

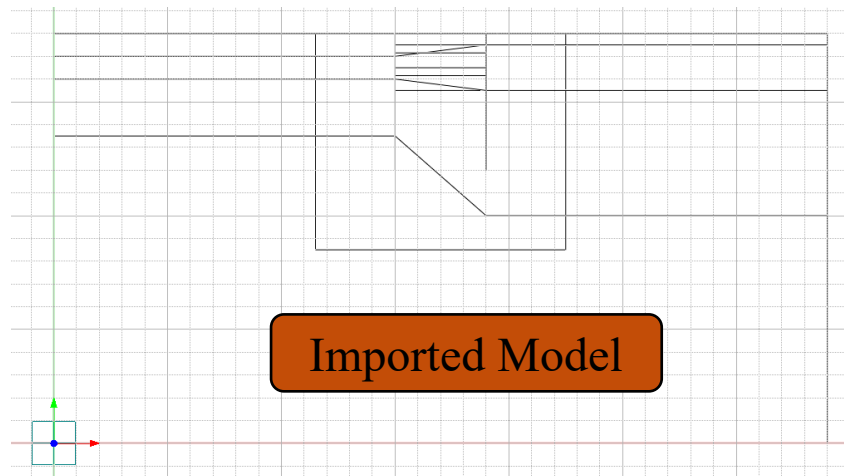
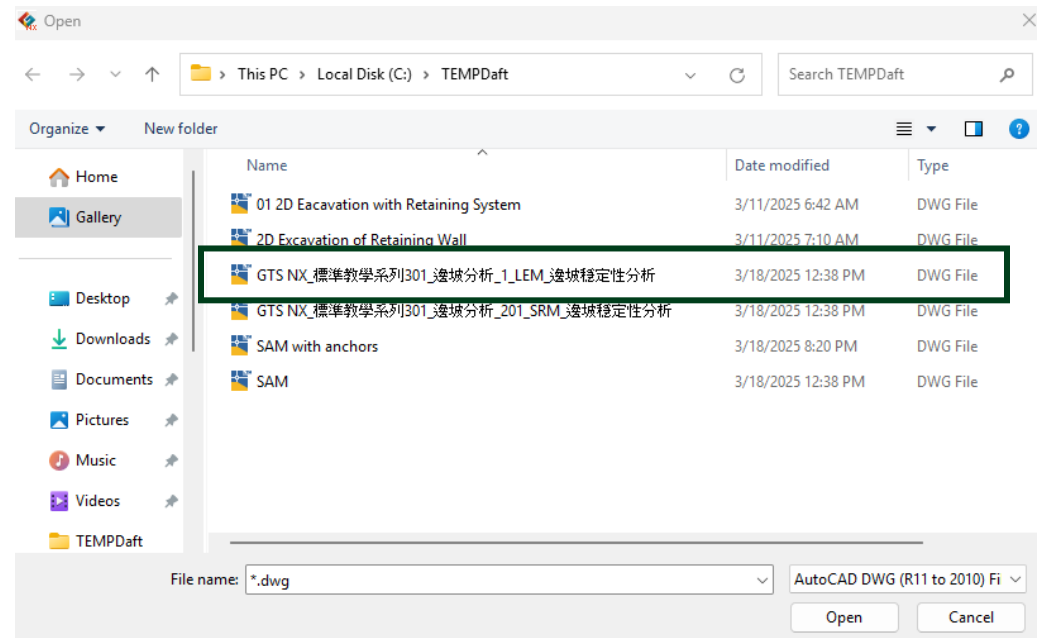
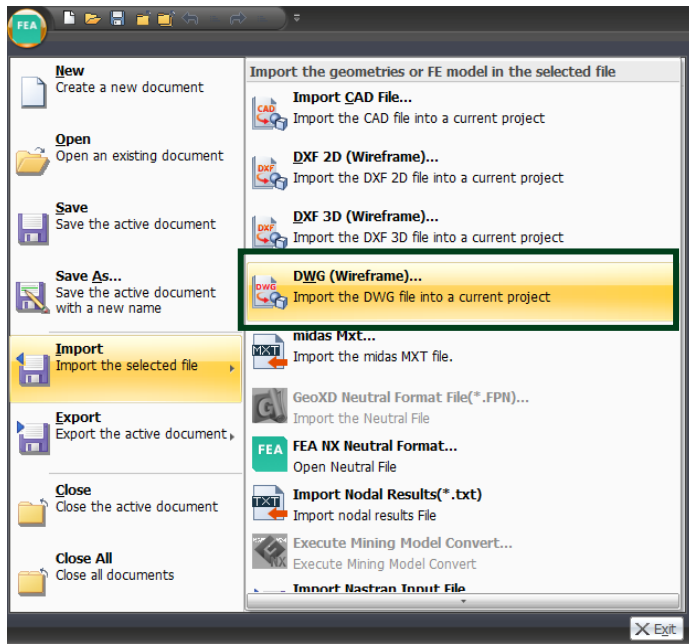


**MIDAS TAIWAN
GTS NX STANDARD TEACHING SERIES**

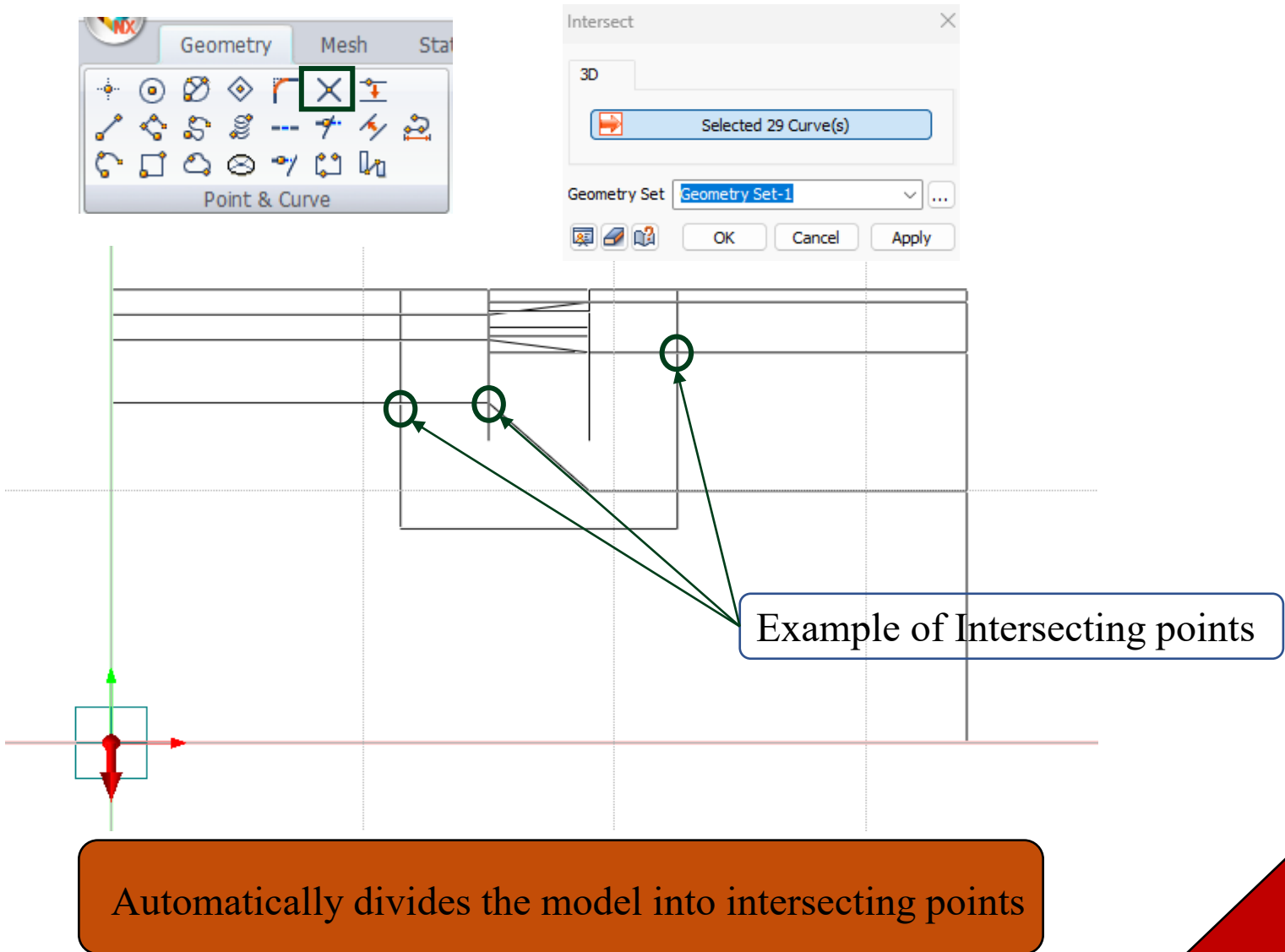
**2D EXCAVATION
WITH SOIL
RETAINING SYSTEM**

沈約翰
support@midasuser.com.tw

2D MODEL IMPORT



INTERSECT FUNCTION



SOIL MATERIAL

Add/Modify Material

No	Name	Type
1	SOIL 1	Isotropic-Mohr-Coulomb
2	SOIL 2	Isotropic-Mohr-Coulomb
3	SOIL 3	Isotropic-Mohr-Coulomb
4	SOIL 4	Isotropic-Mohr-Coulomb
5	CONCRETE	Isotropic-Elastic
6	STEEL	Isotropic-Elastic
7	Interface Mat...	Interface and Pile-Interface
8	Interface Mat...	Interface and Pile-Interface
9	Interface Mat...	Interface and Pile-Interface
10	Interface Mat...	Interface and Pile-Interface

Create...
Modify...
Excel
Export to Excel
Renumber
Database
Close

General steps for defining a specific soil material

Material

ID 1 Name SOIL 1 Color

Model Type Mohr-Coulomb

General Porous Non-Linear Thermal Time Dependent

Elastic Modulus(E) 15000 kN/m²
Inc. of Elastic Modulus 0 kN/m²
Inc. of Elastic Modulus Ref. Height 0 m
Poisson's Ratio(ν) 0.25
Unit Weight(γ) 18 kN/m³

Initial Stress Parameters
Ko Determination 0.5
Automatic
Manual Anisotropy

Thermal Parameter
Thermal Coefficient 1e-06 1/[T]
Molecular vapor diffusion coefficient 0 m²/sec
Thermal diffusion enhancement 0

Damping Ratio(For Dynamic)
Damping Ratio 0.05

Safety Result(Mohr-Coulomb)
Cohesion(C) 30 kN/m²
Frictional Angle(ϕ) 36 [deg]
Tensile Strength 0 kN/m²

OK Cancel

Material

ID 1 Name SOIL 1 Color

Model Type Mohr-Coulomb

General Porous Non-Linear Thermal Time Dependent

Unit Weight(Saturated) 18 kN/m³
Initial Void Ratio(e_0) 0.5

Drainage Parameters
Undrained Poisson's Ratio 0.495
Skempton's B Coefficient 0.983277592

Seepage & Consolidation Parameters
Permeability Coefficients
kx 1e-06 ky 1e-06 kz 1e-06 m/sec

Specific Storage(S_s) 5.23021 1/m

Material

ID 1 Name SOIL 1 Color

Model Type Mohr-Coulomb

General Porous Non-Linear Thermal Time Dependent

Cohesion(C) 5 kN/m²
Inc. of Cohesion 0 kN/m²
Inc. of Cohesion Ref. Height 0 m
Frictional Angle(ϕ) 30 [deg]

Dilatancy Angle 0 [deg]
Tension Cut-off
Tensile Strength 0 kN/m²
Cut-off Yield Surface Rankine

SOIL PROPERTY

Add/Modify Property

No	Name	Type	Sub-Type
1		2D	Shell
2	SOIL1	2D	Plane Strain
3	SOIL2	2D	Plane Strain
4	SOIL3	2D	Plane Strain
5	SOIL4	2D	Plane Strain
6	D-Wall	1D	Beam
7	S1(UB 610x229x...	1D	Truss
8	S2(UB 610x229x...	1D	Truss
9	Interface Proper...	Other	Interface
10	Interface Proper...	Other	Interface
11	Interface Proper...	Other	Interface
12	Interface Proper...	Other	Interface
13	Rigid Link	Other	Rigid Link

Create/Modify 1D Property

Beam

ID 6 Name D-Wall Color [Yellow]

