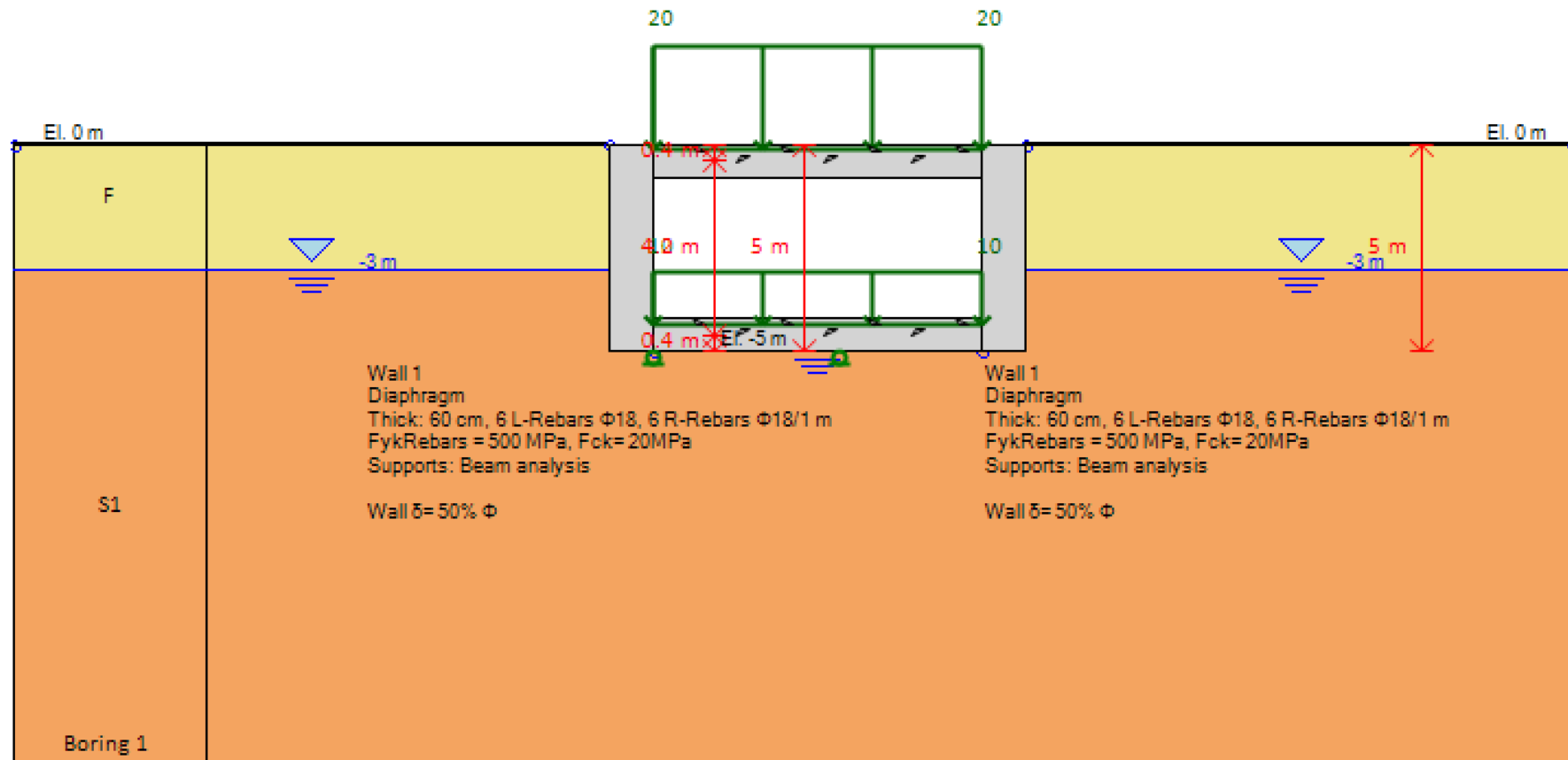


Example 6: Concrete Drain Box

Example 6: Concrete Drain Box Limit Equilibrium – Non-Linear – Finite Element Analysis





A. Soil Properties and Stratigraphy (Soil Layers)

Elev. (m)	Soil (-)	γ_t (kN/m ³)	C' (kPa)	ϕ' (deg)	Eoed (kPa)	Eur (ksf)	m (-)
0	F - Sand	19.5	0	30	14000	42000	0.5
-3	S1 - Sand	20.5	0	34	28000	84000	0.4

El. 0 m

F
 $\gamma_t = 19.5$ kN/m³
 $\phi' = 30$ deg

S1
 $\gamma_t = 20.5$ kN/m³
 $\phi' = 34$ deg

Boring 1

1. General Boring Information - Coordinates

Name: Boring 1

Coordinates X: -20 m Y: 0 m

The x coordinate controls where the boring is shown in your design section view. Each design section uses one boring (soil strata). You can use a different boring on each design section.

