Constitutive Virtual Laboratory
or
assistance in parameter determination
in ZSoil v2016

Rafal OBRZUD
GeoMod Ing. SA, Lausanne
robrzud@geomod.ch

ZSoil® 2015
Content

- What’s Virtual Laboratory?
- Assistance in parameter determination v2016
Motivation for developing the parameter selection tool

Client Request
• Realistic simulation of soil-structure interaction

Requirement
• FEM
• Advanced constitutive models

Getting stuck
• Large number of parameters
• Missing data for parameter identification
• Uncertainty in parameter selection

ZSoil solution
• Virtual Laboratory
What’s Virtual Laboratory?

- A highly-interactive tool for assistance in parameter selection for constitutive models for soils
- First-guess for model parameters for any incomplete or complete material data
- Automatic or interactive knowledge extraction
- Parameter identification from laboratory curves
- Provides parameter ranges (parametric studies)
- Testing constitutive models
What’s Virtual Laboratory?

Virtual Laboratory

Data Input

Constitutive model

Parameter determination methods

Parameter verification and validation

General soil description
Known numeric data
In situ test data
What’s Virtual Laboratory?

Virtual Laboratory

- Data Input
- Constitutive model
- Parameter determination methods
- Parameter verification and validation

Selecting model formulation
 Assistance in choosing a relevant constitutive model
What’s Virtual Laboratory?

Virtual Laboratory

- Data Input
- Constitutive model
- Parameter determination methods
- Parameter verification and validation

Automatic selection
Interactive selection
Parameter identification
What’s Virtual Laboratory?

Virtual Laboratory

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Simulating basic laboratory tests
Comparing numerical model response with laboratory curves
What’s Virtual Laboratory?

Virtual Laboratory

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Current progress of parameter determination

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Assistance in parameter determination v2016

Data Input

Constitutive model

Parameter determination methods

Parameter verification and validation

Current progress of parameter determination
Excel dependency left behind
Import from ASCII files

This import wizard allows setting the delimiters the data contains:

- Delimiters:
  - Comma
  - Semicolon
  - Tab
  - Space
  - Other:

- Text qualifier:
  - (None)

- First row is header
- Preview rows

Data preview:

<table>
<thead>
<tr>
<th>Mat. label</th>
<th>y</th>
<th>phi</th>
<th>c</th>
<th>E</th>
<th>Su/(W/sg)0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>gamma</td>
<td>phi</td>
<td>c</td>
<td>E</td>
<td>Su/(W/sg)0</td>
</tr>
<tr>
<td>2</td>
<td>[KPa]</td>
<td>[deg]</td>
<td>[KPa]</td>
<td>[KPa]</td>
<td>[KPa]</td>
</tr>
<tr>
<td>3</td>
<td>Clay</td>
<td>12</td>
<td>10</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Clayey sand</td>
<td>13</td>
<td>32</td>
<td>14</td>
<td>35000</td>
</tr>
<tr>
<td>5</td>
<td>Medium Sand</td>
<td>20</td>
<td>36</td>
<td>0</td>
<td>120000</td>
</tr>
</tbody>
</table>

Physical Soil Properties:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit weight of skeleton</td>
<td>γ_s</td>
<td></td>
<td>[MM3]/m^3</td>
</tr>
<tr>
<td>Moisture content</td>
<td>w_0</td>
<td></td>
<td>[%]</td>
</tr>
<tr>
<td>Degree of saturation</td>
<td>S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial porosity</td>
<td>µ_0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Import Tabular Data
Material is analyzed according to “all-at-once” principle

Single determination extracts all possible knowledge regardless of the current constitutive model
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Parameter determination methods

GENERAL RULE

User-predefined input parameters remain fixed during automatic and interactive parameter selection
Transformation of estimated stiffness moduli to the reference ones

\[
E^{DMT}(\sigma_{\text{ref}}) = \frac{E^{DMT}(\sigma'_{v0})}{\left(\frac{\sigma_3 + a}{\sigma_{\text{ref}} + a}\right)^m}
\]

\[
\sigma_3 = \min(\sigma'_{v0}; \sigma'_{v0} \cdot K_0)
\]
What can you expect in v2016?

- unified and user-friendly interface
- tremendous improvement in management of correlations (document-oriented database easy to extend)
- open gateway for implementing an environment for user-defined correlations
### Improved interface for automatic parameter selection

#### What can you expect in v2016?

- **Improved interface for automatic parameter selection**

#### Image Description

A screenshot of the improved interface for automatic parameter selection in v2016. The interface includes a section for manual input data, a table for identified model parameters, and a user-defined values section. The interface allows for the selection of parameters, with options for units and values. Parameters include soil behavior type, stress history, saturation state, density, gradation, and particle shape. The interface is designed to optimize parameter selection for soil analysis.
What can you expect in v2016?

- **new correlations** including estimation for parameters belonging to “flow” group:
  - saturation constant (van Genuchten WRC)
  - permeability coefficients
  - additional classification within poorly-graded sands (coarse, medium, fine) for improved estimation of hydraulic conductivity, friction angle, etc.
  - cohesion
What can you expect in v2016?

- 4 constitutive models for soils
  - Hardening – Soil small strain
  - Modified Cam Clay
  - Mohr- Coulomb
  - Cap
What can you expect in v2016?

- Improvements of existing algorithms for parameter selection
  - Improved predictions for $E_{50}$ and $E_{ur}$

\[ E_z = \frac{1}{1 + \frac{0.001 \cdot R_f}{2E_{50}} \cdot q_f(\phi, c)} \]

Friction angle [deg] vs. $E_z / E_{s0}$ for $c = 100$ kPa
What can you expect in v2016?

New interface for Interactive Parameter Selection

- Filters
- Current correlation
- Tabular data
- Input variable
- Help
- Graphical comparison
What can you expect in v2016?

- filtering the database of correlations
  - parameter
  - applicability (soil class)
  - recommended (those used in automatic selection)
  - user’s favorite
  - checked only
What can you expect in v2016?

Interactive selection with parameter sequence wizard

Interactive selection w/o wizard

NB. Automatic selection = interactive selection with wizard + ‘recommended’ filter
What can you expect in v2016?

what should be improved...

Parameter identification

identification traces

test grouping
What can you expect in v2016?

Parameter identification

$max (q/p')$

$max (\sigma'_1 - \sigma'_3)$

$p' = (\sigma_1 - 2\sigma'_3) / 3$ [kPa]

$\Delta u$
What can you expect in v2016?
Thank you for your attention