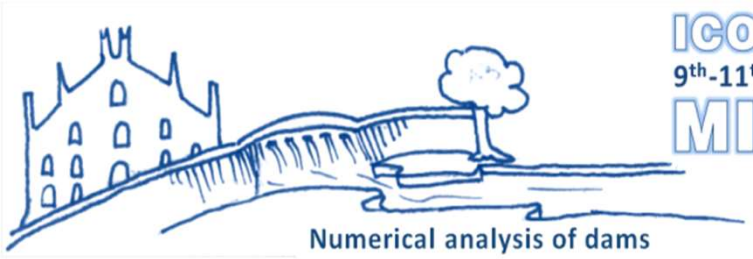


ICOLD-BW 2019
9th-11th September
MILANO

CIGB ICOLD

15th ICOLD International Benchmark Workshop

10.09.19

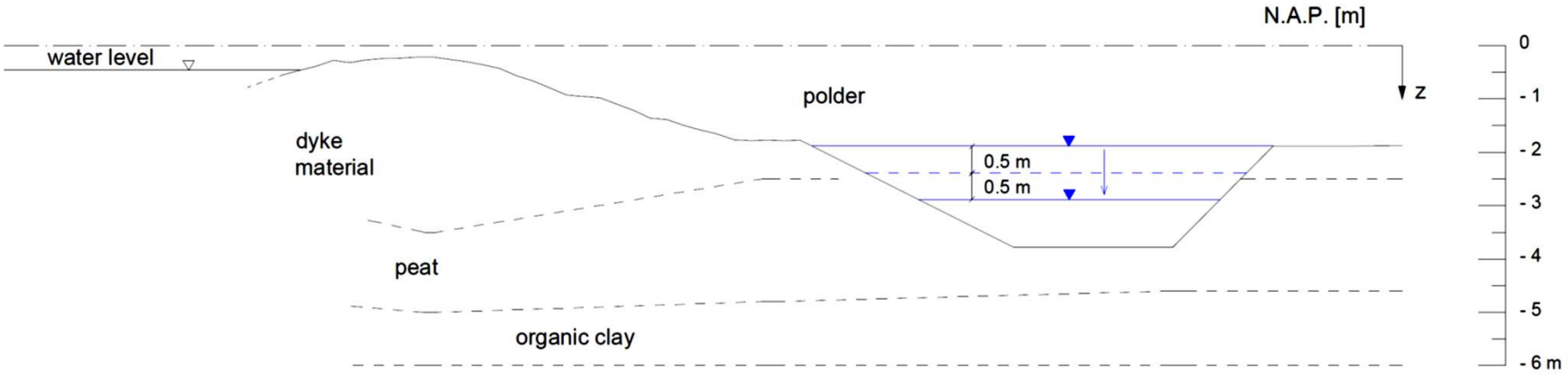
Contribution to Theme C:
Leendert de Boerspolder: Coupled hydro-mechanical analysis of the pre-failure and the failure behaviour of a dyke on soft subsoil

