Assistance in Parameter Determination

in ZSoil v2014

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Contents

- **Introduction**
- Parameter selection with the aid of Parameter Determination Toolbox v2014

Motivation for developing a parameter selection assistance

Client Request	• Realistic simulation of soil-structure interaction
Requirement	• FEM • Advanced constitutive models
Getting stacked	• Large number of parameters • Missing data for parameter identification • Uncertainty in parameter selection

ZSoil solution	• PARAMETER IDENTIFICATION TOOLBOX
	  • automatic parameter selection
	  • user-engaged parameter selection
	  • assistance in decision for ranges of parameters
	  • automated analysis of laboratory experimental data

Characterization of soils for engineering purposes

- **Field tests**
  - Estimation of small strain stiffness characteristics based on undisturbed soil structure (geophysical tests, SDMT, SCPTU)
  - Soil characterization at *in situ* stress conditions (DMT, CPTU)
  - Qualitative soil description

- **Laboratory tests**
  - Basic characterization (macroscopic soil description, grain size distribution, physical properties)
  - Full stress-strain relationship (mechanical ≡ model properties)

Characterization by means of field tests

- **Geophysical test, SCPT, DMT**

  Small strain stiffness: V_s G_0

- **DMT** (empirical correlations) E_{ur} E_{oed} K_0 OCR ϕ

- **CPT** (empirical correlations) V_s G_0 E_{50} E_{oed} K_0 OCR ϕ

  liquefaction potential

- **SPT** (empirical correlations)

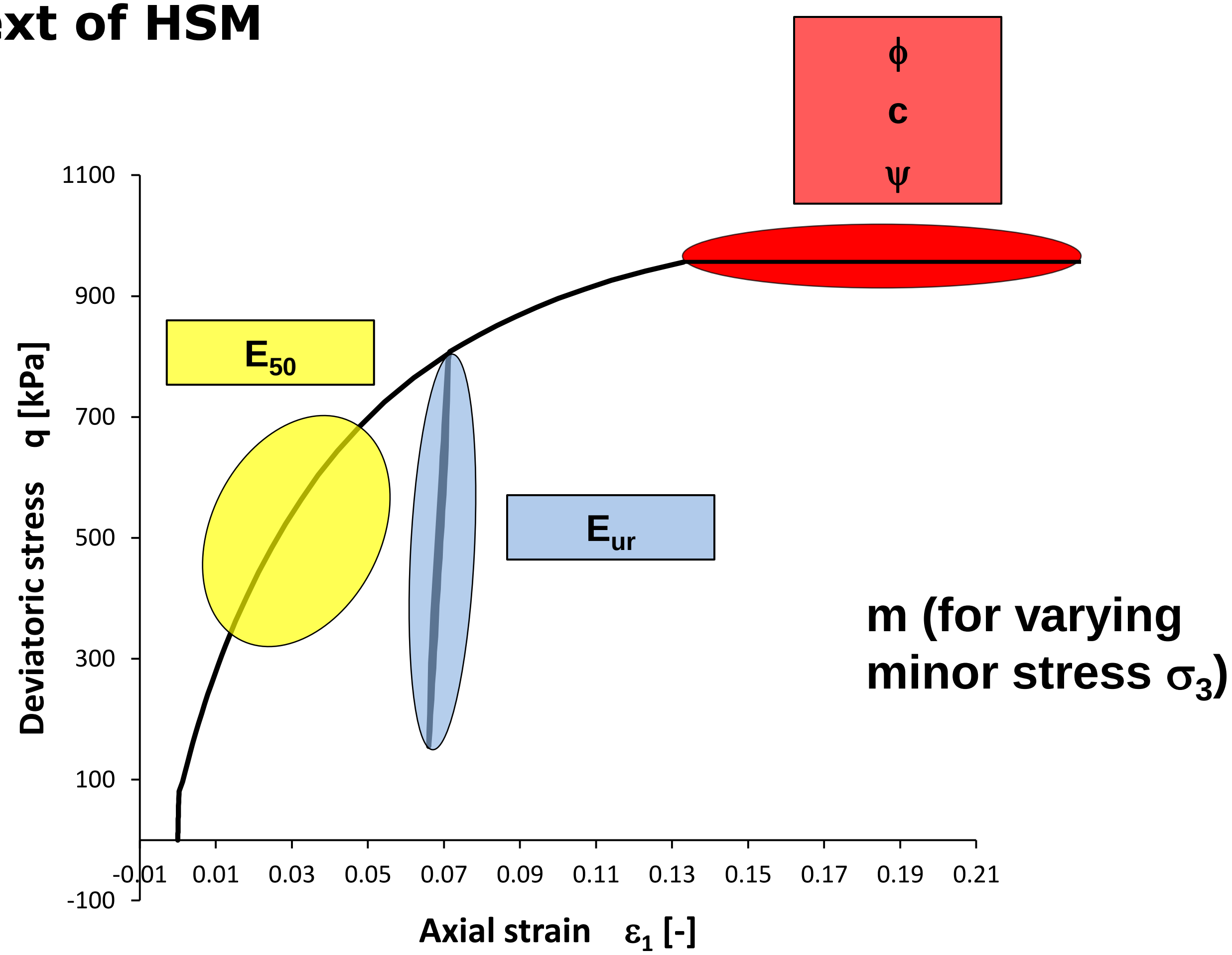
  Small strain stiffness V_s

  Strength characteristics ϕ

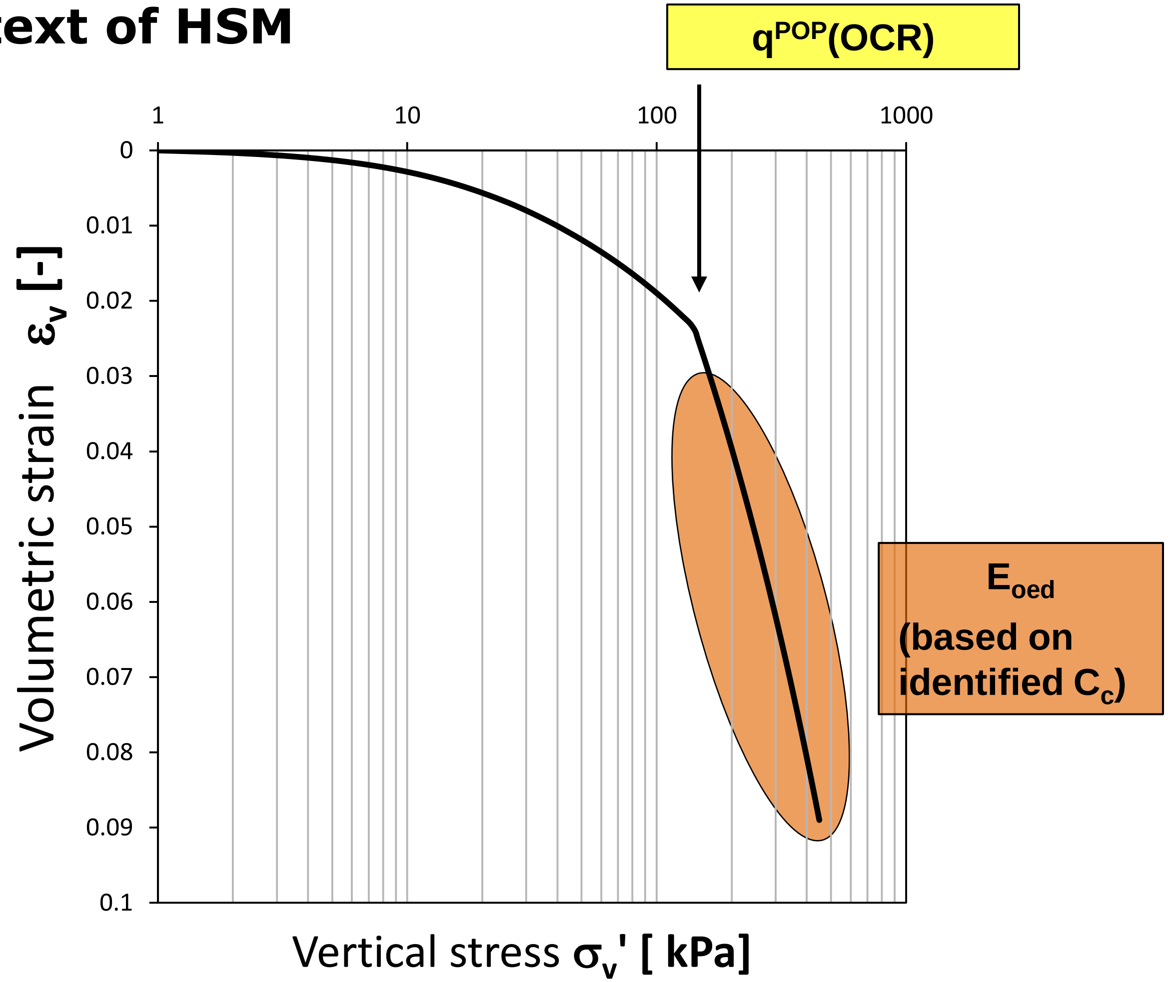
  Liquefaction potential

Characterization by means of laboratory tests

… in the context of HSM



… in the context of HSM



Parameter selection assistance in ZSoil 2014

User input data

Increasing reliability of selected parameters

User input data	Result
I. Basic soil properties - **keywords** (soil behviour type, density or consistency, gradation or plasticity, etc.)	→ Basic parameter estimation (ZSoil v2011: HSM dedicated)
II. Auxiliary data - **numeric data** (basic soil properties, *in situ* test data	→ Advanced parameter estimation (ZSoil v2012: HSM dedicated)
III. Experiemental data - **labroratory curves**	→ Advanced parameter identification (ZSoil v2014: most popular soil models)

An interactive tool providing an **assistance for parameter selection** for incomplete or complete experimental results

Help → Reports

PARAMETER DETERMINATION TOOLBOX

Z_Soil.PC 120201 report
revised 31.09.2014

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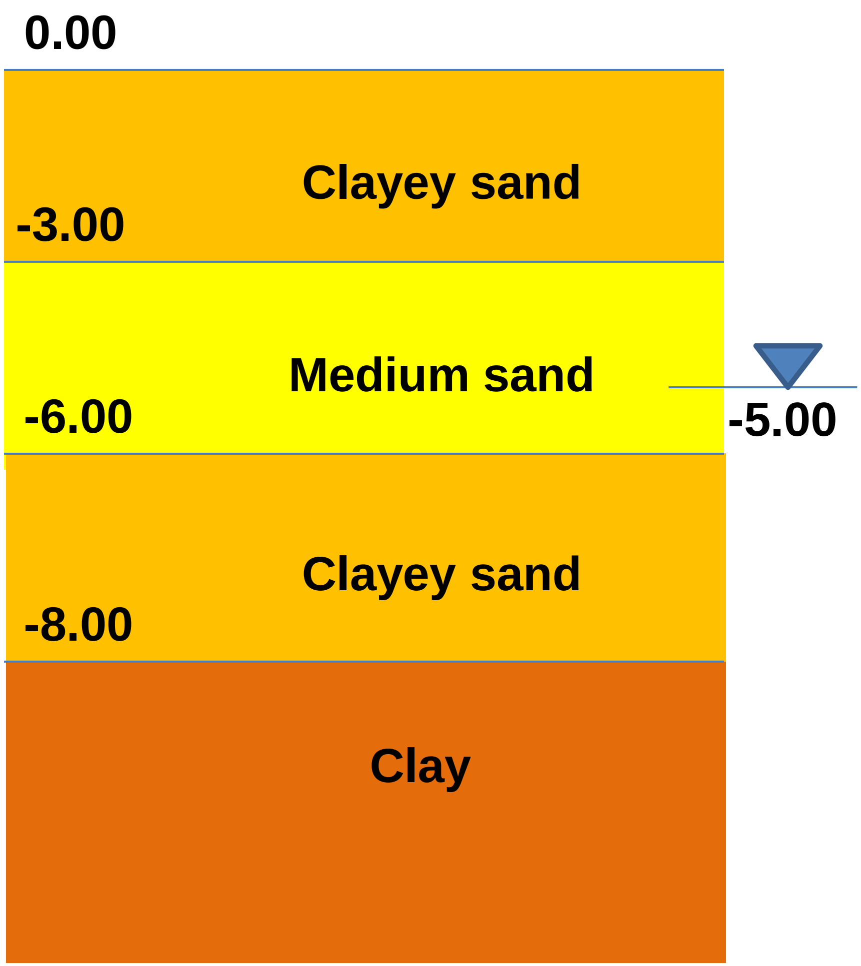
Exercise 2 – Parameter identification

Soil stratigraphy



Available data

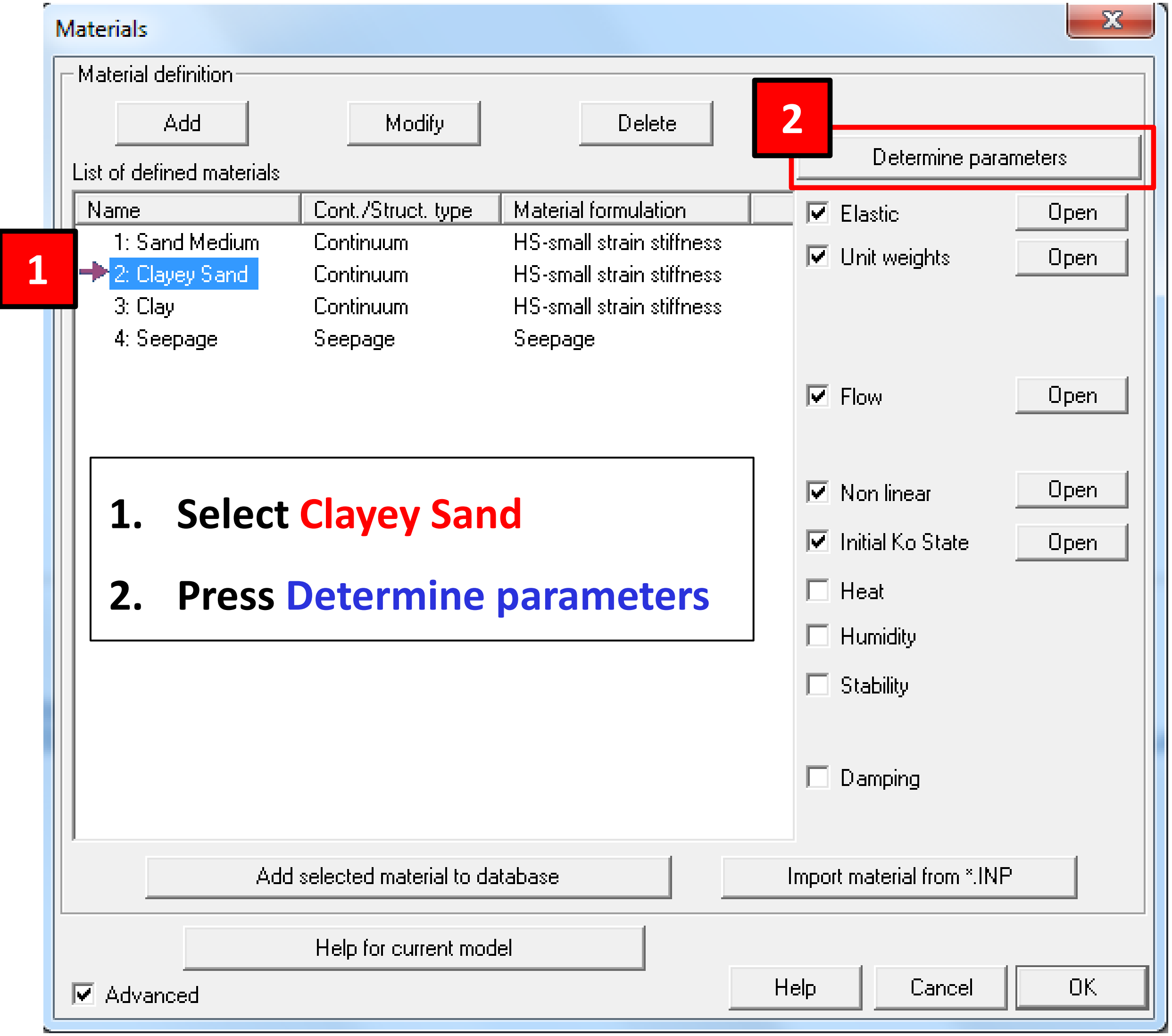
General soil description
V_s (determining E_0)
SPT (determining ϕ)

3 tests TX-CD
General soil description
V_s

as for 1st layer

3 tests TX-CU
V_s
DMT, CPTU (determining OCR)

Exercise 2 – Tool for parameter identification



Toolbox available for:

- **Mohr-Coulomb**
- **Cap**
- **Cam-Clay**
- **HSM**

Clayey sand – data:

General soil description (estimation based on incomplete data)

V_s (determining E_0)

SPT (determining ϕ)

