_θ and σ_z. The backpressure never changes during a test. All the tests start from a fixed cell pressure; i.e. a fixed spherical state of stress.

Starting from a spherical state of stress, the axial and torsional stresses can be increased or decreased keeping a constant ratio. In such a case the inclination of the major principal stress β remains constant and is given by the formula:

$$\tan 2\beta = \frac{2\tau_{\theta z}}{\Delta\sigma_z - \Delta\sigma_\theta}$$

and

$$b = \sin^2 \beta$$

Notice that if the cell pressure remains constant, $\Delta\sigma_\theta = 0$ and

$$\tan 2\beta = \frac{2\tau_{\theta z}}{\Delta\sigma_z}$$

$\Delta\sigma_z$, under those circumstances is the additional axial stress produced by the piston, beyond the value due to the cell pressure.

If $\Delta\sigma_z$ and the cell pressure are changed such that the sum of the 3 normal stresses σ_r, σ_θ, σ_z remains constant and equal to three times the initial value of the spherical stress (i.e. the initial cell pressure), the test is called a generalized test. In this case the stress path remains on the octahedral or Π plane.

If the cell pressure remains constant and only the axial and torsional stresses are changed, the test is referred to as a direct test.

The shearing stress $\tau_{\theta z}$ is given by

$$\tau_{\theta z} = \frac{3M_t}{2\pi(R_0^3 - R_i^3)}$$

Where R_i and R_0 are the inner and outer radii.

The axial strains ε_z and shearing strains $\gamma_{\theta z}$ are incremental or logarithmic.

The volumetric strain is:

$$\varepsilon_v = \varepsilon_r + \varepsilon_\theta + \varepsilon_z = \varepsilon_1 + \varepsilon_2 + \varepsilon_3$$

The shearing strain is computed from

$$\gamma_{\theta z} = 2\varepsilon_{\theta z} = \frac{R_m \theta}{L}$$

Where θ is the angle of rotation, L the instantaneous length and R_m is the mean radius given by

$$R_m = \frac{2(R_0^3 - R_i^3)}{3(R_0^2 - R_i^2)}$$

The principal stresses and strains are computed by using the usual formulas. The parameter b is given by $(\sigma_2 - \sigma_3)/(\sigma_1 - \sigma_3) = \sin^2\beta$.

- In a compression test the vertical stress is increased and the lateral stresses (effective cell pressure) are kept consant.

- In an extension test the vertical stress is decreased and the lateral stresses are kept constant.

- In a hydrostatic compressive test the effective cell pressure $\sigma`_c$ is increased then decreased and the volume change measured.

It is to be noticed that extension tests fail through a necking instability and that the shear strength at failure is not a re1iab1e quantity.

The known equations for membrane corrections were applied and indicated a negligible effect of the membrane. Therefore no membrane effects were introduced in the data.

$$b = \frac{(\sigma 2 - \sigma 3)}{(\sigma 1 - \sigma 3)} = \sin^2 \beta$$

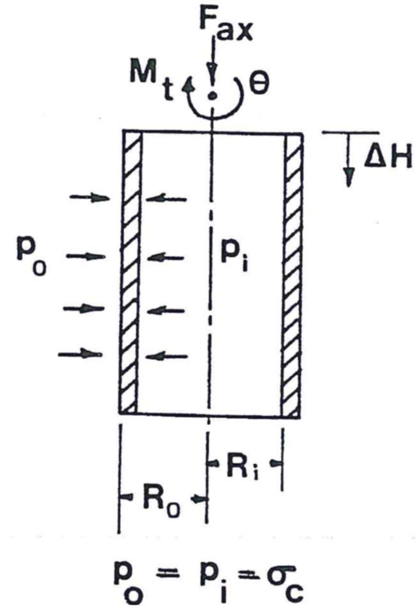


Figure 6-1

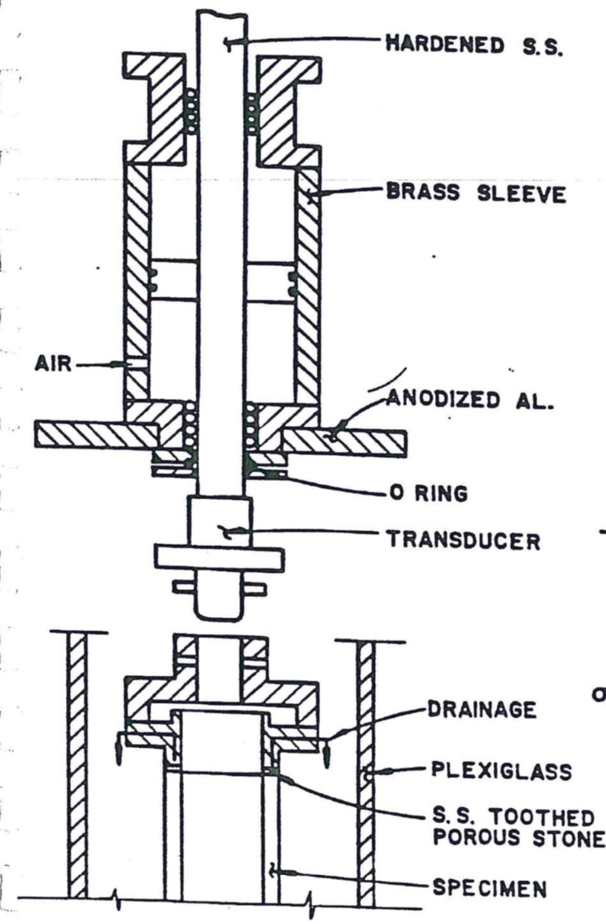


Figure 6-2

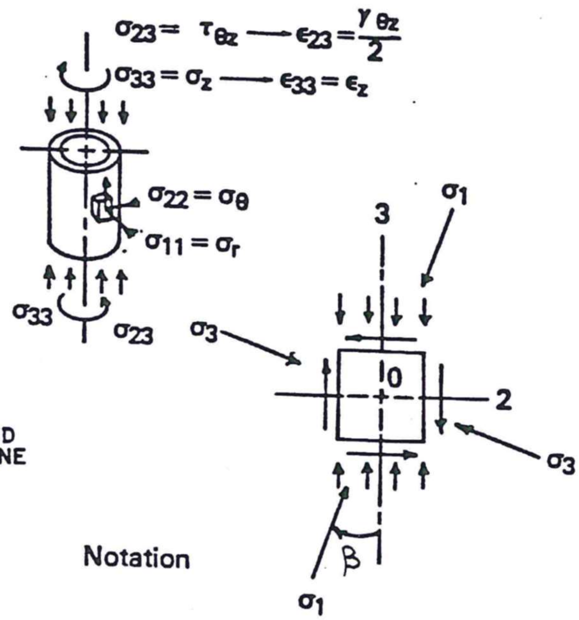


Figure 6-3

6.2 The Cube

The Grenoble True Triaxial Apparatus (TTA) is an apparatus with rigid boundaries. The measurements consist of 3 principal stresses and 3 principal strains. The kinetic controls are performed by 6 electrics motors synchronized 2 by 2. The dimension of testing box can vary from 5 cm to 15 cm with maximum speed of 5 mm/min. The applied stresses can go up to 10 MPa. During a test the box is completely closed through the use of hydraulic jacks. There are no gaps between the loading plates.

Ref: J. Lanier & Z. Zitouni, Development of a data base sing the Grenoble true triaxial apparatus', Constitutive Equations for Granular Non-Cohesive Soils.

6.2.1 Specimen preparation with the cube device

A plastic mould holds the membrane to the nominal dimensions of the sample. The sand is first pluviated in layers, then either vibrated vertically or tamped to reach its desired density. Hostun sand samples were always tamped. Reid Bedford sand samples were always vibrated.

