



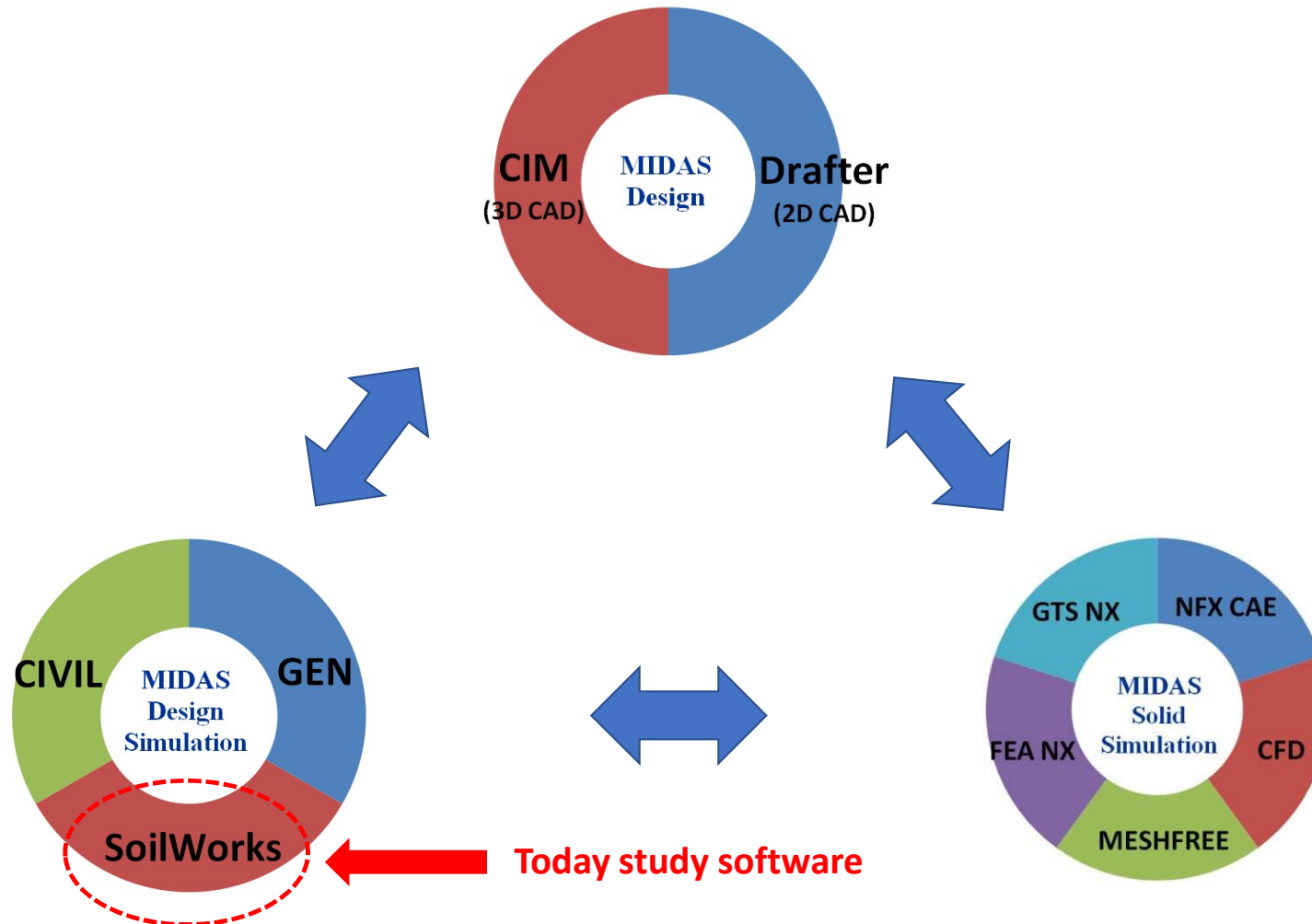
# Midas Taiwan

## SOILWORKS INTRODUCTION

E-mail: [support@midasuser.com](mailto:support@midasuser.com)

Date: 2025.07.04

# Midas Package Integration Approach





## **CONTENT**

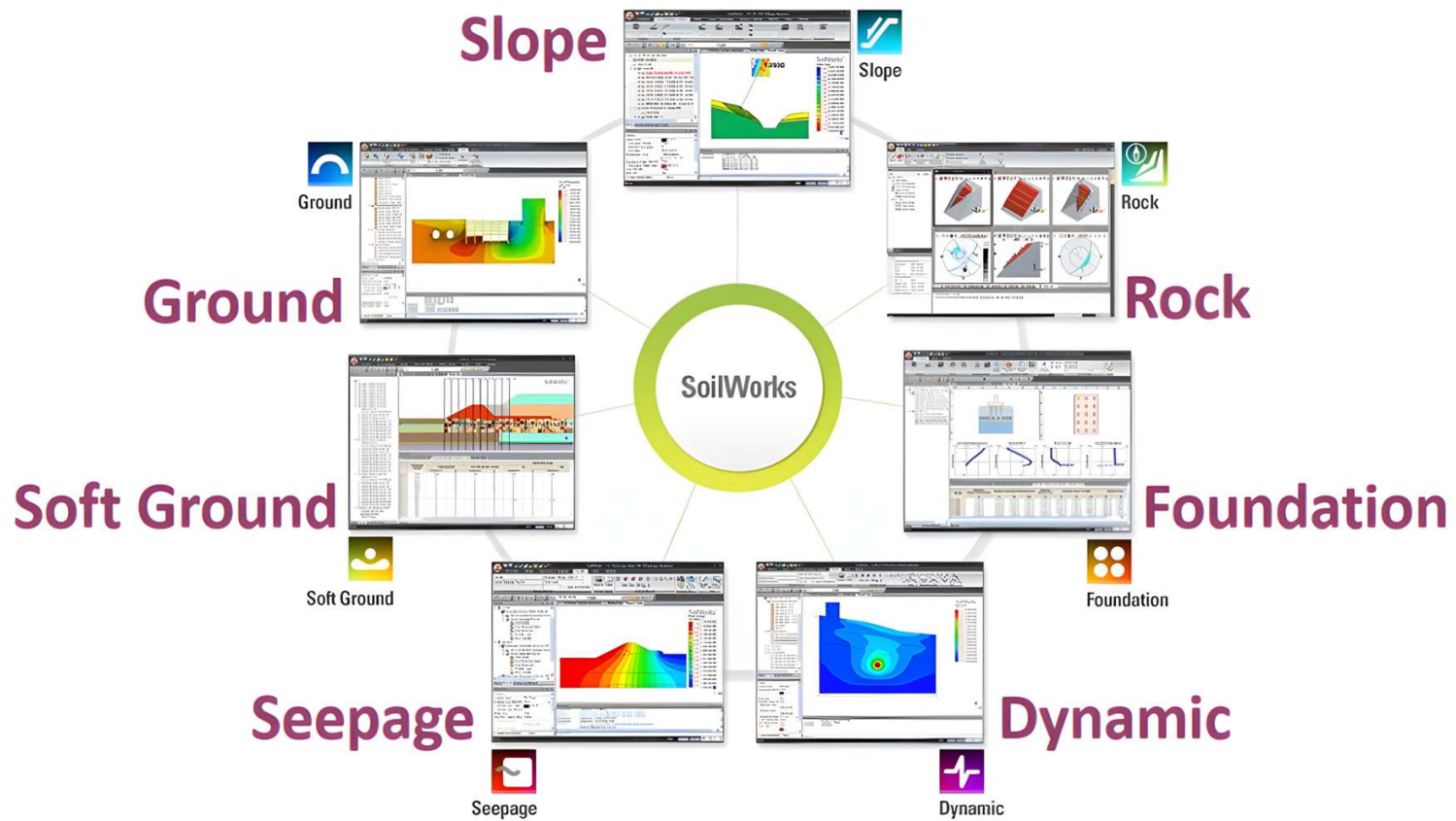
☒ Overview of SoilWorks

☒ SMART SoilWorks

☒ Project application

# Overview - Functionality

- 2D FEM and Analytical software
- Fully integrated Pre/Post and Solver





# Overview – Work Flow

Structural &  
Geotechnical  
engineers

SoilWorks



Complete FEM Software Package

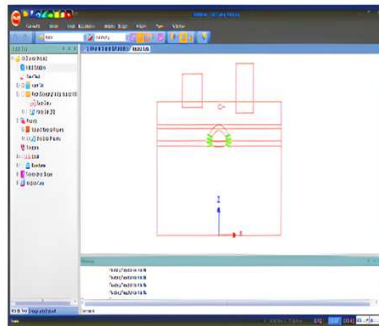
CAD based environment

Intuitive

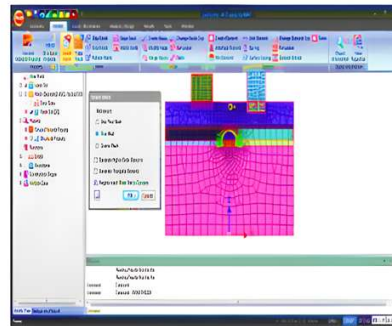
Automation

Robust

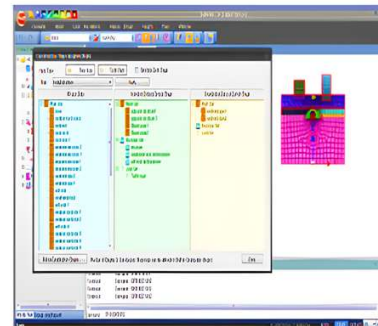
Work Flow



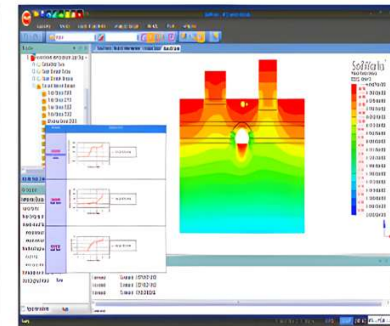
Geometry Modeling



Properties/ Meshing/  
Loads/ Boundaries



Analysis

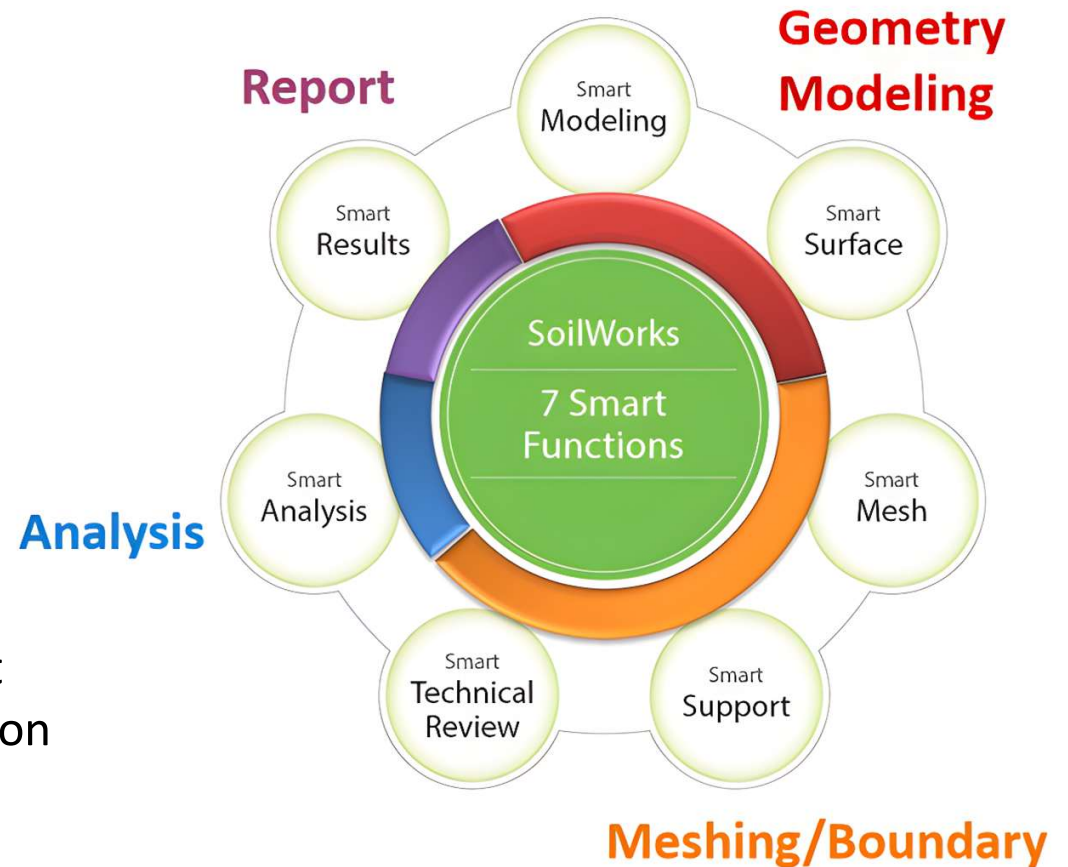


Post-Processing

# SMART SoilWorks

## How is it fast?

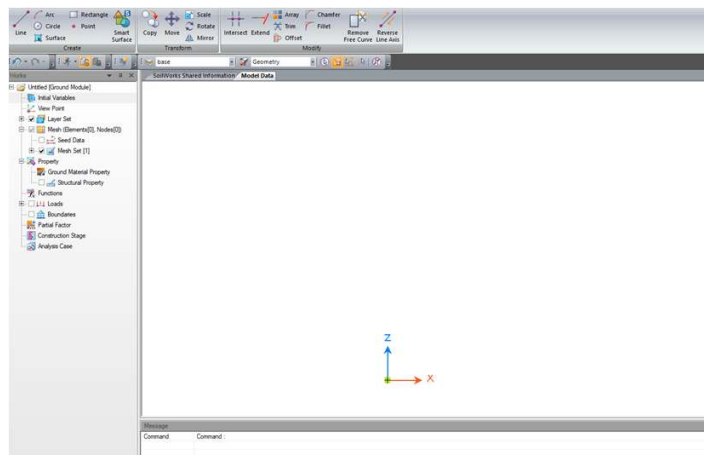
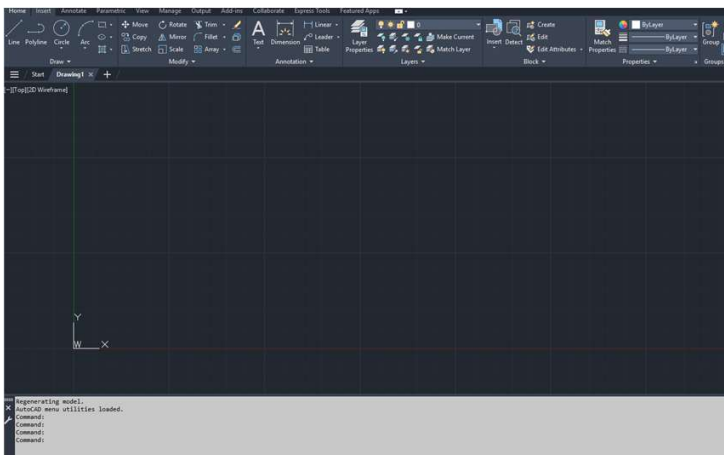
- 👍 Innovative features
- 👍 Reduced steps for engineers
- 👍 Elimination of repetitive process
- 👍 **7 SMART Automated Features** for fast modeling, analysis and results extraction



# 1. SMART modeling

## Easy to create geometry 👍

CAD based operating environment



- Use a CAD file function
- CAD command line
- Simple and convenient
- Shortens modeling time

AutoCAD

SoilWorks

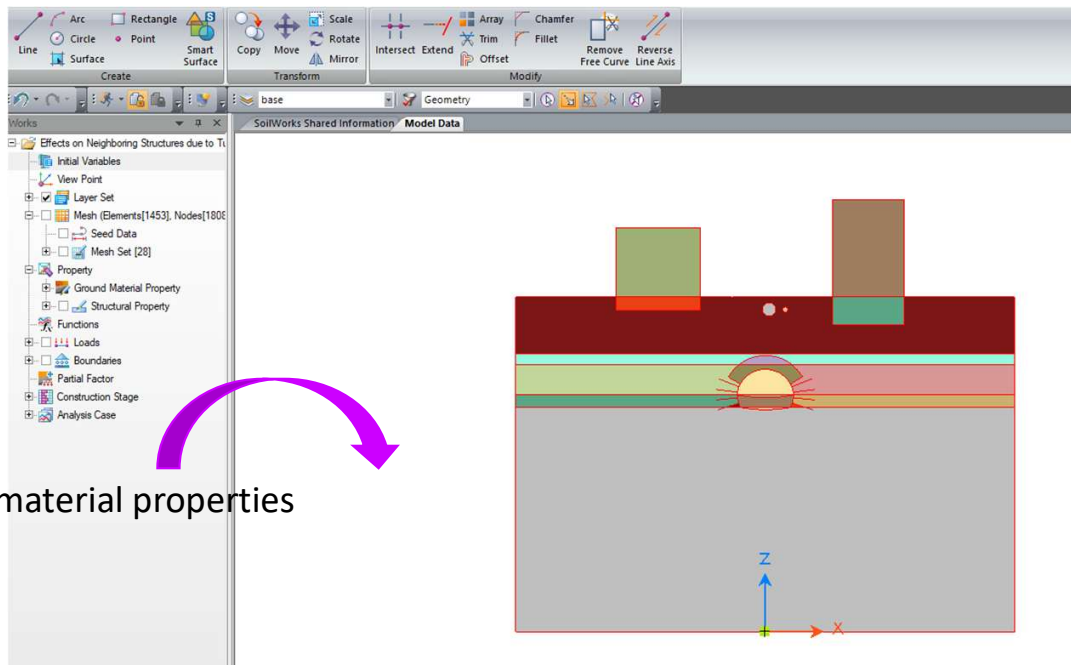
CAD based environment

## 2. SMART surface



### Auto-generated surfaces 👍

Enclosed domains by surfaces automatically



Drag & Drop material properties

- Automatic surface creation
- Drag and drop material properties

### 3. SMART mesh



Easy to meshing 👍

No need for in-depth knowledge of FEM to Meshing

#### Auto Mesh

Generate  
(unstructured)  
Auto-mesh for a  
closed domain

#### Map Mesh

Generate  
structured mesh  
for a closed  
domain

#### Grid Mesh

Generate orthogonal  
mesh for a closed  
domain using  
Quadrilateral and  
Triangular Element

#### Pattern Mesh

Generate mesh for  
2D elements by  
pre-defined mesh  
pattern

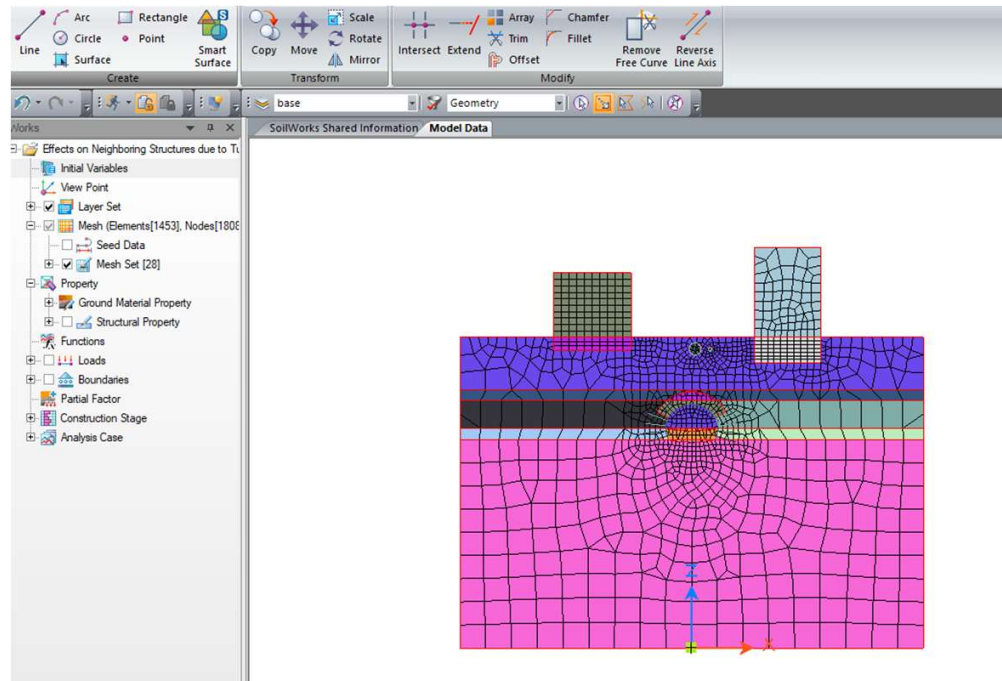
**SMART Mesh**

## 4. SMART support



## Auto-generated boundary conditions 👍

Auto-generation of boundary conditions

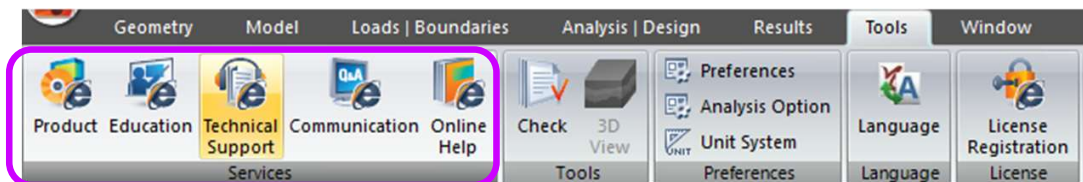


- Automatic boundary generation
- Intuitive checking

## 5. SMART Technical Review

Easy to practice 

Technical review to prevent analysis errors

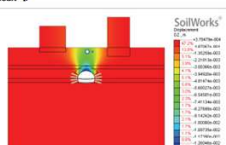


**06. Result Analysis & Report Generation**

**1. Analysis of Results**  
Check the deformed shape of the tunnel and the axial forces of structure due to construction stages.

From the Result Tree, select **Structure Effect Check > Cured Lower Reinforcement > Displacements > Vertical Displacement (DZIV)**

1. Check the displacement at 'Tunnel Crown'
2. Check the settlements of the tunnel and adjacent structures through the Main Menu, 'Result > Detail Result > Result Tag'
3. Check the displacements by construction stages from the Main Menu, 'Result > Graphic Result'



[Vertical Displacement at the final stage]

From the Result Tree, select **Structure Effect Check > Cured Lower Reinforcement > Beam Element Force > select Beam Axial Force (Nx)**

1. Check axial forces at 'Tunnel Shotcrete' & 'Adjacent Structure'
2. Check the magnitudes of axial forces through the Main Menu, 'Result > Detail Result > Result Value Tag'
3. Check the change in axial forces by construction stages through the Main Menu, 'Result > Graphic Result'.
4. Repeat the steps from 1 to 3 to check the axial forces in rock bolts.

**06. Result Analysis & Report Generation**

**2. Report Generation**  
Generate a report of analysis results.

From the Design & Report Tree, **Report > Ground > double click Ground Analysis Result Check**

**1.1.1 Analysis results**

A representative result system has been selected on the basis of structural and geotechnical factors for numerical analysis.

The analysis results have been completed by construction stages reflecting temporary support structures.

The analysis results need to be compared with actual measurement measurements in actual construction.

If the design/analysis conditions differ from the construction conditions, or analysis reflecting the site conditions needs to take place which may result in change in construction method, increased length, temporary support method, etc.

**0 Displacements by construction stages**

4 Tunnel

Member	Ground Displacement	Tunnel	Ground Displacement
1 Tunnel	0.000-000	0.000-000	0.000-000
2 Tunnel	0.000-000	0.000-000	0.000-000
3 Tunnel	0.000-000	0.000-000	0.000-000
4 Tunnel	0.000-000	0.000-000	0.000-000
5 Tunnel	0.000-000	0.000-000	0.000-000
6 Tunnel	0.000-000	0.000-000	0.000-000
7 Tunnel	0.000-000	0.000-000	0.000-000
8 Tunnel	0.000-000	0.000-000	0.000-000
9 Tunnel	0.000-000	0.000-000	0.000-000
10 Tunnel	0.000-000	0.000-000	0.000-000
11 Tunnel	0.000-000	0.000-000	0.000-000
12 Tunnel	0.000-000	0.000-000	0.000-000
13 Tunnel	0.000-000	0.000-000	0.000-000
14 Tunnel	0.000-000	0.000-000	0.000-000
15 Tunnel	0.000-000	0.000-000	0.000-000
16 Tunnel	0.000-000	0.000-000	0.000-000
17 Tunnel	0.000-000	0.000-000	0.000-000
18 Tunnel	0.000-000	0.000-000	0.000-000
19 Tunnel	0.000-000	0.000-000	0.000-000
20 Tunnel	0.000-000	0.000-000	0.000-000
21 Tunnel	0.000-000	0.000-000	0.000-000
22 Tunnel	0.000-000	0.000-000	0.000-000
23 Tunnel	0.000-000	0.000-000	0.000-000
24 Tunnel	0.000-000	0.000-000	0.000-000
25 Tunnel	0.000-000	0.000-000	0.000-000
26 Tunnel	0.000-000	0.000-000	0.000-000
27 Tunnel	0.000-000	0.000-000	0.000-000
28 Tunnel	0.000-000	0.000-000	0.000-000
29 Tunnel	0.000-000	0.000-000	0.000-000
30 Tunnel	0.000-000	0.000-000	0.000-000
31 Tunnel	0.000-000	0.000-000	0.000-000
32 Tunnel	0.000-000	0.000-000	0.000-000
33 Tunnel	0.000-000	0.000-000	0.000-000
34 Tunnel	0.000-000	0.000-000	0.000-000
35 Tunnel	0.000-000	0.000-000	0.000-000
36 Tunnel	0.000-000	0.000-000	0.000-000
37 Tunnel	0.000-000	0.000-000	0.000-000
38 Tunnel	0.000-000	0.000-000	0.000-000
39 Tunnel	0.000-000	0.000-000	0.000-000
40 Tunnel	0.000-000	0.000-000	0.000-000
41 Tunnel	0.000-000	0.000-000	0.000-000
42 Tunnel	0.000-000	0.000-000	0.000-000
43 Tunnel	0.000-000	0.000-000	0.000-000
44 Tunnel	0.000-000	0.000-000	0.000-000
45 Tunnel	0.000-000	0.000-000	0.000-000
46 Tunnel	0.000-000	0.000-000	0.000-000
47 Tunnel	0.000-000	0.000-000	0.000-000
48 Tunnel	0.000-000	0.000-000	0.000-000
49 Tunnel	0.000-000	0.000-000	0.000-000
50 Tunnel	0.000-000	0.000-000	0.000-000
51 Tunnel	0.000-000	0.000-000	0.000-000
52 Tunnel	0.000-000	0.000-000	0.000-000
53 Tunnel	0.000-000	0.000-000	0.000-000
54 Tunnel	0.000-000	0.000-000	0.000-000
55 Tunnel	0.000-000	0.000-000	0.000-000
56 Tunnel	0.000-000	0.000-000	0.000-000
57 Tunnel	0.000-000	0.000-000	0.000-000
58 Tunnel	0.000-000	0.000-000	0.000-000
59 Tunnel	0.000-000	0.000-000	0.000-000
60 Tunnel	0.000-000	0.000-000	0.000-000
61 Tunnel	0.000-000	0.000-000	0.000-000
62 Tunnel	0.000-000	0.000-000	0.000-000
63 Tunnel	0.000-000	0.000-000	0.000-000
64 Tunnel	0.000-000	0.000-000	0.000-000
65 Tunnel	0.000-000	0.000-000	0.000-000
66 Tunnel	0.000-000	0.000-000	0.000-000
67 Tunnel	0.000-000	0.000-000	0.000-000
68 Tunnel	0.000-000	0.000-000	0.000-000
69 Tunnel	0.000-000	0.000-000	0.000-000
70 Tunnel	0.000-000	0.000-000	0.000-000
71 Tunnel	0.000-000	0.000-000	0.000-000
72 Tunnel	0.000-000	0.000-000	0.000-000
73 Tunnel	0.000-000	0.000-000	0.000-000
74 Tunnel	0.000-000	0.000-000	0.000-000
75 Tunnel	0.000-000	0.000-000	0.000-000
76 Tunnel	0.000-000	0.000-000	0.000-000
77 Tunnel	0.000-000	0.000-000	0.000-000
78 Tunnel	0.000-000	0.000-000	0.000-000
79 Tunnel	0.000-000	0.000-000	0.000-000
80 Tunnel	0.000-000	0.000-000	0.000-000
81 Tunnel	0.000-000	0.000-000	0.000-000
82 Tunnel	0.000-000	0.000-000	0.000-000
83 Tunnel	0.000-000	0.000-000	0.000-000
84 Tunnel	0.000-000	0.000-000	0.000-000
85 Tunnel	0.000-000	0.000-000	0.000-000
86 Tunnel	0.000-000	0.000-000	0.000-000
87 Tunnel	0.000-000	0.000-000	0.000-000
88 Tunnel	0.000-000	0.000-000	0.000-000
89 Tunnel	0.000-000	0.000-000	0.000-000
90 Tunnel	0.000-000	0.000-000	0.000-000
91 Tunnel	0.000-000	0.000-000	0.000-000
92 Tunnel	0.000-000	0.000-000	0.000-000
93 Tunnel	0.000-000	0.000-000	0.000-000
94 Tunnel	0.000-000	0.000-000	0.000-000
95 Tunnel	0.000-000	0.000-000	0.000-000
96 Tunnel	0.000-000	0.000-000	0.000-000
97 Tunnel	0.000-000	0.000-000	0.000-000
98 Tunnel	0.000-000	0.000-000	0.000-000
99 Tunnel	0.000-000	0.000-000	0.000-000
100 Tunnel	0.000-000	0.000-000	0.000-000

[Ground Analysis Result Report]

From the Design & Report Tree, **Report > Ground > double click Adjacent Structure Check**

**1. Adjacent Structures Review Results**

**1.1 Settlement check for adjacent structures**

**1.1.1 Alternative sinking calculation method**

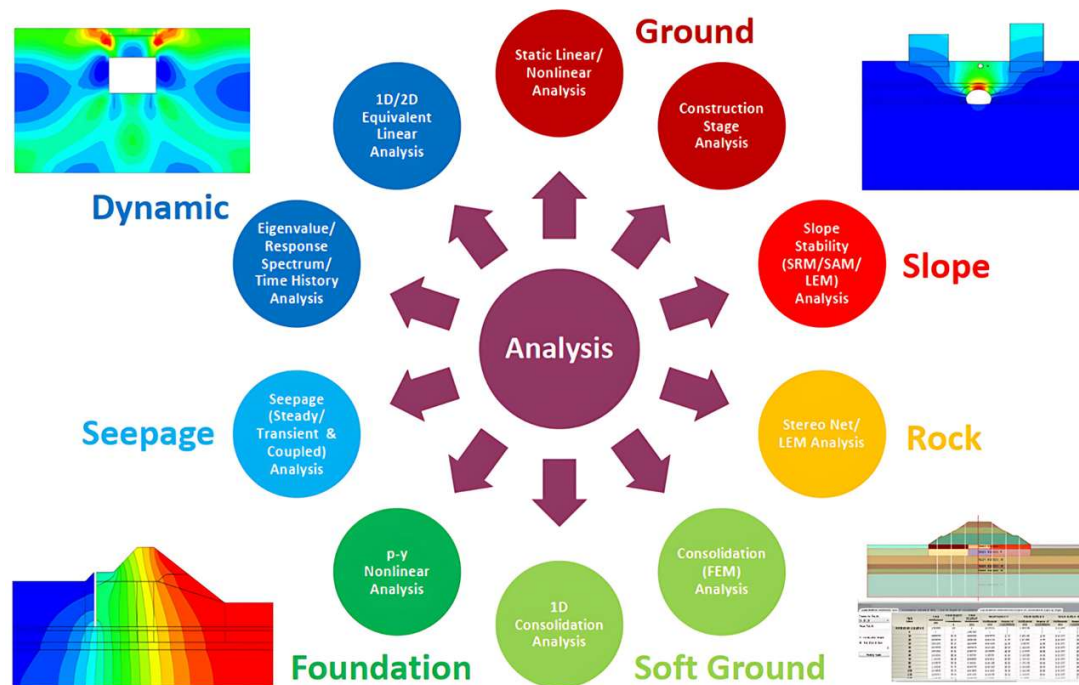
- Check errors
- Enhance analytical skills