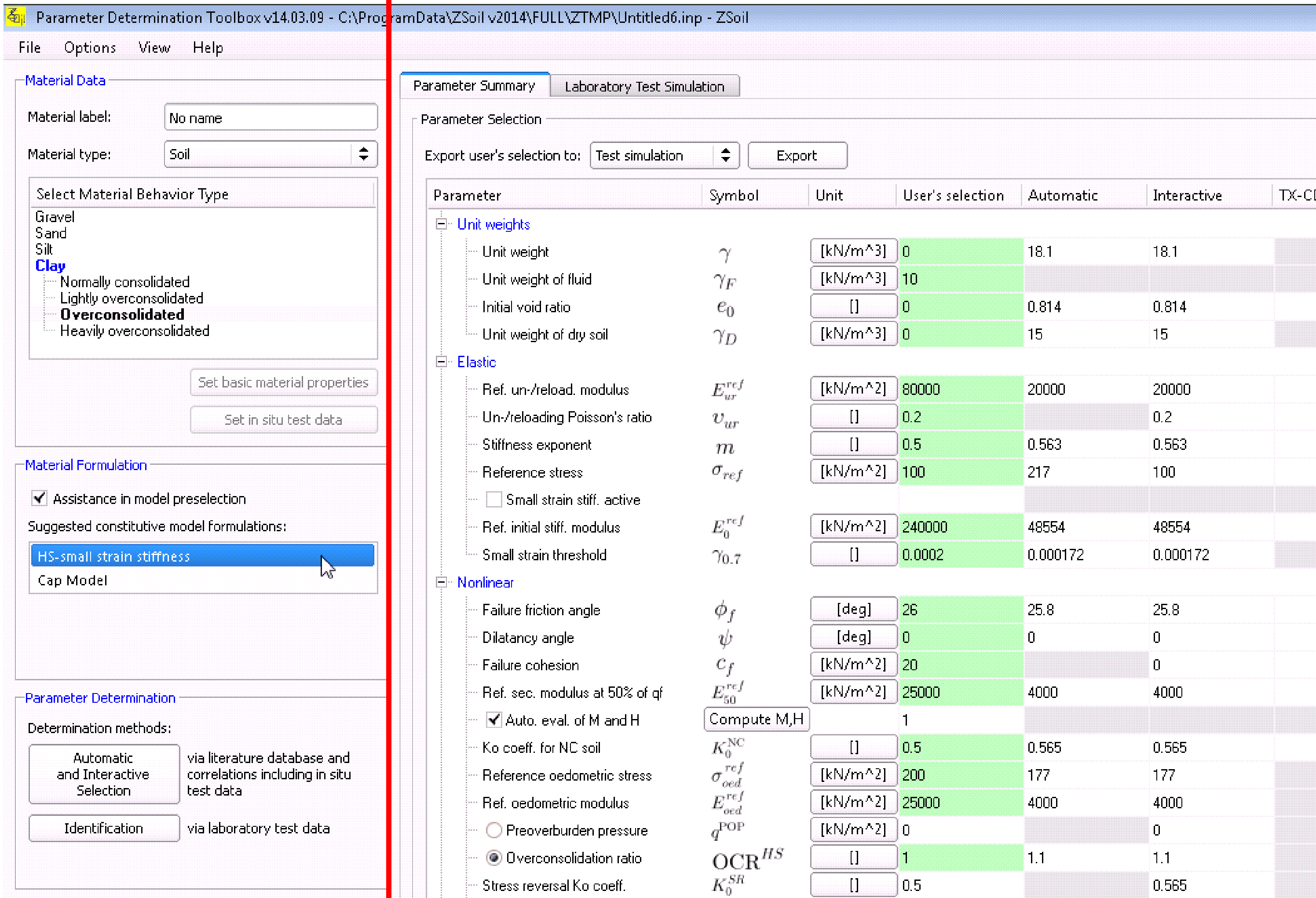
Assistance in parameter selection in ZSoil 2014

POST-PROCESSING OF ESTIMATED PARAMETERS

DEFINING BASIC PROPERTIES OF MATERIAL

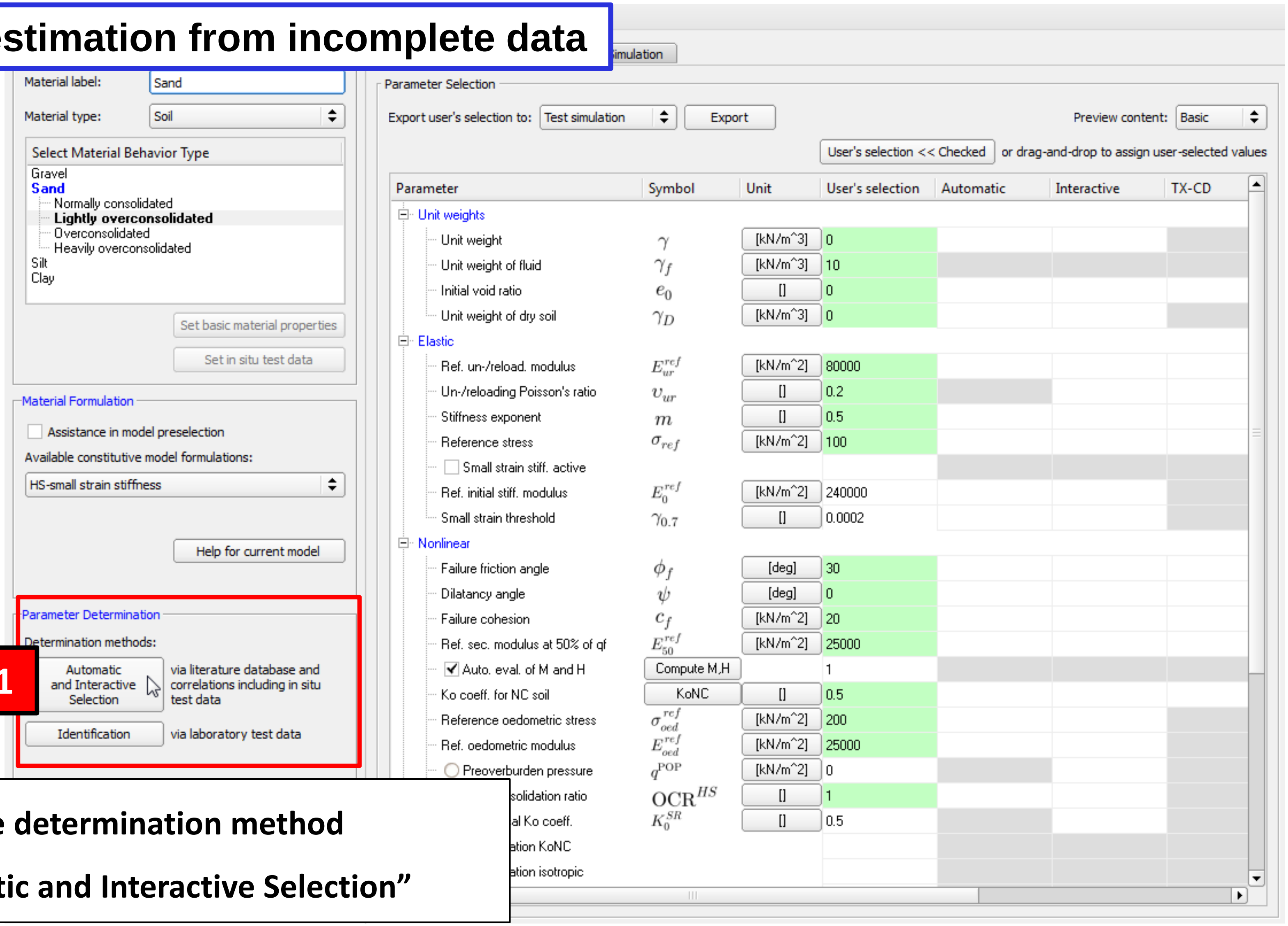
SELECTING CONSTITUTIVE MODEL

PARAMETER IDENTIFICATION METHODS



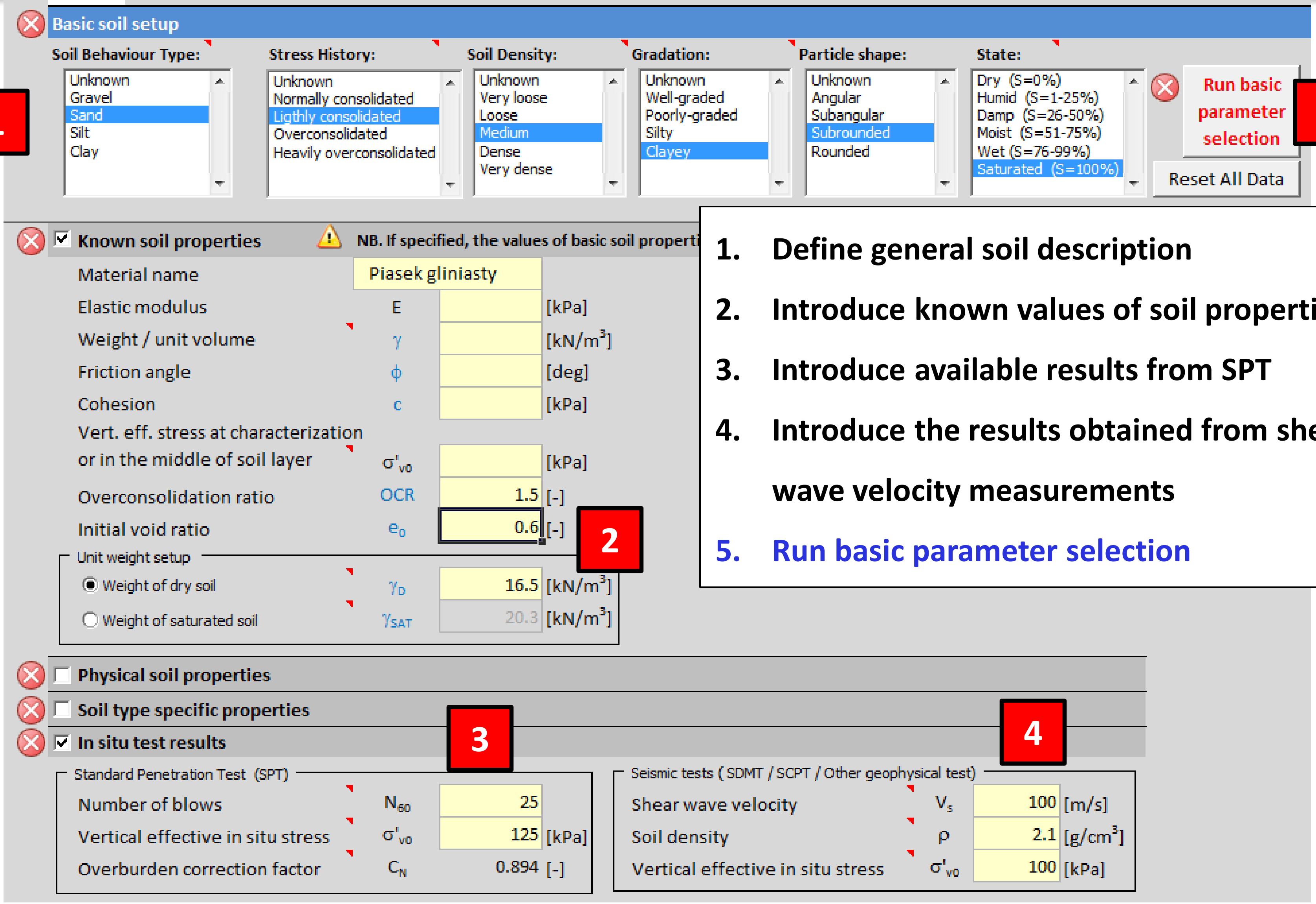
Exercise 2 – Parameter estimation for Clayey sand

Parameter estimation from incomplete data



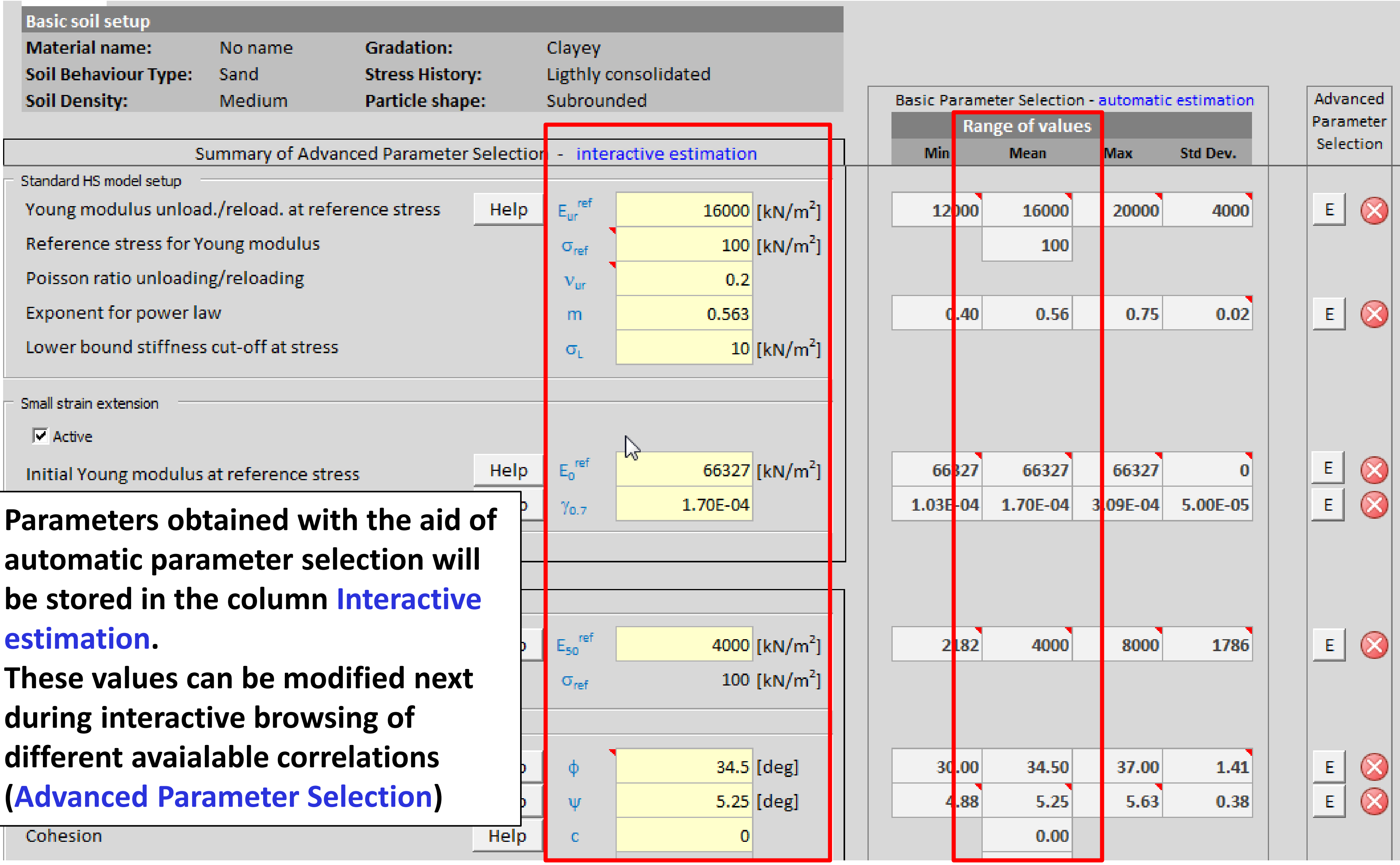
1. **Select the determination method „Automatic and Interactive Selection"**

Exercise 2 – Introducing available data



1. **Define general soil description**
2. **Introduce known values of soil properties**
3. **Introduce available results from SPT**
4. **Introduce the results obtained from shear wave velocity measurements**
5. **Run basic parameter selection**

Exercise 2 – Post-processing of results



Parameters obtained with the aid of automatic parameter selection will be stored in the column Interactive estimation.
These values can be modified next during interactive browsing of different avaialable correlations (Advanced Parameter Selection)

Exercise 2 – Interactive control of applied correlations

☑ Friction angle	ϕ			Approximative value ϕ [˚]		
Correlation Type	**Soil Type**		**Auxiliary data**	**Min**	**Average**	**Max**
☐ 1 Typical values	Select soil type ...		Dense	N/A	N/A	N/A
☐ 2 Typical values	SC Clayey sands, sandy-clay mix			29.0	34.0	39.0
☑ 3 Typical values	Medium Dr: 36-65%			30	33.5	37
☐ 4 Typical values	Fine Grained	Select gradation ...	Dr: 60%		N/A	
☑ 5 Empirical	Relative density	D_r [%]:	50		35.5	

Test type	Measurement or transformed measurement		Value	Min	Average	Max
☐ 6 Marchetti's dilatometer DMT	Horizontal stress index	K_D [-]:	not specified	N/A	N/A	N/A
☐ 7 Cone penetration test CPT	Cone resistance	q_t [kPa]:	not specified		N/A	
	Effective vert. in situ stress	σ'_{v0} [kPa]:	not specified			
☐ 8 Standard penetration test SPT	Number of blows per 0.3m		10-30 Medium sand	30	33	36
☐ 9 Standard penetration test SPT				35	37.5	40
☐ 10 Standard penetration test SPT	Number of blows per 0.3m	N_{60}:	25	35.6	38.6	41.6
	Effective vert. in situ stress	σ'_{v0} [kPa]:	125			
	☑ Use overburden correction factor	C_N [-]:	0.894			
☐ 11 Standard penetration test SPT					36.1	
☐ 12 Standard penetration test SPT					41.0	
☐ 13 Standard penetration test SPT					38.0	
☐ 14 Standard penetration test SPT					34.4	
					34.6	
			Min/Mean/Max	30.00	34.50	37.00
			Standard Deviation		1.4	