With a small vacuum applied, the mould was removed and the sample placed in the middle of six compressive plates properly greased to minimize friction. The membrane was punctured to allow for drainage and the initial hydrostatic pressure was applied to the sample. The membrane has an average thickness of 0.3mm. All the cube tests were conducted on dry specimens. (See Figure 6-4 and Figure 6-5)

6.2.2 Testing with the cube device

The specimen is deformed between 6 rigid platens. The nominal size of the cube is 10 cm x 10 cm x 10 cm. The dimensions of the sides can change from 5 cm to 15 cm. The strains are calculated from the displacements which are measured by 3 LVDT's with an accuracy better than 0.05 mm. The stresses are directly measured by 3 pressure cells embedded in the pates and insensitive to tangential stress. Feedback allows one to control stresses or strains in a totally automated way.

Referring to the figures at the end of this section the following notations and definitions will be used:

1. For the Stresses (see Figure 6-4, Figure 6-5 and Figure 6-6)

In the cube OZ is always the vertical direction. The three directions OX, OY and OZ are associated with 01, 02 and 03. This means that $\sigma_1 = \sigma_x$, $\sigma_2 = \sigma_y$ and $\sigma_3 = \sigma_z$; and σ_1 is not necessarily the major principal stress.

- The components of the stress tensor are

$$\sigma_i(\sigma_1, \sigma_2, \sigma_3)\ or\ (\sigma_x, \sigma_y, \sigma_z)$$

- The mean pressure is σ_m with

$$3\sigma_m = \sigma_1 + \sigma_2 + \sigma_3 = 3P$$

- In the Octahedral or Π plane the intensity of the deviator ρ_σ= OM= SD2, is given by (Figure 6-6).

$$SD2 = OM = \rho_\sigma = \sqrt{\frac{1}{3}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]}$$

ϕ_σ = phase angle for stress

- In a compression test σ_z is the major principal stress and $\sigma_x = \sigma_y$ are the intermediate and minor principal stresses.

- With the previous notation

$$\sigma_1 = \sigma_m + \sqrt{\frac{2}{3}} SD2 \cos \phi_\sigma$$

$$\sigma_2 = \sigma_m + \sqrt{\frac{2}{3}} SD2 \cos(\phi_\sigma - 120^\circ)$$

$$\sigma_3 = \sigma_m + \sqrt{\frac{2}{3}} SD2 \cos(\phi_\sigma + 120^\circ)$$

2. <u>For the Strains</u> (see Figure 6-4, Figure 6-5 and Figure 6-7)

   Here too the directions 1, 2 and 3 are associated with OX, OY and OZ respectively.

   - The components of the strain tensor

$$\varepsilon_i(\varepsilon_1, \varepsilon_2, \varepsilon_3) \; or \; (\varepsilon_x, \varepsilon_y, \varepsilon_z)$$

   are computed incrementally or logarithmically.

   - The volumetric strain

$$\varepsilon_v = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = -LOG(V/V_0)$$

   is computed incrementally or logarithmically.

- In the octahedral or the Π plane the intensity of the deviator ρ_ε =OM= ID2 is given by (Figure 6-7)

$$ID2 = OM = \rho_\varepsilon = \sqrt{\frac{1}{3}[(\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_2 - \varepsilon_3)^2 + (\varepsilon_3 - \varepsilon_1)^2]}$$

ϕ_ϵ = phase angle for strain

- In a compression test, the vertical stress is increased and the lateral stresses are kept constant.

- In an extension test, the vertical stress is decreased and the lateral stresses are kept constant.

- In a hydrostatic compression test, the effective spherical stress is increased then decreased and the volume changes measured.

Bifurcation phenomena are quite visible beyond the peak.

A constant b is obtained by varying σ_1 and σ_3 while $\sigma_2 = \sigma_y$ is kept constant and equal to the initial spherical effective stress.

In the circular type test the loading starts from a spherical state of stress and during the whole test this mean stress remains constant; in other words we stay on the octahedral or Π plane. Referring to Figure 6-6, the loading path begins at 0 then proceeds along OA by increasing the vertical stress and decreasing the lateral ones. This corresponds to a phase angle ϕ_σ of -120°=. Then two cycles ABCABCA are performed.

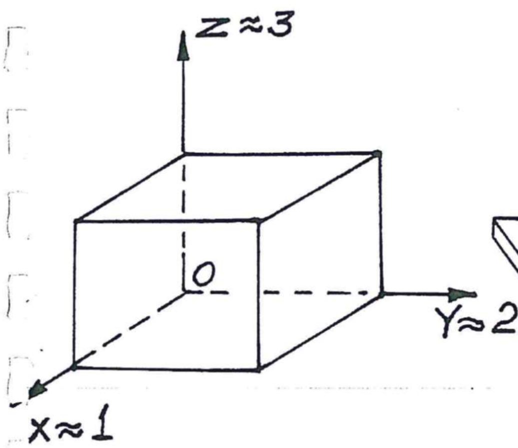


Figure 6-4

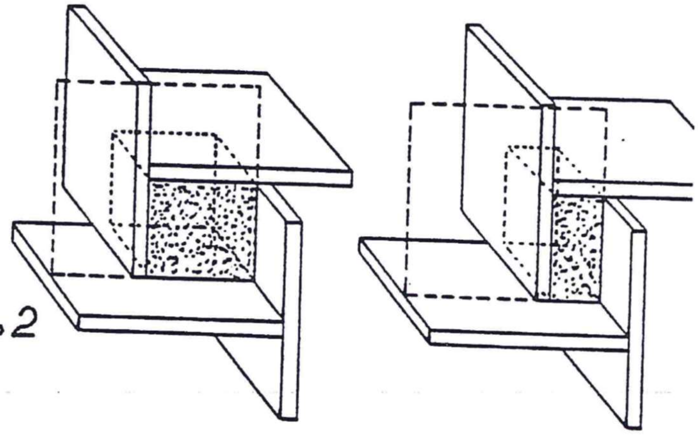


Figure 6-5

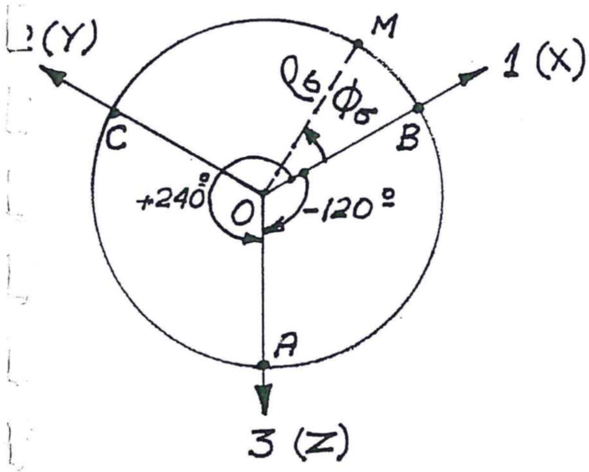


Figure 6-6

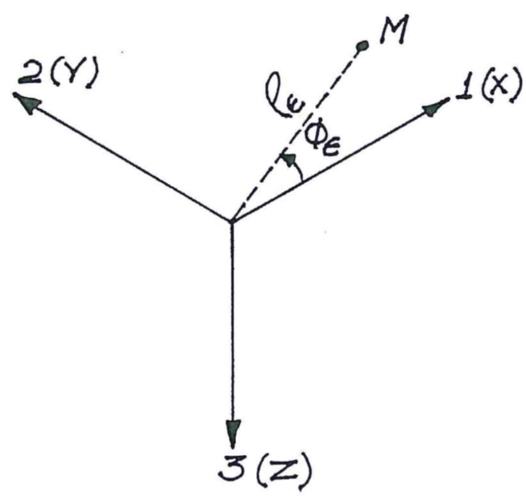


Figure 6-7

7 NOTATION AND LIST OF ALL THE TESTS

7.1 Notation

At the end of this section we give a printout of the listing of all the tests in the data base. The files are grouped in directories based on the type of testing device, and the name of the material tested. The legend for the letters at the top of the list is as follows:

Symbol	Definition
N	Index Number
File_Name	File Name
Format	File Format
Soil_Name	Soil Name
Type	File Type
GS	Group Symbol
RD	Relative Density
	L => Loose
	N, D => Dense
	U => Undefine
VR	Void Ratio
ECP	Effective Cell Pressure (kpa)
b	b
MS	Mean stress
	C => Constant
	V => Variable
LP	Loading Path
	1- Proportional Loading
	2- Proportional Loading with unloading
	3- Cyclic
	4- Complex

In the listing notice that the files for a particular device and a particular material have been grouped according to the effective cell pressure ECP; which is also most of the time, the consolidation pressure. In every grouping various values of b are covered.

When one is conducting a hollow cylinder test in which axial and torsional stresses are varied while keeping a constant ratio, the stress path is radial; and the inclination of the major principal stress on the axis of symmetry β is connected to β by

$$b = \sin^2\beta$$

In an attempt to include as much information as possible in the name of a file, the following numbering convention is used for the effective cell pressure and the value of b.

Nomenclature	ECP (psi,bar)	ECP (kPa)
1:	30 psi	(206.85 kPA)
2:	50 psi	(344.75 kPA)
3:	70 psi	(482.65 kPa)
4:	2 bar	(200.00 kPa)
5:	5 bar	(500.00 kPa)
6:	3.5 bar	(350.00 kPa)

Nomenclature	**β**	**b**
0:	0	0
1:	15	0.067
2:	31.75	0.277
3:	32.33	0.286
4:	45	0.5
5:	54.69	0.666
6:	58.25	0.723
7:	75	0.933
8:	90	1

Also, for the relative density of the material, three letters L, M and N are used for loose, medium and dense respectively.

The letter D is used for tests in which the mean stress varies. In a hollow cylinder test this involves increasing the axial load while the cell pressure is kept constant. The letter G is used for what is referred to as a generalized test. This is a test in which the mean stress remains constant. In the hollow cylinder this is done by increasing or decreasing the axial load while decreasing or increasing the cell pressure. Different combinations can be used to obtain this result in the case of a cube.

The letter U means that the test involves unloading.

The letter T refers to a specimen that has been trimmed to a dogbone shape to avoid end effects.

The letter H refers to a test in which the specimen has been subjected to a hydrostatic stress alone. Those tests usually involve a loading and unloading sequence.

The letter C refers to a complex stress path.

Thus as listed in the table at the end of this document,

Test 83:	CASE_DB|CUBE|SPEC|DL36U				
Cube special test using Reid Bedford Sand. All SPEC tests were performed on Reid Bedford Sand unless noted otherwise.					
DL36U	D	L	3	4	U
	Mean Stress = Direct Test	Relative Density = Loose	ECP = 483 kPa	b = 0.72	Loading = Unloading

Test 171:	CASE_DB|HC|MCGILL|DN22T				
Hollow Cylinder test using McGill Hydrite Clay.					
DN22T	D	N	2	2	T
	Mean Stress = Direct Test	Relative Density = Dense	ECP = 345 kPa	b = 0.25	Trimmed to a dog bone shape

There is a test conducted on McGill clay whose file name is DN2F4T (Test No. 176). This is a test in which the height was kept constant during pure torsion causing the axial load to vary slightly and with it the value of b.

There are two collections of tests which are special, namely, 'CASE_DB|CUBE|SPEC' and 'CASE_DB|HC|SPEC'.

Consider the first case CASE_DB|CUBE|SPEC whose files extend from No. 76 to No. 90 in the list:

1. Tests 76 and 77 have the word circular in their name and a three letter extension indicating the type of sand used. In those tests, the stress path is circular in the PI plane.

2. In Test 78 (DL24U) there are three cycles of loading and unloading with a constant mean stress and b = 0.5:

a. $\sigma_z \nearrow$, $\sigma_x \searrow$, σ_y = const; and the reverse

b. $\sigma_z \nearrow$, $\sigma_x \searrow$, σ_y = const; and the reverse

c. σ_z = const, $\sigma_x \nearrow$, $\sigma_y \searrow$; and the reverse

3. Tests 79, 80 and 81 have A, B and C in their name. They have been grouped because this is really one test in which loading was applied first in the Z direction and reversed; then applied in the X direction and reversed; then applied in the Y direction and reversed.

4. In test 82(DL30U), 83(DL36U) and 84(DL38U) b remains constant during the loading and the unloading phases. Examine those tests and note the pattern of changes in σ_x, σ_y, and σ_z.

5. Tests 85 to 88 have stress reversals, such that upon reversal the value of b jumps between two values; 0 and 1, 0.27 and 0.73, 0.73 and 0.27, and 1 and 0 respectively.

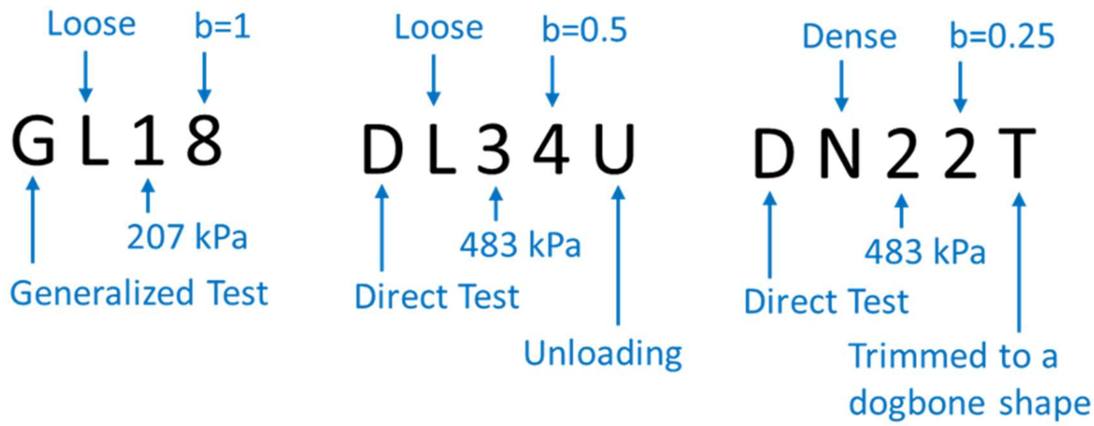
6. Please examine the pattern of changes in σ_x, σ_y, and σ_z.

7. Tests 89 and 90 were loaded and unloaded hydrostatically.

Consider the second directory CASE_DB|HC|SPEC with two files, namely 259 and 260. In those two tests the hollow cylinders were axially loaded to a given level then subjected to five cycles of torsion; at the end of which they were loaded in torsion to failure. Those two tests were used during the Case workshop to validate some of the proposed models.

Please examine now the following listing and the various groupings. To validate a given model, pick the group of tests that correspond to your own conditions (or is close to it), pick the basic tests needed to obtain your constants and try to predict the results of more complicated tests.