## 6. SMART Analysis

### Various analysis type 👍

Robust parametric analysis capability and data interface between modules



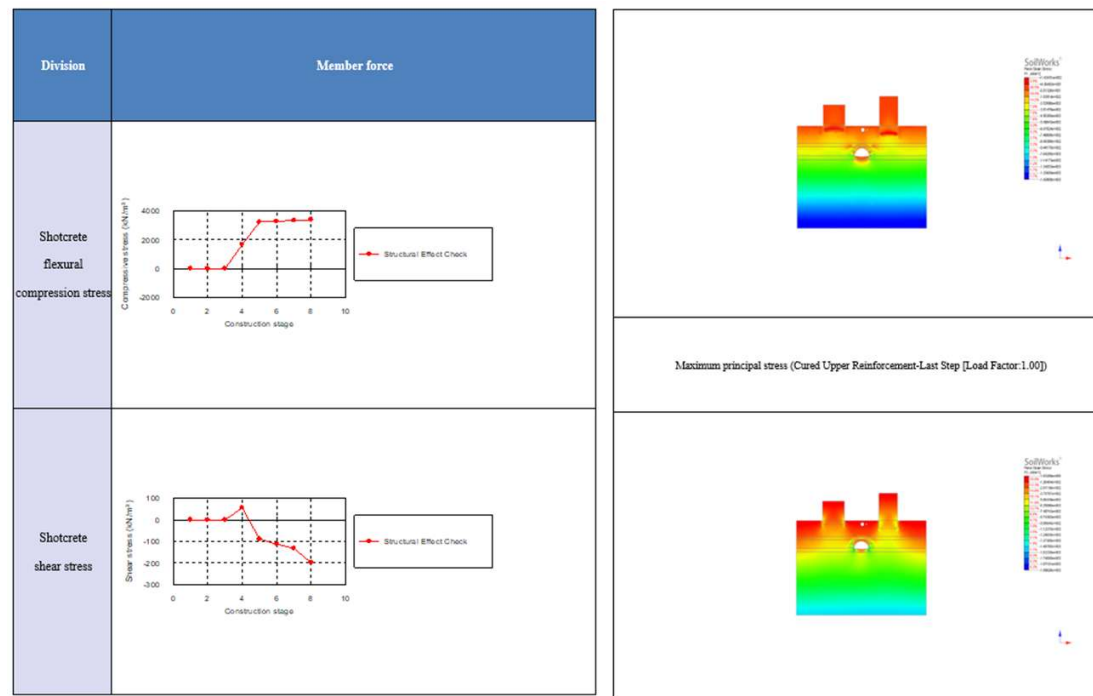
- Robust parametric analysis
- Coupled analysis



## 7. SMART Results

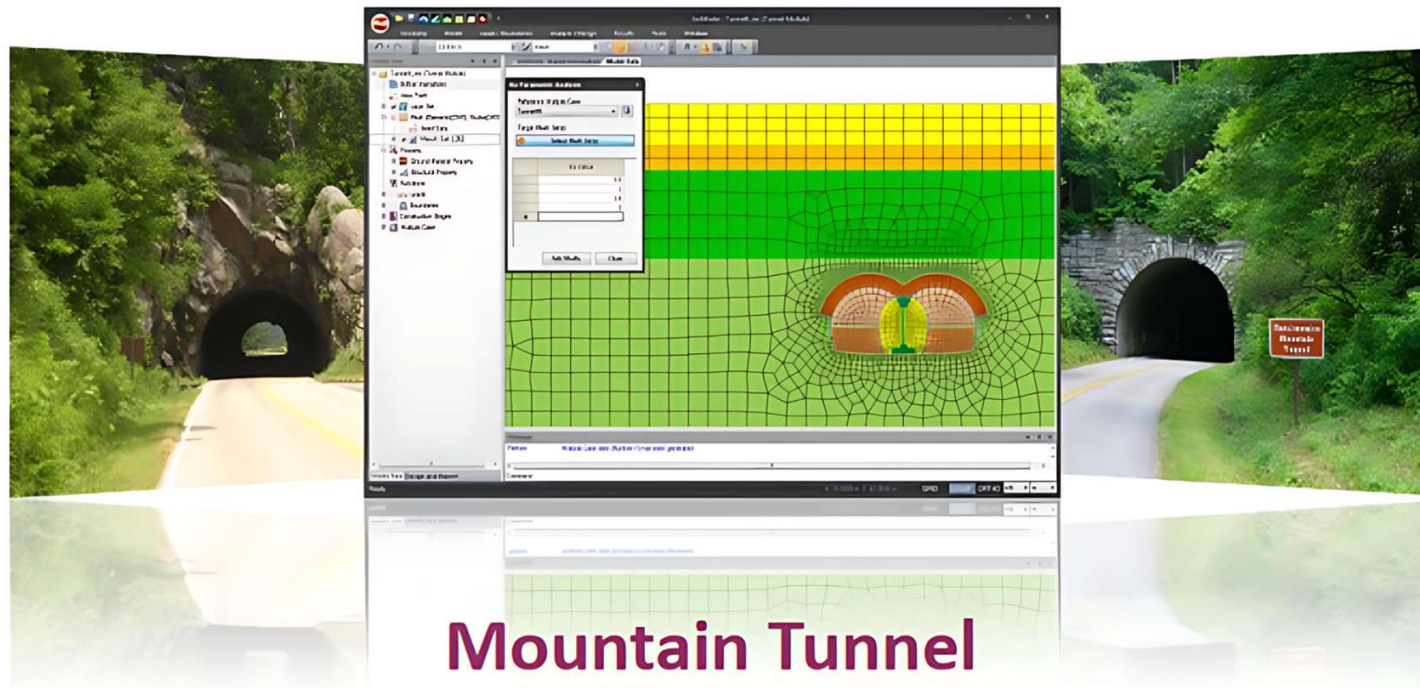
### Easy for observing results 👍

Auto-generation of high quality reports



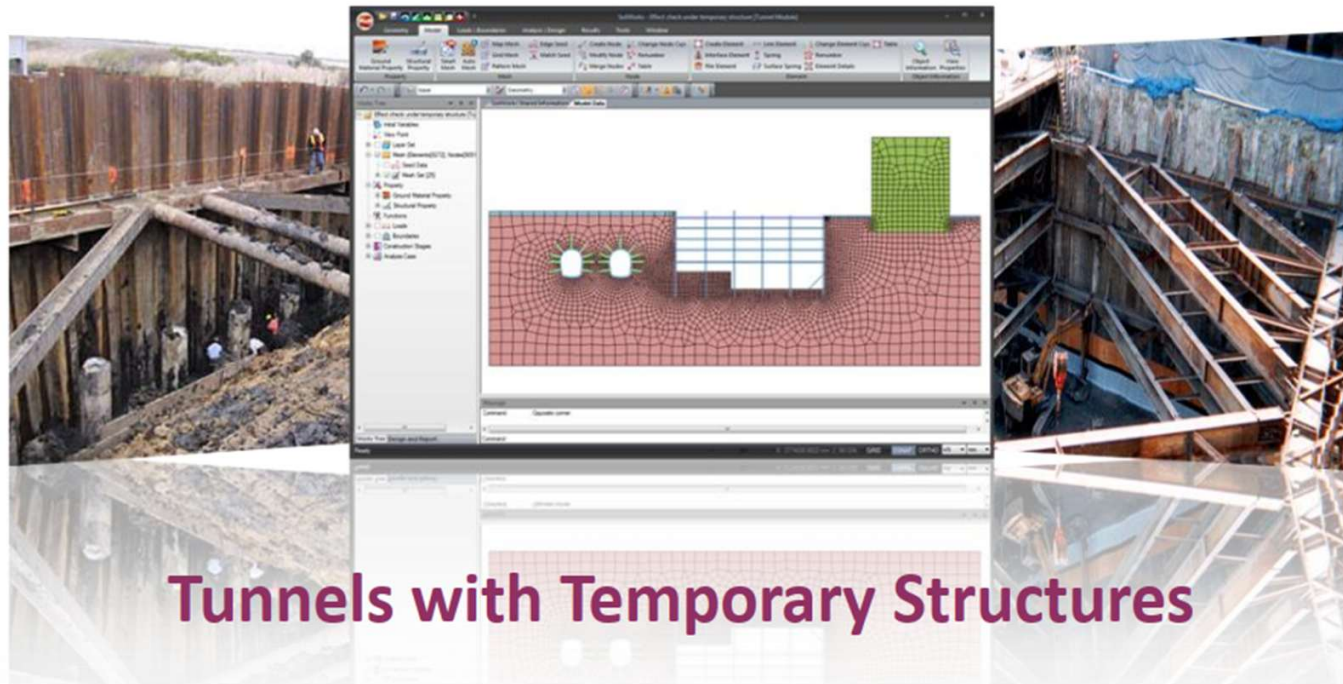
- High quality report generation
- Simplify work process
- Increase productivity

# Project application



- Stress & deformation check through change in  $K_0$
- Stability check for central pillar
- Considering the reinforced zone

# Project application



- Check the differential settlement of the adjacent building
- Tunnel stability check during the excavation work
- Excavation analysis considering temporary structures

## Project application



- Check the differential settlement of the adjacent building
- Stability check for the existing sewer pipes
- Shallow tunnel stability check considering reinforced zone



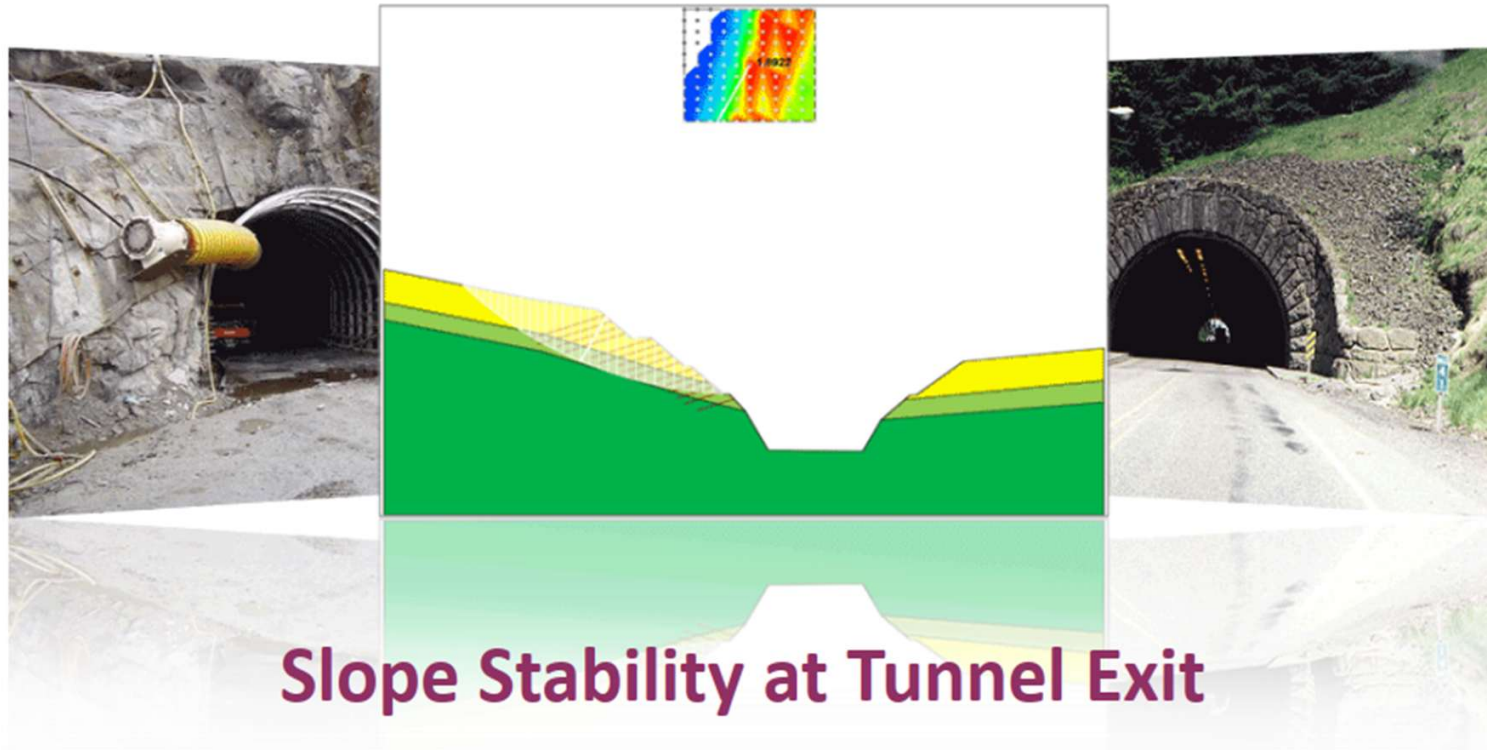
# Project application



## Reinforcement for Cut Slopes

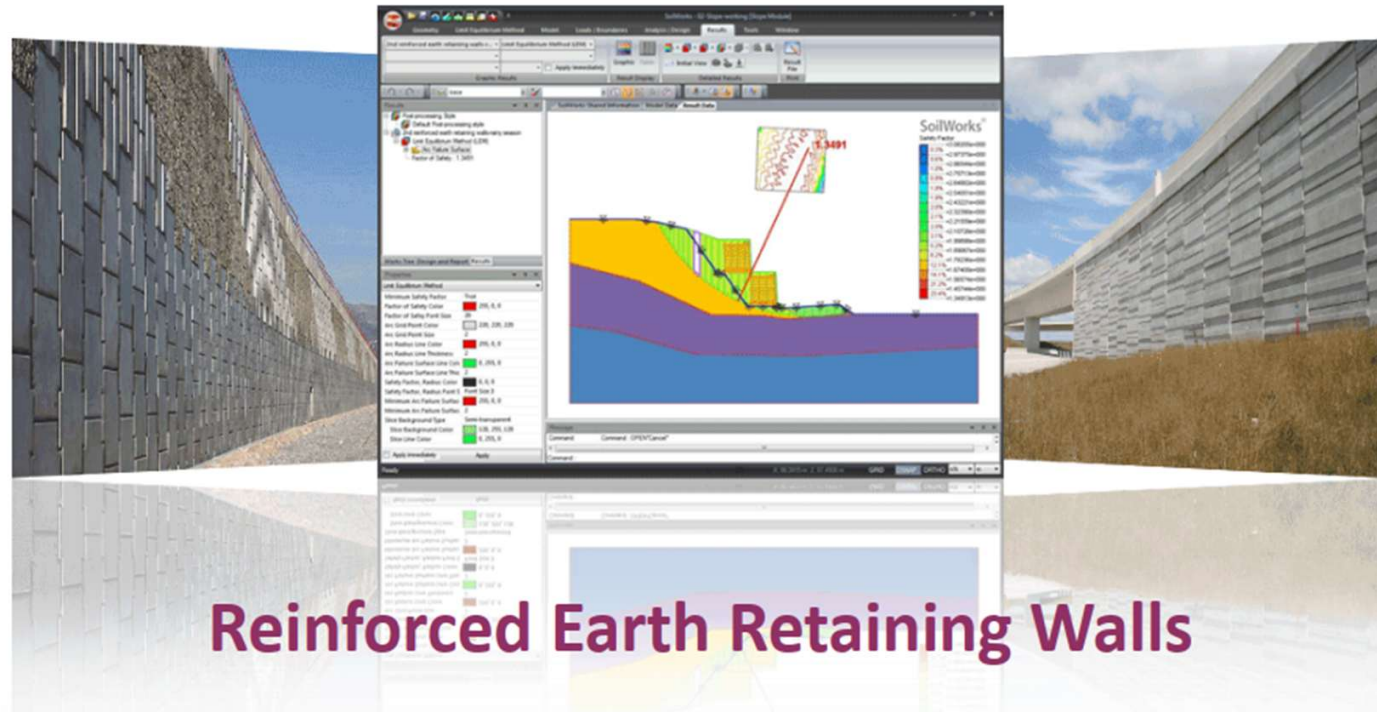
- Simultaneous analysis of reinforced/ unreinforced slopes
- Considering dry/ rainy seasons conditions
- Stability check reflecting the rainfall intensity

## Project application



- Stability check for the both side of slopes
- Calculation of safety factors by SRM as well as LEM
- Pseudo static analysis considering seismic loading condition

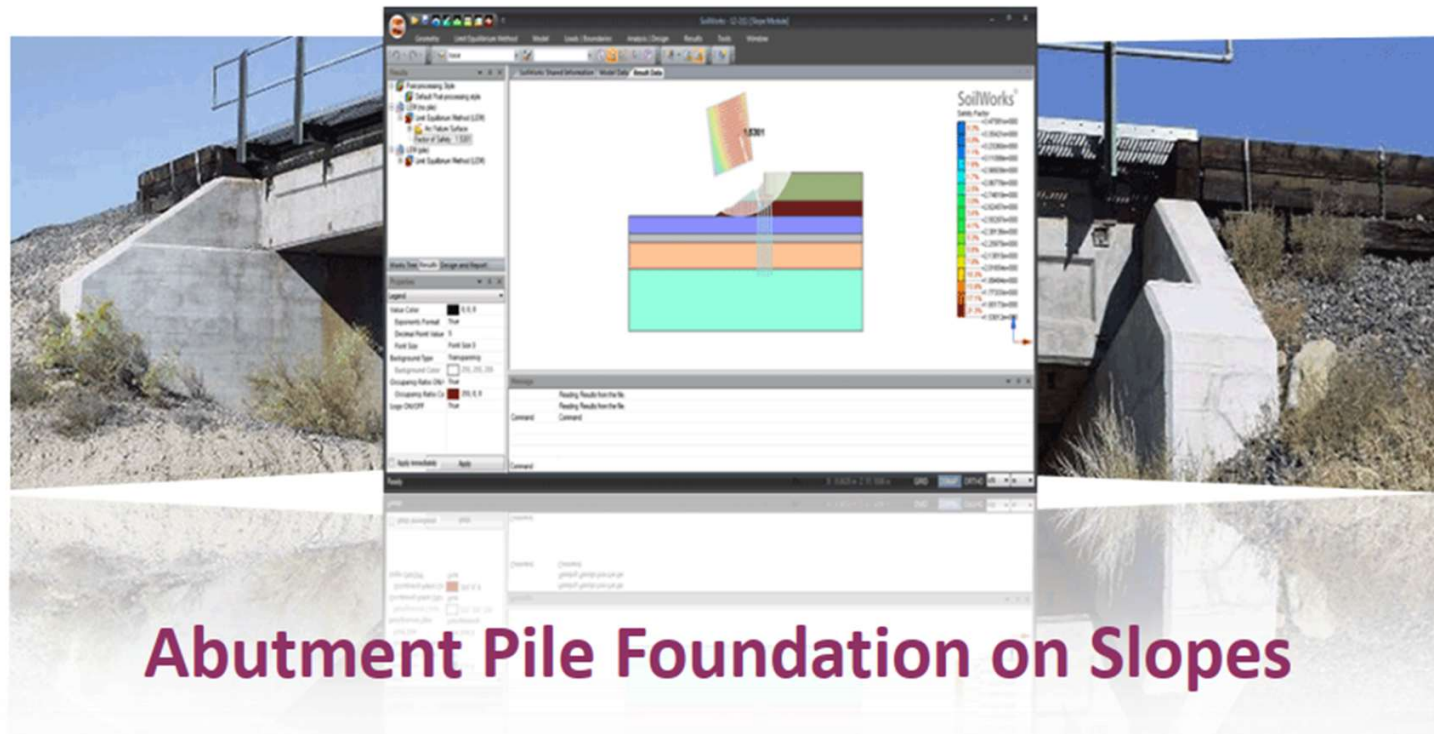
# Project application



## Reinforced Earth Retaining Walls

- Stability check reflecting multiple arc failure surfaces
- Reflecting various practical reinforcement materials
- Considering dry/ rainy season conditions

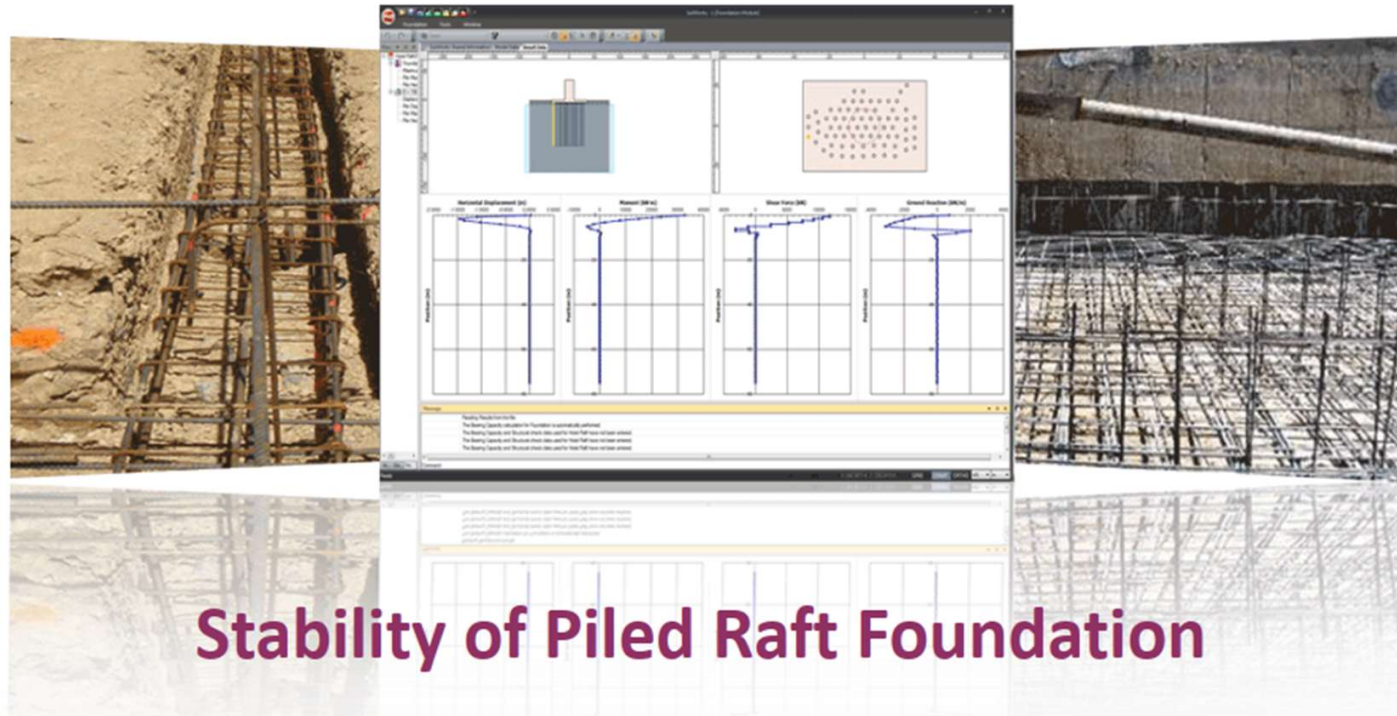
# Project application



- Lateral displacements of an abutment foundation system
- P-y analysis for pile foundations
- Construction stage analysis reflecting excavation and backfill

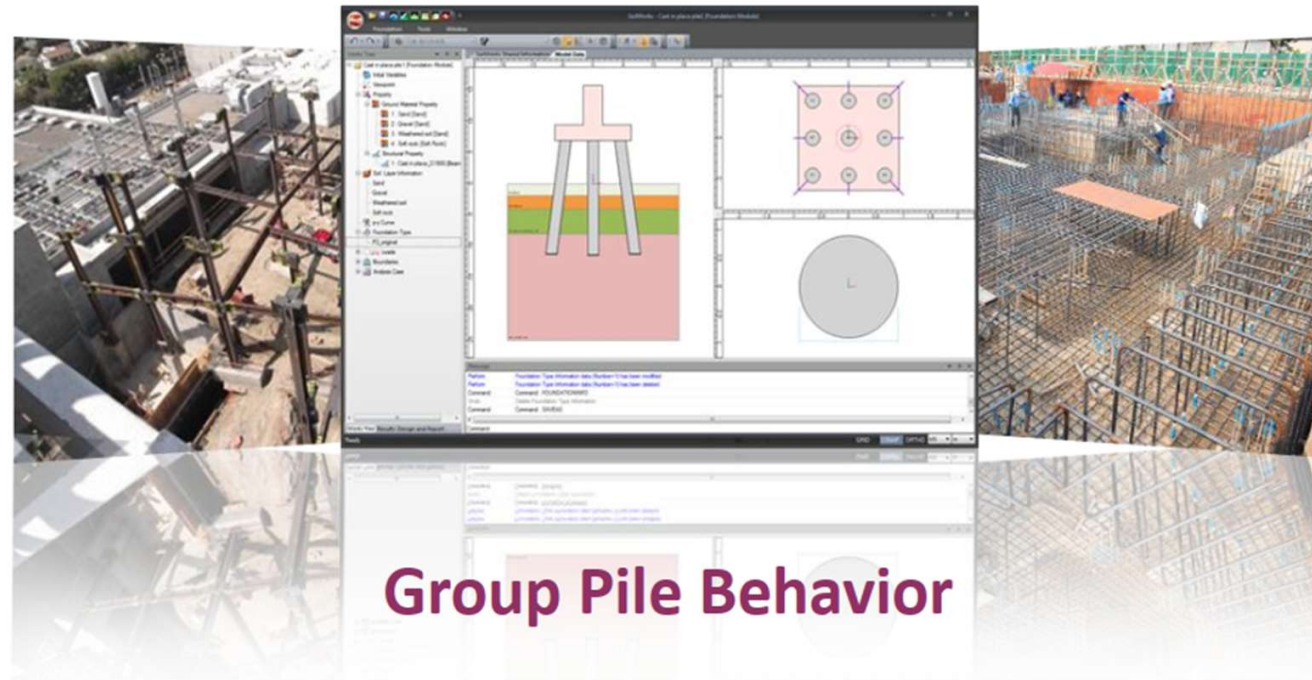


# Project application



- Stability check for the building foundation system
- Group pile analysis for 76 cast-in-place piles
- Considering horizontal and vertical loading conditions

# Project application



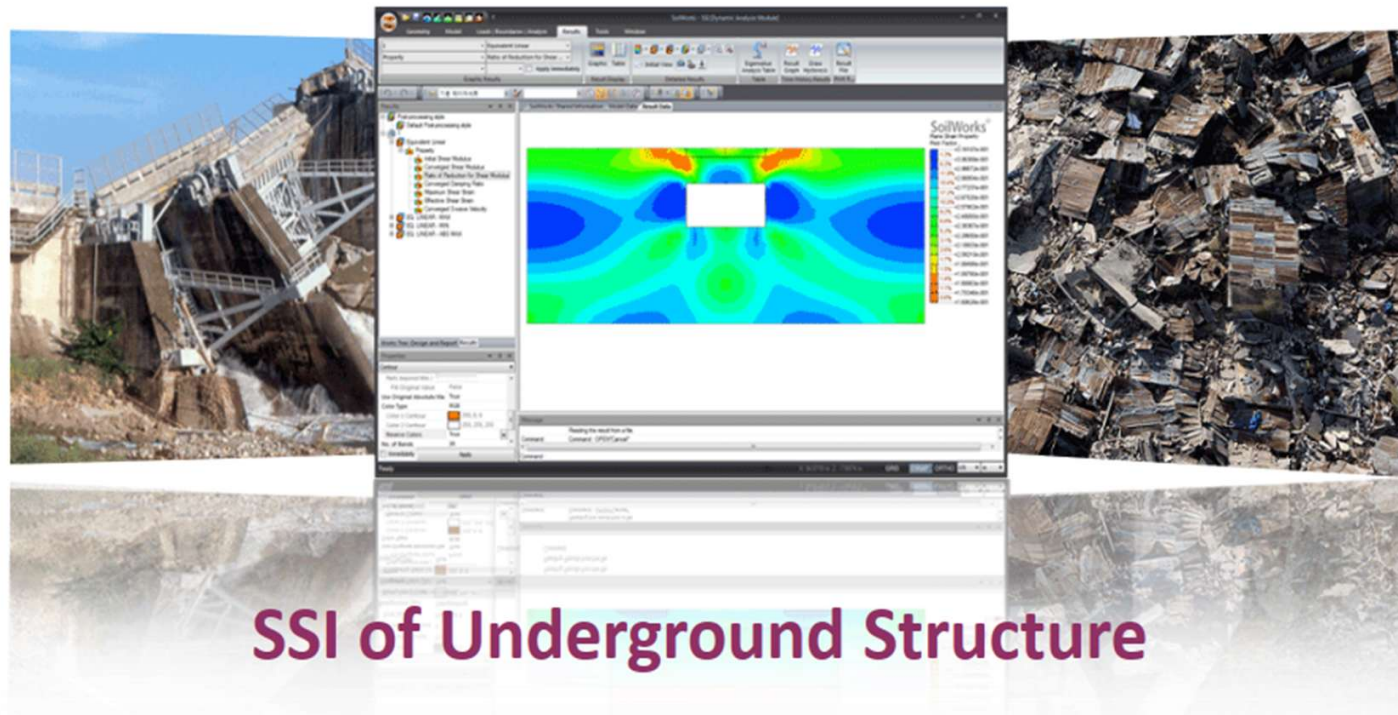
- Vertical and horizontal displacements check for the battered pile
- Checking member forces for determining pile type/ shape/ size
- Results comparison with 3D FEM analysis

# Project application



- Calculation of primary & secondary consolidation settlements
- Parametric analysis for drainage types and spacing
- Check through the 1-D theoretical & finite element analysis

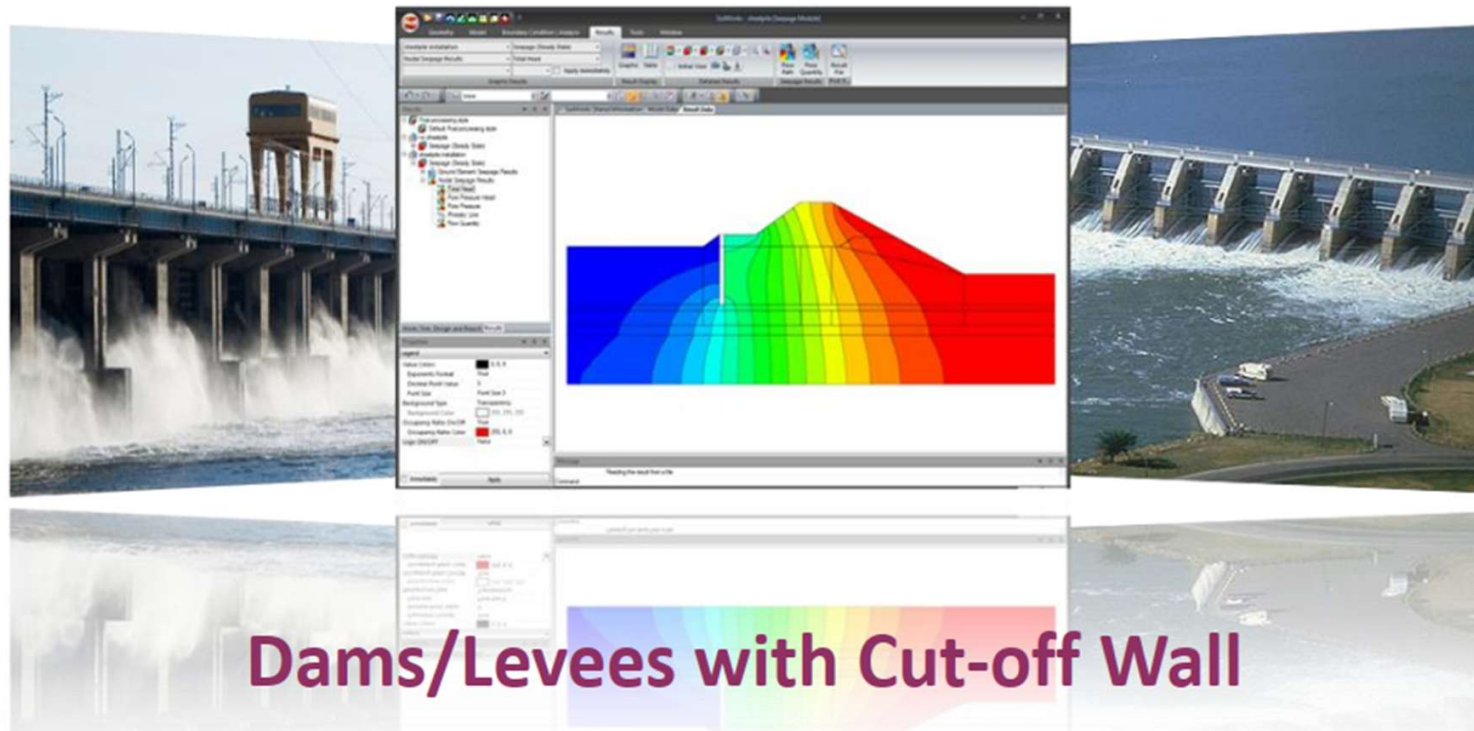
# Project application



- Checking the stability of structures under the seismic condition
- Applying the historical seismic waves and artificial waves
- Considering dynamic nonlinear properties of ground



# Project application



- Checking the optimal embedded depth of a sheet pile
- Checking the outflow speed at the protected side
- Seepage-stress coupled analysis

# Why SoilWorks?

## 7 smart features

- 👍 Save modeling and learning time
- 👍 Practical results
- 👍 Report generation

## Engineer support

- 👍 Engineer: easy to use with no in-depth FEM knowledge
- 👍 Senior engineer: simple design works

## 7-in-1 software

- 👍 Requires only 1 software for all geotechnical work

Thank you! 