Material 5: CONCRETE

Hinge Property

Taper

	Section-i	Section-j
Cross Sectional Area(A)	1	1 m ²
Torsional Constant(Ix)	0.140596345	0.140596345 m ⁴
Torsional Stress Coeff.	0.682395003	0.682395003 m
Area Moment of Inertia(Iy)	0.083333333	0.083333333 m ⁴
Area Moment of Inertia(Iz)	0.083333333	0.083333333 m ⁴
Effective Shear Area(Ay)	0.833441841	0.833441841 m ²
Effective Shear Area(Az)	0.833441841	0.833441841 m ²
Shear Stress Coefficient(Gy)	1.5	1.5 1/m ²
Shear Stress Coefficient(Gz)	1.5	1.5 1/m ²

y Axis Variable Constant

z Axis Variable Constant

Spacing 1 m

Section... Solid Rectangle

Apply

Create/Modify 2D Property

Plane Strain

ID 2 Name SOIL1 Color [Yellow]

Material 1: SOIL1

Material CSys CSys Global Rectangular Angle 0 [deg]

Plane Strain Property

OK Cancel Apply

Truss

ID 7 Name S1(UB 610x229x101 @ 4 Color [White])

Constitutive Behavior From Material

Material 6: STEEL

Hinge Property

Cross Sectional Area(A) 0.0129 m²

Torsional Constant 0 m⁴

Torsional Stress Coeff. 0 m

Spacing 4 m

Section... H-Section

Truss Property

OK Cancel

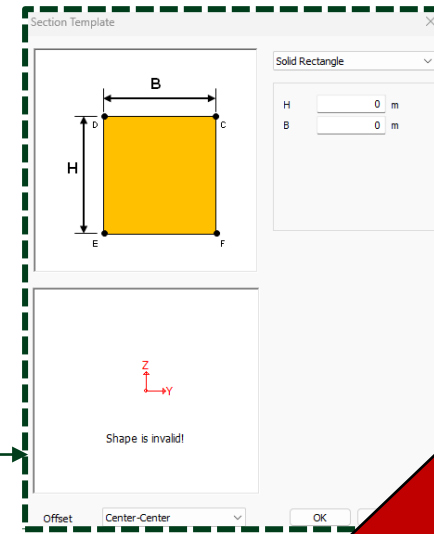
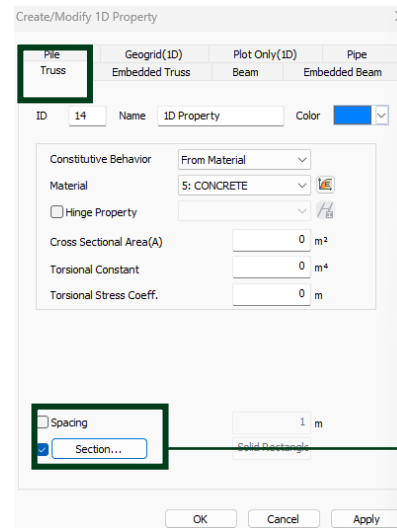
BEAM - TRUSS ELEMENT

Beam and Truss element comparison

Feature	Truss Element	Beam Element
Resists Axial Force	✓ Yes	✓ Yes
Resists Bending	✗ No	✓ Yes
Resists Shear	✗ No	✓ Yes
Resists Torsion	✗ No	✓ Yes
Degrees of Freedom (DOF)	3 per node (UX, UY, UZ)	6 per node (UX, UY, UZ, RX, RY, RZ)
Transfers Moments	✗ No	✓ Yes
Typical Application	Trusses, cables	Beams, frames

Truss Library

Note: Spacing defines the distance between each individual element that will be generated along a line or curve when using truss-type elements.



ELEMENT PROPERTY

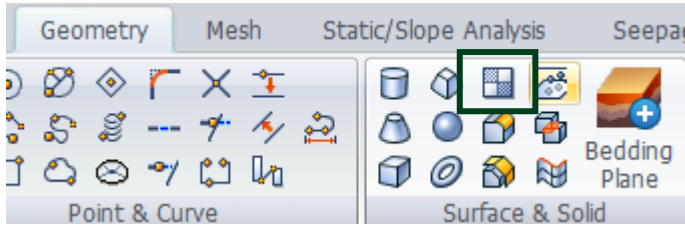
Ground Property

Name	Interface (SOIL 1)	Interface (SOIL 2)	Interface (SOIL 3)	Interface (SOIL 4)	SOIL 1	SOIL 2	SOIL 3	SOIL 4
Type	Other	Other	Other	Other	2D	2D	2D	2D
Model Type	Interface	Interface	Interface	Interface	Plane Strain	Plane Strain	Plane Strain	Plane Strain
Interface Type	Line	Line	Line	Line				
Material	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 1	SOIL 2	SOIL 3	SOIL 4

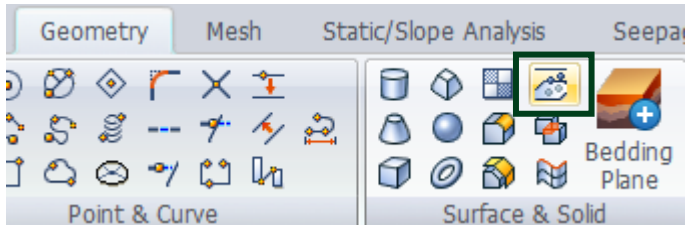
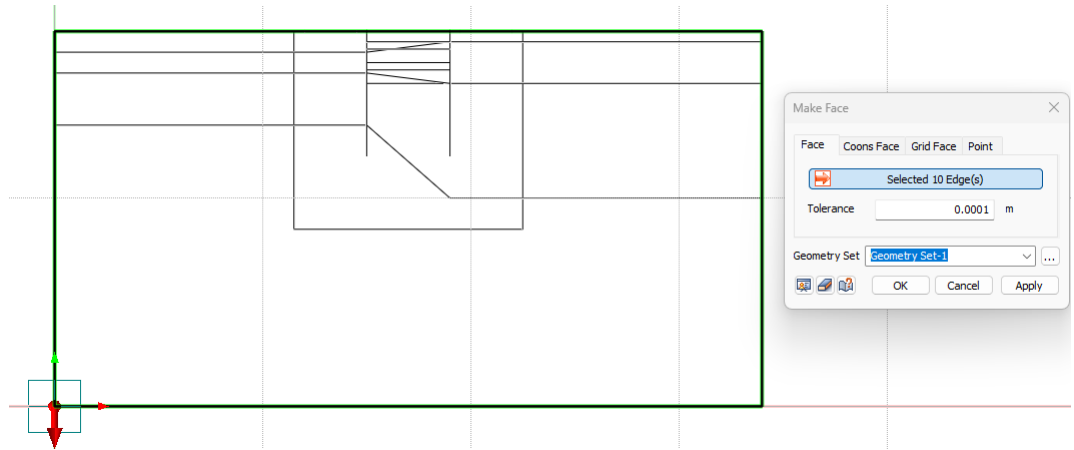
Structural Property

Name	D-Wall	S1	S2
Type	1D	1D	1D
Model Type	Beam	Truss	Truss
Material	CONCRETE	STEEL	STEEL
Section	Solid Rectangle	H-Section	H-Section
Section Size	1x1m @ 1m c/c	UB 610x229x101 @ 4m c/c	UB 610x229x101 @ 4m c/c

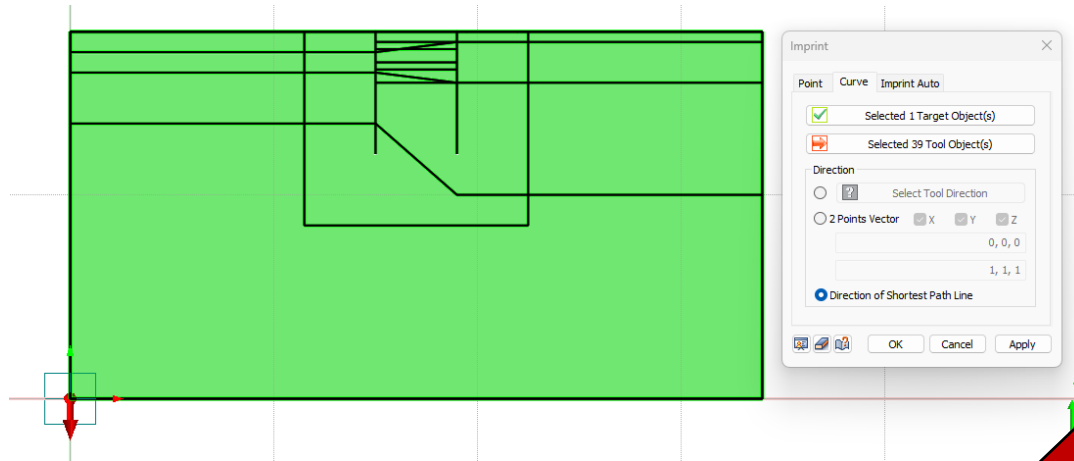
GEOMETRIC MODEL



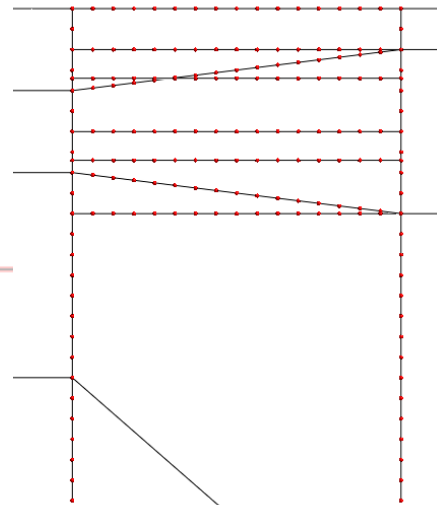
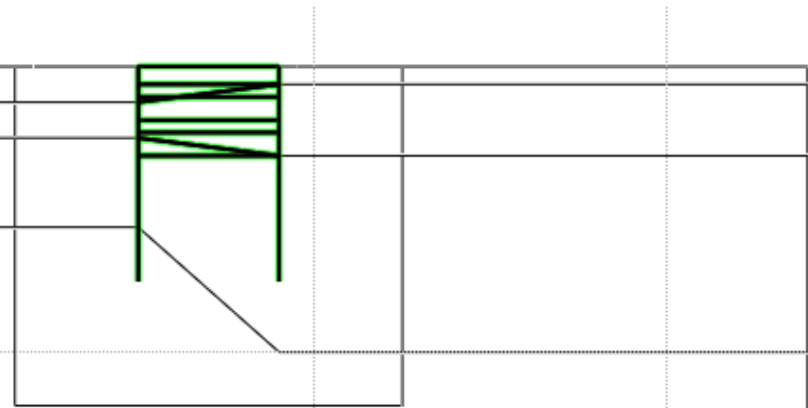
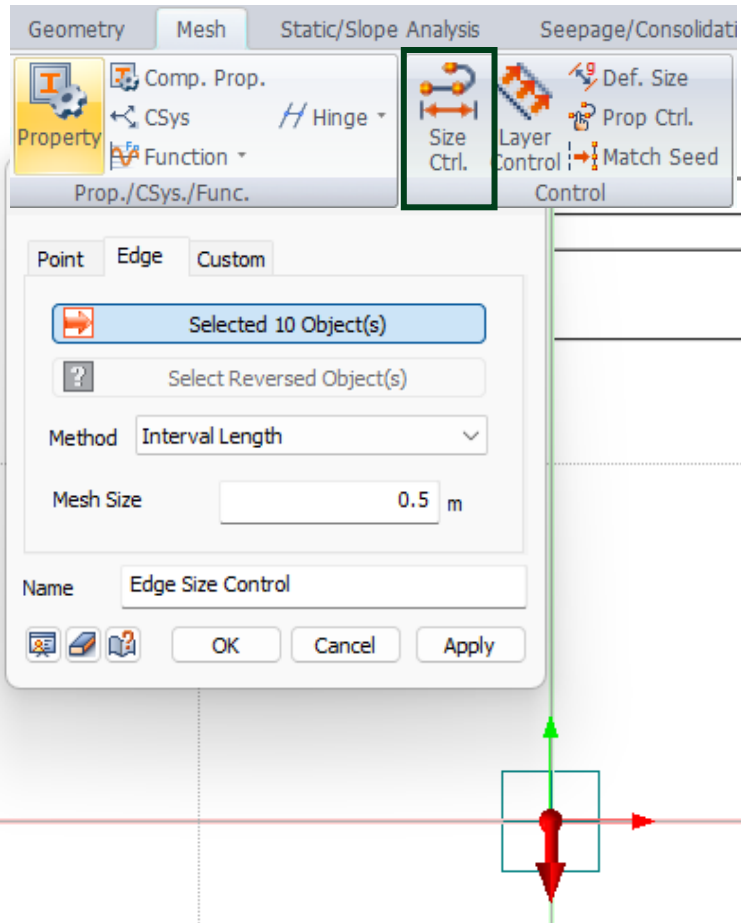
Face Function