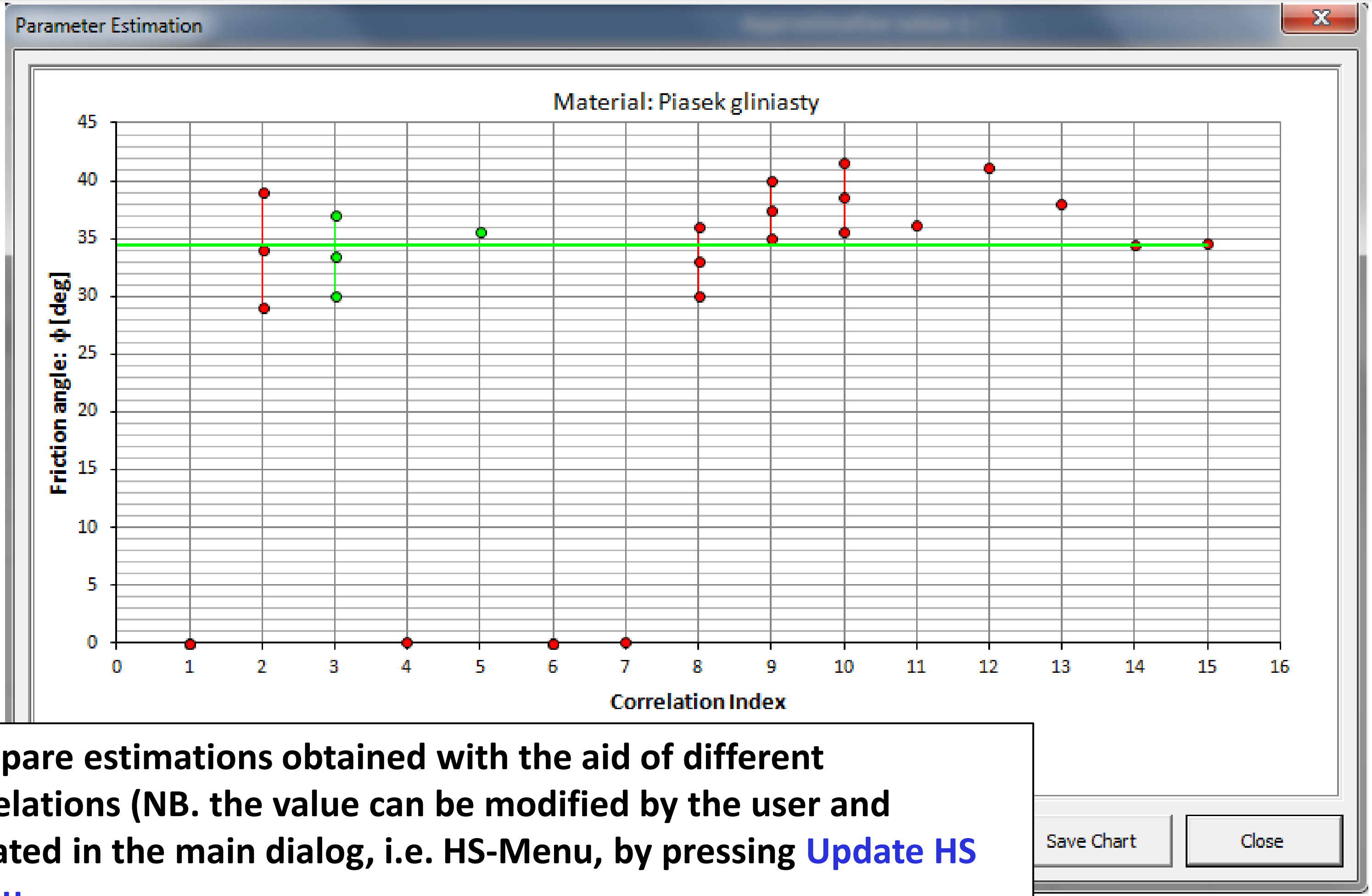
1. Press Plot to run a graphical summary of estimations obtained from different correlations that have been applied during automatic parameter selection, and estimations based on SPT results

1

Plot

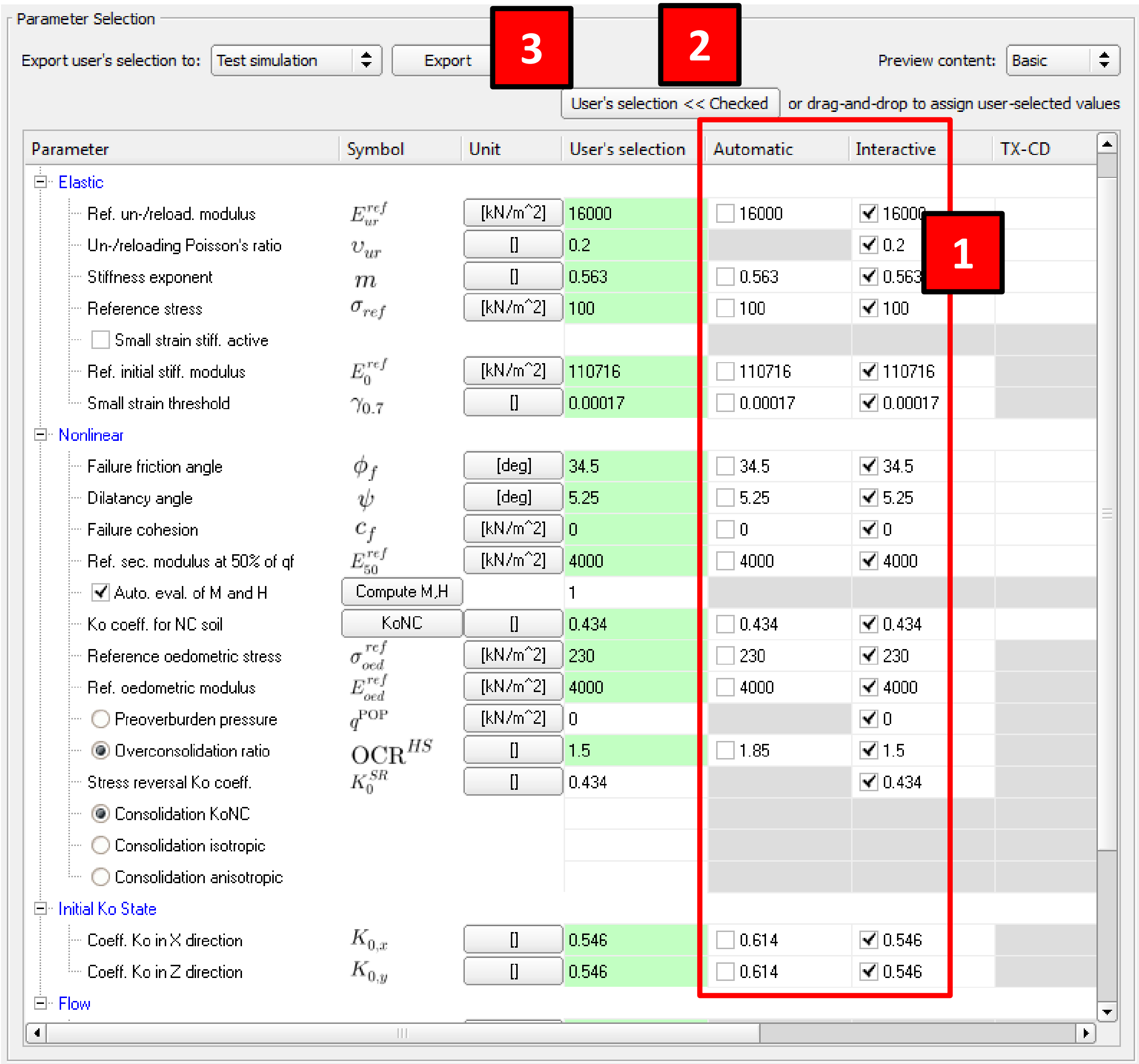
Selected Value 34.5 Update HS Menu

Exercise 2 – Interactive control of applied correlations



1. **Compare estimations obtained with the aid of different correlations (NB. the value can be modified by the user and updated in the main dialog, i.e. HS-Menu, by pressing Update HS Menu**
2. **Return to the main dialog by pressing HS-Menu button or click right mouse button to see the context menu**

Exercise 2 – Final selection & exporting parameters for simulating TXCD



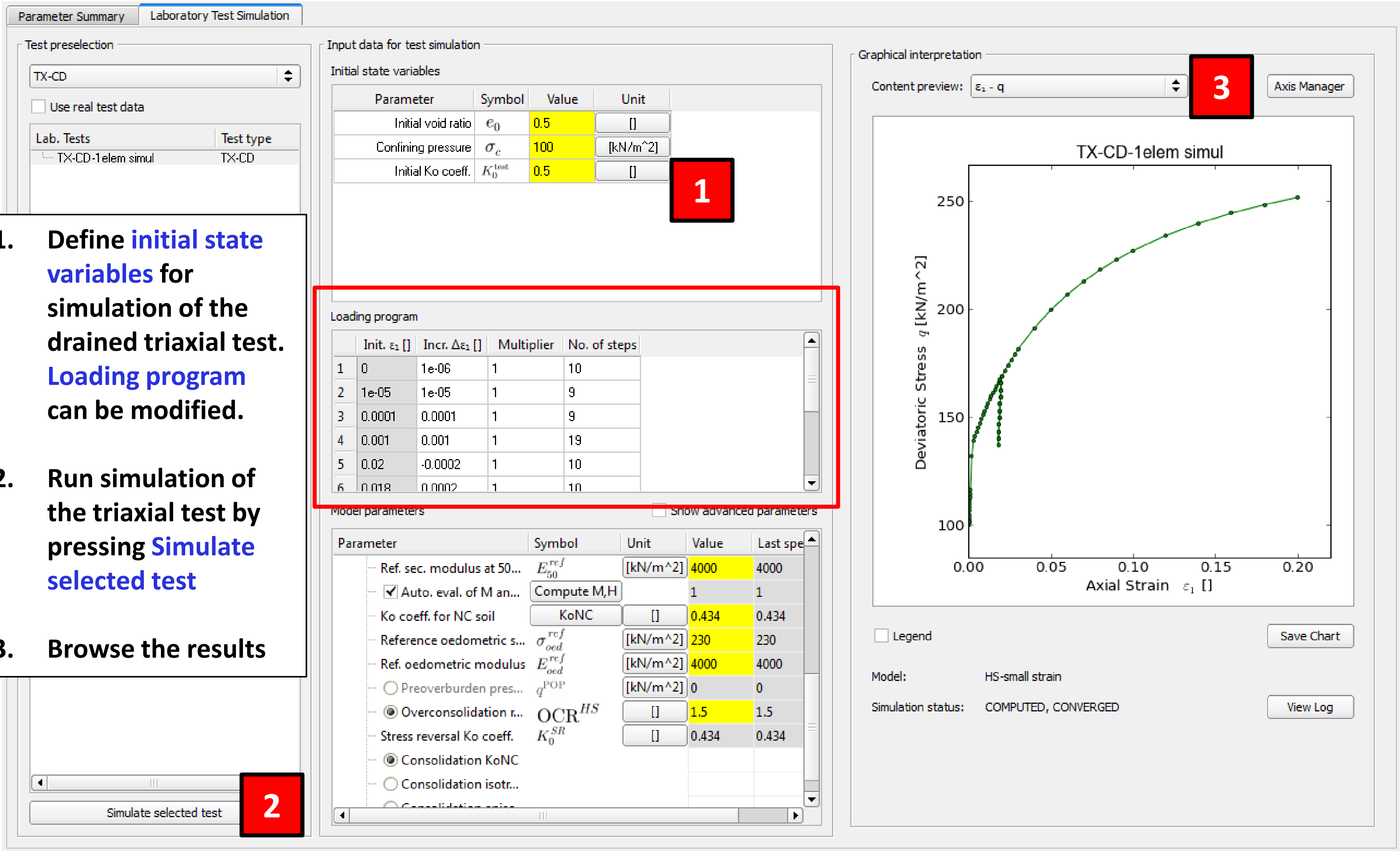
0. Leave the dialog for automatic and interactive parameter estimation - **Update and Exit**

1. Mark all parameters from column **Interactive**

2. Move marked values using **Copy checked to user's selection**

3. In order to verify effectivness of parameter identification, **Export** user's selection to **Test simulation**; you will be asked whether you'd like to automatically move to **Laboratory Test Simulation**

Exercise 2 – Simulation of a drained triaxial test

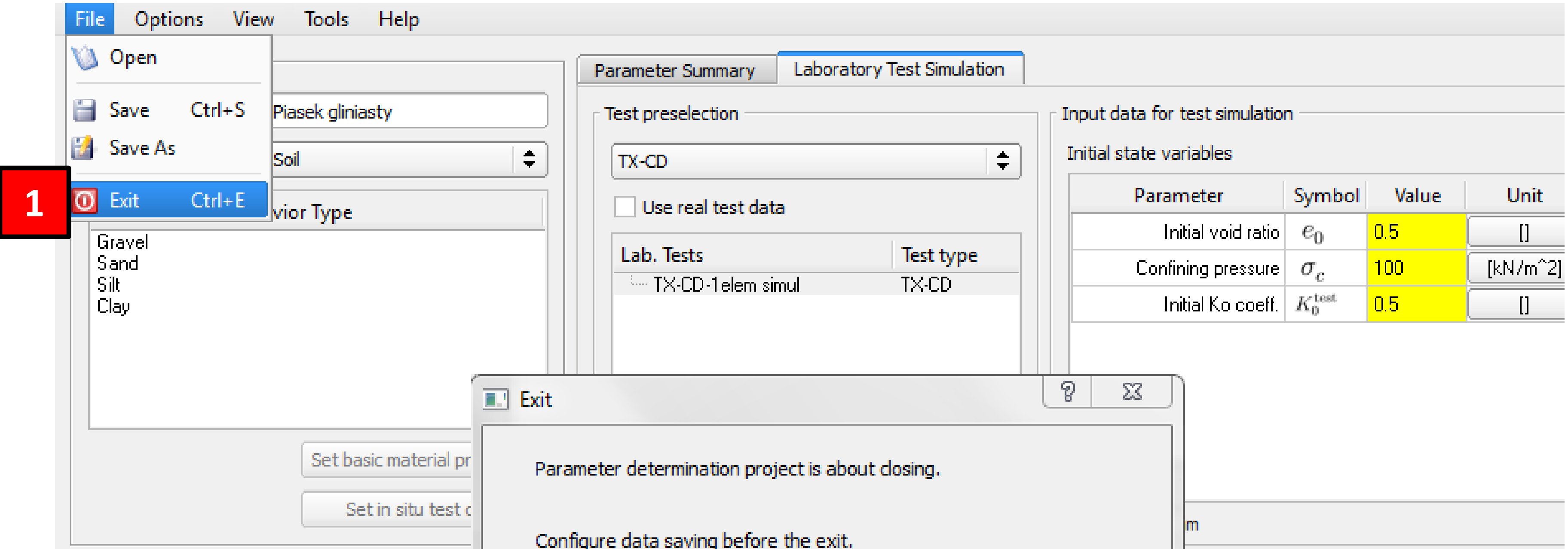


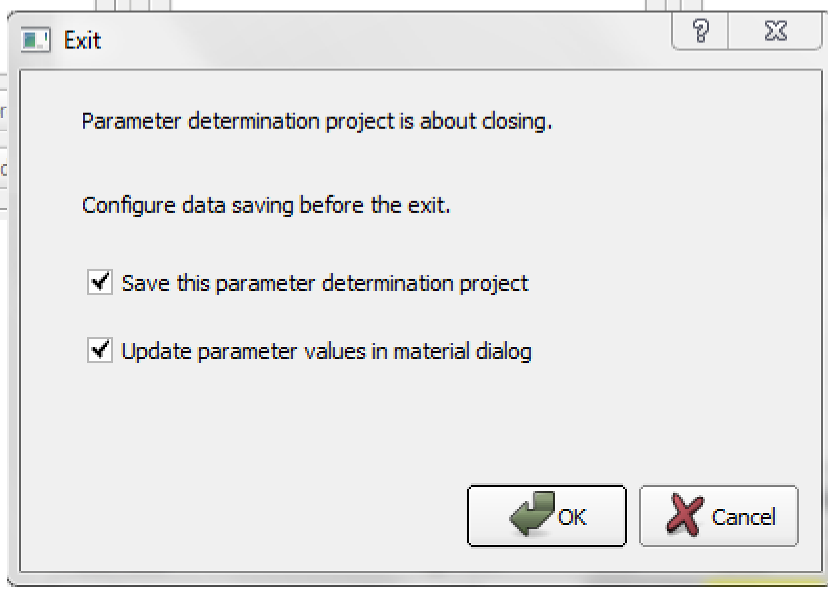
1. Define **initial state variables** for simulation of the drained triaxial test. **Loading program** can be modified.

