Reference: *SoilWorks Tutorials*

SoilWorks – Slope Module

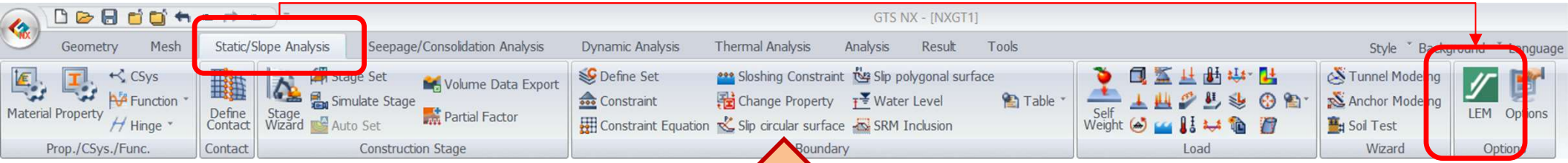
LIMIT EQUILIBRIUM METHOD

MIDAS e-mail: support@midasuser.com
Tam@midasuser.com.tw

DATE: 2026.05.22

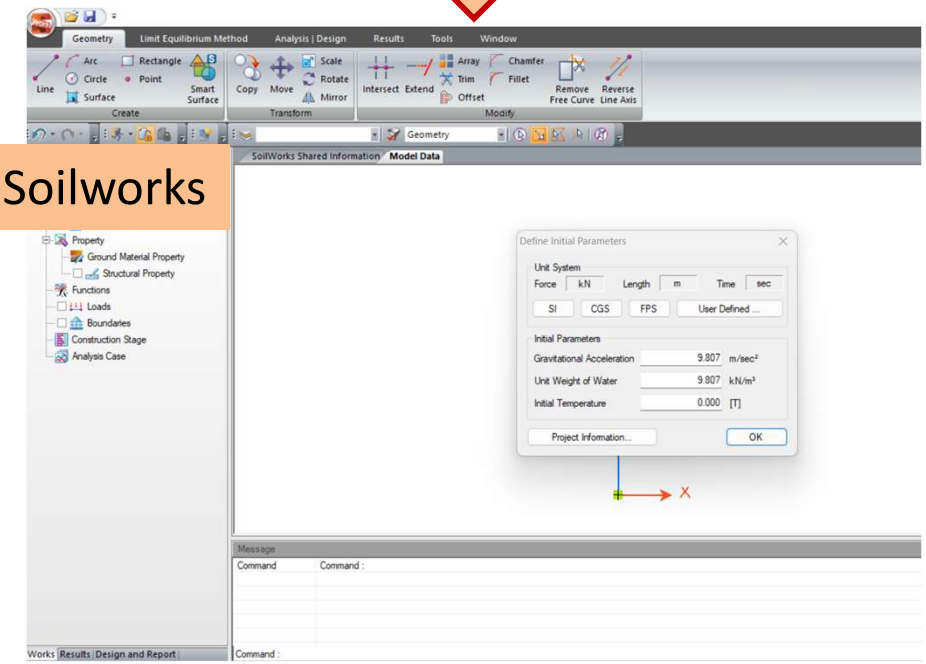
LEM Soilworks is integrated in GTS NX

LEM Soilworks is operated in GTS NX

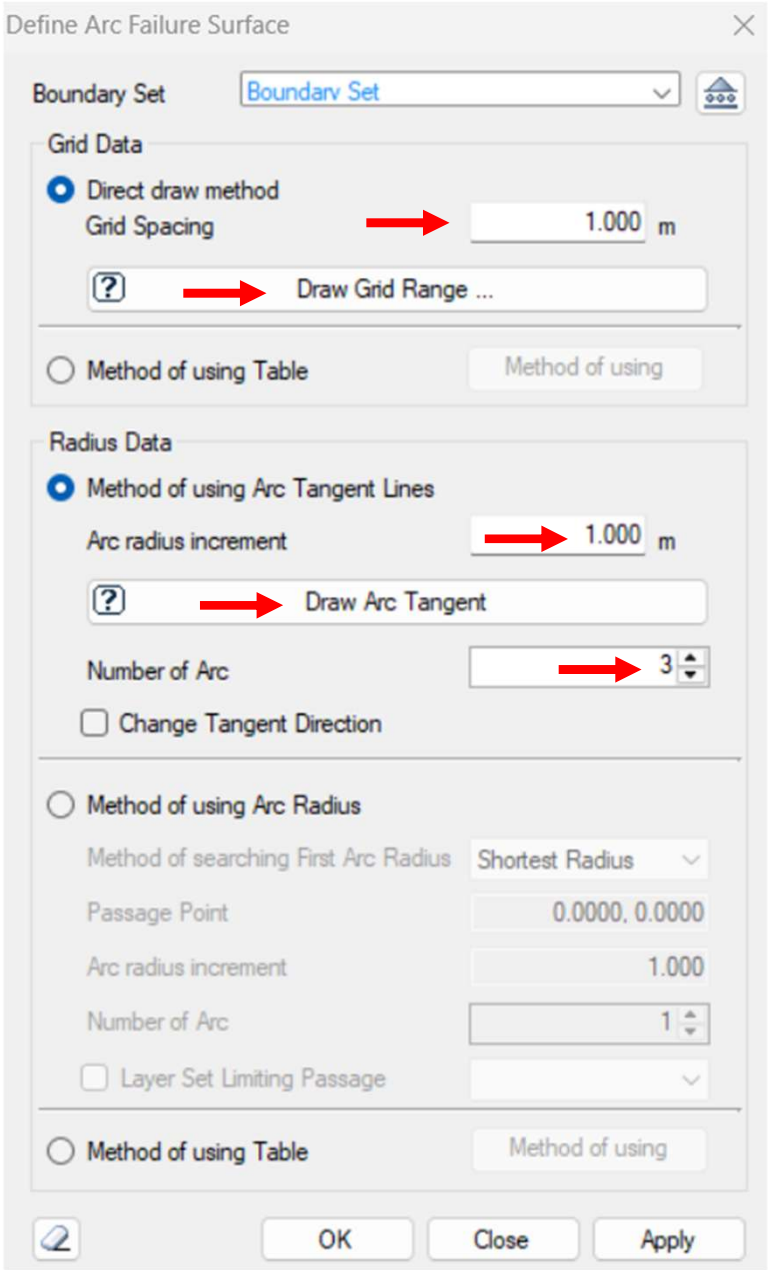


Static slope/Analysis → LEM → Soilworks

LEM in Soilworks



LEM in Soilworks



OPEN SOILWORKS ➡ SLOPE MODULE

LEM ➡ ARC FAILURE SURFACE

OUTLINE

Part 1:

LEM for Soil Nail Reinforced Slope Stability

Part 2:

LEM for Stability Analysis of Reinforced Earth Retaining Walls

Part 1:

LEM for Soil Nail Reinforced Slope Stability

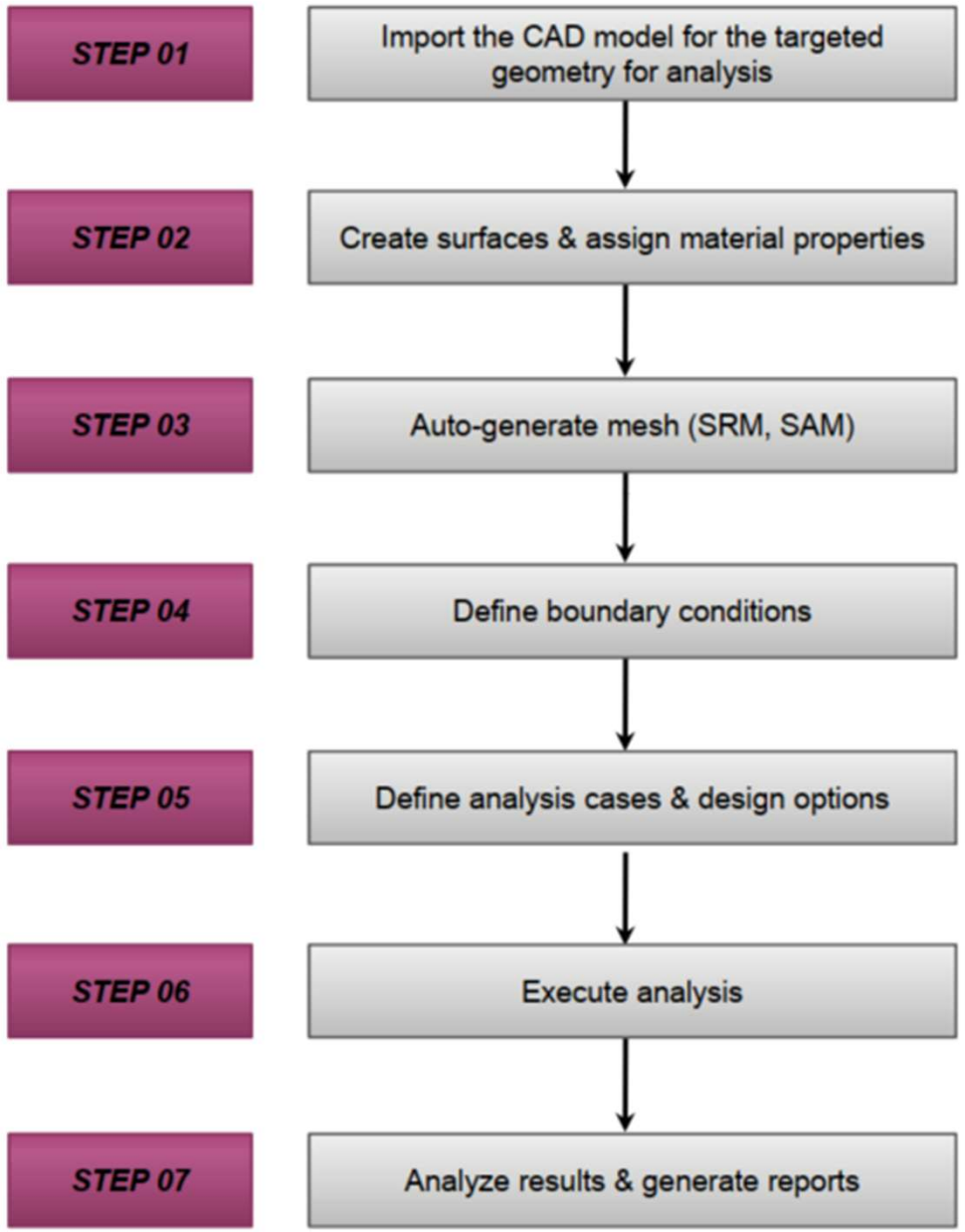
Learning Objective

- Expose to slope stability analysis using:

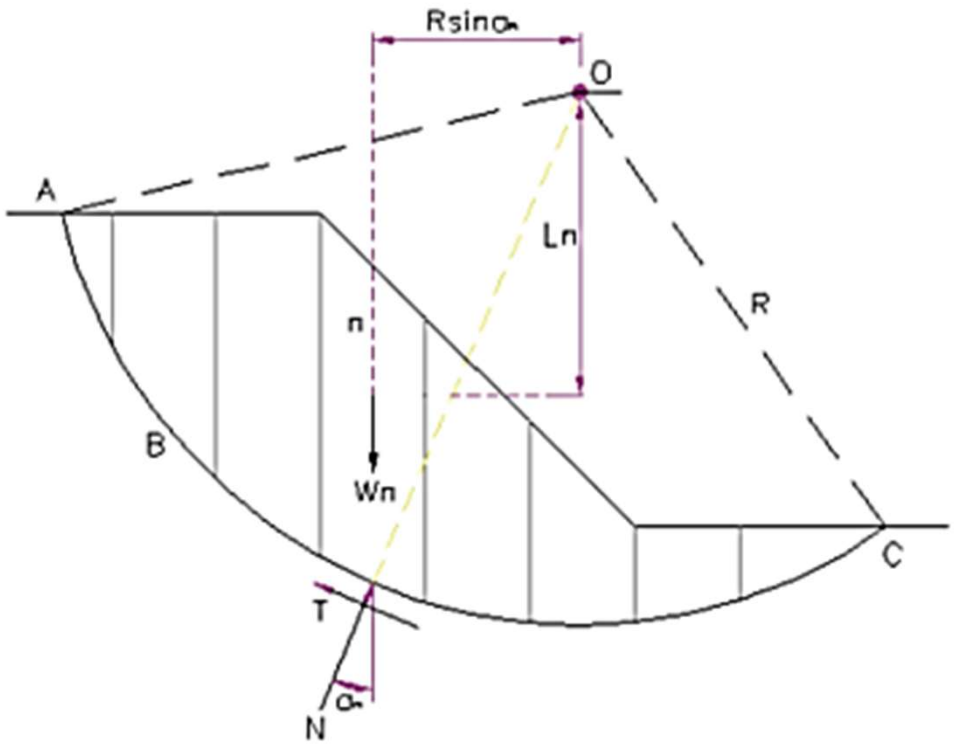
  ✓ LEM
  (Limit Equilibrium Method)

  ✓ SRM
  (Strength Reduction Method)

