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BEST SOIL: Soft Soil modelling and parameter determination

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Background

- In design for SLS, it is necessary to make accurate predictions for both the short term and long term deformations of geotechnical structures.
- Especially in urban areas, this cannot be done with simple hand calculation methods.
- Numerical analyses are often performed, using commercial finite element codes such as Plaxis, without full understanding of the models used.

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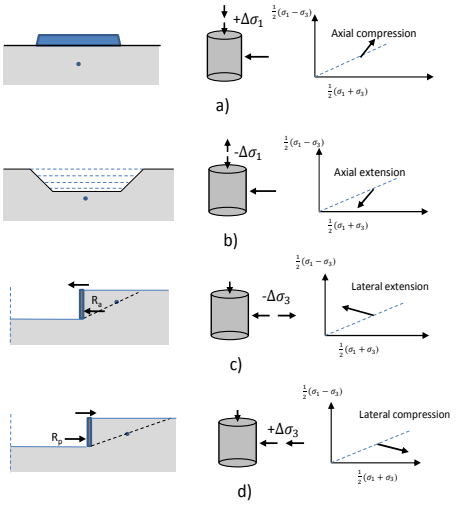
Banbrukarföreningen Grundläggning

Aim

- To develop best practice guidelines for soil model selection, for typical Swedish soft soil conditions, with consideration of different geotechnical problems (see Fig. 1).



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Banbrukarföreningen Grundläggning

Objectives

- Description of the models and their parameter determination based on high quality soil data.
- Simulations of typical laboratory tests with the models. This will give indications of which models are likely to be suited for which type of problem.
- Application of the models for simulating simple benchmark problems (e.g. embankment, cut slope, ret. wall)
- Development of best practice guidelines for the use of the “standard” and “advanced” soil models, which will be disseminated as part of a 1-day training course aimed at practicing geotechnical engineers.

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Methodology

- Soil models considered:
  - (Mohr Coulomb) – not suited for deformation analyses
  - Soft Soil
  - Soft Soil Creep
  - Hardening Soil
  - Creep-SCLAY1S
- Parameter determination from Utby test data
- Simulations of lab tests
- Simulations of benchmark problems (ongoing)
- 1 day training course (Spring 2017)

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Expected results

- Development of best practice guidelines for the use of the “standard” and “advanced” soil models
- A 1-day training course aimed at practicing geotechnical engineers in 2017

Limitations

- Constitutive models available in Plaxis FE suite
- Soft (sensitive) soils only considered
- No consideration of small strain stiffness (as too limited data/not enough high quality data available in Sweden)

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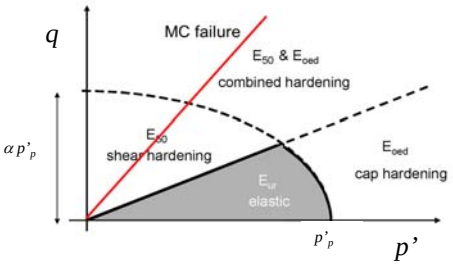
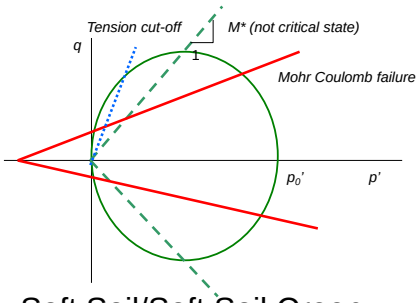
Standard models



HS model



Soft Soil/Soft Soil Creep

Common features:

- Isotropic
- MC failure
- Stress/state dependent stiffnesses

- Size defined by OCR/POP
- Same K_0^{nc} imposed

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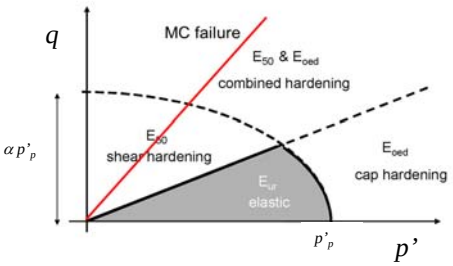
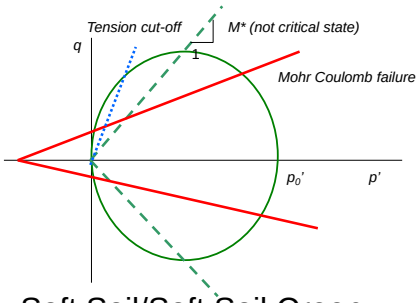
Standard models



HS model



Soft Soil/Soft Soil Creep

Differences:

- HS also deviatoric hardening
- Difficult parameters

- Simple parameter determination
- Creep (SSC only)

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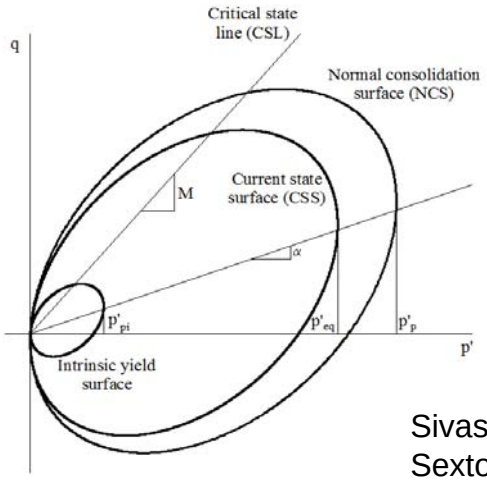
Creep-SCLAY1S model



- Anisotropy (initial & evolution)
- Bonding and destructuration
- Rate-dependency
- Size based on OCR/POP
- Creep

Sivasithamparam et al. 2015, Sexton et al. 2016

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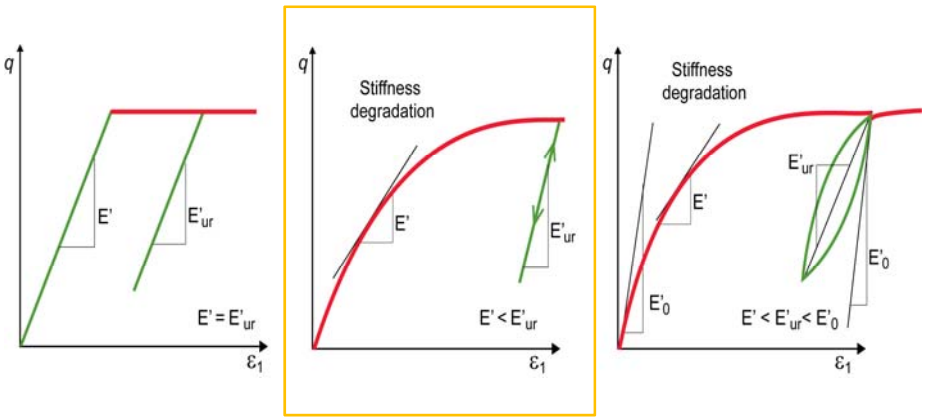
Comparison of models



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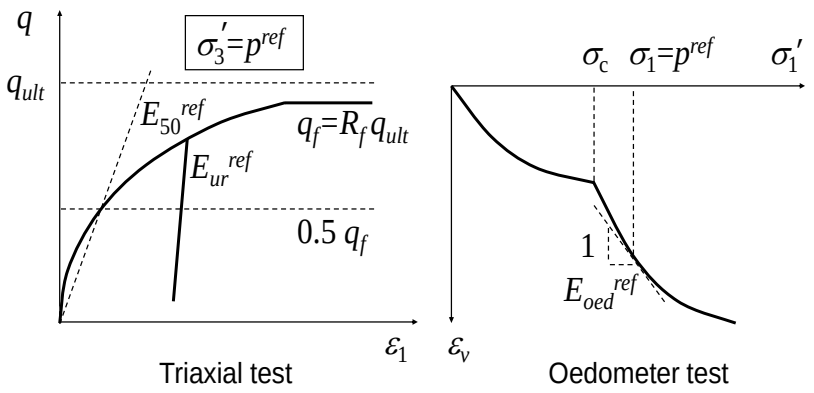
Difficult stiffness parameters



DRAINED!