7.2 List of Tests in the Data Base



GS = Group Symbol
ECP = Effective Cell Pressure
RD = Relative Density
MS = Mean Stress
VR = Void Ratio
LP = Loading Path

N	File_Name	Format	Soil_Name	Type	GS	RD	VR	ECP	b	MS	LP
	CASE_DB-CUBE-HOSTUN										
0	CASE_DB|CUBE|HOSTUN|DL40	CUBE	Hostun	Sand	SP	L	0.756	200	0.000	V	1
1	CASE_DB|CUBE|HOSTUN|DL43	CUBE	Hostun	Sand	SP	L	0.773	200	0.286	V	1
2	CASE_DB|CUBE|HOSTUN|DL44	CUBE	Hostun	Sand	SP	L	0.745	200	0.500	C	1
3	CASE_DB|CUBE|HOSTUN|DL45	CUBE	Hostun	Sand	SP	L	0.761	200	0.666	V	1
4	CASE_DB|CUBE|HOSTUN|DL48	CUBE	Hostun	Sand	SP	L	0.77	200	1.000	V	1
5	CASE_DB|CUBE|HOSTUN|DL50	CUBE	Hostun	Sand	SP	L	0.751	500	0.000	V	1
6	CASE_DB|CUBE|HOSTUN|DL53	CUBE	Hostun	Sand	SP	L	0.754	500	0.286	V	1
7	CASE_DB|CUBE|HOSTUN|DL54	CUBE	Hostun	Sand	SP	L	0.810	500	0.500	C	1
8	CASE_DB|CUBE|HOSTUN|DL55	CUBE	Hostun	Sand	SP	L	0.773	500	0.666	V	1
9	CASE_DB|CUBE|HOSTUN|DL58	CUBE	Hostun	Sand	SP	L	0.806	500	1.000	V	1
10	CASE_DB|CUBE|HOSTUN|DN40	CUBE	Hostun	Sand	SP	D	0.635	200	0.000	V	1
11	CASE_DB|CUBE|HOSTUN|DN43	CUBE	Hostun	Sand	SP	D	0.651	200	0.286	V	1
12	CASE_DB|CUBE|HOSTUN|DN44	CUBE	Hostun	Sand	SP	D	0.635	200	0.500	C	1
13	CASE_DB|CUBE|HOSTUN|DN45	CUBE	Hostun	Sand	SP	D	0.645	200	0.666	V	1
14	CASE_DB|CUBE|HOSTUN|DN48	CUBE	Hostun	Sand	SP	D	0.645	200	1.000	V	1
15	CASE_DB|CUBE|HOSTUN|DN50	CUBE	Hostun	Sand	SP	D	0.631	500	0.000	V	1
16	CASE_DB|CUBE|HOSTUN|DN53	CUBE	Hostun	Sand	SP	D	0.626	500	0.286	V	1
17	CASE_DB|CUBE|HOSTUN|DN54	CUBE	Hostun	Sand	SP	D	0.622	500	0.500	C	1
18	CASE_DB|CUBE|HOSTUN|DN55	CUBE	Hostun	Sand	SP	D	0.638	500	0.666	V	1
19	CASE_DB|CUBE|HOSTUN|DN58	CUBE	Hostun	Sand	SP	D	0.621	500	1.000	V	1
20	CASE_DB|CUBE|HOSTUN|DN60	CUBE	Hostun	Sand	SP	D	0.64	350	0.000	V	1
21	CASE_DB|CUBE|HOSTUN|GL40	CUBE	Hostun	Sand	SP	L	0.756	200	0.000	C	1
22	CASE_DB|CUBE|HOSTUN|GL43	CUBE	Hostun	Sand	SP	L	0.755	200	0.286	C	1

23	CASE_DB|CUBE|HOSTUN|GL45	CUBE	Hostun	Sand	SP	L	0.755	200	0.666	C	1
24	CASE_DB|CUBE|HOSTUN|GL48	CUBE	Hostun	Sand	SP	L	0.748	200	1.000	C	1
25	CASE_DB|CUBE|HOSTUN|GL50	CUBE	Hostun	Sand	SP	L	0.728	500	0.000	C	1
26	CASE_DB|CUBE|HOSTUN|GL53	CUBE	Hostun	Sand	SP	L	0.763	500	0.286	C	1
27	CASE_DB|CUBE|HOSTUN|GL55	CUBE	Hostun	Sand	SP	L	0.756	500	0.666	C	1
28	CASE_DB|CUBE|HOSTUN|GL58	CUBE	Hostun	Sand	SP	L	0.75	500	1.000	C	1
29	CASE_DB|CUBE|HOSTUN|GN40	CUBE	Hostun	Sand	SP	D	0.643	200	0.000	C	1
30	CASE_DB|CUBE|HOSTUN|GN43	CUBE	Hostun	Sand	SP	D	0.648	200	0.286	C	1
31	CASE_DB|CUBE|HOSTUN|GN45	CUBE	Hostun	Sand	SP	D	0.640	200	0.666	C	1
32	CASE_DB|CUBE|HOSTUN|GN48	CUBE	Hostun	Sand	SP	D	0.639	200	1.000	C	1
33	CASE_DB|CUBE|HOSTUN|GN50	CUBE	Hostun	Sand	SP	D	0.635	500	0.000	C	1
34	CASE_DB|CUBE|HOSTUN|GN53	CUBE	Hostun	Sand	SP	D	0.641	500	0.286	C	1
35	CASE_DB|CUBE|HOSTUN|GN55	CUBE	Hostun	Sand	SP	D	0.641	500	0.666	C	1
36	CASE_DB|CUBE|HOSTUN|GN58	CUBE	Hostun	Sand	SP	D	0.64	500	1.000	C	1
37	CASE_DB|CUBE|HOSTUN|HN	CUBE	Hostun	Sand	SP	D	0.646	100	0.000	V	2
	CASE_DB|CUBE|LSI30										
38	CASE_DB|CUBE|LSI30|DN10	CUBE	Lsi30	Sand	SP	D	0.589	207	0.000	V	1
39	CASE_DB|CUBE|LSI30|DN12	CUBE	Lsi30	Sand	SP	D	0.577	207	0.277	V	1
40	CASE_DB|CUBE|LSI30|DN14	CUBE	Lsi30	Sand	SP	D	0.588	207	0.500	C	1
41	CASE_DB|CUBE|LSI30|DN16	CUBE	Lsi30	Sand	SP	D	0.575	207	0.723	V	1
42	CASE_DB|CUBE|LSI30|DN18	CUBE	Lsi30	Sand	SP	D	0.581	207	1.000	V	1
43	CASE_DB|CUBE|LSI30|DN30	CUBE	Lsi30	Sand	SP	D	0.566	483	0.000	V	1
44	CASE_DB|CUBE|LSI30|DN32	CUBE	Lsi30	Sand	SP	D	0.567	483	0.277	V	1
45	CASE_DB|CUBE|LSI30|DN34	CUBE	Lsi30	Sand	SP	D	0.571	483	0.500	C	1
46	CASE_DB|CUBE|LSI30|DN36	CUBE	Lsi30	Sand	SP	D	0.563	483	0.723	V	1
47	CASE_DB|CUBE|LSI30|DN38	CUBE	Lsi30	Sand	SP	D	0.575	483	1.000	V	1
48	CASE_DB|CUBE|LSI30|GN10	CUBE	Lsi30	Sand	SP	D	0.576	207	0.000	C	1
49	CASE_DB|CUBE|LSI30|GN12	CUBE	Lsi30	Sand	SP	D	0.579	207	0.277	C	1
50	CASE_DB|CUBE|LSI30|GN16	CUBE	Lsi30	Sand	SP	D	0.575	207	0.723	C	1
51	CASE_DB|CUBE|LSI30|GN18	CUBE	Lsi30	Sand	SP	D	0.55	207	1.000	C	1
52	CASE_DB|CUBE|LSI30|GN30	CUBE	Lsi30	Sand	SP	D	0.579	483	0.000	C	1
53	CASE_DB|CUBE|LSI30|GN32	CUBE	Lsi30	Sand	SP	D	0.558	483	0.277	C	1
54	CASE_DB|CUBE|LSI30|GN36	CUBE	Lsi30	Sand	SP	D	0.556	483	0.723	C	1
55	CASE_DB|CUBE|LSI30|GN38	CUBE	Lsi30	Sand	SP	D	0.567	483	1.000	C	1
	CASE_DB|CUBE|REID										
56	CASE_DB|CUBE|REID|DL10	CUBE	Reid Bedford	Sand	SP	L	0.674	207	0.000	V	1
57	CASE_DB|CUBE|REID|DL20	CUBE	Reid Bedford	Sand	SP	L	0.655	345	0.000	V	1
58	CASE_DB|CUBE|REID|DL22	CUBE	Reid Bedford	Sand	SP	L	0.662	345	0.277	V	1
59	CASE_DB|CUBE|REID|DL24	CUBE	Reid Bedford	Sand	SP	L	0.638	345	0.500	C	1
60	CASE_DB|CUBE|REID|DL26	CUBE	Reid Bedford	Sand	SP	L	0.643	345	0.723	V	1
61	CASE_DB|CUBE|REID|DL28	CUBE	Reid Bedford	Sand	SP	L	0.646	345	1.000	V	1