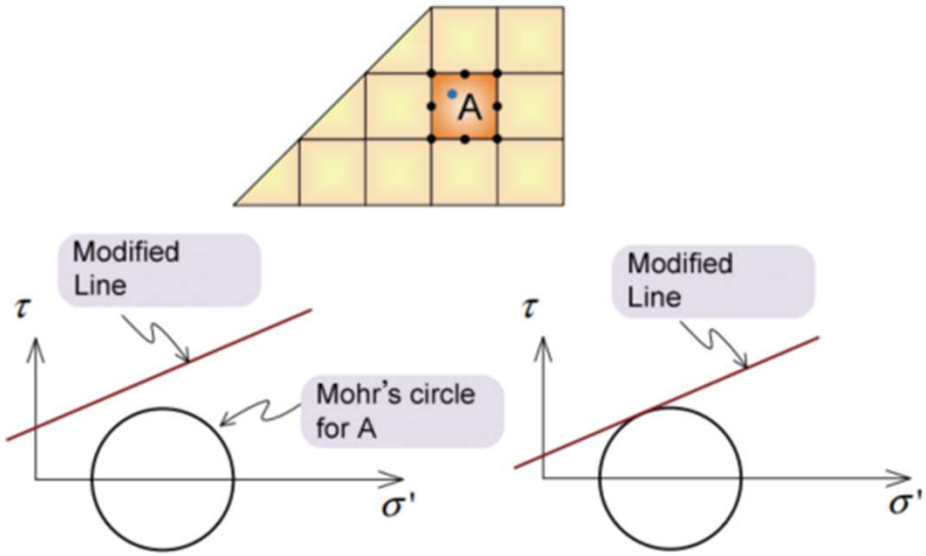
  ✓ SAM
  (Stress Analysis Method)



Overview



Fig, Limit Equilibrium Method



Fig, Strength Reduction Method

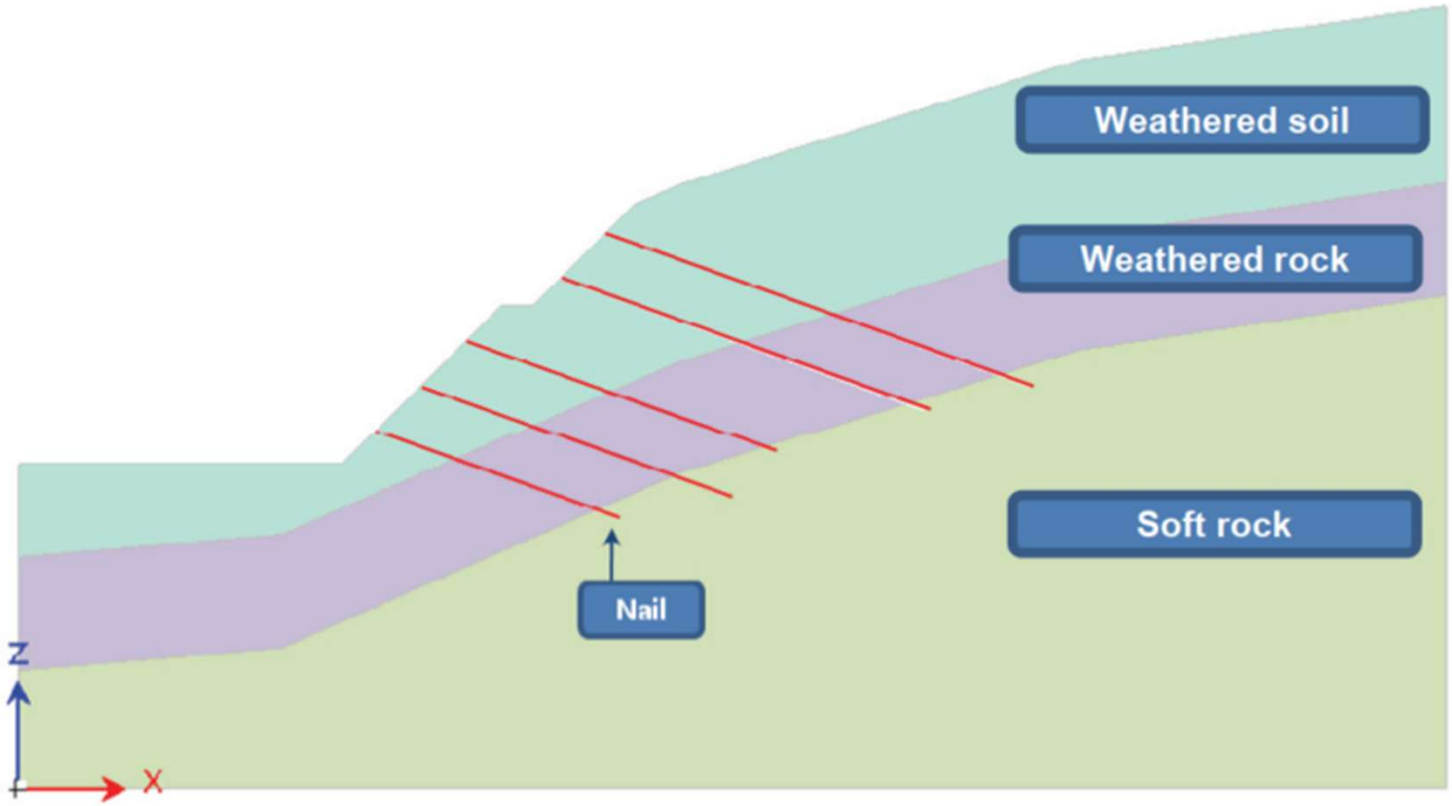
$$Fs = \frac{\sum_{n=1}^{n=p}(cb_n + W_n \tan\phi + \Delta T \tan\phi)\frac{1}{m}\alpha(n)}{\sum_{n=1}^{n=p}(\sin\alpha_n)}$$

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

W : Total weight of soil slices (tf/m³)
α : Angle of slope (degree)
C : Cohesion of soil (tf/m²)
b : Slice width (m)
ø : Internal angle of friction (degree)
ΔT : Tn - Tn+1

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^2)	Unit Weight (kN/m^3)	Saturated Unit Weight (kN/m^3)	Poisson's Ratio	Cohesion (kN/m^2)	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

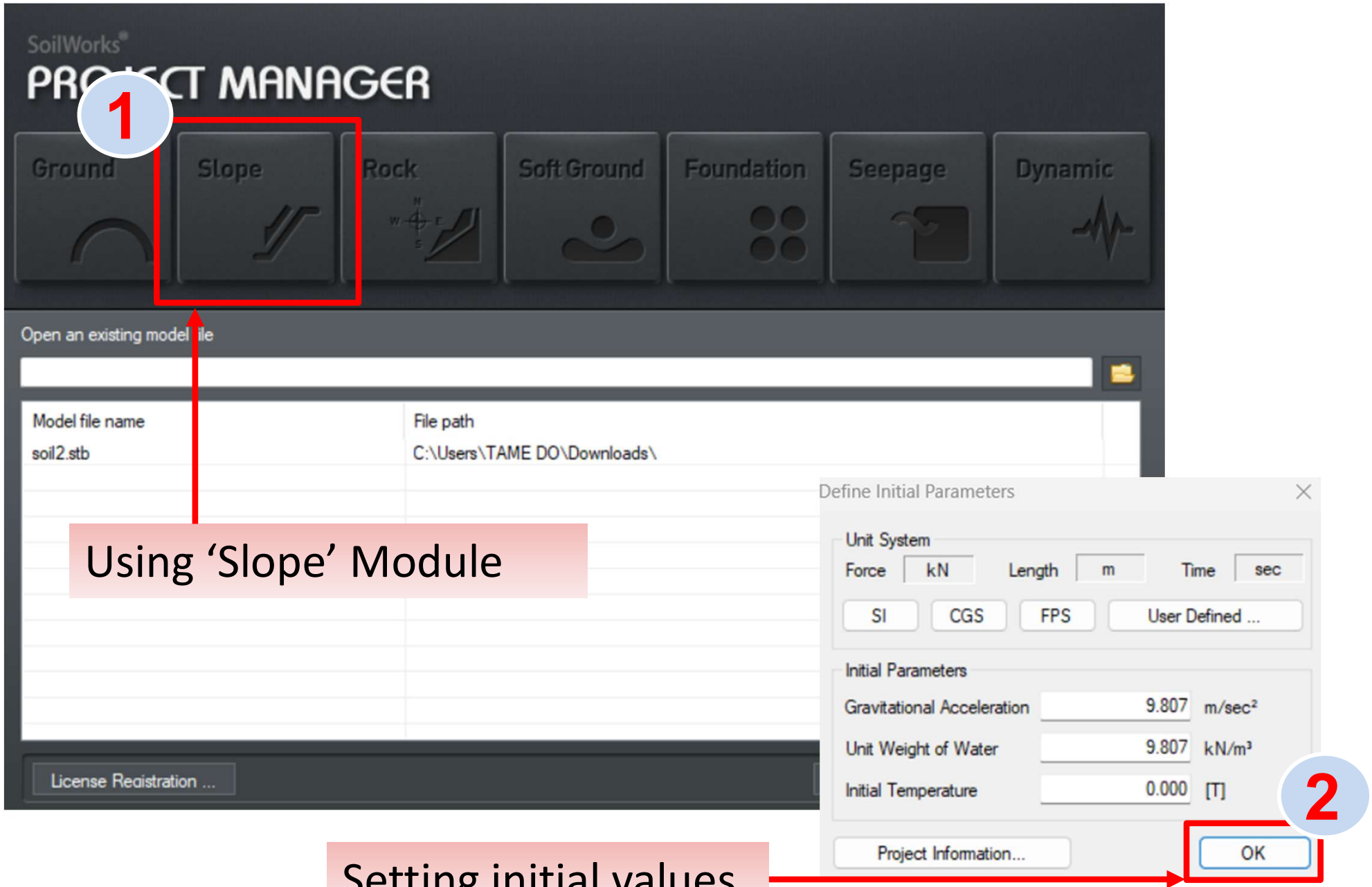
▶ Structural properties

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

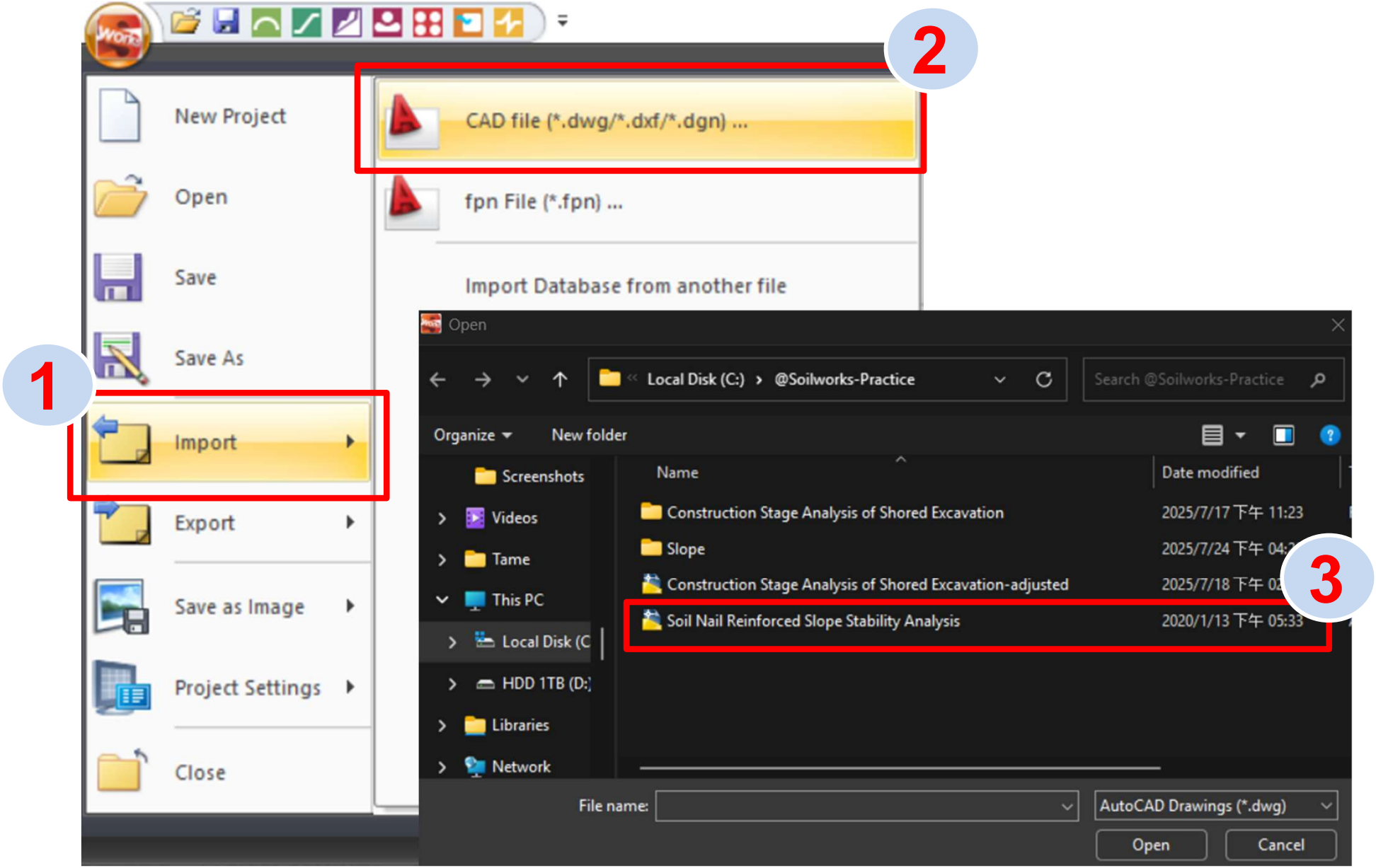
No	Structure Type	Model Type	Horizontal Spacing (m)	Rebar Section Area (m^2)	Modulus of Elasticity (kN/m^2)	Poisson's Ratio	Unit Weight (kN/m^3)	Yield Strength (kN/m_2)
1	Nail	Embedded Truss	2.0	10	115	0.05	25	350,000