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Results

Parameter set for Hardening Soil model			
Symbol	Description of the parameters	Set 1	Set 2
E_{50}^{ref}	Secant stiffness from drained test	15000 kPa	421 kPa
E_{oed}^{ref}	Tangent stiffness in primary oedometer loading	4700 kPa	337 kPa
E_{ur}^{ref}	Unloading/reloading stiffness	30000 kPa	7500 kPa
$\nu'_{ur}{}^{ref}$	Poisson's ratio for unload-reload	0.20	0.20
K_0^{NC}	K_0 for NC soil	0.38	0.38
p^{ref}	Reference stress for stiffnesses	100 kPa	100 kPa
m	Power for stress-level dependency of stiffness	1.00	1.00
Φ_{cv}'	Critical state friction angle	38.3	38.3
R_f	Failure ratio (default value taken)	0.900	0.900

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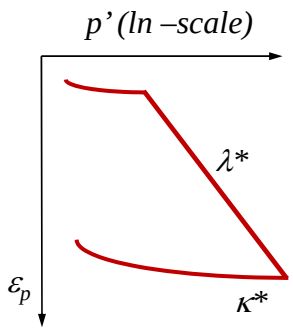
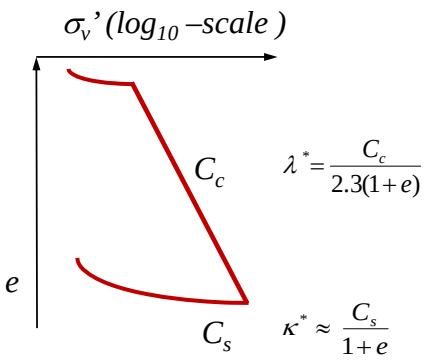
Easy stiffness parameters



a) Definition of λ^* and κ^*



b) Linking of λ^* and κ^* *to* C_c *and* C_s

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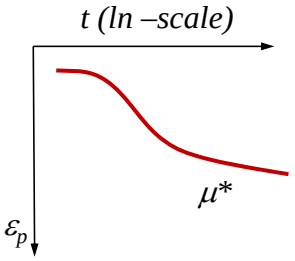
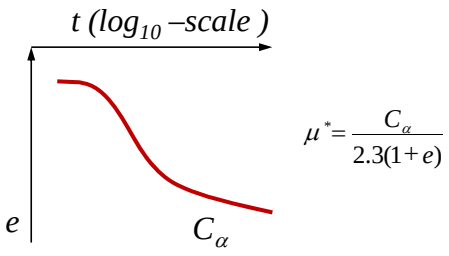
Easy creep parameters



a) Definition of μ^*



b) Linking of μ^* *to* C_α

Additional creep related parameter:
Reference time τ (SSC assumes 1 day)

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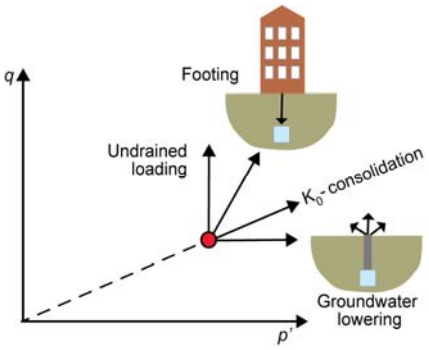
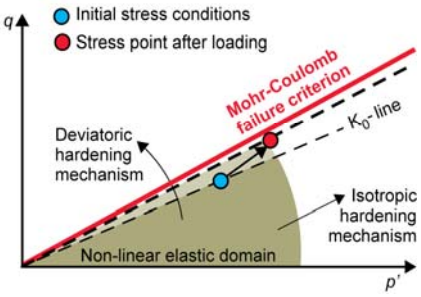
Modelling of loading problems (drained stress paths)





