De rol van modelparameters in het Soft Soil Creep model

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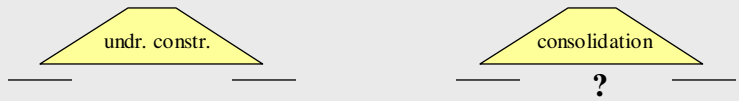
Introduction

Observation during embankment construction and consolidation:

- Lateral displacements away from the embankment toe

FE calculations tend to show:

- During undrained construction: lateral displacements away from the embankment toe
- During consolidation: lateral displacements towards the embankment toe (lateral confinement)



Introduction

Lateral confinement is unrealistic and results from the use of simplified constitutive models where Hooke's law plays a dominant role

Solutions to improve lateral displacements:

- Anisotropy (Ladd et.al., 1994)
- Creep (this contribution)
- Hardening plasticity (?)

Soft Soil Creep model

$$\dot{\varepsilon}_v = \dot{\varepsilon}_v^e + \dot{\varepsilon}_v^c = \frac{\kappa^*}{p'}\dot{p}' + \frac{\mu^*}{\tau}\left(\frac{p^{eq}}{p_p^{eq}}\right)^{\frac{\lambda^*-\kappa^*}{\mu^*}}$$

$$p^{eq} = p' + \frac{q^2}{M^2 p'}$$

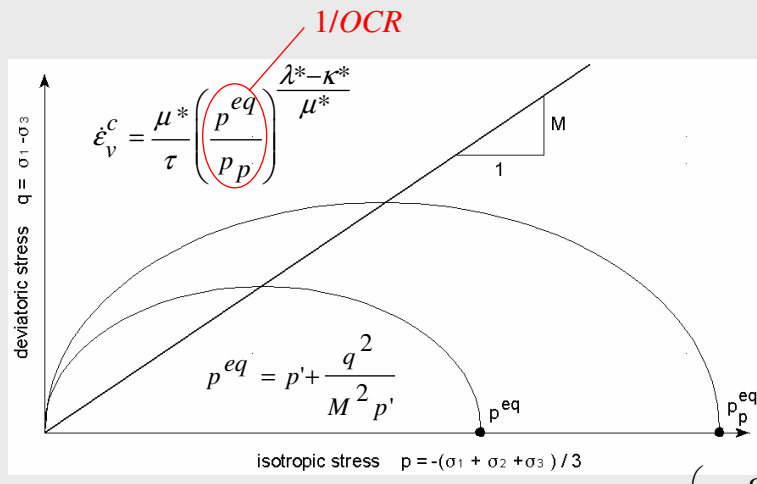
$$p_p^{eq} = p_p^0 \exp\left(\frac{-\varepsilon_v^c}{\lambda^*-\kappa^*}\right)$$

$$\varepsilon_v^c = \int \dot{\varepsilon}_v^c \, dt$$

Parameters:

κ^*	=	Modified swelling index
λ^*	=	Modified compression index
μ^*	=	Modified creep index
ν_{ur}	=	Poisson's ratio for unloading / rel.
τ	=	Intrinsic time parameter (1 day)
M	=	Steepness of the creep contour
p_p	=	Isotropic preconsolidation stress

Soft Soil Creep model

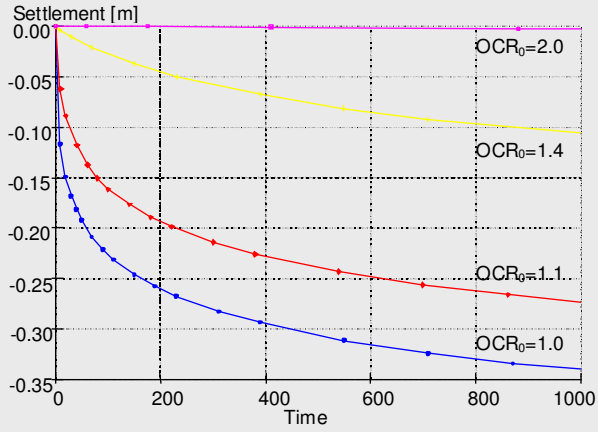


$$p_p^{eq} = p_p^0 \exp\left(\frac{-\varepsilon_v^c}{\lambda^*-\kappa^*}\right)$$

One-dimensional compression

Influence of initial OCR on settlement of a 10m thick layer with initial stresses:

γ = 17 kN/m^3
κ^* = 0.02
λ^* = 0.10
μ^* = 0.005
ν_{ur} = 0.15
φ' = 26°
c' = 1 kN/m^2
K_0^{nc} = 0.70
K_0 = 0.70