Donatella Sterpi

Department of Civil and Environmental Engineering
Politecnico di Milano

POLITECNICO
MILANO 1863

Leendert de Boerspolder: preliminary investigation



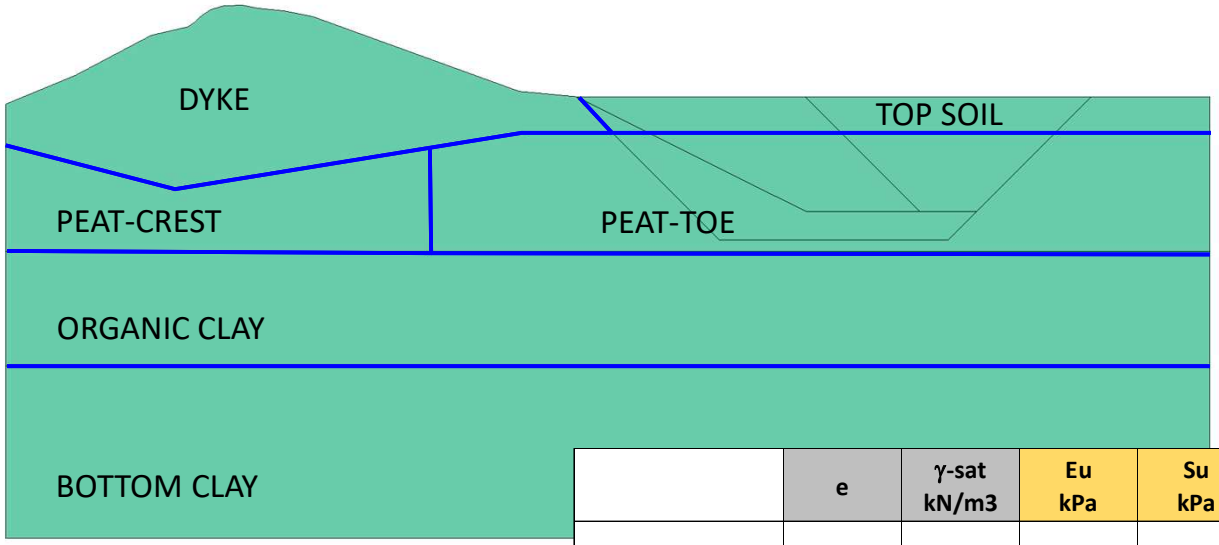
Materials

Available tests

Parameters

	CPT crest & toe	Lab. Tests	Tx CU	D. SIMPLE SHEAR	OEDOM.
DYKE MATERIAL	Su (Eu)	γ, e OCR	Su, c, ϕ OCR Eu		OCR E-oed k
TOP-SOIL	Su (Eu)	γ, e			
PEAT-CREST	Su (Eu)	γ, e OCR		G c, ϕ	OCR E-oed k
PEAT-TOE	Su (Eu)	γ, e OCR		G c, ϕ	OCR E-oed k
ORGANIC CLAY	Su (Eu)	γ, e OCR	Su, c, ϕ OCR Eu		OCR E-oed k
BOTTOM CLAY	Su (Eu)	γ, e OCR			

GEOTECHNICAL MODEL

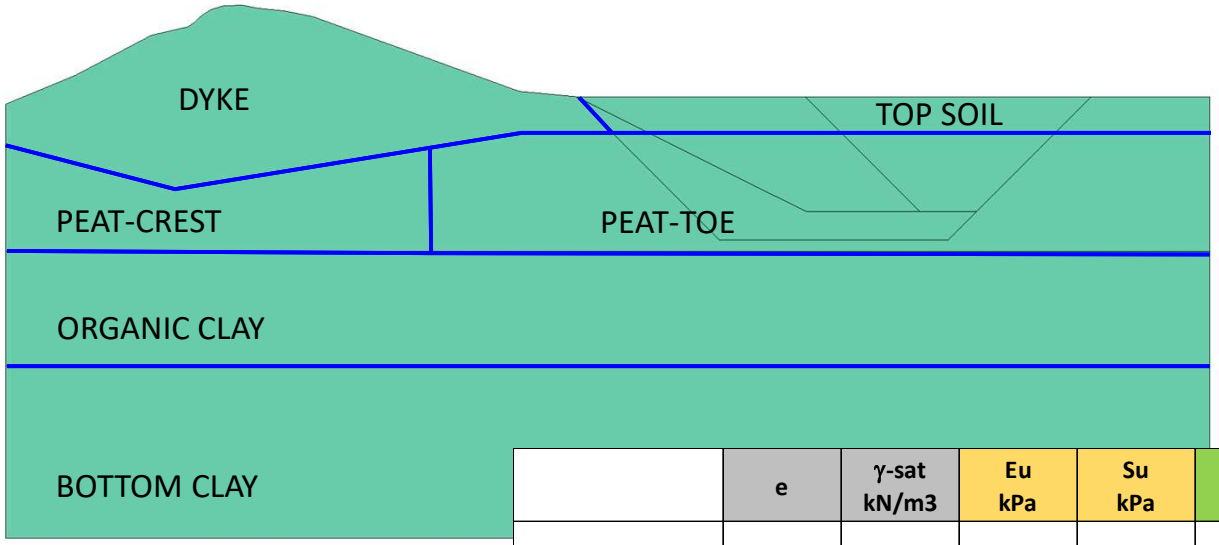


Worked out parameters for the
- Undrained (1-phase)
- Drained (1-phase)
- HM coupled (2-phases)

analyses

	e	γ-sat kN/m3	Eu kPa	Su kPa	E kPa	ν	c kPa	ϕ	k m/s
DYKE MATERIAL	0.68	18.6	8500	20	464		6.25	30	1.5 e-10
TOP-SOIL	2	13.65		32					
PEAT-CREST	8.5	9.98	1200	35	1010		6	25	3.1 e-10
PEAT-TOE	10.7	9.82	390	20	328	0.26	3	33	1. e-8
ORGANIC CLAY	2.4	13.68	6000	15	2383		10.4	24	3.6 e-11
BOTTOM CLAY	2.3	14		12					