**MIDAS**

[www.midasuser.com.tw](http://www.midasuser.com.tw)



## SoilWorks – Ground Module

# Analysis of Shored Excavation

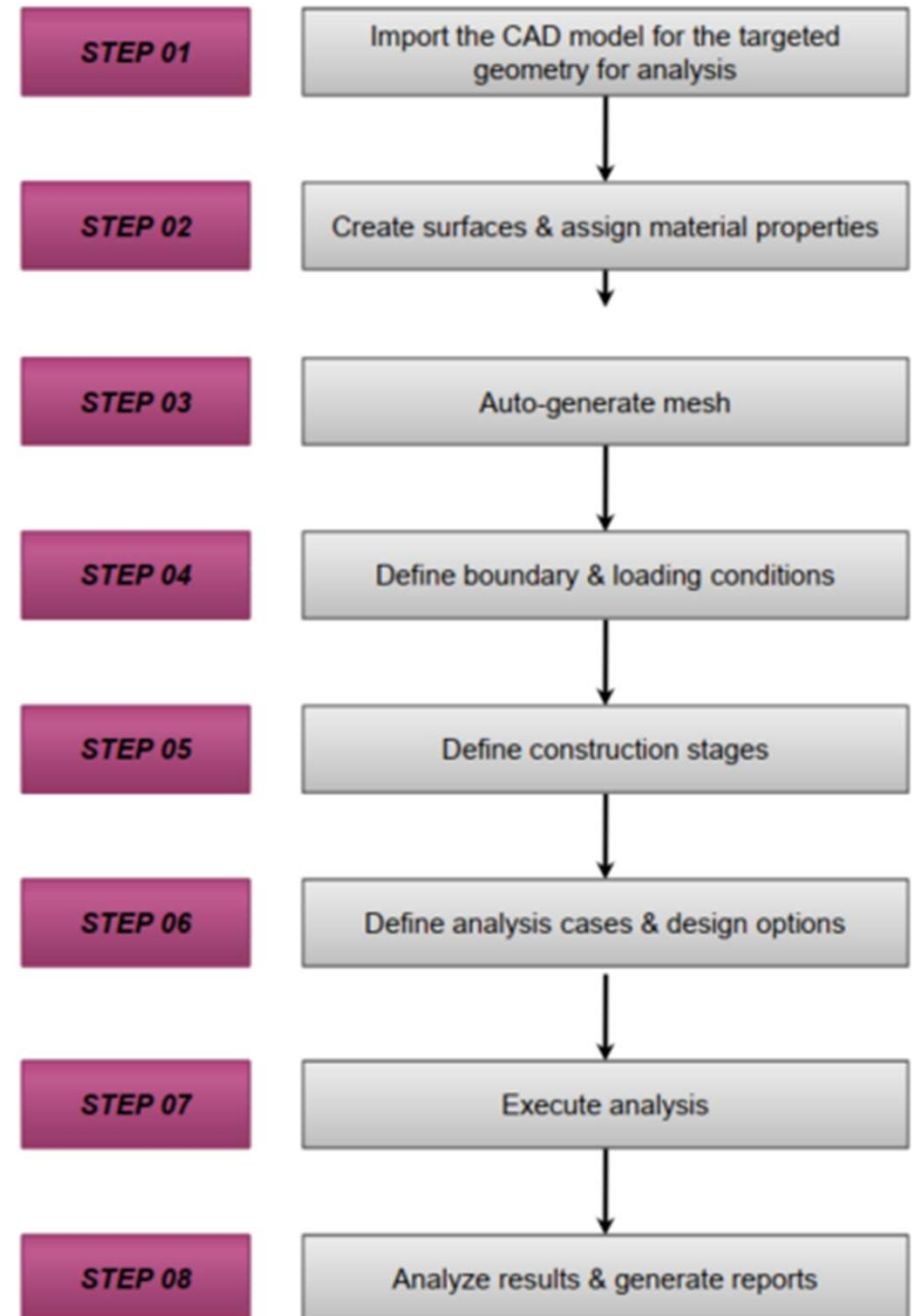
Midas e-mail: [support@midasuser.com](mailto:support@midasuser.com)

My e-mail: [tam@midasuser.com.tw](mailto:tam@midasuser.com.tw)



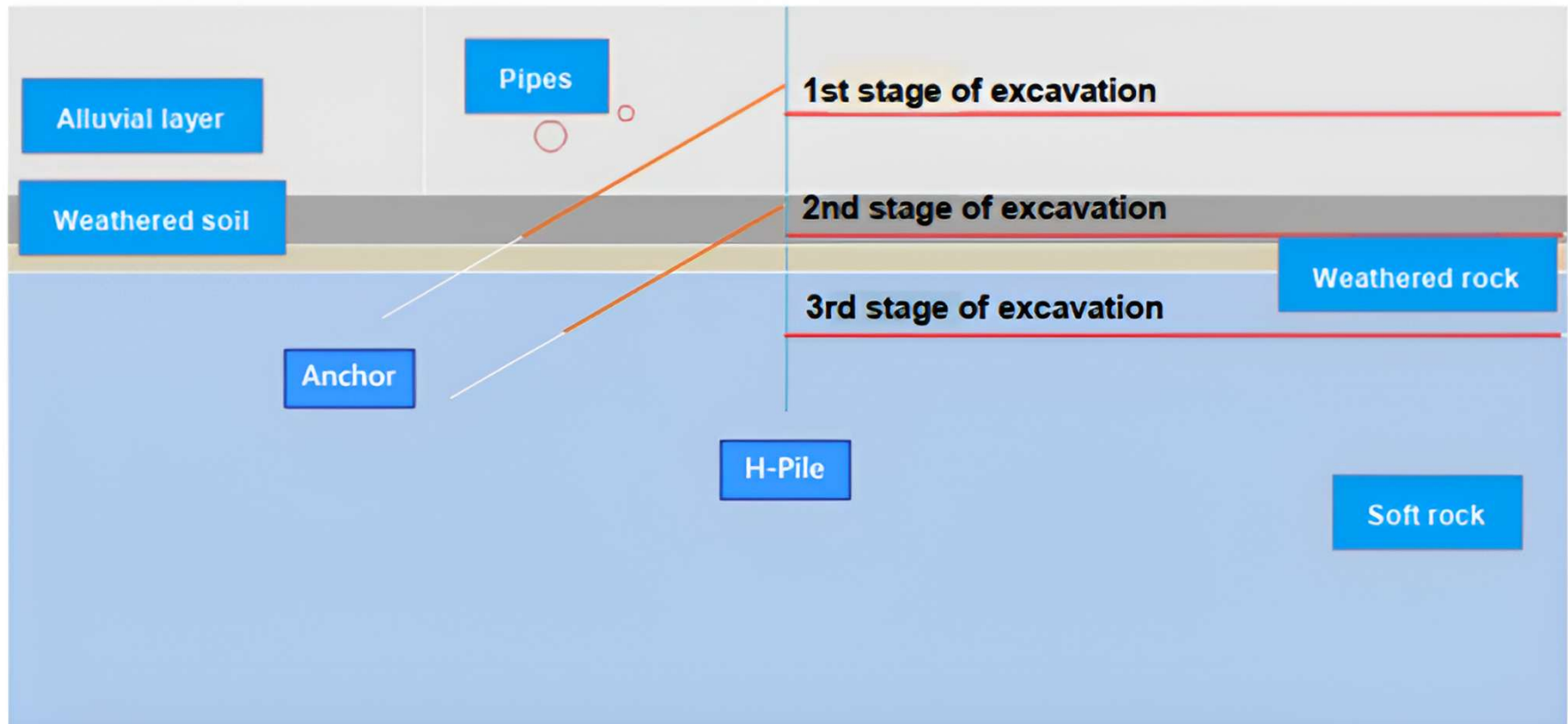
# Learning Objective

- Review of the effects on underground structures due to shored excavation
- Learn various basic functions and the workflow of SoilWorks in the process
- Understand result analysis and report generation



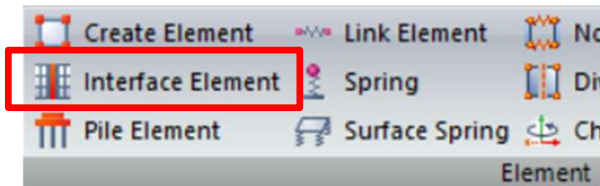
# Overview

- Investigating soil-structure displacements
- Stress distribution and the effects on adjacent structures



Fig, Model configuration

# Interface Wizard



## ► Interface Wizard equation from Midas SoilWorks manual:

$$K_n = E_{\text{oed},i} / t_v$$

$$K_t = G_i / t_v$$

$$C_i = R \times C_{\text{soil}}$$

Here,

$$E_{\text{oed},i} = 2 \times G_i \times (1 - v_i) / (1 - 2 \times v_i)$$

$$G_i = R^2 \times G_{\text{soil}}$$

$$G_{\text{soil}} = E / (2(1 + v_{\text{soil}}))$$

Where,

$K_n$ : Normal Stiffness Modulus

$K_t$ : Shear Stiffness Modulus

$t_v$ : Virtual Thickness Factor

$R$ : Strength Reduction Factor

$C_i$ : Interface Cohesion

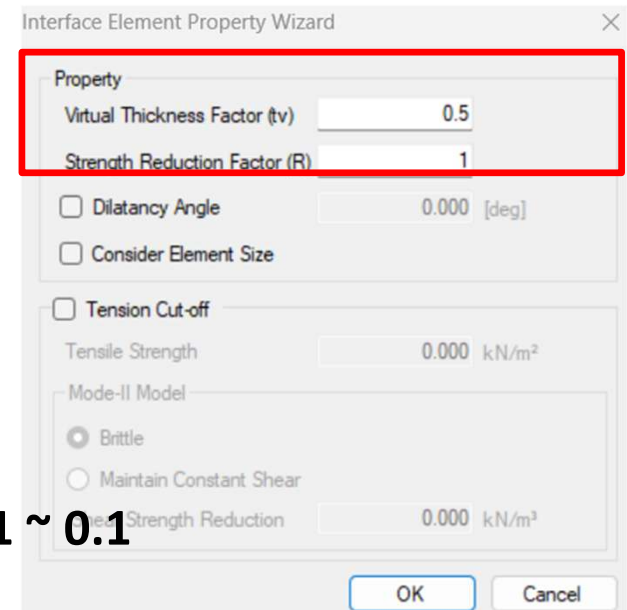
**$K_n$  (Normal stiffness modulus)** is the elasticity modulus for bonding and un-bonding behavior in the normal direction to the interface element

**$K_t$  (Shear stiffness modulus)** is the elasticity modulus for slip behavior in the normal direction to the interface element

## ► Strength Reduction factor (R)

- Sandy soil/ Steel material:  $R = 0.6 \sim 0.7$
- Clay/ Steel material:  $R = 0.5$
- Sandy soil/ Concrete:  $R = 1.0 \sim 0.8$
- Clay/ Concrete:  $R = 1.0 \sim 0.7$

The general **Virtual Thickness Factor** range is **0.01 ~ 0.1**  
(If the stiffness is high, use a smaller value)



# Learning Objective

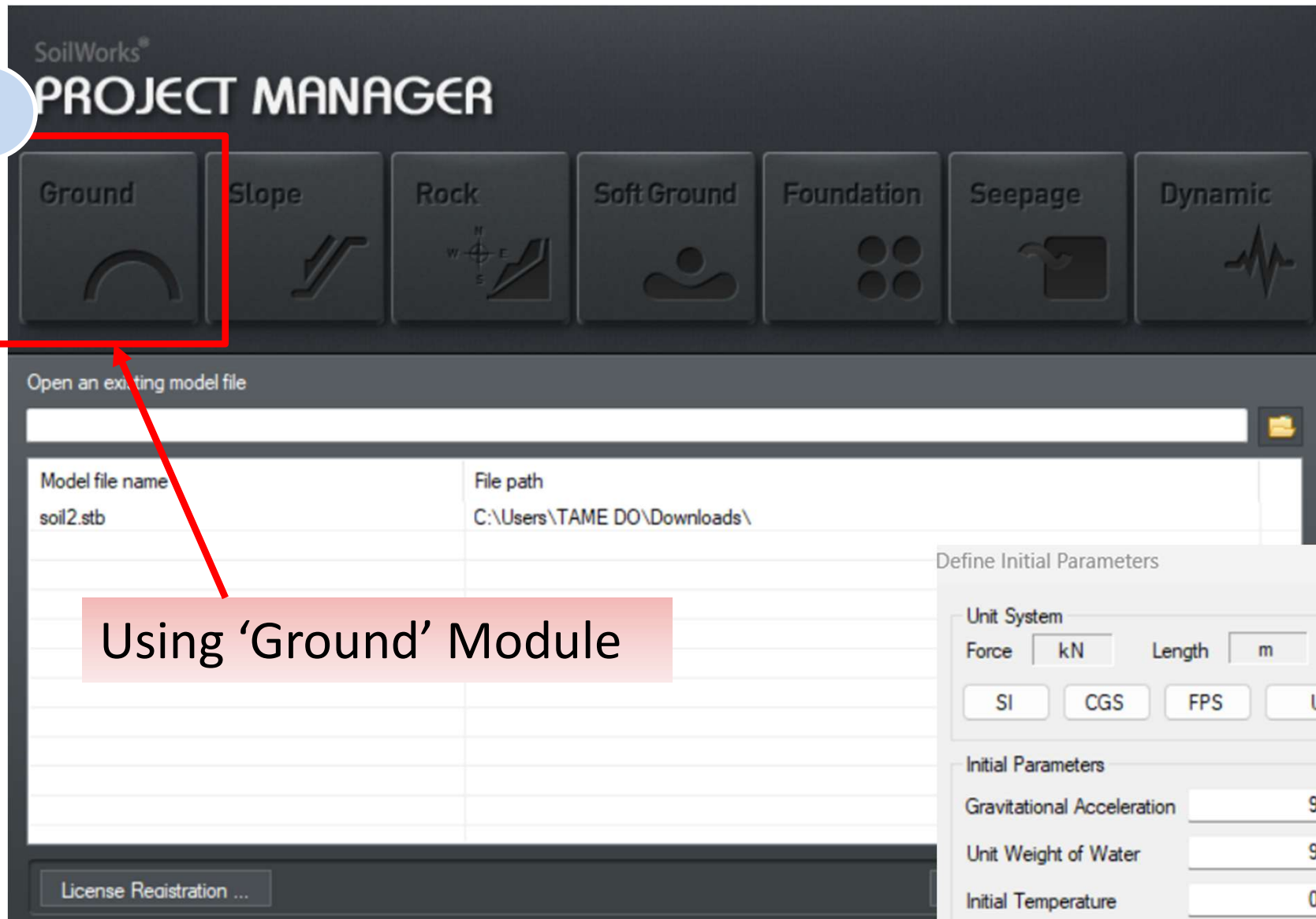
## ► Ground properties

No	Ground Type	Model Type	Modulus of Elasticity (kN/m <sup>2</sup> )	Unit Weight (kN/m <sup>3</sup> )	Saturated Unit Weight (kN/m <sup>3</sup> )	Poisson's Ratio	Cohesion (kN/m <sup>2</sup> )	Internal Friction Angle (degree)
1	Alluvial layer	Mohr Coulomb	8,000	17	18	0.35	15	20
2	Weathered soil	Mohr Coulomb	36,500	18.5	19.5	0.33	17.5	31
3	Weathered rock	Mohr Coulomb	150,000	21	22	0.3	50	33
4	Soft rock	Mohr Coulomb	1,850,000	24	25	0.28	180	35.5

## ► Structural properties

No	Structure Type	Model Type	Modulus of Elasticity (kN/m <sup>2</sup> )	Poisson's Ratio	Unit Weight (kN/m <sup>3</sup> )	Horizontal spacing (m)	Section (m)	Design Strength (kN/m <sup>2</sup> )
1	Pipe	Beam	230,000,000	0.3	24	1	Rectangle H: 0.03 m, B : 1 m	
2	H-Pile	Beam	210,000,000	0.3	77	1.8	H: 298x201x9/14(mm)	Yield: 240,000
3	Anchor	Embedded Truss	200,000,000	0.3	77	2.7	Area: 0.00039484(m <sup>2</sup> )	Yield: 1,570,000

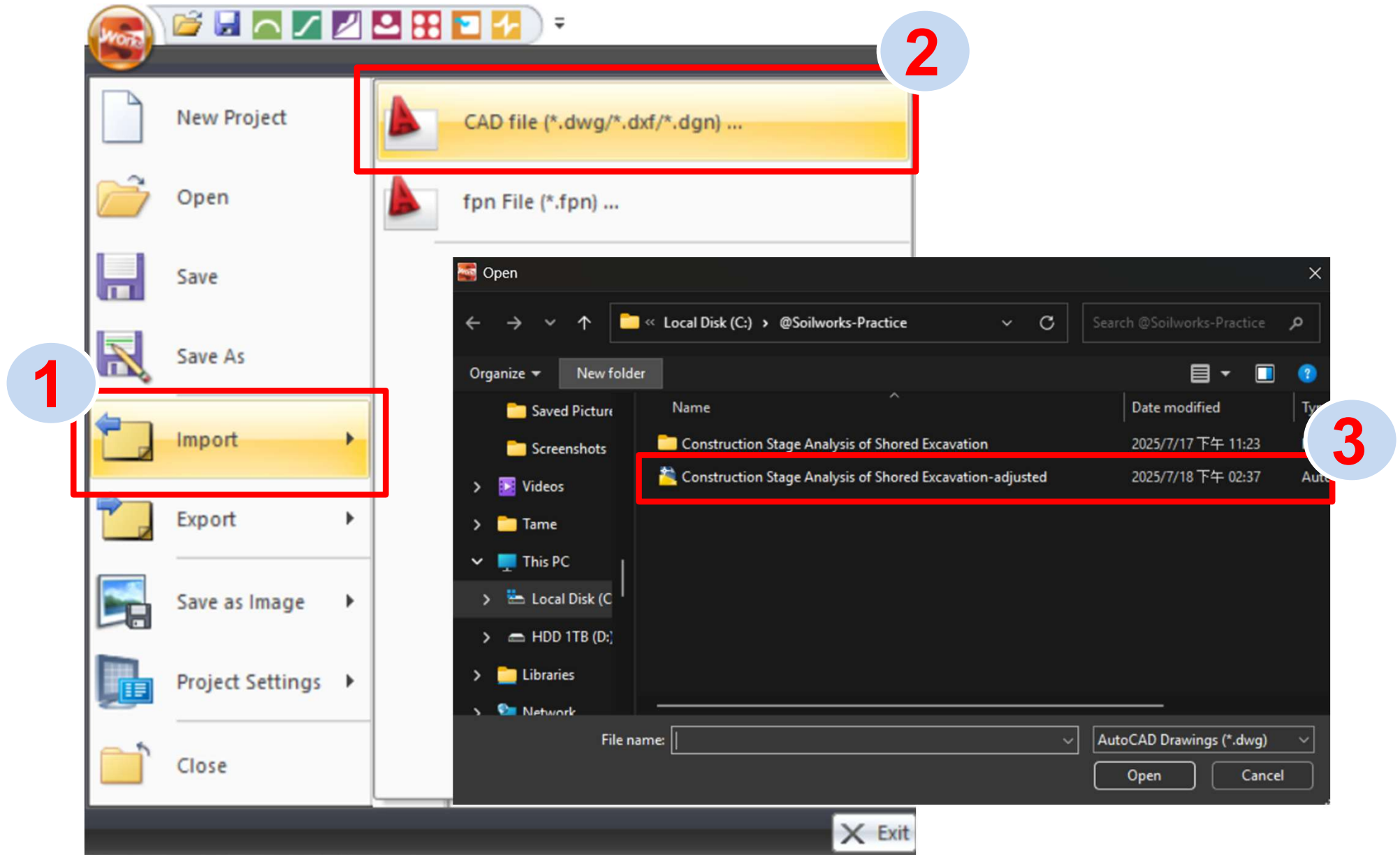
# Start SoilWorks



Using 'Ground' Module

Setting initial values

# Import File





# Define Ground Properties

Define Ground Material Property

**6**

ID	Name
1	Alluvial Layer
2	Weathered Soil
3	Weathered R...
4	Soft Rock

**2**

Database ...

**1**

Ground Material Property

**3**

Ground Material Database

Database: 1.1 Schist#1

No.	Soil Type	Modulus of Elasticity (kN/m <sup>2</sup> )	Unit Weight (kN/m <sup>3</sup> )	Saturated Unit Weight (kN/m <sup>3</sup> )	Poisson's Ratio	Cohesion (kN/m <sup>2</sup> )	Internal Friction Angle ([deg])	Select
1	Landfill Layer	13000	18	18	0.33	0	27	<input type="checkbox"/>
2	Alluvial Layer	8000	17	18	0.35	15	20	<input checked="" type="checkbox"/>
3	Weathered Soil	36500	18.5	19.5	0.33	17.5	31	<input checked="" type="checkbox"/>
4	Weathered Rock	150000	21	22	0.3	50	33	<input checked="" type="checkbox"/>
5	Soft Rock	1850000	24	25	0.28	180	35.5	<input checked="" type="checkbox"/>
6	Hard Rock	17500000	26	27	0.23	1750	40.5	<input type="checkbox"/>

**4**

**5**

Assign

**General**

ID: 1 Name: [ ]

Model Type: Mohr-Coulomb

**General Parameters**

Modulus of Elasticity (E)	20000000	kN/m <sup>2</sup>
Poisson's Ratio (ν)	0.3	
Temperature Coeff. (α)	1E-06	
Unit Weight (γ <sub>t</sub> )	20	kN/m <sup>3</sup>
Saturated Unit Weight	21	kN/m <sup>3</sup>
Cohesion (c)	30	kN/m <sup>2</sup>
Internal Friction Angle (Φ)	36	[deg]
Earth Pressure Coeff. (K <sub>0</sub> )	1	
Draining Condition	Drained	

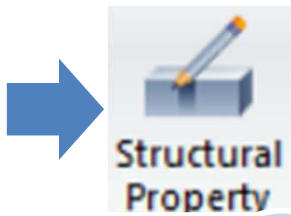
**Additional Parameters**

Variation in Modulus of Elasticity	0	kN/m <sup>2</sup>
Variation in Cohesion	0	kN/m <sup>2</sup>
Reference Height	0	m
<input type="checkbox"/> Dilatancy Angle (Ψ)	36	[deg]
<input type="checkbox"/> Tensile Strength	2000	kN/m <sup>2</sup>
<input type="checkbox"/> Calculate Safety Factor (Mohr-Coulomb)		
Cohesion (c)	30	kN/m <sup>2</sup>
Internal Friction Angle (φ)	36	[deg]

Reset Save Model Type: Mohr-Coulomb **5** Assign Close

MIDAS

# Define Strutural Properties



General

ID 1

Name Pipe

Element Type Beam

Standard NONE

Horizontal Spacing 1.000 m

Section

Shape Rectangle ☐ Tapered Section

Sub-Shapes U Type

Section User Defined

Section-2 User Defined

Material

Material Type User Defined

Concrete User Defined

Steel Grade User Defined

Section Data

Section

H 0.3 m

B 1 m

Stiffness Calculation

Area	0.3 m <sup>2</sup>
Iy	0.00225 m <sup>4</sup>
Zy	0.015 m <sup>3</sup>
Ry	0.086603 m

Material Data

User Defined

Steel

Properties

Modulus of Elasticity	230000000 kN/m <sup>2</sup>
Poisson's Ratio	0.3
Unit Weight	24 kN/m <sup>3</sup>
Thermal Coefficient	5.5E-06

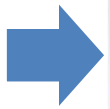
Design Strength

Allowable Comp.	9600 kN/m <sup>2</sup>
Allowable Tens. Stress	640 kN/m <sup>2</sup>
Allowable Shear	400 kN/m <sup>2</sup>

Add Modify Delete Close

Define: 'Pile Property'





# Define Ground Properties

**General**

ID 1

Name H-Pile

Element Type Beam

Standard NONE

Horizontal Spacing 1.8 m

**Section**

Shape H

☐ Tapered Section

Sub-Shapes U Type

Section User Defined

Section-2 User Defined

**Material**

Material Type Steel

Concrete User Defined

SteelGrade User Defined

**Section Data**

Section

Section	
H	0.298 m
B1	0.201 m
tw	0.009 m
tf1	0.014 m
B2	0 m
tf2	0 m

**Stiffness Calculation**

Area	0.008058 m <sup>2</sup>
Iy	0.000128 m <sup>4</sup>
Zy	0.000861 m <sup>3</sup>
Ry	0.126201 m

**Material Data**

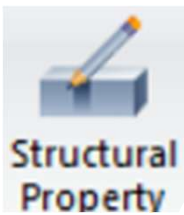
User Defined

Steel

**Properties**

Modulus of Elasticity	230000000 kN/m <sup>2</sup>
Poisson's Ratio	0.3
Unit Weight	24 kN/m <sup>3</sup>
Thermal Coefficient	0.000006
<b>Design Strength</b>	
Yield Strength	240000 kN/m <sup>2</sup>

Add Modify Delete Close



# Define Ground Properties

**1**

**2**

General

ID 3

Name Anchor

Element Type Embedded Truss

Standard NONE

Horizontal Spacing 2.7 m

**3**

Section

Shape Strand

Sub-Shapes U Type

Section User Defined

Section-2 User Defined

**4**

Material

Material Type Strand

Concrete User Defined

StrandGrade User Defined

**5**

Section Data

Section

Section-2

**6**

Stiffness

Area 0.00039484 m<sup>2</sup>

**7**

Material Data

User Defined

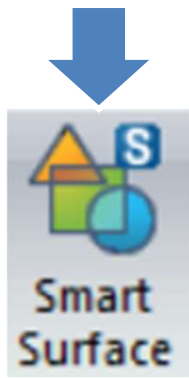
Steel Wire

**8**

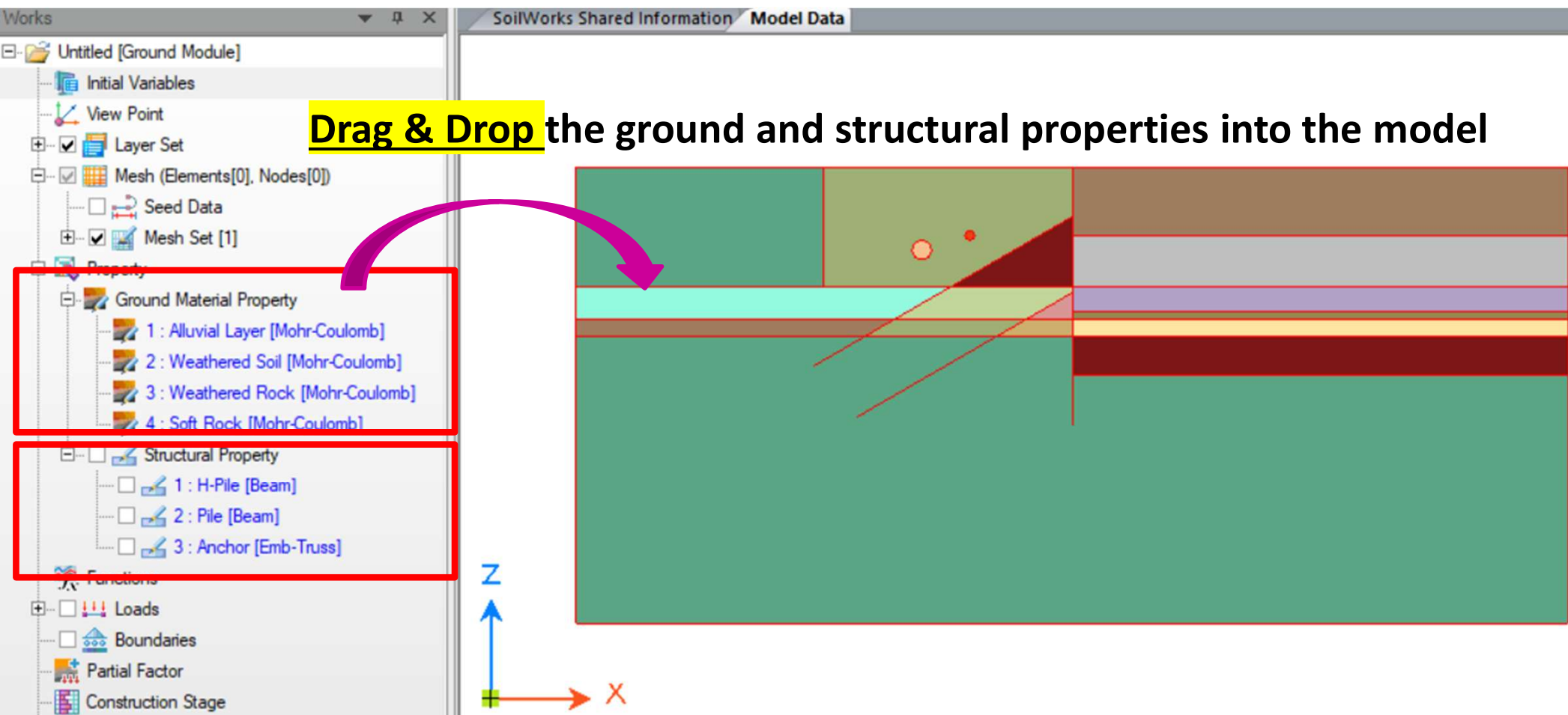
Properties	
Modulus of Elasticity	200000000 kN/m <sup>2</sup>
Poisson's Ratio	0.3
Unit Weight	77 kN/m <sup>3</sup>
Thermal Coefficient	5.5E-06
<b>Design Strength</b>	
Yield Strength	240000 kN/m <sup>2</sup>

