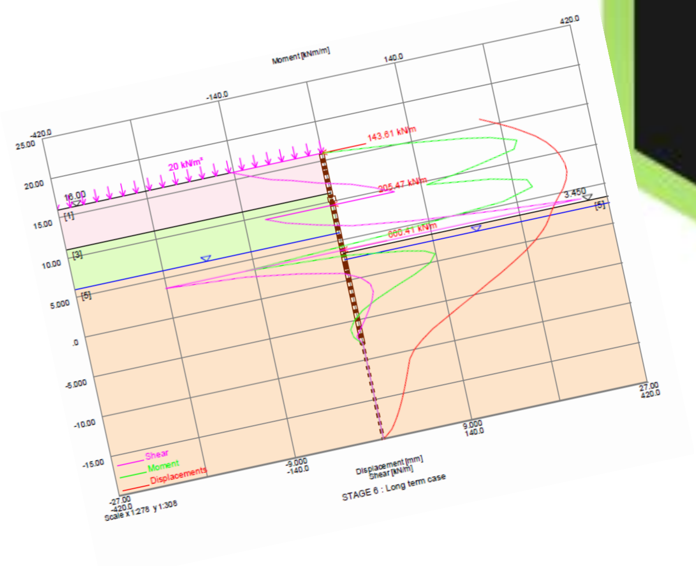
Oasys Frew Webinar - Session 2 of 2
Embedded Retaining Wall Analysis

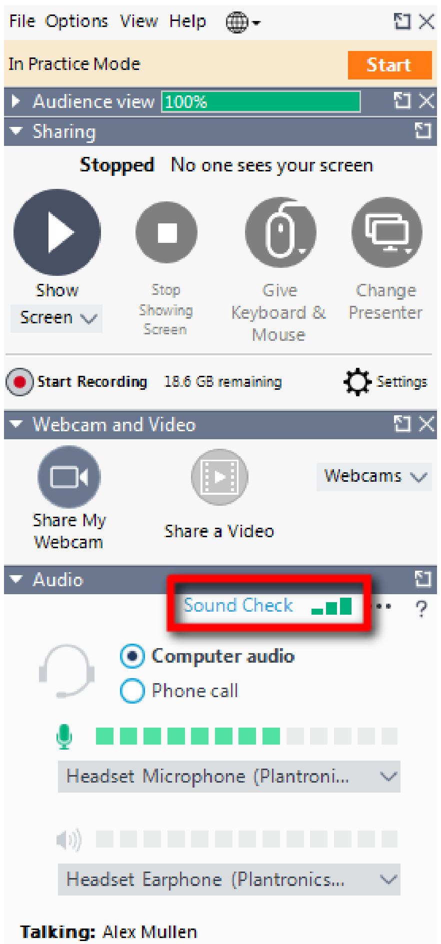
Oasys

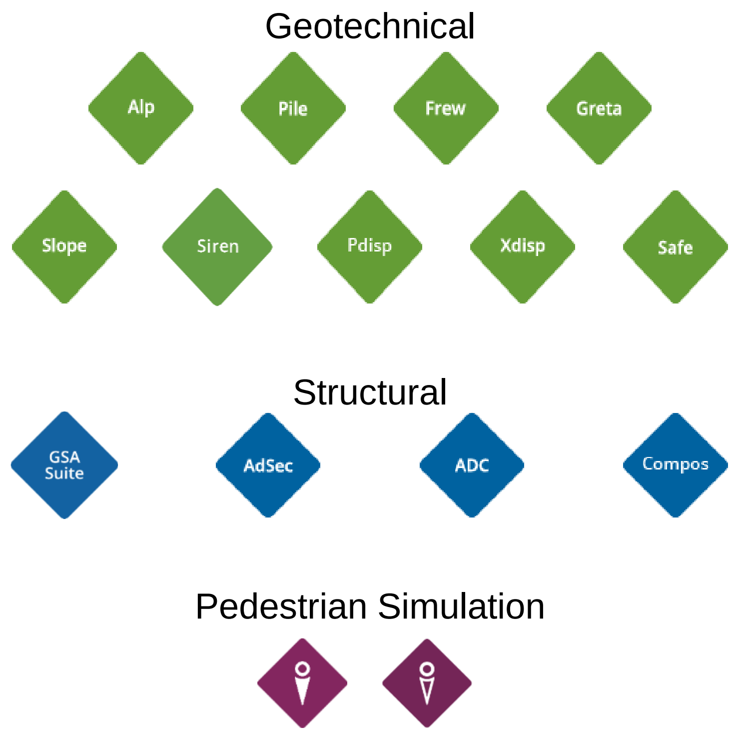
Zeena Farook



The webinar has started

Can you hear us?





Oasys
YOUR IDEAS BROUGHT TO LIFE

Who is Oasys?

- Wholly owned by Arup
- Formed in 1976 to develop software for in-house and external use
- Most programming and sales staff are engineers
- In recent years have added marketing and sales staff
- Have expanded the development team worldwide

Oasys Customers

Frew Training Webinar Session 2 Objectives

- Cover Advanced Analysis Methods
  - General Modelling Methods
  - Integral Bridge Analysis
  - Seismic Analysis

Previous Webinars:

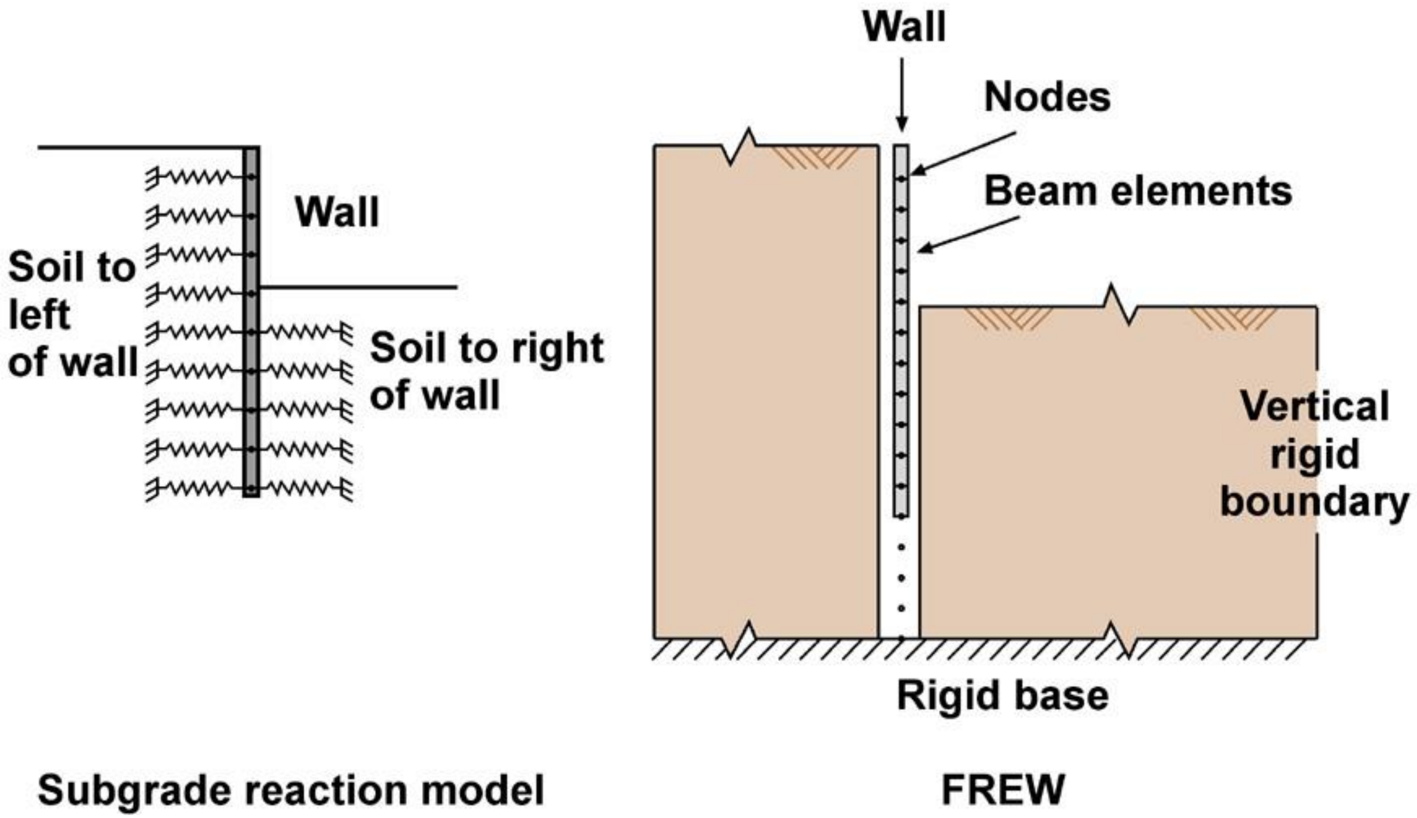
- Partial Factors (EC7)
- Automation/sensitivity analysis

Session 1 – Introduction to Methodology and setting up a model

What does it do?

- Embedded retaining wall analysis over the complete construction sequence
- Soil structure interaction/pseudo FE so calculates soil response using FE mesh results
- Stability checks for cantilever and propped walls
- Earth and water pressure calculations at every stage
- Suitable for sheet pile, secant, contiguous or diaphragm walls

How does it work?



- Wall modelled as series of elastic beam elements
- Soil to each side of the wall connected to nodes
- Only horizontal forces are transmitted

Methods of Analysis

- Limit Equilibrium
  - Checks stability of wall for assumed failure mechanism

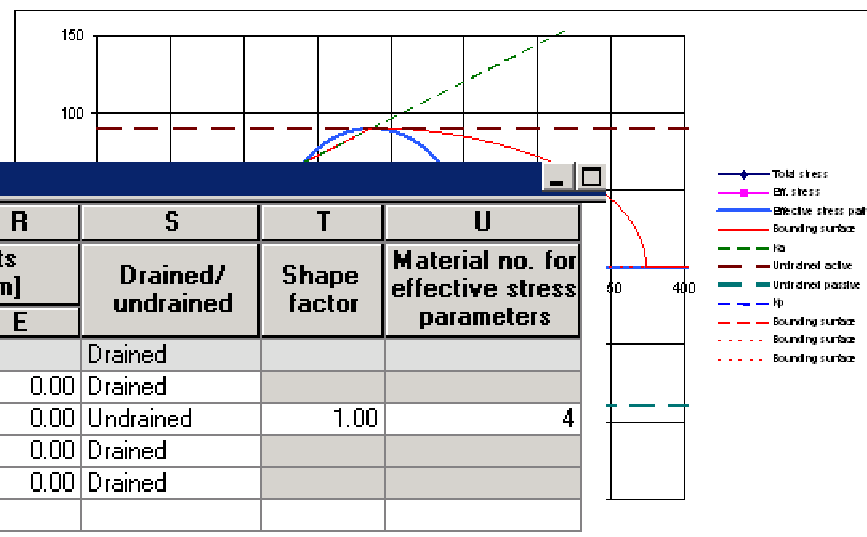
- Soil-Structure Interaction (SSI)

Modelling methods

- Effects to be modelled:
  - Undrained-drained transition
  - Modelling props
  - Relaxation & Creep
  - Modelling Sloping Ground
  - Modelling Berms
  - Modelling Shafts
  - Thermal Effects

Undrained-drained transition

- Sequence
  - Initialise stresses with drained materials
  - Switch to undrained soils
  - Model sequence
  - Apply estimated undrained pore pressure profile to undrained materials (no movement)
  - Switch to drained parameters (no movement)
  - Switch to long term pore pressures
- FREW will calculate undrained pore pressure profile based on Mohr Coulomb or modified Cam Clay model
- Need to assign undrained materials pore pressure calculation on