GEOTECHNICAL MODEL



Consistency and Reliability

	e	γ-sat kN/m3	Eu kPa	Su kPa	E kPa	ν	c kPa	ϕ	k m/s
DYKE MATERIAL	0.68	18.6	8500	20	464		6.25	30	1.5 e-10
TOP-SOIL	2	13.65		32					
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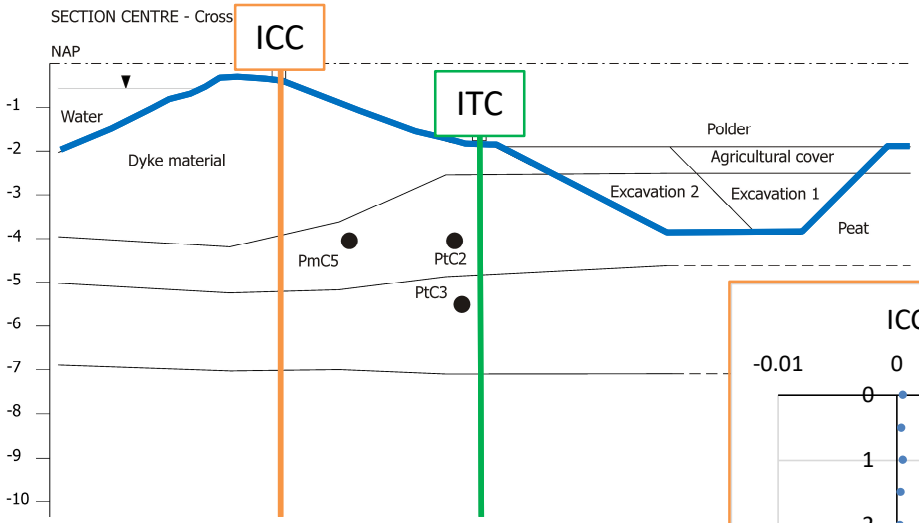
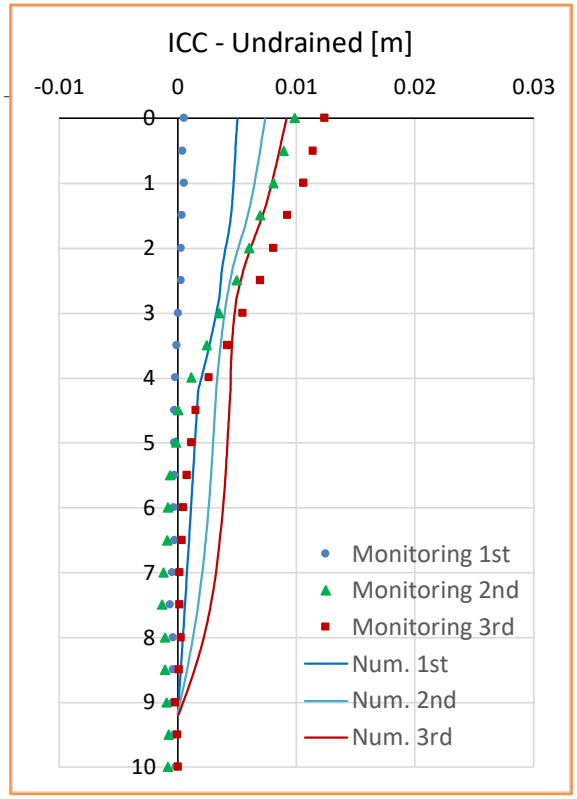
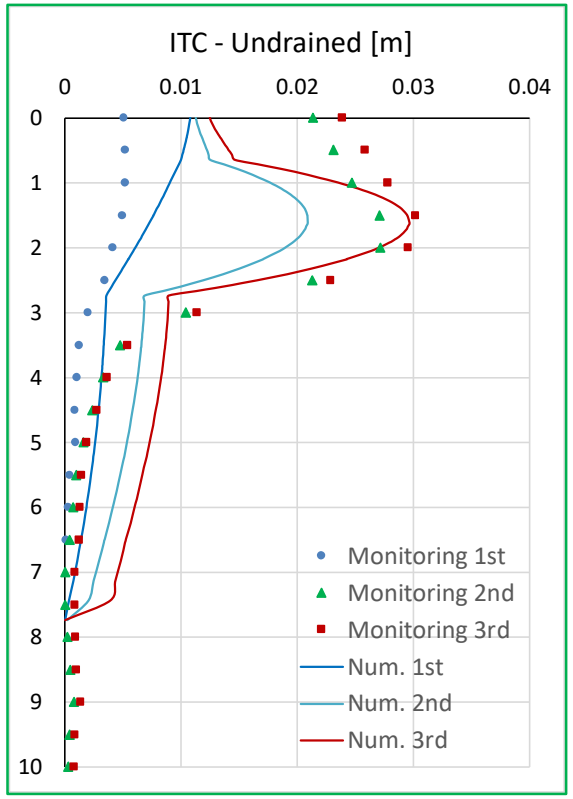
ORGANIC CLAY	2.4	13.68	6000	15	2383		10.4	24	3.6 e-11
BOTTOM CLAY	2.3	14		12					