**9**

Add Modify Delete Close

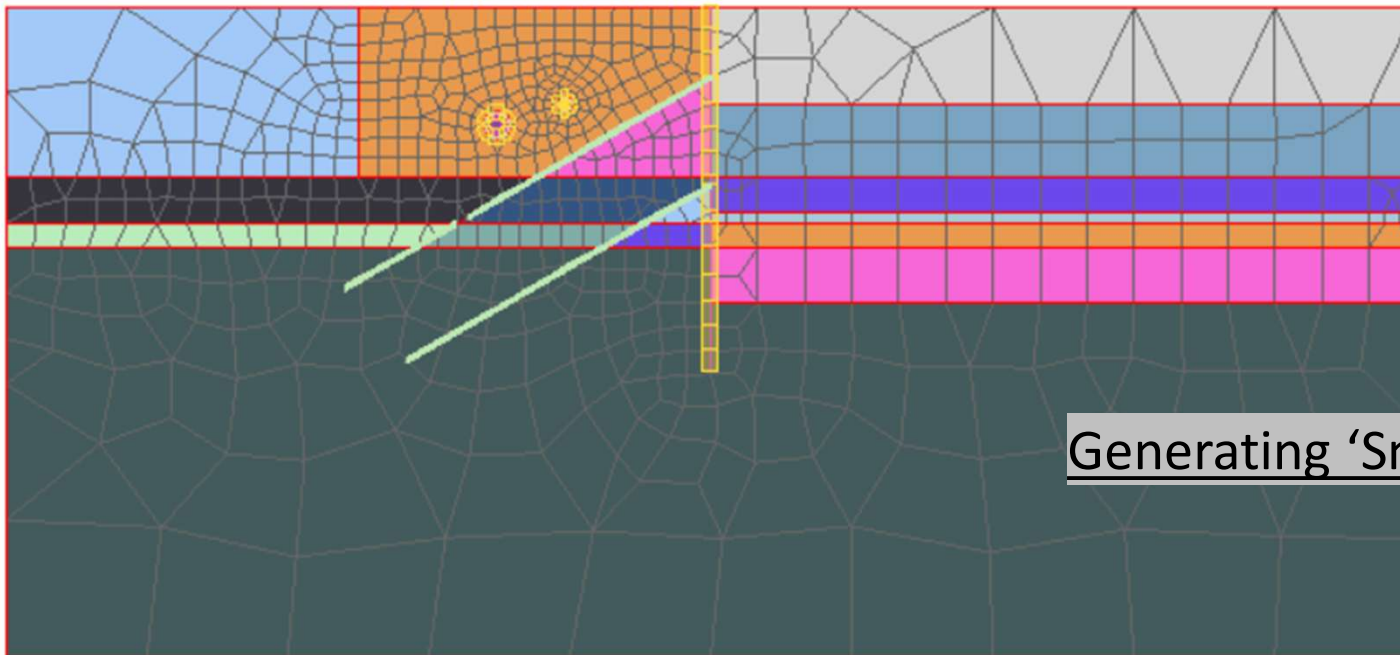
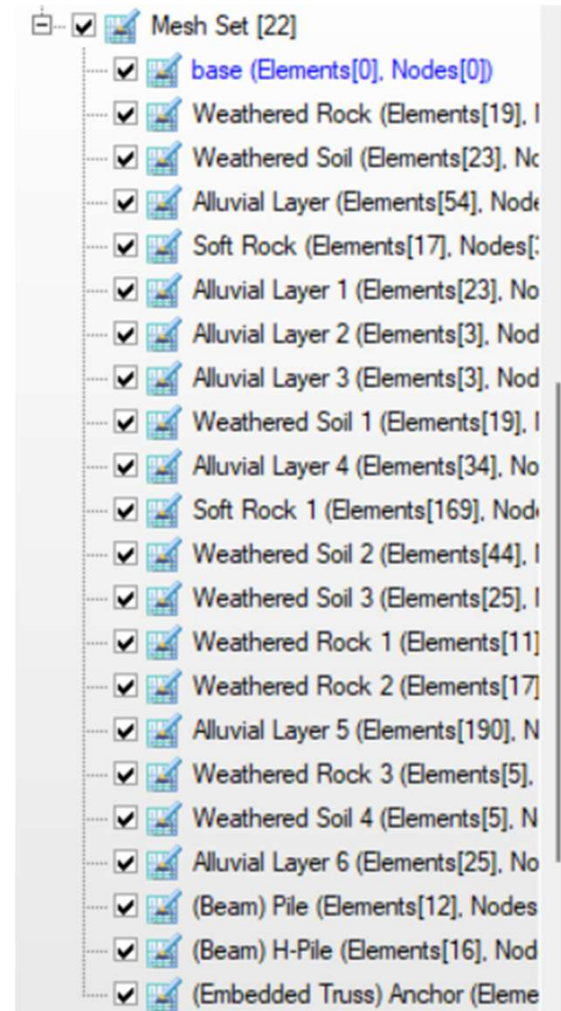
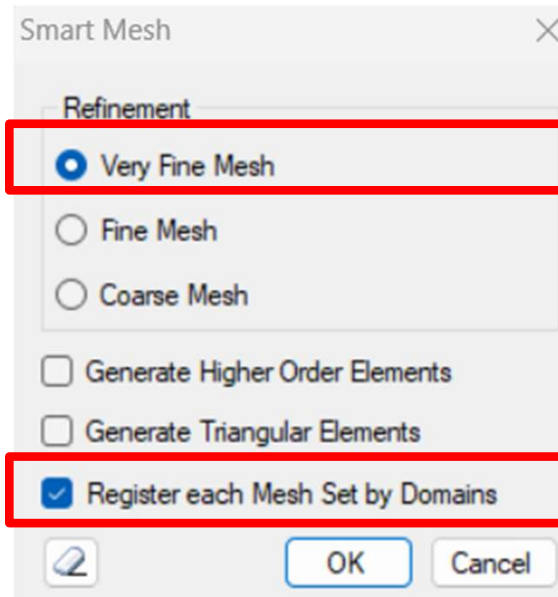
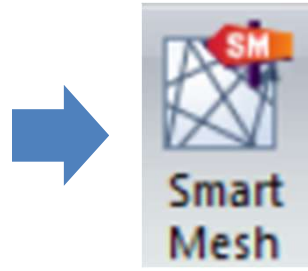


# Smart Surfaces



**Fig,** Creating 'Smart Surfaces' automatically

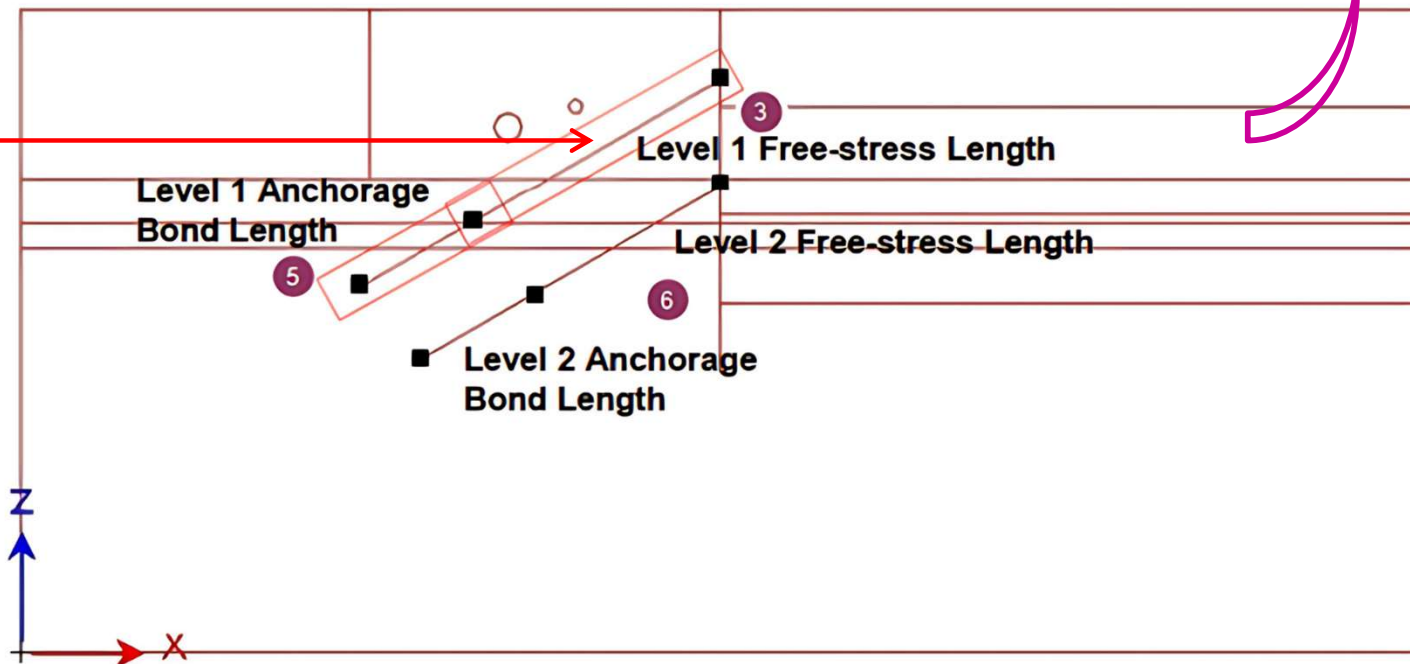
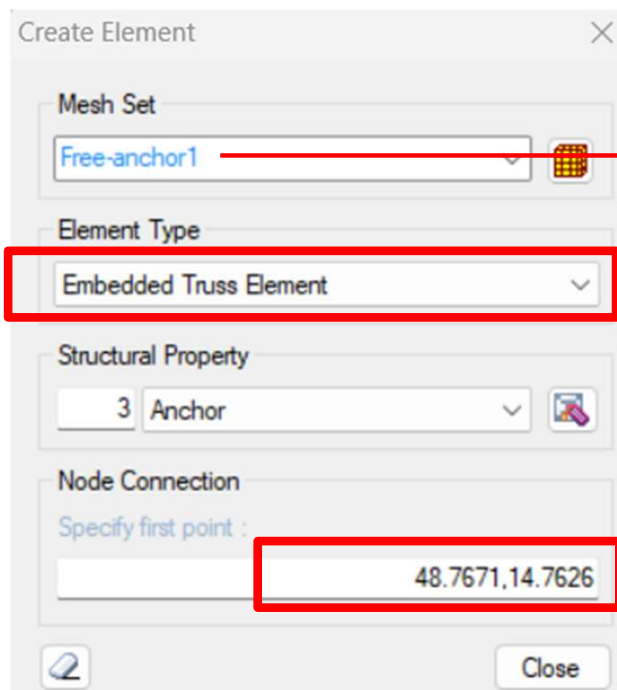
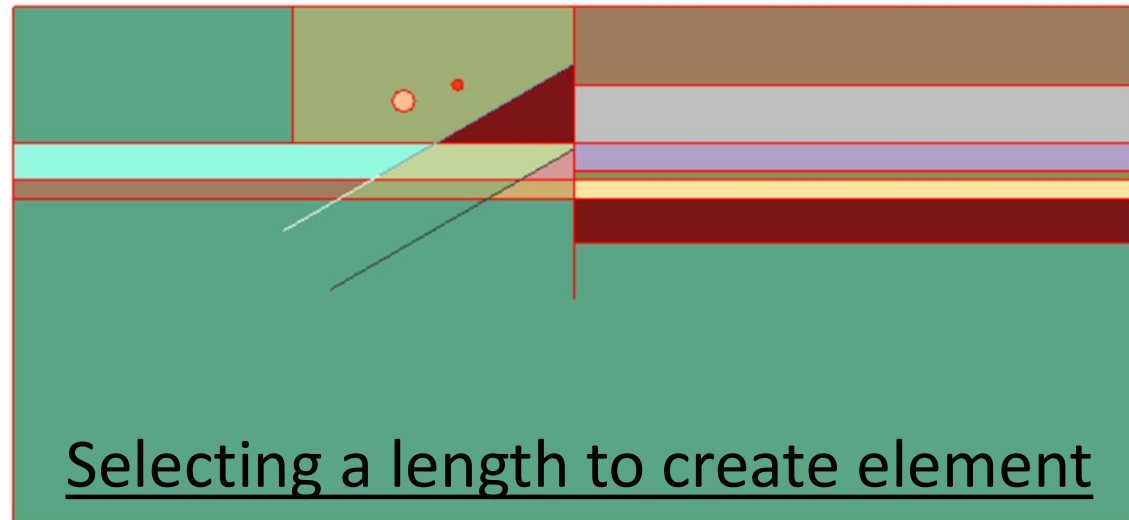
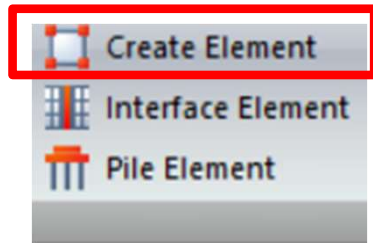
# Smart Mesh



Generating 'Smart Mesh' automatically



# Create Anchor Elements



Fig, Generating mesh

# Create Interface Elements

**Create Interface Element**

Method: Create from Truss/Beam Elements

Select 1D Element(s) (16)

Structural Property: ☒ Property Wizard

Mesh Set: Mesh Set

☒ Create Rigid Links automatically

☐ Create End Link

☒ Addition of Mesh Set for Interface Elements

**Interface Element Property Wizard**

Property

Virtual Thickness Factor (tv): 0.5

Strength Reduction Factor (R): 1

☐ Dilatancy Angle: 0.000 [deg]

☐ Consider Element Size

☐ Tension Cut-off

Tensile Strength: 0.000 kN/m<sup>2</sup>

Mode-II Model

☒ Brittle

☐ Maintain Constant Shear

Shear Strength Reduction: 0.000 kN/m<sup>3</sup>

Mesh Set\_L (Elements[16], Nodes[33])

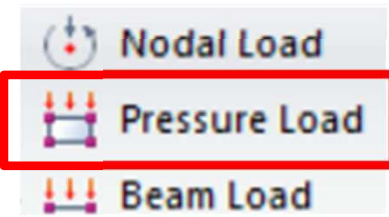
Mesh Set\_R (Elements[16], Nodes[33])

Mesh Set-Link (Elements[16], Nodes[32])

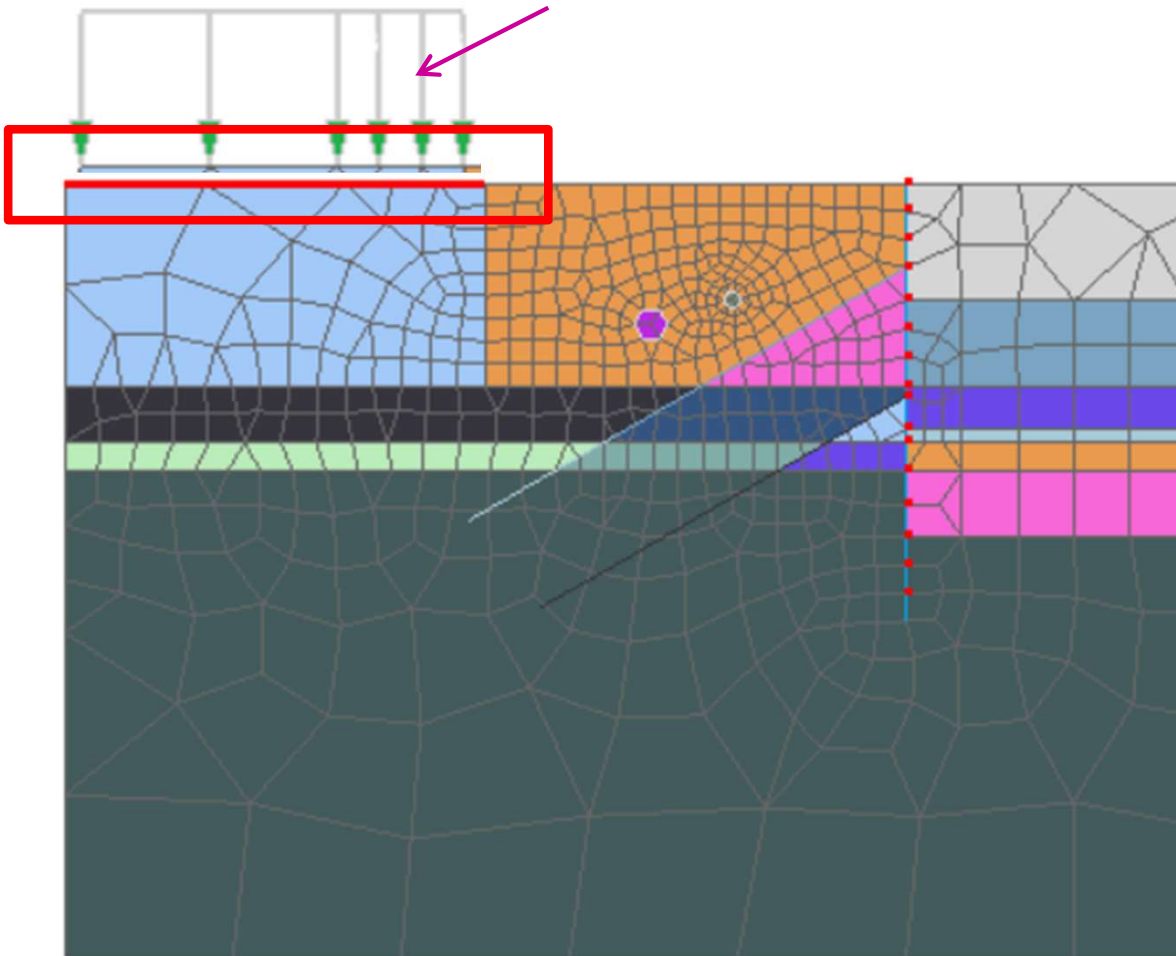
MIDAS



# Define Loading Conditions



Assign pressure: 13 kPa



Define Pressure Load

Load Set: Overburden load

Select Object(s)

Type: Element Boundary Curve

Select Element Boundary Curve(s) (5)

Diagram showing the pressure load application on a rectangular element (E3) with nodes N1, N2, N3, N4 and edges E1, E2, E3, E4. The load is applied to the top edge (E3) with a value of 13 kN/m².

Direction: Normal Direction

Load Value

☒ Uniform ☐ Linear

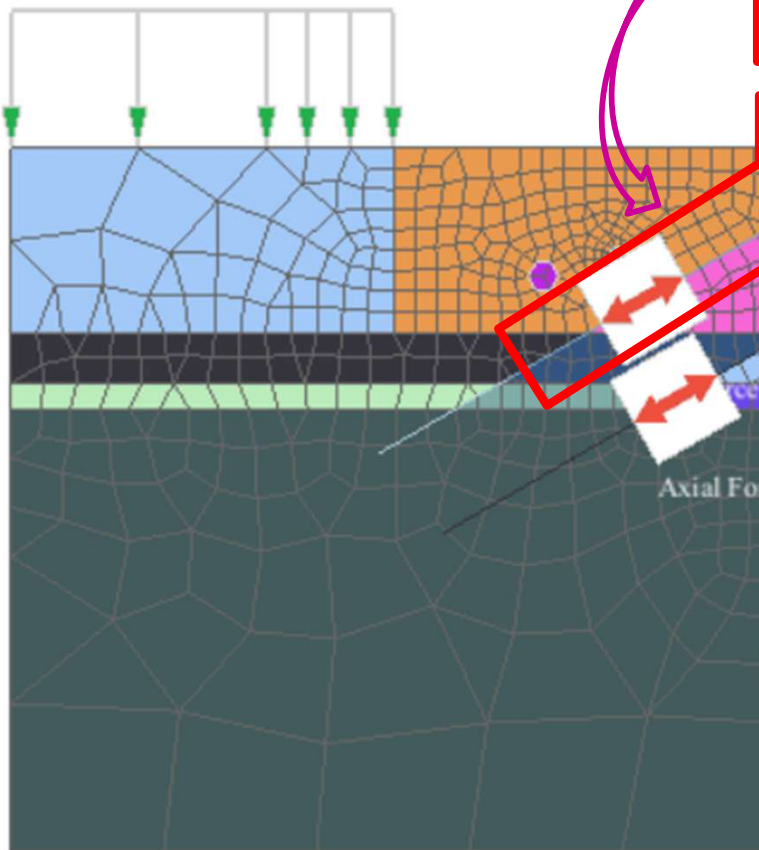
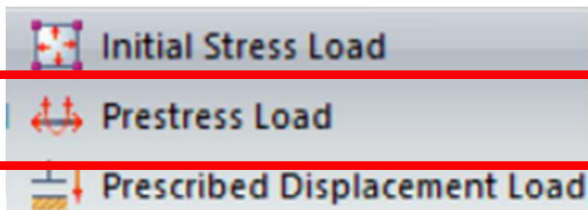
P1: 13 kN/m²

P2: 0.000 kN/m²

Functions: None

OK Close Apply

# Prestress Load - Anchors



Define Prestress Load

Load Set: Prestress-Anchor1

Element Type:  
☒ Truss Element  
☐ Planar Element

Select Object:  
Type: Element  
Select 1D Element(s) (1)

Prestress:  
Axial Force: 220 kN  
☒ Pretension  
Tension (+), Compression (-)  
Functions: None

OK Close Apply

Prestress – Anchor 1

Define Prestress Load

Load Set: Prestress-Anchor2

Element Type:  
☒ Truss Element  
☐ Planar Element

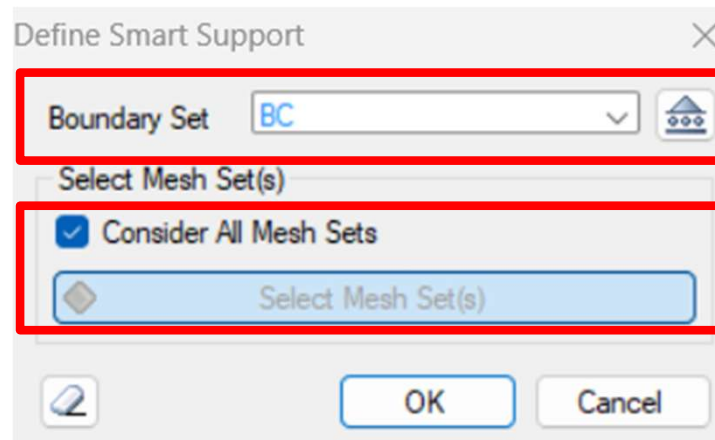
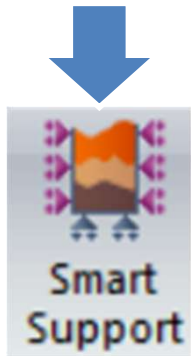
Select Object:  
Type: Element  
Select 1D Element(s) (1)

Prestress:  
Axial Force: 220 kN  
☐ Pretension  
Tension (+), Compression (-)  
Functions: None

OK Close Apply

Prestress – Anchor 2

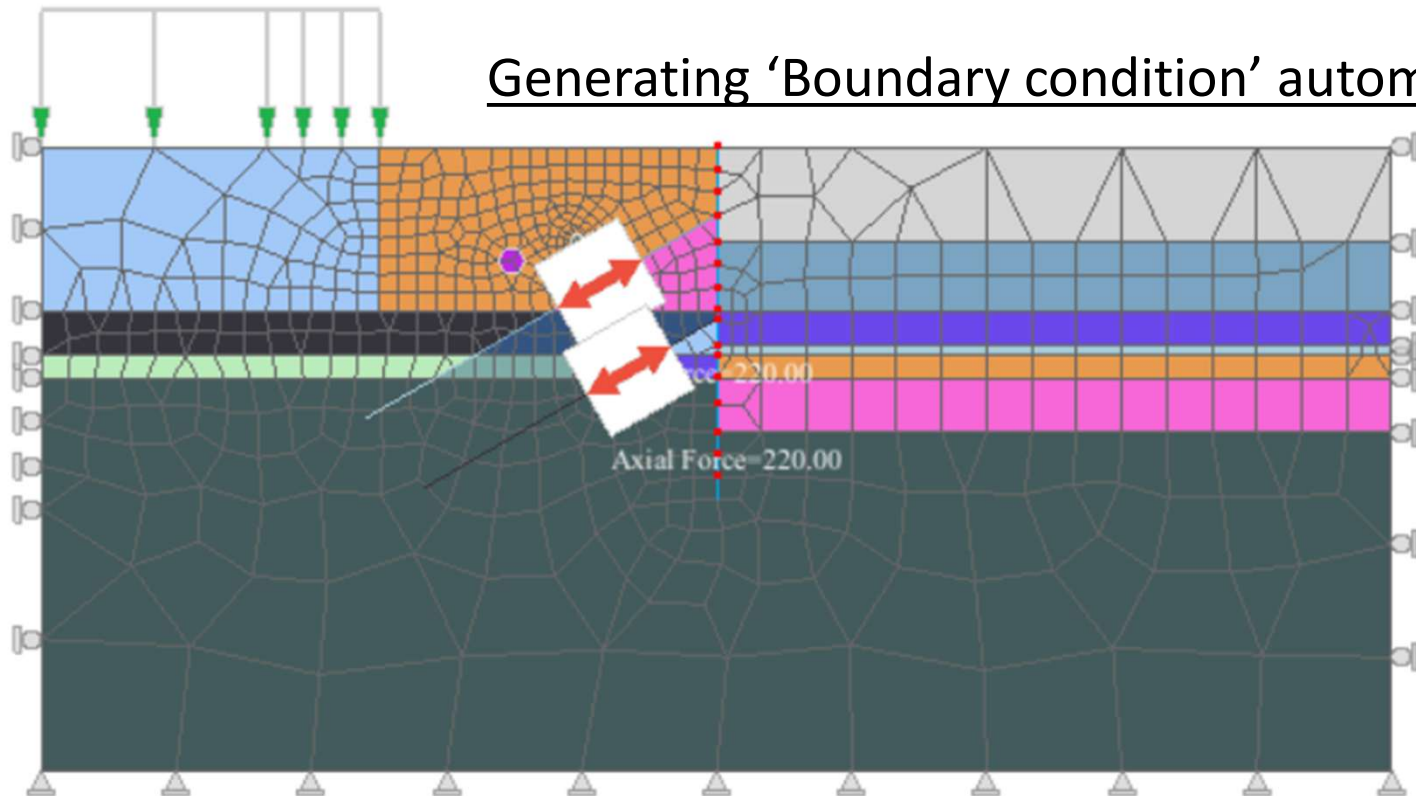
# Smart Support



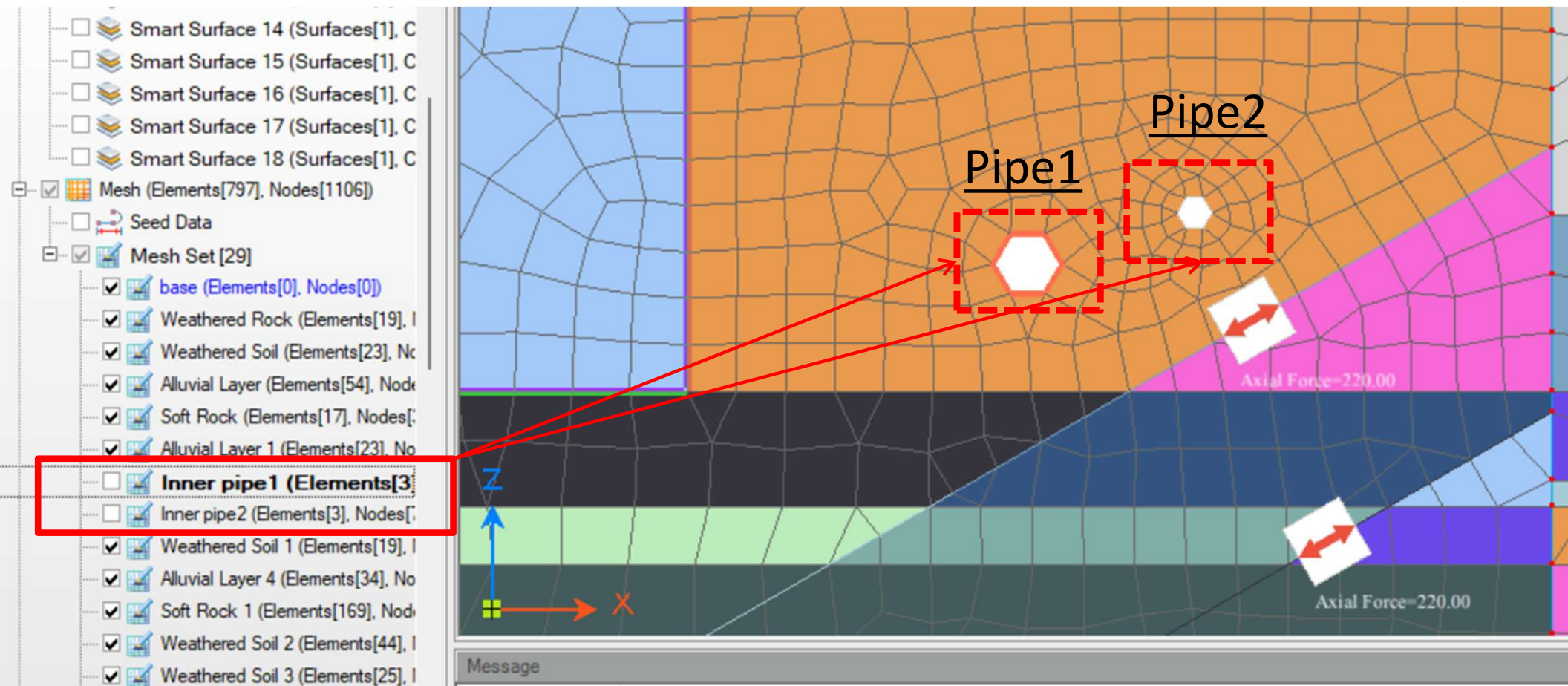
Naming for boundary set

Considered all mesh sets

Generating 'Boundary condition' automatically



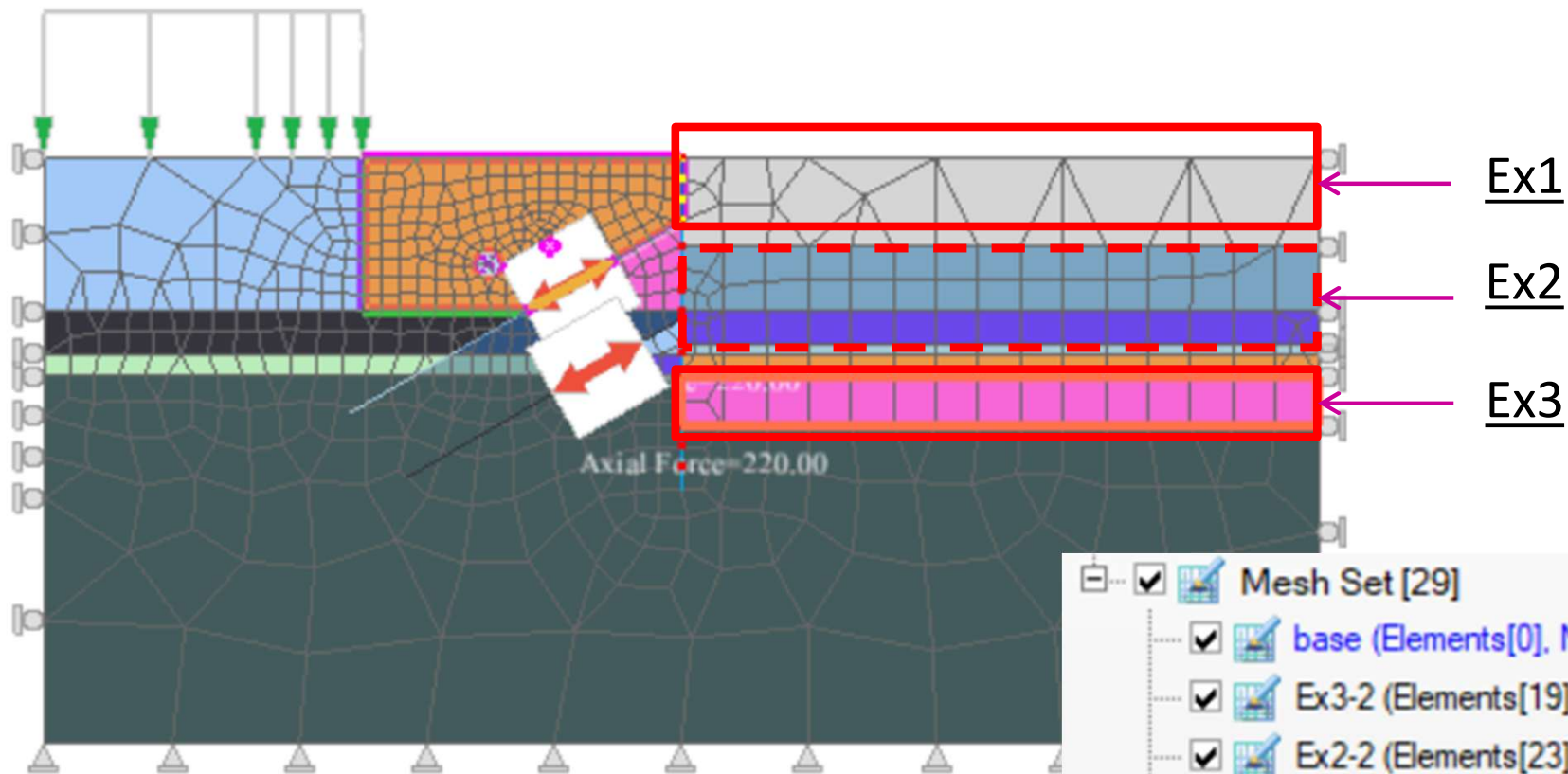
# Re-name soil mesh



**Fig,** Adjusting the mesh set name

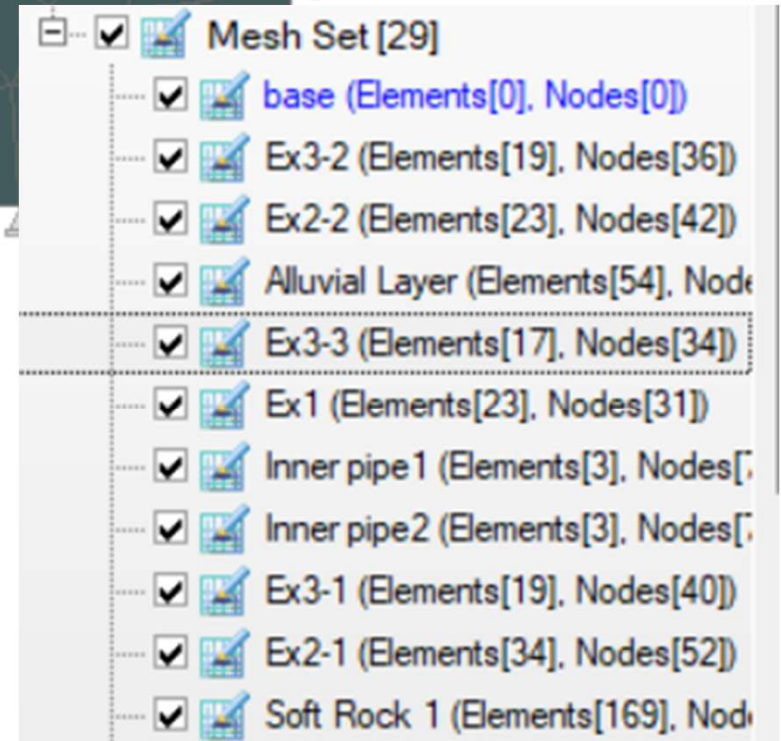


# Re-name soil mesh



Re-name the soil name into the excavation name

→ To control the mesh set



# Define Construction Stages

The image shows the 'Define Construction Stages' dialog box in a software application. The dialog is divided into several sections. On the left, there is a list of construction stages: 'Initial', 'RW', 'Ex1', 'Ex2', and 'Ex3'. A red box labeled '1' highlights the 'Define Construction Stage Analysis Model ...' button at the bottom left. A red box labeled '2' highlights the 'Add Construction Stage' dialog box, which has 'Analysis Type' set to 'Nonlinear Static Analysis' and 'No.' set to '5'. A red box labeled '3' highlights the 'Ex3' stage in the list. A red box labeled '4' highlights the 'Name' field in the 'Construction Stage Data' section, which is set to 'Ex3'. A red box labeled '5' highlights the 'Modify' button at the bottom right. A purple arrow points from the text 'Creating No. of construction stages, then modified its name' to the 'Ex3' stage in the list. Another purple arrow points from the 'Ex3' stage to the 'Modify' button.