MIDAS

Start SoilWorks



Import File


1
2
3
New Project
Open
Save
Save As
Import
Export
Save as Image
Project Settings
Close
CAD file (*.dwg/*.dxf/*.dgn) ...
fpn File (*.fpn) ...
Import Database from another file
Open
Local Disk (C:) › @Soilworks-Practice
Search @Soilworks-Practice
Organize
New folder
Screenshots
Videos
Tame
This PC
Local Disk (C
HDD 1TB (D:)
Libraries
Network
Name
Date modified
Construction Stage Analysis of Shored Excavation
2025/7/17 下午 11:23
Slope
Construction Stage Analysis of Shored Excavation-adjusted
Soil Nail Reinforced Slope Stability Analysis
2020/1/13 下午 05:33
File name:
AutoCAD Drawings (*.dwg)
Open
Cancel

Define Ground Properties (SRM & LEM)

Define Ground Material Property

Data

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

6

General

ID 1 Name

Model Type: Mohr-Coulomb

General Parameters

Modulus of Elasticity (E)	20000000	kN/m²
Poisson's Ratio (υ)	0.3	
Temperature Coeff. (α)	1E-06	
Unit Weight (Yt)	20	kN/m³
Saturated Unit Weight	21	kN/m³
Cohesion (c)	30	kN/m²
Internal Friction Angle (Φ)	36	[deg]
Earth Pressure Coeff. (Ko)	1	
Draining Condition	Drained	

Additional Parameters

Variation in Modulus of Elasticity	0	kN/
Variation in Cohesion	0	kN/
Reference Height	0	m
Dilatancy Angle (Ψ)	36	[deg
Tensile Strength	2000	kN/m²

1

Ground Material Property

Ground Material Database

Database: 1.1 Schist#1

3

Select All | Unselect All

No.	Soil Type	Modulus of Elasticity (kN/m²)	Unit Weight (kN/m³)	Saturated Unit Weight (kN/m³)	Poisson's Ratio	Cohesion (kN/m²)	Internal Friction Angle ([deg])	Select
1	Landfill Layer	13000	18	19	0.33	0	27	
2	Alluvial Layer	8000	17	18	0.35	15	20	
3	Weathered Soil	36500	18.5	19.5	0.33	17.5	31	☑
4	Weathered Rock	150000	21	22	0.3	50	33	☑
5	Soft Rock	1850000	24	25	0.28	180	35.5	☑
6	Hard Rock	17500000	26	27	0.23	1750	40.5	☐

4

2

Database ...

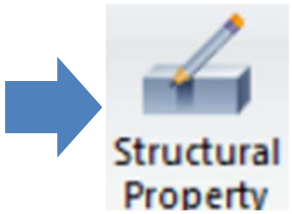
Reset | Save | Model Type: Mohr-Coulomb | Assign | Close

5

MIDAS

Mohr-Coulomb (LEM) for LEM analysis

Define Strutural Properties



Define: ‘Pile Property’

Define Structural Property

Data

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 qs		
Equivalent Radius	0.05	m
Pullout Force		kN/m
Shear Force	50	kN
Shear Force Function	None	...

Reset Add Modify Delete Close

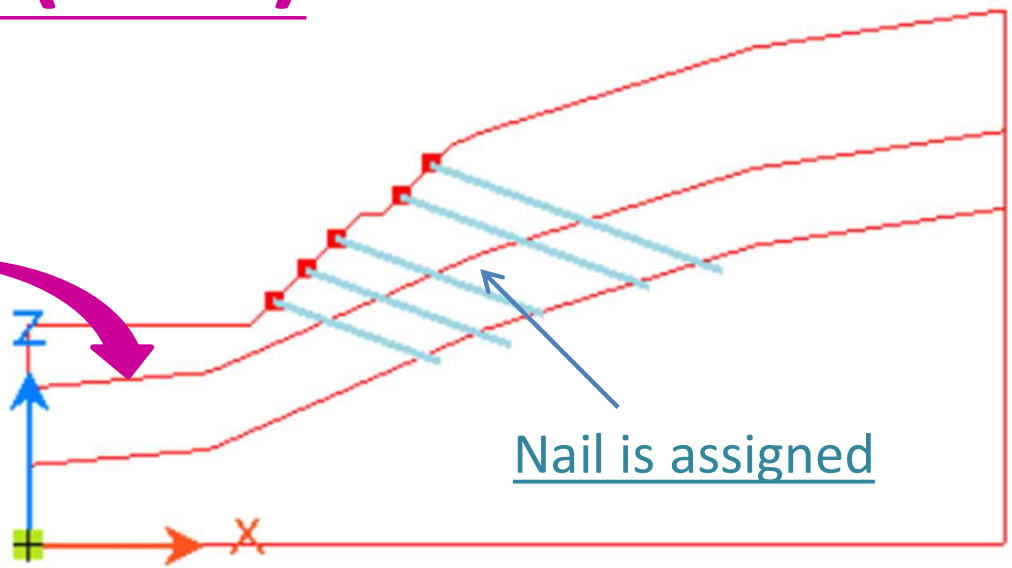
1

2

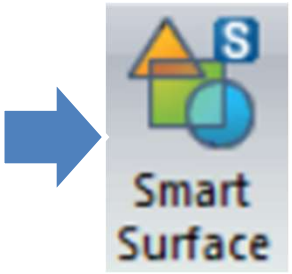
3

Nail (LEM)

Drag & Drop

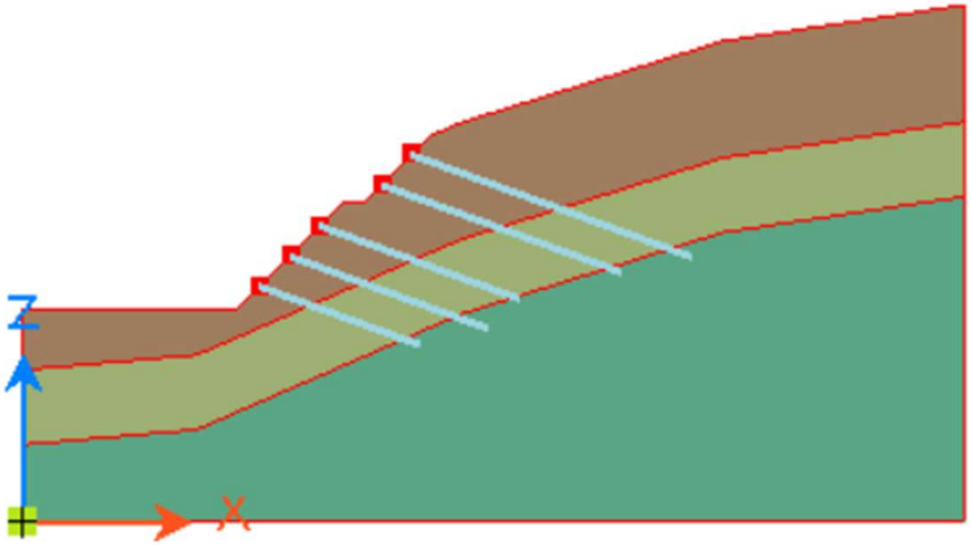


Fig, Assigning 'Embedded truss'



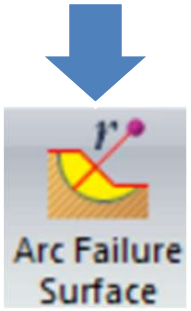
Nail (LEM) is available in SoilWorks

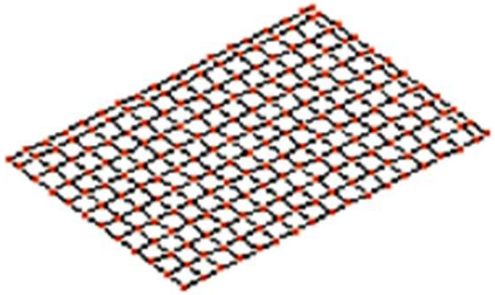
No mesh is required



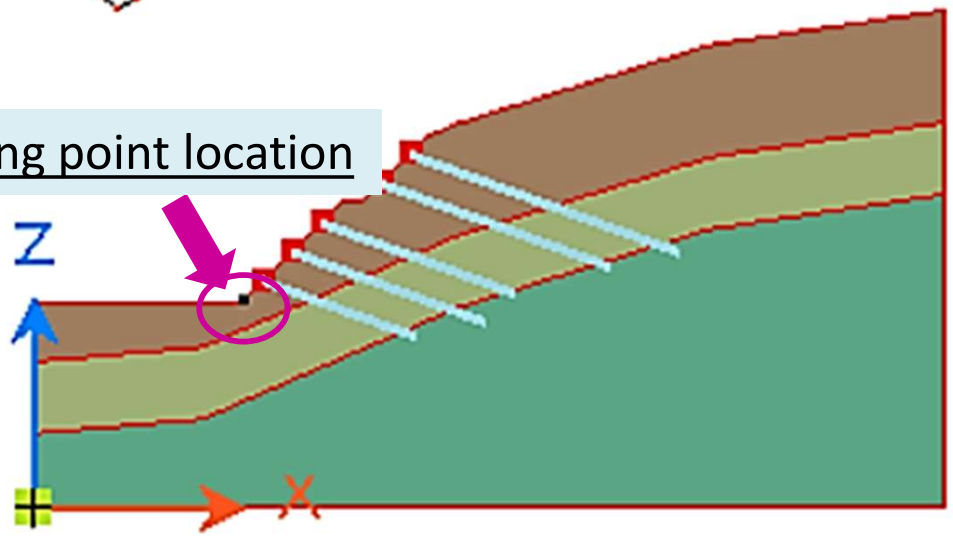
Fig, Assigning 'Smart surface'

