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NGM 2016 – workshop FE

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Agenda

- Outcome from EG4
- Work done in Sweden
  - New FE guide
  - New handbook for SPW
- Some outstanding issues
- DISCUSSION

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Results from EG4

- New section, on numerical methods, in EC7 is recommended
- Some general outcome
  - Due to the complexity of numerical methods, there are many influences on their prediction of limit states. Should consider the sensitivity of limit state prediction to these influences, including:
    - discretization of geometry
    - initial stress states
    - preceding construction stages
    - boundary conditions
    - drainage conditions
    - constitutive behaviour (e.g. stiffness, dilatancy, yield criteria, flow rules)
    - strength and stiffness of structural elements

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Results from EG4

- SLS

  1. Improved predictions of deformations may be achieved by considering, for example, non-linear stress- and strain-dependent stiffness or creep behavior.

  2. In order to check that serviceability limit states are sufficiently unlikely to be exceeded, cautious estimates of the strength, stiffness and initial stress state of the ground should be used in numerical analyses, complying with the definition of characteristic values of material properties in 2.4.5.2. If a “most probable” estimate of deformations is also required, best estimate values of parameters should be adopted.

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Results from EG4

- ULS

1. Design approach is a mandatory dual application of input factoring (IFA) and output factoring (OFA) approaches (see table below). Design structural forces shall be the largest value obtained from the two approaches. Geotechnical failure shall be verified by IFA
2. IFA may either be performed with design values from the start and throughout all the construction stages of an analysis or with characteristic values during sequential construction stages with dedicated adjunct stages used only to change to design values at appropriate stages (staged factoring)
3. Strength reduction may be continued beyond partial factor value to find most critical failure mechanism. Ground strength reduction should be combined with structural element strength reduction to identify critical failure mechanisms of combined geotechnical and structural failures, while structural resistance should still be verified also by OFA.

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Results from EG4

- ULS

4. Partial factors on strength should be applied to the strengths (drained, undrained, etc) computed by the constitutive model taking into account all influences on the computed strength, not only phi, c' and cu depending on the constitutive model.
5. For correct application of partial factors it is necessary to have a clear definition of what is an action, and action effect and a resistance. For example many authors differ on whether passive earth pressure is a favourable action or a resistance

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Results from EG4

'BASIC' PARTIAL FACTORS FOR PERSISTENT, TRANSIENT AND ACCIDENTAL DESIGN SITUATIONS FOR GEO/STR ULTIMATE LIMIT STATES

		Numerical methods	
Approach		IFA	OFA
Partial factors on actions (from EN 1990) including importance factor K_{FI}			
Unfavourable permanent	$\gamma_{G,n}$	1.0	1.0
Unfavourable variable	$\gamma_{Q,n}$	1.3/1.0	1.1/1.0
Favourable perm.	$\gamma_{G,fav,n}$	1.0	1.0
Partial factors on ground parameters including importance factor K_{MI}			
Drained strength[A]	$\gamma_{\phi,n}$	1.25/1.1	1.0
Undrained strength[B]	$\gamma_{cu,n}$	1.4	
Unconfined strength[C]	γ_{qu}	1.4	
Weight density	$\gamma_{\gamma,n}$	1.0	
Partial factors on effects of actions including importance factor K_{EI}			
Permanent[D]	γ_{EG}	1.0	1.35/1.0
Variable[D]	γ_{EQ}		

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Work in progress in Sweden

Short guide for the use of FE

Anders Kullingsjö

Minna Karstunen

Per-Evert Bengtsson

Tara Wood

Anders Fredriksson

New guideline for SPW including FE

Anders Fredriksson

Håkan Stille

Anders Ryner

Anders Kullingsjö

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FE guide (ongoing)

Will give some recommendations regarding

- Soil-models
- Needed input parameters
- Evaluating the results
- Structural elements
- How to end up with a safe construction
- How to encourage the use of more sophisticated tools (eg. FE) and / or soil models

Some preliminary statements

- Best guess values to start with
- Some way of IFA and OFA (factors not discussed)
- Sensitivity analyses (strength, stiffness, in situ pressure etc. (+ - values not specified)

The idea is to allow lower factors on IFA and OFA as far as the design covers the outcome from the sensitivity analyses.