2. Run simulation of the triaxial test by pressing **Simulate selected test**

3. Browse the results

Exercise 2 – Exit from Parameter Determination Toolbox

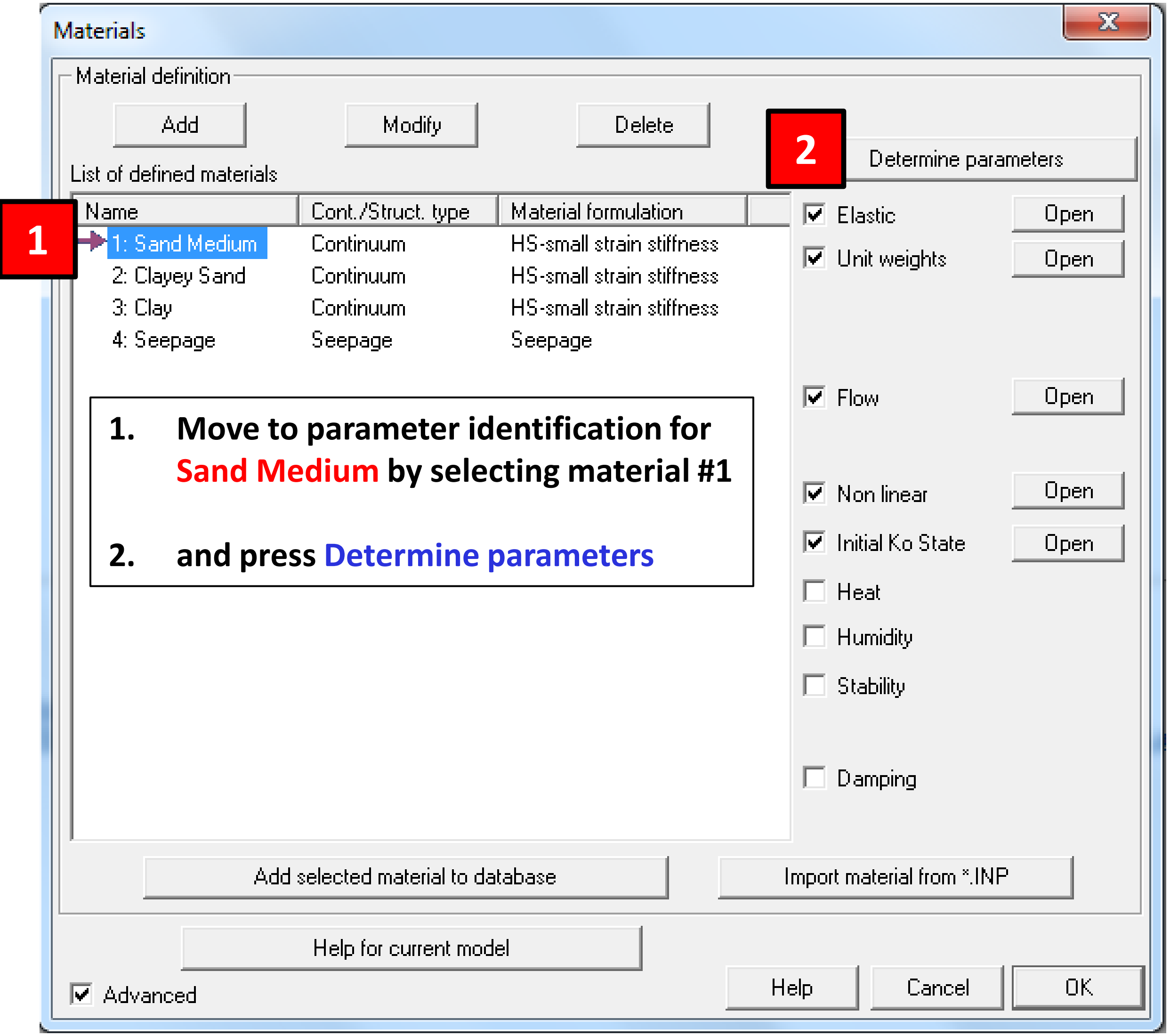




1. **Exit Parameter Determination Toolbox**

2. **Accept saving the parameter determination project and updating parameter values in material dialog**

Exercise 2 – Parameter identification for Medium Sand



Sand medium – dane:

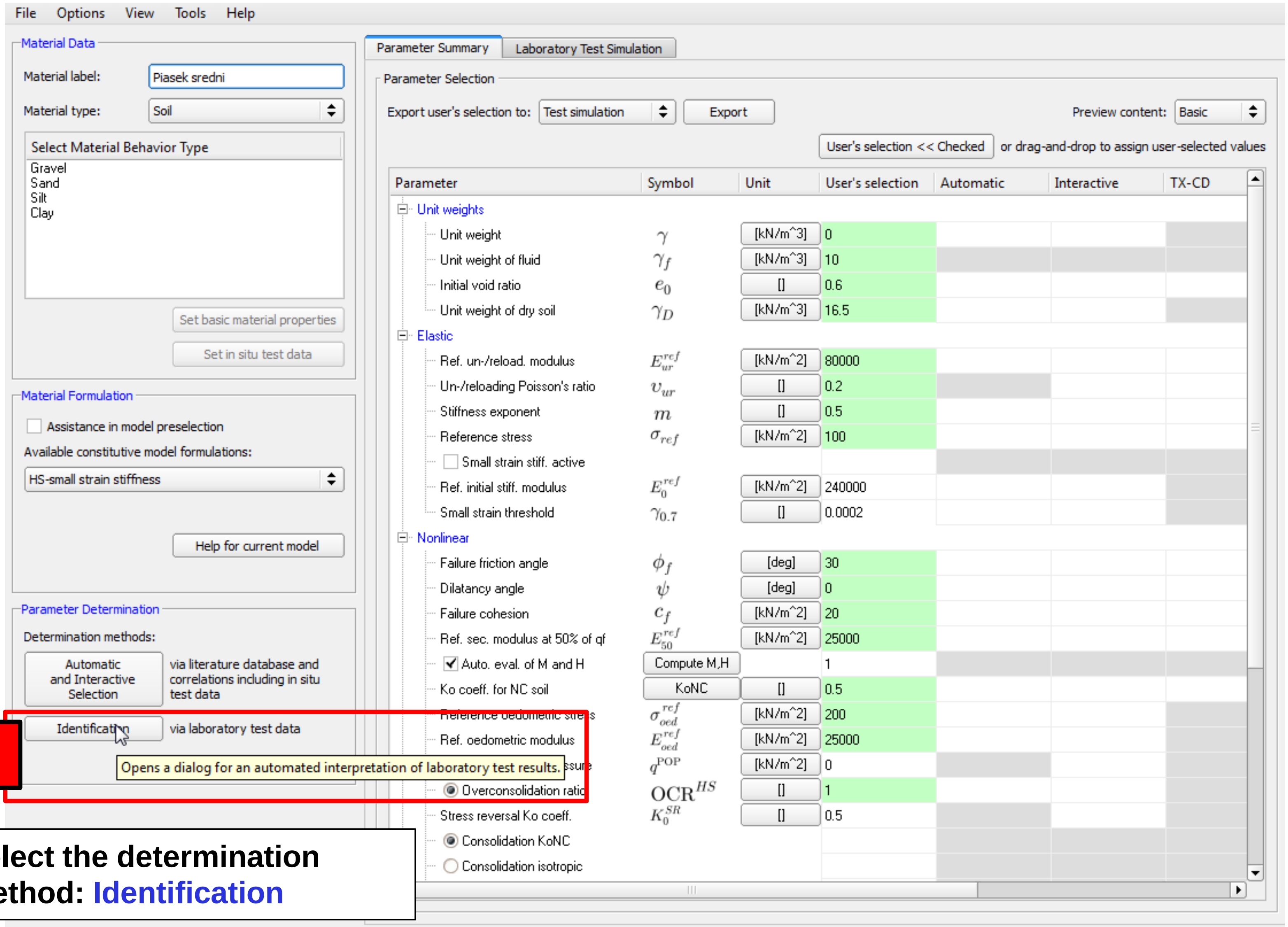
3 drained triaxial tests

General soil description (parameter estimation from incomplete data)

V_s (determining E_0)

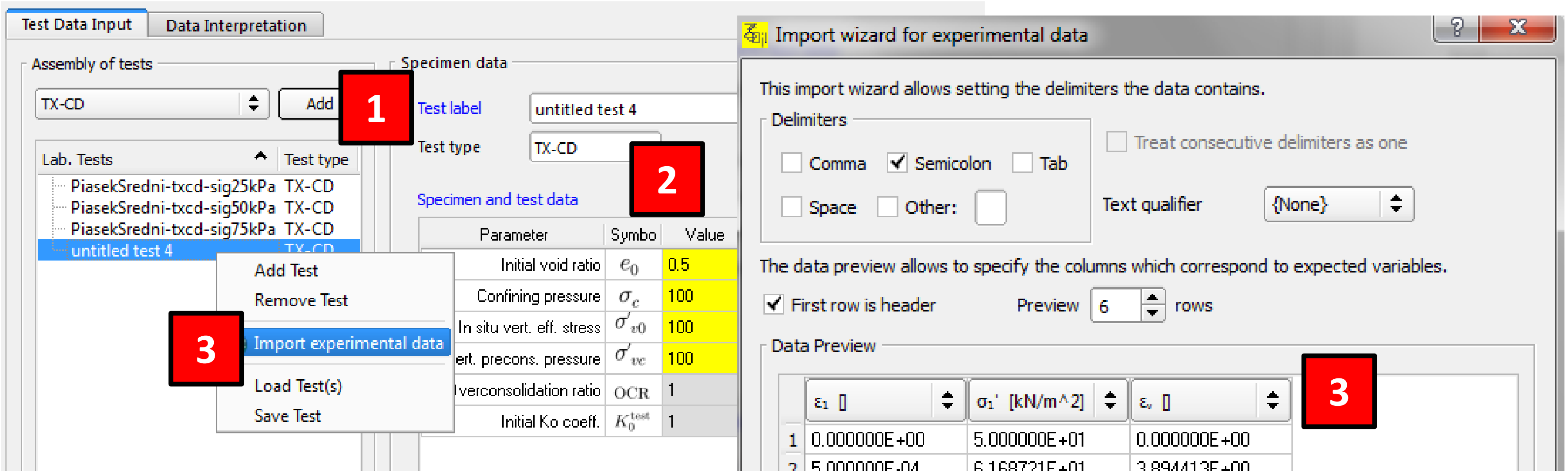
SPT (determining ϕ)

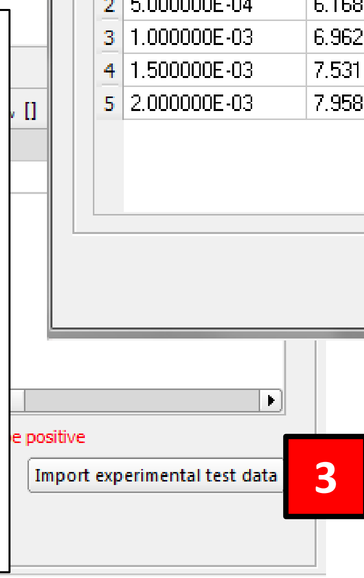
Exercise 2 – Initializing the identification from laboratory data



1. Select the determination method: Identification

Exercise 2 – Import experimental test data





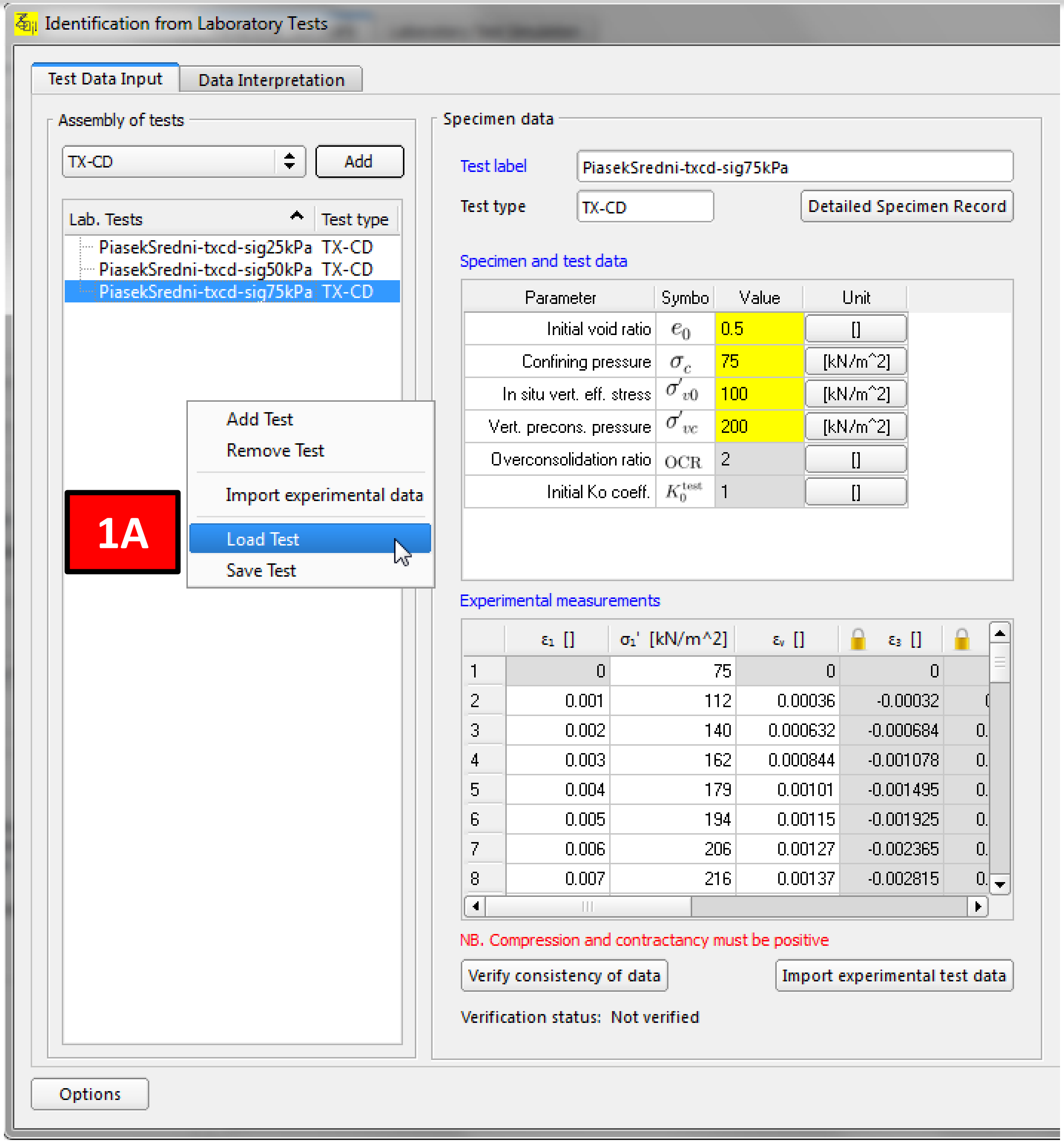
In order to define a new laboratory test:

1. **Preselect the type of test and press Add**

2. **Give a label to the test and define initial state variables**

3. **Import test results from an ASCII file by pressing Import experimental data, selecting the file, and assigning variables to corresponding columns**

Exercise 2 – Import experimental test data



1B

Import prepared data files:

SandMedium-txcd-sig25kPa.pit

SandMedium-txcd-sig50kPa.pit

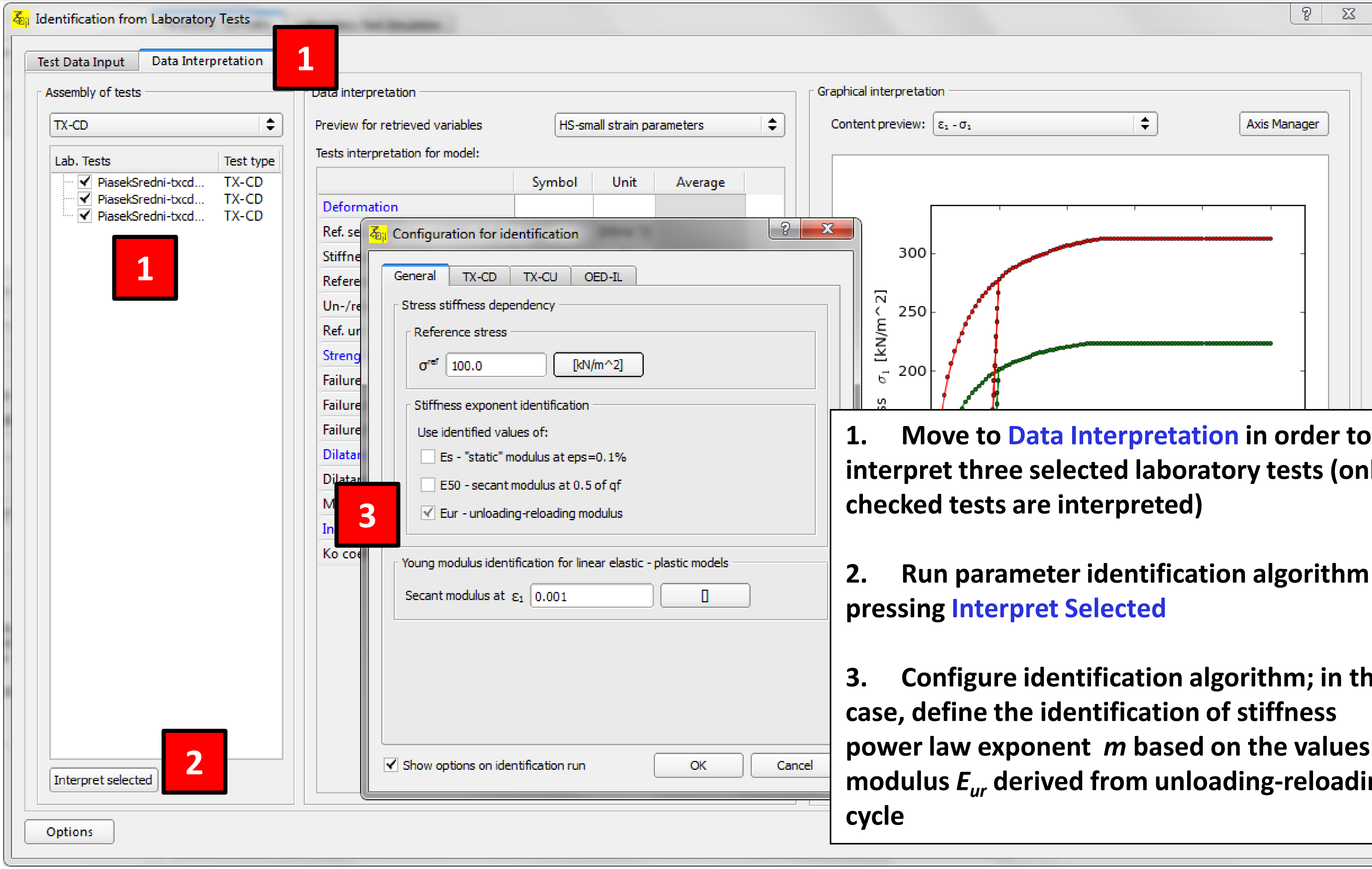
SandMedium-txcd-sig75kPa.pit

1A. In order to import prepared in advance and saved experimental data for three triaxial tests, click right button and select Load test(s)