Define Construction Stages

Construction Stage Data

Name

Analysis Type: Nonlinear Static Analysis

Partial Factor: None

☐ Load Step

No. of Steps: 1

Save Step: ☒ Last Step ☐ All Steps

☐ Water Level

0.000 m

☐ Load Distribution

☐ Initialize Displacement

☐ Undrained Condition

Add

Initial

RW

Ex1

Ex2

Ex3

Add Construction Stage

Analysis Type: Nonlinear Static Analysis

No.: 5

OK

Cancel

Define Construction Stage Analysis Model ...

Construction Stage Data

Name: Ex3

Analysis Type: Nonlinear Static Analysis

Partial Factor: None

☐ Load Step

No. of Steps: 1

Save Step: ☒ Last Step ☐ All Steps

☐ Water Level

0.000 m

☐ Load Distribution

☐ Initialize Displacement

☐ Undrained Condition

Add

Modify

Creating No. of construction stages, then modified its name



# CS – Intial

Construction Stage Analysis Model

Input Type: ☒ Tree Style ☐ Table Style ☐ Simulate Each Stage

Step: Initial

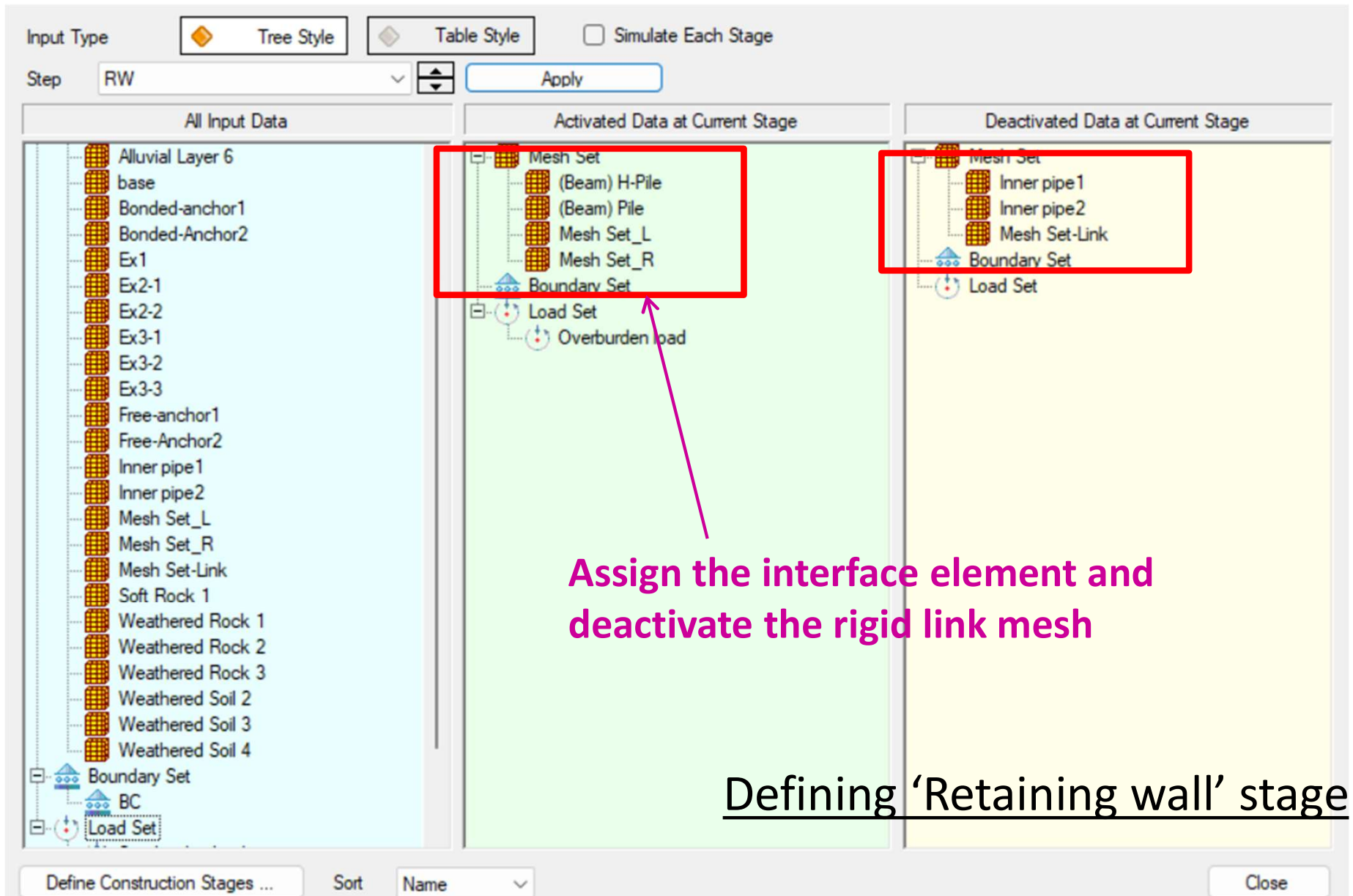
All Input Data	Activated Data at Current Stage	Deactivated Data at Current Stage
<ul style="list-style-type: none"><li>Alluvial Layer 5</li><li>Alluvial Layer 6</li><li>base</li><li>Bonded-anchor1</li><li>Bonded-Ancor2</li><li>Free-anchor1</li><li>Free-Ancor2</li><li>Inner pipe1</li><li>Inner pipe2</li><li>Mesh Set_L</li><li>Mesh Set_R</li><li>Mesh Set-Link</li><li>Soft Rock</li><li>Soft Rock 1</li><li>Weathered Rock</li><li>Weathered Rock 1</li><li>Weathered Rock 2</li><li>Weathered Rock 3</li><li>Weathered Soil</li><li>Weathered Soil 1</li><li>Weathered Soil 2</li><li>Weathered Soil 3</li><li>Weathered Soil 4</li><li>Boundary Set</li><li>BC</li><li>Load Set</li><li>Overburden load</li></ul>	<ul style="list-style-type: none"><li>Mesh Set</li><li>Alluvial Layer</li><li>Alluvial Layer 1</li><li>Alluvial Layer 4</li><li>Alluvial Layer 5</li><li>Alluvial Layer 6</li><li>base</li><li>Inner pipe1</li><li>Inner pipe2</li><li>Mesh Set-Link</li><li>Soft Rock</li><li>Soft Rock 1</li><li>Weathered Rock</li><li>Weathered Rock 1</li><li>Weathered Rock 2</li><li>Weathered Rock 3</li><li>Weathered Soil</li><li>Weathered Soil 1</li><li>Weathered Soil 2</li><li>Weathered Soil 3</li><li>Weathered Soil 4</li><li>Boundary Set</li><li>BC</li><li>Load Set</li><li>Self Weight</li></ul>	<ul style="list-style-type: none"><li>Mesh Set</li><li>Boundary Set</li><li>Load Set</li></ul>

Assign the rigid link mesh

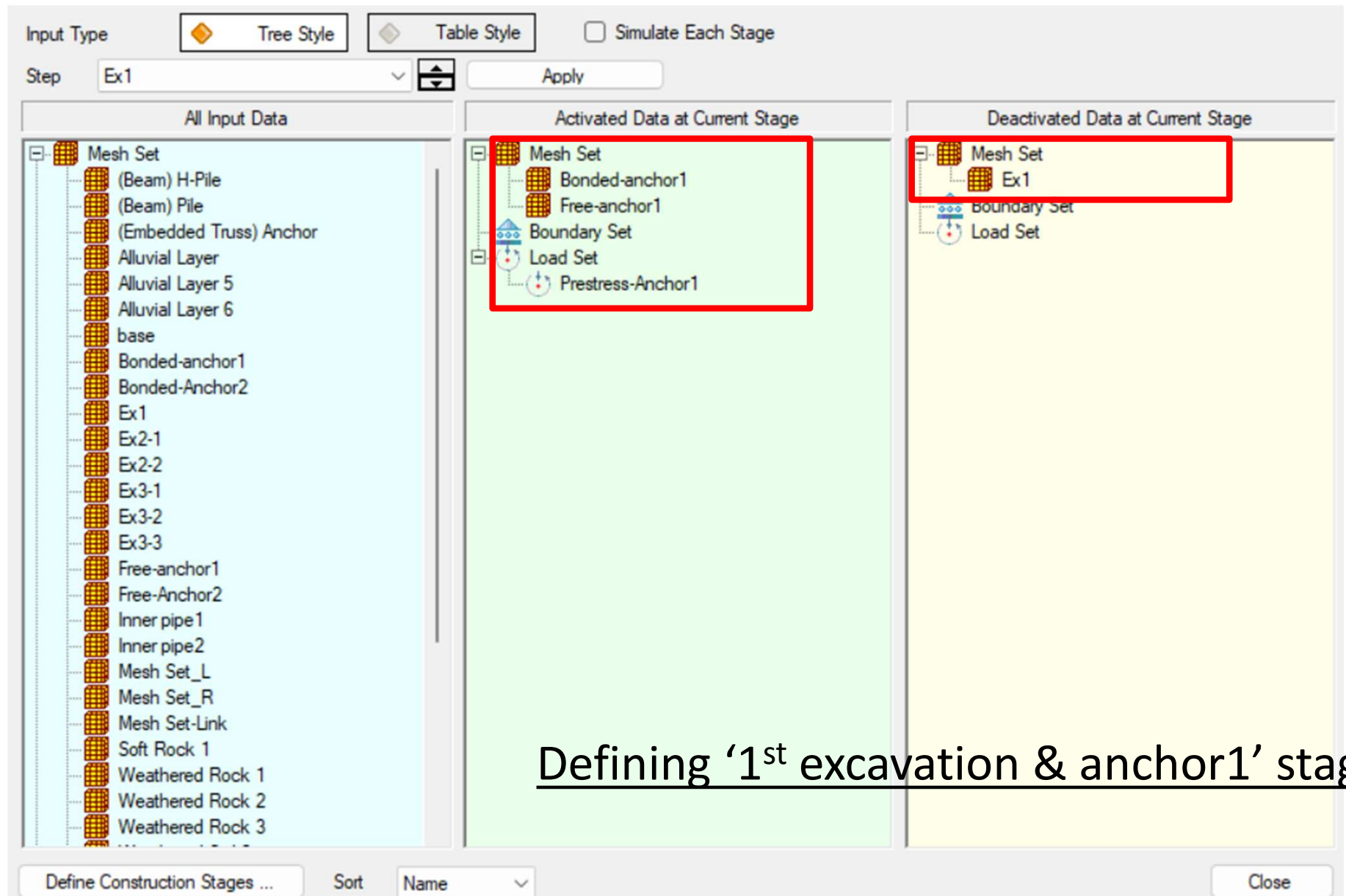
Defining 'Initial condition' stage

Define Construction Stages ... Sort Name

# CS – RW

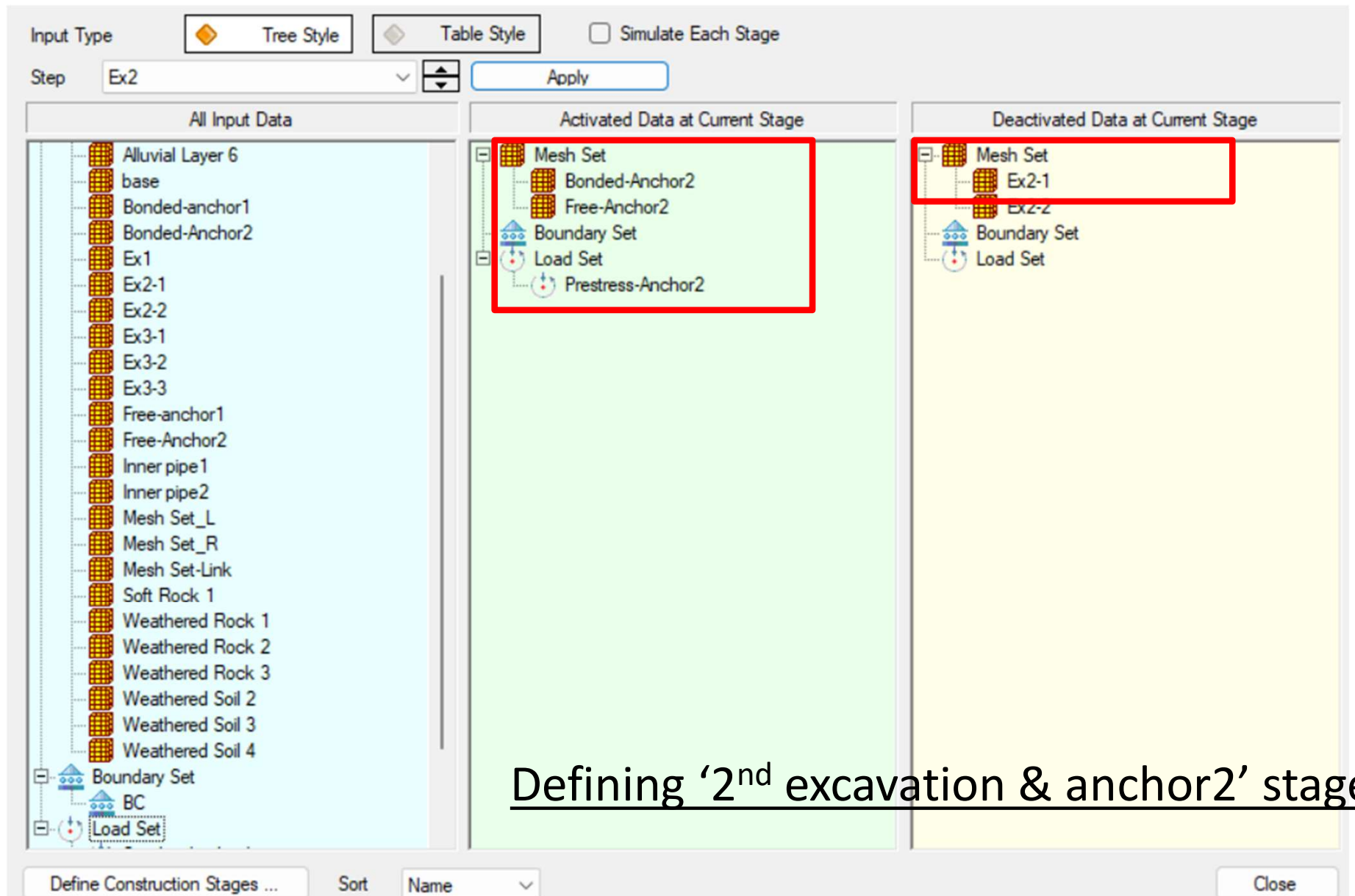


# CS – Ex1



Defining '1<sup>st</sup> excavation & anchor1' stage

# CS – Ex2



Defining '2<sup>nd</sup> excavation & anchor2' stage

# CS – Ex3

Input Type ☒ Tree Style ☐ Table Style ☐ Simulate Each Stage

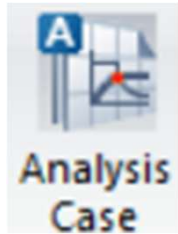
Step Ex3

All Input Data	Activated Data at Current Stage	Deactivated Data at Current Stage
<ul style="list-style-type: none"><li>Mesh Set</li><li>(Beam) H-Pile</li><li>(Beam) Pile</li><li>(Embedded Truss) Anchor</li><li>Alluvial Layer</li><li>Alluvial Layer 5</li><li>Alluvial Layer 6</li><li>base</li><li>Bonded-anchor1</li><li>Bonded-Anchor2</li><li>Ex1</li><li>Ex2-1</li><li>Ex2-2</li><li>Ex3-1</li><li>Ex3-2</li><li>Ex3-3</li><li>Free-anchor1</li><li>Free-Anchor2</li><li>Inner pipe1</li><li>Inner pipe2</li><li>Mesh Set_L</li><li>Mesh Set_R</li><li>Mesh Set-Link</li><li>Soft Rock 1</li><li>Weathered Rock 1</li><li>Weathered Rock 2</li><li>Weathered Rock 3</li></ul>	<ul style="list-style-type: none"><li>Mesh Set</li><li>Boundary Set</li><li>Load Set</li></ul>	<ul style="list-style-type: none"><li>Mesh Set</li><li>Ex3-1</li><li>Ex3-2</li><li>Ex3-3</li><li>Boundary Set</li><li>Load Set</li></ul>

Define Construction Stages ... Sort Name

Defining '3<sup>rd</sup> excavation' stage





# Analysis Setting

Add/Modify Analysis Case

Name: 2DExcav

Analysis Method: Static Nonlinear Analysis

Analysis Control Data

Analysis by each Load Set in the Analysis Model

Define Analysis Model

Use All Mesh Sets Use All Boundary Sets Use All Load Sets

All Input Data

- Mesh Set
  - base
  - Ex3-2
  - Ex2-2
  - Alluvial Layer
  - Ex3-3
  - Ex1
  - Inner pipe 1
  - Inner pipe 2
  - Ex3-1
  - Ex2-1
  - Soft Rock 1
  - Weathered Soil 2
  - Weathered Soil 3
  - Weathered Rock 1
  - Weathered Rock 2
  - Alluvial Layer 5
  - Weathered Rock 3
  - Weathered Soil 4
  - Alluvial Layer 6
  - (Beam) Pile

Data used in Analysis

- Mesh Set
- Boundary Set
- Load Set

OK Close Apply

Analysis Control

Static Nonlinear Analysis

☒ Initial Stage for Stress Analysis Initial

☒ Ko Condition

Load Step and No. of Iterations

No. of Load Steps: 1

Maximum Number of Iterations per Load Step: 30

Convergence Criteria

☐ Energy Norm 0.001

☒ Displacement Norm 0.001

☐ Unequilibrium Force Norm 0.001

Nonlinear Option

☐ Constant Stiffness Method

☒ Newton-Raphson Method

☐ Auto-define

Initial Load Factor: 1

Minimum Load Factor: 1E-05

☒ Include acceleration of convergence

Save Step Results

☒ Last Step ☐ All Steps

OK Cancel

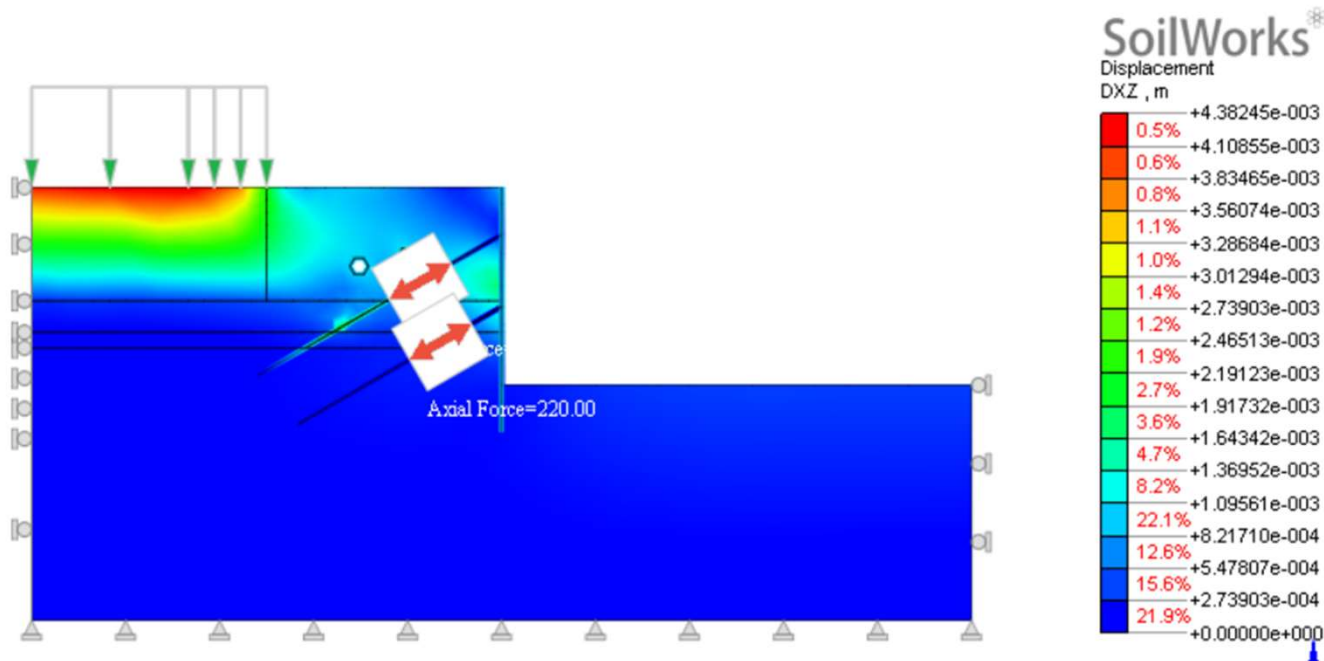
RUN analysis

Analysis Case

2DExcav [Construction Stage Analysis]

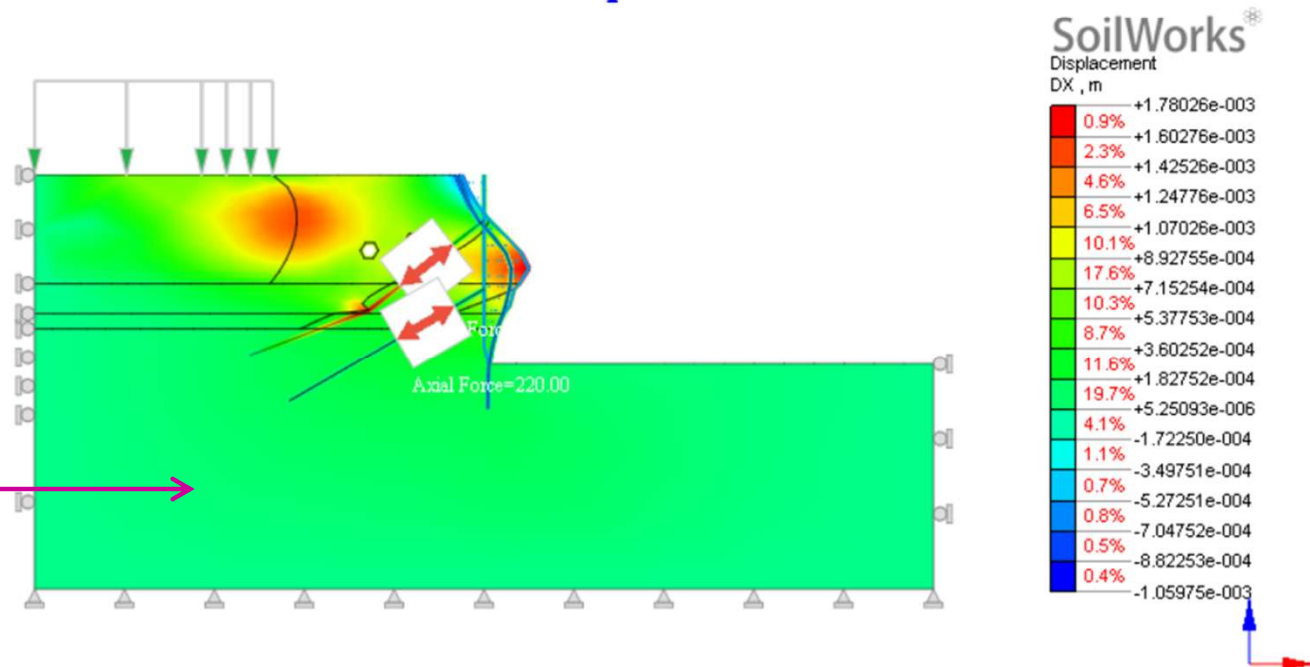


# Results - Displacements

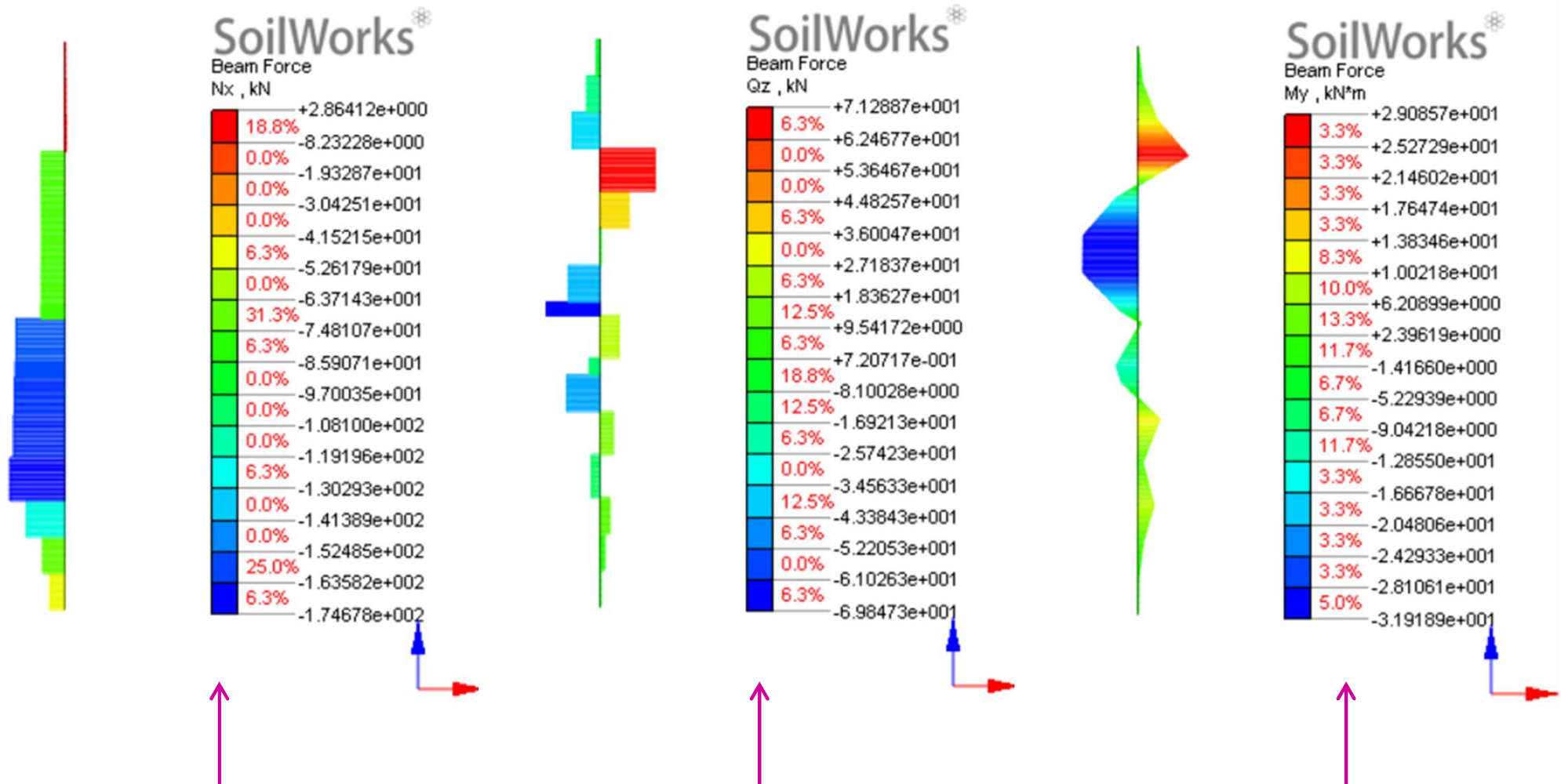


Total displacement

Lateral displacement  
(Deformed shape)