Imprint Function



MESH - SIZE CONTROL



Mesh size control to increase the accuracy in plastic area

Mesh size of 0.5 m

MESH - GENERATE MESH

Generate mesh for soil layer 1

Soil 1

Advanced Option

- Merge Nodes
- Tolerance: 0.0001
- Element Size Growth Rate: Fine (slider), Coarse: 1
- Min/Max Element Size: 2.000
- Small (slider), Large: 1
- 2D Mesher: Delaunay Mesher
- Element Type: Tri+Quad
- Higher-Order Element
- Midside Nodes on Geometry
- Skip Meshed Face(s)
- Pattern Mesh
- Register Each Mesh Independently

Generate mesh(Face)

Auto-Face | Auto-Area | Map-Face | Map-Area

Selected 7 Object(s)

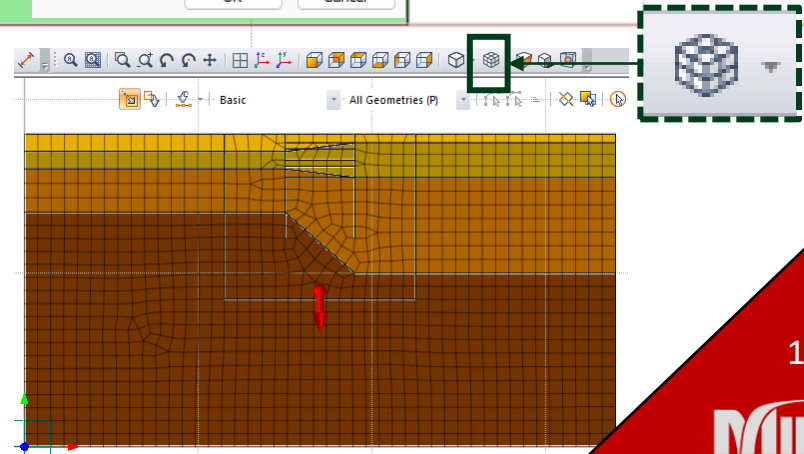
Size Method: Size | Division | 2 | <

Property: 1 | 1: SOIL 1

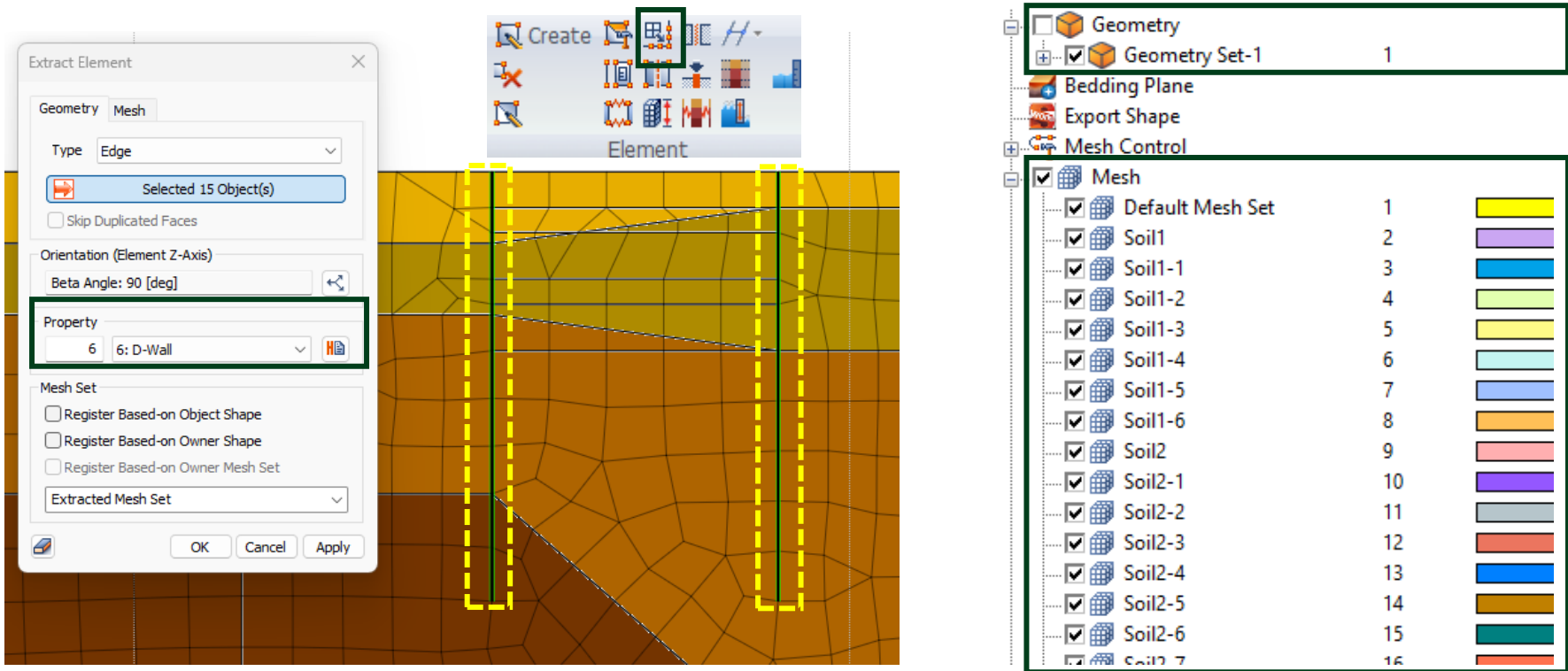
Mesh Set: Soil 1

OK | Cancel | Apply | >>

To show 'Property color'
Display Mode (Mesh) → Property color



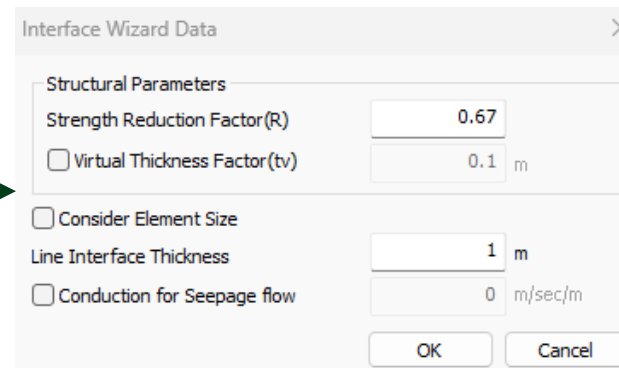
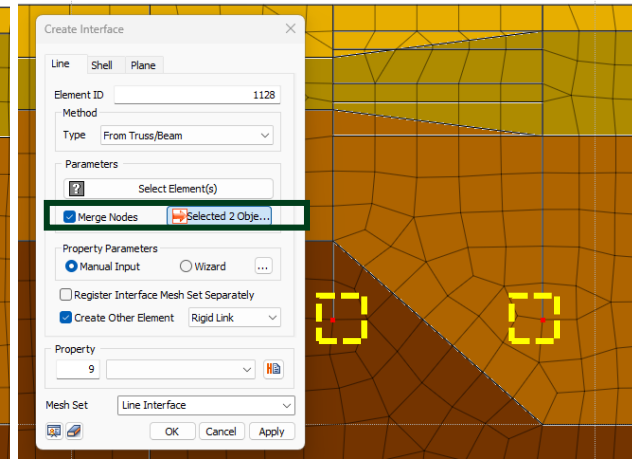
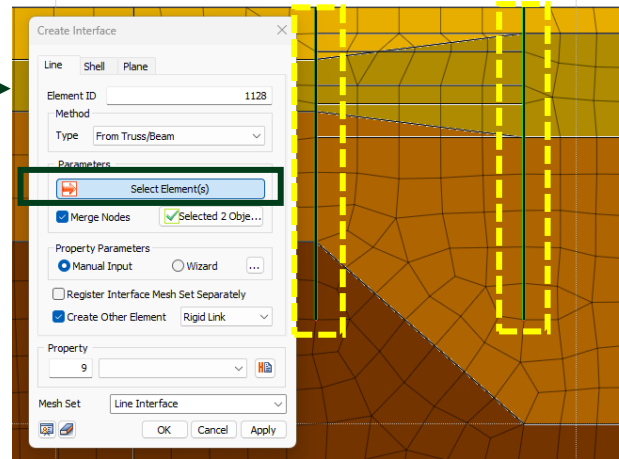
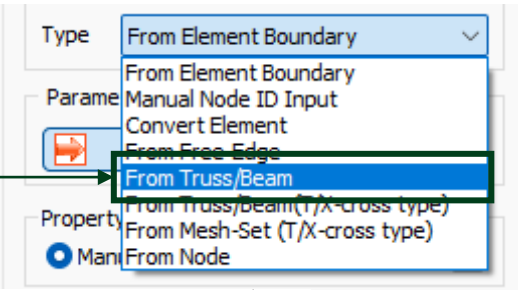
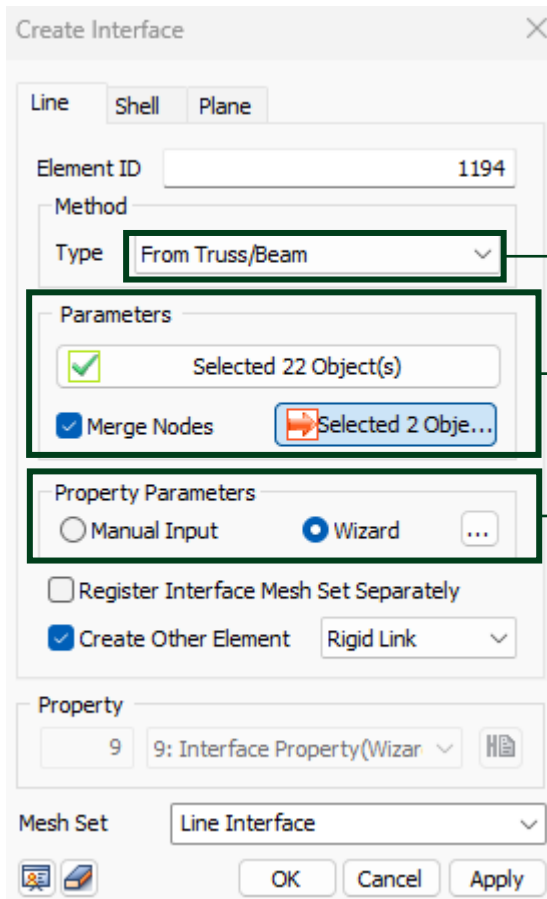
MESH - EXTRACT ELEMENT



‘Extract elements’ for retaining wall

Note: By using the ‘Extract Elements’ function, it is needed to open geometry and corresponding mesh set

INTERFACE



INTERFACE WIZARD

Interface Wizard equation from Midas GTX NX manual

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

$$K_t = G_i / t_v$$

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

Here,

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

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

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

Where:

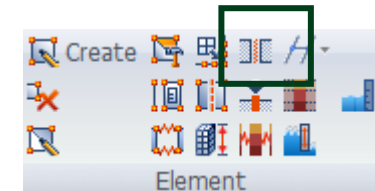
K_n : Normal Stiffness Modulus

K_t : Shear Stiffness Modulus

t_v : Virtual Thickness Factor

R: Strength Reduction Factor

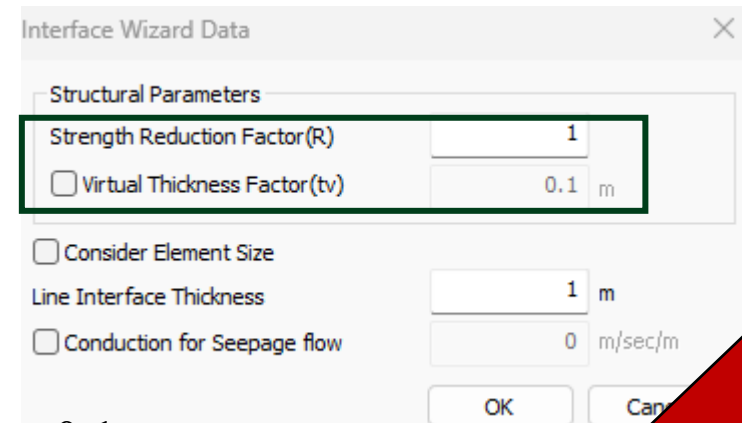
C_i : Interface Cohesion



Normal Stiffness Modulus (Kn) is the elasticity modulus for **bonding and un-bonding behavior** in the normal direction to the interface element