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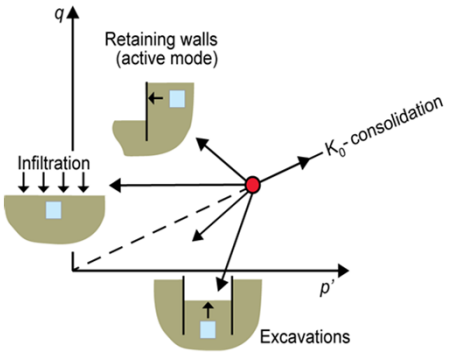
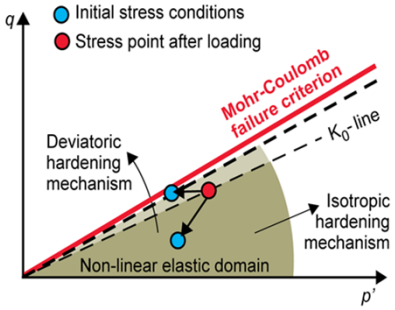
Modelling of unloading problems (drained stress paths)





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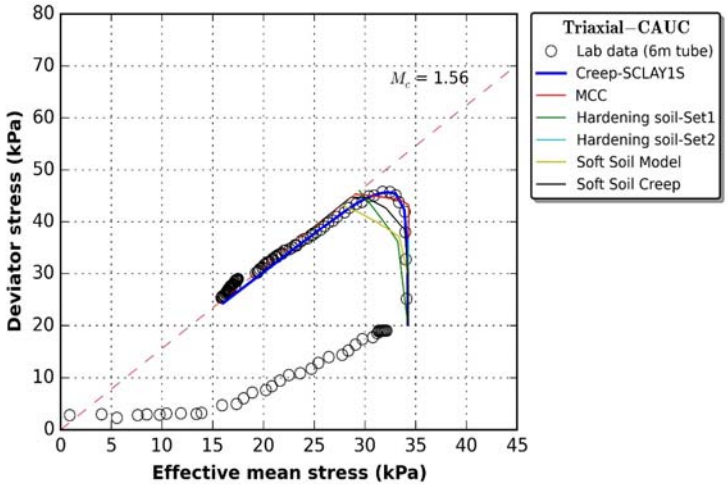
CAUC (stress path)



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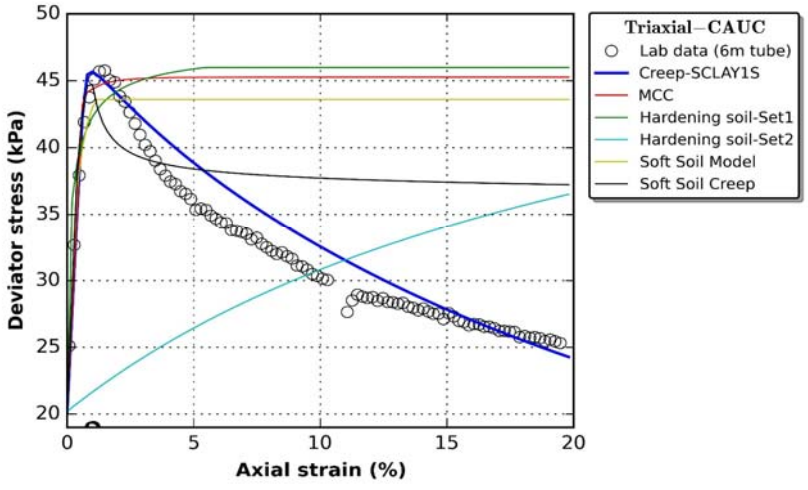
CAUC (stress-strain)