# Results – Retaining wall internal forces

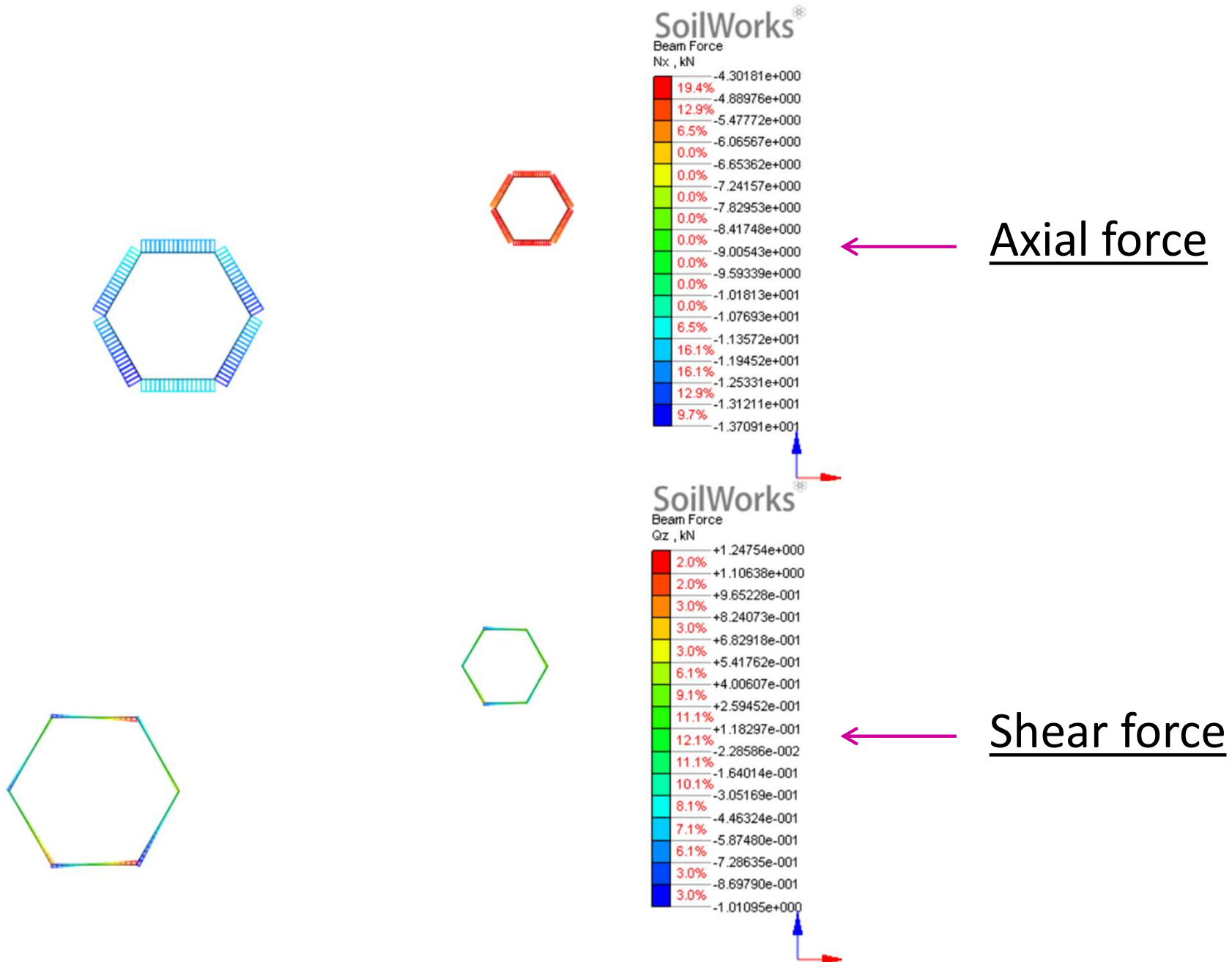


Axial force

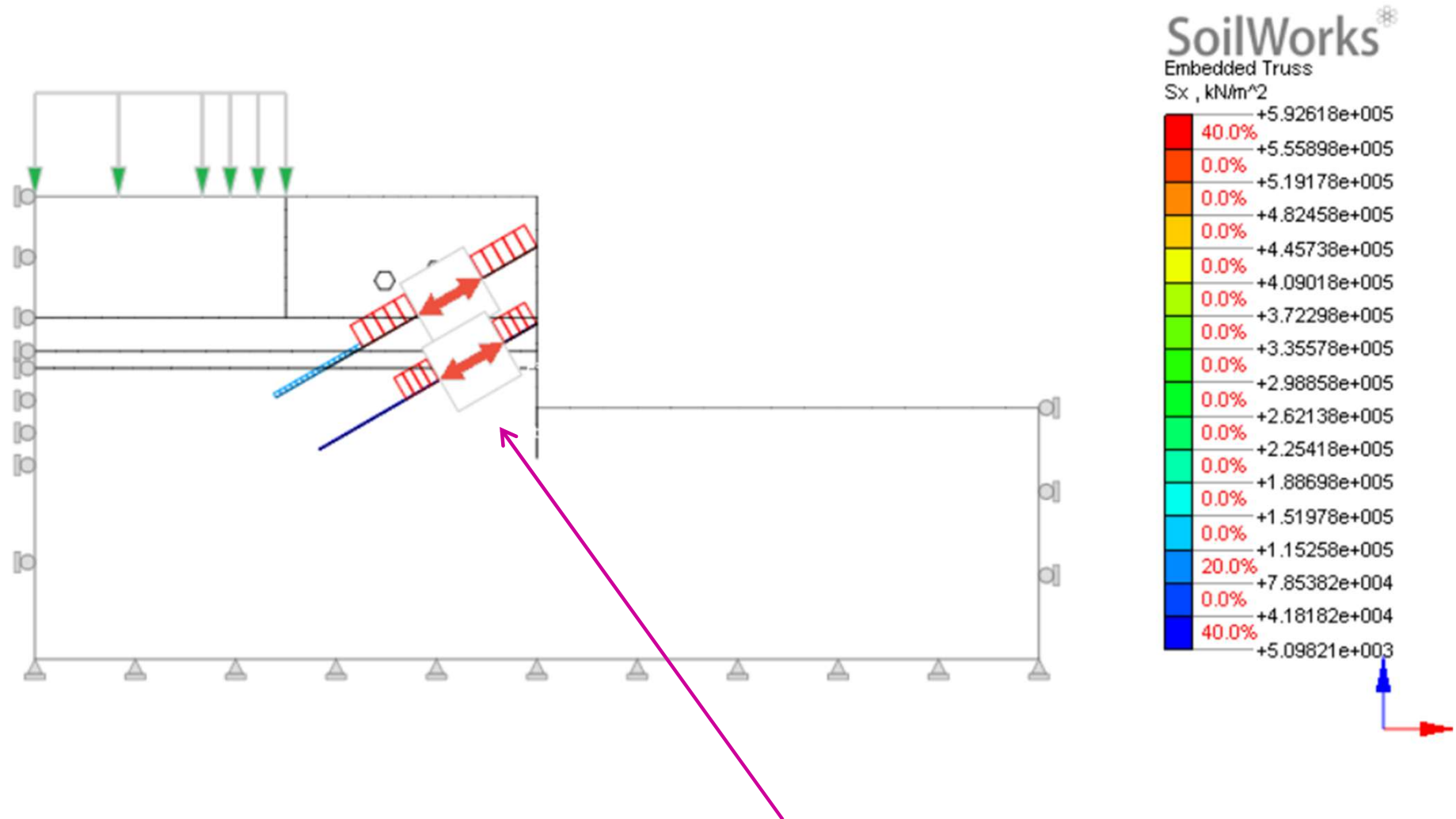
Shear force

Bending moment

# Results – Pipe internal forces



# Results – Anchor internal force



Axial force in the 'Prestress length' of anchors

Thank you! 



## SoilWorks – Slope Module

# Soil Nail Reinforced Slope Stability

Midas e-mail: [support@midasuser.com](mailto:support@midasuser.com)

My e-mail: [tam@midasuser.com.tw](mailto:tam@midasuser.com.tw)





# OUTLINE

**Part 1:** General introduction

**Part 2:** Strength Reduction Method

**Part 3:** Limit Equilibrium Method

**Part 4:** Results and discussion

**Part 5:** Results and discussion

## Part 1: General introduction

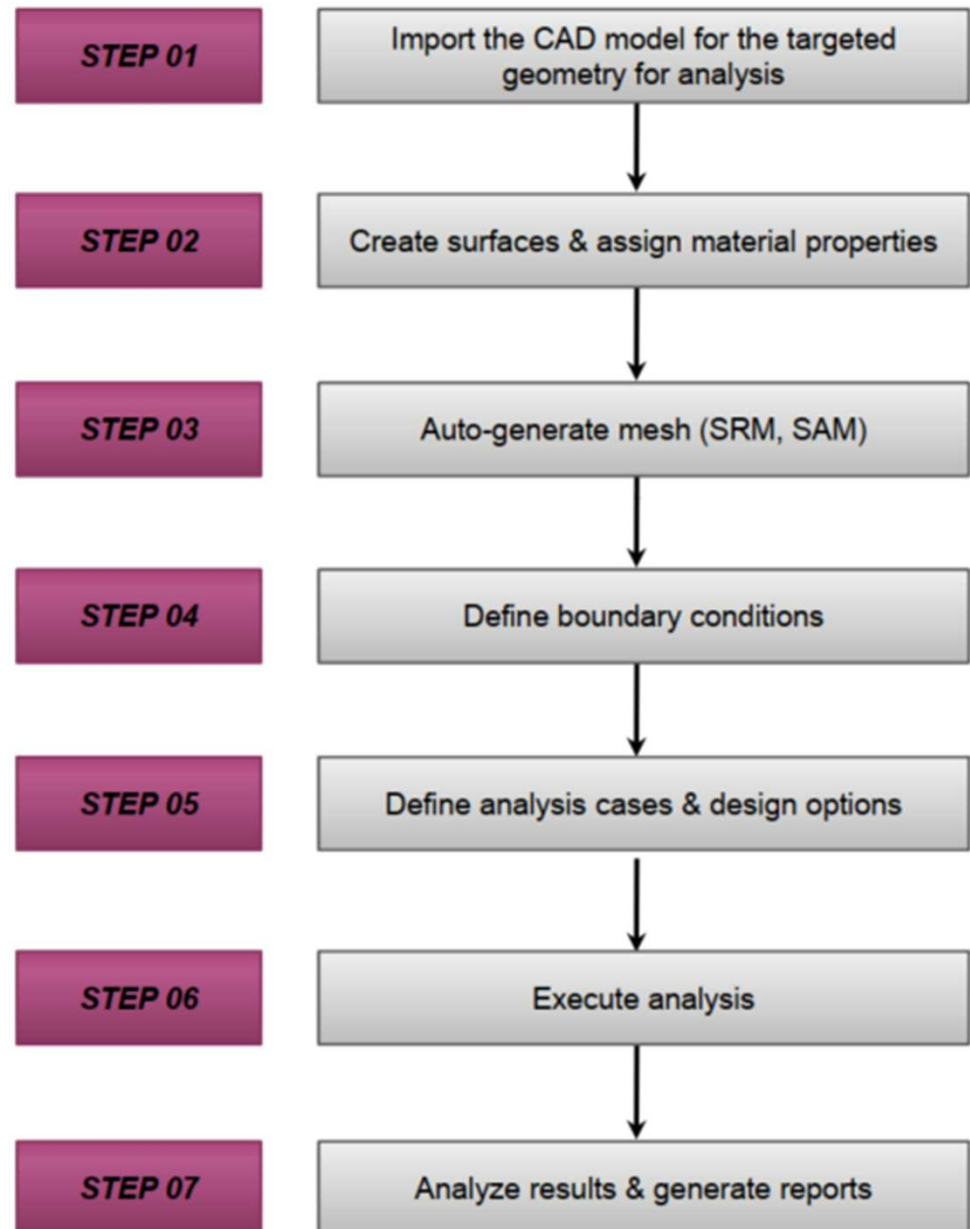
# Learning Objective

- Expose to slope stability analysis using:

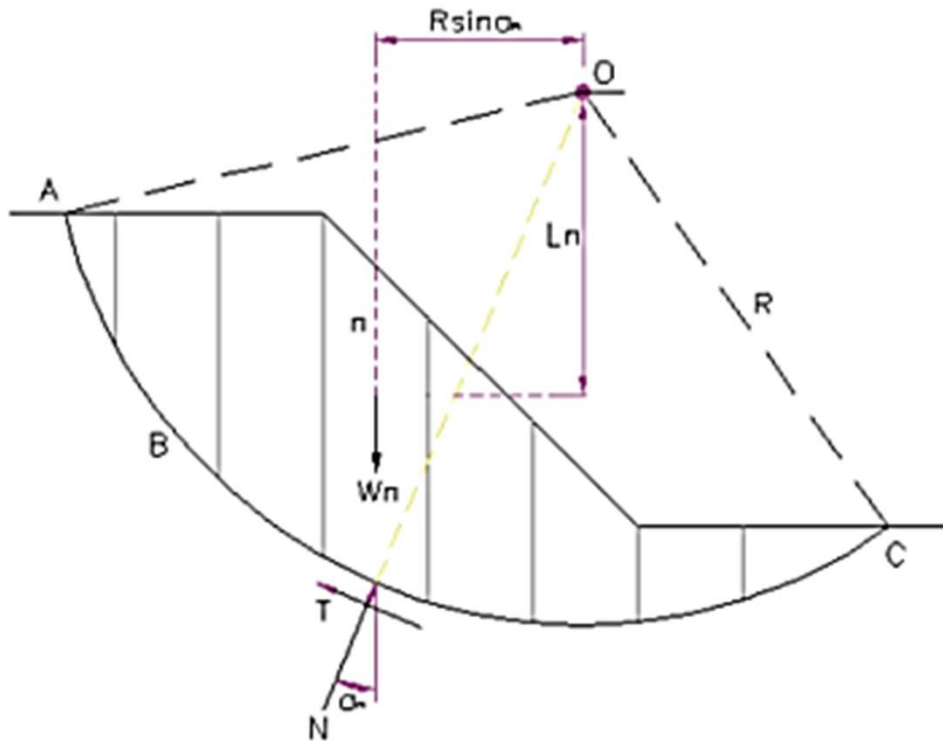
✓ LEM  
(Limit Equilibrium Method)

✓ SRM  
(Strength Reduction Method)

✓ SAM  
(Stress Analysis Method)



# Overview



**Fig, Limit Equilibrium Method**

$$F_s = \frac{\sum_{n=1}^{n=p} (cb_n + W_n \tan \phi + \Delta T \tan \phi) \frac{1}{m} \alpha(n)}{\sum_{n=1}^{n=p} (\sin \alpha_n)}$$

where  $m \alpha(n) = \cos \alpha_n + \frac{\tan \phi \cdot \sin \alpha_n}{F_s}$

W : Total weight of soil slices (tf/m<sup>3</sup>)

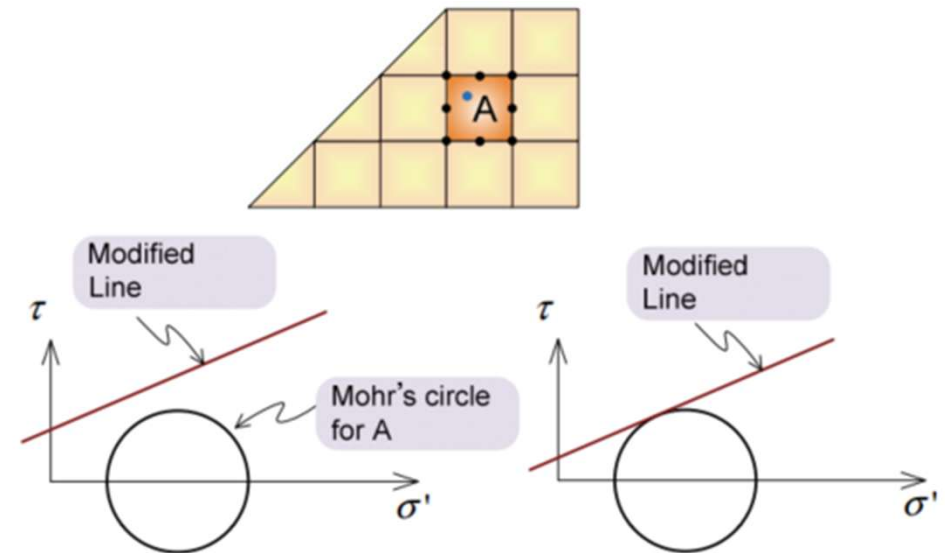
$\alpha$  : Angle of slope (degree)

C : Cohesion of soil (tf/m<sup>2</sup>)

b : Slice width (m)

$\phi$  : Internal angle of friction (degree)

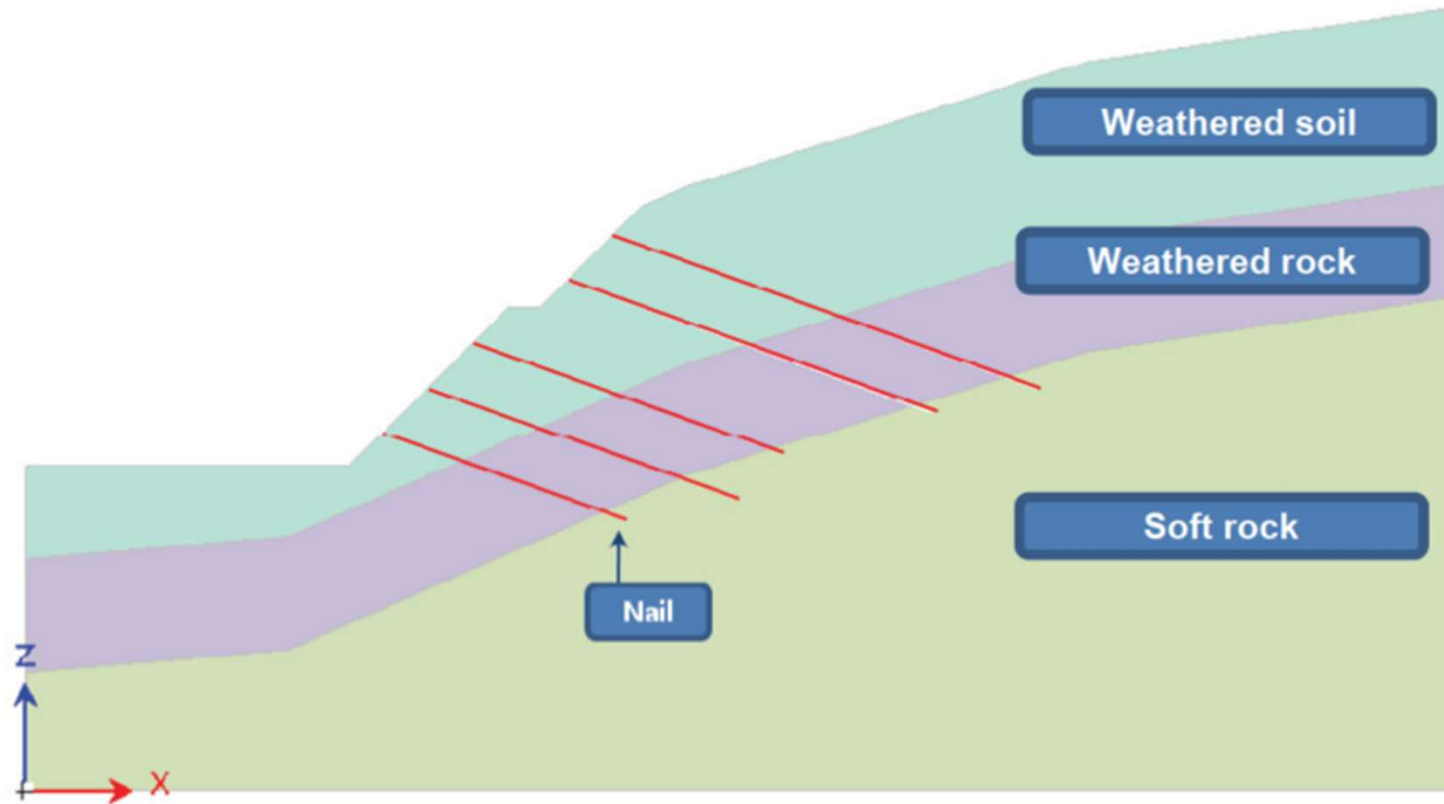
$\Delta T$  :  $T_n - T_{n+1}$



**Fig, Strength Reduction Method**

In **SAM**, based on the stress analysis results, safety factors for various sliding surfaces used in LEM are calculated.

# Overview



Fig, Soil distribution

- Nailing can be assigned as 'Embedded truss'
- Then, No need the same node between soil & truss



# Property

## ► Ground properties

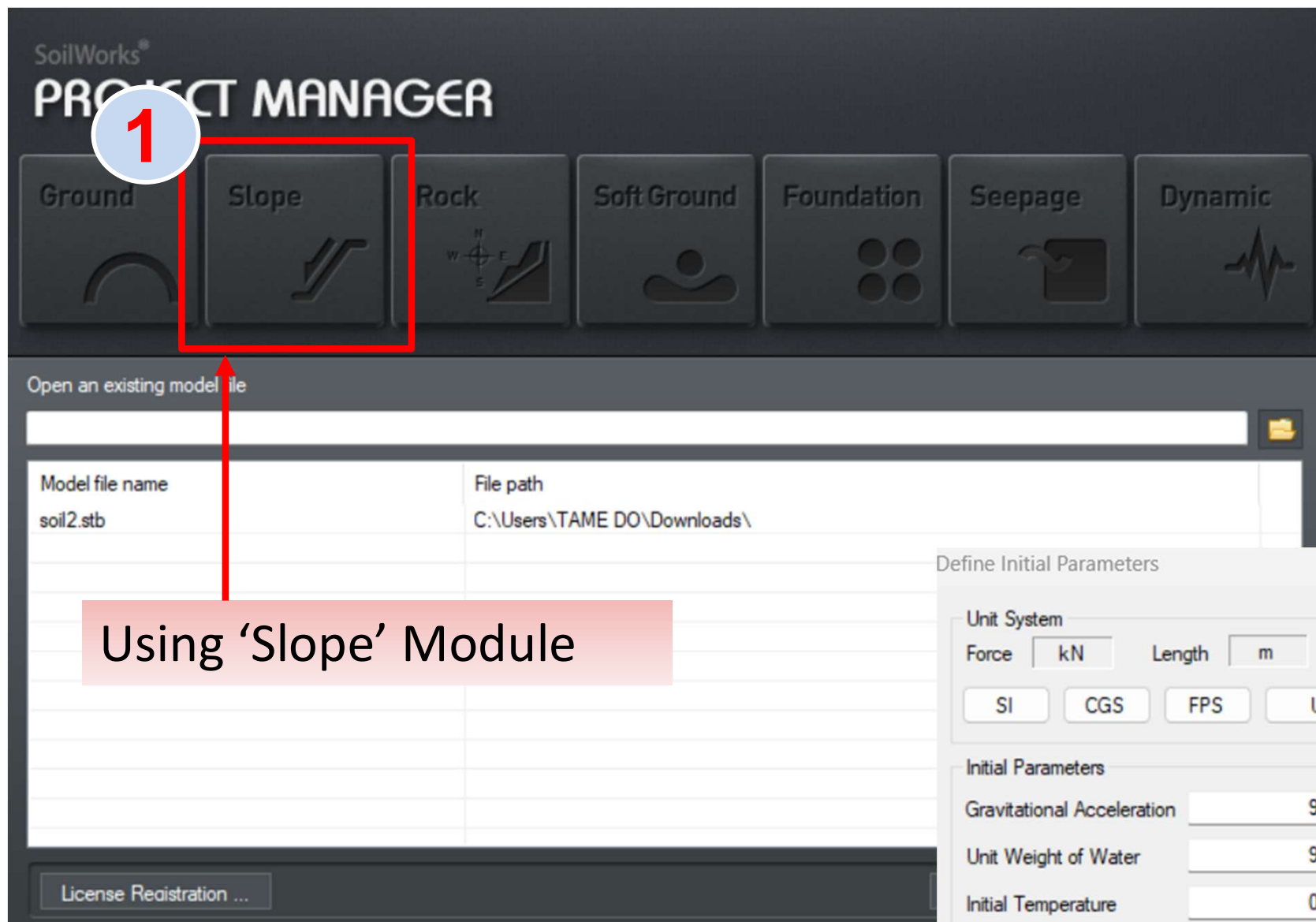
No	Ground Type	Model Type	Modulus of Elasticity (kN/m <sup>2</sup> )	Unit Weight (kN/m <sup>3</sup> )	Saturated Unit Weight (kN/m <sup>3</sup> )	Poisson's Ratio	Cohesion (kN/m <sup>2</sup> )	Internal Friction Angle (degree)
1	Weathered soil	Mohr Coulomb	36,500	18.5	19.5	0.33	17.5	31
2	Weathered rock	Mohr Coulomb	150,000	21	22	0.30	50	33
3	Soft rock	Mohr Coulomb	1,850,000	24	25	0.28	180	35.5
4	Weathered soil	Mohr Coulomb (LEM)	-	18.5	-	-	17.5	31
5	Weathered rock	Mohr Coulomb (LEM)	-	21	-	-	50	33
6	Soft rock	Mohr Coulomb (LEM)	-	24	-	-	180	35.5

## ► Structural properties

No	Structure Type	Model Type	Reinforcement Spacing (m)	Initial Diffusion Width (m)	Initial Diffusion Angle (deg)	Tensile Strength (kN)	Equivalent Radius (m)
1	Nail (LEM)	Nail (LEM)	2.0	1.0	10	115	0.05

No	Structure Type	Model Type	Horizontal Spacing (m)	Rebar Section Area (m <sup>2</sup> )	Modulus of Elasticity (kN/m <sup>2</sup> )	Poisson's Ratio	Unit Weight (kN/m <sup>3</sup> )	Yield Strength (kN/m <sup>2</sup> )
1	Nail	Embedded Truss	2.0	10	115	0.05	25	350,000

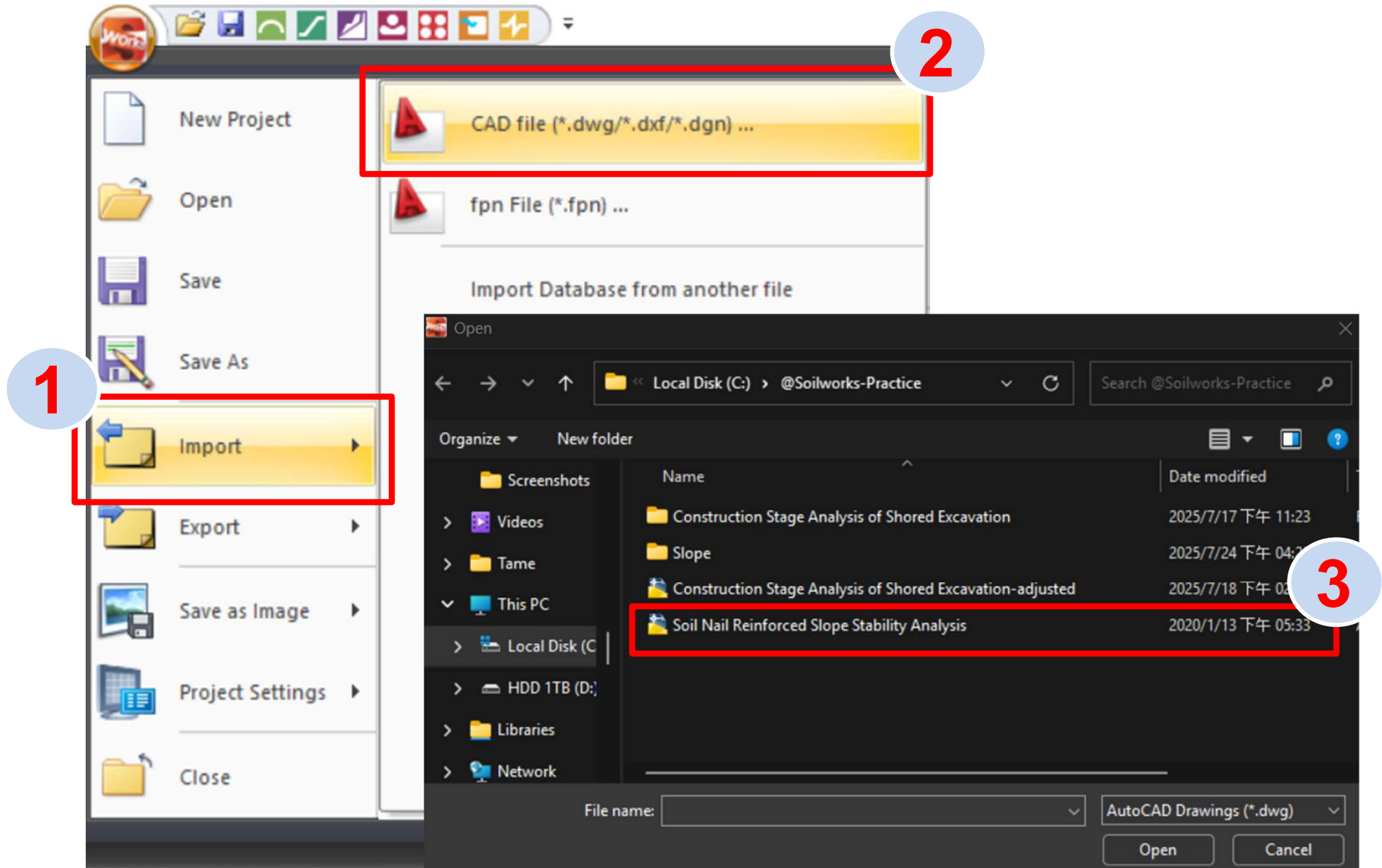
# Start SoilWorks



Using 'Slope' Module

Setting initial values

# Import File



# Define Ground Properties (SRM & LEM)

Define Ground Material Property

**6**

ID	Name
1	Weathered Soil
2	Weathered R...
3	Soft Rock

**1**

General

ID  Name

Model Type

General Parameters

Modulus of Elasticity (E)	20000000	kN/m <sup>2</sup>
Poisson's Ratio (u)	0.3	
Temperature Coeff. (α)	1E-06	
Unit Weight (Yt)	20	kN/m <sup>3</sup>
Saturated Unit Weight	21	kN/m <sup>3</sup>
Cohesion (c)	30	kN/m <sup>2</sup>
Internal Friction Angle (Φ)	36	[deg]
Earth Pressure Coeff. (Ko)	1	
Draining Condition	Drained	

Additional Parameters

Variation in Modulus of Elasticity	0	kN/m <sup>2</sup>
Variation in Cohesion	0	kN/m <sup>2</sup>
Reference Height	0	m
<input type="checkbox"/> Dilatancy Angle (Ψ)	36	[deg]
<input type="checkbox"/> Tensile Strength	2000	kN/m <sup>2</sup>

**2**

Database ...