SPT Data Option (Applies to Design Section)

SPT Record: Not assigned Add edit SPT records

Pass same SPT log to boring (3D visualizations)

CPT Record Option (Applies to Design Section)

CPT Record: Not assigned Add edit CPT records

2. Boring Layers - Layer Elevations

	Top Elev. (m)	Soil Type	OCR	Ko	Edit
▶	0	F	1	0.5	Edit
	-3	S1	1	0.441	Edit
*					

4.2 m | 5 m | 10

A. General | C. Elasto-plastic | D. Bond | E. Adv. | F. Piles

4. Unit Weights - Density

γ_t 19.5 kN/m³ > γ_{bulk} 18.5 kN/m³; $\gamma' = 9.5$

5. Strength Parameters and Poisson Ratio

Drained strength properties

c' 0 kPa > ϕ' 30 degrees >

Peak - constant vol. (for estimation)

ϕ_{cv}' Omitted degrees >

ϕ_{peak}' Omitted degrees >

ν 0.35 >

B. Wall Section Properties, Wall Position and Depth

X-Coordinate	X = 0
Wall Type	Concrete Diaphragm
Thickness	0.6 m
Long. Reinforcement	6 Ø18mm Rebars (each side)
Shear Reinforcement	Ø8mm Bars @ 10cm Spacing
Materials	S500 Rebars, C20/25 Concrete

General | Advanced features

1. Wall Name
Wall 1

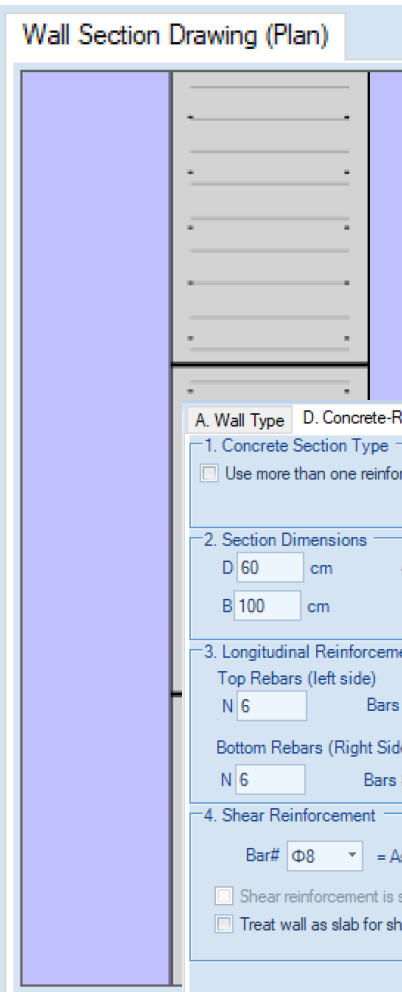
2. Wall Section Properties
Section: Wall 1 Edit section data
 Use gravity wall section
Equivalent wall Thickness: 0.6 m

3. Dimensions
Top EL: 0 m
Depth L: 5 m
Bottom: -5 m
 Use custom passive Elev.

 Wall is permeable
 Include wall weight

4. 3D Wall Coordinates
xWall: 0 m Out-of-plane y: 0 m

7. Wall Nodes (Analysis Settings)
Number of Nodes nD (0-21): 21
Limit equilibrium analyses use nD to divide wall into smaller elements. BEF uses Mesh DELTA as defined in the "Analysis Tab" in then main form and recalculates nD.