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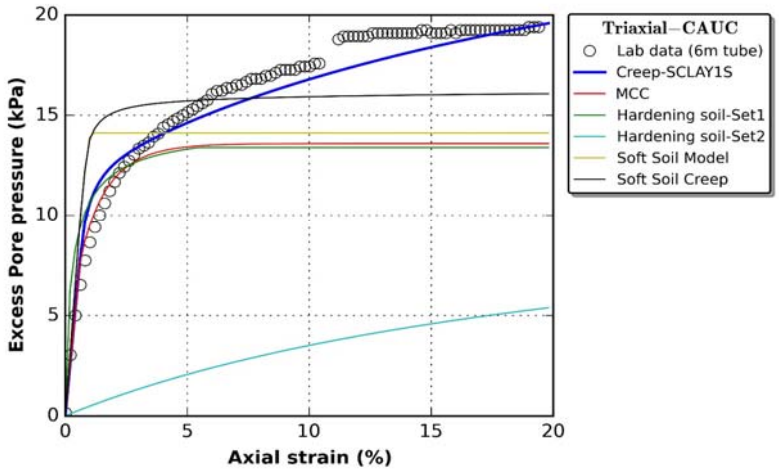
CAUC (pore pressure)



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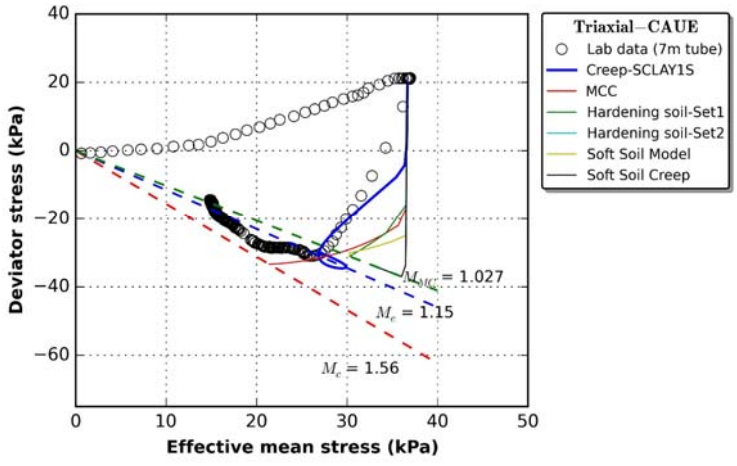
CAUE (stress path)



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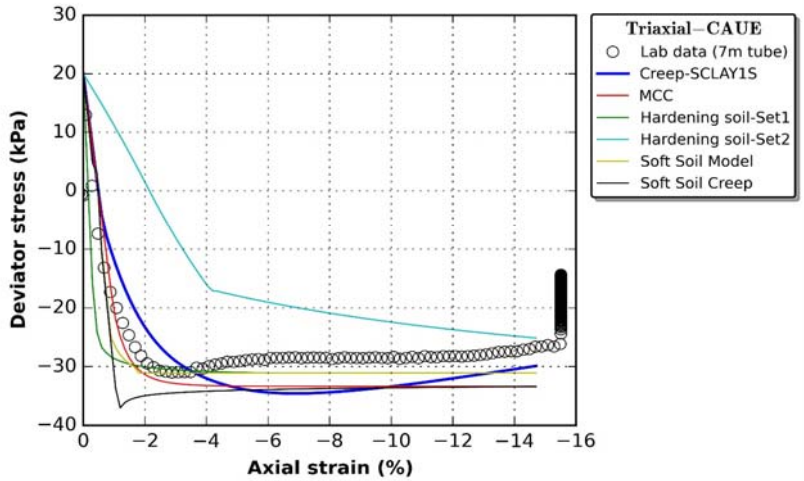
CAUE (stress-strain)