Ground Material Database

Database

Select All Unselect All

No.	Soil Type	Modulus of Elasticity (kN/m <sup>2</sup> )	Unit Weight (kN/m <sup>3</sup> )	Saturated Unit Weight (kN/m <sup>3</sup> )	Poisson's Ratio	Cohesion (kN/m <sup>2</sup> )	Internal Friction Angle ([deg])	Select
1	Landfill Layer	13000	18	19	0.33	0	27	<input type="checkbox"/>
2	Alluvial Layer	8000	17	18	0.35	15	20	<input type="checkbox"/>
3	Weathered Soil	36500	18.5	19.5	0.33	17.5	31	<input checked="" type="checkbox"/>
4	Weathered Rock	150000	21	22	0.3	50	33	<input checked="" type="checkbox"/>
5	Soft Rock	1850000	24	25	0.28	180	35.5	<input checked="" type="checkbox"/>
6	Hard Rock	17500000	26	27	0.23	1750	40.5	<input type="checkbox"/>

**3**

Model Type

**4**

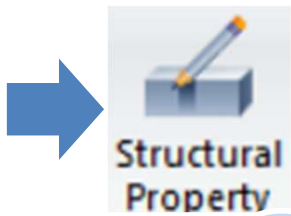
Assign

**5**

Close

## Part 2: Strength Reduction Method (SRM)





# Define Strutural Properties

1

General

ID 1

Name Nail

2

Element Type Embedded Truss

Standard NONE

Horizontal Spacing 2 m

3

Section

Shape Rebar

Sub-Shapes U Type

Section User Defined

Section-2 User Defined

Material

Material Type Rebar

Concrete User Defined

RebarGrade User Defined

4

Section Data

Section

5

Stiffness

Area 0.000642 m<sup>2</sup>

6

Material Data

User Defined

Rebar

7

Properties	
Modulus of Elasticity	200000000 kN/m <sup>2</sup>
Poisson's Ratio	0.3
Unit Weight	77 kN/m <sup>3</sup>
Thermal Coefficient	0.0000055
Design Strength	
Yield Strength	350000 kN/m <sup>2</sup>

8

Add

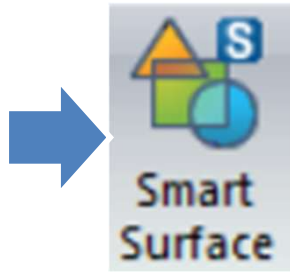
Modify

Delete

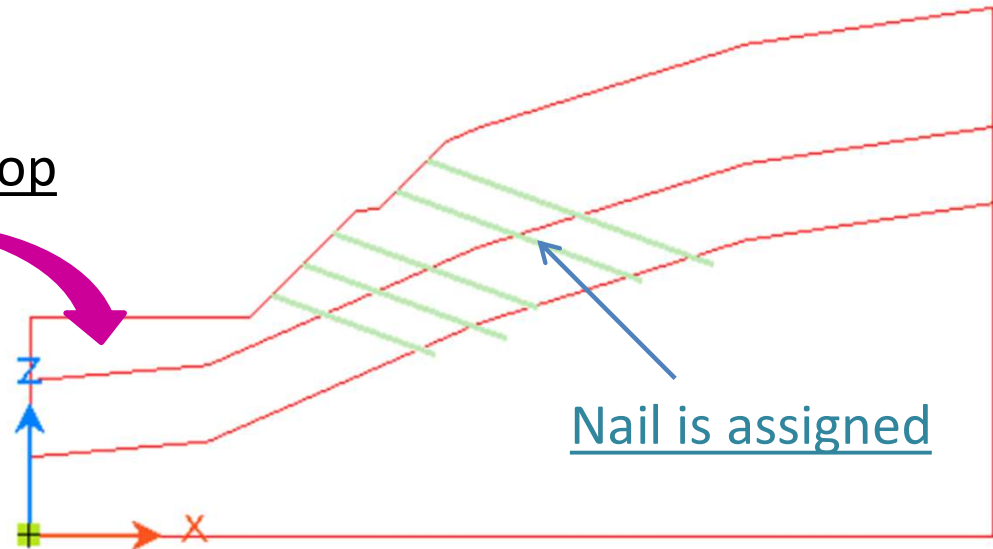
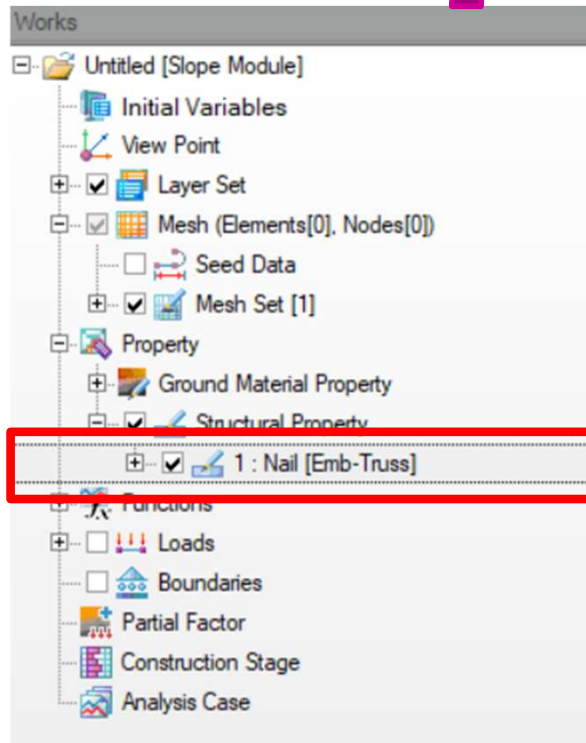
Close

Define: 'Pile Property'

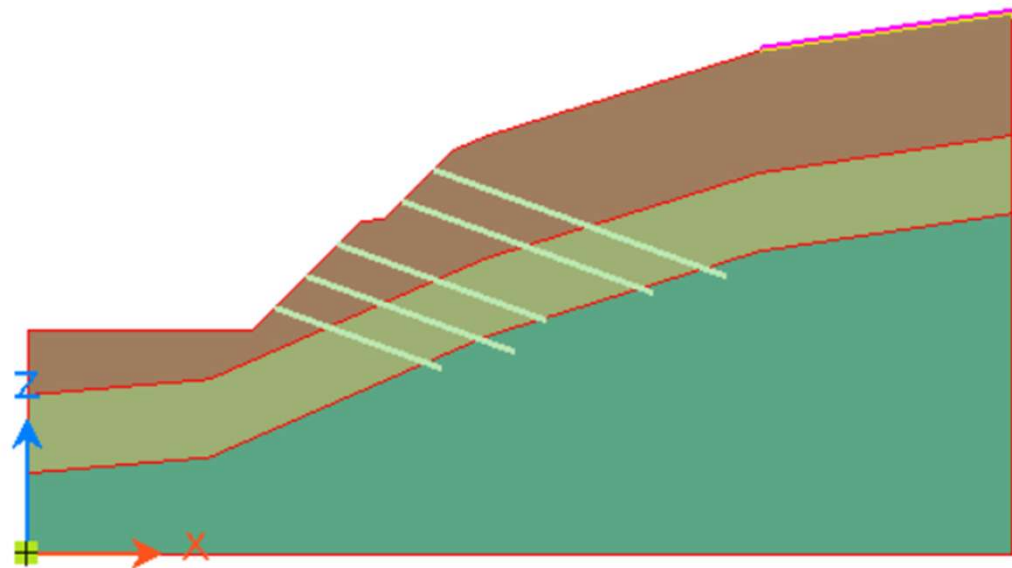
# Embedded truss



Drag & Drop

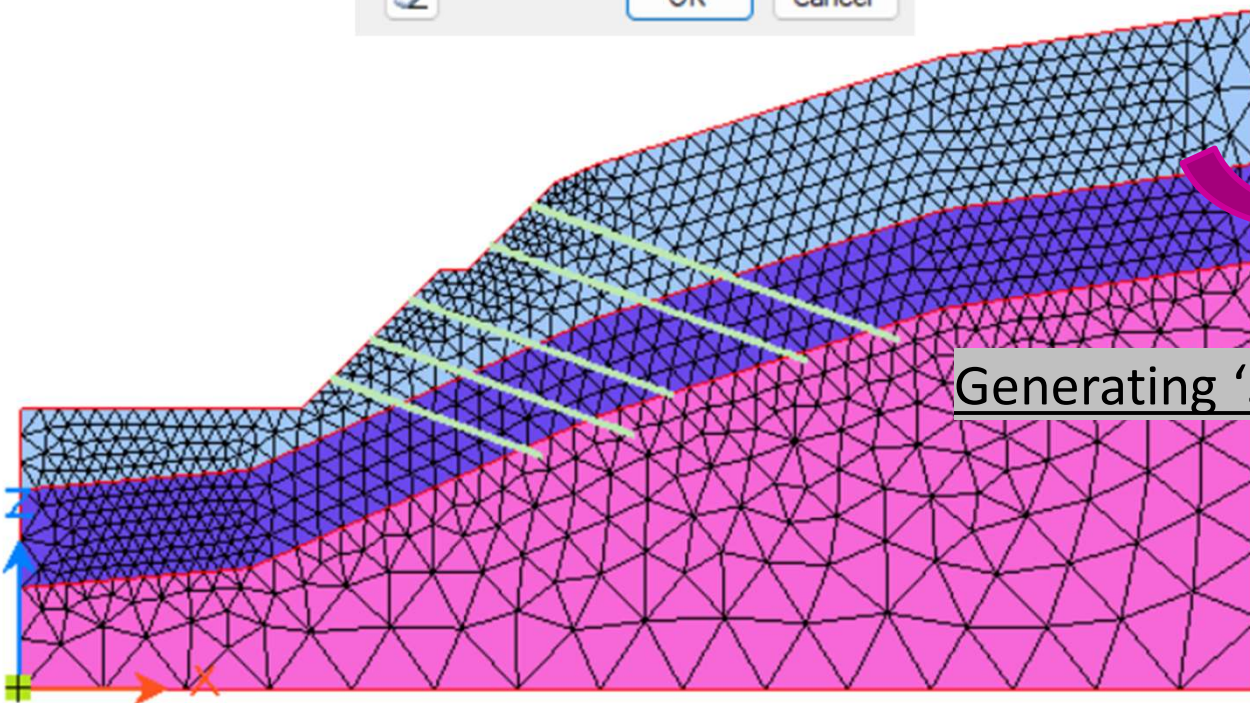
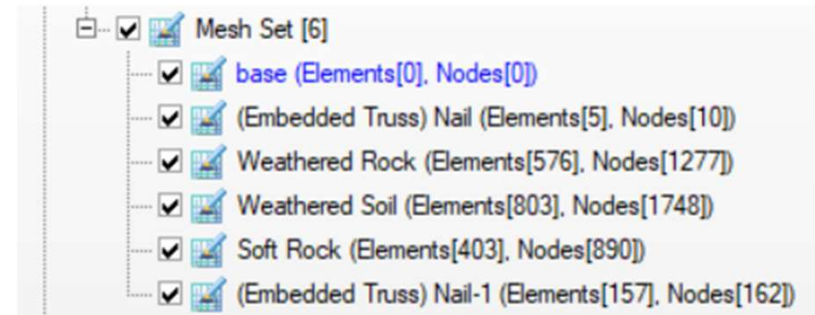
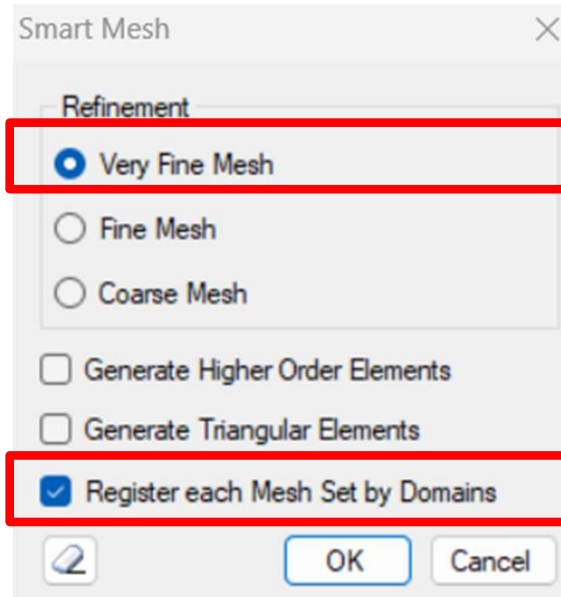
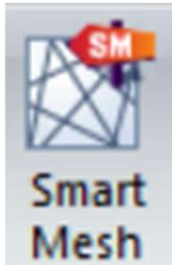


**Fig, Assigning 'Embedded truss'**



**Fig, Assigning 'Smart surface'**

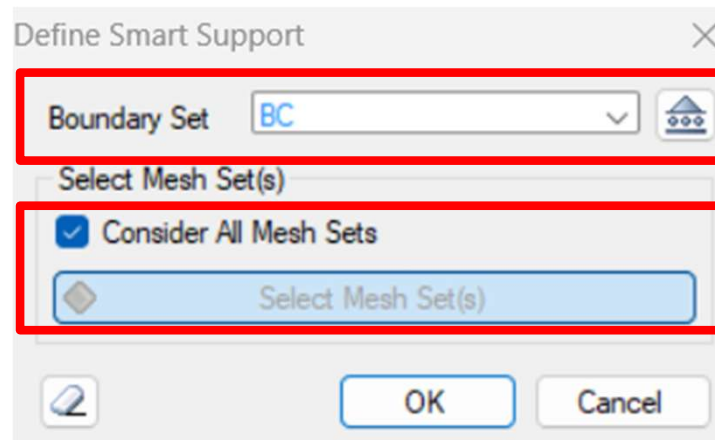
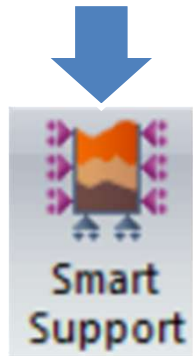
# Smart Mesh



Generating 'Smart Mesh' automatically



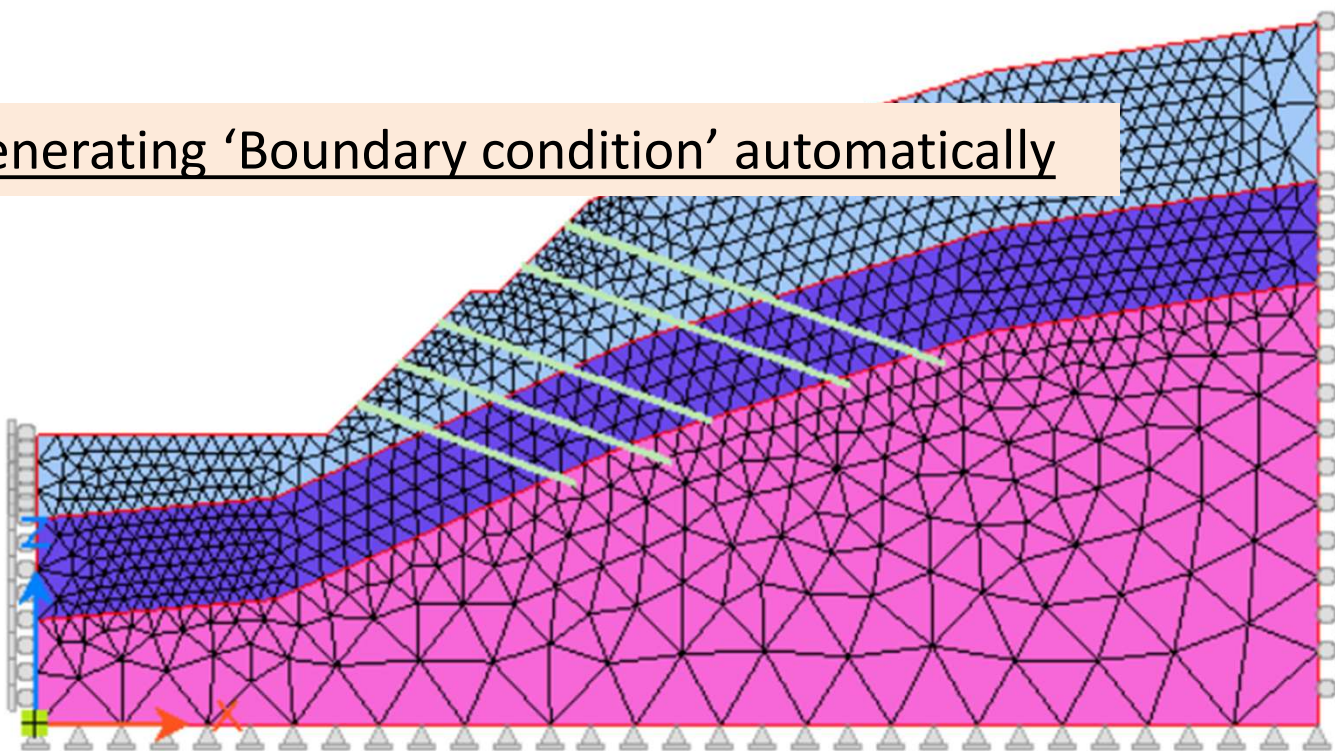
# Smart Support



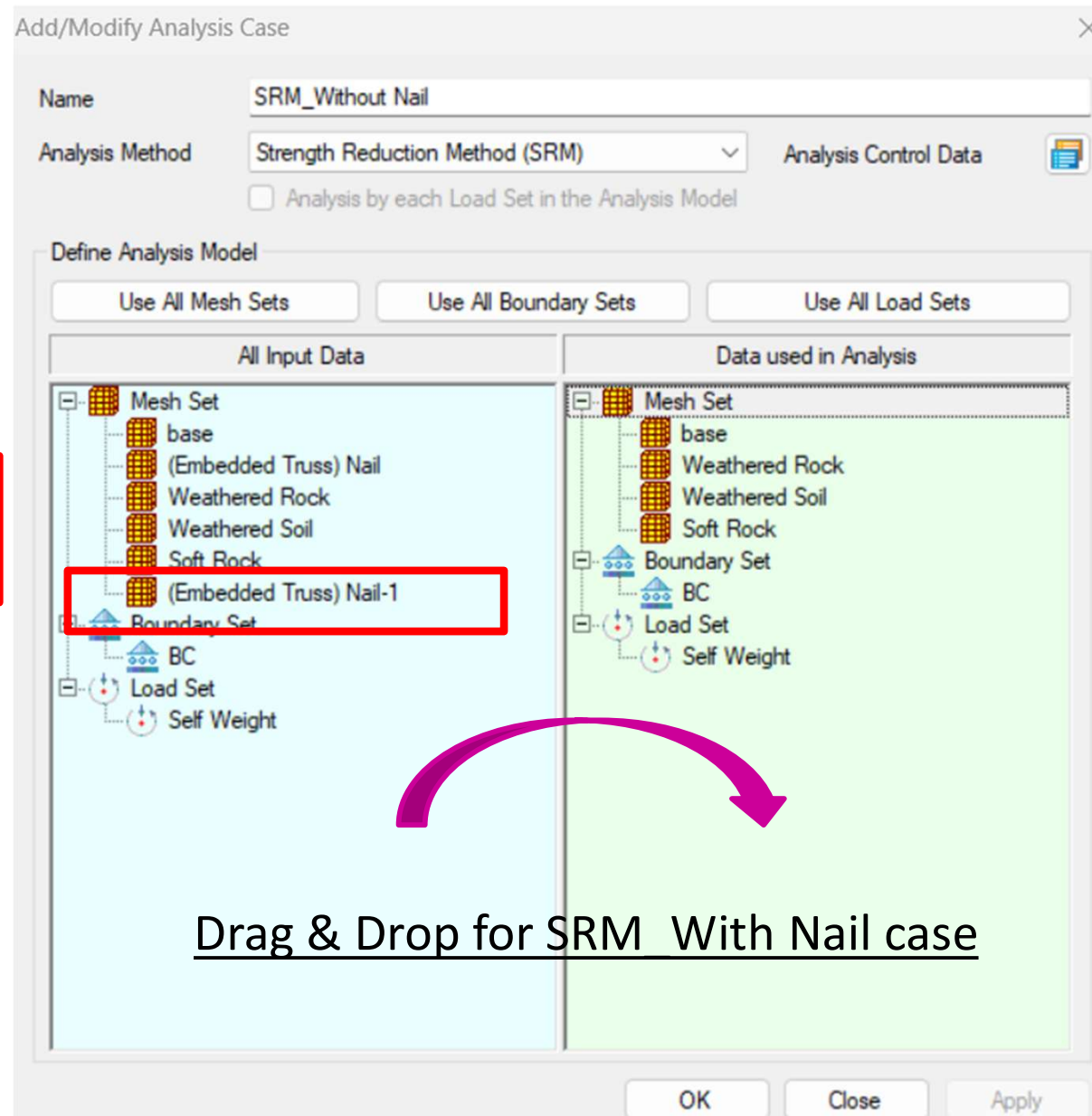
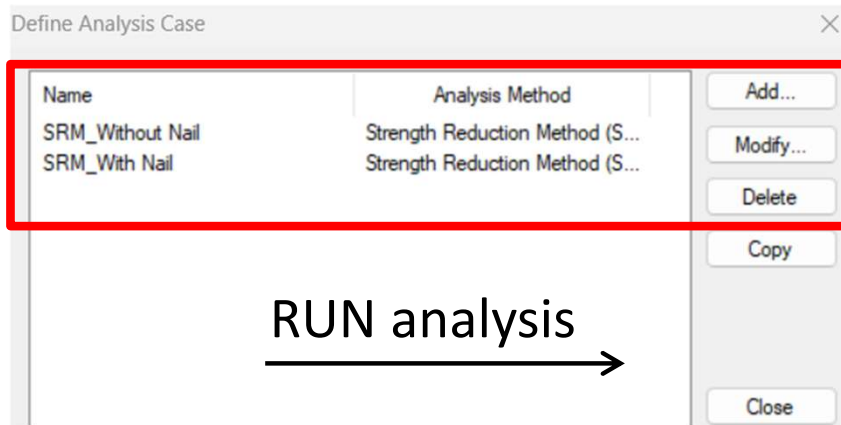
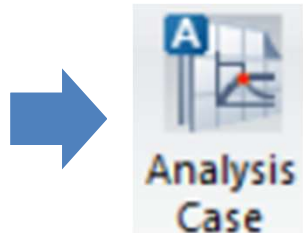
← Naming for boundary set

← Considered all mesh sets

Generating 'Boundary condition' automatically



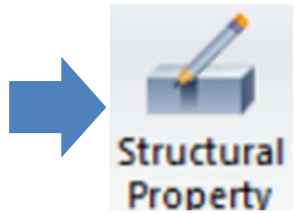
# Analysis Setting





## Part 3: Limit Equilibrium Method (LEM)

# Define Structural Properties



Define Structural Property

ID	Name
1	Nail (LEM)

General

ID 2 Name Nail (LEM)

Element Type Nail (LEM)

Stiffness

**General**

Spacing 2 m

Initial Diffusion Width 1 m

Initial Diffusion Angle 10 [deg]

Adjust Reinf. Effect by FS Independent

**Reinforcement Load**

Tensile Force 115 kN

Tension/Shear Application Method Nail

☒ RCS calculation from  $q_s$

Equivalent Radius 0.05 m

Pullout Force kN/m

Shear Force 50 kN

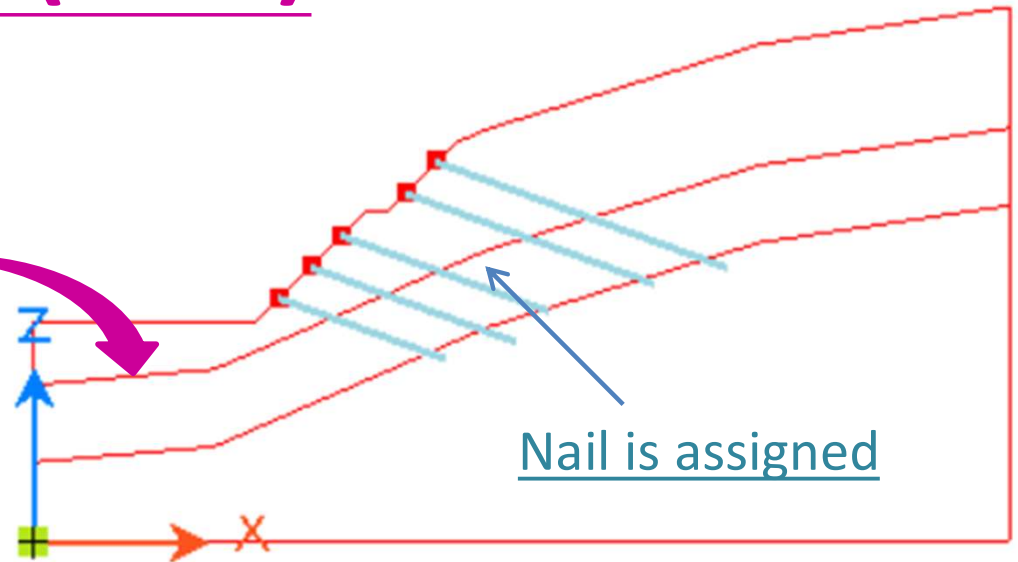
Shear Force Function None

Reset Add Modify Delete Close

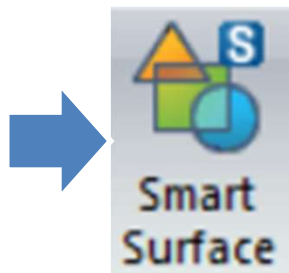
Define: 'Pile Property'

# Nail (LEM)

Drag & Drop

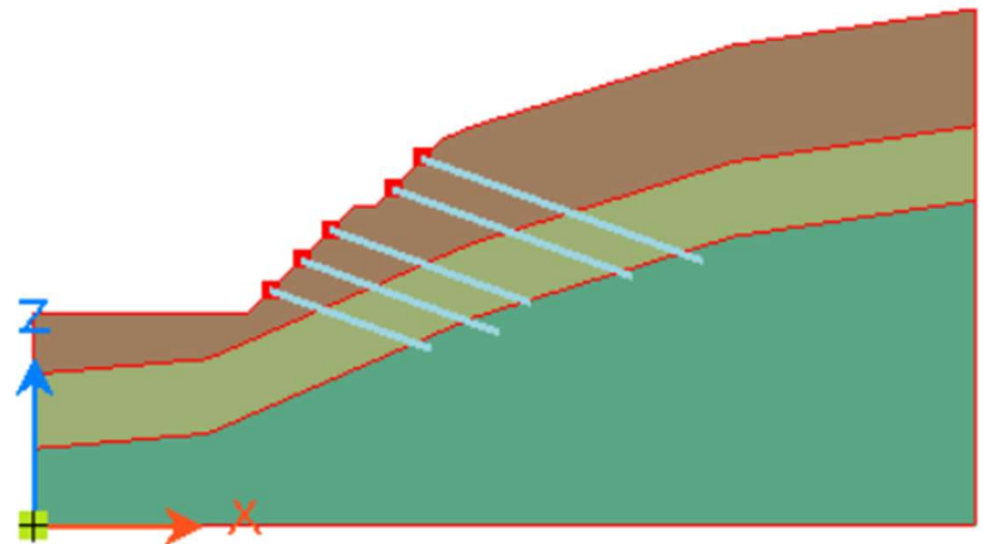


**Fig, Assigning 'Embedded truss'**



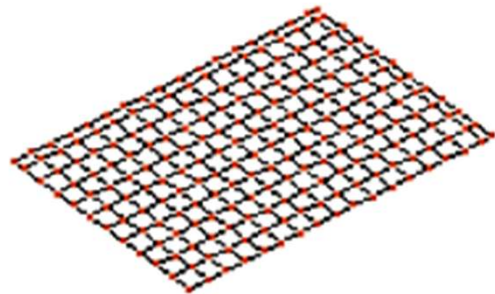
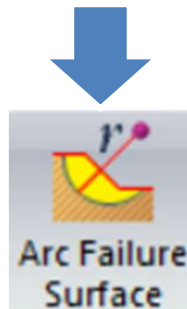
Nail (LEM) is available in SoilWorks

No mesh is required

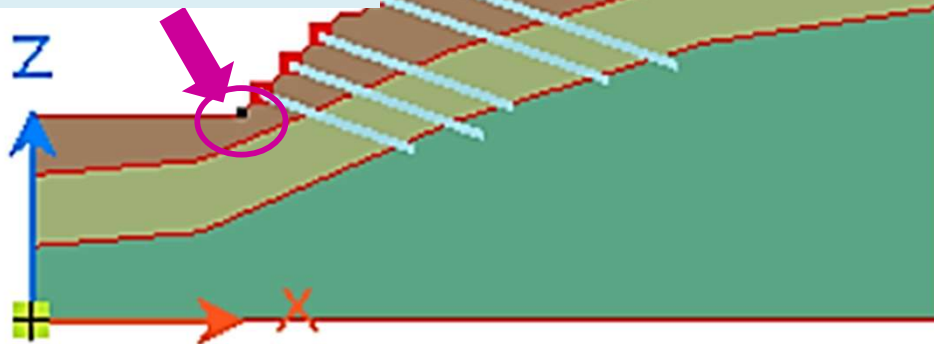


**Fig, Assigning 'Smart surface'**

# Arc Support



Passing point location



Define Arc Failure Surface

Boundary Set Arc BC

Grid Data

☒ Direct draw method  
Grid Spacing 1.000 m  
Draw Grid Range ...

☐ Method of using Table Method of using

Radius Data

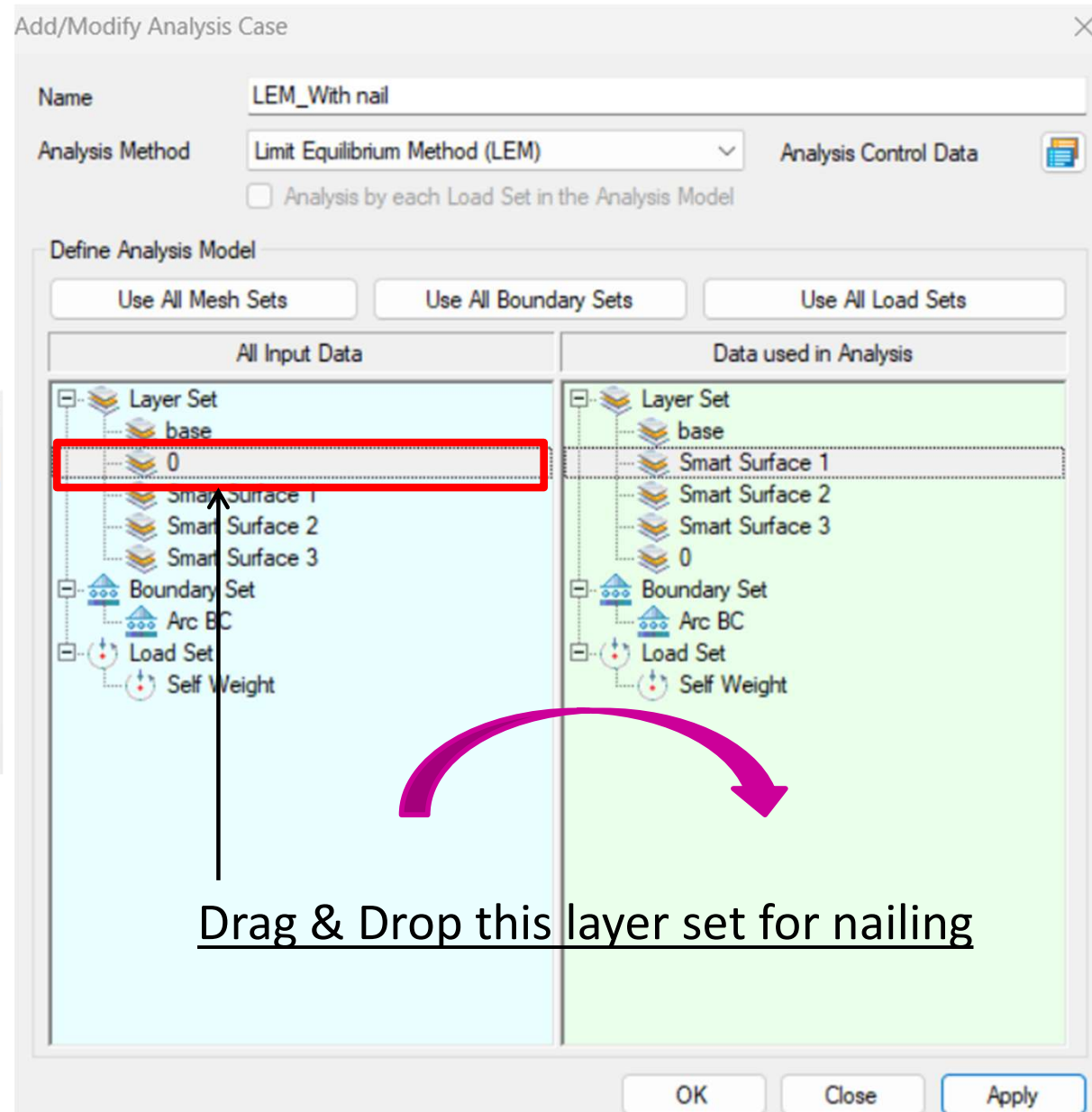
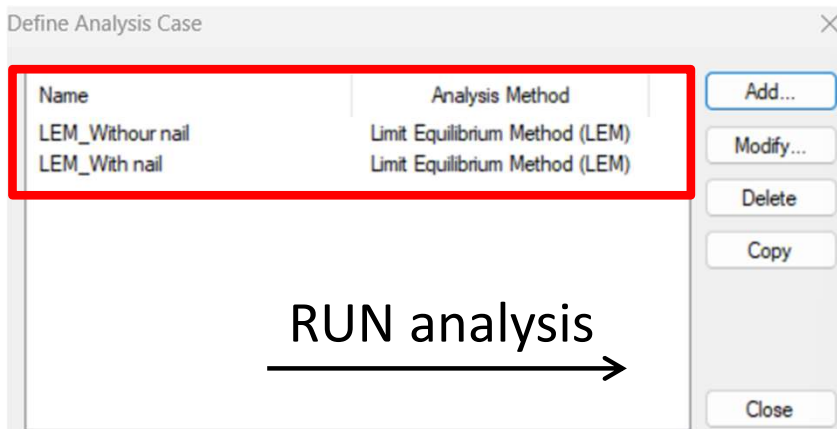
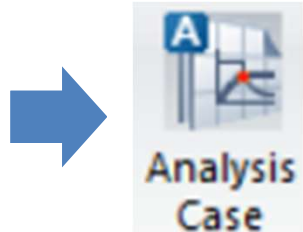
☐ Method of using Arc Tangent Lines  
Arc radius increment 1.000 m  
? Draw Arc Tangent  
Number of Arc 3  
☐ Change Tangent Direction

☒ Method of using Arc Radius  
Method of searching First Arc Radius Passage Point  
Passage Point 10.0000, 10.0000  
Arc radius increment 1.000  
Number of Arc 10  
☐ Layer Set Limiting Passage