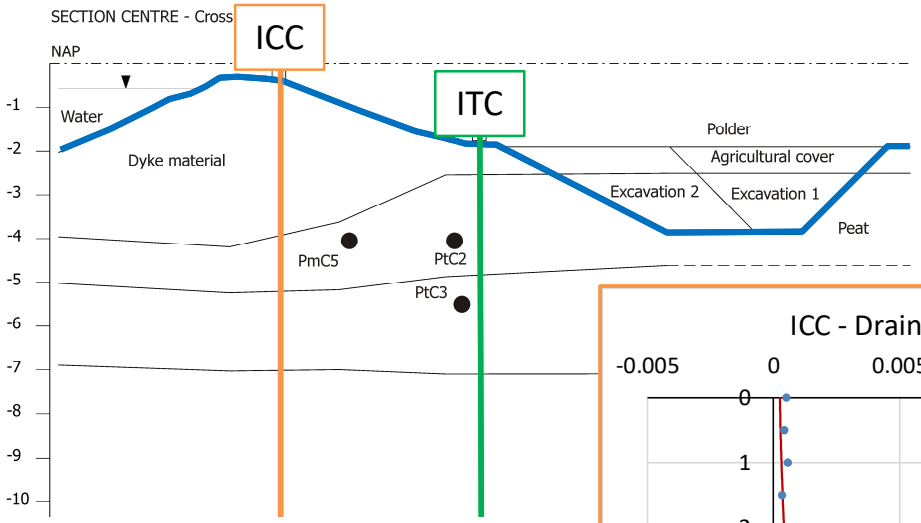
UNDRAINED ANALYSIS: INCLINOMETERS

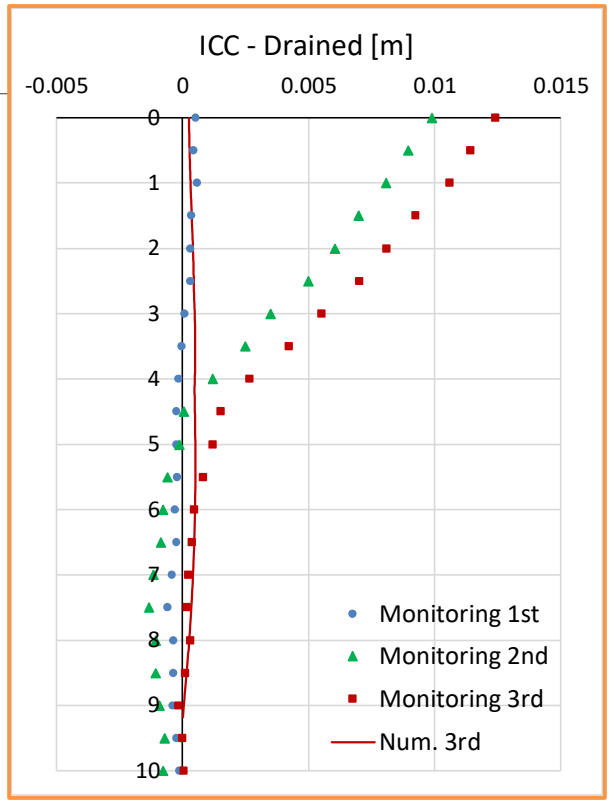


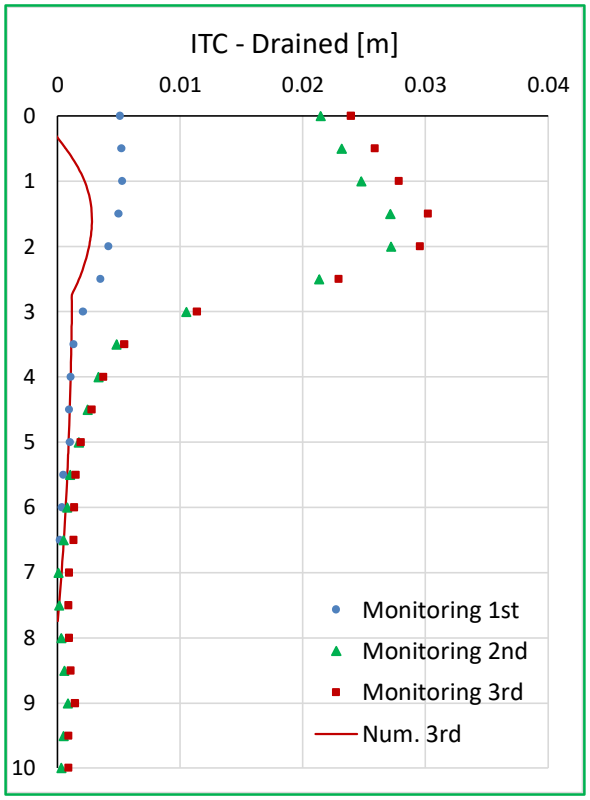




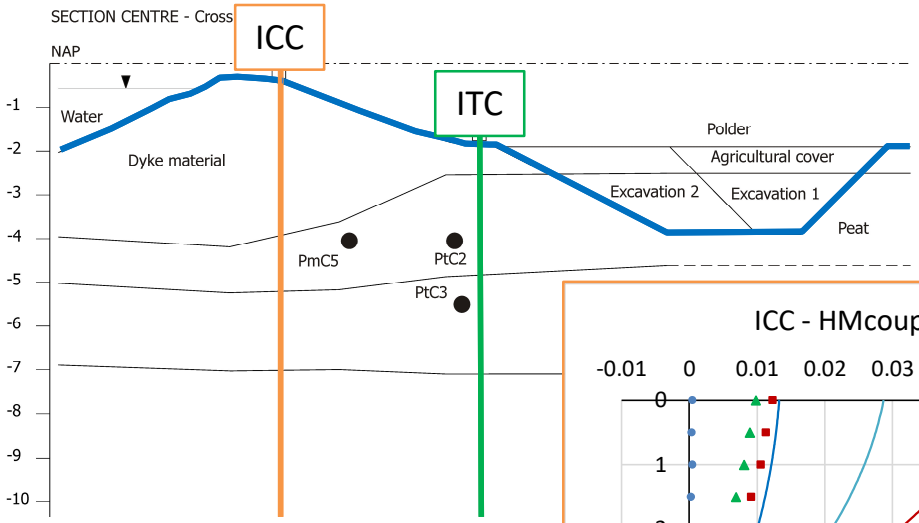
DRAINED ANALYSIS: INCLINOMETERS