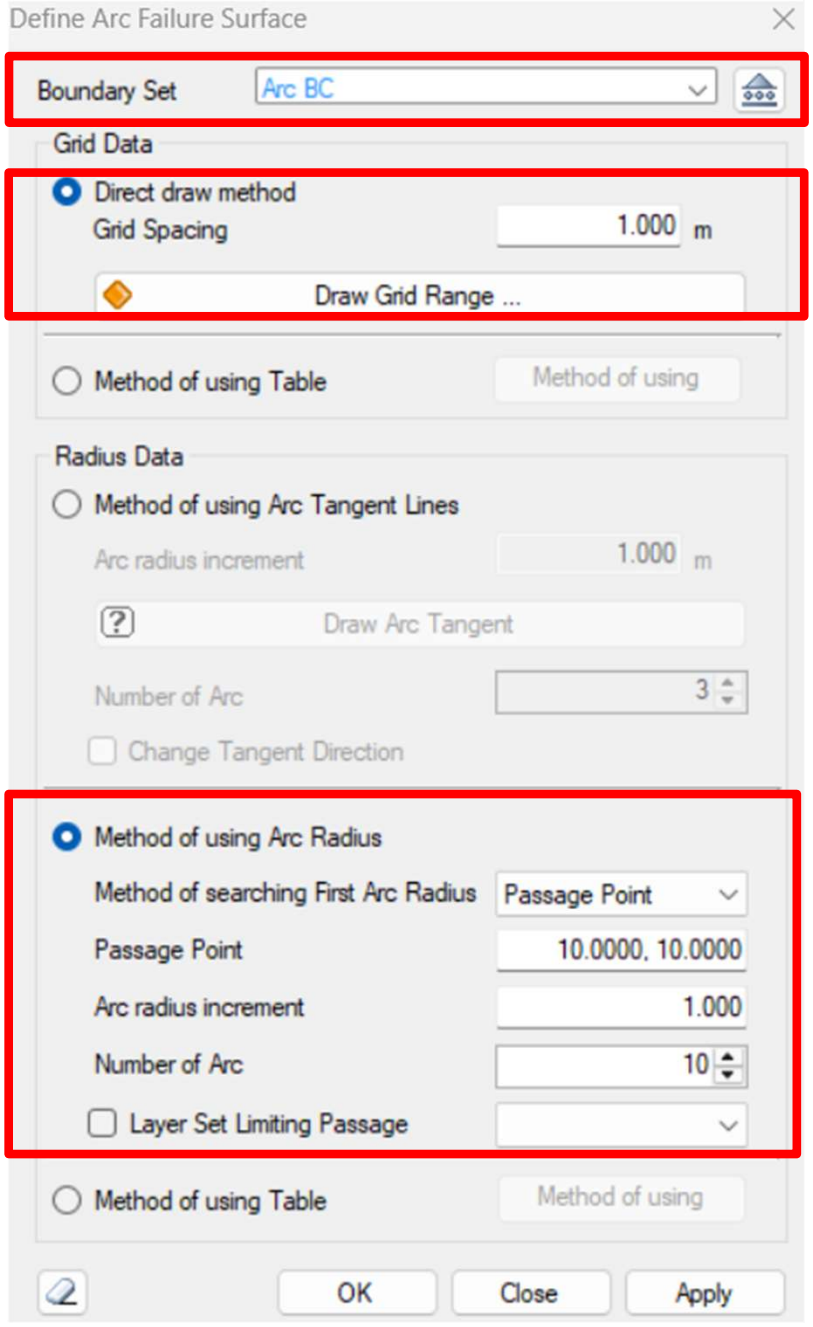
Arc Support



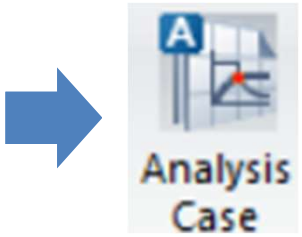


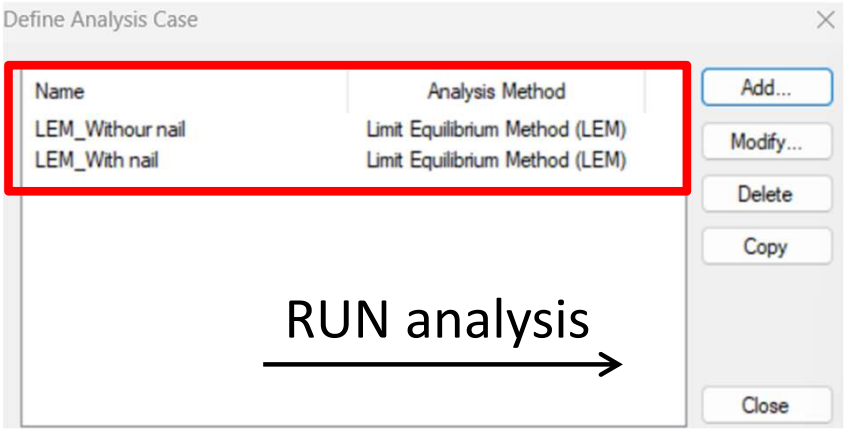
Passing point location

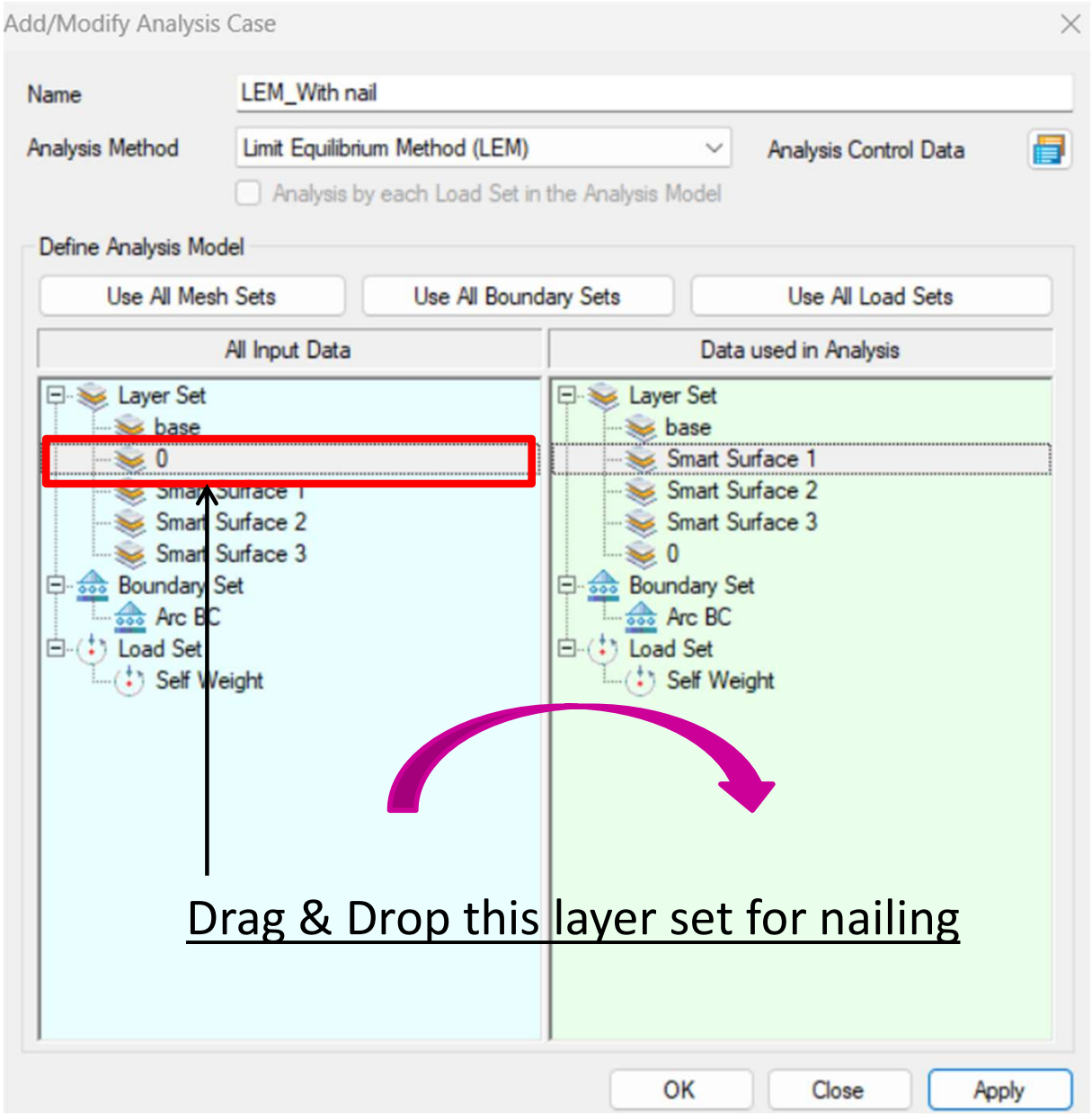




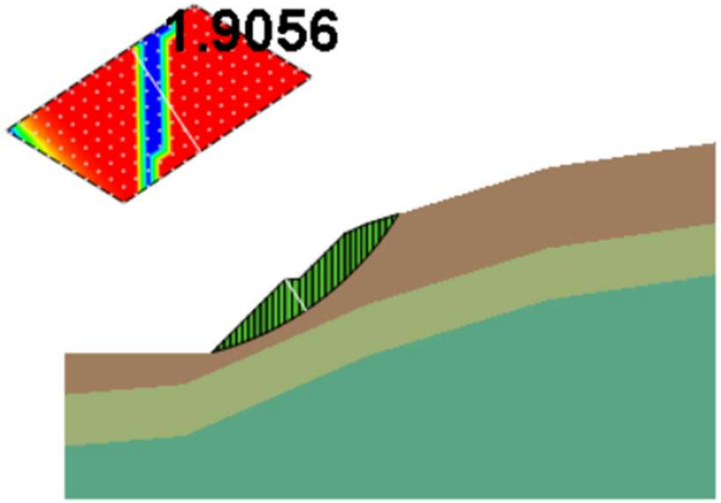
Analysis Setting

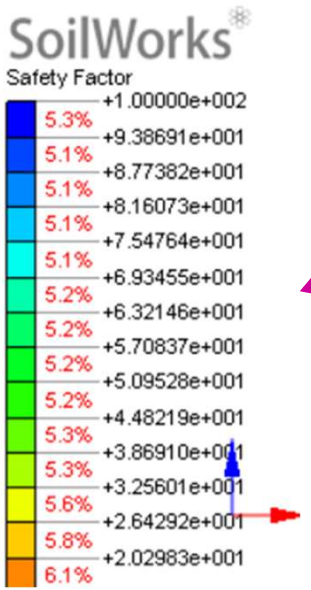






Results – Horizontal Displacements (LEM)