J	K	L	M	N	O	P	Q	R	S	T	U
Ka	Kp	Kac	Kpc	Kr	c0 [kN/m²]	y0 [m]	Gradients [kN/m²/m]		Drained/ undrained	Shape factor	Material no. for effective stress parameters
							c	E			
									Drained		
0.361	2.770	1.202	3.329	1.000	0.00	0.00	0.00	0.00	Drained		
1.000	1.000	2.000	2.000	1.000	50.00	46.25	2.10	0.00	Undrained	1.00	4
0.361	2.770	1.202	3.329	0.250	0.00	0.00	0.00	0.00	Drained		
0.422	2.371	1.299	3.080	0.250	0.00	0.00	0.00	0.00	Drained		

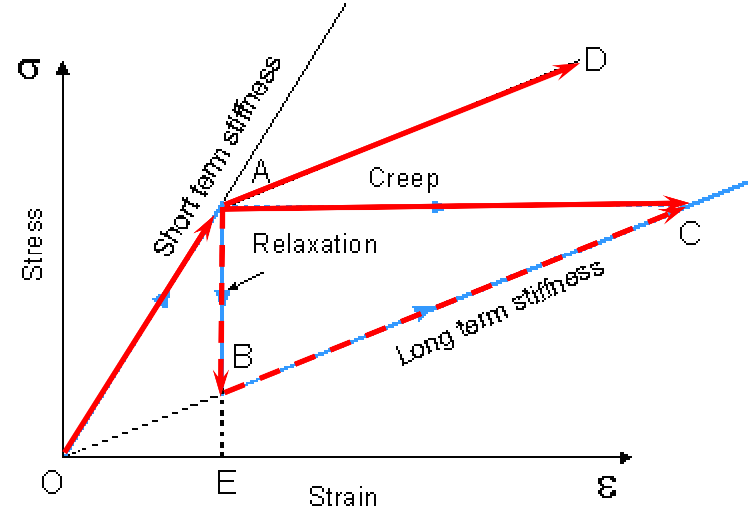
Modelling props

- A prop with:
  - pre-stress and no stiffness is an applied force
  - stiffness, k, only is a spring:
    $F = k\delta$
- To apply:
  - A moment restraint, apply a spring with 90º angle and a 1m lever arm
  - A moment, apply a force with 90º angle and a 1m lever arm
- Only horizontal & moment component is taken into account

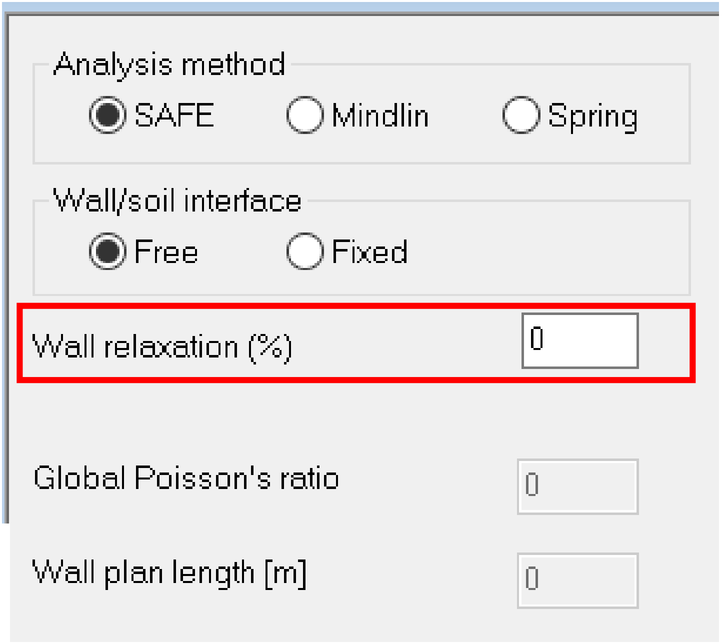
Strut	Stage In	Stage Out	Level [m]	Prestress [kN/m]	Stiffness [kN/m/m]	Angle [°]	Lever arm [m]
Defaults							
1	2	3	28.000	200.00	0.00	40.00	0.30
2	3	4	28.000	200.00	5000.00	40.00	0.30
3	4		30.000	0.00	30000.00	0.00	0.00
4	4		24.700	0.00	30000.00	0.00	0.00
5							

Relaxation and Creep

- Creep – strain at constant stress
- FREW uses a tangent modulus, so can't just change stiffness
- Wall relaxation is specified in Analysis Data – Wall EI and stress in wall is reduced by specified percentage (AB)
- System is then out of equilibrium and has to move (BC)
- Similar effect required for props, but is not automatic. Initially need to install two props (of k/2). At creep stage, remove one of the props