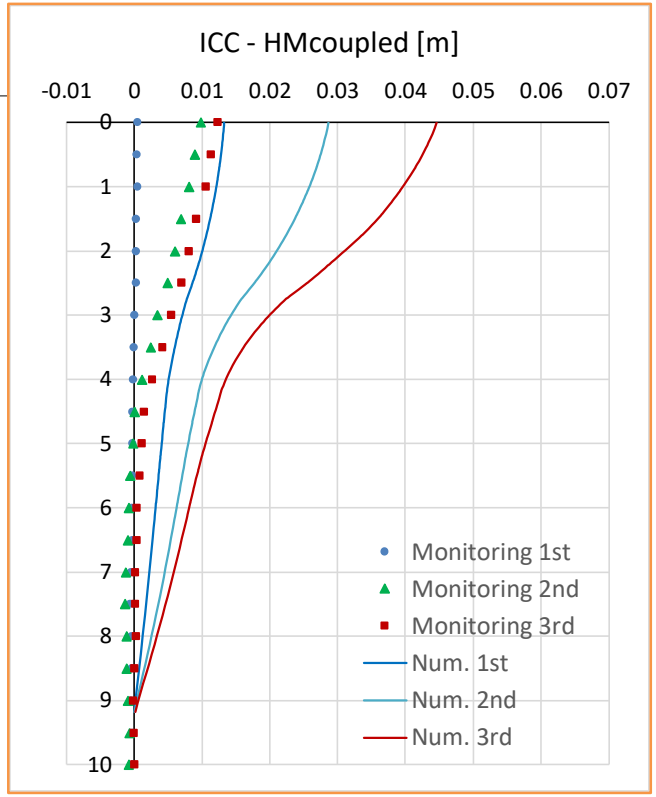


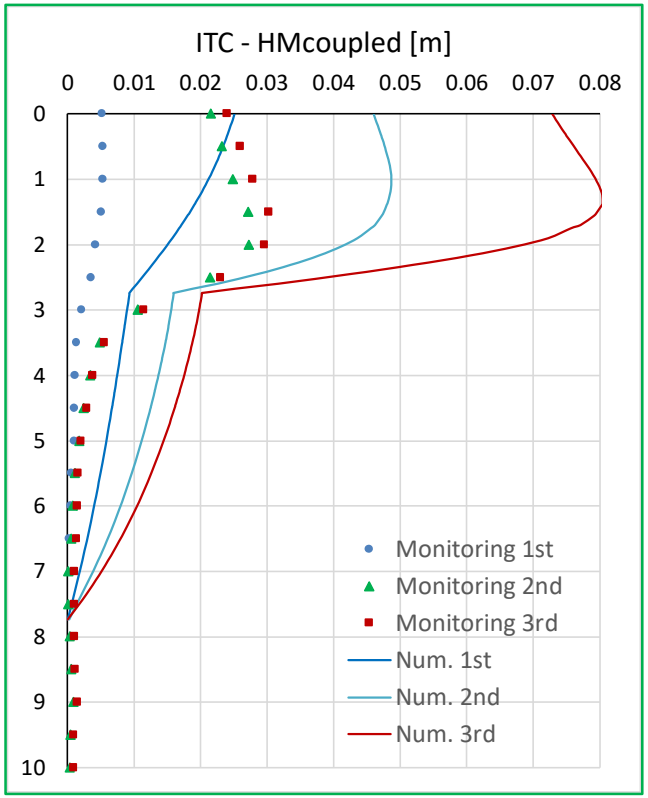




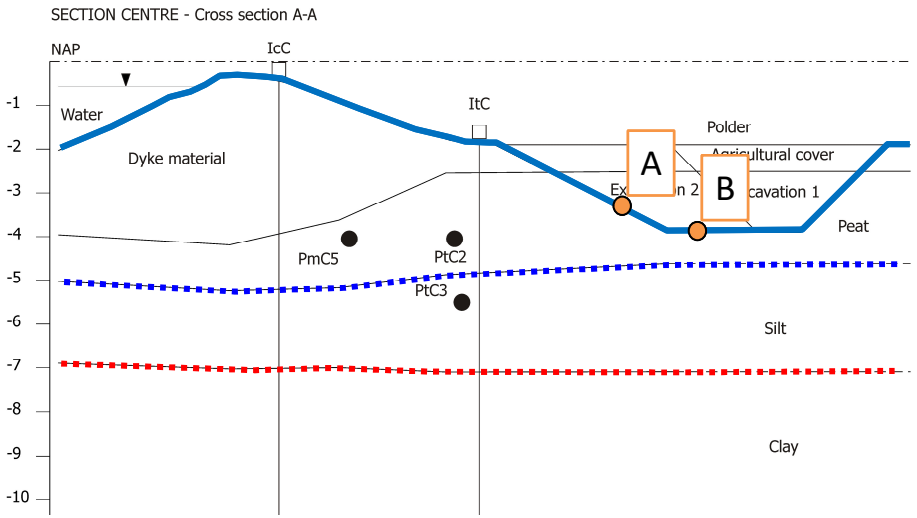
H-M COUPLED ANALYSIS: INCLINOMETERS

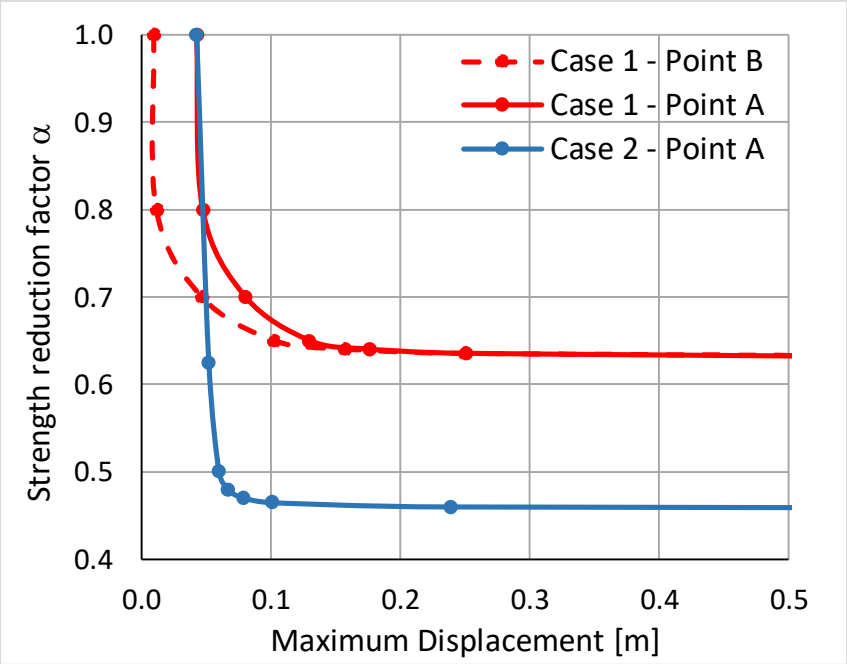






SAFETY FACTOR ASSESSMENT – STRENGTH REDUCTION METHOD