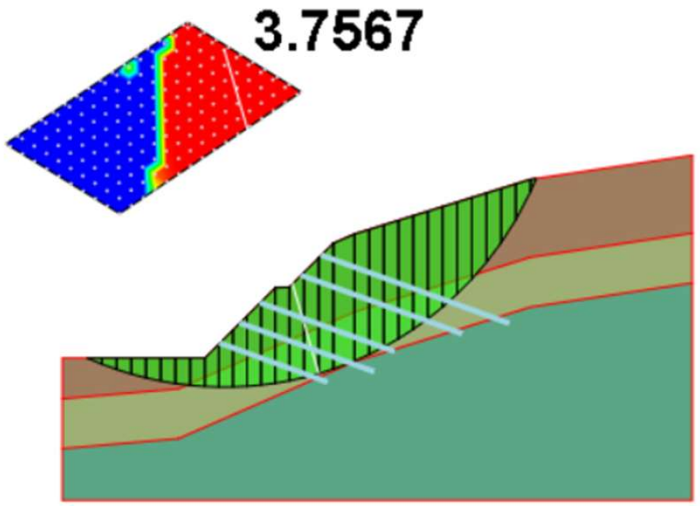


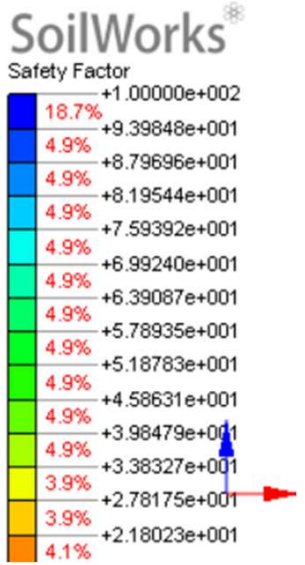
LEM-Without Nail

Without Nail

FOS = 1.9056

LEM-With Nail

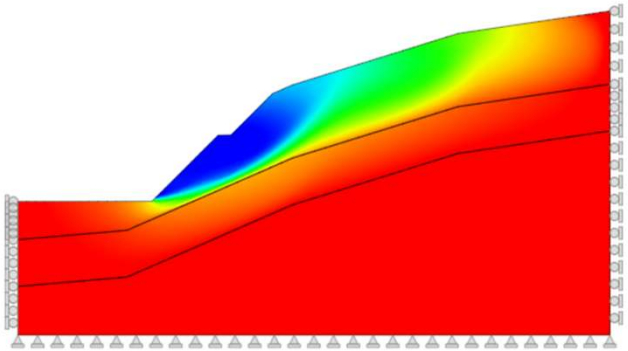


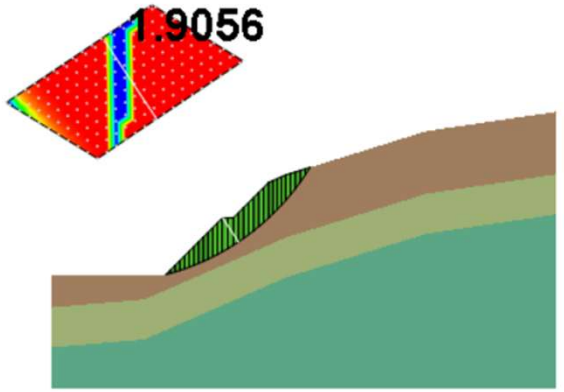


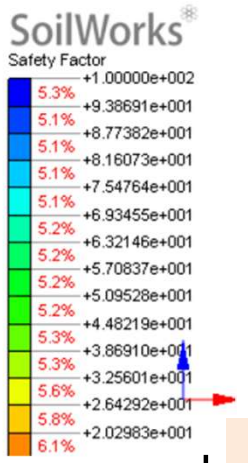
With Nail

FOS = 3.7567

SRM & LEM Comparison







Increased by 48.78%

Without Nail

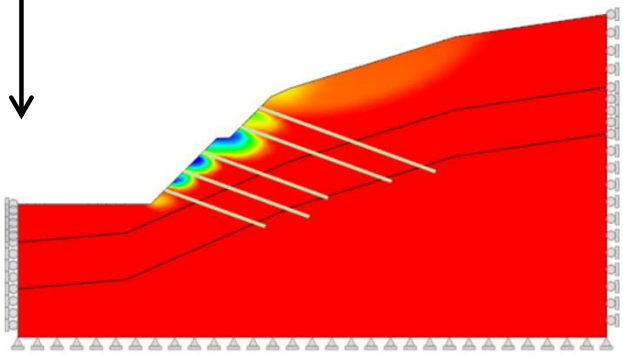
FOS = 1.8375

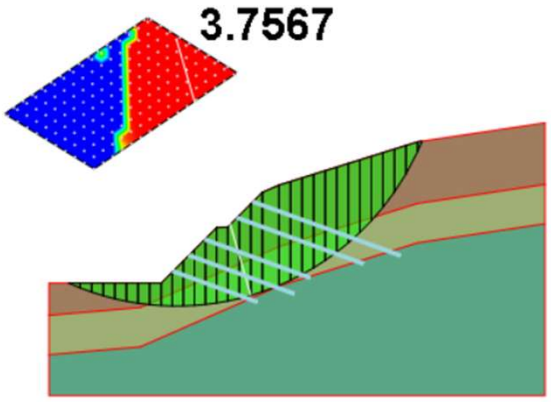
Increased by 3.57%

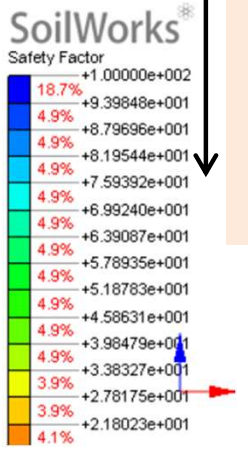
Without Nail

FOS = 1.9056

Increased by 49.27%







With Nail

FOS = 3.5875

Increased by 4.50%

With Nail

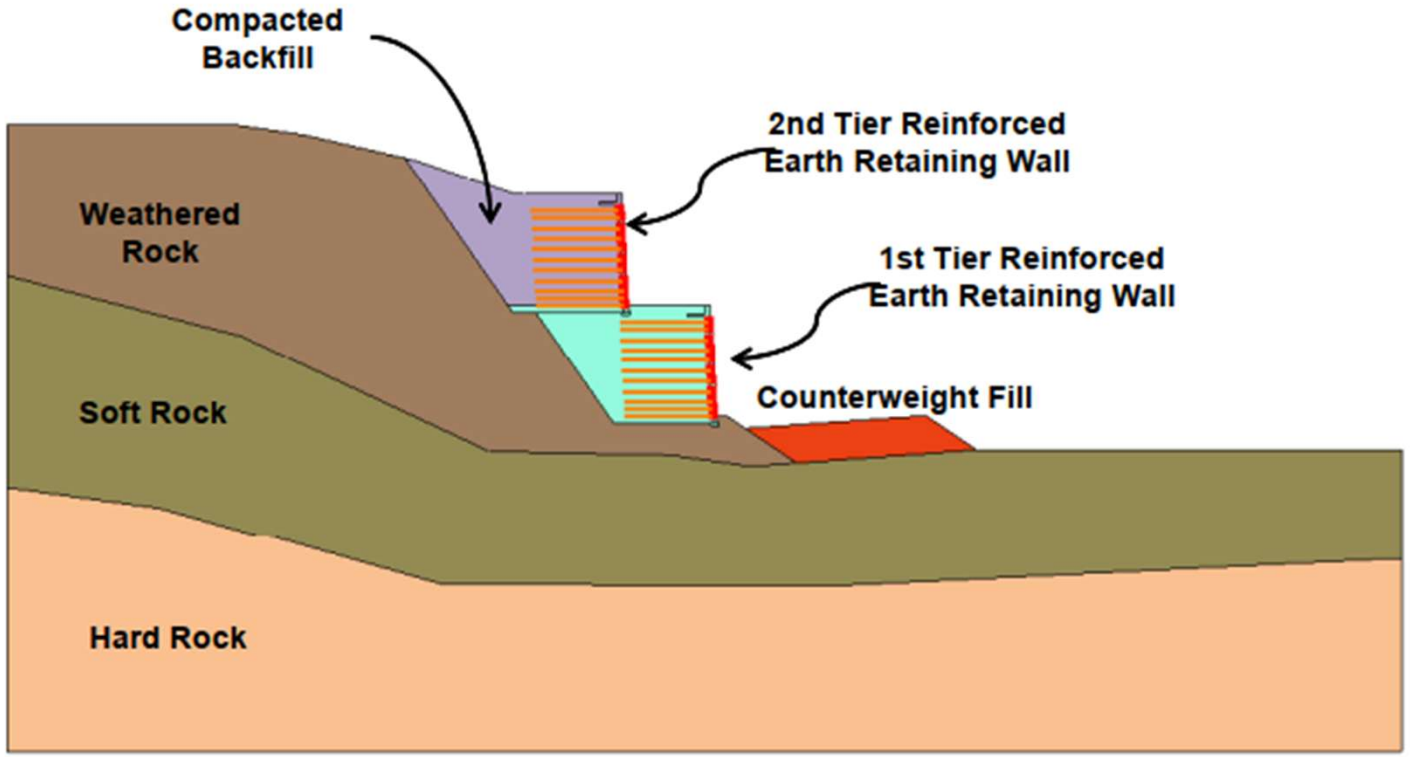
FOS = 3.7567

MIDAS

Part 2:

LEM for Stability Analysis of Reinforced Earth Retaining Walls

Stability Analysis of Reinforced Earth Retaining Walls - LEM

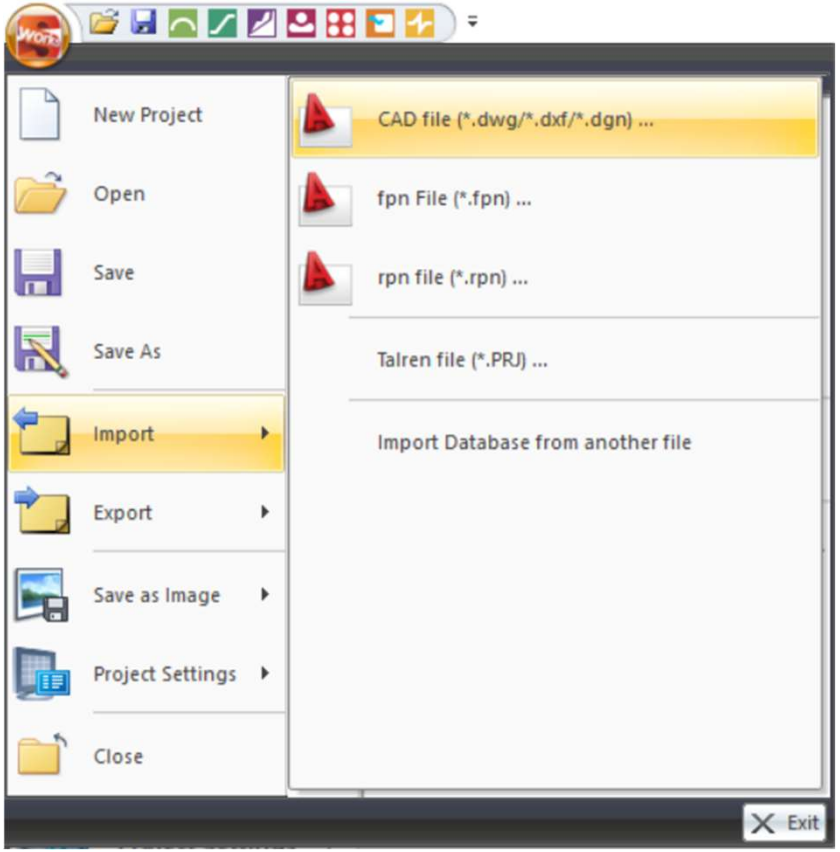


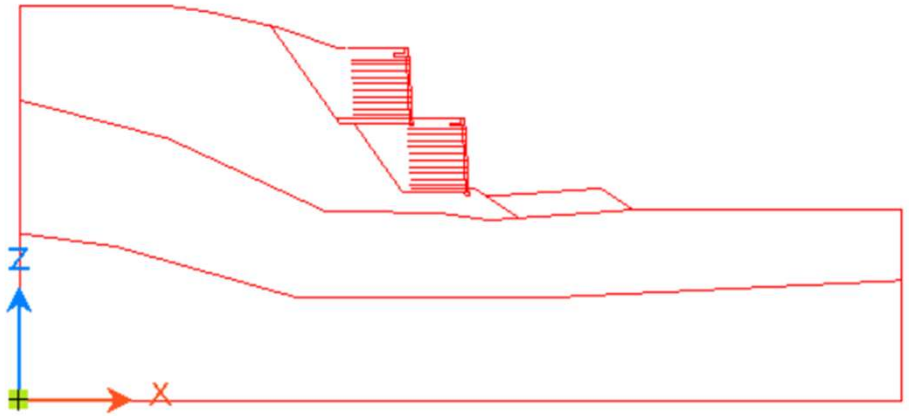
Fig, LEM study on Reinforce Earth Retaining Walls
*(**Source:** SoilWorks tutorial – Slope module)*

- LEM to check the stability of the reinforced earth retaining walls
- Soilworks provides LEM by Bishop, Janbu, and Fellenius for user selection

CAD (.dwg) Import

Select ‘Slope module’





Imported cad drawing into Soilworks

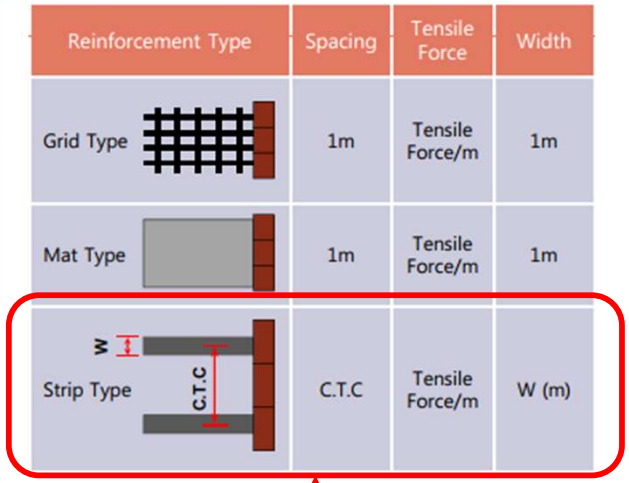
Material Properties

Structural properties

No	Name /Member Type	Reinforcement Spacing [m]	Initial Diffusion Width [m]	Initial Diffusion Angle [deg]	Tensile Force [kN]	Width [m]	Backfill Unit Weight [kN/m3]	Friction Coefficient
1	Geogrid /Strip(LEM)	1	2	15	150	1	19.5	0.3

Ground properties

No	Ground Type	Unit Weight [kN/m^3]	Saturated Unit Weight [kN/m^3]	Cohesion [kN/m^2]	Internal Friction Angle [deg]
1	Weathered rock	20	21	35	30
2	Soft rock	23	24	150	35
3	Hard Rock	24	25	200	37
4	Backfill	18.5	19.5	14	32
5	Counterweight Fill	18.6	19.6	15	25
6	Concrete Block	20	21	980	40



Geogrid is used as strip type for LEM in Soilworks

Database in Soilworks

Ground Material Database

Database: 1.1 Schist#1 | Select All | Unselect All

No.	Soil Type	Modulus of Elasticity (kN/m²)	Unit Weight (kN/m³)	Saturated Unit Weight (kN/m³)	Poisson's Ratio	Cohesion (kN/m²)	Internal Friction Angle ([deg])	Select
1	Landfill Layer	13000	18	19	0.33	0	27	☐
2	Alluvial Layer	8000	17	18	0.35	15	20	☐
3	Weathered Soil	36500	18.5	19.5	0.33	17.5	31	☐
4	Weathered Rock	150000	21	22	0.3	50	33	☑
5	Soft Rock	1850000	24	25	0.28	180	35.5	☑
6	Hard Rock	17500000	26	27	0.23	1750	40.5	☑

Define Ground Material Property

Data

ID	Name
1	Weathered R...
2	Soft Rock
3	Hard Rock
4	Backfill
5	Counterweight fill
6	Concrete block

Define Structural Property

Data

ID	Name
1	Geogrid

General: ID 1, Name Geogrid, Element Type Strip/Fabric (LEM)

Stiffness

General		
Spacing	1	m
Initial Diffusion Width	2	m
Initial Diffusion Angle	15	[deg]
Adjust Reinf. Effect by FS		Dependent
Reinforcement Vector	0	
Reinforcement Load		
Tensile Force	150	kN
Consider Pullout Force		Simplified Method
Width	1	m
No. of Contact		Side2
Unit Weight of Backfill	19.5	kN/m³
Friction Coefficient	0.3	

Reset | Add | Modify | Delete | Close

for structural property

In MIDAS website, **these material can download and import in GTS NX & FEA NX conveniently**

Reference: 材料庫MaterialLibrary

土壤本構模型系統 | Mohr Coulomb 模型 | Drucker Prager 模型 | Hardening Soil 模型 | HS Small 模型 | Modified MC 模型 | 材料庫管理

Mohr-Coulomb (MC) Material Library 莫爾-庫侖 (MC) 材料庫 | 資料出處 : Soilworks ★單位 (KN /m/ J/ sec)

