SO-Unconfined

Version 1.2.8658.1

Scientific Manual

This software is developed by Soil Office Software Group and is aimed at the evaluation of unconfined compression tests. Smart capabilities are implemented. Also test data and corresponding calculations are available in addition to software outputs.

Soil Office

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1 INTRODUCTION

1-1 SOIL OFFICE

"Soil Office" is a developer of geotechnical engineering software since 2013. Our main objective is to develop functional and user friendly software, capable of performing precise calculations. The following software is currently considered:

- SO-Foundation: Bearing capacity of shallow foundations
- SO-Lab: Soil mechanics laboratory tests and boring logs including:

  - SO-Sieve: Sieve analysis, Hydrometer & Atterberg limits
  - SO-Shear: Direct shear
  - SO-Unconfined: Unconfined compression
  - SO-Triaxial: Triaxial compression
  - SO-Consolidation: One-dimensional consolidation
  - SO-Log: Geotechnical engineering boring logs

Feel free to contact us regarding any criticism, recommendation or additional information.

1-2 SO-UNCONFINED

SO-Unconfined is aimed at the evaluation of unconfined compression tests. It has a user-friendly interface and lots of smart capabilities are implemented. Individual tabs are assigned for project information (including basic information, borings and samples) and tests. Test data and corresponding calculations are available in addition to software outputs.

Note that unconfined compression tests could randomly be generated based on user-defined criteria.

1-3 SOFTWARE CAPABILITIES

1-3-1 GENERAL FEATURES

- Supports "Metric", "SI", "English [ksf]" and "English [psi]" units.
- User is informed about the common ranges regarding input parameters.
- Test data and corresponding calculations are presented in a separate format.
- Blank laboratory data sheets may be used for test data input.
- Saving files with a minimal size.

1-3-2 UNCONFINED COMPRESSION TEST CALCULATIONS

−   Various data input options.

−   Test data can be edited using either graph or table.

−   Random generation of unconfined compression tests based on user-defined criteria, including the following:

  • Simulation of soil behavior using hyperbolic equation.

  • Custom definition of soil behavior.

  • …

2 SOFTWARE INTERFACE

2-1 GENERAL

After running SO-Unconfined, the following menus are visible on the top ribbon:

File menu: Contains commands relating to the handling of files, such as creating a new project, save, etc.

Main: Project information, borings and samples are determined using this menu.

Test: Contains the following:

- **Unconfined compression:** Is aimed at the evaluation of unconfined compression tests.
- **Edit:** Test performed on a sample can be copied, moved or deleted using this menu.

Export: Contains the following:

- **Export:** Is used to export software outputs.
- **Blank:** Includes blank laboratory data sheets.

Help: Contains the following:

- **Scientific manual:** Describes functionality of different parts of the software and the theories of the utilized methods.
- **Index:** Contains indexed help topics.

License: The permit to use the software and information on the client.

About: Contains general information.

- **SO-Unconfined:** Brief description about the current software and its version.
- **Soil Office:** Introducing Soil Office Software Group.

Units: Switches between the available unit systems.

2-2 DETAILS ON MENUS

2-2-1 FILE MENU

This menu is consisted of the following:

New: Creation of a new project.
Open: Opens a previously defined project.
Save: Saves project (with *.sou extension).
Save as: Saves project with a different name.
Sample project: Sample project in order to demonstrate software features and easily work with it. A number of unconfined compression tests have been calculated or generated by a variety of methods.
Close: Closes project.
Exit: Closes project and exits SO-Unconfined.

2-2-2 MAIN

2-2-2-1 PROJECT INFORMATION

Basic project information including name, client, location and code are entered in this section. A separate field is also dedicated for notes. The user can specify the project location on the map and the coordinates will be shown in the corresponding field. Project address is also presented by activating the "Reverse geocoding" option and the user may accept it or not.

2-2-2-2 TABLE OF BORINGS

Project borings are identified through this table. The input parameters are listed below:

Boring method: Whenever the boring is machine-drilled and the method is not included in the available options or the user prefers it not to be specified, the "-" option can be used.
Name: Boring name.
Depth: Boring depth.
Elev.: Ground elevation at top of boring.
GWT: Depth to water table measured from boring top (Ground Water Table).
Note: Notes regarding the boring such as weather conditions including recent rain or other events that could affect subsurface conditions.
Export: Defines whether the boring is included in the output or not. This option is active by default.
Contractor: Name of the drilling contractor.
Start date: Start date of drilling.
Finish date: Finish date of drilling.