1B. Select files and open them

2. Browse imported resuts by seleacting each test separately in Assembly of tests

Exercise 2 – Parameter identification Clayey Sand

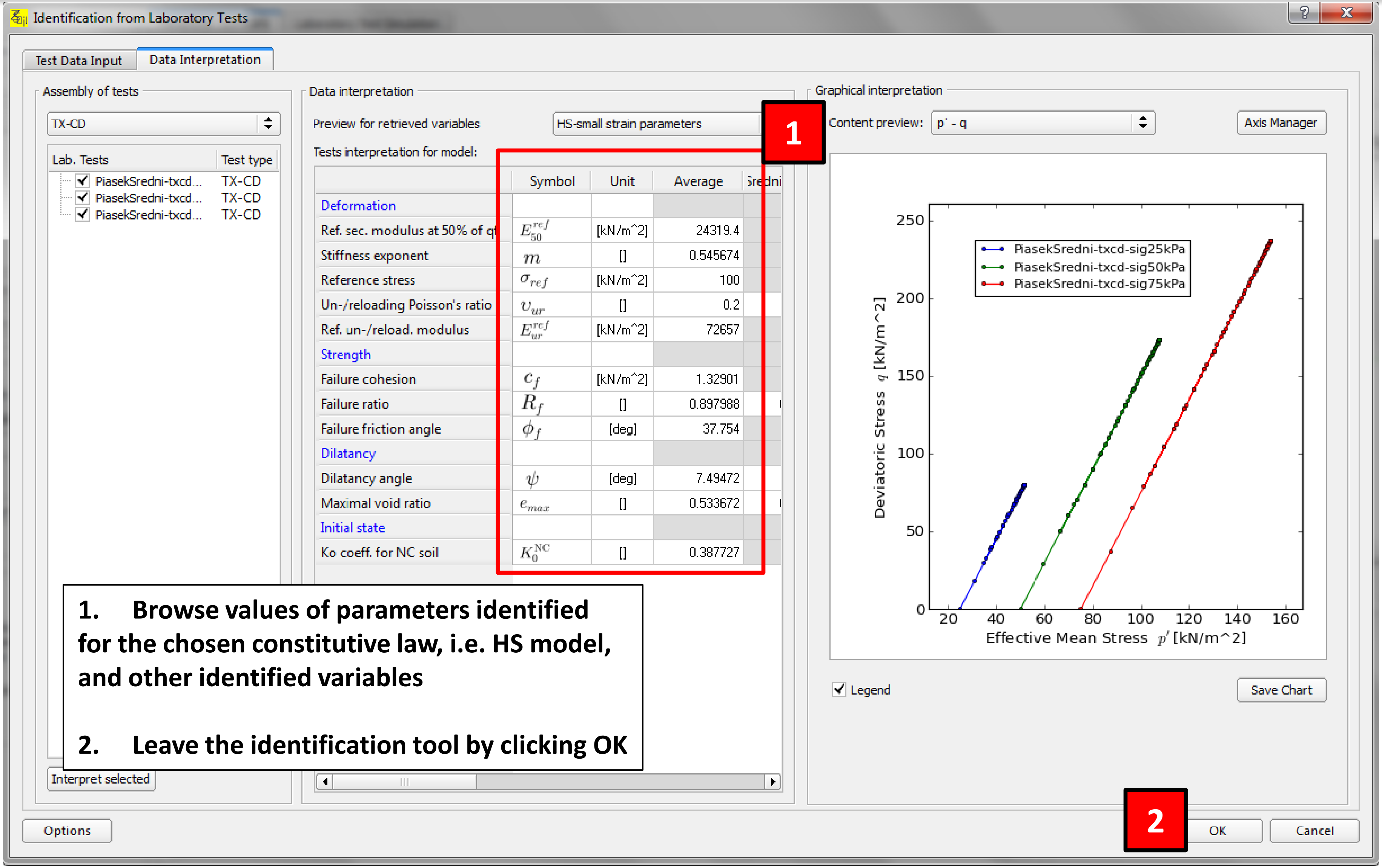


1. Move to **Data Interpretation** in order to interpret three selected laboratory tests (only checked tests are interpreted)

2. Run parameter identification algorithm by pressing **Interpret Selected**

3. Configure identification algorithm; in this case, define the identification of stiffness power law exponent *m* based on the values of modulus E_{ur} derived from unloading-reloading cycle

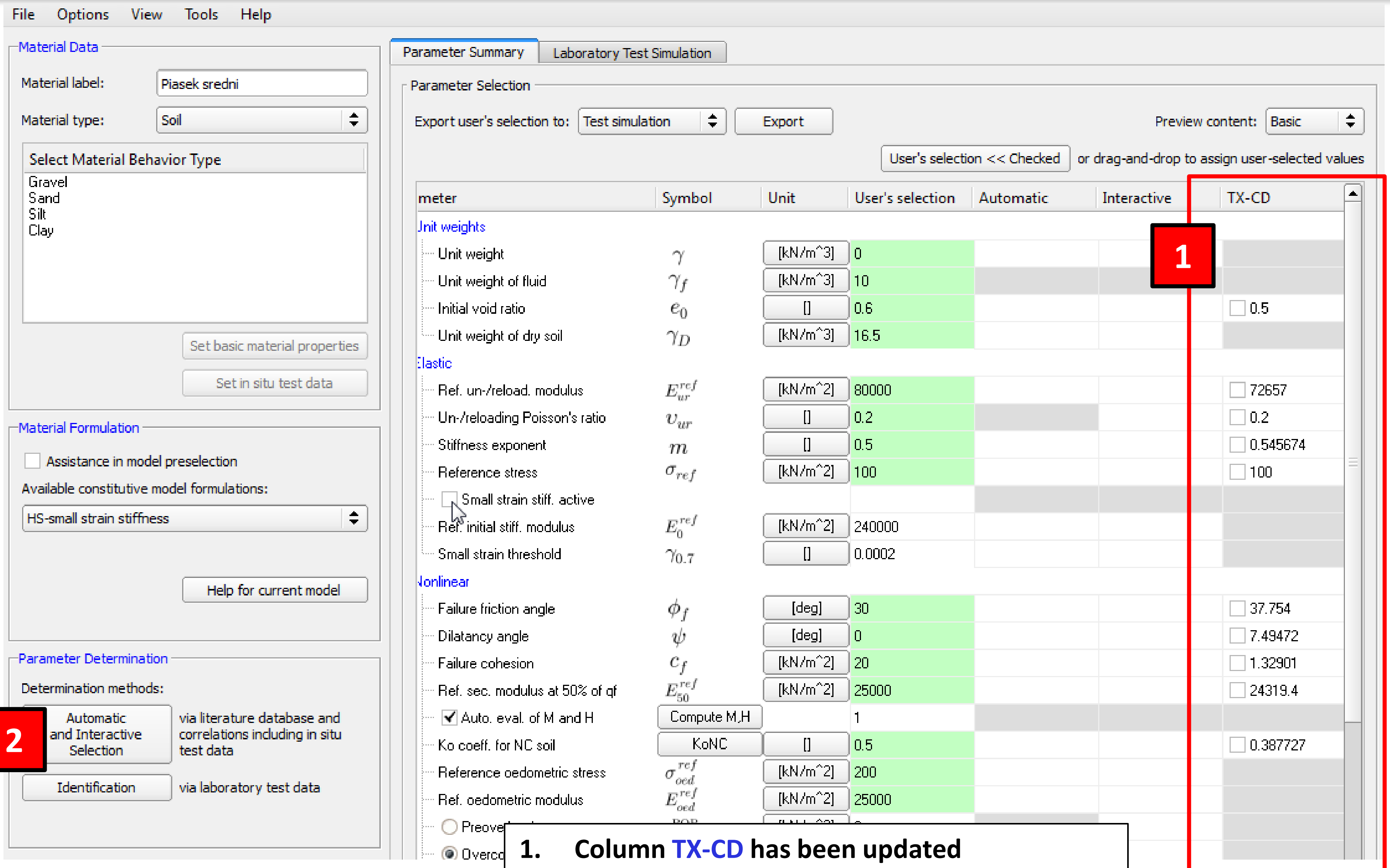
Exercise 2 – Post-processing of results



1. Browse values of parameters identified for the chosen constitutive law, i.e. HS model, and other identified variables

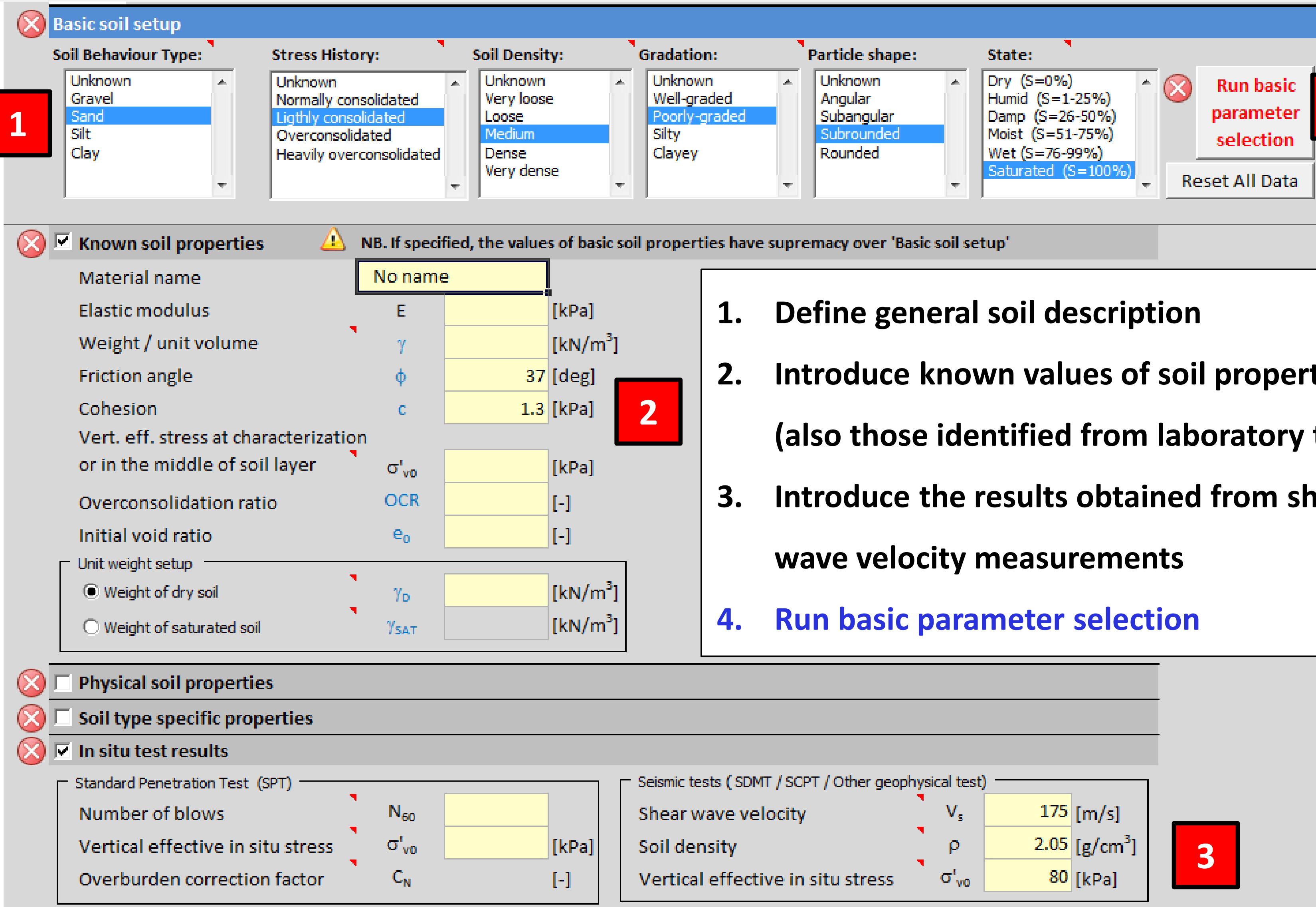
2. Leave the identification tool by clicking OK

Exercise 2 – Post-processing of results



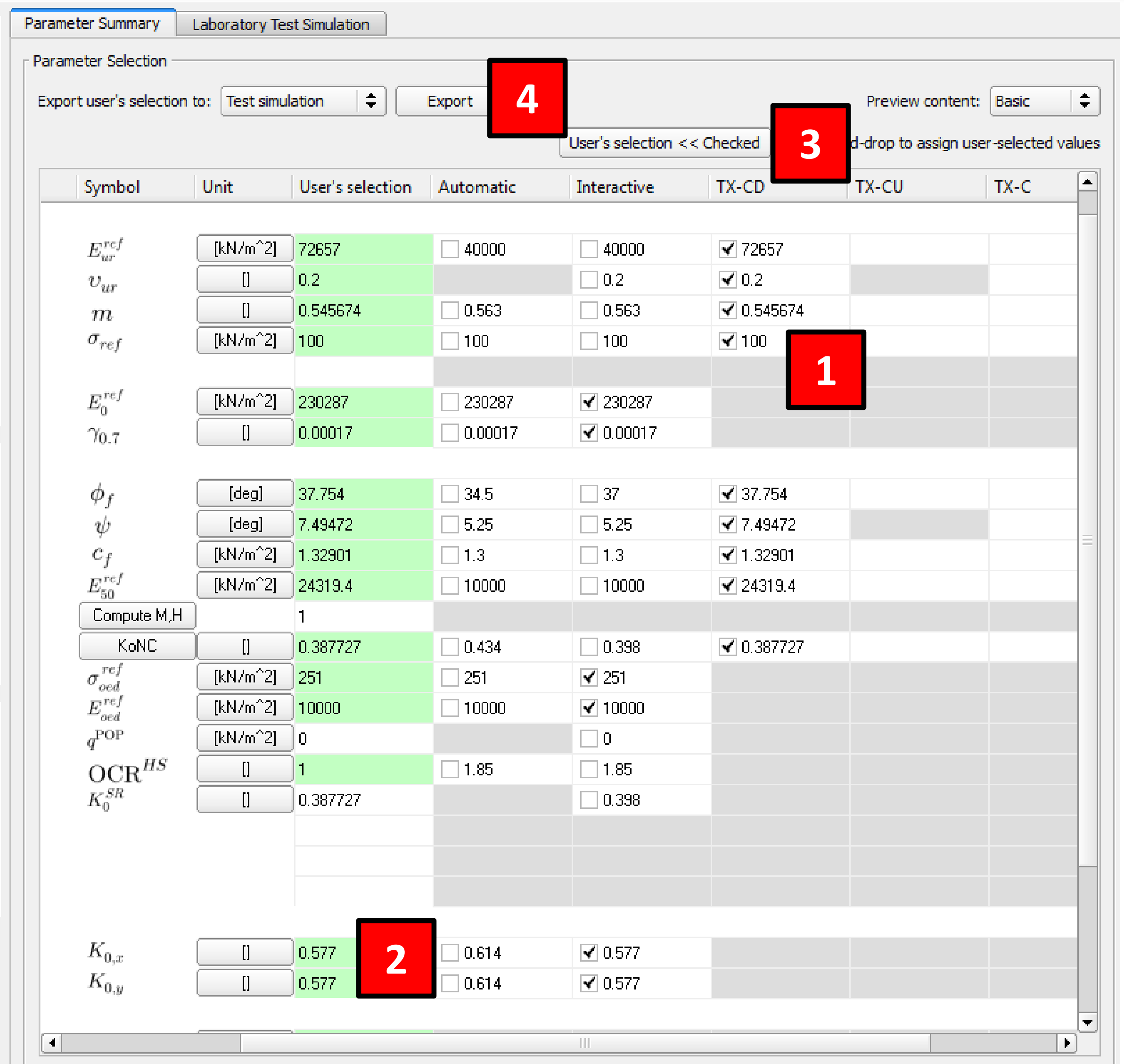
1. Column **TX-CD** has been updated
2. Press **Automatic and Interactive Selection** to determine the remaining parameters

Exercise 2 – Estimation based on available data



1. **Define general soil description**
2. **Introduce known values of soil properties (also those identified from laboratory test)**
3. **Introduce the results obtained from shear wave velocity measurements**
4. **Run basic parameter selection**

Exercise 2 – Final selection & exporting parameters for simulating TXCD



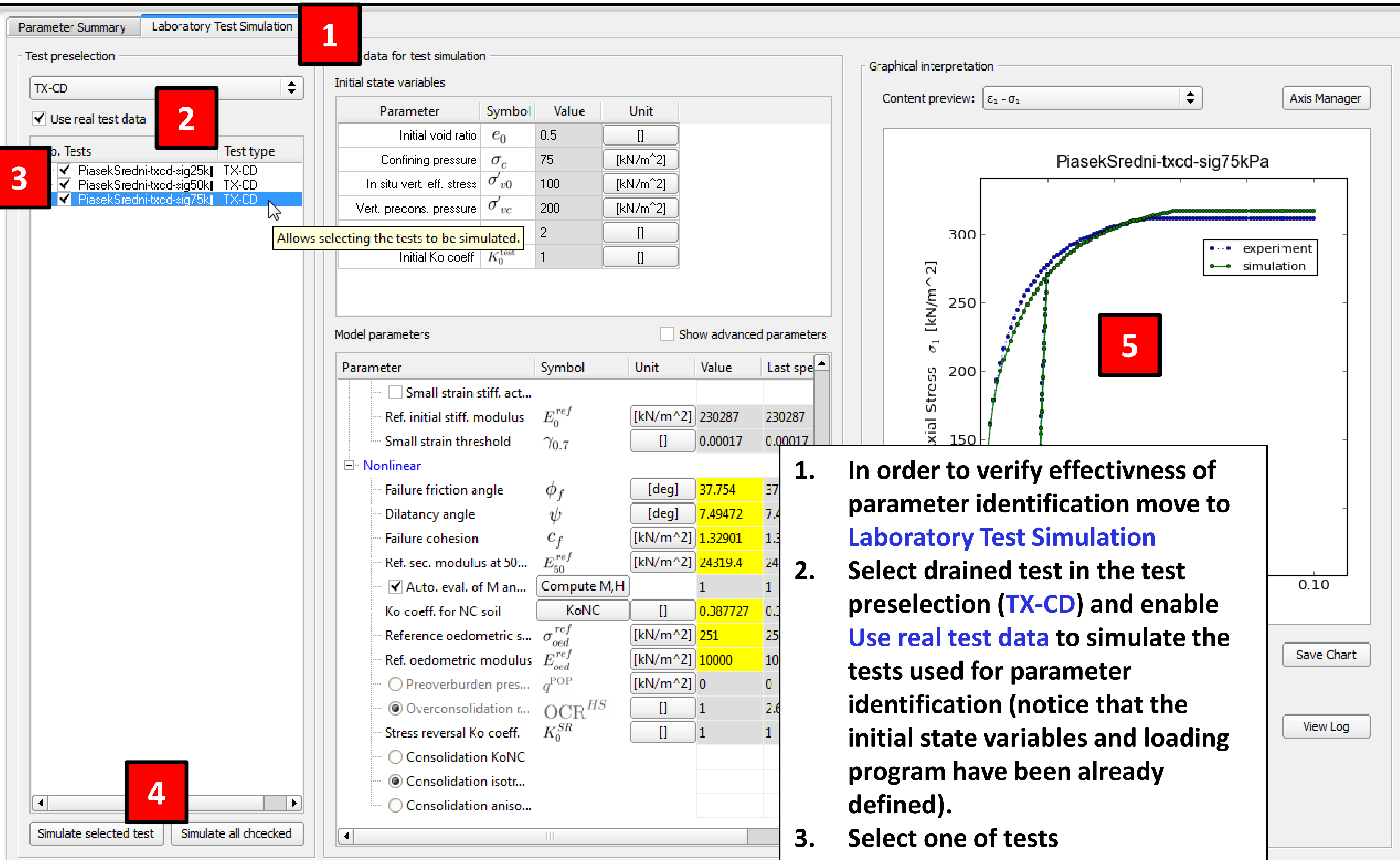
0. Leave the dialog for automatic and interactive parameter estimation - **Update and Exit**