A. Wall Type | D. Concrete-Rebar | F. Draw

1. Concrete Section Type
 Use more than one reinforcement sections Define custom reinforcement

2. Section Dimensions
D: 60 cm A: 6000 cm² Ixx: 1800000 cm⁴ Recalculate box - slice analysis
B: 100 cm Eff. conc: 25 % Used with recal button and for secant piles

3. Longitudinal Reinforcement (Tension - Compression)
Top Rebars (left side): N: 6 Bars #: Ø18 = AsTop: 15.27 cm² Ctop: 6 cm
Bottom Rebars (Right Side): N: 6 Bars #: Ø18 = AsBot: 15.27 cm² Cbot: 6 cm

4. Shear Reinforcement
Bar#: Ø8 = As: 0.503 cm² sV: 10 cm sH: 10 cm
 Shear reinforcement is spiral Metric Rebars D10 for 10mm Diam
 Treat wall as slab for shear capacity calculations (diaphragm walls only)

Elevation view
Shear reinforcement
Top view
Shear reinforcement



C. Support Section Properties and Elevation

A. General | B. Options | C. Results | D. Notes | E. Envelope

1. Dimensions

1.1 Coordinates at Wall

X m

Z m

1.2 Angles

α deg

1.3 Lengths

Lfree m

Horizontal Spacing m

2. Support Type and Structural Section Used

Structural Section

Include slab weight in vertical stress (tr)

2. Unbraced Lengths Options

Use user-defined unbraced lengths

3. Slab Live Load kPa Apply same load to all stages

Change support type

Support	Top Slab	Base Slab
Support Type	0.8m Concrete Slab	0.8m Concrete Slab
Elevation on Wall	Z = - 0.4 m	Z = - 4.6 m
Hor. Spacing	Continuous	Continuous
Long. Reinforcement	5 Ø10mm Bars/m of Slab (top and bottom)	
Materials	S500 Rebars, C20/25 Concrete	