The up and down arrows located on the right side of the table, are for the purpose of altering the order of the borings.

2-2-2-3 TABLE OF SAMPLES

Samples obtained within each of the borings are introduced in this table. The input parameters are listed below:

Depth: Sample depth.
USCS: Soil type according to USCS (Unified Soil Classification System).
Sample category: Sample category including "Disturbed", "Undisturbed" and "Rock core".
Sample type: Varies by boring method and sample category. "-" may be used if empty for any reason.
Color: Sample color. Some colors are available by default and others can be defined by the user.
Code: Sample code.
Note: Notes regarding sample or its extrusion process.

2-2-3 TEST

2-2-3-1 UNCONFINED COMPRESSION

SO-Unconfined is aimed at the evaluation of unconfined compression tests and can be used in the following situations:

‒ Test data: are entered and calculations are performed.
‒ Test generation: This option is mainly for the generation of random unconfined compression tests based on user-defined criteria and includes two options: "Hyperbolic" and "Free sketch".

Note that the mentioned methods are selectable using the radio buttons available in the "Graphs & Advanced Options" section.

2-2-3-1-1 TEST DATA

This option is active by default. Various sections are considered for the input and evaluation of test data which are described below:

❖ Sample properties

Sample properties are determined through this section including:

D: sample diameter.
L: sample height.
A: sample cross-sectional area.
G_s: specific gravity of soil solids.
w: moisture content.
γ_w: wet unit weight.
γ_d: dry unit weight.
e: void ratio.
S: degree of saturation.

❖ <u>Data Input</u>

This section is dedicated to the input of test data and includes the following:

Above the table

This section mainly contains settings regarding data entry of the test table.

Strain rate
Gauge factor, 1 div.
Load:

- Ring factor
- Load
- Stress

Test table

Table columns are as follows:

Elapsed time
Axial

- Deformation reading
- Deformation
- Strain

Corrected area
Axial

- Load reading
- Load
- Stress

The "More …" option, available below the test table, is displayed in red when filled and contains:

Date: Test date.
Time: Test time.
Tested by: Name of the technician.
Note: Notes regarding the test.

❖ <u>Sketch / Photo</u>

The user can place an image of the sample in this section.

❖ Graphs & Advanced Options

Variation of axial stress with axial strain is plotted. Changes in the graph are automatically applied to the test table and vice versa.

❖ Results Summary

The results summary of the performed test is accessible through this section. The following columns are included in the table:

BH/TP: Borehole or test pit name.
Depth: Sample depth.
q_u: Unconfined compressive strength.
c_u: Undrained shear strength (using Tresca failure criterion) equal to one half of the unconfined compressive strength $\left(^1/_2\, q_u\right)$.
ε_{qu}: Axial strain corresponding to the unconfined compressive strength.
E_{50}: Secant modulus of elasticity corresponding to $50[\%] \times q_u$.

Note that by activating the "Remolded" option, the sample is reported as "remolded" in the output.

Note:

1- By altering the unconfined compressive strength (q_u) (via the summary results table), axial stress values in the test table, are accordingly multiplied by the same ratio.
2- By altering the axial strain corresponding to the unconfined compressive strength (ε_{qu}) (via the summary results table), axial strain values in the test table, are accordingly multiplied by the same ratio.

2-2-3-1-2 HYPERBOLIC

This option enables the generation of sample unconfined compression tests using the following equation:

$$q = \frac{\varepsilon}{\dfrac{1}{E} + \dfrac{\varepsilon}{q_{hyp}}}$$

Where:

q: Axial stress.
ε: Axial strain.
E: Modulus of elasticity.
q_{hyp}: Hyperbolic axial stress.