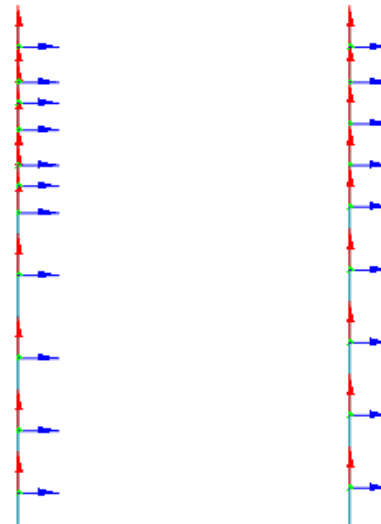
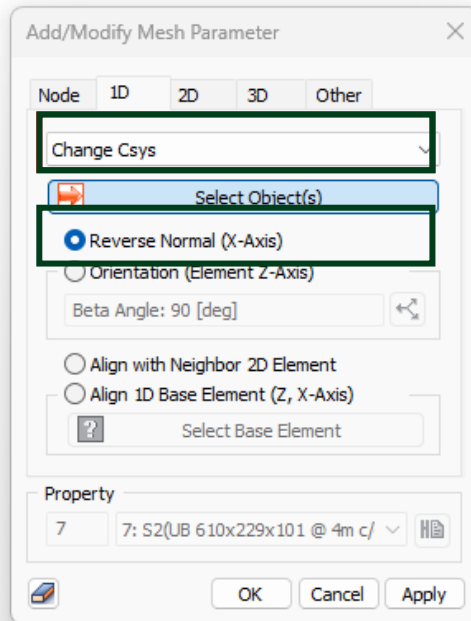
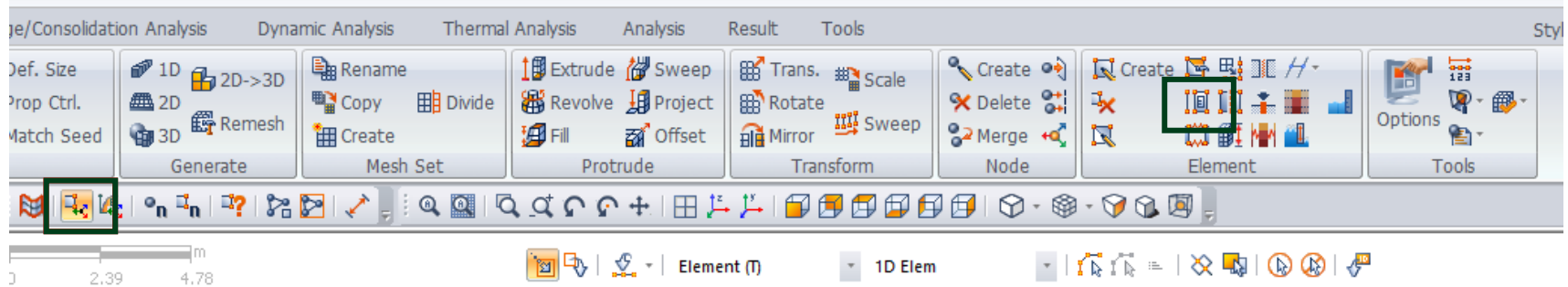
Shear stiffness modulus (Kt) is the elasticity modulus for **slip behavior** in the normal direction to the interface element

Strength Reduction Factor	R
Sandy Soil/Steel Material	0.6~0.7
Clay/ Steel Material	0.5
Sandy Soil/ Concrete	0.8~1.0
Clay / Concrete	0.7 ~ 1.0



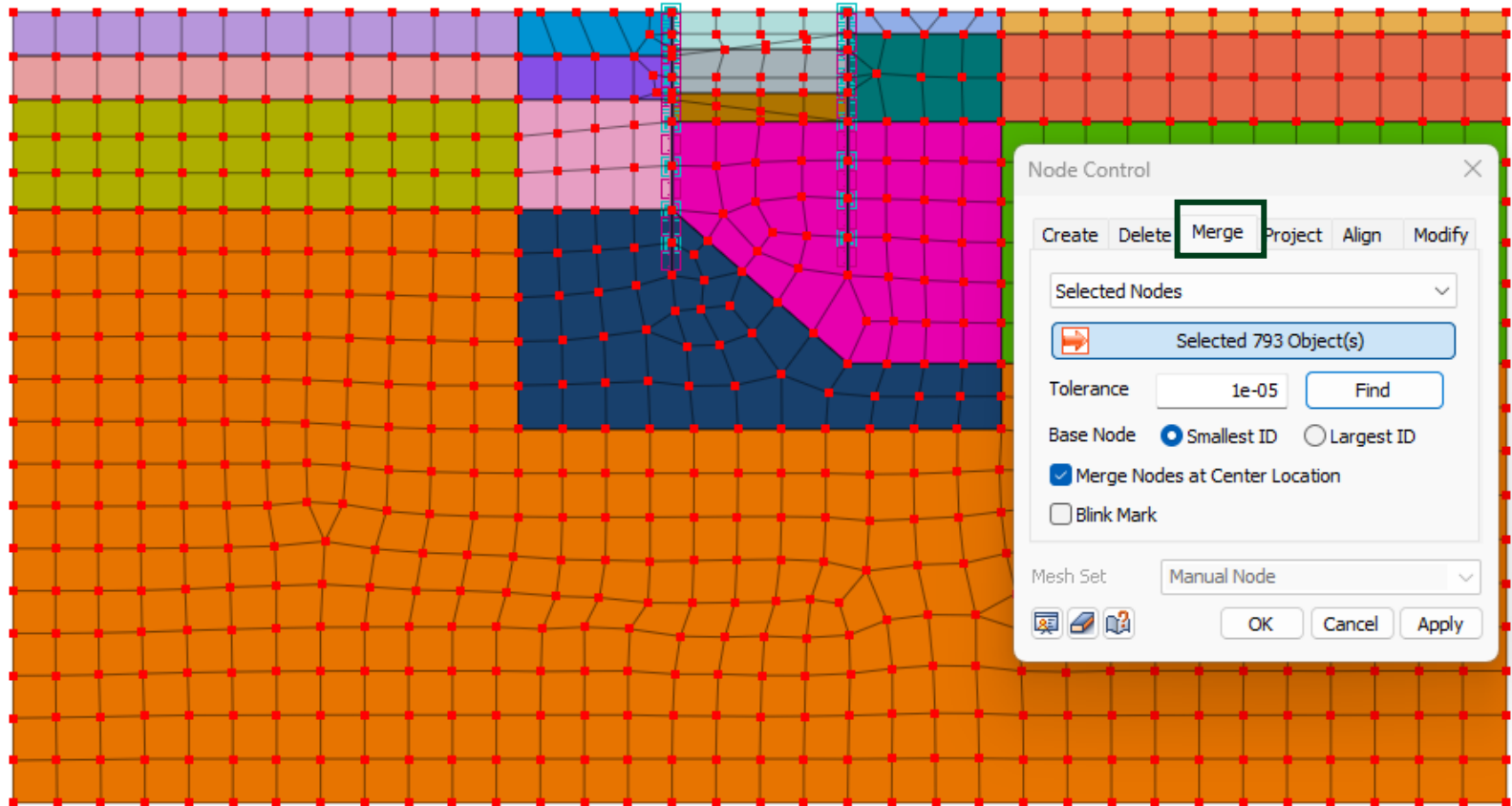
The general **Virtual Thickness Factor** range is **0.01 ~ 0.1**
(If the stiffness is high, use a smaller value)

LOCAL AXIS READJUSTMENT



Changing the axis of the local retaining wall axis

MERGE NODE

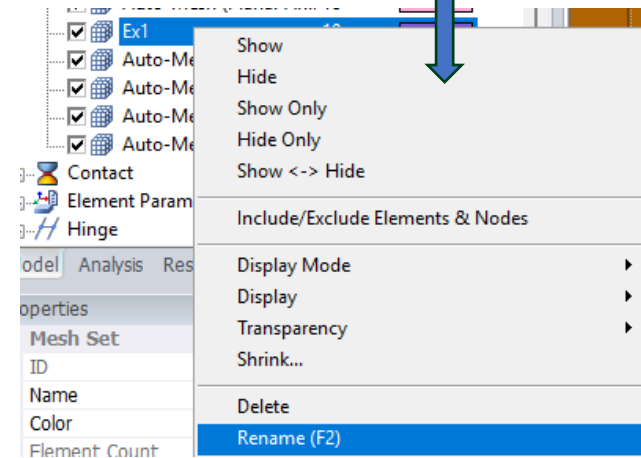
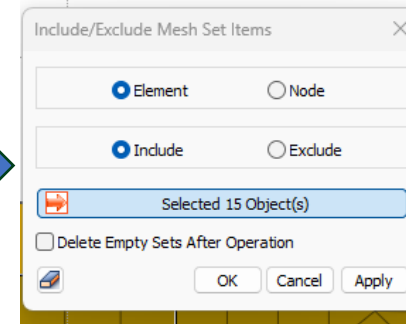
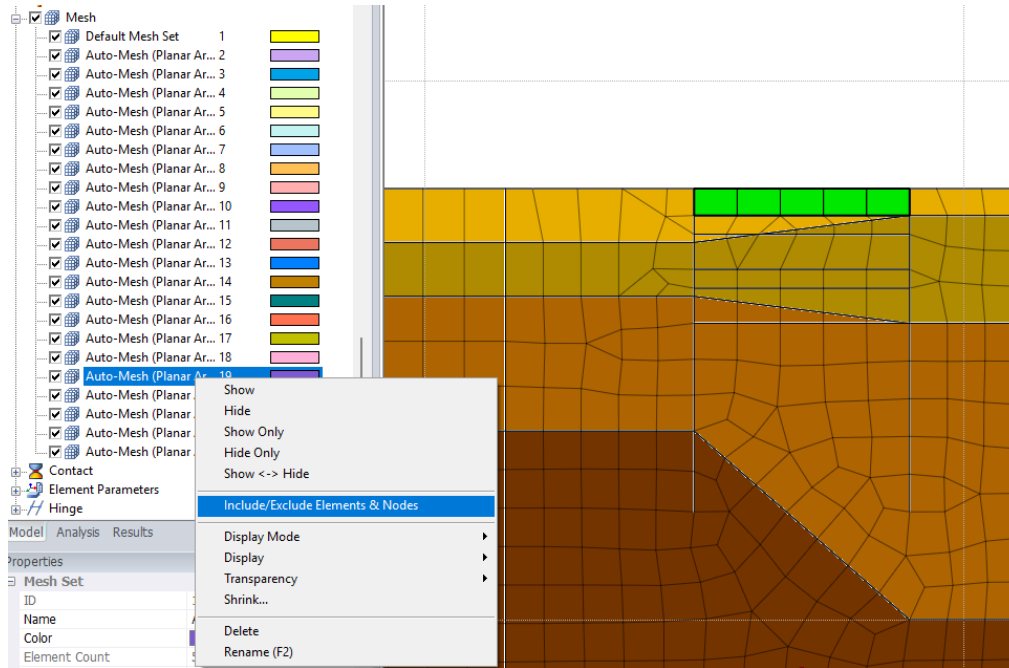