☐ Method of using Table Method of using

OK Close Apply

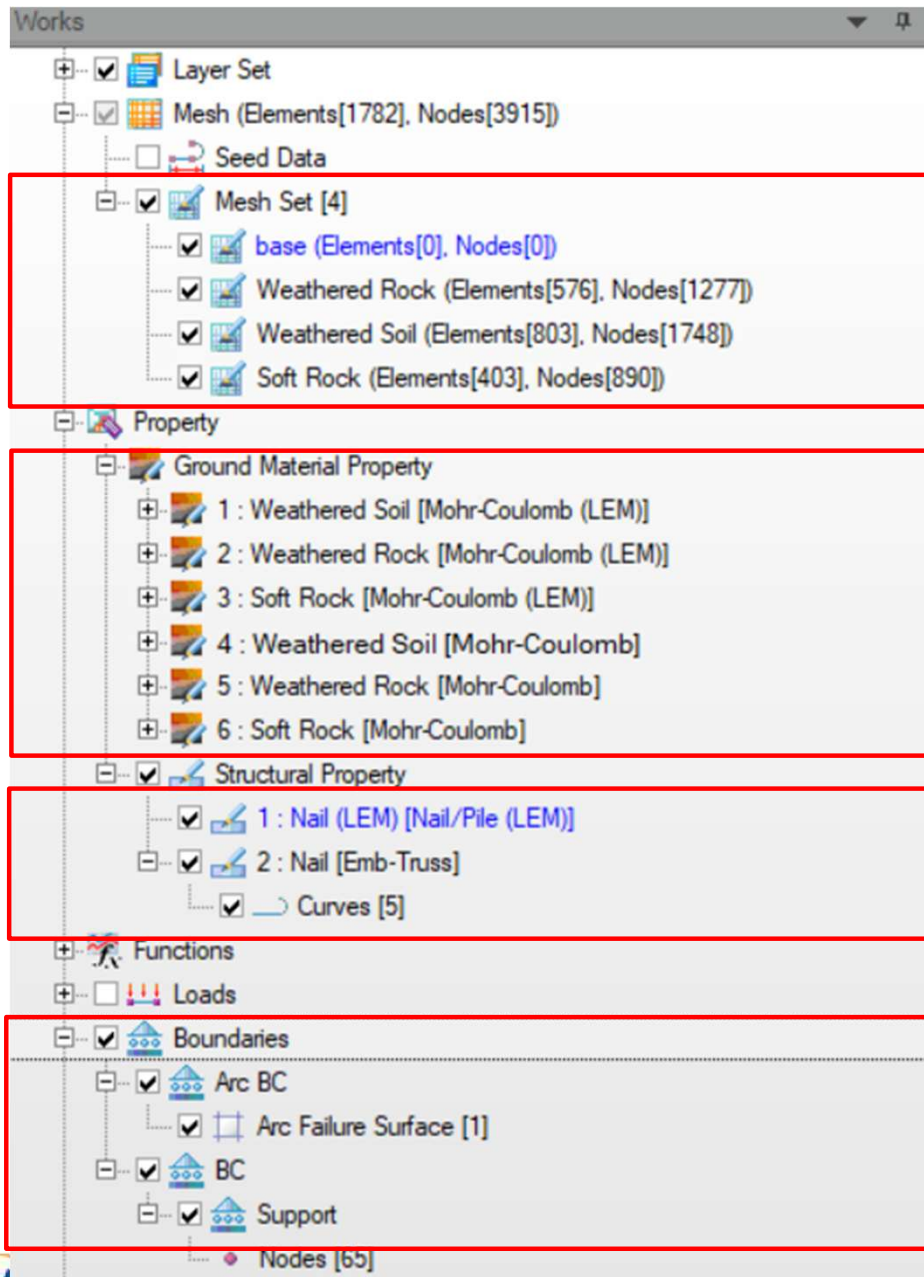
# Analysis Setting





## Part 4: Stress Analysis Method (SAM)

# Required Assignment in SAM



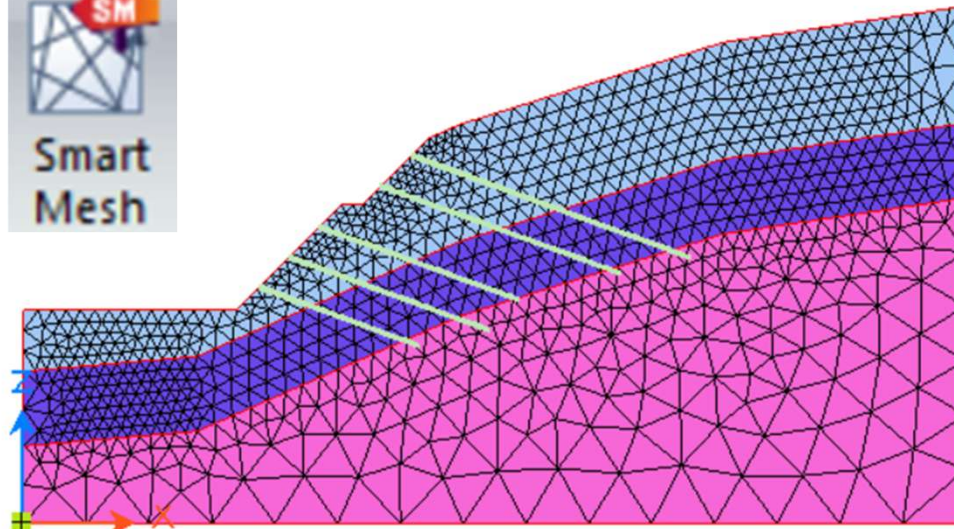
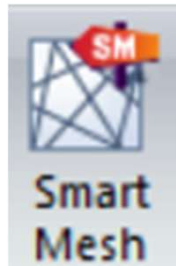
Mesh generation is required

Material Property as Mohr-Coulomb SRM model is only required

Nail for SRM is only required

Arc & Normal BC are required

# Smart Mesh + Smart Support



Define Arc Failure Surface

Boundary Set **Arc BC**

Grid Data

☒ Direct draw method  
Grid Spacing **1.000 m**  
Draw Grid Range ...

☐ Method of using Table  
Method of using

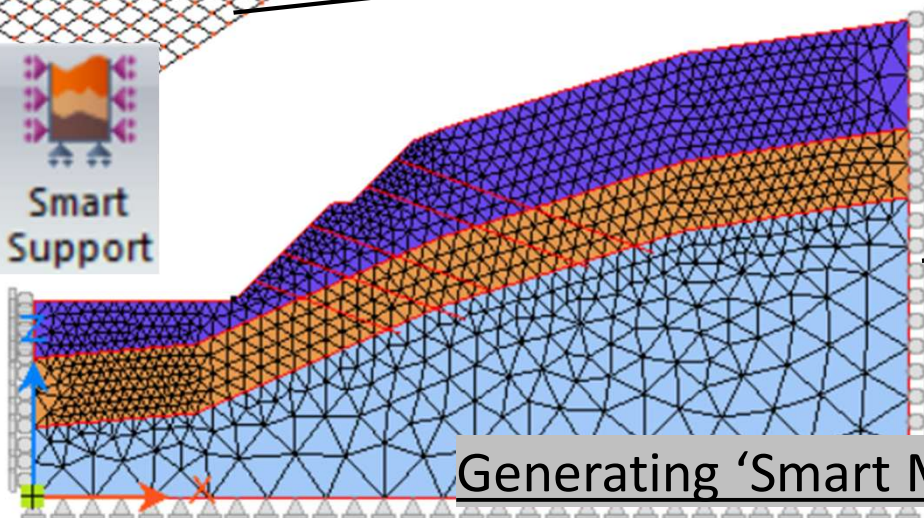
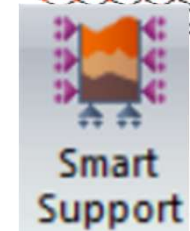
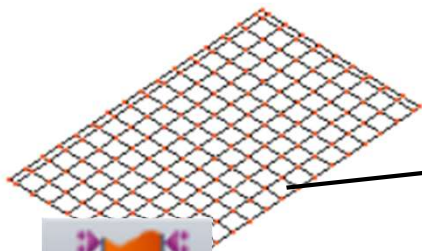
Radius Data

☐ Method of using Arc Tangent Lines  
Arc radius increment **1.000 m**  
Draw Arc Tangent

Number of Arc **3**

☐ Change Tangent Direction

☒ Method of using Arc Radius  
Method of searching First Arc Radius **Passage Point**  
Passage Point **10.0000, 10.0000**  
Arc radius increment **1.000**  
Number of Arc **10**  
☐ Layer Set Limiting Passage



Define Smart Support

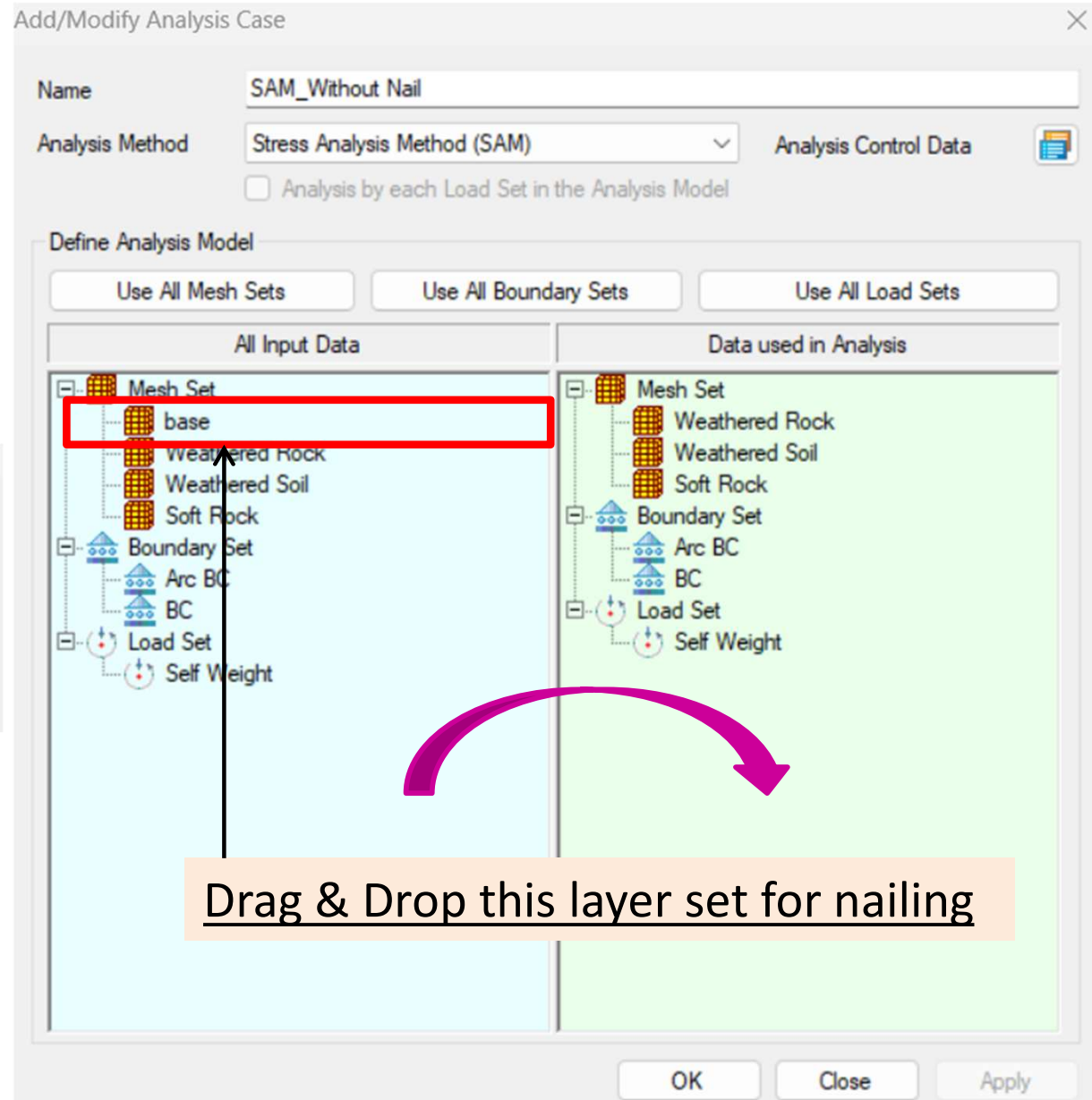
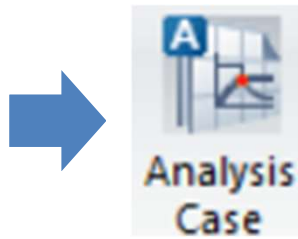
Boundary Set **BC**

Select Mesh Set(s)

☒ Consider All Mesh Sets  
Select Mesh Set(s)

Generating 'Smart Mesh and Smart Support' automatically

# Analysis Setting

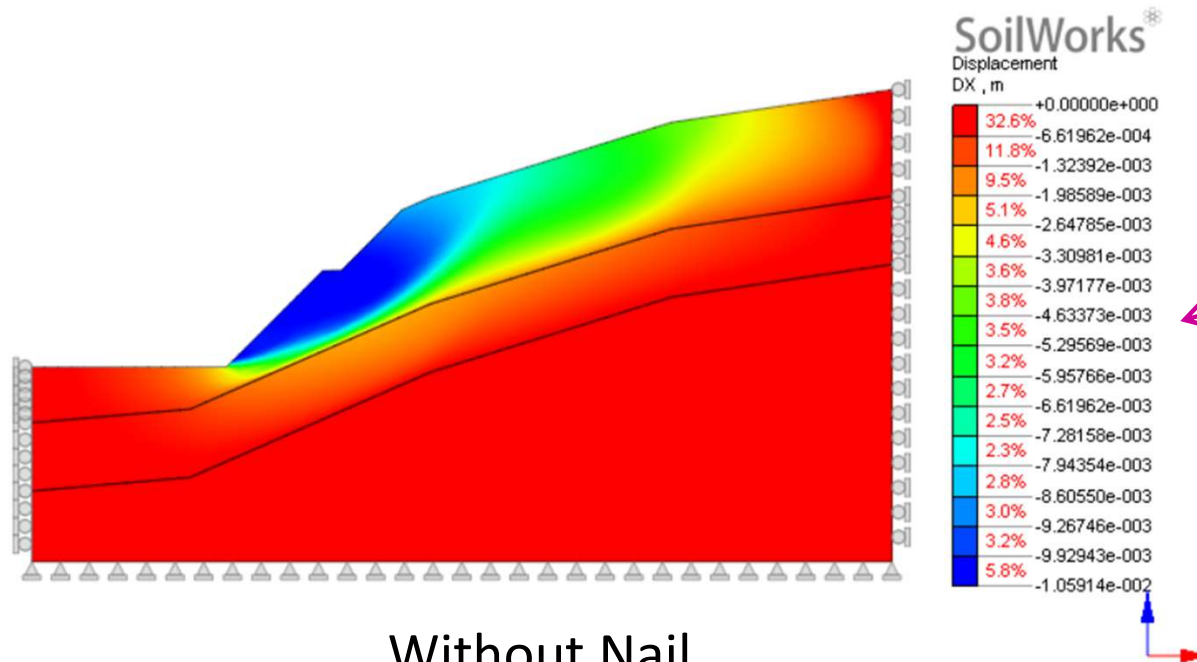


RUN analysis

## Part 5: Results and discussion

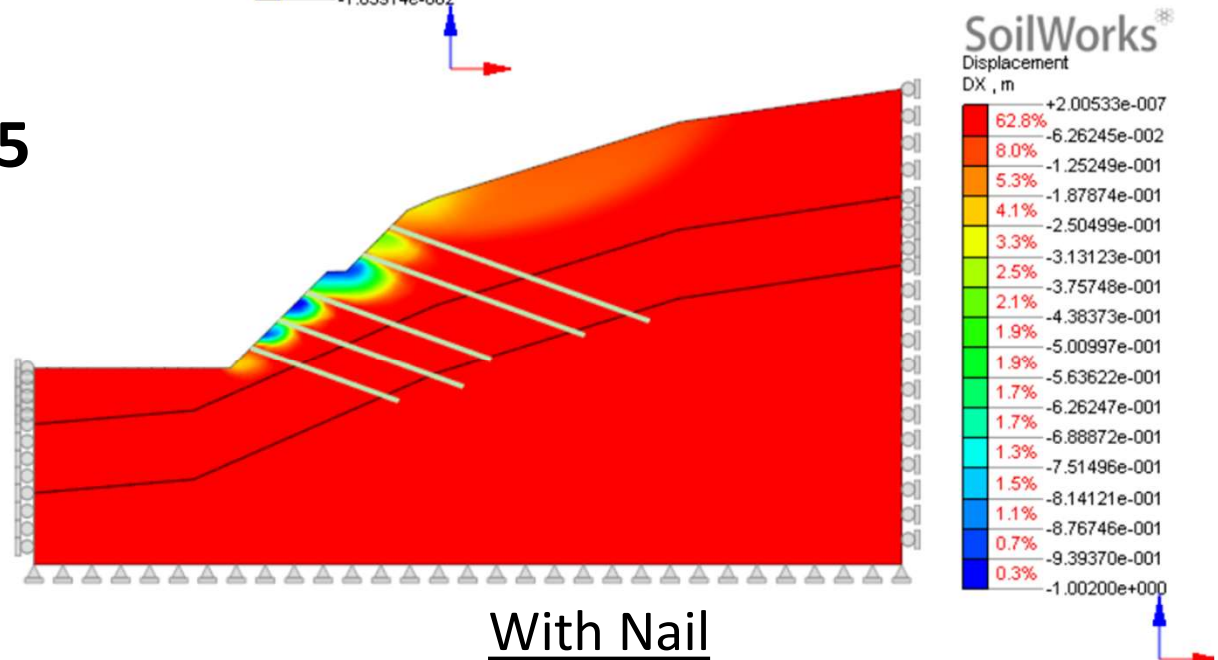


# Results – Horizontal Displacements (SRM)



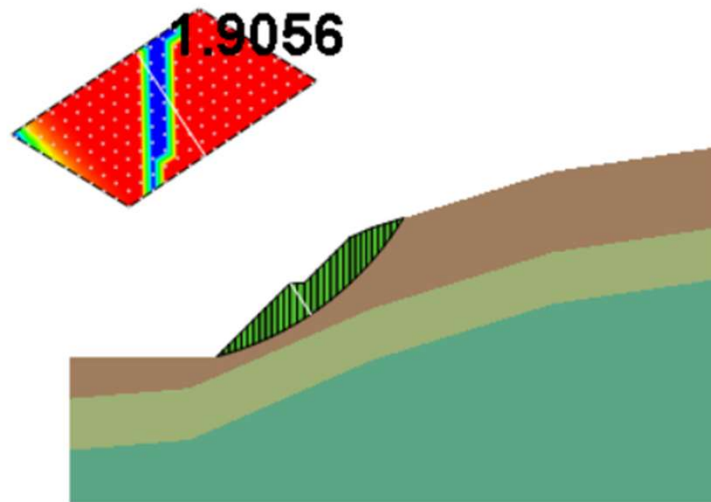
Without Nail  
**FOS = 1.8375**

Horizontal displacement

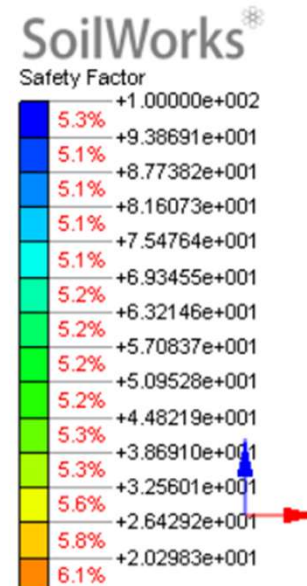


With Nail  
**FOS = 3.5875**

# Results – Horizontal Displacements (LEM)

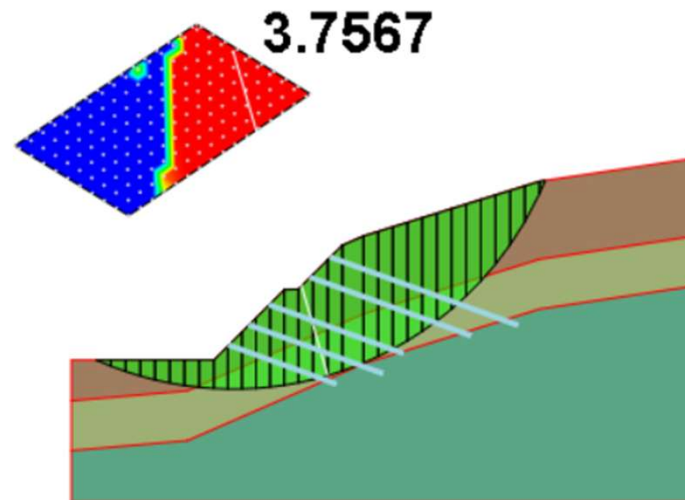


Without Nail  
**FOS = 1.9056**

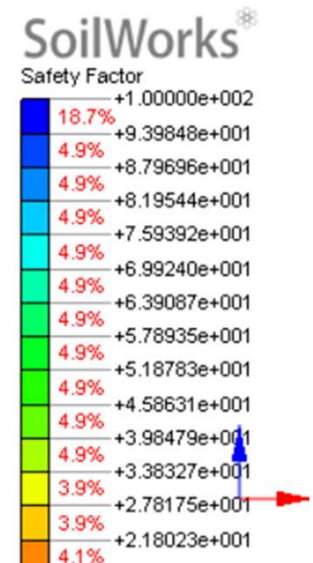


LEM-Without Nail

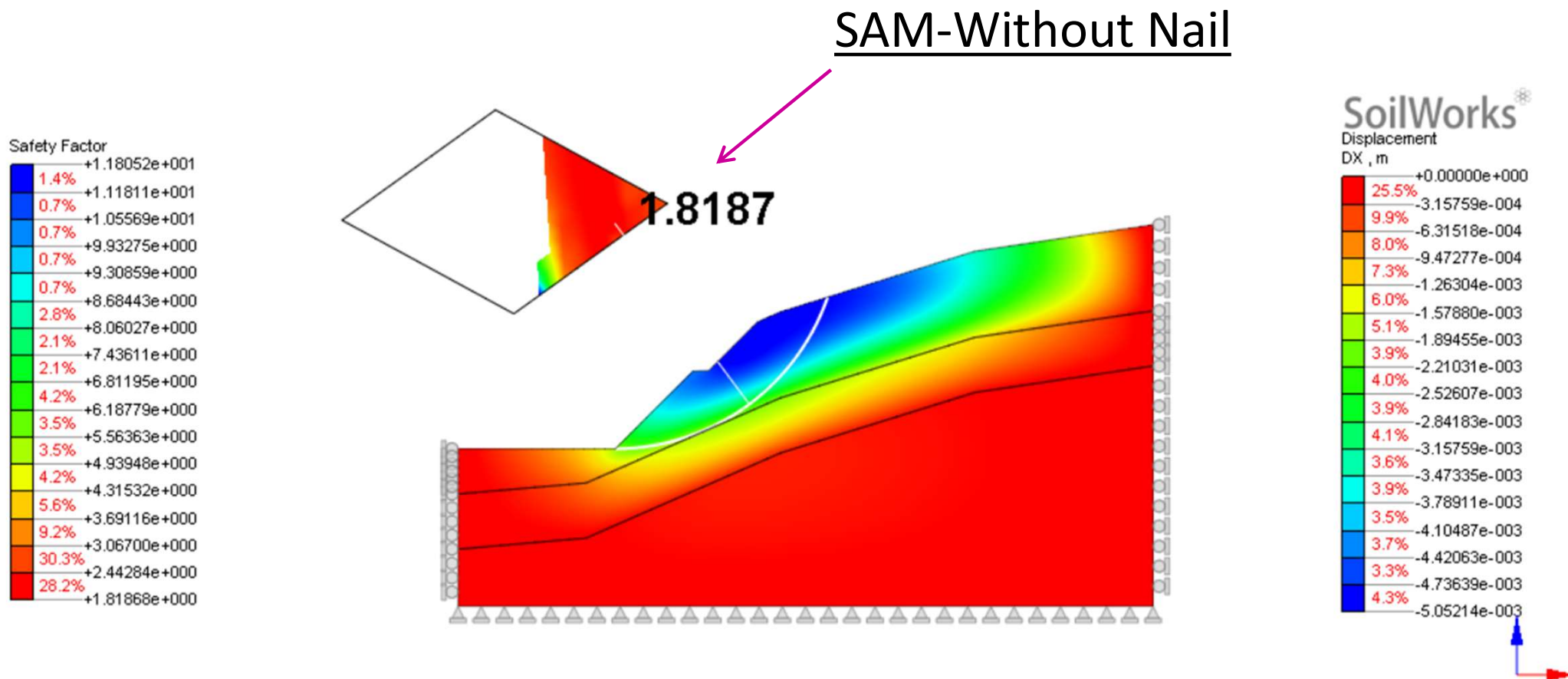
LEM-With Nail



With Nail  
**FOS = 3.7567**



# Results – Horizontal Displacements (SAM)



Without Nail (SAM)  
**FOS = 1.8187**

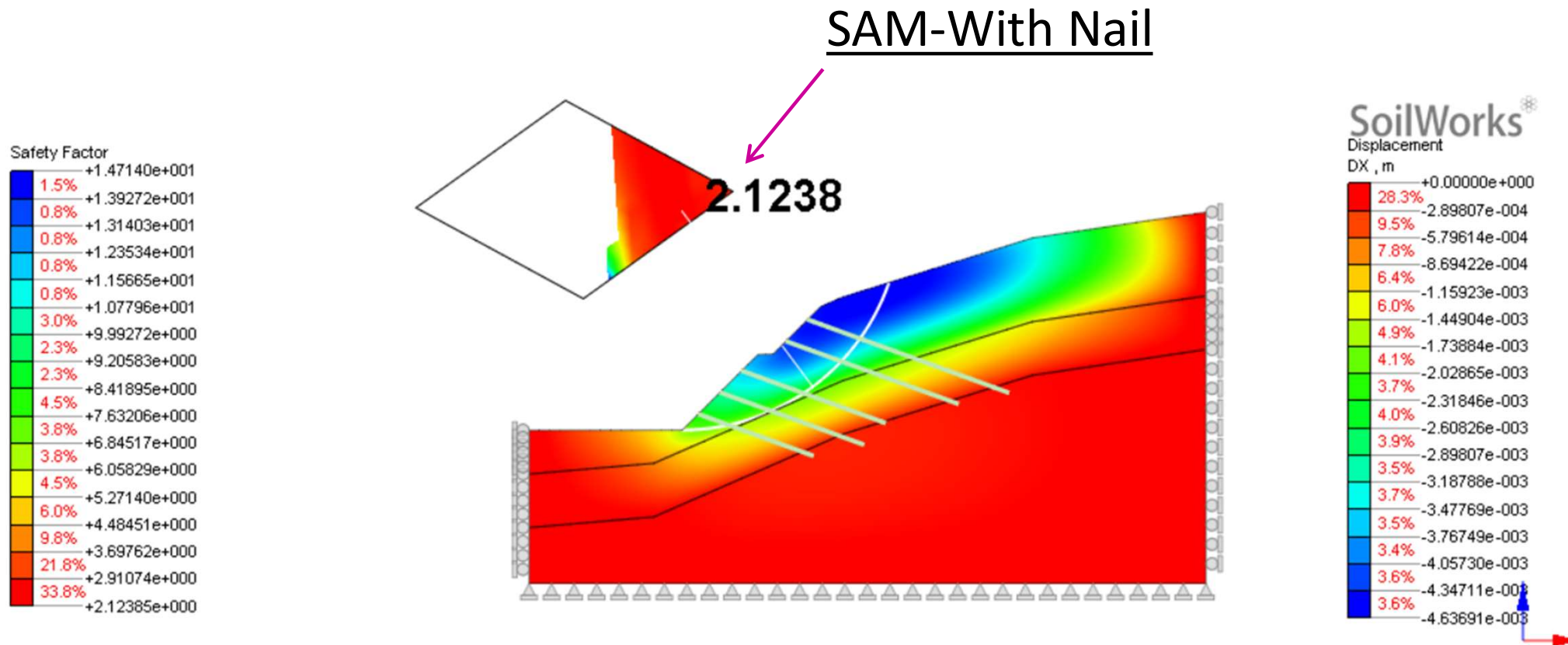
<

Without Nail (SRM)  
**FOS = 1.8375**

<

Without Nail (LEM)  
**FOS = 1.9056**

# Results – Horizontal Displacements (SAM)



With Nail (SAM)  
**FOS = 2.1238**

<

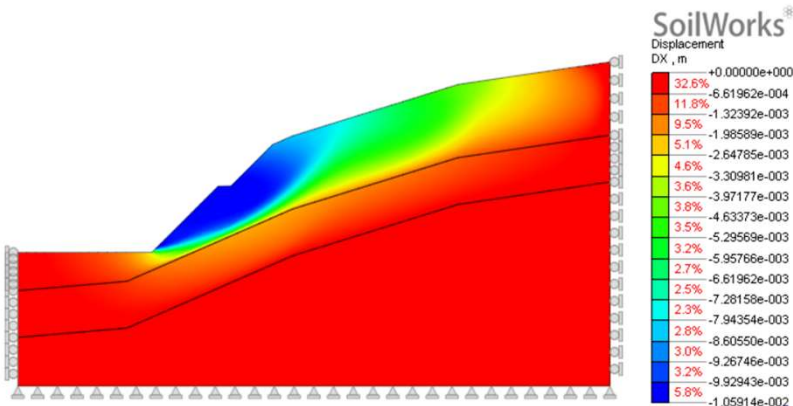
With Nail (SRM)  
**FOS = 3.5875**

<

With Nail (LEM)  
**FOS = 3.7567**

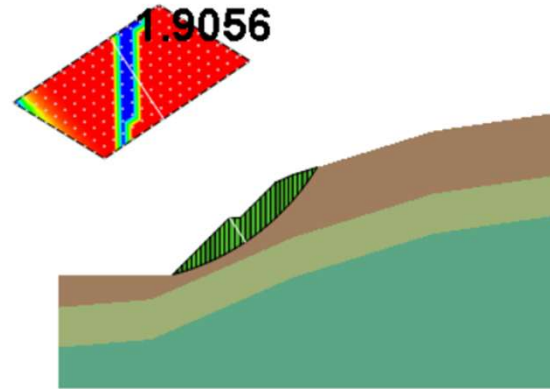


# SRM & LEM Comparison

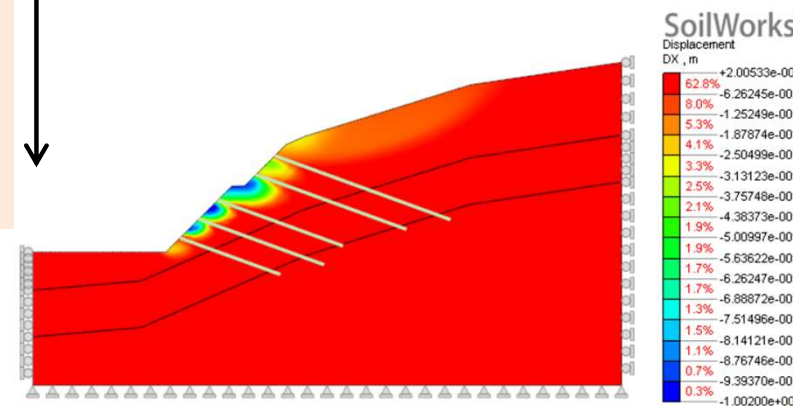


Without Nail  
**FOS = 1.8375**

Increased by 3.57%

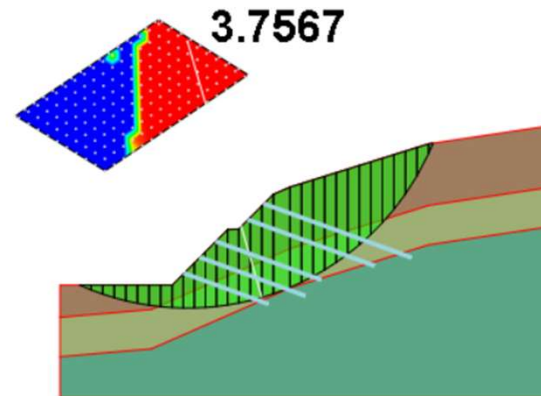


Without Nail  
**FOS = 1.9056**



With Nail  
**FOS = 3.5875**

Increased by 4.50%



With Nail  
**FOS = 3.7567**

Increased by 48.78%

Increased by 49.27%



Thank you! 