62	CASE_DB|CUBE|REID|DL30	CUBE	Reid Bedford	Sand	SP	L	0.644	483	0.000	V	1
63	CASE_DB|CUBE|REID|DL32	CUBE	Reid Bedford	Sand	SP	L	0.655	483	0.277	V	1
64	CASE_DB|CUBE|REID|DL34	CUBE	Reid Bedford	Sand	SP	L	0.645	483	0.500	C	1
65	CASE_DB|CUBE|REID|DL36	CUBE	Reid Bedford	Sand	SP	L	0.665	483	0.723	V	1
66	CASE_DB|CUBE|REID|DL38	CUBE	Reid Bedford	Sand	SP	L	0.636	483	1.000	V	1
67	CASE_DB|CUBE|REID|GL10	CUBE	Reid Bedford	Sand	SP	L	0.670	207	0.000	C	1
68	CASE_DB|CUBE|REID|GL12	CUBE	Reid Bedford	Sand	SP	L	0.670	207	0.277	C	1
69	CASE_DB|CUBE|REID|GL16	CUBE	Reid Bedford	Sand	SP	L	0.648	207	0.723	C	1
70	CASE_DB|CUBE|REID|GL18	CUBE	Reid Bedford	Sand	SP	L	0.661	207	1.000	C	1
71	CASE_DB|CUBE|REID|GL30	CUBE	Reid Bedford	Sand	SP	L	0.649	483	0.000	C	1
72	CASE_DB|CUBE|REID|GL32	CUBE	Reid Bedford	Sand	SP	L	0.650	483	0.277	C	1
73	CASE_DB|CUBE|REID|GL36	CUBE	Reid Bedford	Sand	SP	L	0.672	483	0.723	C	1
74	CASE_DB|CUBE|REID|GL38	CUBE	Reid Bedford	Sand	SP	L	0.650	483	1.000	C	1
75	CASE_DB|CUBE|REID|HL	CUBE	Reid Bedford	Sand	SP	L	0.654	100	0.000	V	2
	CASE_DB|CUBE|SPEC										
76	CASE_DB|CUBE|SPEC|CIRCULAR.HOS	CUBE	Hostun	Sand	SP	D	0.632	500	-1.000	V	4
77	CASE_DB|CUBE|SPEC|CIRCULAR.REI	CUBE	Reid Bedford	Sand	SP	L	0.628	345	-1.000	V	4
78	CASE_DB|CUBE|SPEC|DL24U	CUBE	Reid Bedford	Sand	SP	L	0.638	345	0.500	C	4
79	CASE_DB|CUBE|SPEC|DL30A	CUBE	Reid Bedford	Sand	SP	L	0.644	483	0.000	V	4
80	CASE_DB|CUBE|SPEC|DL30B	CUBE	Reid Bedford	Sand	SP	L	0.688	483	0.000	V	4
81	CASE_DB|CUBE|SPEC|DL30C	CUBE	Reid Bedford	Sand	SP	L	0.713	483	0.000	V	4
82	CASE_DB|CUBE|SPEC|DL30U	CUBE	Reid Bedford	Sand	SP	L	0.644	483	0.000	V	4
83	CASE_DB|CUBE|SPEC|DL36U	CUBE	Reid Bedford	Sand	SP	L	0.665	483	0.720	V	4
84	CASE_DB|CUBE|SPEC|DL38U	CUBE	Reid Bedford	Sand	SP	L	0.635	483	1.000	V	4
85	CASE_DB|CUBE|SPEC|GL3S0U	CUBE	Reid Bedford	Sand	SP	L	0.649	483	-1.000	V	4
86	CASE_DB|CUBE|SPEC|GL3S2U	CUBE	Reid Bedford	Sand	SP	L	0.650	483	-1.000	V	4
87	CASE_DB|CUBE|SPEC|GL3S6U	CUBE	Reid Bedford	Sand	SP	L	0.672	483	-1.000	V	4
88	CASE_DB|CUBE|SPEC|GL3S8U	CUBE	Reid Bedford	Sand	SP	L	0.650	483	-1.000	V	4
89	CASE_DB|CUBE|SPEC|HL3U1	CUBE	Reid Bedford	Sand	SP	L	0.638	483	0.000	V	2
90	CASE_DB|CUBE|SPEC|HL3U2	CUBE	Reid Bedford	Sand	SP	L	0.677	483	0.000	V	2
	CASE_DB|HC|EPK										
91	CASE_DB|HC|EPK|DN20	HC	Kaolinite	Clay	CH	U	0.916	345	0.000	V	1
92	CASE_DB|HC|EPK|DN22	HC	Kaolinite	Clay	CH	U	0.911	345	0.250	V	1
93	CASE_DB|HC|EPK|DN22T	HC	Kaolinite	Clay	CH	U	0.906	345	0.250	V	1
94	CASE_DB|HC|EPK|DN24	HC	Kaolinite	Clay	CH	U	0.867	345	0.500	C	1
95	CASE_DB|HC|EPK|DN24T	HC	Kaolinite	Clay	CH	U	0.864	345	0.500	C	1
96	CASE_DB|HC|EPK|DN26	HC	Kaolinite	Clay	CH	U	0.927	345	0.750	V	1
97	CASE_DB|HC|EPK|DN26T	HC	Kaolinite	Clay	CH	U	0.906	345	0.750	V	1
98	CASE_DB|HC|EPK|DN28	HC	Kaolinite	Clay	CH	U	0.887	345	1.000	V	1
99	CASE_DB|HC|EPK|DN70	HC	Kaolinite	Clay	CH	U	0.928	241	0.000	V	1
100	CASE_DB|HC|EPK|DN72	HC	Kaolinite	Clay	CH	U	0.950	241	0.250	V	1