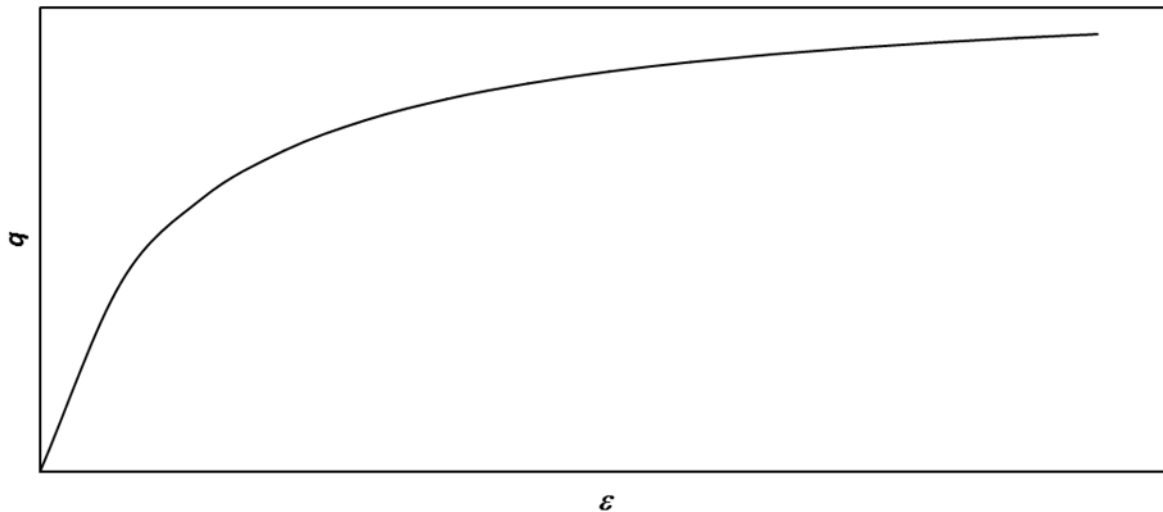Note that axial stress variations using hyperbolic formula are as below:

Figure 2-1 Axial stress variations using hyperbolic formula

The table above the "axial stress plot" is used for the generation of sample tests. The following parameters are included:

E & q_{u}: are previously defined.
ε_{ult}: Axial strain corresponding to the unconfined compressive strength.

After the completion of the table, the below options are available for the generation of sample tests:

Readings: Axial deformation readings regarding sample test generation, can be determined using the following two criteria:

- Divisions: The axial strain corresponding to the unconfined compressive strength, is divided to the number defined by the user.
- User-defined: The user can define custom readings regarding the test.

Tolerance: This option specifies the maximum allowable difference of the axial stress in calculated and generated modes.

Create nodes: Clicking on this button, creates sample unconfined compression tests based on the available data and settings, and the test table is updated accordingly.

2-2-3-1-3 FREE SKETCH

This option is also dedicated to the generation of sample unconfined compression tests. In this method, unlike the "Hyperbolic" method where the axial stress values are calculated using the mentioned formula, the overall shape of the axial stress variations' graph is determined by user's will. Corresponding table is located above the "axial stress plot" and contains the following:

q_u: is previously defined.

Type: Overall graph shape; Peak & Ultimate. Peak identifies situations where the axial stress reaches a peak value and decreases afterwards. Ultimate refers to situations where the axial stress reaches the maximum at the ultimate reading.

ε_{Peak}: Axial strain corresponding to the peak axial stress.

ε_{ult}: Axial strain corresponding to the ultimate axial stress.

After the completion of the table, the following options can be used for the generation of sample tests:

Primary points: Indicates the number of main points creating the overall graph shape. The number of primary points can be changed by user's will and is limited to a minimum of 5.

Create shape: By clicking this button, the overall shape of the axial stress variation graph is created. Note that the graph shape is random and a new graph is created each time the button is clicked.

Readings: Axial deformation readings regarding sample test generation, can be determined using the following two criteria:

- Divisions: Each segment of the axial stress variation graph (between two adjacent primary points) is divided to the number defined by the user.
- User-defined: The user can define custom readings regarding the test.

Tolerance: This option specifies the maximum allowable difference of the axial stress in calculated and generated modes.

Create nodes: Clicking on this button, creates sample unconfined compression tests based on the available data and settings, and the test table is updated accordingly.

2-2-3-2 EDIT

Tests performed on a sample can be copied, moved or deleted using this menu.

Whenever the destination sample contains some data, **the user is not asked for overwrite confirmation.** Therefore the user has to be cautious while using this menu.

2-2-4 EXPORT

2-2-4-1 EXPORT

Is used to export software outputs, including:

Output: Final test results.

Test data: Test data and corresponding calculations.

2-2-4-2 BLANK

Blank laboratory data sheets are accessible through this menu.

3 ERRORS

Possible errors in the software are divided to primary and secondary errors which are described in the current chapter.

3-1 PRIMARY ERRORS

Whenever wrong or illogical data are entered, the corresponding cells' colors are altered and a message is shown in the bottom ribbon to guide the user. The utilized colors are described below:

Red: The cell is empty or of the wrong data type.
Orange: The entered value is not acceptable.
Green: Calculations may be performed, but the cell value seems to be illogical.
Pink: Demo version limitations.

Note: Project data cannot be exported while primary errors (except green type) exist.