1. Mark all parameters from column **TX-CD** …
2. … and selected values in column **Interactive**

3. Move marked values using **Copy checked to user's selection**

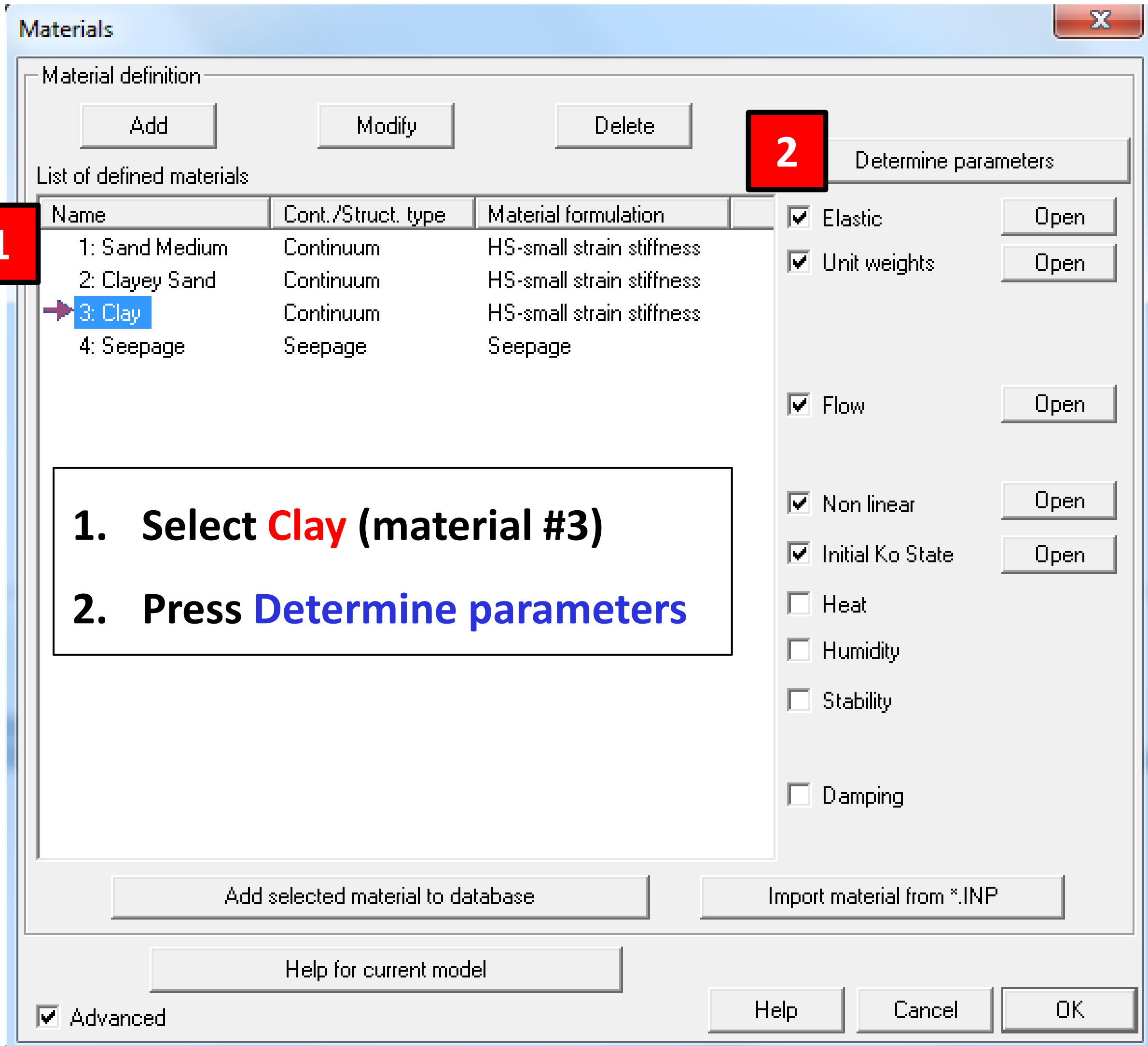
4. In order to verify effectivness of parameter identification, export user's selection to **Test simulation;** you will be asked whether you'd like to automatically move to **Laboratory Test Simulation**

Exercise 2 – Reproducing results derived from drained test



1. In order to verify effectivness of parameter identification move to **Laboratory Test Simulation**
2. Select drained test in the test preselection (**TX-CD**) and enable **Use real test data** to simulate the tests used for parameter identification (notice that the initial state variables and loading program have been already defined).
3. Select one of tests
4. Press **Simulate selected test**
5. Compare model responses with laboratory curves

Exercise 2 – Parameter identification for Clay



Clay – data:

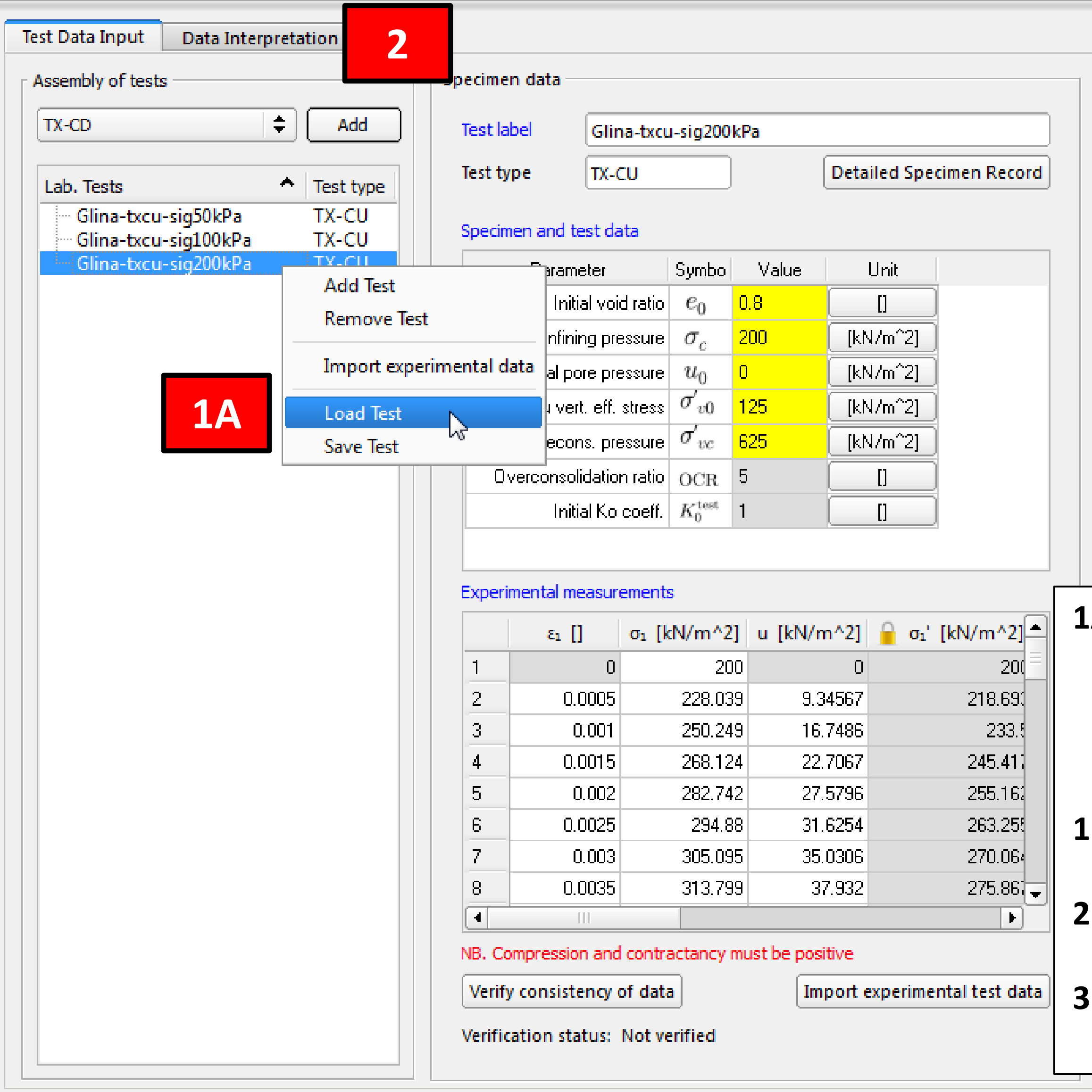
3 undrained triaxial tests

General soil description (parameter estimation from incomplete data)

V_s (determining E_0)

DMT, CPTU (determining OCR)

Exercise 2 – Import experimental data (undrained tests)



1B

Load test from files:

Clay-txcu-sig50kPa.pit

Clay-txcu-sig100kPa.pit

Clay-txcu-sig200kPa.pit

3 Interpret selected

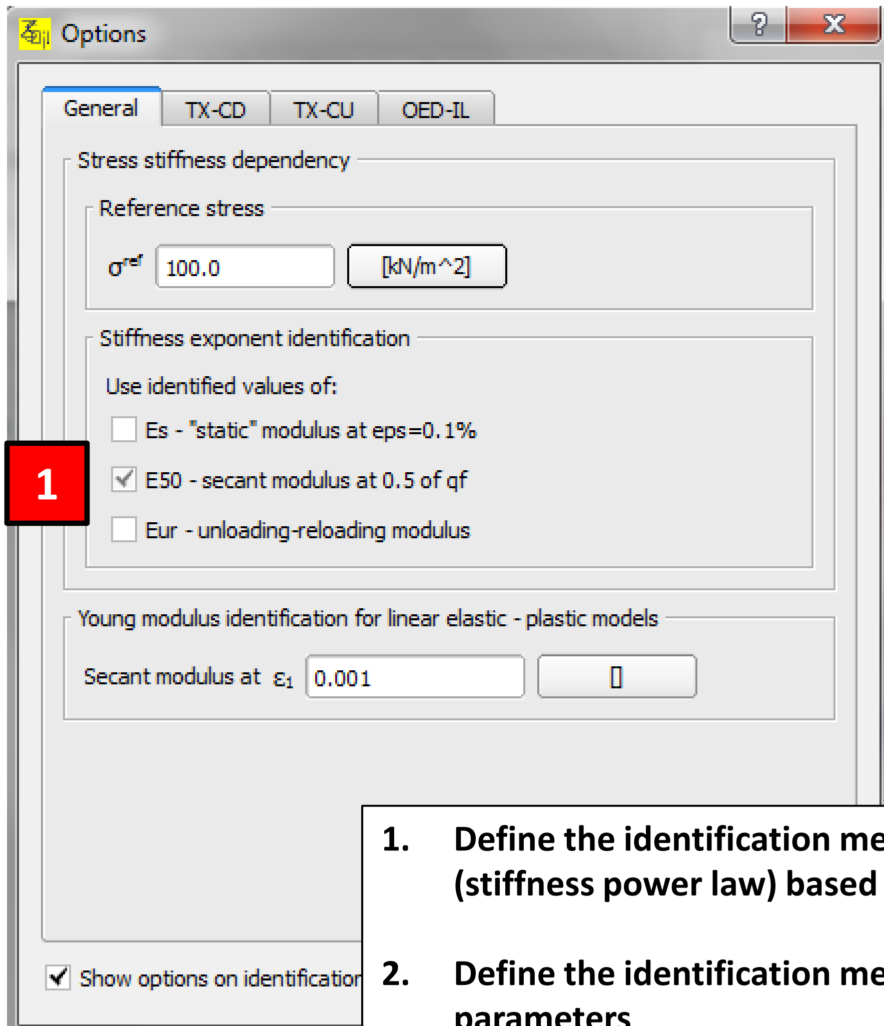
1A. Import prepared in advance and saved experimental data for three undrained triaxial tests, click right button and select Load test(s)

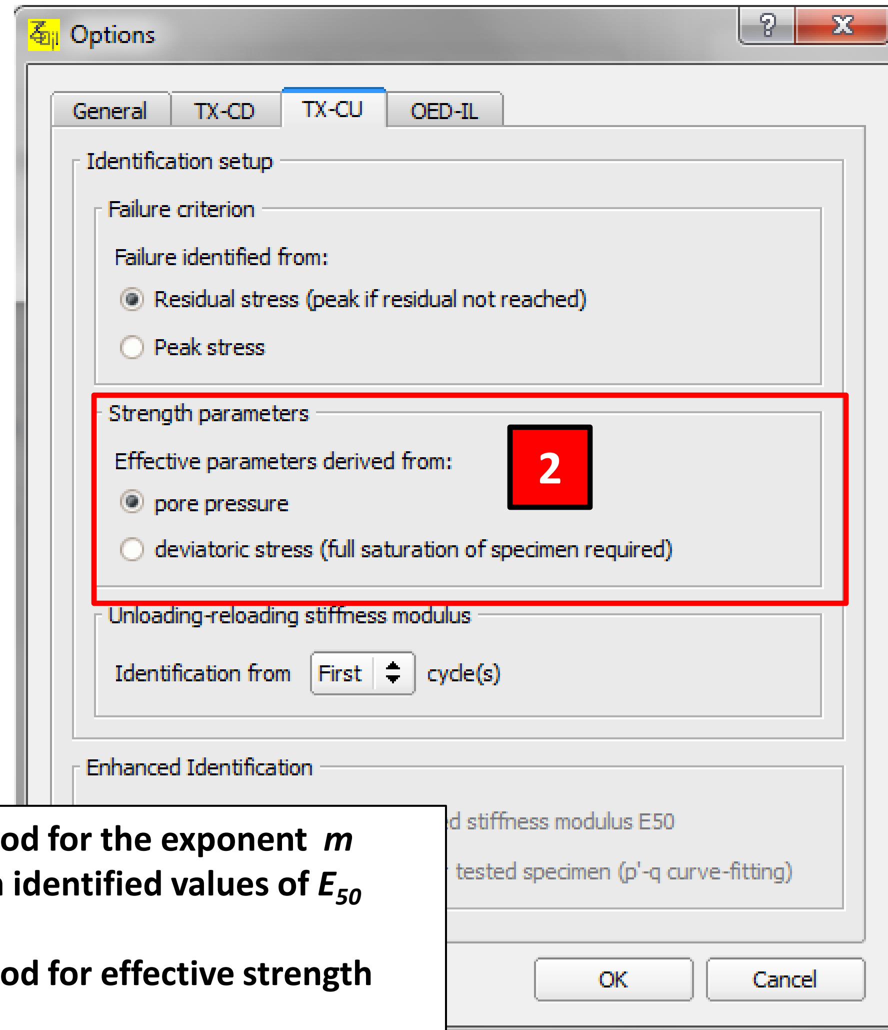
1B. Select files and open them

2. Move to Data interpretation tab widget

3. Run interpretation of laboratory curves by pressing Interpret selected

Exercise 2 – Setting options for identification



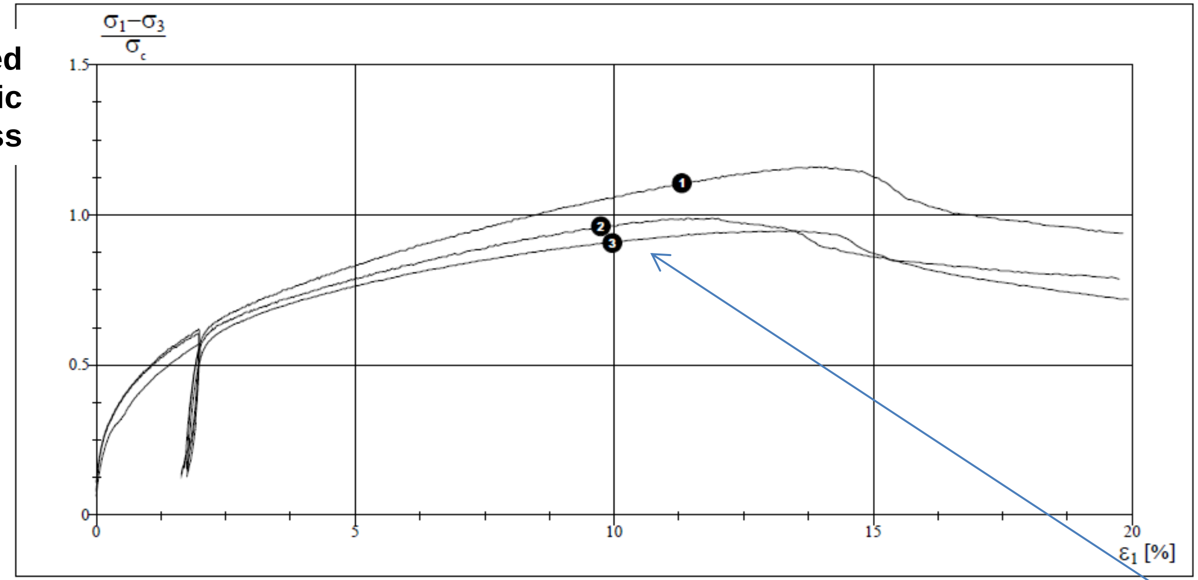


1. **Define the identification method for the exponent *m* (stiffness power law) based on identified values of E_{50}**