101	CASE_DB|HC|EPK|DN74	HC	Kaolinite	Clay	CH	U	0.940	241	0.500	C	1
102	CASE_DB|HC|EPK|DN76	HC	Kaolinite	Clay	CH	U	0.968	241	0.750	V	1
103	CASE_DB|HC|EPK|DN78	HC	Kaolinite	Clay	CH	U	0.934	241	1.000	V	1
104	CASE_DB|HC|EPK|DN80	HC	Kaolinite	Clay	CH	U	0.859	552	0.000	V	1
105	CASE_DB|HC|EPK|DN82	HC	Kaolinite	Clay	CH	U	0.846	552	0.250	V	1
106	CASE_DB|HC|EPK|DN84	HC	Kaolinite	Clay	CH	U	0.851	552	0.500	C	1
107	CASE_DB|HC|EPK|DN86	HC	Kaolinite	Clay	CH	U	0.869	552	0.750	V	1
108	CASE_DB|HC|EPK|DN88	HC	Kaolinite	Clay	CH	U	0.864	552	1.000	V	1
	CASE_DB|HC|HOSTUN										
109	CASE_DB|HC|HOSTUN|DL40	HC	Hostun	Sand	SP	L	0.736	200	0.000	V	1
110	CASE_DB|HC|HOSTUN|DL43	HC	Hostun	Sand	SP	L	0.717	200	0.286	V	1
111	CASE_DB|HC|HOSTUN|DL44	HC	Hostun	Sand	SP	L	0.717	200	0.500	C	1
112	CASE_DB|HC|HOSTUN|DL45	HC	Hostun	Sand	SP	L	0.707	200	0.666	V	1
113	CASE_DB|HC|HOSTUN|DL48	HC	Hostun	Sand	SP	L	0.717	200	1.000	V	1
114	CASE_DB|HC|HOSTUN|DL50	HC	Hostun	Sand	SP	L	0.707	500	0.000	V	1
115	CASE_DB|HC|HOSTUN|DL53	HC	Hostun	Sand	SP	L	0.717	500	286.000	V	1
116	CASE_DB|HC|HOSTUN|DL54	HC	Hostun	Sand	SP	L	0.707	500	0.500	C	1
117	CASE_DB|HC|HOSTUN|DL55	HC	Hostun	Sand	SP	L	0.701	500	0.666	V	1
118	CASE_DB|HC|HOSTUN|DL58	HC	Hostun	Sand	SP	L	0.717	500	1.000	V	1
119	CASE_DB|HC|HOSTUN|DN40	HC	Hostun	Sand	SP	D	0.613	203	0.000	V	1
120	CASE_DB|HC|HOSTUN|DN40U	HC	Hostun	Sand	SP	D	0.624	200	0.000	V	2
121	CASE_DB|HC|HOSTUN|DN43	HC	Hostun	Sand	SP	D	0.613	203	0.289	V	1
122	CASE_DB|HC|HOSTUN|DN44	HC	Hostun	Sand	SP	D	0.616	203	0.500	C	1
123	CASE_DB|HC|HOSTUN|DN45	HC	Hostun	Sand	SP	D	0.635	200	0.660	V	1
124	CASE_DB|HC|HOSTUN|DN48	HC	Hostun	Sand	SP	D	0.613	203	1.000	V	1
125	CASE_DB|HC|HOSTUN|DN50	HC	Hostun	Sand	SP	D	0.605	500	0.000	V	1
126	CASE_DB|HC|HOSTUN|DN50U	HC	Hostun	Sand	SP	D	0.613	500	0.000	V	2
127	CASE_DB|HC|HOSTUN|DN53	HC	Hostun	Sand	SP	D	0.605	500	0.286	V	1
128	CASE_DB|HC|HOSTUN|DN54	HC	Hostun	Sand	SP	D	0.624	500	0.500	C	1
129	CASE_DB|HC|HOSTUN|DN55	HC	Hostun	Sand	SP	D	0.613	500	0.660	V	1
130	CASE_DB|HC|HOSTUN|DN58	HC	Hostun	Sand	SP	D	0.613	500	1.000	V	1
131	CASE_DB|HC|HOSTUN|DN60	HC	Hostun	Sand	SP	D	0.624	350	0.000	V	1
132	CASE_DB|HC|HOSTUN|GL40	HC	Hostun	Sand	SP	L	0.741	200	0.000	C	1
133	CASE_DB|HC|HOSTUN|GL43	HC	Hostun	Sand	SP	L	0.717	200	0.286	C	1
134	CASE_DB|HC|HOSTUN|GL45	HC	Hostun	Sand	SP	L	0.717	200	0.666	C	1
135	CASE_DB|HC|HOSTUN|GL48	HC	Hostun	Sand	SP	L	0.736	200	1.000	C	1
136	CASE_DB|HC|HOSTUN|GL50	HC	Hostun	Sand	SP	L	0.696	500	0.000	C	1
137	CASE_DB|HC|HOSTUN|GL53	HC	Hostun	Sand	SP	L	0.736	500	0.286	C	1
138	CASE_DB|HC|HOSTUN|GL55	HC	Hostun	Sand	SP	L	0.741	500	0.666	C	1
139	CASE_DB|HC|HOSTUN|GN40	HC	Hostun	Sand	SP	D	0.624	203	0.000	C	1
140	CASE_DB|HC|HOSTUN|GN43	HC	Hostun	Sand	SP	D	0.613	200	0.286	C	1
141	CASE_DB|HC|HOSTUN|GN45	HC	Hostun	Sand	SP	D	0.624	200	0.660	C	1

142	CASE_DB|HC|HOSTUN|GN48	HC	Hostun	Sand	SP	D	0.613	203	1.000	C	1
143	CASE_DB|HC|HOSTUN|GN50	HC	Hostun	Sand	SP	D	0.605	500	0.000	C	1
144	CASE_DB|HC|HOSTUN|GN53	HC	Hostun	Sand	SP	D	0.613	500	0.286	C	1
145	CASE_DB|HC|HOSTUN|GN55	HC	Hostun	Sand	SP	D	0.624	500	0.666	C	1
146	CASE_DB|HC|HOSTUN|HL	HC	Hostun	Sand	SP	L	0.707	69	0.000	V	2
147	CASE_DB|HC|HOSTUN|HN	HC	Hostun	Sand	SP	D	0.613	69	0.000	V	2
	CASE_DB|HC|LSI30										
148	CASE_DB|HC|LSI30|DN10	HC	Lsi30	Sand	SP	D	0.551	207	0.000	V	1
149	CASE_DB|HC|LSI30|DN12	HC	Lsi30	Sand	SP	D	0.569	207	0.277	V	1
150	CASE_DB|HC|LSI30|DN14	HC	Lsi30	Sand	SP	D	0.561	207	0.500	C	1
151	CASE_DB|HC|LSI30|DN16	HC	Lsi30	Sand	SP	D	0.561	207	0.723	V	1
152	CASE_DB|HC|LSI30|DN18	HC	Lsi30	Sand	SP	D	0.569	207	1.000	V	1
153	CASE_DB|HC|LSI30|DN30	HC	Lsi30	Sand	SP	D	0.561	483	0.000	V	1
154	CASE_DB|HC|LSI30|DN32	HC	Lsi30	Sand	SP	D	0.561	483	0.277	V	1
155	CASE_DB|HC|LSI30|DN34	HC	Lsi30	Sand	SP	D	0.561	483	0.500	C	1
156	CASE_DB|HC|LSI30|DN36	HC	Lsi30	Sand	SP	D	0.551	483	0.723	V	1
157	CASE_DB|HC|LSI30|DN38	HC	Lsi30	Sand	SP	D	0.569	483	1.000	V	1
158	CASE_DB|HC|LSI30|GN10	HC	Lsi30	Sand	SP	D	0.543	207	0.000	C	1
159	CASE_DB|HC|LSI30|GN12	HC	Lsi30	Sand	SP	D	0.561	207	0.277	C	1
160	CASE_DB|HC|LSI30|GN16	HC	Lsi30	Sand	SP	D	0.569	207	0.723	C	1
161	CASE_DB|HC|LSI30|GN18	HC	Lsi30	Sand	SP	D	0.561	207	1.000	C	1
162	CASE_DB|HC|LSI30|GN30	HC	Lsi30	Sand	SP	D	0.561	483	0.000	C	1
163	CASE_DB|HC|LSI30|GN32	HC	Lsi30	Sand	SP	D	0.551	483	0.277	C	1
164	CASE_DB|HC|LSI30|GN36	HC	Lsi30	Sand	SP	D	0.551	483	0.723	C	1
165	CASE_DB|HC|LSI30|HN	HC	Lsi30	Sand	SP	D	0.580	69	0.000	V	2
166	CASE_DB|HC|LSI30|HNA	HC	Lsi30	Sand	SP	D	0.580	69	0.000	V	1
167	CASE_DB|HC|LSI30|HNB	HC	Lsi30	Sand	SP	D	0.580	400	0.000	V	1
168	CASE_DB|HC|LSI30|HNC	HC	Lsi30	Sand	SP	D	0.580	69	0.000	V	1
	CASE_DB|HC|MCGILL										
169	CASE_DB|HC|MCGILL|DN20	HC	Hydrite 121	Clay	CL	U	0.924	345	0.000	V	1
170	CASE_DB|HC|MCGILL|DN22	HC	Hydrite 121	Clay	CL	U	0.853	345	0.250	V	1
171	CASE_DB|HC|MCGILL|DN22T	HC	Hydrite 121	Clay	CL	U	0.822	345	0.250	V	1
172	CASE_DB|HC|MCGILL|DN24	HC	Hydrite 121	Clay	CL	U	0.877	345	0.500	C	1
173	CASE_DB|HC|MCGILL|DN24T	HC	Hydrite 121	Clay	CL	U	0.773	345	0.500	C	1
174	CASE_DB|HC|MCGILL|DN26	HC	Hydrite 121	Clay	CL	U	0.835	345	0.750	V	1
175	CASE_DB|HC|MCGILL|DN28	HC	Hydrite 121	Clay	CL	U	0.827	345	1.000	V	1
176	CASE_DB|HC|MCGILL|DN2F4T	HC	Hydrite 121	Clay	CL	U	0.767	345	-1.000	V	4
	CASE_DB|HC|REID										
177	CASE_DB|HC|REID|DL10	HC	Reid Bedford	Sand	SP	L	0.718	207	0.000	V	1
178	CASE_DB|HC|REID|DL10U	HC	Reid Bedford	Sand	SP	L	0.67	207	0.000	V	2