Reduction of the undrained strength

$\mathbf{Su_{red} = \alpha\, Su}$

Reduction factor α : $\mathbf{\alpha_{min} < \alpha < 1}$

Safety factor: $\mathbf{Fs = 1 / \alpha_{min}}$

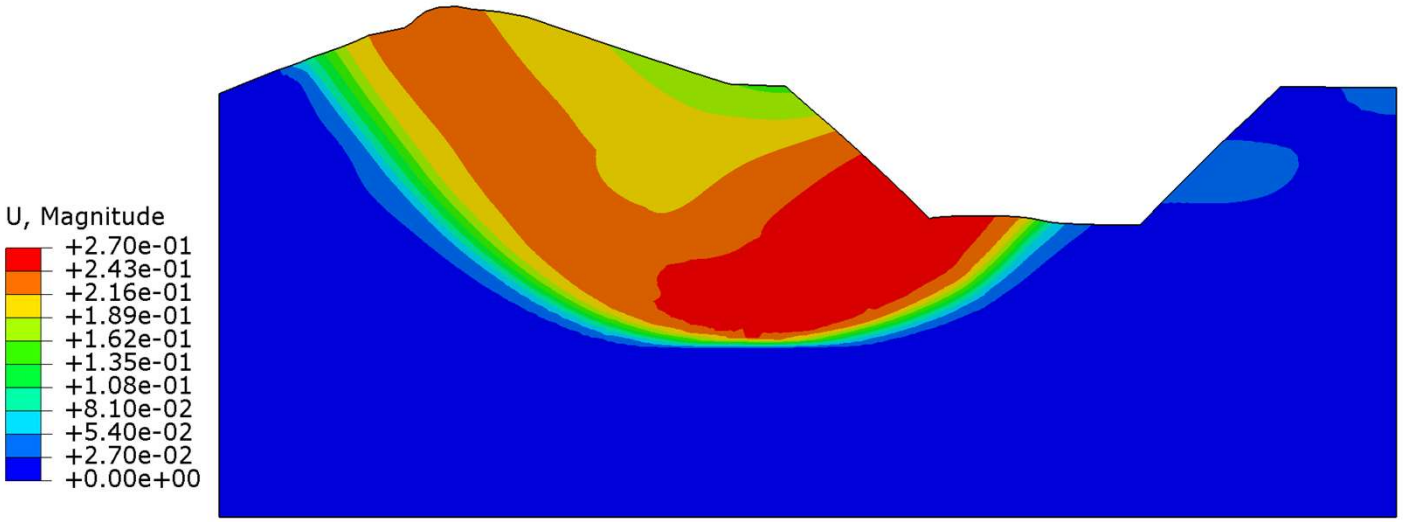
Case 1: on peat & organic clay — Fs = 1.57