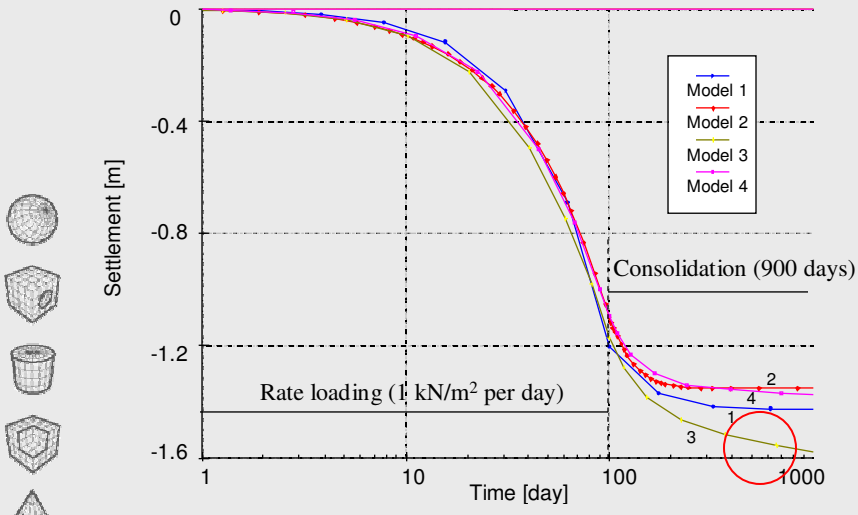
One-dimensional compression

10 m thick undrained clay layer with initial stresses (K_0=0.72)

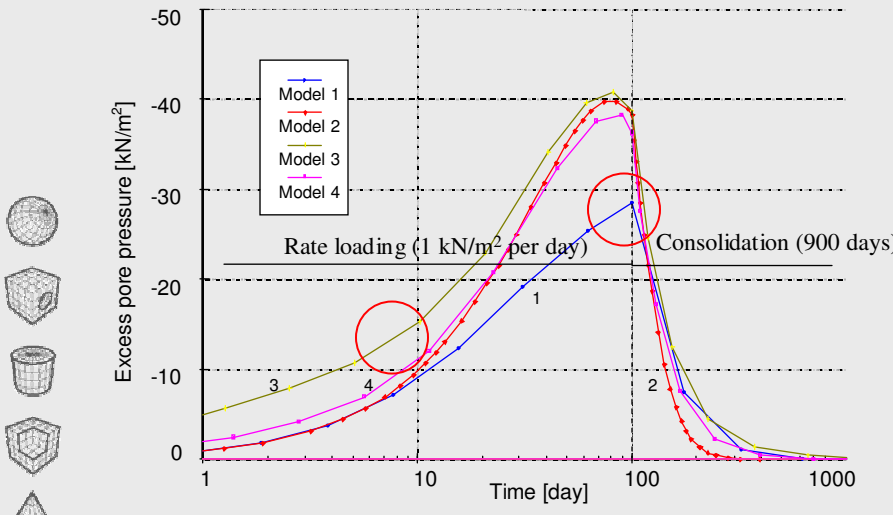
Model 1	Model 2	Model 3	Model 4
Mohr-Coulomb	Modified Cam-Clay (Soft Soil)	Soft Soil Creep	Soft Soil Creep
E_{ref}=50 kN/m^2	λ^*=0.10	λ^*=0.10	λ^*=0.10
E_{inc}=150 kN/m^3	κ^*=0.02	κ^*=0.02	κ^*=0.02
		μ^*=0.004	μ^*=0.001
ν' = 0.35	ν_{ur}=0.15	ν_{ur}=0.15	ν_{ur}=0.15
	M=0.99	M=0.99	M=0.99
	OCR_0=1.0	OCR_0=1.0	OCR_0=1.0