- 片岩Schist
  - 片岩#1
  - 片岩#2
- 片麻岩Gneiss
  - 片麻岩#1
  - 片麻岩#2
  - 片麻岩#3
- 安山岩Andesite
  - 安山岩#1
  - 安山岩#2
- 沉積岩Sedimentary Rock
  - 沉積岩#1
- 角閃岩Amphibolite
  - 角閃岩#1
- 花崗岩Granite
  - 花崗岩#1
  - 花崗岩#2
  - 花崗岩#3
- 花崗閃長岩Granite Diorite
  - 花崗閃長岩#1
- 砂岩Sandstone
  - 砂岩#1

顯示 10 筆結果 | 搜尋：

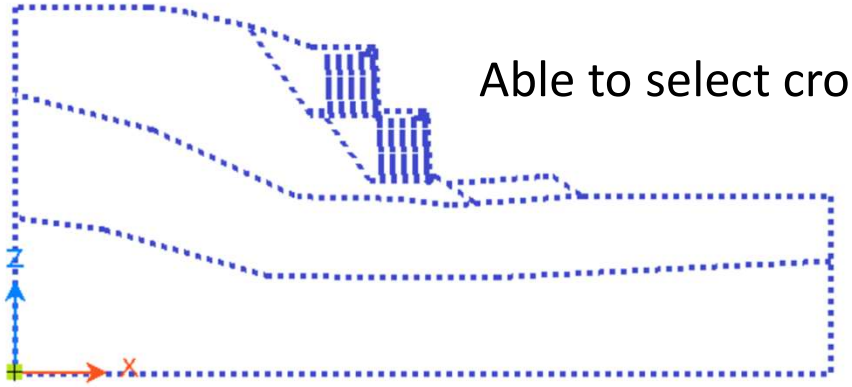
全選	名稱	E	γ	γ_sat	ν	Nonlinear C	φ
☐	片岩#1-垃圾填埋層/人工回填層	13000	18	19	0.33	0	27
☐	片岩#1-沖積層	8000	17	18	0.35	15	20
☐	片岩#1-硬岩	17500000	26	27	0.23	1750	40.5
☐	片岩#1-軟岩	1850000	24	25	0.28	180	35.5
☐	片岩#1-風化土	36500	18.5	19.5	0.33	17.5	31
☐	片岩#1-風化岩	150000	21	22	0.3	50	33