down to the red line

Case 2: on peat only — Fs = 2.17

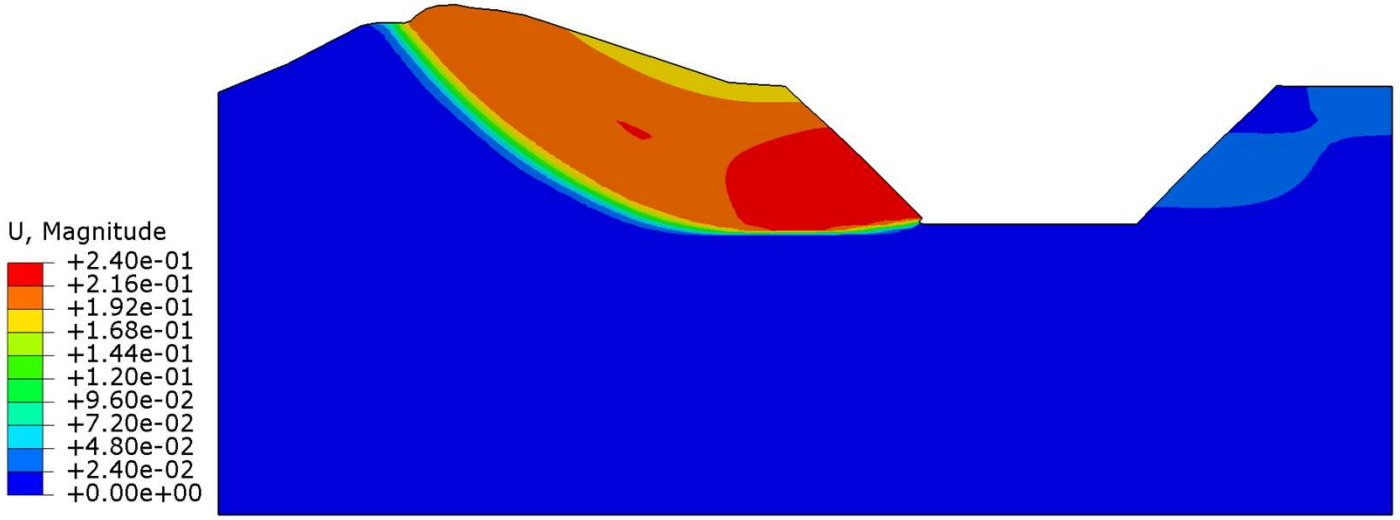
to the blue line

FAILURE BY STRENGTH REDUCTION METHOD: displacements



Case 1:
on peat &
organic clay

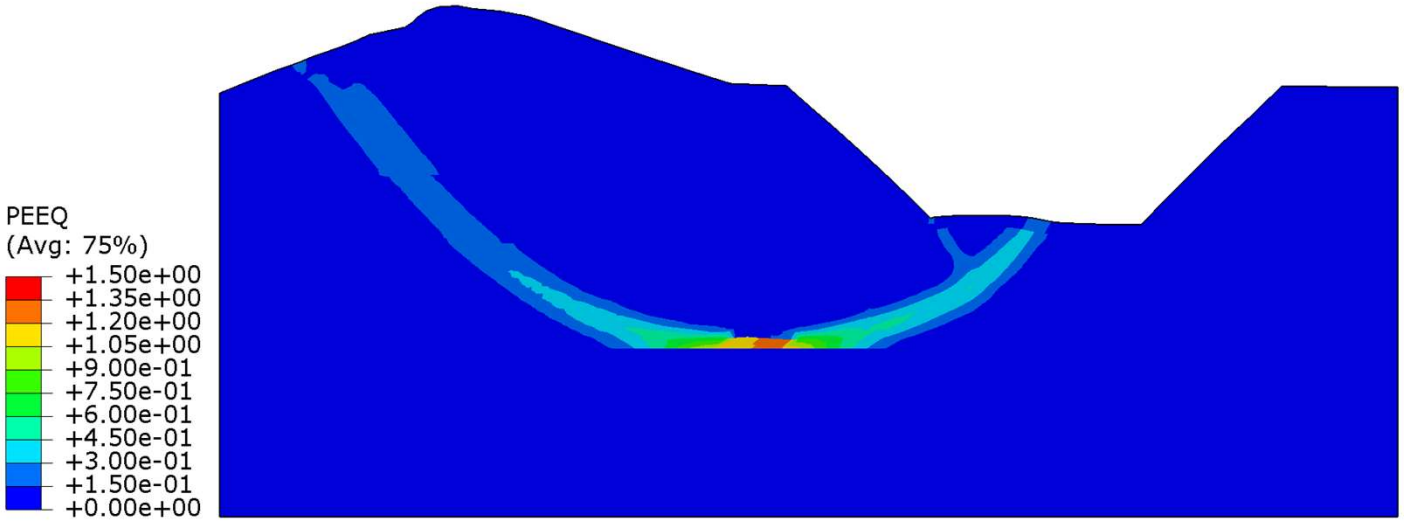
Fs = 1.57



Case 2:
on peat only

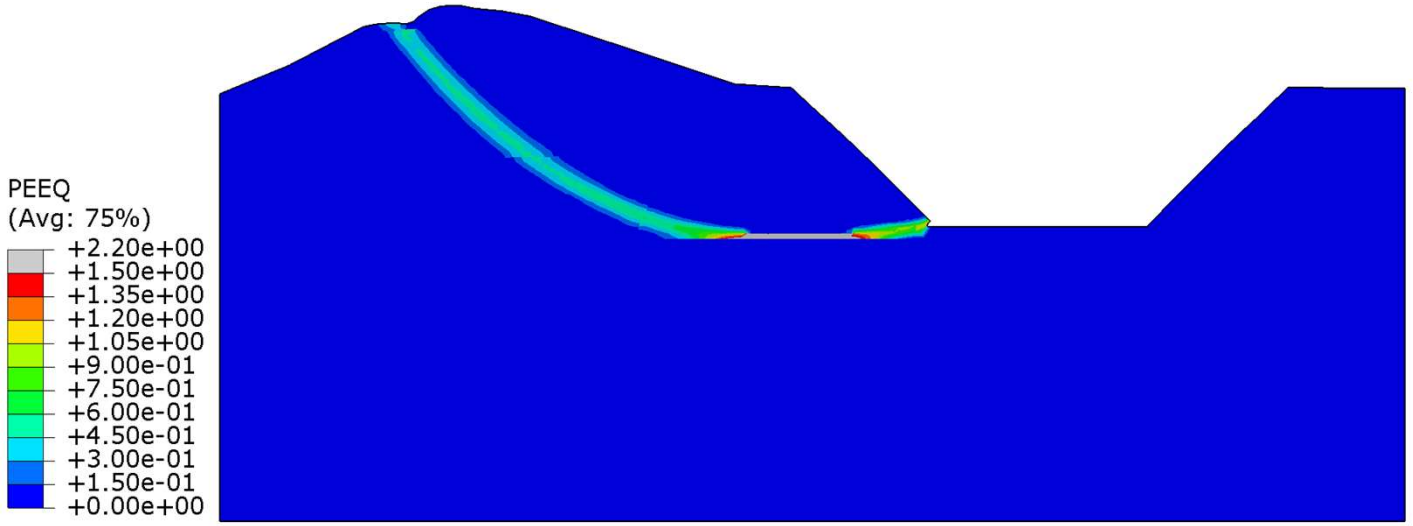
Fs = 2.17

FAILURE BY STRENGTH REDUCTION METHOD: shear plastic strains



Case 1:
on peat &
organic clay

Fs = 1.57



Case 2:
on peat only

Fs = 2.17

CLOSING COMMENTS

Limits of the analysis

- the dewatering and water filling were neglected
- the constitutive models are simply elastic-perfectly plastic
- no back analysis was performed

Difficulties in the assessment of the mechanical properties

Lack of on-site information about the hydraulic conductivity

CLOSING COMMENTS

Limits of the analysis

- the dewatering and water filling were neglected
- the constitutive models are simply elastic-perfectly plastic
- no back analysis was performed

Difficulties in the assessment of the mechanical properties
Lack of on-site information about the hydraulic conductivity

The simple modelling *can* capture the qualitative response

- but fails in the prediction of the failure

Are we able to assign proper and reliable values to the parameters?

- in simple and more sophisticated constitutive models