Checking the merge node function for interface

Selecting all nodes → Mesh → Node → Merge → Find

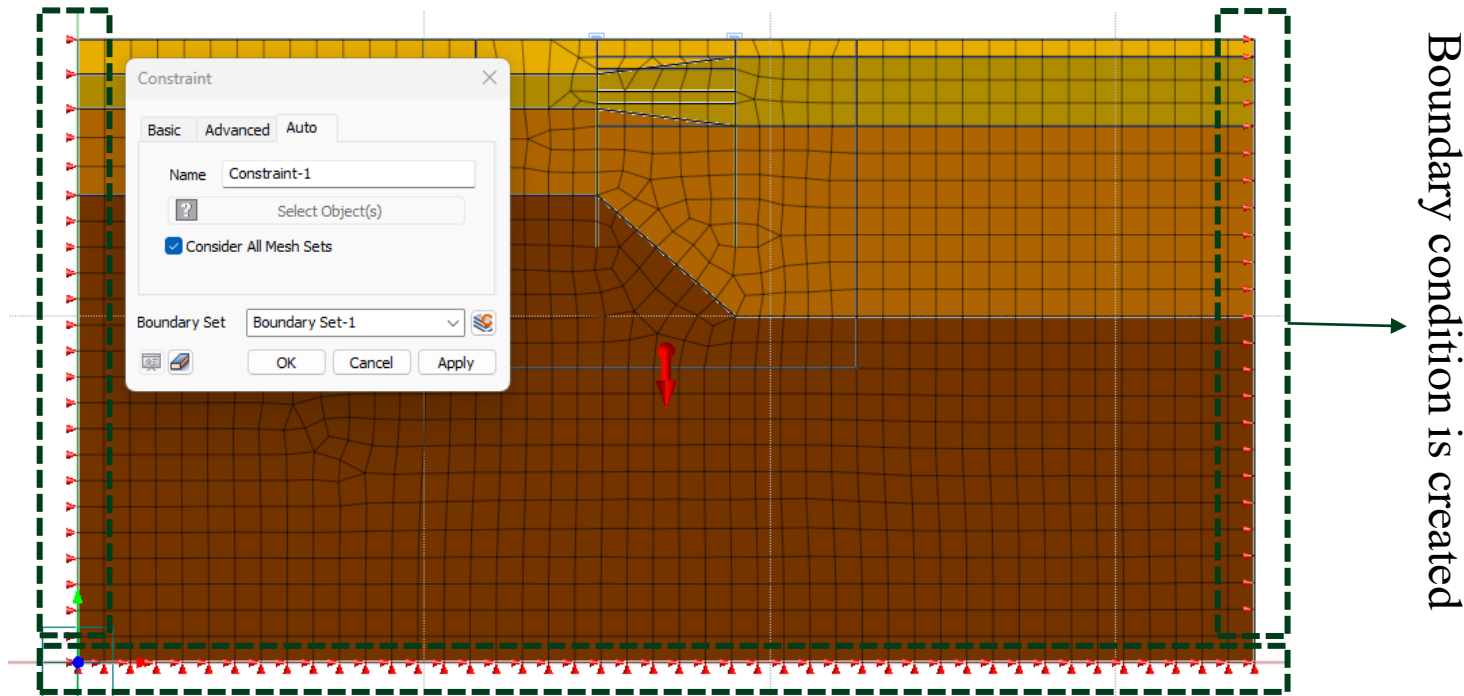
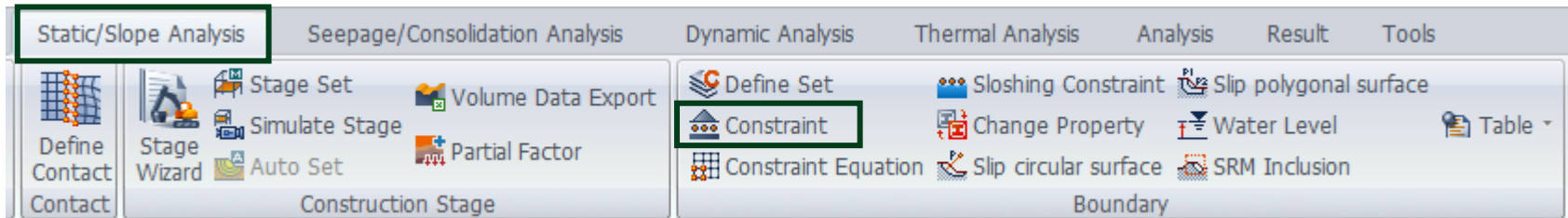
MESH GROUPING

Model Tree



NOTE: Step is generally done for organizing meshes

BOUNDARY CONDITION



NOTE: Automatic constraint creates a fix restrictions (restrained x and y axes) on the bottom part of soil model, and pin restriction on the sides (restrained y axis).

CONSTRUCTION STAGE

Construction Stage Set

Name: Excav

Stage Type: Stress

No	Name	Type
1	Excav	Stress

Buttons: Add, Modify, Copy, Delete, Define CS...

Define construction stage:

Stage Name → Set Data → Initial condition → Save → New

Define Construction Stage

Construction Stage Set Name: Excav-RW

Stage ID: 1: Initial

Stage Name: Initial

Stage Type: Stress

Buttons: Move to Previous, Move to Next, New, Insert, Delete

Set Data	Activated Data	Deactivated Data
<ul style="list-style-type: none">Mesh<ul style="list-style-type: none">Default Mesh SetEx1Ex2Ex3Line InterfaceRWRigid Link Mesh<ul style="list-style-type: none">Soil1Soil1-1Soil1-2Soil1-3Soil1-5Soil1-6Soil2Soil2-1Soil2-10Soil2-11Soil2-12Soil2-13Soil2-14Soil2-3Soil2-4Soil2-6Soil2-7Soil2-8Soil2-9	<ul style="list-style-type: none">Mesh<ul style="list-style-type: none">Default Mesh SetEx1Ex2Ex3Rigid Link Mesh<ul style="list-style-type: none">Soil1Soil1-1Soil1-2Soil1-3Soil1-5Soil1-6Soil2Soil2-1Soil2-10Soil2-11Soil2-12Soil2-13Soil2-14Soil2-3Soil2-4Soil2-6Soil2-7Soil2-8Soil2-9	<ul style="list-style-type: none">MeshBoundary ConditionStatic LoadCombined Load SetsContact

Initial Condition:

- Define Water Level For Global
- Define Water Level For Mesh Set
- Sub Stage...
- LDF...
- Clear Displacement
- Clear Strain
- Slope Stability(SRM)
- Slope Stability(SAM)

Buttons: Analysis Control..., Output Control..., Input Water Level..., Copy To Specific Stage..., Save, Close

CONSTRUCTION STAGE 1

Define Construction Stage

Geometries (P)

Construction Stage Set Name: Excav-RW

Stage ID: 1: Initial (Move to Previous, Move to Next)

Stage Name: Initial (New, Insert, Delete)

Stage Type: Stress

Set Data: Mesh, Default Mesh Set, Ex1, Ex2, Ex3, Line Interface, RW, Rigid Link Mesh, Soil1, Soil1-1, Soil1-2, Soil1-3, Soil1-5, Soil1-6, Soil1-6, Soil2, Soil2-1, Soil2-10, Soil2-11, Soil2-12, Soil2-13, Soil2-14, Soil2-3, Soil2-4, Soil2-6, Soil2-7, Soil2-8, Soil2-8

Activated Data: Mesh, Default Mesh Set, Ex1, Ex2, Ex3, Rigid Link Mesh, Soil1, Soil1-1, Soil1-2, Soil1-3, Soil1-5, Soil1-6, Soil2, Soil2-1, Soil2-10, Soil2-11, Soil2-12, Soil2-13, Soil2-14, Soil2-3, Soil2-4, Soil2-6, Soil2-7, Soil2-8, Soil2-9, Boundary Condition

Deactivated Data: Mesh, Boundary Condition, Static Load, Combined Load Sets, Contact

Analysis Control...
Output Control...
Initial Condition
 Define Water Level For Global (0 m, None)
 Define Water Level For Mesh Set (Input Water Level...)
 Sub Stage...
 LDF... (Copy To Specific Stage...)
 Clear Displacement
 Clear Strain
 Slope Stability(SRM)
 Slope Stability(SAM)

Sort By: Name (Show Data, Activate)

Save Close

Stage 1: Initial Conditions

CONSTRUCTION STAGE 2

Define Construction Stage

Construction Stage Set Name: Excav-RW

Stage ID: 2: RW (Move to Previous, Move to Next)

Stage Name: RW (New, Insert, Delete)

Stage Type: Stress

Set Data

- Mesh
 - Default Mesh Set
 - Ex1
 - Ex2
 - Ex3
 - Line Interface
 - RW
 - Rigid Link Mesh
 - Soil1
 - Soil1-1
 - Soil1-2
 - Soil1-3
 - Soil1-5
 - Soil1-6
 - Soil2
 - Soil2-1
 - Soil2-10
 - Soil2-11
 - Soil2-12
 - Soil2-13
 - Soil2-14
 - Soil2-3
 - Soil2-4
 - Soil2-6
 - Soil2-7
 - Soil2-8

Activated Data

- Mesh
- Line Interface
- RW
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

Deactivated Data

- Mesh
- Rigid Link Mesh
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

Analysis Control...
Output Control...

Initial Condition

- Define Water Level For Global (0 m, None, ...)
- Define Water Level For Mesh Set (Input Water Level...)

Sub Stage...

LDF... Copy To Specific Stage...

Clear Displacement
 Clear Strain
 Slope Stability (SRM)
 Slope Stability (SAM)

Geometries (P)

Y
X

Stage 2: Retaining Wall

CONSTRUCTION STAGE 4

Define Construction Stage

Construction Stage Set Name: Excav-RW

Stage ID: 4: Ex2 Move to Previous Move to Next

Stage Name: Ex2 New Insert Delete

Stage Type: Stress

Set Data

- Mesh
 - Default Mesh Set
 - Ex1
 - Ex2
 - Ex3
 - Line Interface
 - RW
 - Rigid Link Mesh
 - Soil1
 - Soil1-1
 - Soil1-2
 - Soil1-3
 - Soil1-5
 - Soil1-6
 - Soil2
 - Soil2-1
 - Soil2-10
 - Soil2-11
 - Soil2-12
 - Soil2-13
 - Soil2-14
 - Soil2-3
 - Soil2-4
 - Soil2-6
 - Soil2-7
 - Soil2-8

Activated Data

- Mesh
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

Deactivated Data

- Mesh
- Ex2
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

Analysis Control...

Output Control...

Initial Condition

- Define Water Level For Global
0 m None ...
- Define Water Level For Mesh Set
Input Water Level...

Sub Stage...

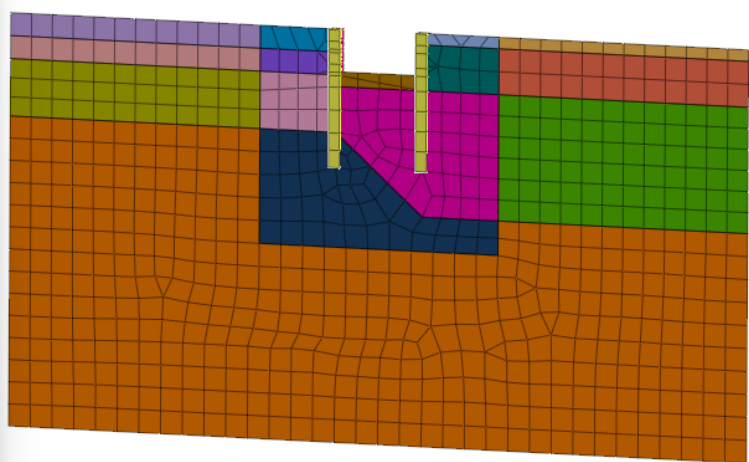
LDF... Copy To Specific Stage...

Clear Displacement

Clear Strain

Slope Stability(SRM)

Slope Stability(SAM)



Stage 4: Excavation Layer 2

CONSTRUCTION STAGE 4

Define Construction Stage

Construction Stage Set Name: Excav-RW

Stage ID: S: Ex3
Stage Name: Ex3
Stage Type: Stress

Buttons: Move to Previous, Move to Next, New, Insert, Delete

Set Data: Mesh, Default Mesh Set, Ex1, Ex2, Ex3, Line Interface, R.W, Rigid Link Mesh, Soil1, Soil1-1, Soil1-2, Soil1-3, Soil1-5, Soil1-6, Soil2, Soil2-1, Soil2-10, Soil2-11, Soil2-12, Soil2-13, Soil2-14, Soil2-3, Soil2-4, Soil2-6, Soil2-7, Soil2-8

Activated Data: Mesh, Boundary Condition, Static Load, Combined Load Sets, Contact

Deactivated Data: Mesh, Ex3, Boundary Condition, Static Load, Combined Load Sets, Contact

Initial Condition:
 Define Water Level For Global (0 m, None)
 Define Water Level For Mesh Set (Input Water Level...)

Sub Stage...
 LDF...
 Copy To Specific Stage...