γ = 15 / 18 kN/m^3 φ = 25° c = 1 kN/m^2 k = 10^{-2} m/day

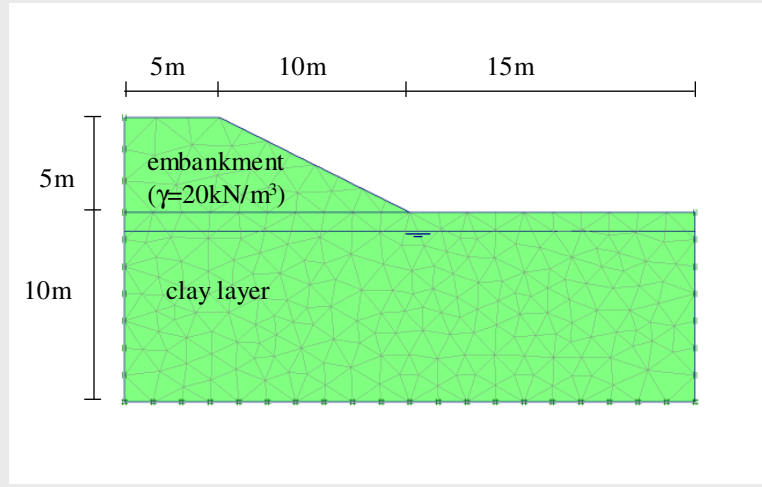
One-dimensional compression



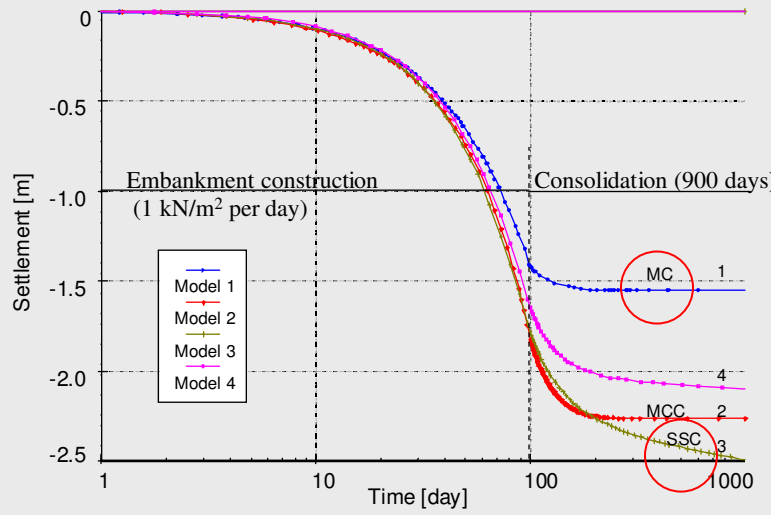
One-dimensional compression



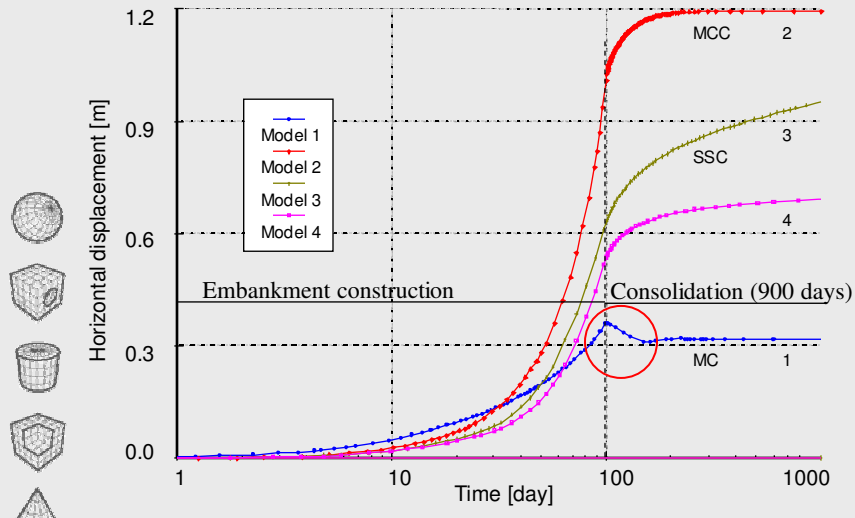
Embankment construction



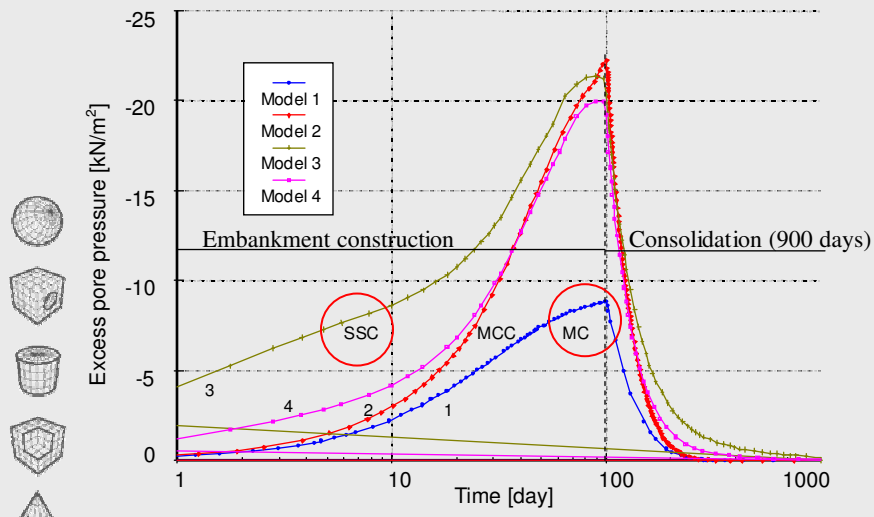
Embankment construction



Embankment construction



Embankment construction

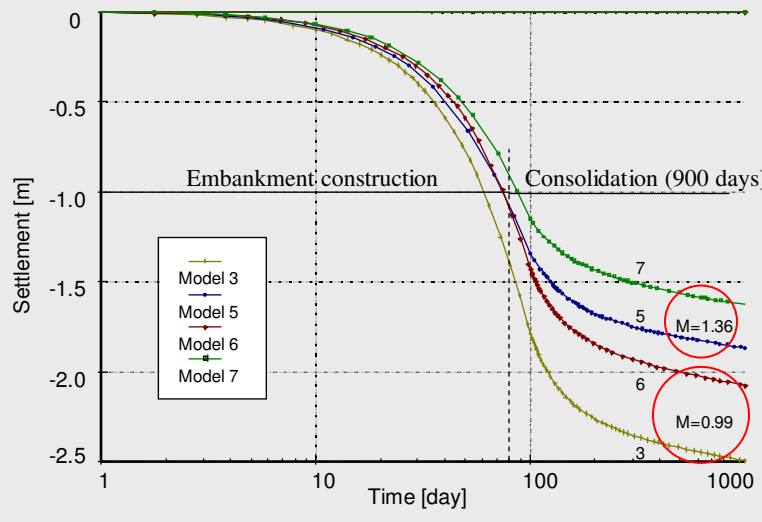


Variation of M (K_0^{nc}) and OCR_0

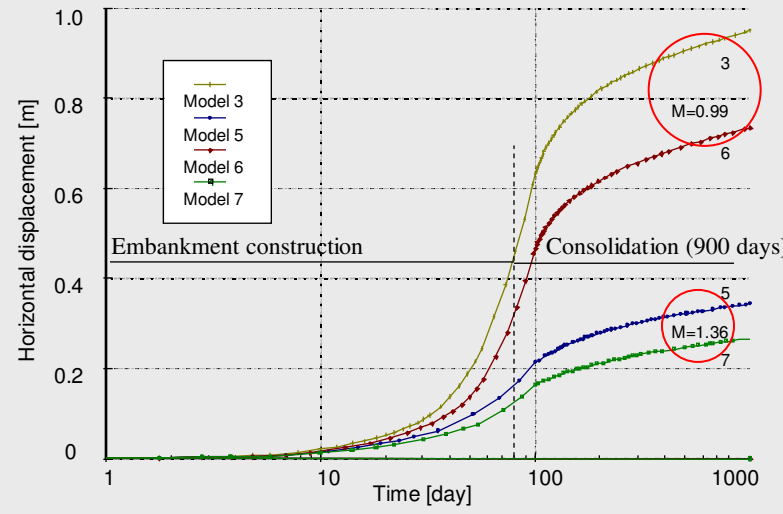
Model 3	Model 5	Model 6	Model 7
Soft Soil Creep	Soft Soil Creep	Soft Soil Creep	Soft Soil Creep
λ^*=0.10	λ^*=0.10	λ^*=0.10	λ^*=0.10
κ^*=0.02	κ^*=0.02	κ^*=0.02	κ^*=0.02
μ^*=0.004	μ^*=0.004	μ^*=0.004	μ^*=0.004
ν_{ur}=0.15	ν_{ur}=0.15	ν_{ur}=0.15	ν_{ur}=0.15
M=0.99	M=1.36	M=0.99	M=1.36
OCR_0=1.0	OCR_0=1.0	OCR_0=1.3	OCR_0=1.3

M = 0.99: standard for SSC model M = 1.36: standard for SS model

Variation of M and OCR_0



Variation of M and OCR_0



Conclusions

- Lateral confinement under embankment during consolidation (MC) can be overcome by creep.
- The MC model gives lower excess pore pressures than the MCC(SS) and the SSC model.
- For realistic values of the creep index, the SSC model gives larger (time-dependent) settlements than the MCC(SS) model.
- For low (unrealistic) values of the creep index, the SSC model gives similar settlements as the MCC(SS) model.
- The settlements due to embankment construction are larger than due to one-dimensional compression with the same maximum load.

Conclusions (cont.)

- The *M*-parameter (steepness of the Cap) in the SSC model is crucial for lateral displacements:
  - Low value (based on friction; default in Plaxis V8) > Displacements too large
  - High value (based on proper K_0^{nc}; default for SS model) > Reasonable displacements
- The initial *OCR*-value in the SSC model should generally be selected larger than 1.0 for NC-clays to get realistic initial creep strain rates (settlements and horizontal displacements)

Thank you for your attention…

Questions ?

Reference:
Brinkgreve, R.B.J., (2004). *Time-dependent behaviour of soft soils during embankment construction – a numerical study.* Proc. NUMOG IX, pp.631-637