3-2 SECONDARY ERRORS

Unlike primary errors, secondary errors do not apply any limitations on exporting project data and are mostly encountered when changes in some data, cause some others to be inaccurate or incompatible. These errors are of 2 types; compatibility and depth:

Compatibility errors: Identify incompatibility among input data.
Depth errors: Identify errors due to depth values.

Secondary errors have the following advantages:

– Software does not crash.
– All errors regarding each input data are individually specified.

Note: By clicking on the error types located beneath the tables, a message is shown and the user is informed about the probable cause (or causes) of the errors.

4 CALCULATION THEORIES

In this chapter, brief description regarding unconfined compression test is presented. Also utilized parameters along with calculation methods are fully described. Note that all parameters are defined in this chapter for the ease of access and the calculational parameters are marked with an asterisk (*).

4-1 TEST SUMMARY

The unconfined compression test covers the determination of the unconfined compressive strength of cohesive soil in the intact, remolded, or reconstituted condition, using strain-controlled application of the axial load.

In this test method, a cylindrical soil specimen is unconfined laterally while loaded axially at an axial strain rate between 0.5 to 2 [%/min]. Measurements are made of elapsed time, axial deformation, and axial load. The unconfined compressive strength (q_u) is calculated as the compressive stress at failure. The undrained shear strength (c_u) is one half of the unconfined compressive strength.

Note that the rate of strain should be chosen so that the time to failure does not exceed about 15 [min].

4-2 SAMPLE PROPERTIES

4-2-1 SI & METRIC

Sample properties are as below:

> D: sample diameter, [cm].
> L: sample height, [cm].
> (∗) A: sample cross-sectional area, [cm^2].
> G_s: specific gravity of soil solids, [-].
> w: moisture content, [%].
> γ_w: wet unit weight, [g/cm^3].
> (∗) γ_d: dry unit weight, [g/cm^3].
> (∗) e: void ratio, [-].
> (∗) S: degree of saturation, [%].

Soil volume and density relations are used for the calculation of above parameters:

$$A = \frac{\pi D^2}{4}$$

$$\gamma_d = \frac{\gamma_w}{1 + w}$$

$$e = \frac{G_s \times \gamma_{water}}{\gamma_d} - 1$$

$$S = \frac{w \times G_s}{e}$$

4-2-2 ENGLISH [KSF] & ENGLISH [PSI]

Sample properties are as below:

D: sample diameter, [in.].
L: sample height, [in.].
(∗) A: sample cross-sectional area, [in.^{2}].
G_s: specific gravity of soil solids, [-].
w: moisture content, [%].
γ_w: wet unit weight, [pcf].
(∗) γ_d: dry unit weight, [pcf].
(∗) e: void ratio, [-].
(∗) S: degree of saturation, [%].

Soil volume and density relations are used for the calculation of above parameters:

$$A = \frac{\pi D^2}{4}$$

$$\gamma_d = \frac{\gamma_w}{1 + w}$$

$$e = \frac{G_s \times \gamma_{water}}{\gamma_d} - 1$$

$$S = \frac{w \times G_s}{e}$$

4-3 TEST TABLE

Current section is separately presented regarding each of the four unit systems; "Metric", "SI", "English [ksf]" and "English [psi]".

4-3-1 METRIC

Unconfined compression test contains the following parameters:

Strain rate $(\dot{\varepsilon})$, [mm/min].
(∗) Elapsed time (t), [min].
Axial

- Deformation reading (R_Δ).
- (∗) Deformation (Δ), [mm].
- (∗) Strain (ε), [%].

(∗) Corrected area (A^*) , [cm^2].
Axial

- Load reading (R_F).
- (∗) Load (F), [kg].
- (∗) Stress (q) , [kg/cm^2].

Calculations are as follows:

$$\Delta = R_\Delta \times Gauge\ factor$$

$$t = \frac{\Delta}{\dot{\varepsilon}}$$

$$\varepsilon = \frac{\Delta}{L} \times 100$$

$$A^* = \frac{A}{1 - \frac{\varepsilon}{100}}$$

$$F = R_F \times Ring\ factor$$

$$q = \frac{F}{A^*}$$

4-3-2 SI

Unconfined compression test contains the following parameters:

Strain rate *(ε̇)*, [mm/min].
(∗) Elapsed time *(t)*, [min].
Axial

- Deformation reading *(R$_Δ$)*.
- (∗) Deformation *(Δ)*, [mm].
- (∗) Strain *(ε)*, [%].