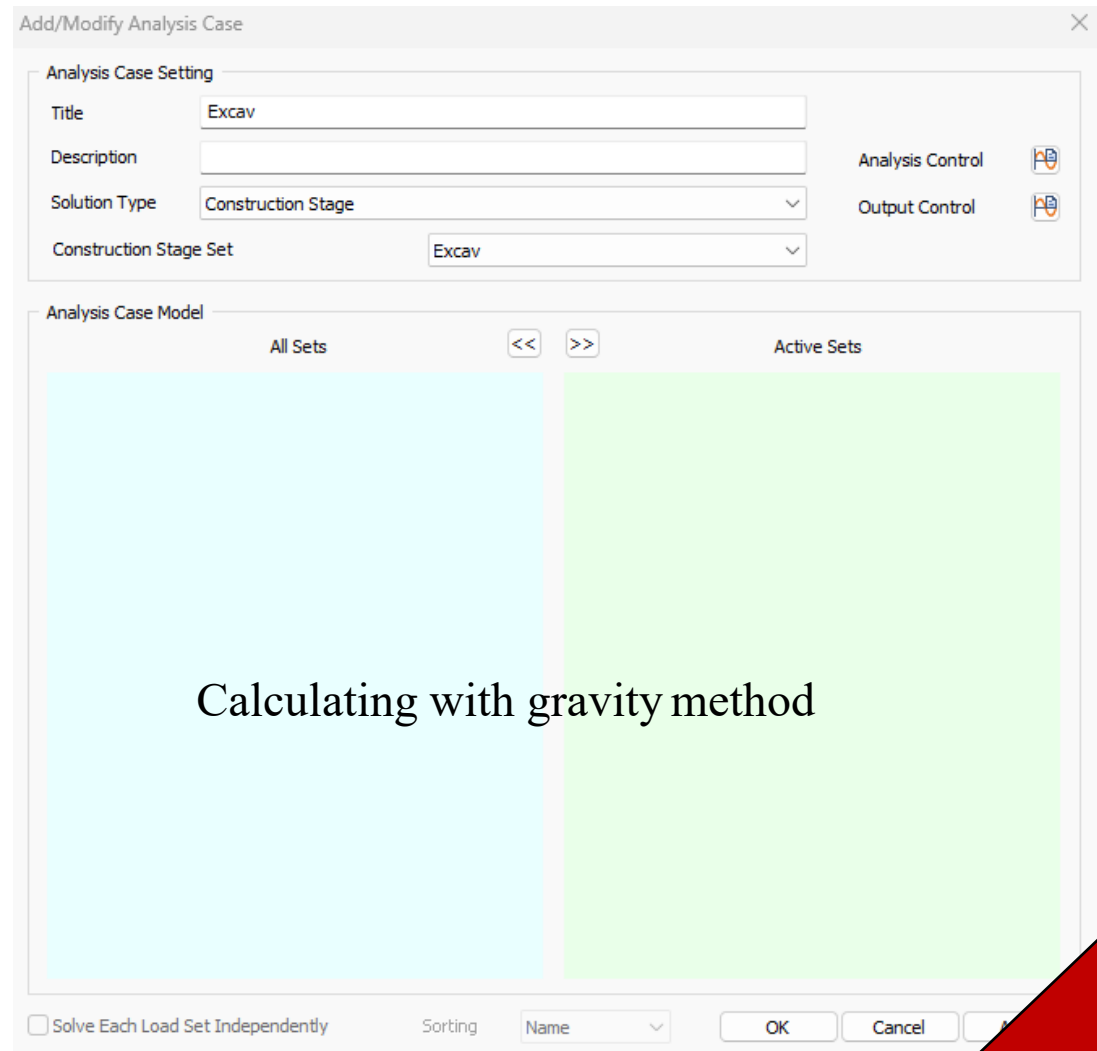
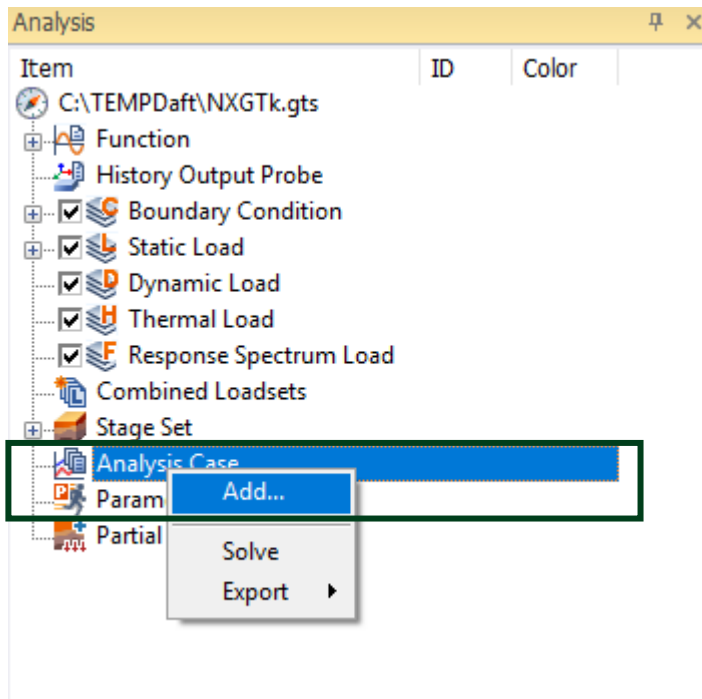
Clear Displacement
 Clear Strain
 Slope Stability(SRM)
 Slope Stability(SAM)

Geometries (M)

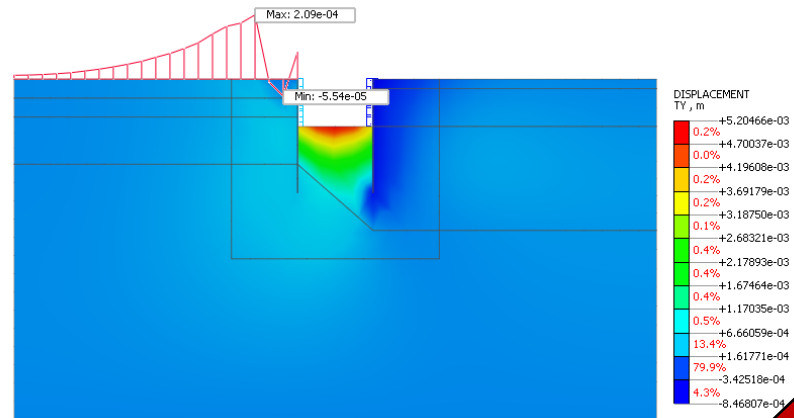
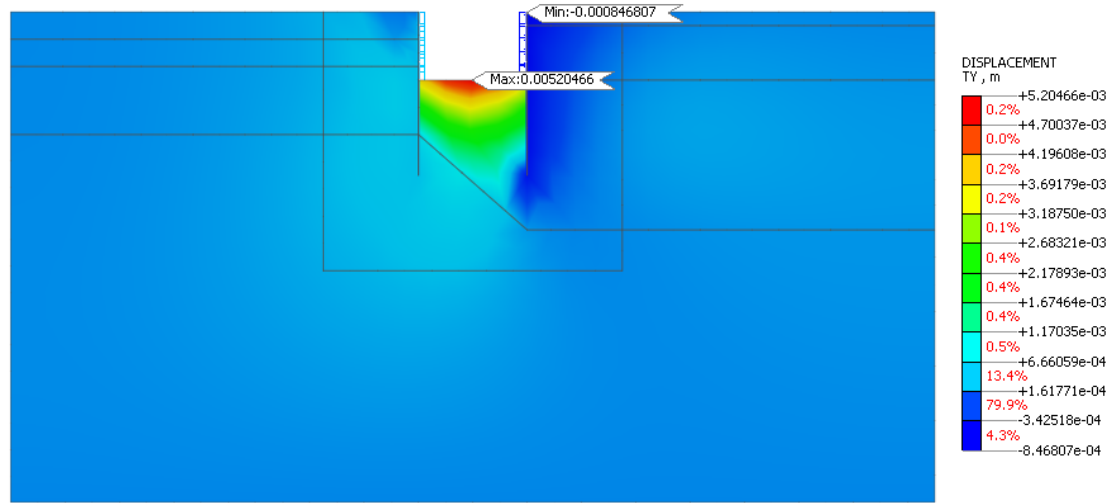
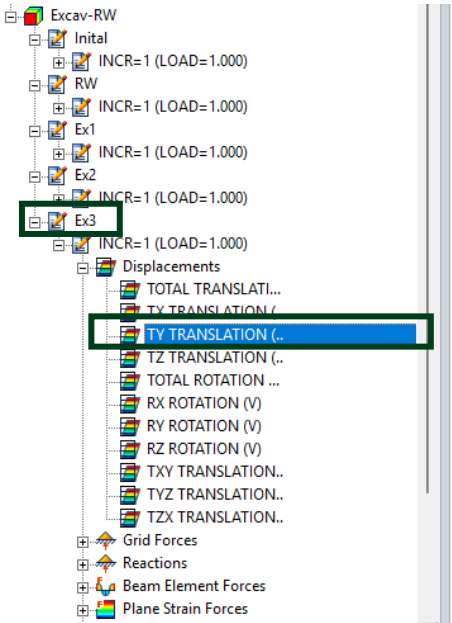
Coordinate System: X, Y, Z

Stage 4: Excavation Layer 3

ANALYSIS CONTROL

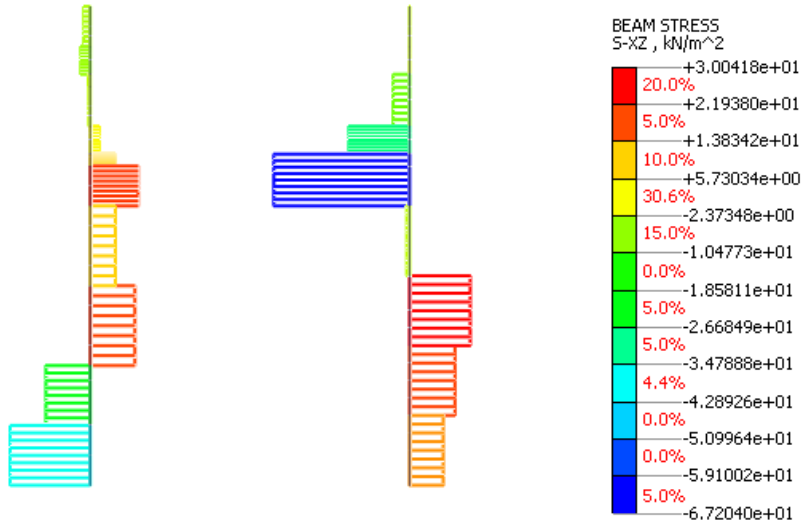


RESULT - VERTICAL DISPLACEMENT

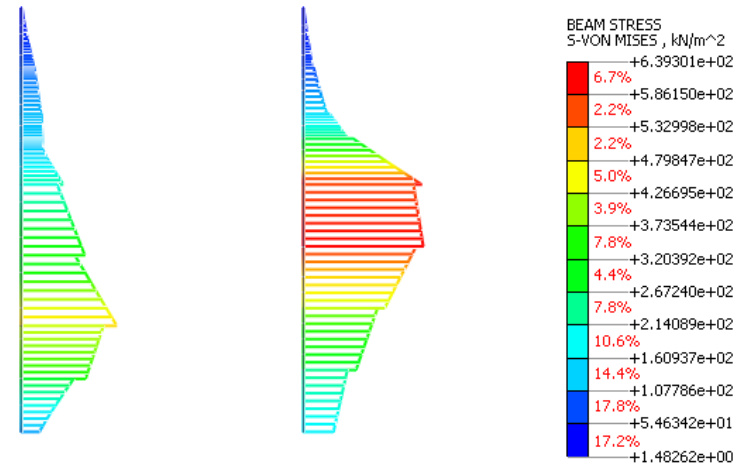


Result → Advanced → Cutting Diagram

RESULT - BEAM STRESSES



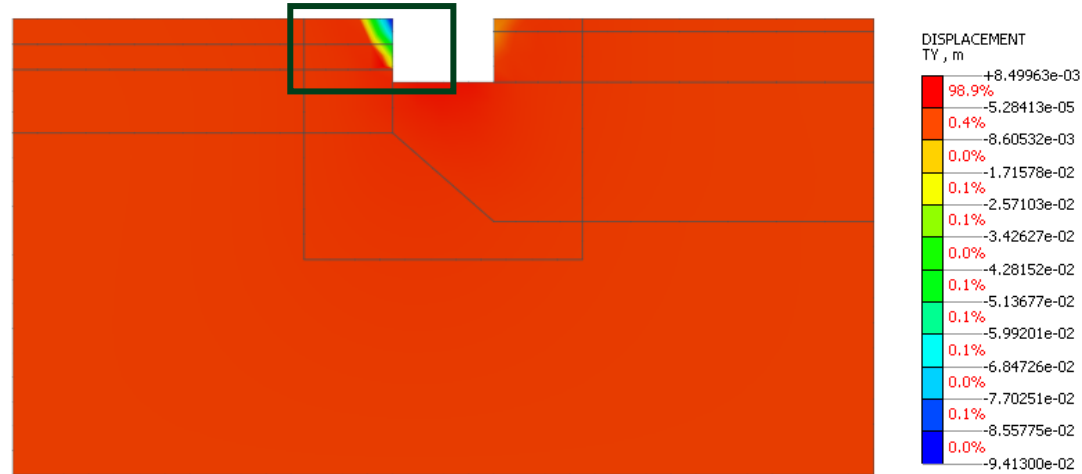
Shear force
Retaining Wall



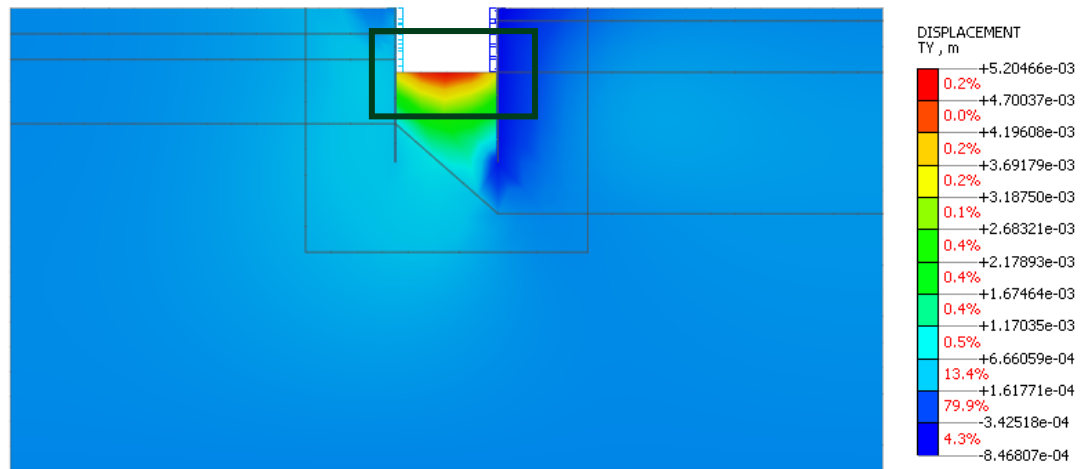
Bending moment
Retaining Wall

RESULT - COMPARISON

Total Displacement
Without RW



Total Displacement
With RW



The comparison highlights the effect of the Retaining Wall in the excavation model.