4. Section Dimensions

D cm A cm² Ixx cm⁴ Load kN/m

B cm

5. Longitudinal Slab Reinforcement

Use bar spacing instead of number of bars

Top Rebars

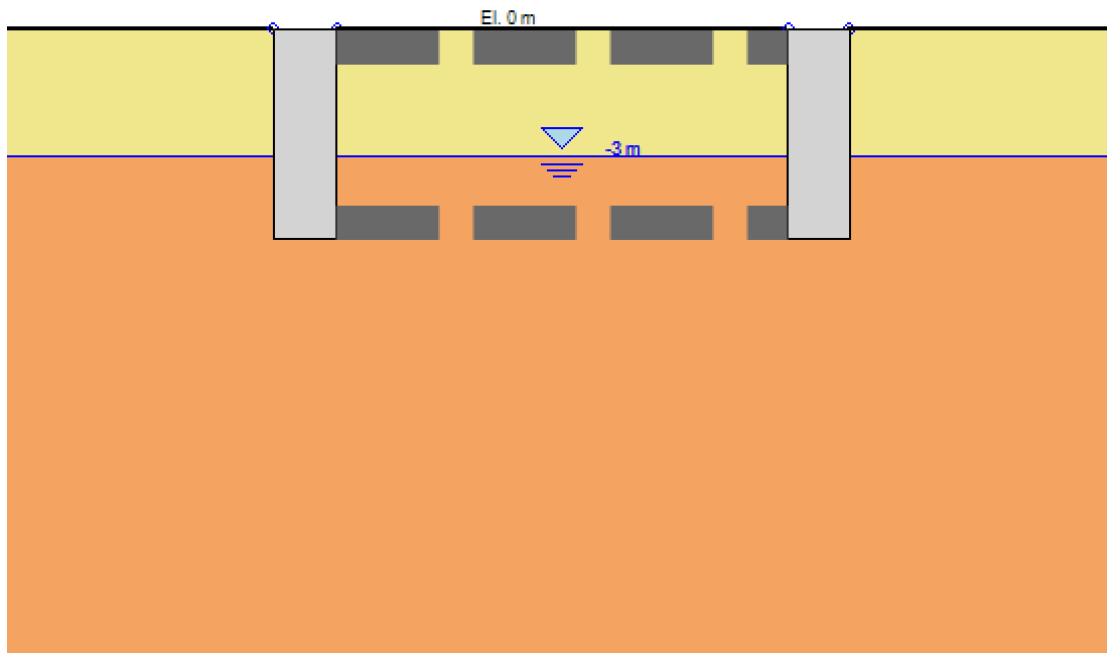
N Bars # = AsTop cm² Ctop cm

Bottom Rebars

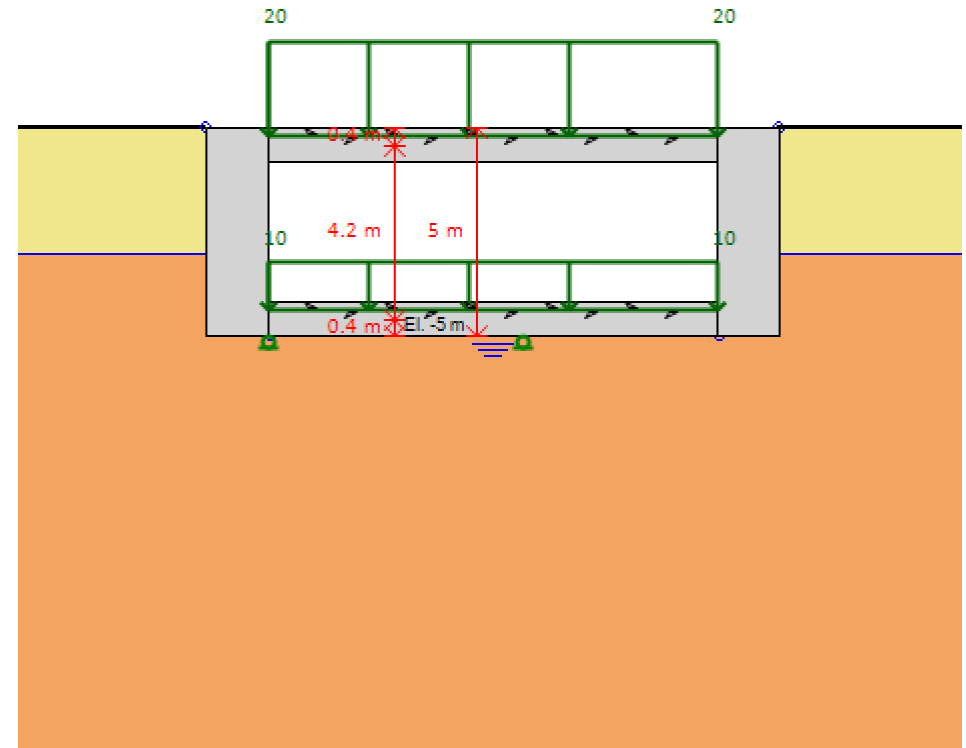
N Bars # = AsBot cm² Cbot cm

Metric Bars Type D10 in mm, US bars indicated with # sign

D. Model in Construction Stages



Stage 0: At-rest Conditions



Stage 1: Drain Box Installation

E1. Analysis Settings & Design Codes

- Wall Friction: 50% of the soil friction
- Water Pressures: Simplified Flow
- Cantilever Method (LEM): Free Earth Method
- Beam Analysis Method: Blum's
- Soil Pressures: At-Rest (All Stages)

The screenshot shows a software interface for analysis settings. It includes several sections: 'Water behaviour' with icons for Clays (Default), Analysis (Hyd.), and Wave Forces; 'Thrust options' with 'KaKp AUTO' and 'Include Wall Friction' checkboxes; '1st wall' and '2nd wall' sections with percentage input fields set to 50; 'Limit Equilibrium Methods (Current Stage)' with 'Drive Pressures: At-rest' and 'Resist Pressures: Passive'; 'Supports: Beam' and 'Cantilever: Free-earth'; 'Beam: Blum's method'; and 'Advanced Options'.

- Steel Code: AISC 360-16 Allowable
- Concrete Code: ACI 318-19
- Analysis Code: None (Service Conditions)