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New guideline for SPW including FE (ongoing)

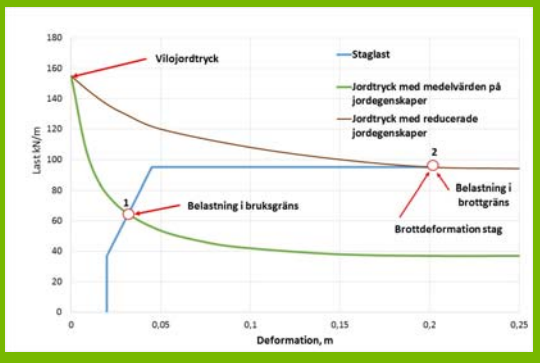
- The idea is to verify ULS for to different scenarios

1. FEA with best “true” values in combination with surcharge loads

   The load effect are the factorized to ensure safe structural elements (model factors)

2. FEA with factorized strengths in combination with surcharge loads ($\gamma_{m\,DA3}$)

   This gives a safety regarding geotechnical failure and the different structural elements



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New guideline for SPW including FE (ongoing)

- The recommended calculation scheme for a wall supported on two levels is

1. FEA with best “true” values in combination with surcharge loads

   The load effect are the factorized to ensure safe structural elements

2. FEA with factorized strengths in combination with surcharge loads

   This gives a safety regarding geotechnical failure and the different structural elements

Skede	Point 1		Point 2	
		Variable loads		Variable loads
Cantilever	x	x	x	x
Pre-stress level 1	x			
GW - lowering	x			
Exc to anchor level 2	x	x	x	x
Pre-stress level 2	x			
Final excavation	x	x	x	x

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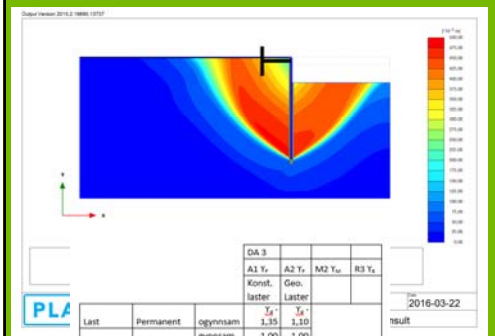
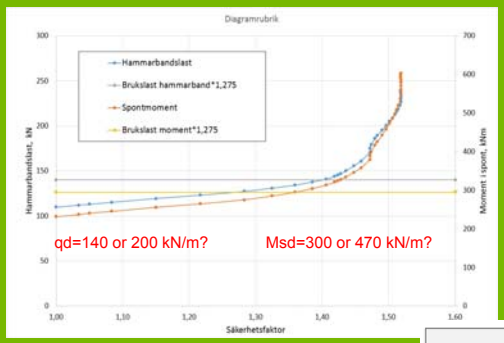
Example from a SPW supported on one level





			DA 3			
			A1 γ_F	A2 γ_F	M2 γ_M	R3 γ_R
			Konst. laster	Geo. Laster		
Last	Permanent	ogynnsam	γ_d · 1,35	γ_d · 1,10		
		gynnsam	1,00	1,00		
	Variabel		γ_d · 1,50	γ_d · 1,40		
Jord	tan ϕ'				1,30	
	effektiv c'				1,30	
	Odränerad c				1,50	
	Enaxlig tryckh.				1,50	
	Tunghet				1,00	
Spont	Bärighet					1,00
	Glidning					1,00
	Jordmotstånd					1,00

	Modellfaktor, γ_{Sd}
Konstruktionselement som har segt brott, t. ex. spont, hammarband, dubb och stag	γ_d · 1,40
Konstruktionselement som har sprött brott t.ex. stämp	γ_d · 1,54
I de fall då belastningen i stort endast består av last från fritt vatten (inte grundvatten)	γ_d · 1,20