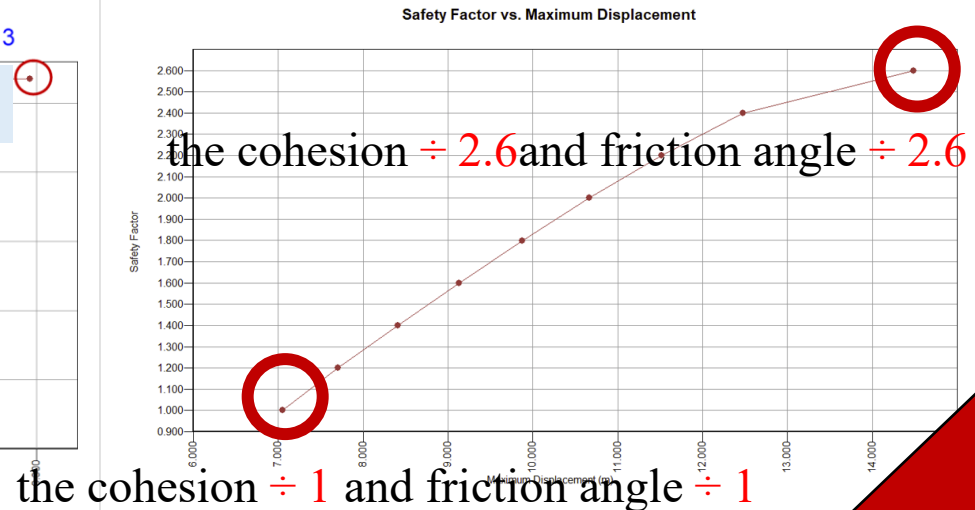
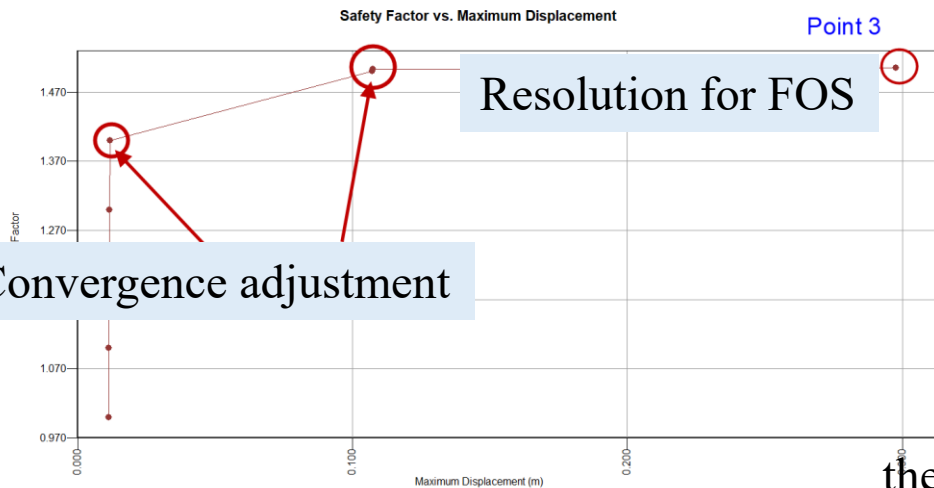
**MIDAS TAIWAN
GTS NX STANDARD TEACHING SERIES**

**DIFFERENT HAZARD
CONDITIONS IN SLOPE
STABILITY**

STRENGTH REDUCTION METHOD (SRM)

In GTS NX, slope stability assessment uses the Strength Reduction Method (SRM), which determines the failure point by progressively reducing the soil's shear strength parameters. In this method, the soil's cohesion (c) and internal friction angle (ϕ) are systematically reduced using a reduction factor F ; this reduction factor value is the safety factor (FoS).

The slope stability calculation depends on the soil strength, which in turn depends on the soil's cohesion and internal friction angle, as well as instability factors such as soil weight, water pressure, and external loads. Users can adjust the convergence criteria (load/displacement/work) in the analysis definition according to their preferences.



Reference

The intensity reduction method proposed by Griffith et al. (1999) and Matsui (1990)

PSEUDO-STATIC SEISMIC

Pseudo-static seismic method is a simplified way to represent earthquake effects by replacing dynamic ground shaking with constant equivalent static forces

Applying inertial body forces proportional to gravity instead of time-varying acceleration

$$F_h = k_h W, \quad F_v = k_v W$$

Where:

- k_h = horizontal seismic coefficient
- k_v = vertical seismic coefficient

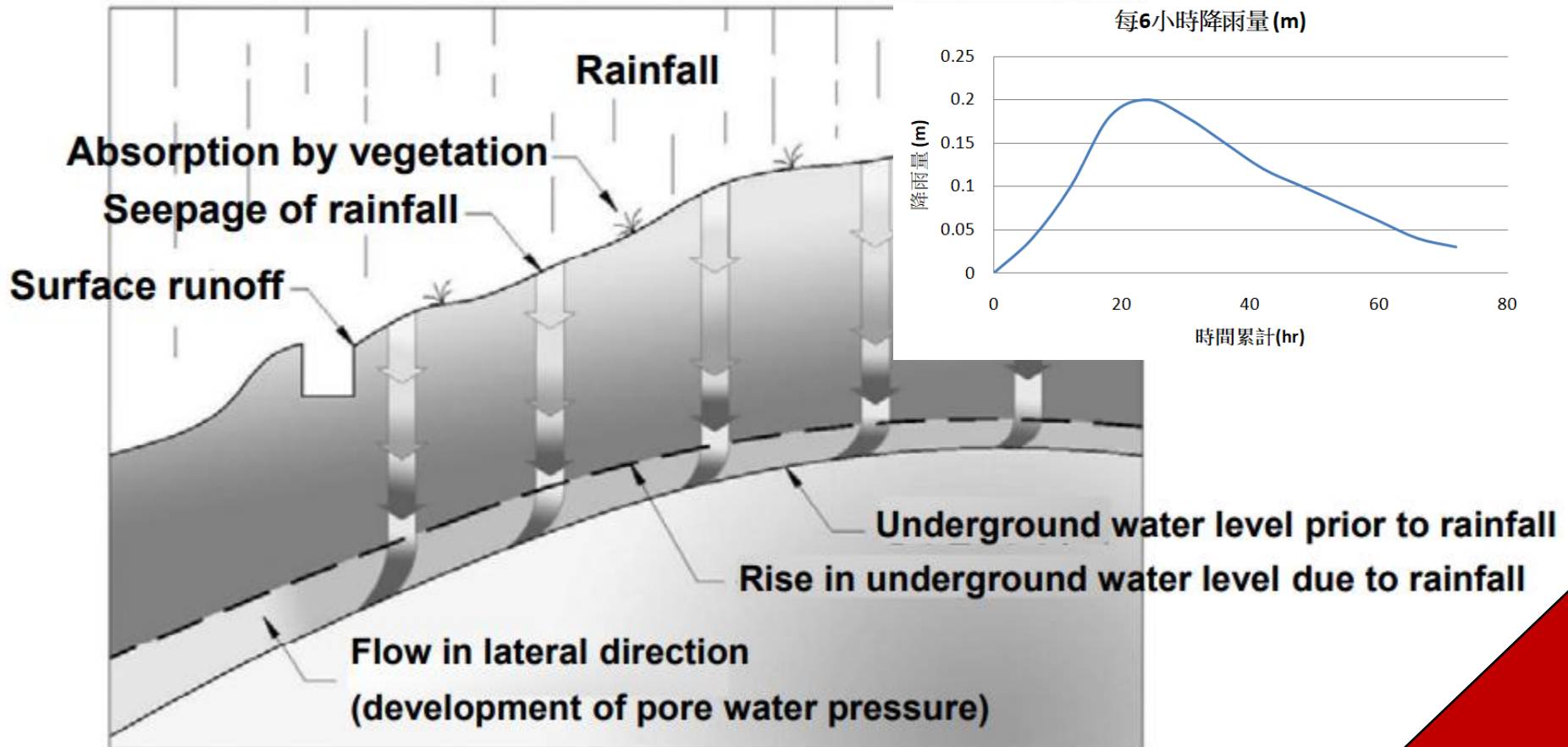
These forces are applied **uniformly to the entire soil mass.**