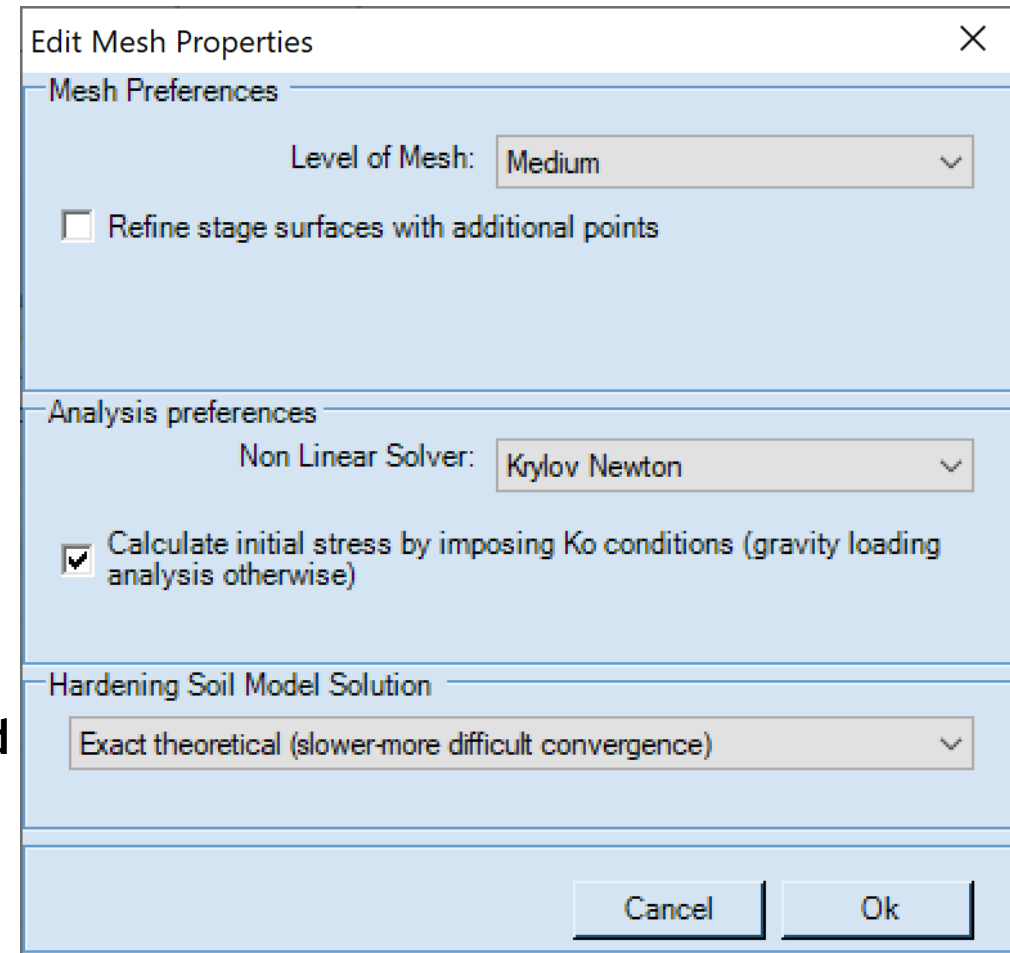
The screenshot shows a dialog box for design code options. It has two sections: 'Concrete Code Options' with a dropdown menu set to '26:ACI 318-19', and 'Steel Code Options' with a dropdown menu set to '22:AISC 360-16 ALL.'.

E2. Additional FEM Analysis Settings & Tips

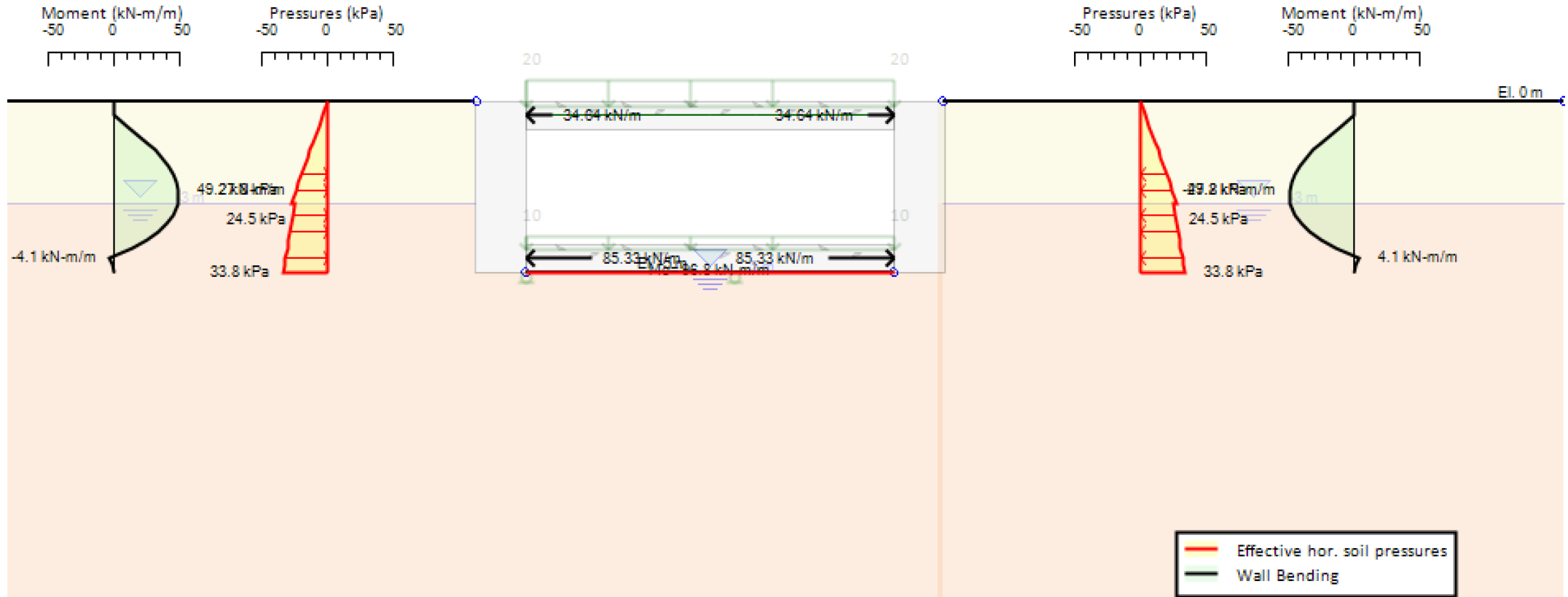
- **Generated Mesh Density: Medium**
- **Non-Linear Solver: Krylov Newton Method**
- **Hardening Soil Model: Exact Theoretical**