(∗) Corrected area *(A*)* , [cm^2].
Axial

- Load reading *(R$_F$)*.
- (∗) Load *(F)*, [N].
- (∗) Stress *(q)* , [kPa].

Calculations are as follows:

$$\Delta = R_\Delta \times Gauge\ factor$$

$$t = \frac{\Delta}{\dot{\varepsilon}}$$

$$\varepsilon = \frac{\Delta}{L} \times 100$$

$$A^* = \frac{A}{1 - \frac{\varepsilon}{100}}$$

$$F = R_F \times Ring\ factor$$

$$q = \frac{F}{A^*}$$

4-3-3 ENGLISH [KSF]

Unconfined compression test contains the following parameters:

Strain rate $(\dot{\varepsilon})$, [in./min].
$(*)$ Elapsed time (t), [min].
Axial

- Deformation reading (R_Δ).
- $(*)$ Deformation (Δ), [in.].
- $(*)$ Strain (ε), [%].

$(*)$ Corrected area (A^*) , [in.^{2}].
Axial

- Load reading (R_F).
- $(*)$ Load (F), [lb].
- $(*)$ Stress (q) , [ksf].

Calculations are as follows:

$$\Delta = R_\Delta \times Gauge\ factor$$

$$t = \frac{\Delta}{\dot{\varepsilon}}$$

$$\varepsilon = \frac{\Delta}{L} \times 100$$

$$A^* = \frac{A}{1 - \dfrac{\varepsilon}{100}}$$

$$F = R_F \times Ring\ factor$$

$$q = \frac{F}{A^*}$$

4-3-4 ENGLISH [PSI]

Unconfined compression test contains the following parameters:

Strain rate $(\dot{\varepsilon})$, [in./min].
$(*)$ Elapsed time (t), [min].
Axial

- Deformation reading (R_Δ).
- $(*)$ Deformation (Δ), [in.].
- $(*)$ Strain (ε), [%].

$(*)$ Corrected area (A^*) , [in.^{2}].
Axial

- Load reading (R_F).
- $(*)$ Load (F), [lb].
- $(*)$ Stress (q) , [psi].

Calculations are as follows:

$$\Delta = R_\Delta \times Gauge\ factor$$

$$t = \frac{\Delta}{\dot{\varepsilon}}$$

$$\varepsilon = \frac{\Delta}{L} \times 100$$

$$A^* = \frac{A}{1 - \dfrac{\varepsilon}{100}}$$

$$F = R_F \times Ring\ factor$$

$$q = \frac{F}{A^*}$$

4-4 RESULT ANALYSIS

According to ASTM D2166, the maximum axial stress or the axial stress corresponding to 15 [%] strain (whichever is secured first), is considered as the unconfined compressive strength (q_u) and the undrained shear strength (c_u) is one half of it. Note that in the current software, the maximum axial stress is reported as the unconfined compressive strength (q_u).

$$c_u = \frac{q_u}{2}$$

5 CONTACT US

Feel free to contact us regarding any criticism, recommendation or additional information.

1- Visit www.soiloffice.com/ContactUs
2- Send an e-mail to info@soiloffice.com
3- Call (+98) 912 313 4107 – Emad Zargaran.
   (Also available on WhatsApp)
4- Call "Emad.Zargaran" via Skype.

6 LIST OF SYMBOLS

Symbol	Description
A	sample cross-sectional area
A^*	corrected cross-sectional area of the sample
c_u	undrained shear strength (using Tresca failure criterion) equal to one half of the unconfined compressive strength
D	sample diameter
e	void ratio
E	modulus of elasticity
E_{50}	secant modulus of elasticity corresponding to $50[\%] \times q_u$
$Elev.$	ground elevation at top of boring
F	axial load
G_s	specific gravity of soil solids
GWT	depth to water table measured from boring top (Ground Water Table)
g_w / γ_w	wet unit weight
g_d / γ_d	dry unit weight
$g_{water} / \gamma_{water}$	water unit weight
L	sample height
q	axial stress
q_{hyp}	hyperbolic axial stress
q_u	unconfined compressive strength
R_Δ	axial deformation reading
R_F	axial load reading
S	degree of saturation
t	elapsed time
$USCS$	Unified Soil Classification System
w	moisture content
Δ	axial deformation
ε	axial strain
$\dot{\varepsilon}$	strain rate
ε_{peak}	axial strain corresponding to the peak axial stress
ε_{qu}	axial strain corresponding to the unconfined compressive strength
ε_{ult}	axial strain corresponding to the unconfined compressive strength / ultimate axial stress