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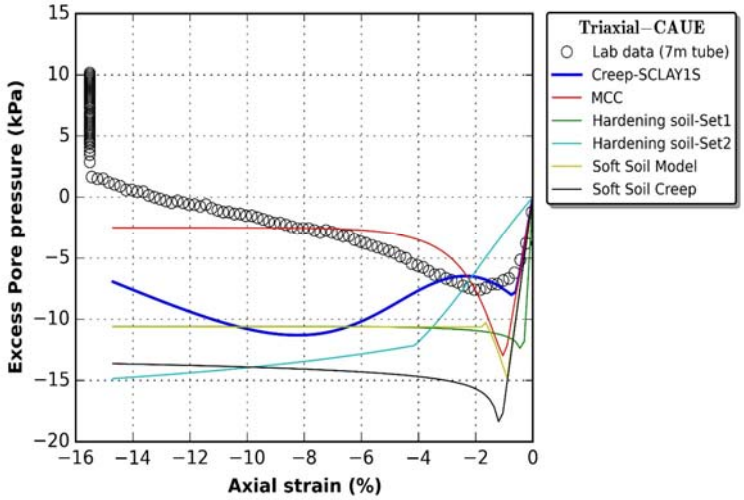
CAUE (pore pressure)



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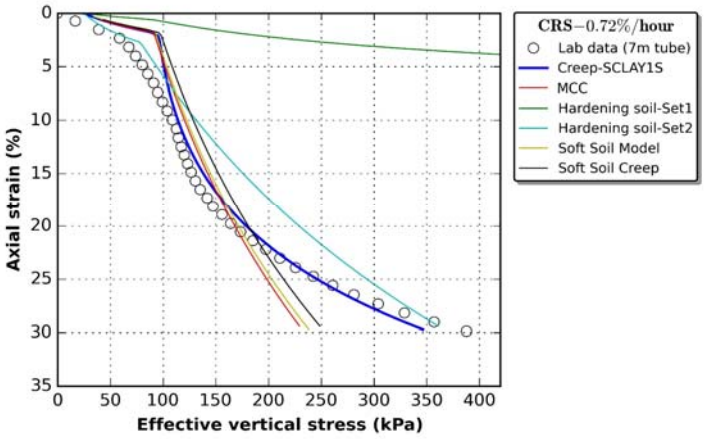
CRS



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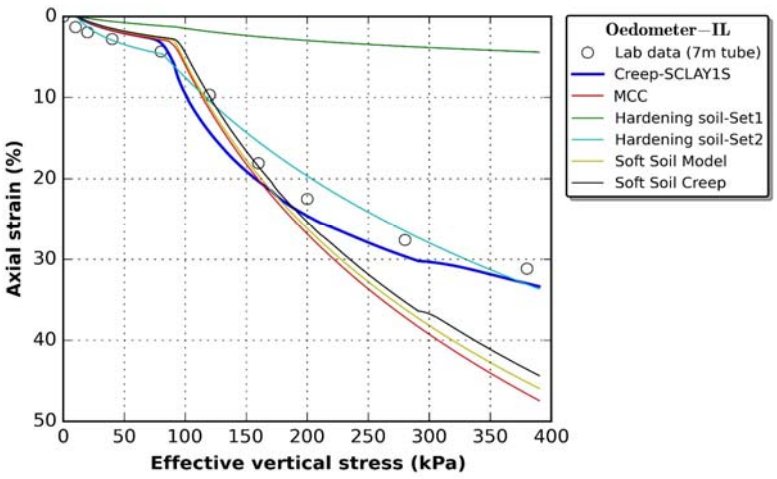
Oedometer (IL)



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Conclusions

- Parameters of HS model difficult to derive and the required testing (=drained triaxial) not routinely done
- Furthermore, HS model is unable to represent soil response in standard tests with a single set of parameters

  Recommendation: Do not use HS model, unless you really have to!
- Parameters of Soft Soil model easy to derive

  SS model works reasonably well but cannot represent creep

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Conclusions

- Soft Soil Creep has a fundamental flaw in its formulation, and hence significantly overpredicts pore pressures.

  In the presence of gravity SSC significantly overpredicts deformations, so need "artificial" (=high OCR).
- Creep-SCLAY1S model has most parameters, but gives the best predictions.

  Many parameters may actually make the model calibration easier…as it is able to represent the soil response do well!