FEM Analysis - Model Convergence Tips:

- ✓ **Always consider a small cohesion for frictional soils**
- ✓ **Always use wall friction for all your walls**
- ✓ **Create a strict staging**
- ✓ **Sometimes an initial stage with green field conditions (not activated walls) might be required**
- ✓ **Always assume realistic prestress values for the anchors (if used)**



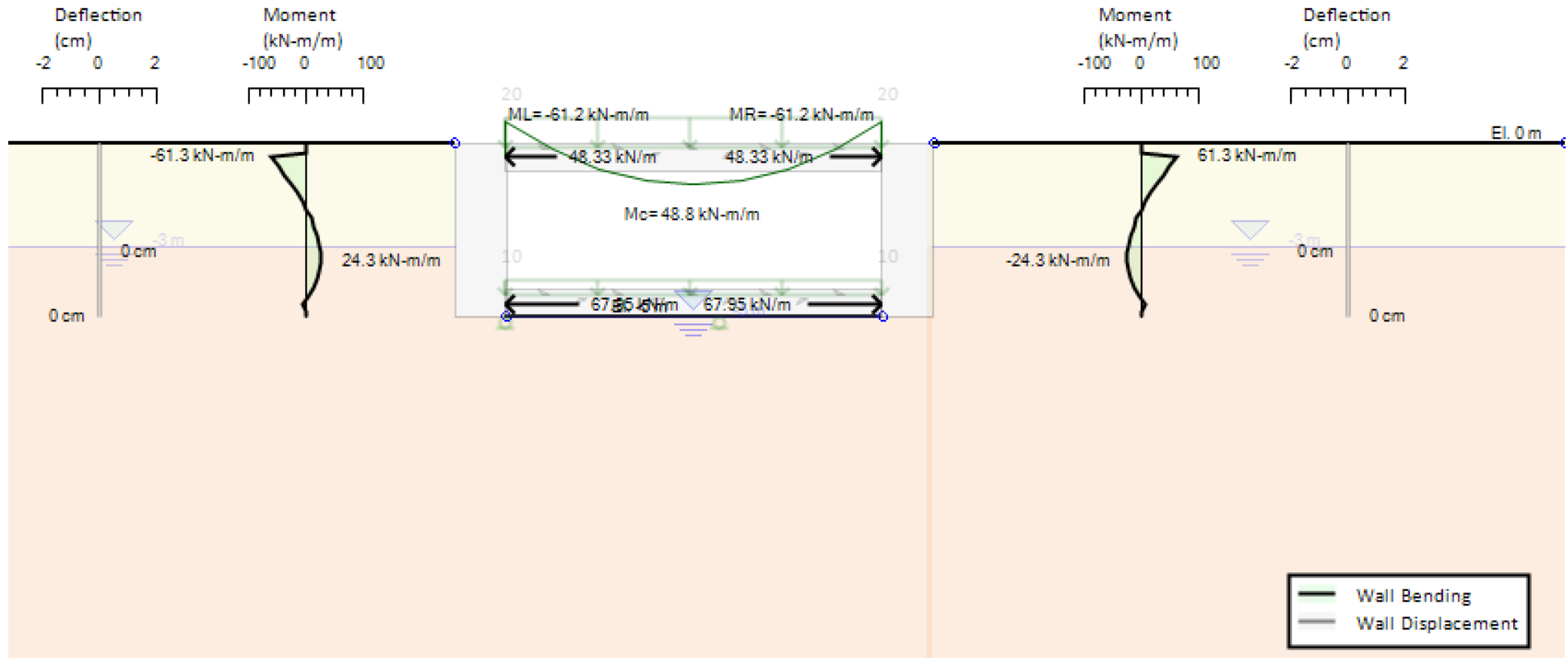