2. **Define the identification method for effective strength parameters**

NB. Effective strength parameters from undrained triaxial tests

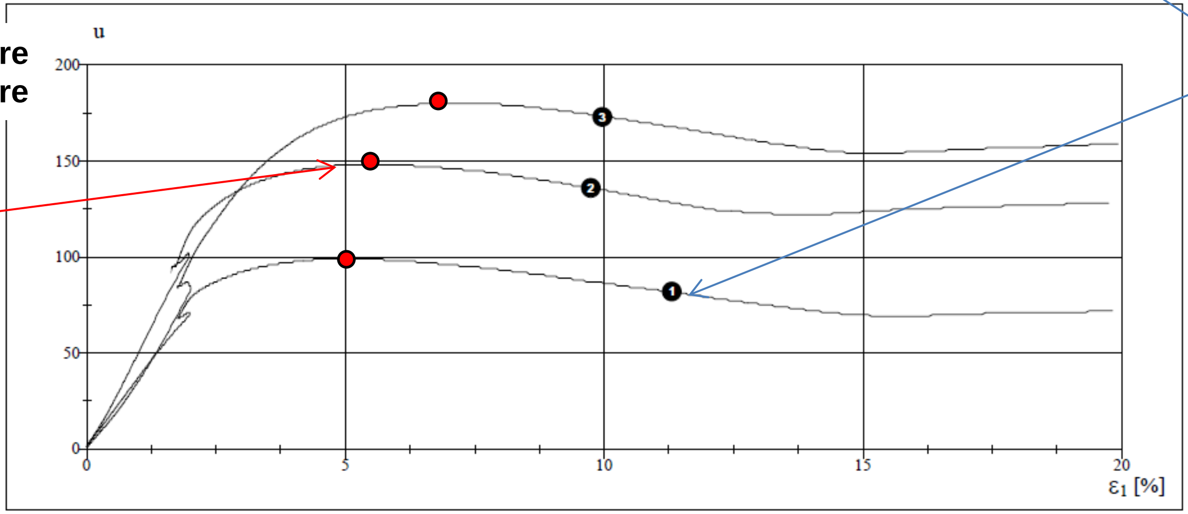
Normalized deviatoric stress



According to the report the degree of saturation in specimens:

100%, 100%, 96%

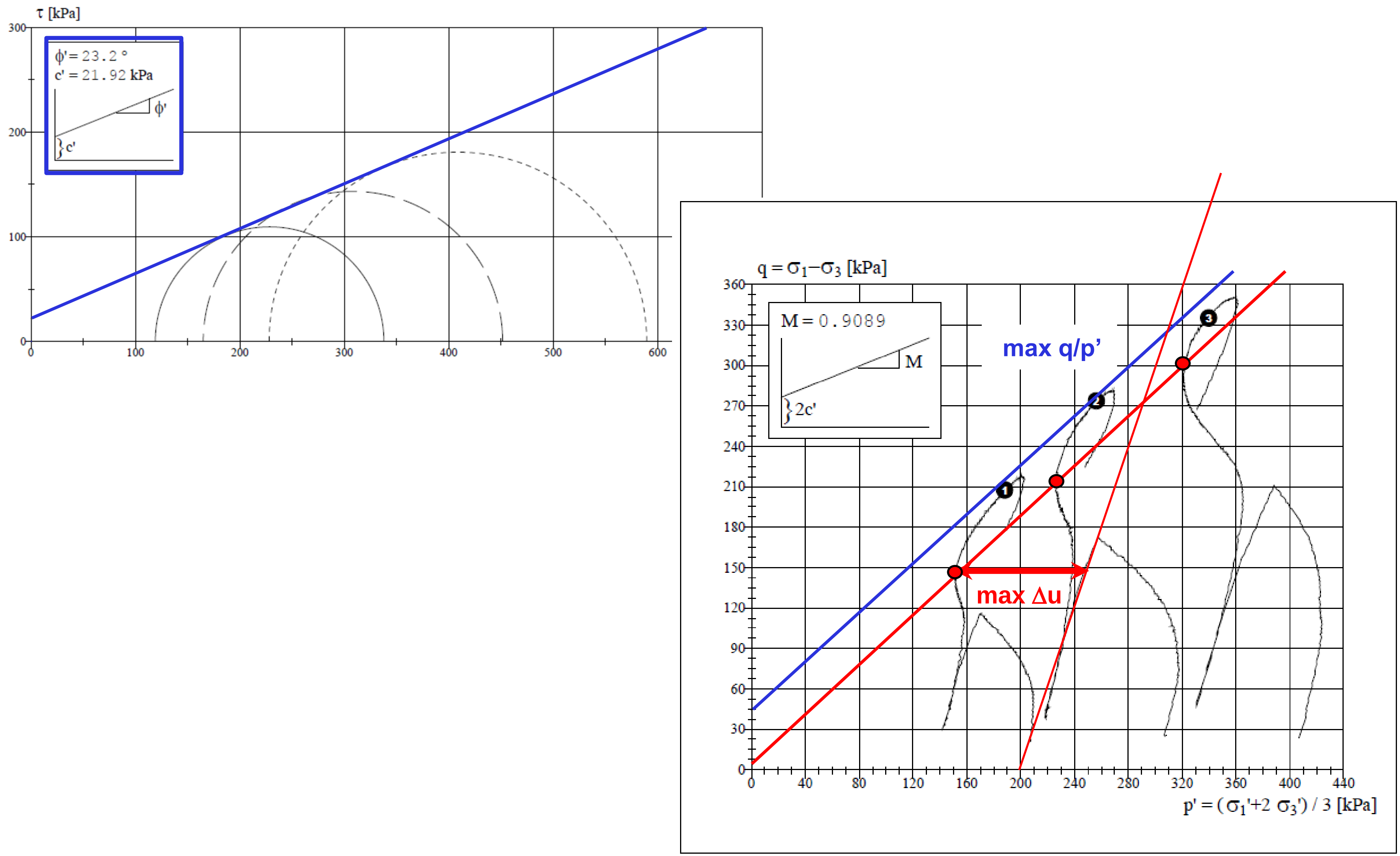
Pore pressure



Maximal pore pressure

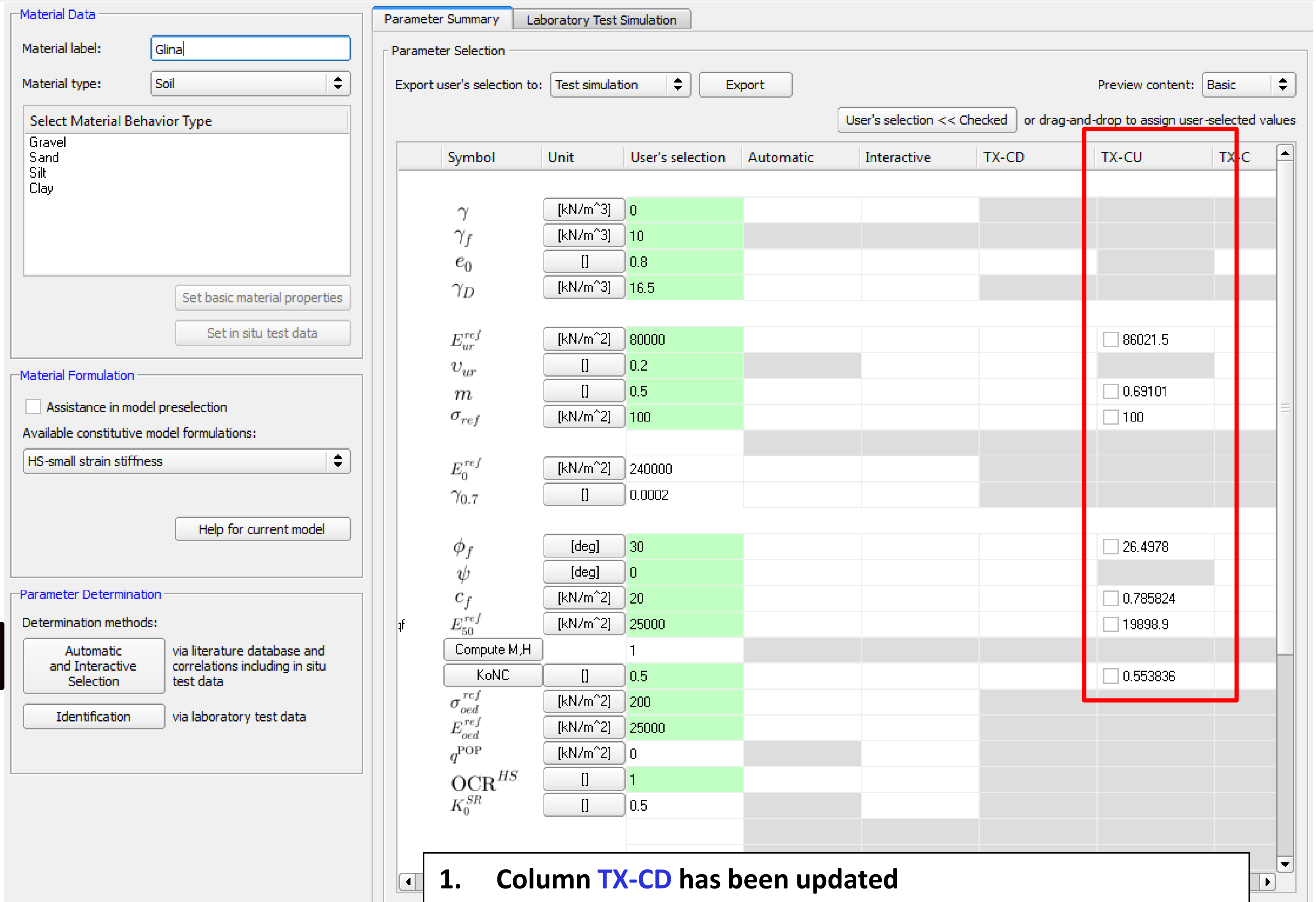
Ultimate state based on maximal q/p' criterion according to interpretation by the testing laboratory

NB. Effective strength parameters from undrained triaxial tests



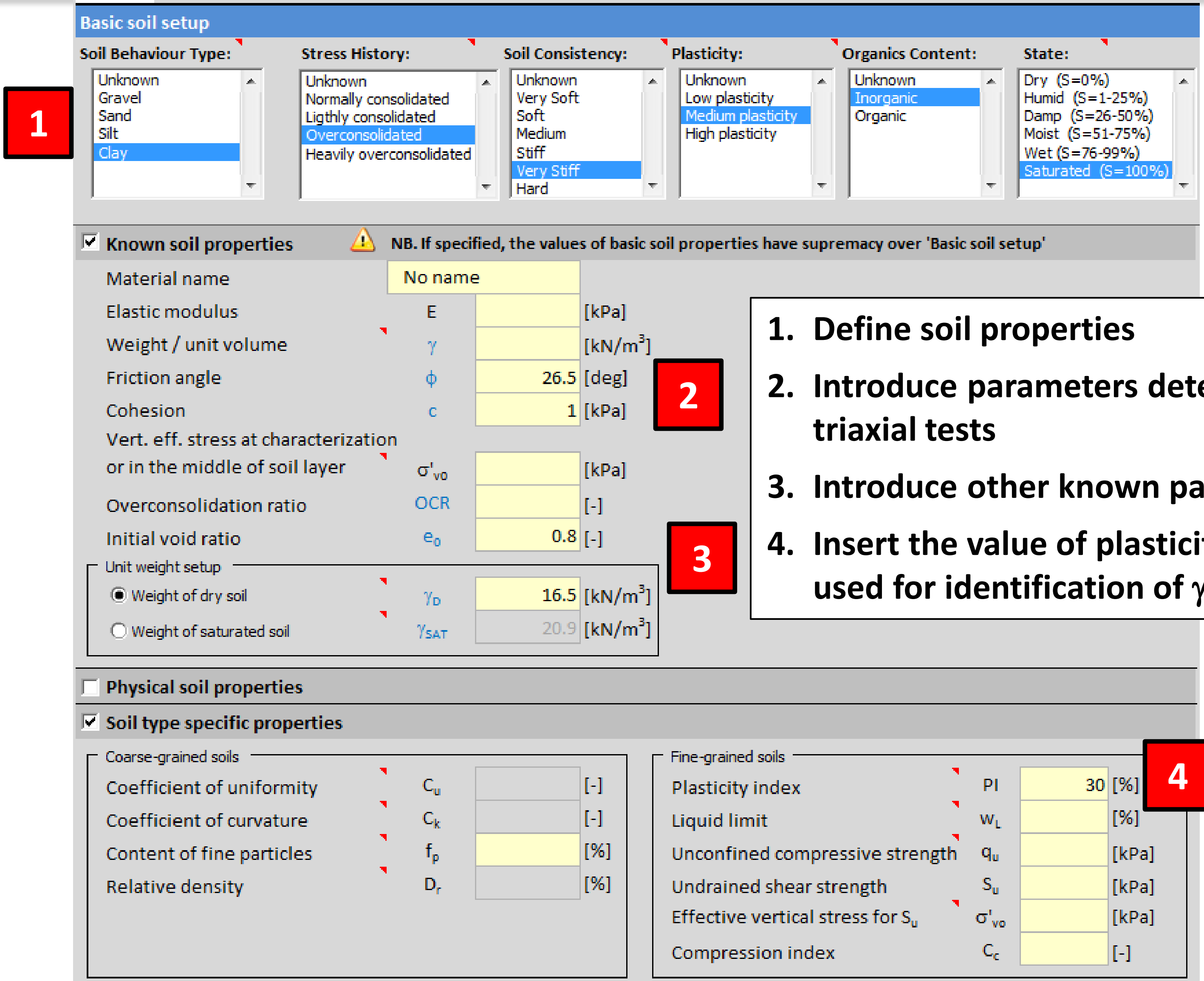
Exercise 2 – Post-processing of results

1



1. Column **TX-CD** has been updated
2. Press **Automatic and Interactive Selection** to estimate the remaining parameters

Exercise 2 – Estimation based on available data



1. **Define soil properties**
2. **Introduce parameters determined from triaxial tests**
3. **Introduce other known parameters**
4. **Insert the value of plasticity index being used for identification of $\gamma_{0.7}$**

Exercise 2 – Introducing data from field testing

☑ **In situ test results**

Standard Penetration Test (SPT)

Number of blows	N_{60}		
Vertical effective in situ stress	σ'_{v0}		[kPa]
Overburden correction factor	C_N		[-]

Seismic tests (SDMT / SCPT / Other geophysical test) 1

Shear wave velocity	V_s	255	[m/s]
Soil density	ρ	1.9	[g/cm^3]
Vertical effective in situ stress	σ'_{v0}	140	[kPa]

Marchetti Dilatometer Test (DMT) 2

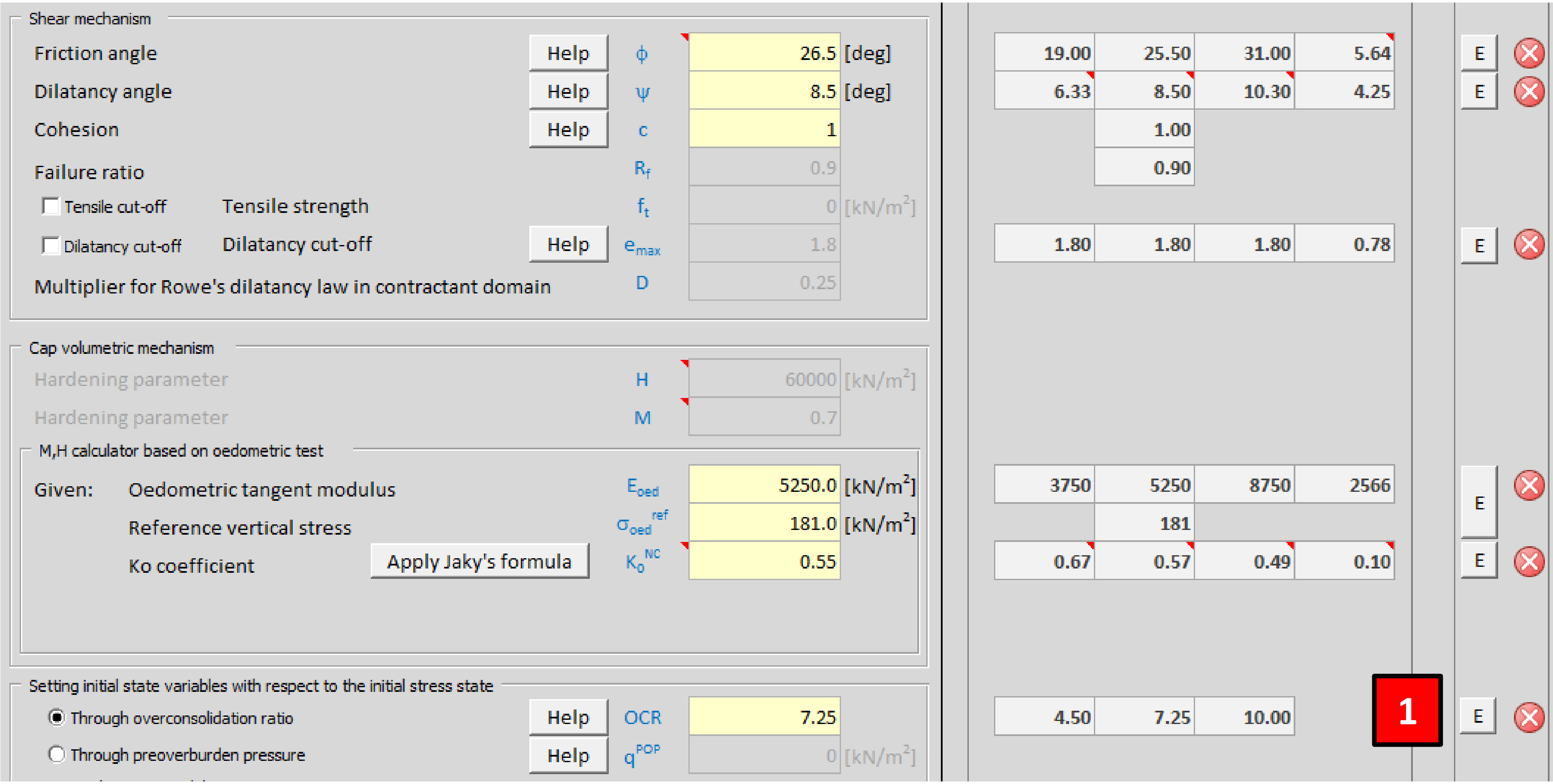
First DMT reading	p_0	952	[kPa]
Second DMT reading	p_1	1149	[kPa]
Hydrostatic pore pressure	u_0	50	[kPa]
Effective *in situ* vertical stress	σ'_{v0}	140	[kPa]
Material index	I_D	0.218	[-]
Horizontal stress index	K_D	6.44	[-]
Dilatometer modulus	E_D	6836	[kPa]
Dimensionless unit weight	γ_{DMT}/γ_W	2.05	[-]
Soil Behaviour Type:		Clay	