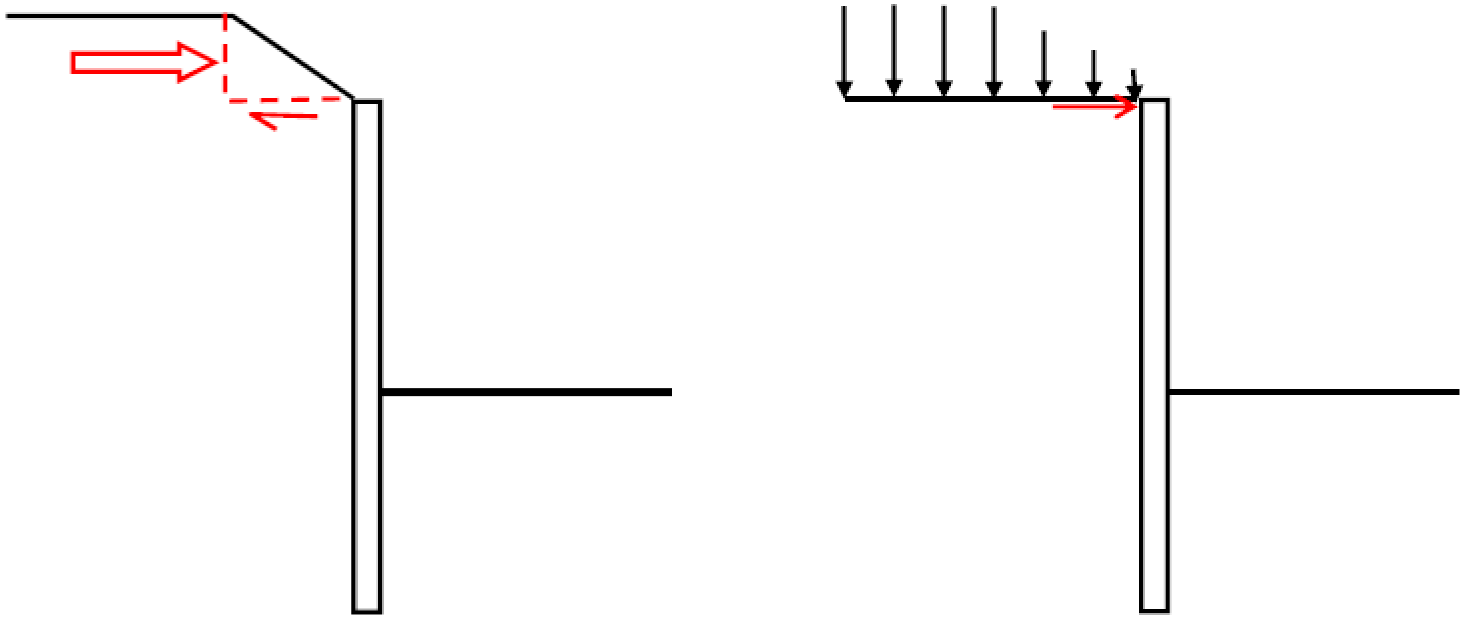


$$Relaxation = \left(\frac{Long\ Term\ EI - Short\ Term\ EI}{Long\ Term\ EI} \right) \times 100$$

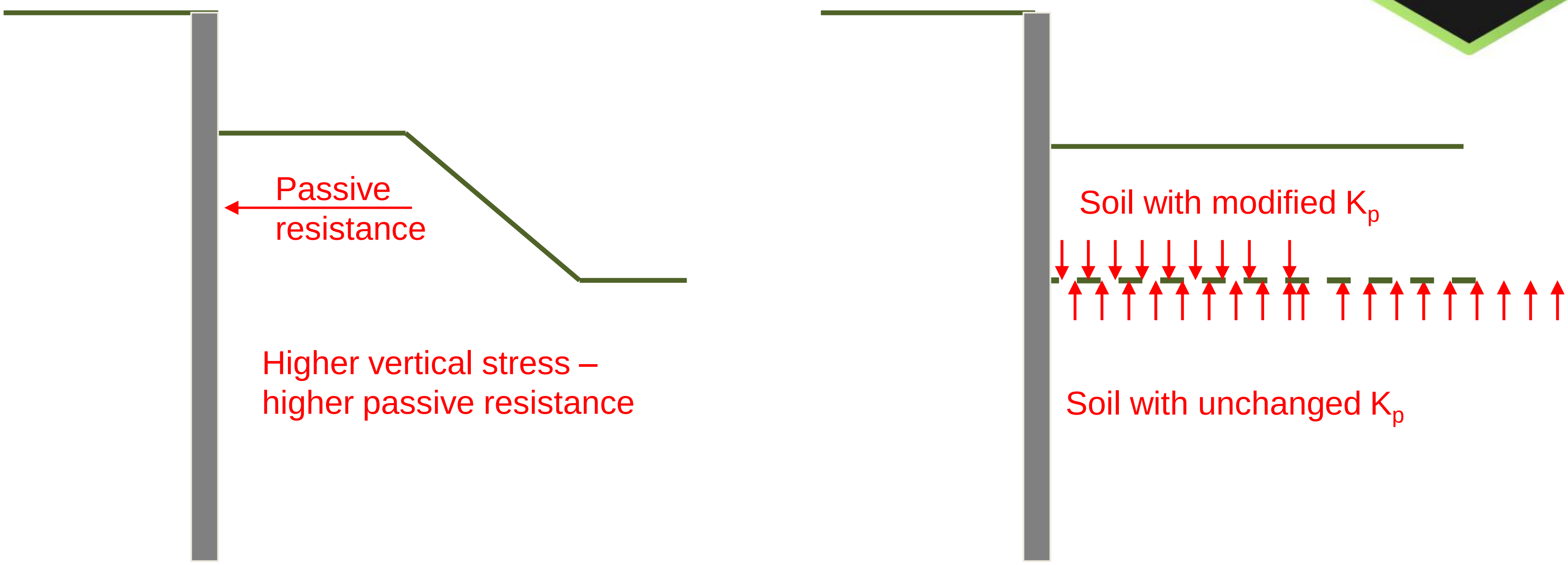


Modelling Sloping Ground

- For slopes of limited extent, may consider modelling as a surcharge.
- However, need to include a lateral force at top of wall



Modelling Berms



1. Simplified method (FREW Manual)
   - Calculate reduced K_p, for berm soil
   - Elastic effect of excavation modelled, but berm weight does not contribute to passive resistance in soil beneath berm
2. Rigorous method based on calculating revised K_p using method of slices