F. LEM Analysis Results



Wall Moments, Support Reactions & Soil Pressures - Stage 1

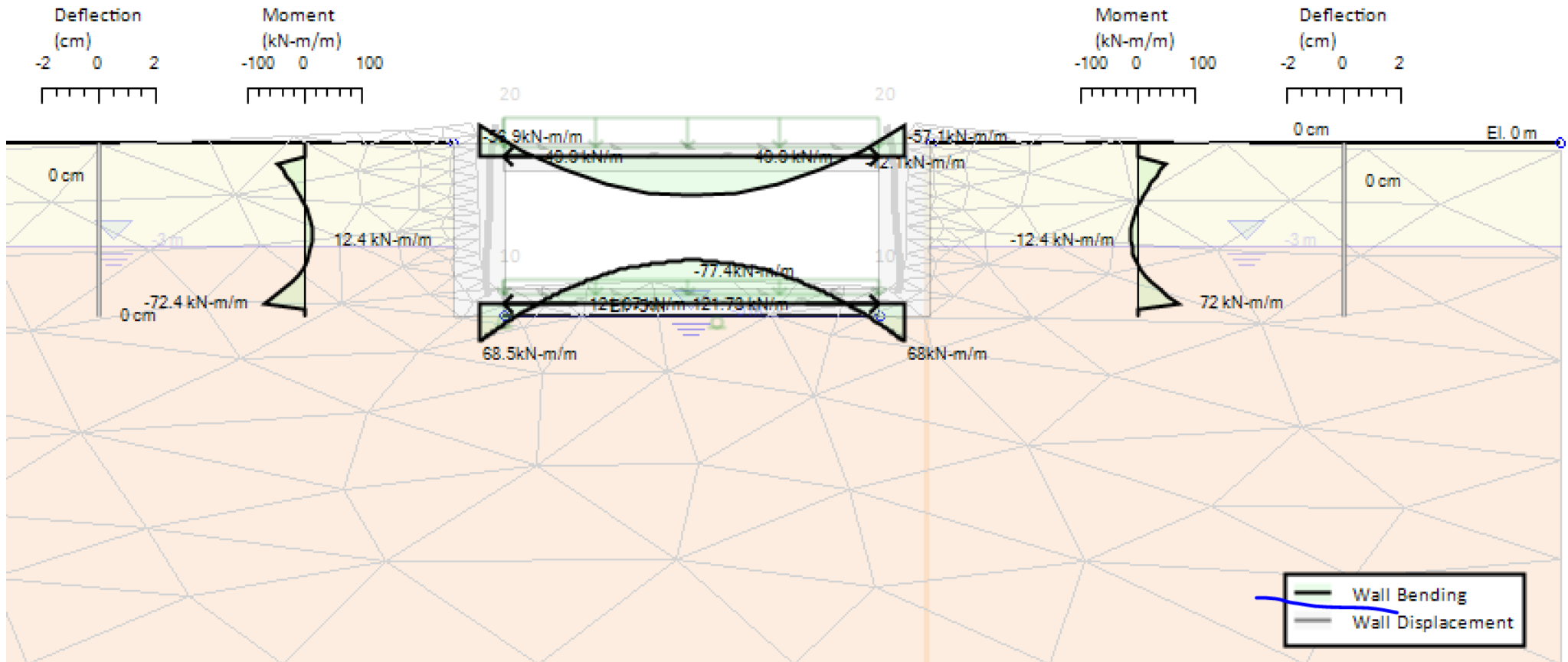
Example 6: Concrete Drain Box

G. Non-Linear Analysis Results



Wall Moments, Displacements & Support Reactions - Stage 5

H. FEM Analysis Results



Wall Moments, Displacements & Support Reactions - Stage 5

Thank You!

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