179	CASE_DB|HC|REID|DL11	HC	Reid Bedford	Sand	SP	L	0.716	207	0.067	V	1
180	CASE_DB|HC|REID|DL12	HC	Reid Bedford	Sand	SP	L	0.716	207	0.277	V	1
181	CASE_DB|HC|REID|DL14	HC	Reid Bedford	Sand	SP	L	0.716	207	0.500	C	1
182	CASE_DB|HC|REID|DL16	HC	Reid Bedford	Sand	SP	L	0.716	207	0.723	V	1
183	CASE_DB|HC|REID|DL17	HC	Reid Bedford	Sand	SP	L	0.716	207	0.933	V	1
184	CASE_DB|HC|REID|DL18	HC	Reid Bedford	Sand	SP	L	0.716	207	1.000	V	1
185	CASE_DB|HC|REID|DL20	HC	Reid Bedford	Sand	SP	L	0.668	345	0.000	V	1
186	CASE_DB|HC|REID|DL21	HC	Reid Bedford	Sand	SP	L	0.716	345	0.067	V	1
187	CASE_DB|HC|REID|DL22	HC	Reid Bedford	Sand	SP	L	0.716	345	0.277	V	1
188	CASE_DB|HC|REID|DL24	HC	Reid Bedford	Sand	SP	L	0.716	345	0.500	C	1
189	CASE_DB|HC|REID|DL26	HC	Reid Bedford	Sand	SP	L	0.716	345	0.723	V	1
190	CASE_DB|HC|REID|DL27	HC	Reid Bedford	Sand	SP	L	0.716	345	0.933	V	1
191	CASE_DB|HC|REID|DL28	HC	Reid Bedford	Sand	SP	L	0.668	345	1.000	V	1
192	CASE_DB|HC|REID|DL30	HC	Reid Bedford	Sand	SP	L	0.668	483	0.000	V	1
193	CASE_DB|HC|REID|DL31	HC	Reid Bedford	Sand	SP	L	0.716	483	0.067	V	1
194	CASE_DB|HC|REID|DL32	HC	Reid Bedford	Sand	SP	L	0.716	483	0.277	V	1
195	CASE_DB|HC|REID|DL34	HC	Reid Bedford	Sand	SP	L	0.716	483	0.500	C	1
196	CASE_DB|HC|REID|DL36	HC	Reid Bedford	Sand	SP	L	0.716	483	0.723	V	1
197	CASE_DB|HC|REID|DL37	HC	Reid Bedford	Sand	SP	L	0.716	483	0.933	V	1
198	CASE_DB|HC|REID|DL38	HC	Reid Bedford	Sand	SP	L	0.668	483	1.000	V	1
199	CASE_DB|HC|REID|DN10	HC	Reid Bedford	Sand	SP	D	0.559	207	0.000	V	1
200	CASE_DB|HC|REID|DN11	HC	Reid Bedford	Sand	SP	D	0.567	207	0.067	V	1
201	CASE_DB|HC|REID|DN12	HC	Reid Bedford	Sand	SP	D	0.559	207	0.277	V	1
202	CASE_DB|HC|REID|DN14	HC	Reid Bedford	Sand	SP	D	0.567	207	0.500	C	1
203	CASE_DB|HC|REID|DN16	HC	Reid Bedford	Sand	SP	D	0.559	207	0.723	V	1
204	CASE_DB|HC|REID|DN17	HC	Reid Bedford	Sand	SP	D	0.559	207	0.933	V	1
205	CASE_DB|HC|REID|DN18	HC	Reid Bedford	Sand	SP	D	0.559	207	1.000	V	1
206	CASE_DB|HC|REID|DN20	HC	Reid Bedford	Sand	SP	D	0.559	345	0.000	V	1
207	CASE_DB|HC|REID|DN21	HC	Reid Bedford	Sand	SP	D	0.559	345	0.067	V	1
208	CASE_DB|HC|REID|DN22	HC	Reid Bedford	Sand	SP	D	0.559	345	0.277	V	1
209	CASE_DB|HC|REID|DN24	HC	Reid Bedford	Sand	SP	D	0.567	345	0.500	C	1
210	CASE_DB|HC|REID|DN26	HC	Reid Bedford	Sand	SP	D	0.559	345	0.723	V	1
211	CASE_DB|HC|REID|DN27	HC	Reid Bedford	Sand	SP	D	0.559	345	0.933	V	1
212	CASE_DB|HC|REID|DN28	HC	Reid Bedford	Sand	SP	D	0.578	345	1.000	V	1
213	CASE_DB|HC|REID|DN30	HC	Reid Bedford	Sand	SP	D	0.559	483	0.000	V	1
214	CASE_DB|HC|REID|DN31	HC	Reid Bedford	Sand	SP	D	0.559	483	0.067	V	1
215	CASE_DB|HC|REID|DN32	HC	Reid Bedford	Sand	SP	D	0.559	483	0.277	V	1
216	CASE_DB|HC|REID|DN34	HC	Reid Bedford	Sand	SP	D	0.567	483	0.500	C	1
217	CASE_DB|HC|REID|DN36	HC	Reid Bedford	Sand	SP	D	0.559	483	0.723	V	1
218	CASE_DB|HC|REID|DN37	HC	Reid Bedford	Sand	SP	D	0.559	483	0.933	V	1
219	CASE_DB|HC|REID|DN38	HC	Reid Bedford	Sand	SP	D	0.567	483	1.000	V	1
220	CASE_DB|HC|REID|GL10	HC	Reid Bedford	Sand	SP	L	0.716	207	0.000	C	1
221	CASE_DB|HC|REID|GL11	HC	Reid Bedford	Sand	SP	L	0.716	207	0.067	C	1