Modelling Berms

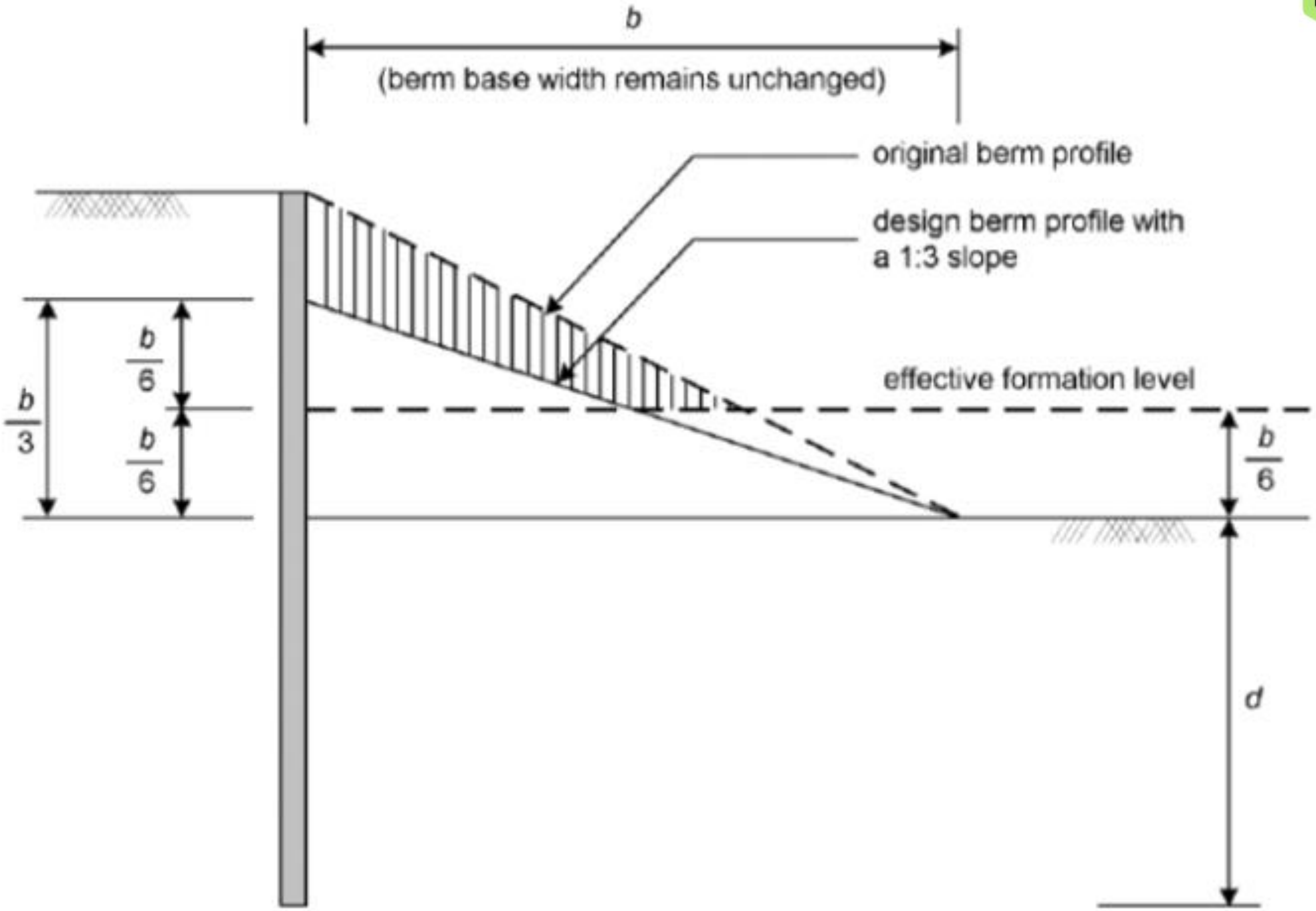
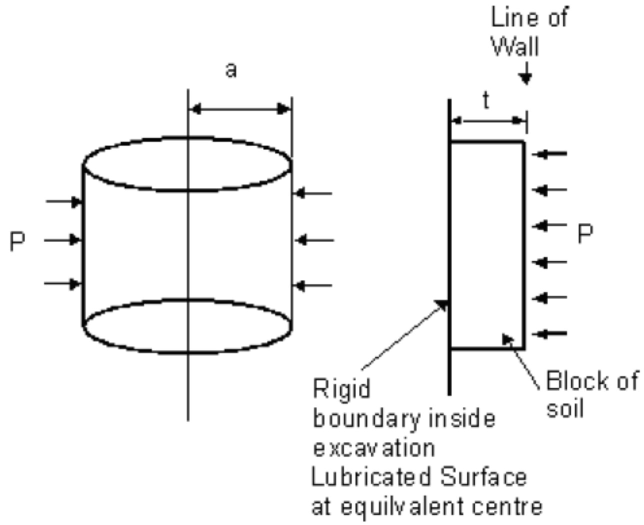
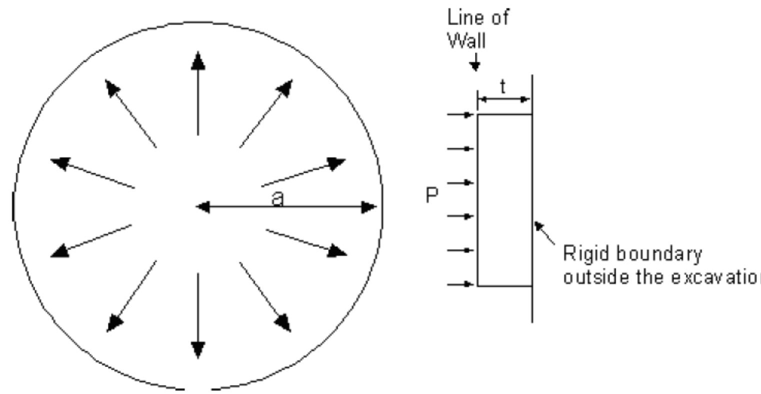