顯示第 1 至 6 筆結果，共 6 筆 | 上一頁 | 1 | 下一頁

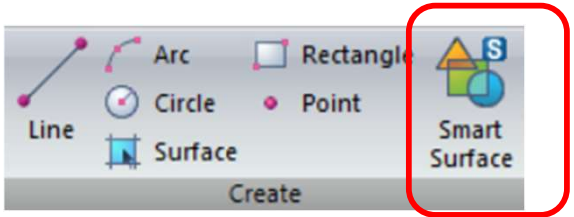
▶ [查看/收合] Excel匯入GTS NX文件說明

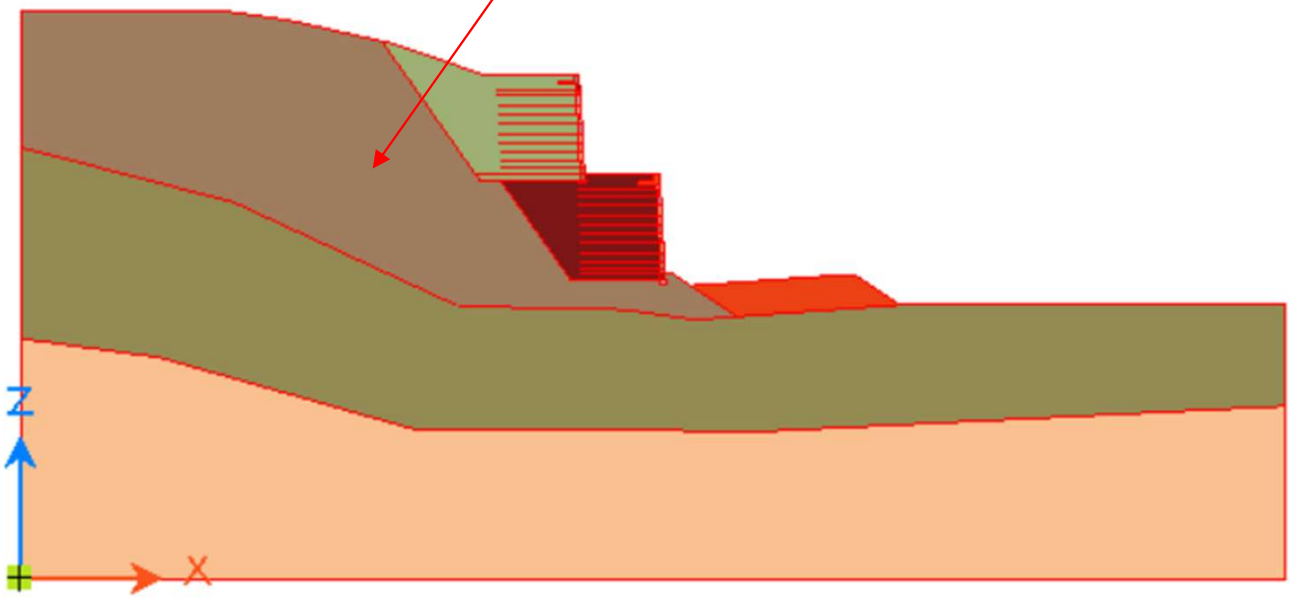
目前已選擇: 0 筆 | 查看清單 | 一次匯出

Intersect Curve/ Display Color

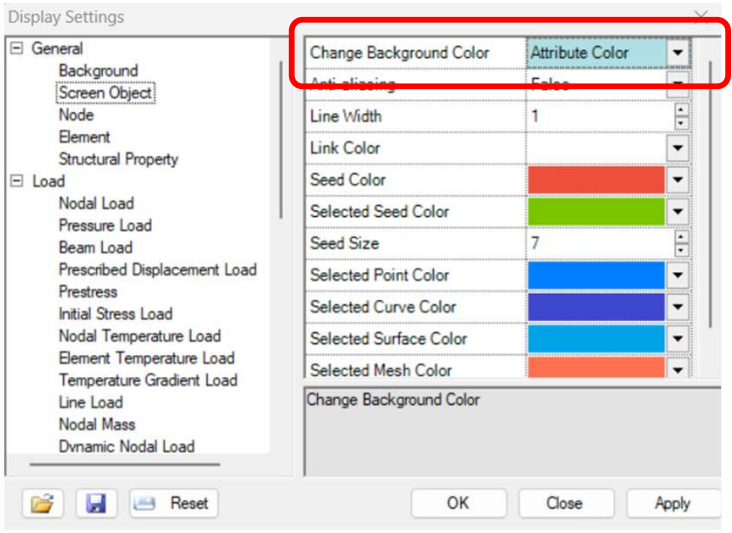


Able to select crossing line in intersect

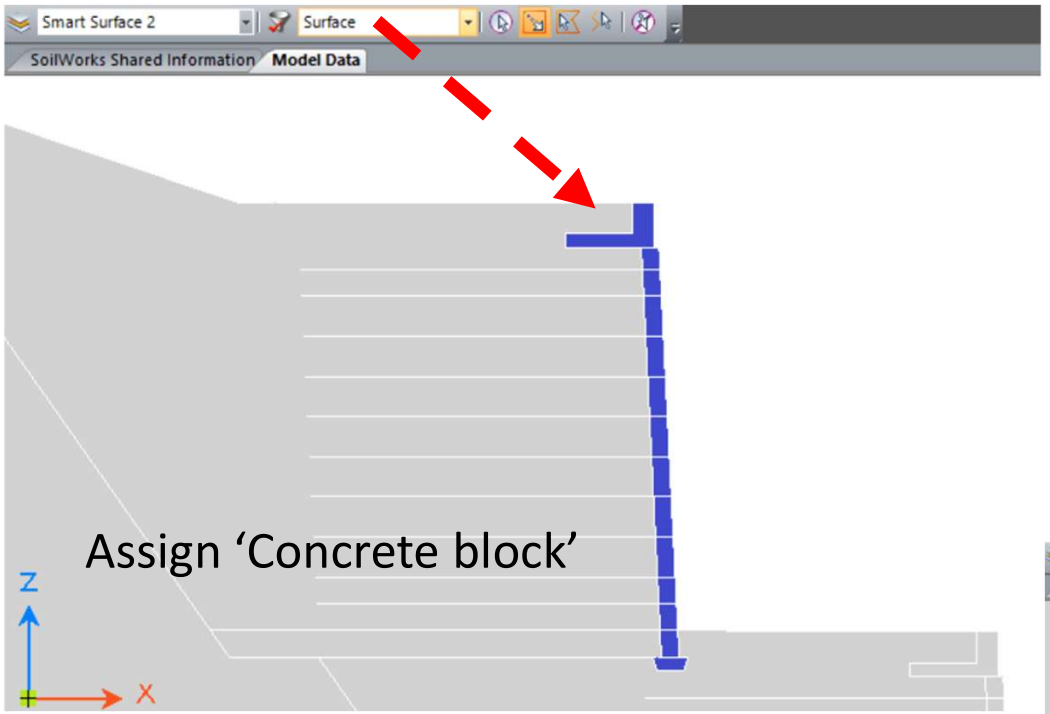


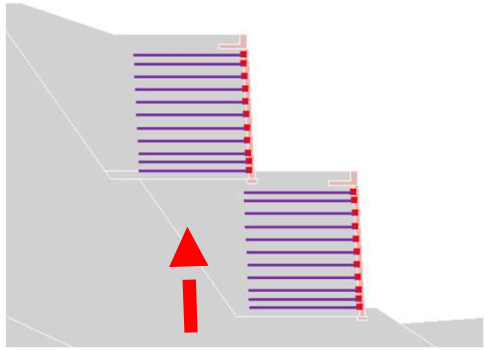


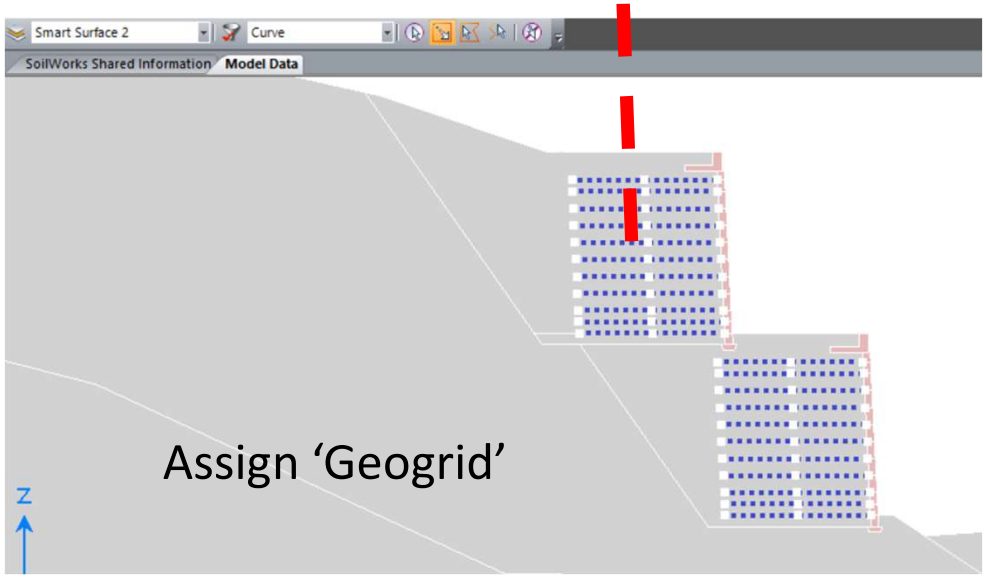
Screen object → Attribute color



Assign Strutural Property

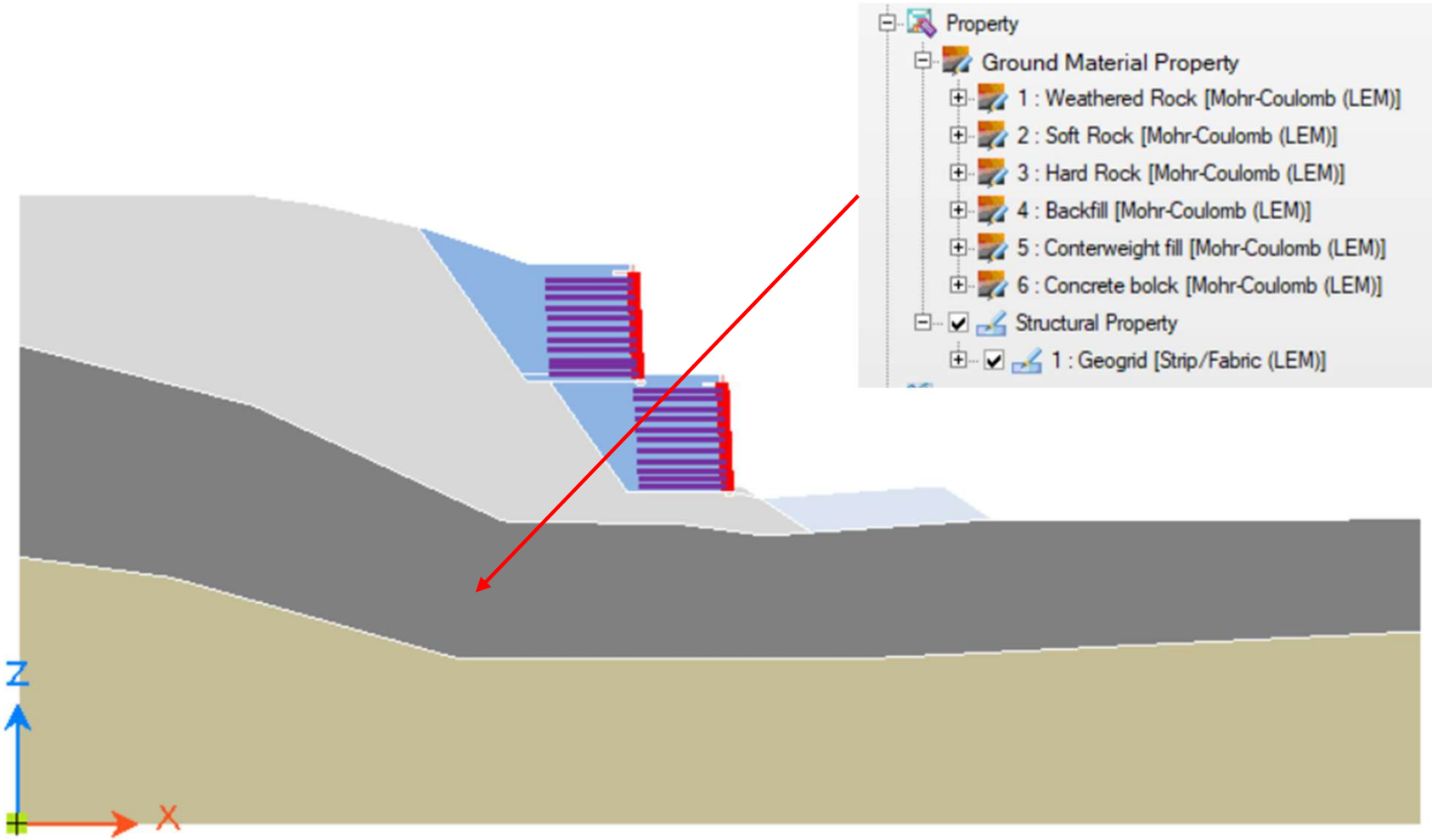






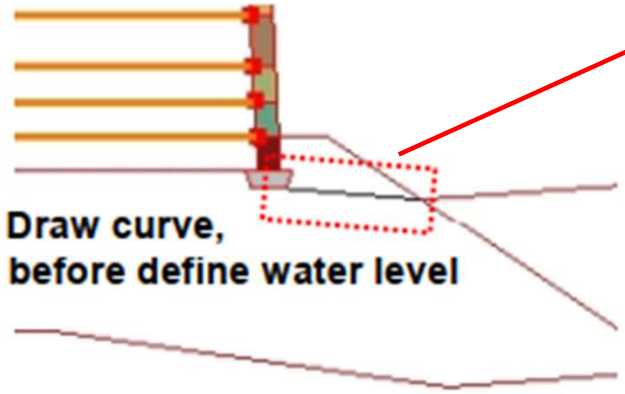
Select area → Drag & drop the correspond property into the surface to assign property in Soilworks

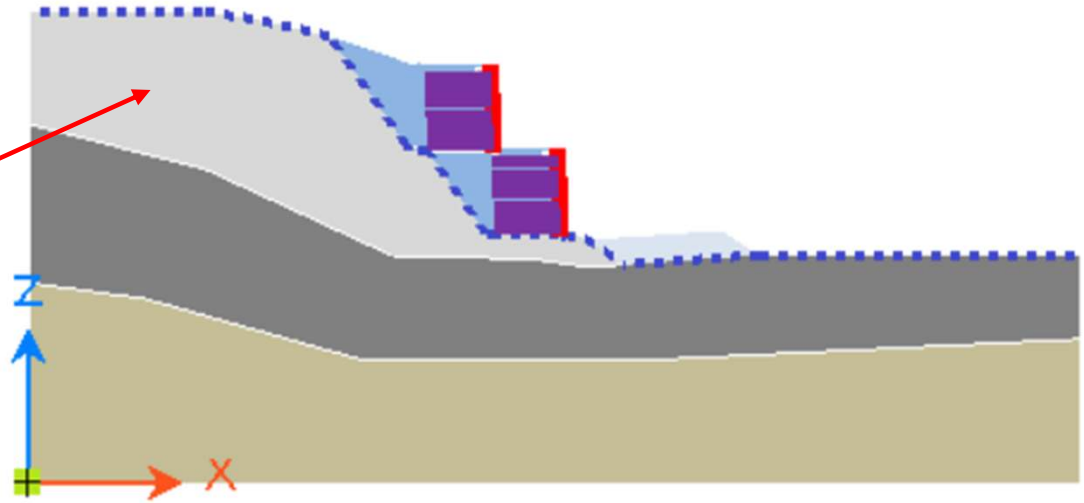
Assign Ground Material Property

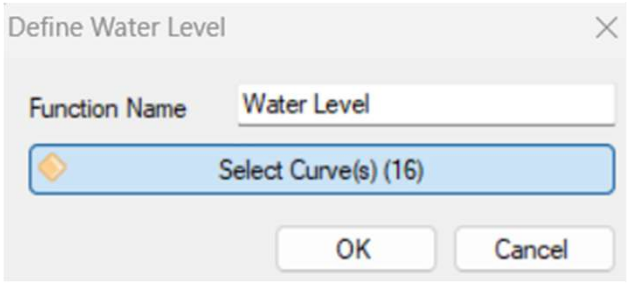


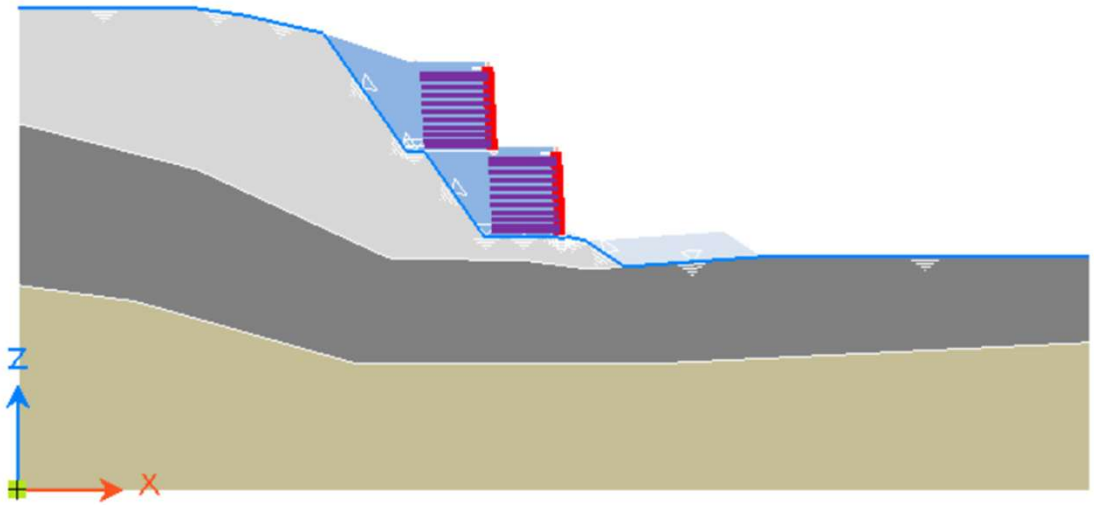
NOTE: Successful assignment will be displayed by the changed of color in surface

Water Level

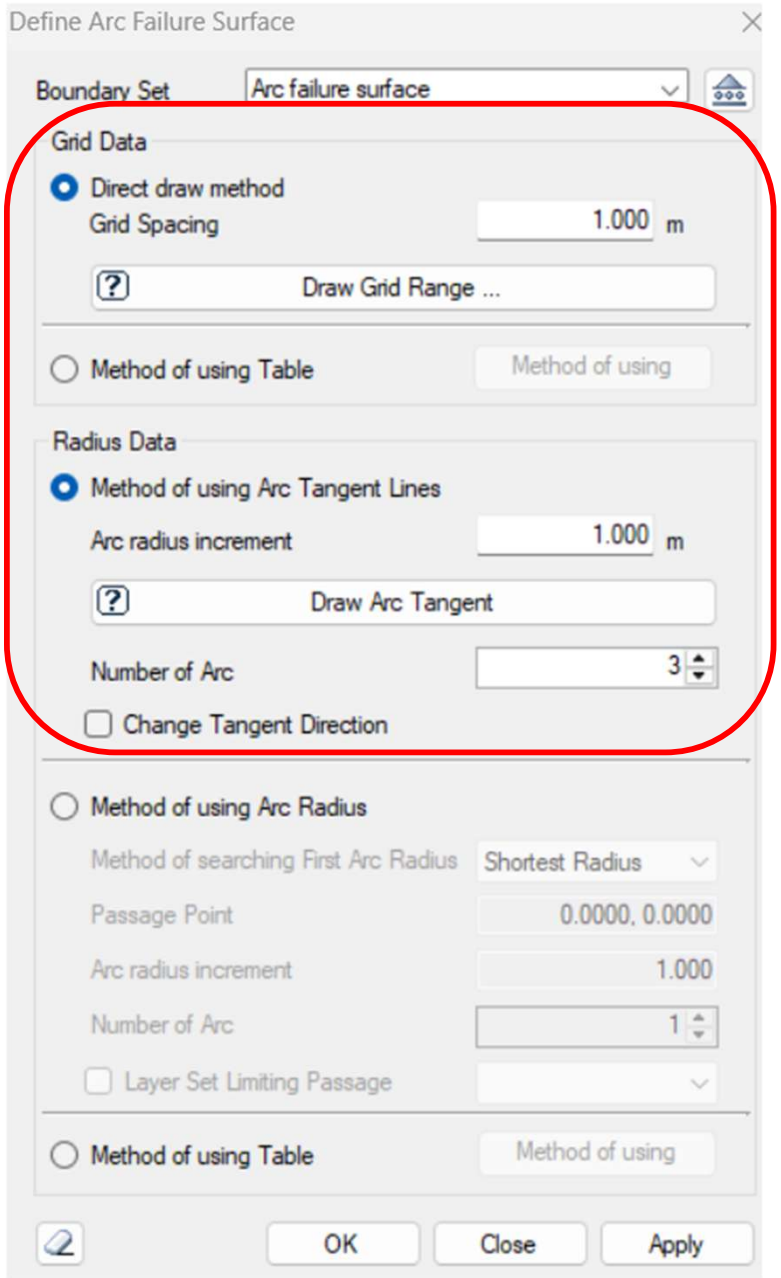

Draw curve,
before define water level

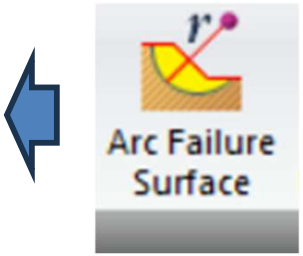

Z
X

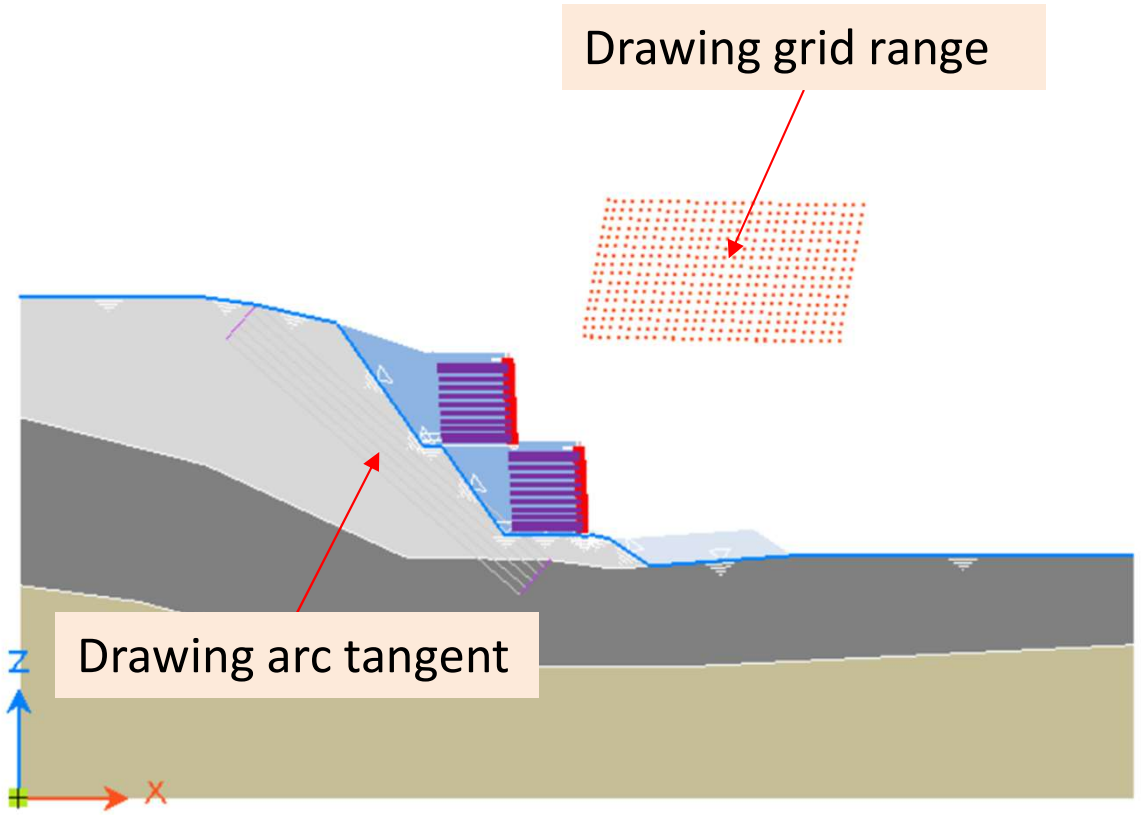

Define Water Level
Function Name
Water Level
Select Curve(s) (16)
OK
Cancel


Z
X

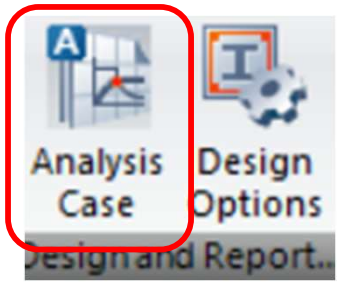
Results – Horizontal Displacements (SRM)