222	CASE_DB|HC|REID|GL12	HC	Reid Bedford	Sand	SP	L	0.716	207	0.277	C	1
223	CASE_DB|HC|REID|GL16	HC	Reid Bedford	Sand	SP	L	0.716	207	0.723	C	1
224	CASE_DB|HC|REID|GL17	HC	Reid Bedford	Sand	SP	L	0.716	207	0.933	C	1
225	CASE_DB|HC|REID|GL18	HC	Reid Bedford	Sand	SP	L	0.716	207	1.000	C	1
226	CASE_DB|HC|REID|GL20	HC	Reid Bedford	Sand	SP	L	0.716	345	0.000	C	1
227	CASE_DB|HC|REID|GL21	HC	Reid Bedford	Sand	SP	L	0.716	345	0.067	C	1
228	CASE_DB|HC|REID|GL22	HC	Reid Bedford	Sand	SP	L	0.716	345	0.277	C	1
229	CASE_DB|HC|REID|GL26	HC	Reid Bedford	Sand	SP	L	0.716	345	0.723	C	1
230	CASE_DB|HC|REID|GL27	HC	Reid Bedford	Sand	SP	L	0.716	345	0.933	C	1
231	CASE_DB|HC|REID|GL28	HC	Reid Bedford	Sand	SP	L	0.716	345	1.000	C	1
232	CASE_DB|HC|REID|GL30	HC	Reid Bedford	Sand	SP	L	0.716	483	0.000	C	1
233	CASE_DB|HC|REID|GL31	HC	Reid Bedford	Sand	SP	L	0.716	483	0.067	C	1
234	CASE_DB|HC|REID|GL32	HC	Reid Bedford	Sand	SP	L	0.716	483	0.277	C	1
235	CASE_DB|HC|REID|GL36	HC	Reid Bedford	Sand	SP	L	0.716	483	0.723	C	1
236	CASE_DB|HC|REID|GN10	HC	Reid Bedford	Sand	SP	D	0.549	207	0.000	C	1
237	CASE_DB|HC|REID|GN11	HC	Reid Bedford	Sand	SP	D	0.567	207	0.067	C	1
238	CASE_DB|HC|REID|GN12	HC	Reid Bedford	Sand	SP	D	0.559	207	0.277	C	1
239	CASE_DB|HC|REID|GN16	HC	Reid Bedford	Sand	SP	D	0.578	207	0.723	C	1
240	CASE_DB|HC|REID|GN17	HC	Reid Bedford	Sand	SP	D	0.549	207	0.933	C	1
241	CASE_DB|HC|REID|GN18	HC	Reid Bedford	Sand	SP	D	0.538	207	1.000	C	1
242	CASE_DB|HC|REID|GN20	HC	Reid Bedford	Sand	SP	D	0.549	345	0.000	C	1
243	CASE_DB|HC|REID|GN21	HC	Reid Bedford	Sand	SP	D	0.578	345	0.067	C	1
244	CASE_DB|HC|REID|GN22	HC	Reid Bedford	Sand	SP	D	0.567	345	0.277	C	1
245	CASE_DB|HC|REID|GN26	HC	Reid Bedford	Sand	SP	D	0.578	345	0.723	C	1
246	CASE_DB|HC|REID|GN27	HC	Reid Bedford	Sand	SP	D	0.538	345	0.933	C	1
247	CASE_DB|HC|REID|GN28	HC	Reid Bedford	Sand	SP	D	0.567	3457	1.000	C	1
248	CASE_DB|HC|REID|GN30	HC	Reid Bedford	Sand	SP	D	0.578	483	0.000	C	1
249	CASE_DB|HC|REID|GN31	HC	Reid Bedford	Sand	SP	D	0.559	483	0.067	C	1
250	CASE_DB|HC|REID|GN32	HC	Reid Bedford	Sand	SP	D	0.559	483	0.277	C	1
251	CASE_DB|HC|REID|GN36	HC	Reid Bedford	Sand	SP	D	0.549	483	0.723	C	1
252	CASE_DB|HC|REID|HL	HC	Reid Bedford	Sand	SP	L	0.660	307	0.000	V	2
253	CASE_DB|HC|REID|HN	HC	Reid Bedford	Sand	SP	D	0.559	69	0.000	V	2
254	CASE_DB|HC|REID|SL10	HC	Reid Bedford	Sand	SP	L	0.716	207	0.000	V	1
255	CASE_DB|HC|REID|SL20	HC	Reid Bedford	Sand	SP	L	0.716	345	0.000	V	1
256	CASE_DB|HC|REID|SL30	HC	Reid Bedford	Sand	SP	L	0.716	483	0.000	V	1
257	CASE_DB|HC|REID|SN10	HC	Reid Bedford	Sand	SP	D	0.538	207	0.000	V	1
258	CASE_DB|HC|REID|SN20	HC	Reid Bedford	Sand	SP	D	0.567	345	0.000	V	1
	CASE_DB|HC|SPEC										
259	CASE_DB|HC|SPEC|CD5.HOS	HC	Hostun	Sand	SP	D	0.611	500	-1.000	V	4
260	CASE_DB|HC|SPEC|CL2.REI	HC	Reid Bedford	Sand	SP	L	0.668	345	-1.000	V	4

8 REFERENCES

1. Saada, A. and Bianchini (Editors): Constitutive Equations for Granular Non-Cohesive Soils, 733 pp., Balkema, Rotterdam, 1988.

2. Saada, A. and Townsend, F., "Strength Laboratory Testing of Soils," A State of the Art paper presented at the ASTM Symposium on the Shear Strength of Soils, Chicago, Illinois, ASTM, STP 740, 1981, pp. 7-77.

3. Saada, A., "Hollow Cylinder Torsional Devices, Their Advantages and Limitations," A State of the Art Paper presented at the ASTM Symposium on Advanced Triaxial Testing of Soil and Rock, Louisville, Kentucky, ASTM, STP 977, pp. 766-795.

9 APPENDIX 1 (RELATED PAPERS)

1. A. Saada & P. Puccini, *The Development of a Data Base Using the Case Hollow Cylinder Apparatus*, Constitutive Equations for Granular Non-Cohesive Soils, A. Saada and G. Bianchinin, Editors, 1988 Balkema, Rotterdam, ISBN 90 6191 7891.

2. J. Lanier & Z. Zitouni, *Development of a Data Base Using the Grenoble True Triaxial Apparatus*, Constitutive Equations for Granular Non-Cohesive Soils, A. Saada and G. Bianchinin, Editors, 1988 Balkema, Rotterdam, ISBN 90 6191 7891.

3. J. Lanier, Z. Zitouni, A. Saada, P. Puccini, G. Bianchini, *Comportement tridimensionnel des sables: comparaison d'essais véritablement triaxiaux et d'essais sur cylinder creux.* Revue Francaise de Géotechnique, No. 49, Octobre 1989, pp. 67-76.

4. G. Banchini, A. Saada, P. Puccini, J. Lanier, Z. Zitouni, *Complex Stress Paths and Validation of Constitutive Models*. Geotechnical Testing Journal, ASTM, Vol. 14, No. 1, March 1991, pp. 13-25.