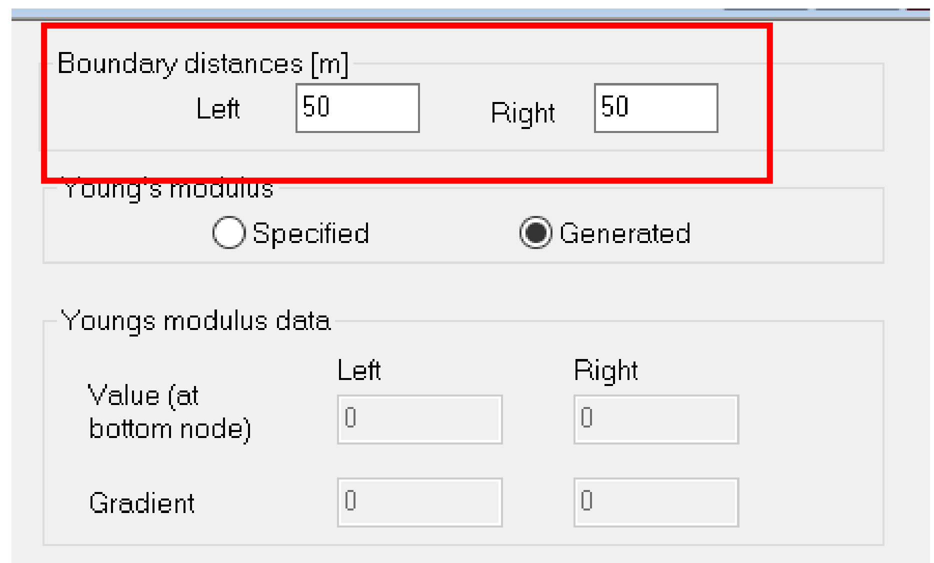
FIGURE 7.3 *Representation of a berm by means of a raised effective formation level (after Fleming et al, 1994)*

Modelling Shafts





- Frew analyses plane strain problem – infinitely long excavation
- Axi-symmetric problem – apply rigid boundary distance that gives equivalent displacements in a cylinder and a soil block



Thermal Effects

Expansion and contraction of slabs/props due to temperature effects can have significant consequences

- Effect is an applied strain:
  $\Delta L = \alpha.\Delta t.L$ α = thermal coefficient of expansion
- Fixed end Force: $\Delta P_{temp} = \alpha.\Delta t.E.A.$
- If wall is *rigid*, applied force = ΔP_{temp}.
  If wall is *flexible*, force = 0 and displacement = ΔL
- Model as a prop with stiffness $k = \Delta P_{temp} / \Delta L$, and prestress $-\Delta L$ (i.e. tension).
- Need additional prop which is equilibrium force from previous stage.
- Does not model soil "ratcheting" of integral bridges

Modelling methods

Effects to be modelled:

- Undrained-drained transition
- Modelling props
- Relaxation & Creep
- Modelling Sloping Ground
- Modelling Berms
- Modelling Shafts
- Thermal Effects

Covered in previous webinar:

- Partial Factor Analysis (EC7)

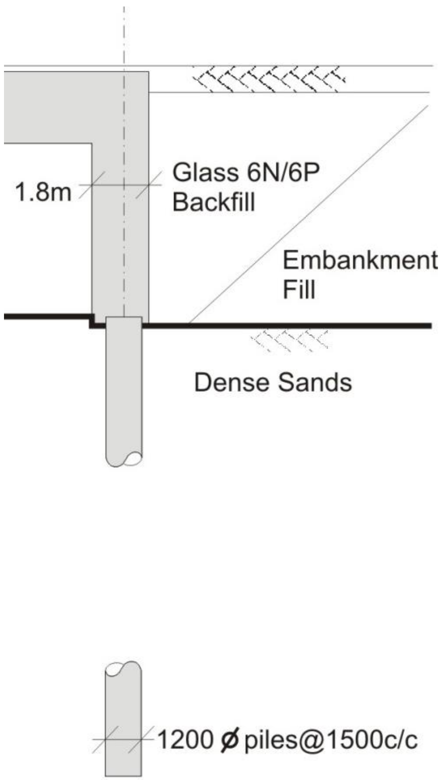
Integral Bridge Analysis

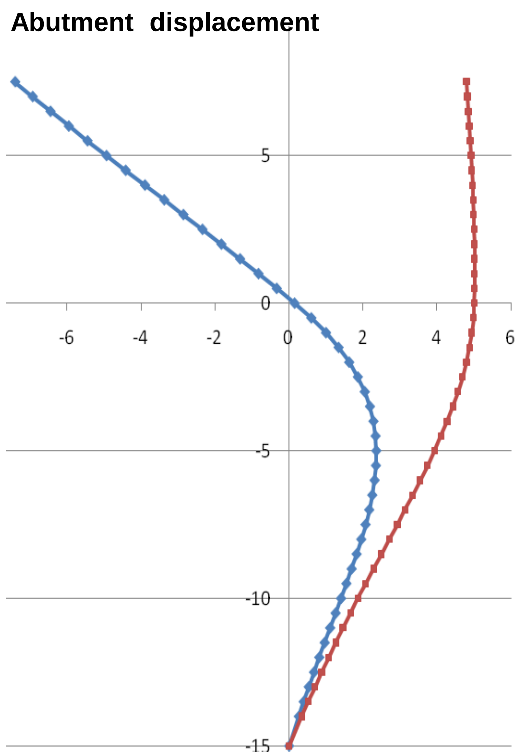
- Section 9 and Annex A of PD 6694-1 cover Integral Bridges
- Based on BA42, but updated to:
  - align with Eurocodes
  - address known issues with BA42
  - embrace latest research in the field
- Some important developments that:
  - enhance efficiency in design
  - provide greater flexibility to designers