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Outstanding issues

- Characteristic values vs. ”most probable”

  In Sweden we have a system that starts from a derived value (observed mean values from adequate methods and/or empirical relations) and ends up with a characteristic value not pessimistic value by default. We can even end up with a characteristic value higher than the observed depending on the system analyzed and what is included in the derived value. This is a big “pit fall” in all our analyses however when it comes to FEA and SLS I prefer to use “most probable” values. To deal with uncertainties a small OFA or a IFA more of a sensitivity analyses could be used.

- Different outcome from different methods

  How to deal with this? If a classic hand calculation gives A and the more accurate method gives B every one is happy if money can be saved, when going from A to B. The contractor (and designer) gets paid for the effort.

  What will happen when B is more expansive than A?

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Outstanding issues (cont)

FEA gives a more rigorous solution than the traditional

- How to encourage the use of FEA?
- Have will traditionally used solutions with less safety that we thought?
- How is willing to pay for increasing the safety level when the old constructions are good enough?

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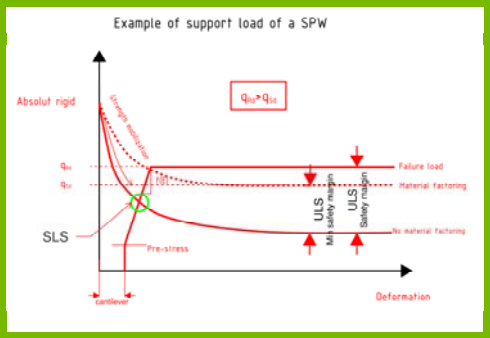
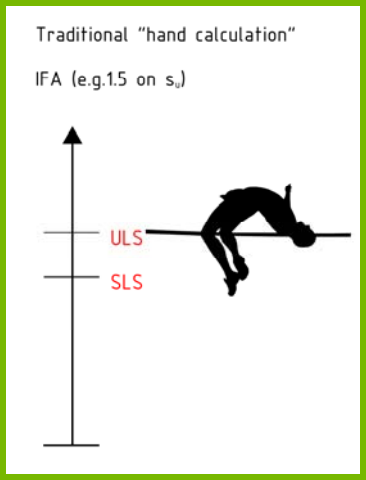
Example from a retaining wall





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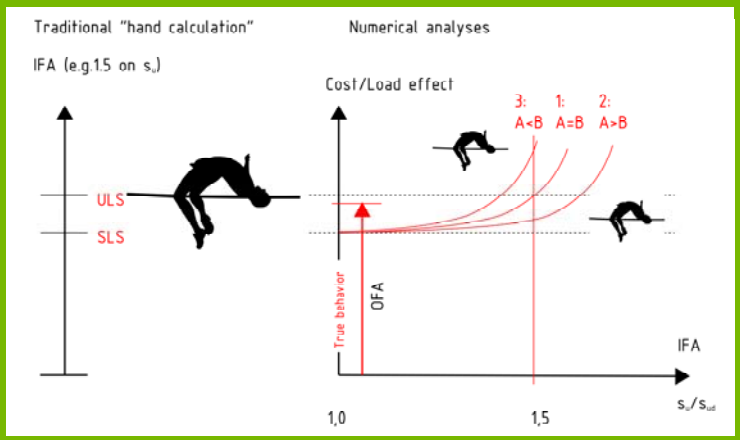
Example from a retaining wall



How the outcome from OFA compared with traditional is not obvious. Here it ´s sketched slightly below the traditional ULS outcome.

When it comes to IFA the non-linearity is obvious.

Case 1: Full agreement

Case 2: The use of FEA pays off, however EG4:s proposal gives that OFA should be used in the design.

Case 3: The structure will be more expansive (if we have to jump higher). How to deal with this in tender situation? Why should anyone present this calc if the old one is good enough, or is it?