Cone Penetration Test (CPT/CPTU) 3

Corrected cone resistance	q_t	2120	[kPa]
Pore pressure behind the cone	u_2	860	[kPa]
Friction sleeve resistance	f_s	115	[kPa]
Total vertical stress	σ_{v0}	190	[kPa]
Hydrostatic pore pressure	u_0	50	[kPa]
Effective vertical stress	σ'_{v0}	140	[kPa]
Dimensionless unit weight	γ_{CPT}/γ_W	1.91	[-]
Normalized cone resistance	Q_t	13.8	[-]
Pore pressure parameter	B_q	0.42	[-]
Normalized friction ratio	F_r	0.0596	[-]

1. **Introduce the results of shear wave velocity measurement**
2. **Introduce representative results obtained for this soil layer from the dilatometric test**
3. **Introduce representative results obtained for this soil layer from CPTU**
4. **Run Basic Parameter Selection**

Exercise 2 – Automatic Selection: post-processing of results



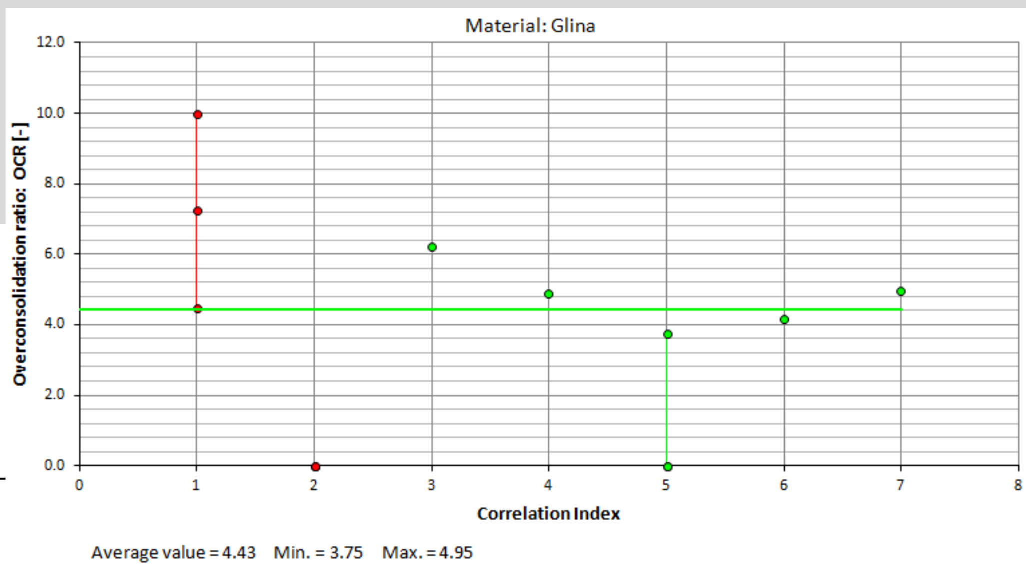
1. **Move to interactive estimation of the overconsolidaiton ratio OCR from DMT and CPTU results**

Exercise 2 – Interactive selection: OCR

Overconsolidation ratio	OCR			Approximative value OCR [-]		
Correlation Type	Soil Type or Other Auxiliary Data			Min	Average	Max
1 Geotechnical convention	Heavily overconsolidated			4.5	7.3	10.0
2 Empirical	Undrained shear strength	s_u [kPa]:	not specified	N/A	N/A	N/A
	Effective vertical stress for S_u	σ'_{v0} [kPa]:	0			
	Specify consolidation mode ...					
Test Type	Measurement or transformed measurement		Value	Min	Average	Max
3 Marchetti's dilatometer DMT	Horizontal stress index				6.20	
4 Marchetti's dilatometer DMT		K_D [-]:	6.44		4.87	
5 Marchetti's dilatometer DMT	Medium plasticity soils			N/A	3.75	N/A
6 Piezocone test CPTU	Site-specific empirical coefficient	k_t [-]	0.3		4.14	
	Total *in situ* vertical stress	σ_{v0} [kPa]:	190			
	Effective *in situ* vertical stress	σ'_{v0} [kPa]:	140			
7 Piezocone test CPTU	Corrected cone resistance	q_t [kPa]:	2120		4.95	
	Site-specific empirical coefficient	k_e [-]	0.55			
	Pore pressure measured behind cone	u_2 [-]	860			
			Min/Mean/Max	3.75	4.43	4.95
			Standard Deviation		0.58	

1

2



Plot

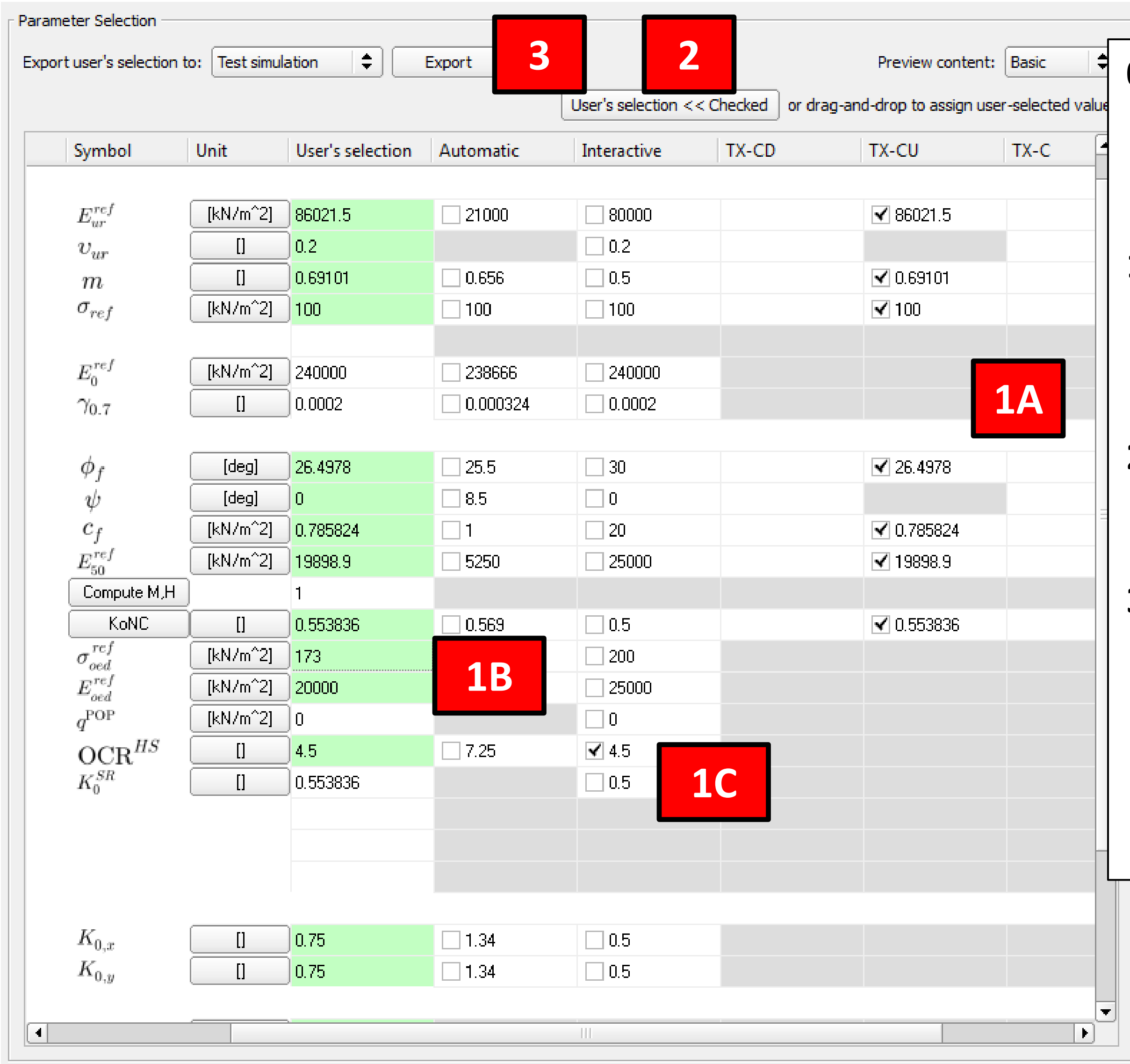
3

Selected Value 4.5 Update HS Menu

4

5

Exercise 2 – Final selection & exporting parameters for simulating TXCU



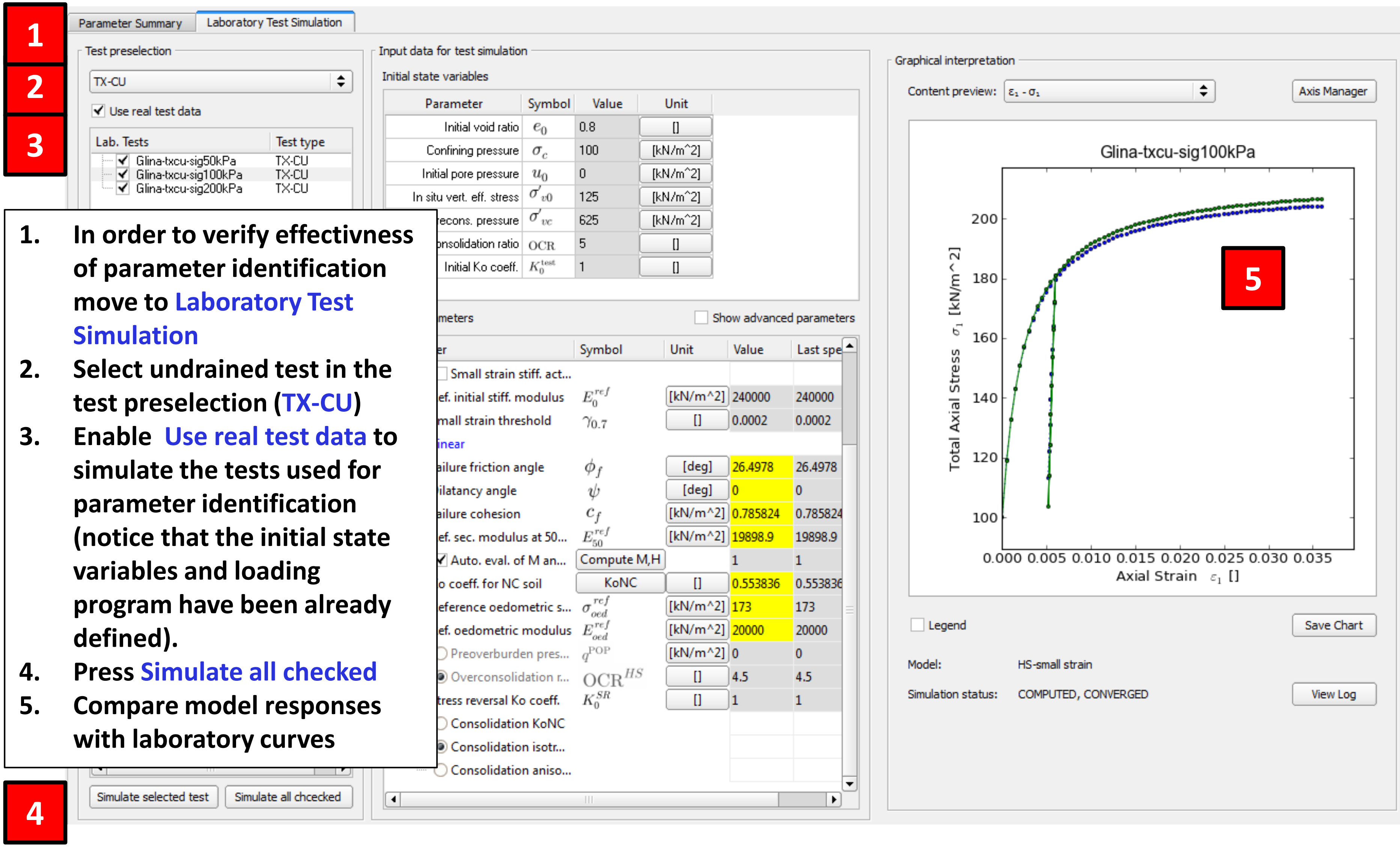
0. Leave the dialog for automatic and interactive parameter estimation - Update and Exit

1. Mark all parameters from column „TX-CU" and OCR value from column Interactive

2. Move marked values using Copy checked to user's selection

3. In order to verify effectivness of parameter identification, export user's selection to Test simulation; you will be asked whether you'd like to automatically move to Laboratory Test Simulation

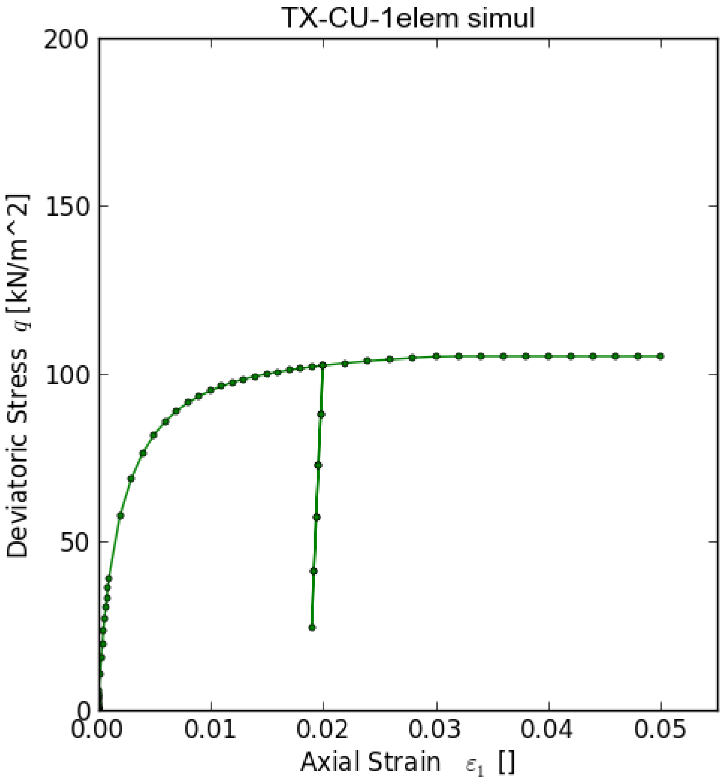
Exercise 2 – Reproducing results derived from undrained test



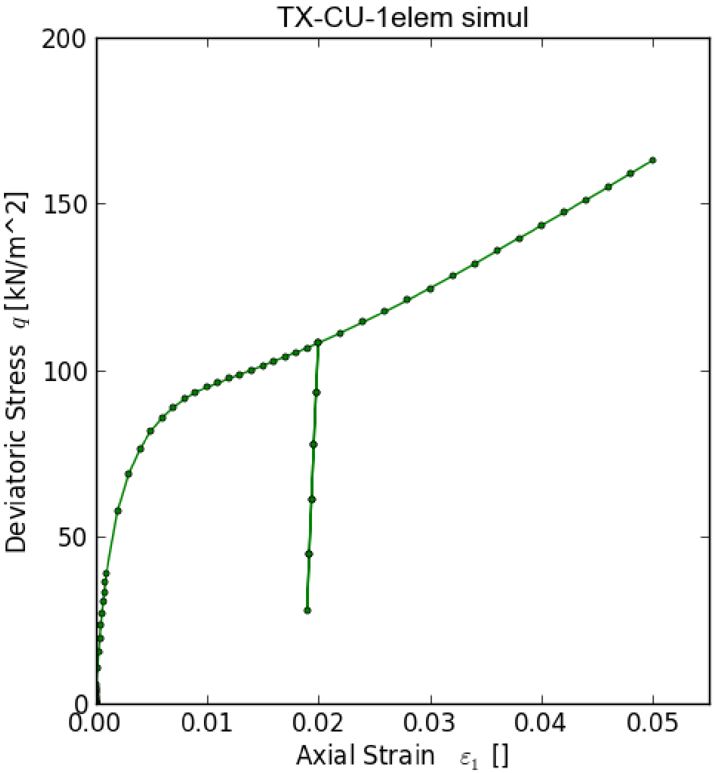
1. In order to verify effectivness of parameter identification move to Laboratory Test Simulation
2. Select undrained test in the test preselection (TX-CU)
3. Enable Use real test data to simulate the tests used for parameter identification (notice that the initial state variables and loading program have been already defined).
4. Press Simulate all checked
5. Compare model responses with laboratory curves

Modeling undrained behavior using the HS model

ψ = 0°



ψ = 3°



ψ > 0 shouldn't be used to simulate undrained behavior of cohesive soils !!!