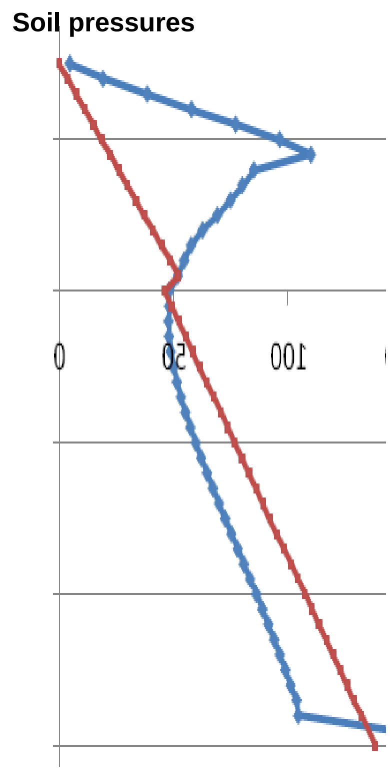
Integral Bridge Theory

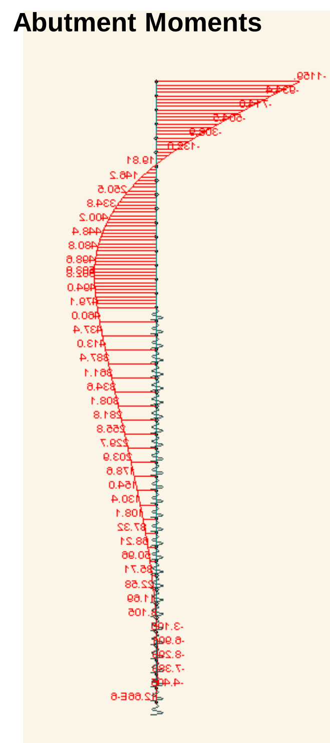
For flexible abutments, soil pressure is a function of the displacement of the abutment which is a function of the soil stiffness.

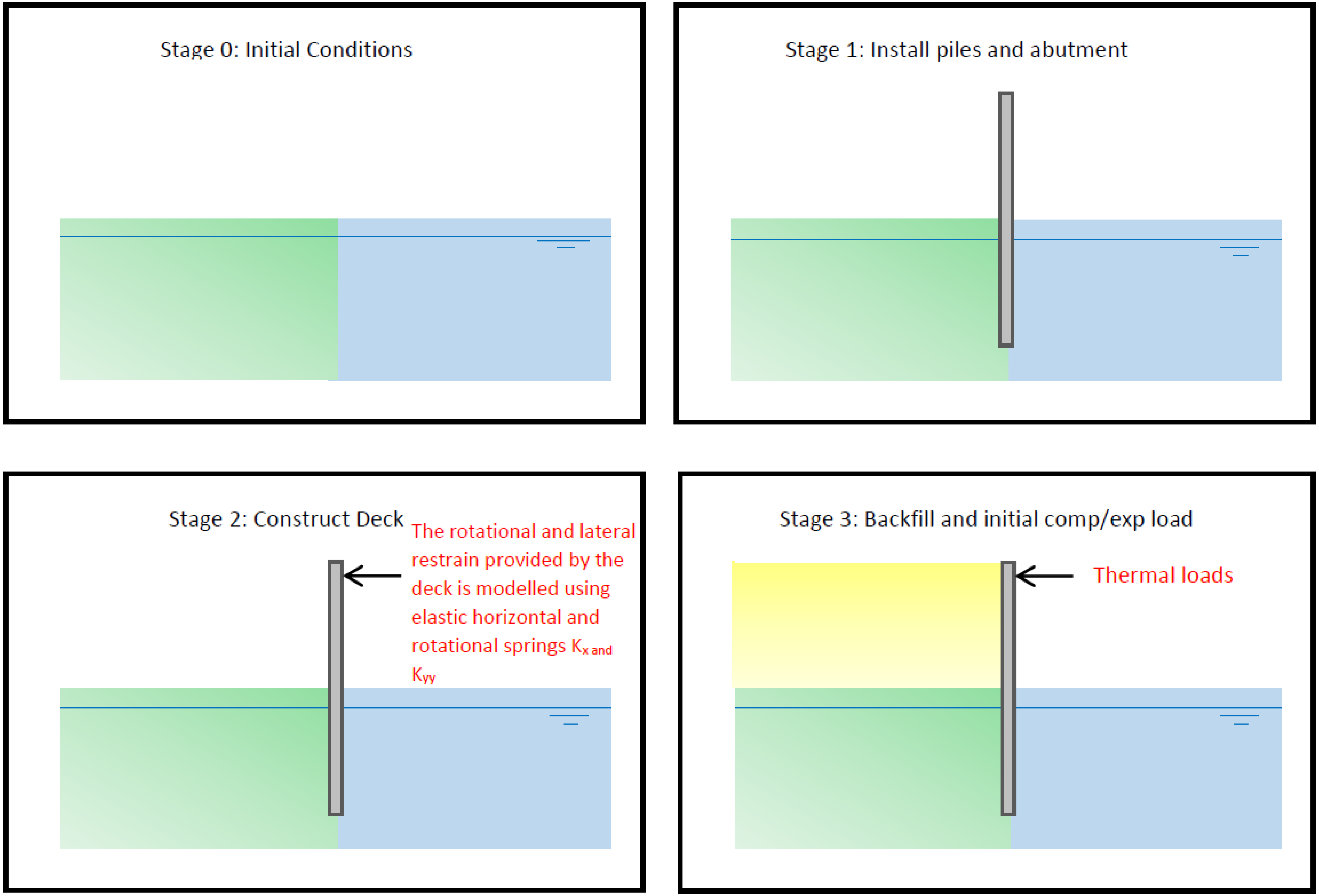
Soil Structure Interaction Required










Stage 0: Initial Conditions
Stage 1: Install piles and abutment
Stage 2: Construct Deck
The rotational and lateral restrain provided by the deck is modelled using elastic horizontal and rotational springs K_{x} and K_{yy}
Stage 3: Backfill and initial comp/exp load
Thermal loads

Seismic Design Considerations

Retaining Walls:

- Dynamic Earth Pressure
- Dynamic Water Pressure
- Load Factors

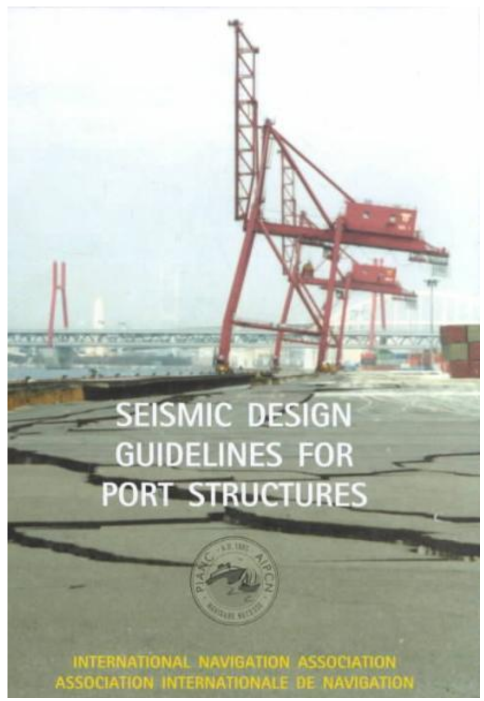
Literature

Frew

- Steedman (1998)
- Design Framework from PIANC (2001)
- EC8


Seismic design of retaining walls

R. S. Steedman, BSc, MPhil, PhD, CEng, FICE, FRSA




BRITISH STANDARD

BS EN 1998-5:2004

Eurocode 8: Design of structures for earthquake resistance —

Part 5: Foundations, retaining structures and geotechnical aspects

The European Standard EN 1998-5:2004 has the status of a British Standard

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BSI British Standards

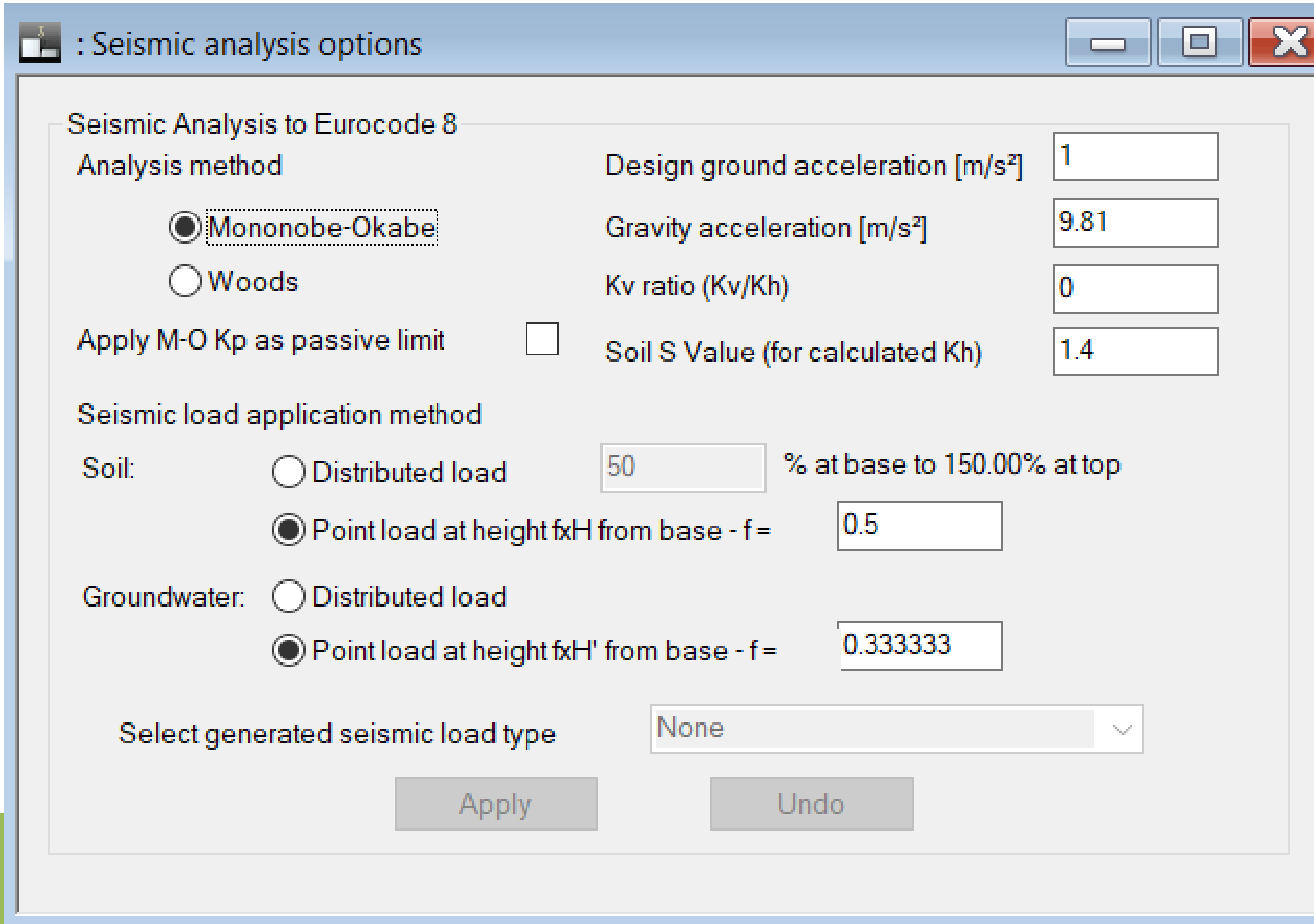
Methods

Define wall-soil-system:

EITHER	Perfectly Rigid / No Displacement
	Wood's
OR	Wall free to displace until min (active) earth pressures occur
	Mononobe-Okabe

Features

- Automatically calculates parameters to Eurocode 8
- Incorporates Mononobe-Okabe and Woods methods
- Kh values can be user defined to comply with other codes



Training and Support

- Tutorial Manual
- User Manual
- Tutorial Videos
- Previous Webinars
    - Tips and Tricks
    - Partial Factors
- Email Support (analysis file and images)
- Training Sessions

Using Frew from home

- Run the analysis file locally (not on a remote network)
- Use the backup feature
  - Tools>Preferences
- Are you using the most recent Build?
  - Help>About Oasys
- To manage your license, use the license portal

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Session 1 – Introduction to Methodology and setting up a model

Any Questions?