Analysis Case



Add/Modify Analysis Case

Name: Test

Analysis Method: Limit Equilibrium Method (LEM)

Analysis Control Data

Analysis by each Load Set in the Analysis Model

Define Analysis Model

Use All Layer Sets | Use All Boundary Sets | Use All Load Sets

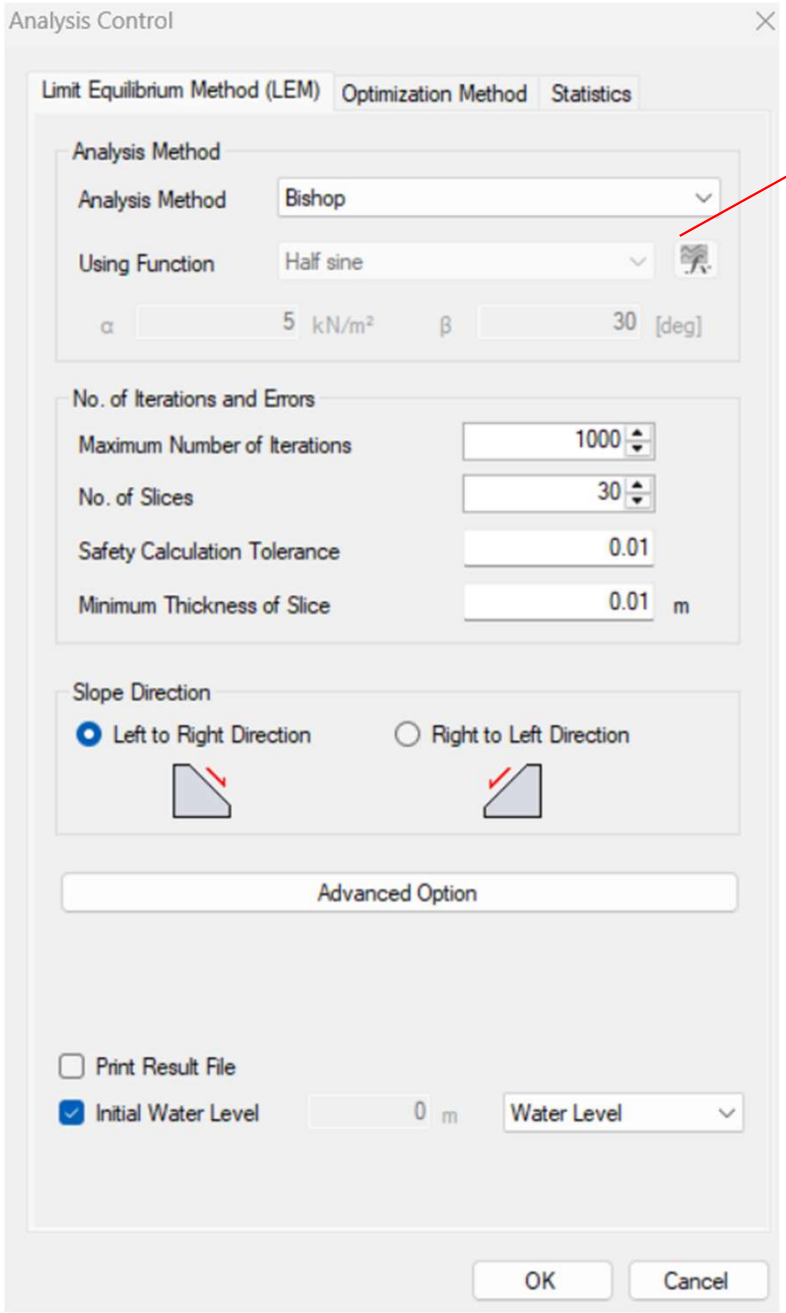
Analysis Control Data …

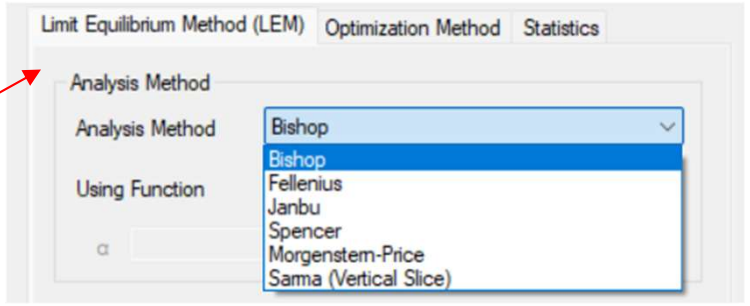
All Input Data	Data used in Analysis
Layer Set	Smart Surface 19
base	Smart Surface 20
0	Smart Surface 21
Smart Surface 1	Smart Surface 22
Smart Surface 2	Smart Surface 23
Smart Surface 3	Smart Surface 24
Smart Surface 4	Smart Surface 25
Smart Surface 5	Smart Surface 26
Smart Surface 6	Smart Surface 27
Smart Surface 7	Smart Surface 28
Smart Surface 8	Smart Surface 29
Smart Surface 9	Smart Surface 30
Smart Surface 10	Smart Surface 31
Smart Surface 11	Smart Surface 32
Smart Surface 12	Smart Surface 33
Smart Surface 13	Smart Surface 34
Smart Surface 14	Smart Surface 35
Smart Surface 15	Boundary Set
Smart Surface 16	Arc failure surface
Smart Surface 17	Load Set
Smart Surface 18	

OK | Close | Apply

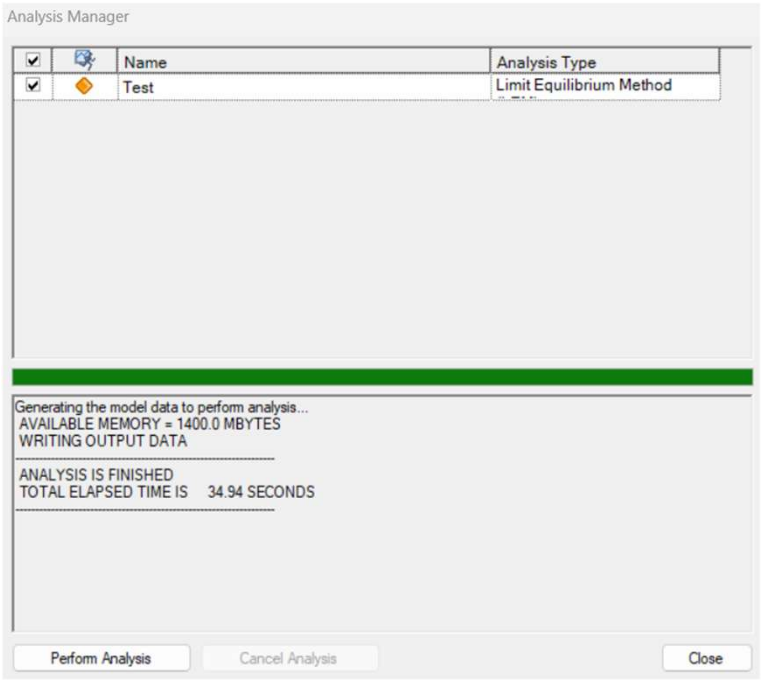
MIDAS

Analysis Control





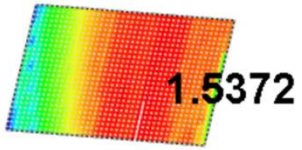
Provides various LEM analysis method

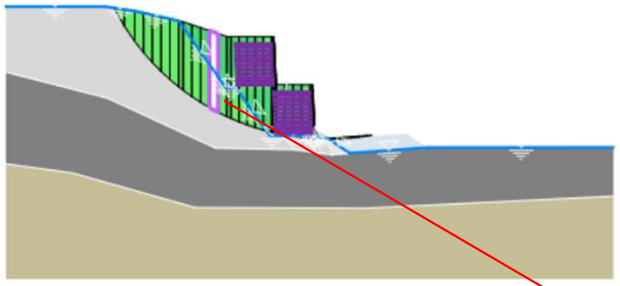


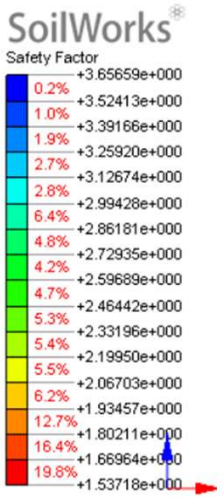
RUN Analysis …

Results – Horizontal Displacements (SRM)

Showing FOS results



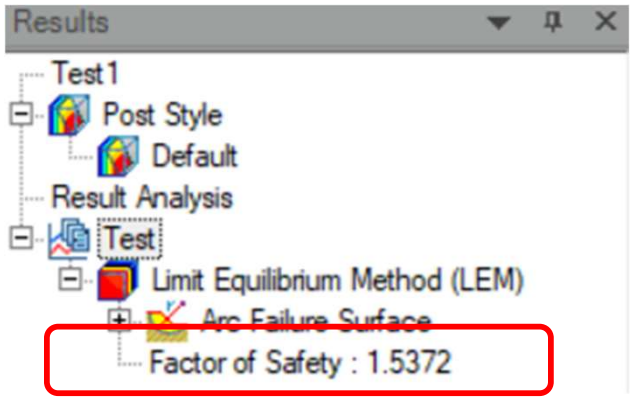


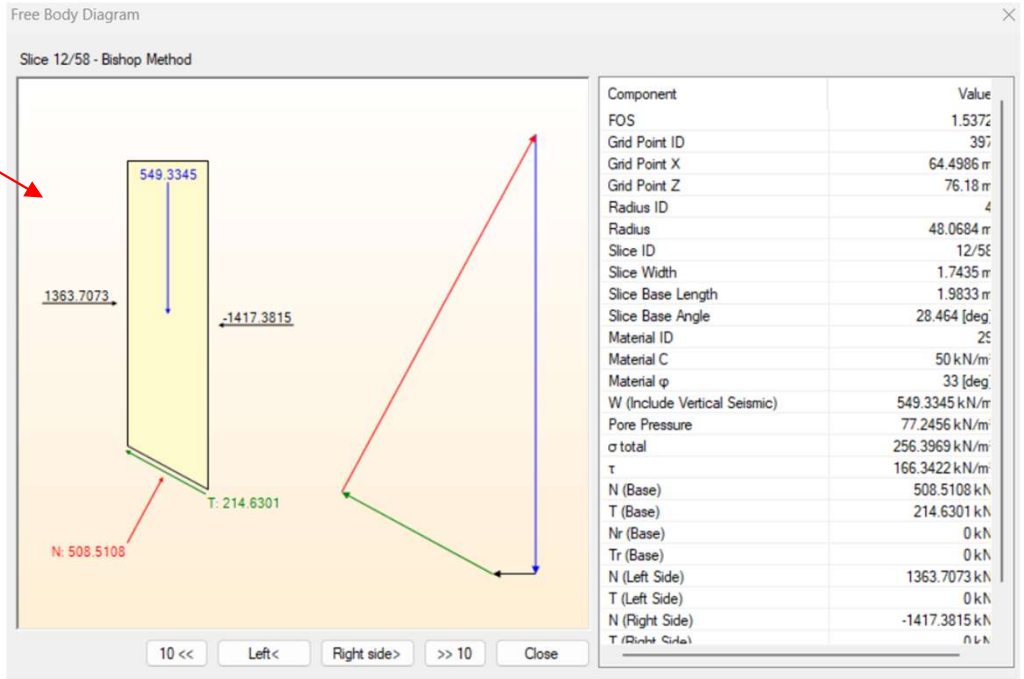


1.5372

for factor of safety

For displaying calculation of forcing






Thank you!