Reference

GTS NX/FEA NX/Soilworks Manual

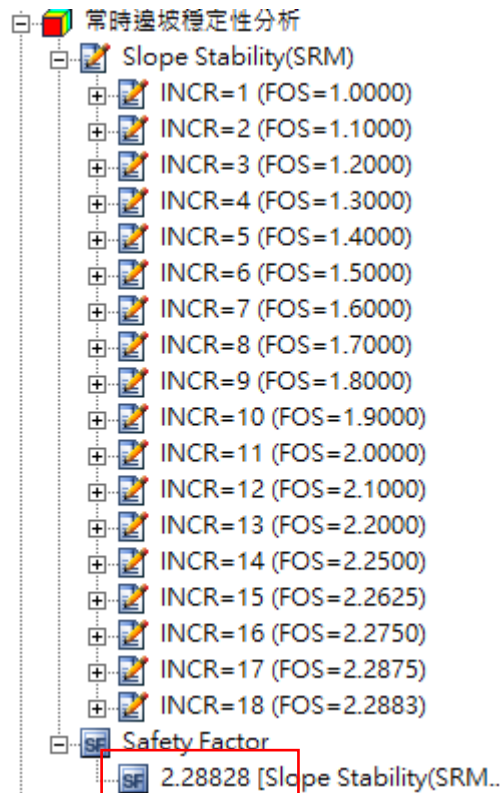
SEEPAGE THROUGH UNSATURATED SLOPE

SEEPAGE INDUCED BY RAINFALL



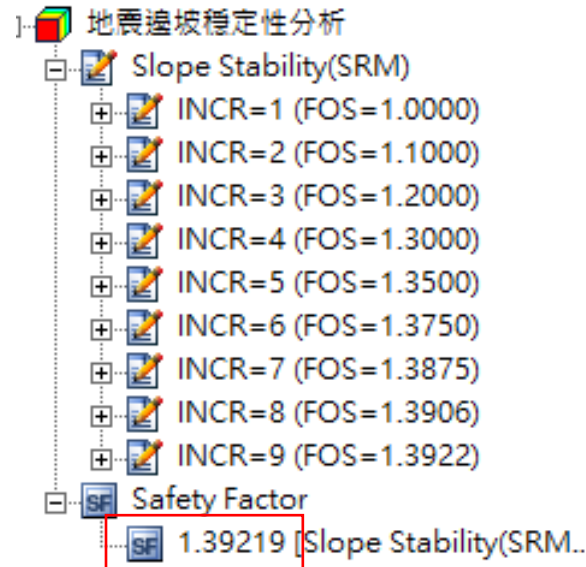
COMPARISON FOR DIFFERENT CASES

Normal case



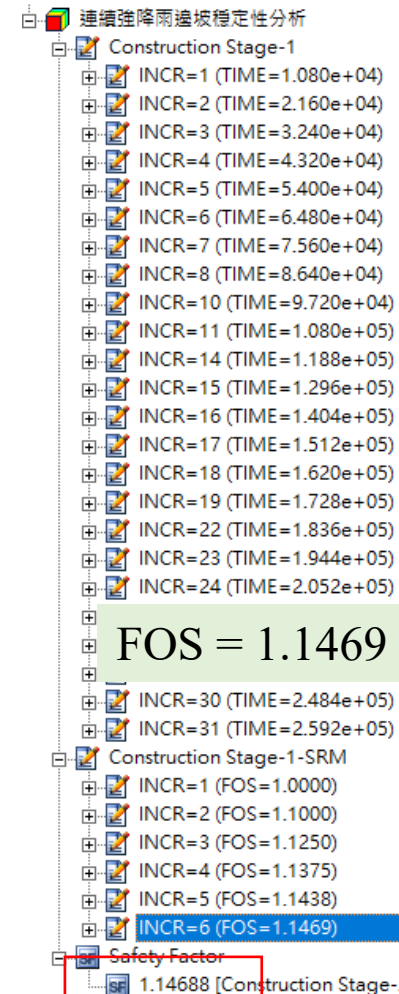
FOS = 2.2883

Pseudo-static seismic



FOS = 1.3922

Heavy rainfall case

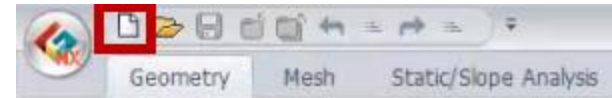




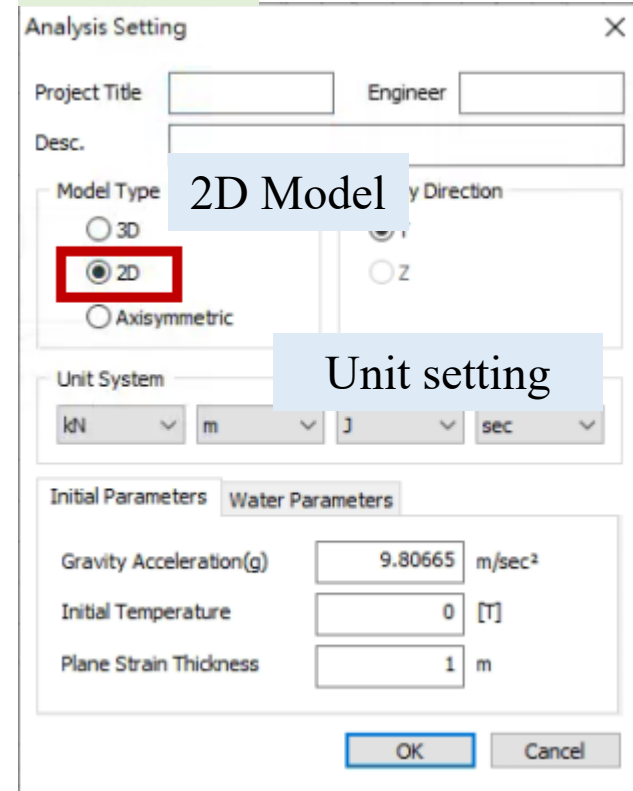
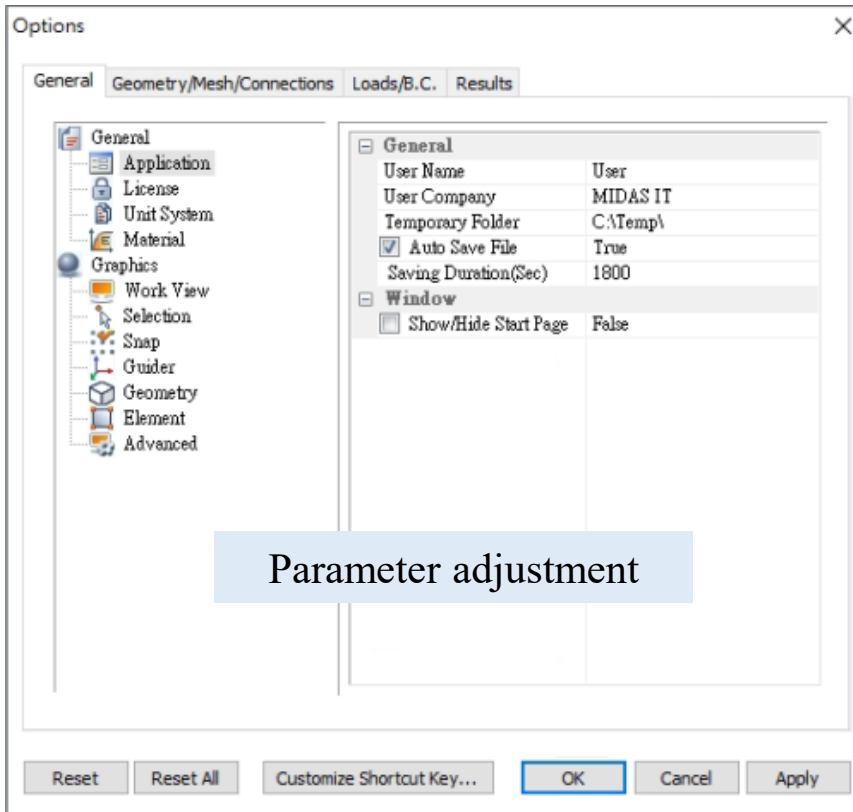
Part 1

NORMAL CONDITION

IMPORT



New file



Unit setting: KN/m/J/sec

2D MODEL IMPORT

Import the geometries or FE model in the selected file

- Import CAD File...**
Import the CAD file into a current project
- DXF 2D (Wireframe)...**
Import the DXF 2D file into a current project
- DXF 3D (Wireframe)...**
Import the DXF 3D file into a current project
- DWG (Wireframe)...**
Import the DWG file into a current project
- midas Mxt...**
Import the midas MXT file.
- GeoXD Neutral Format File(*.FPN)...**
Import the Neutral File
- GTS NX Neutral Format...**
Open Neutral File
- Import Nodal Results(*.txt)**
Import nodal results File
- Execute Mining Model Convert...**

Open CAD File...

Look in: Practice

Name	Date modified	Type	Size
Geometry import.X_T	16/12/2025 10:00 AM	X_T File	12 KB

Import CAD file name:
'Geometry import'

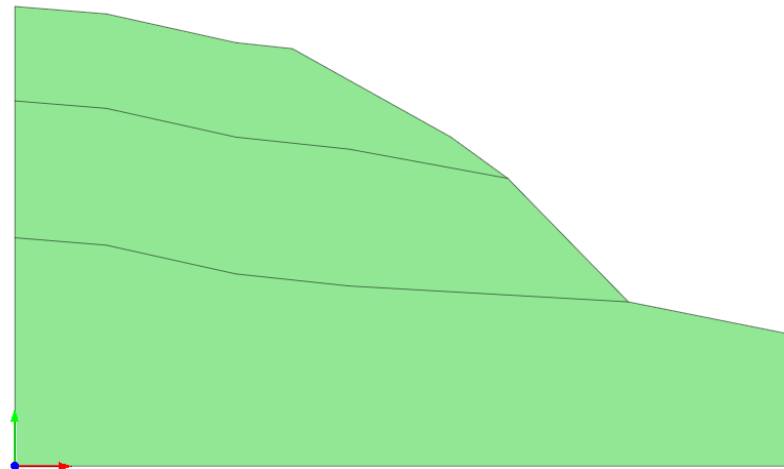
File name: Geometry import

Files of type: Parasolid (9 to 36) Files (*.x_t;*.xmt_bin;*.x_b;*.xmt_bin)

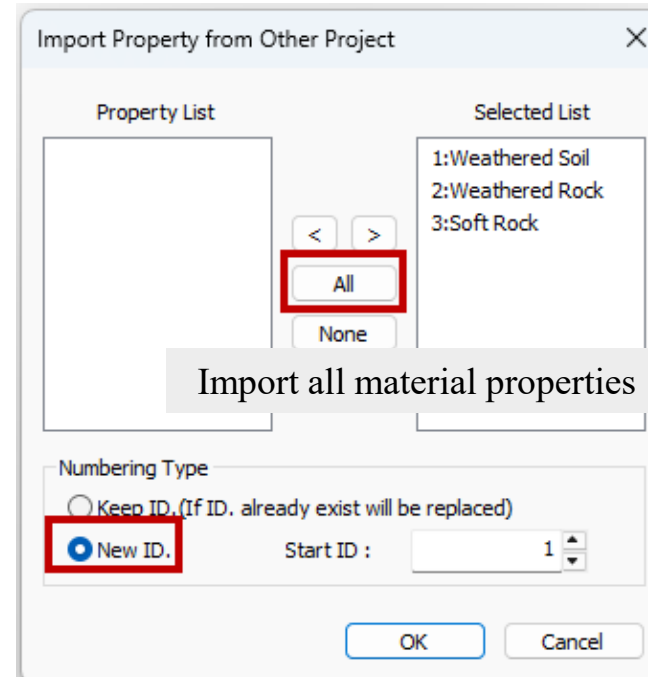
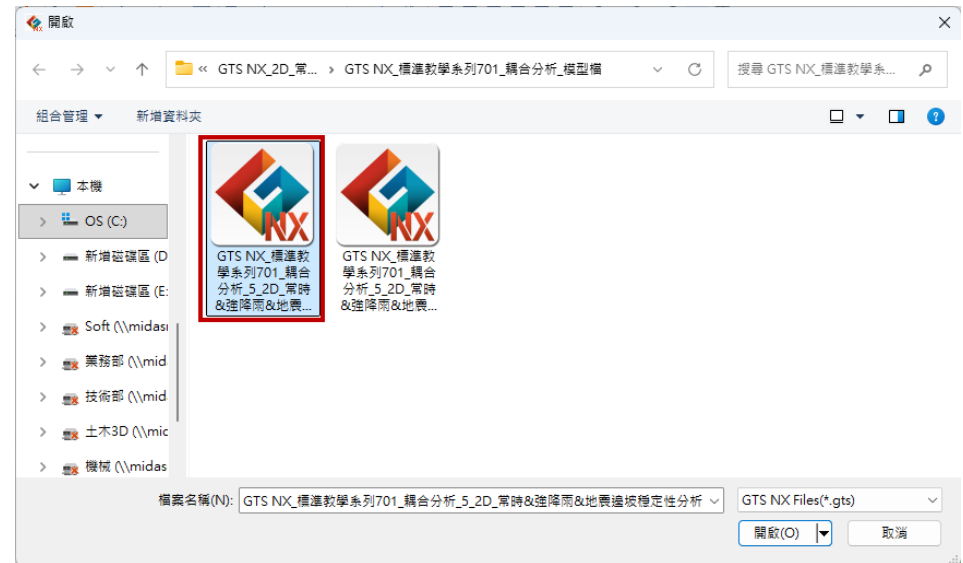
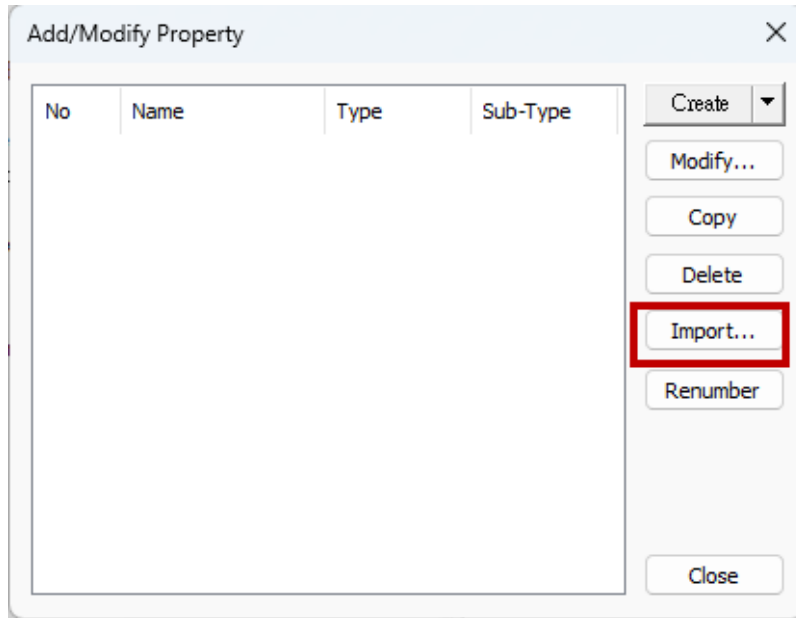
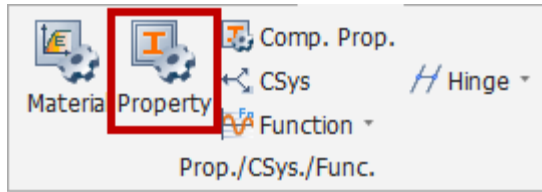
Open as read-only

Length Unit of the Model(s) m

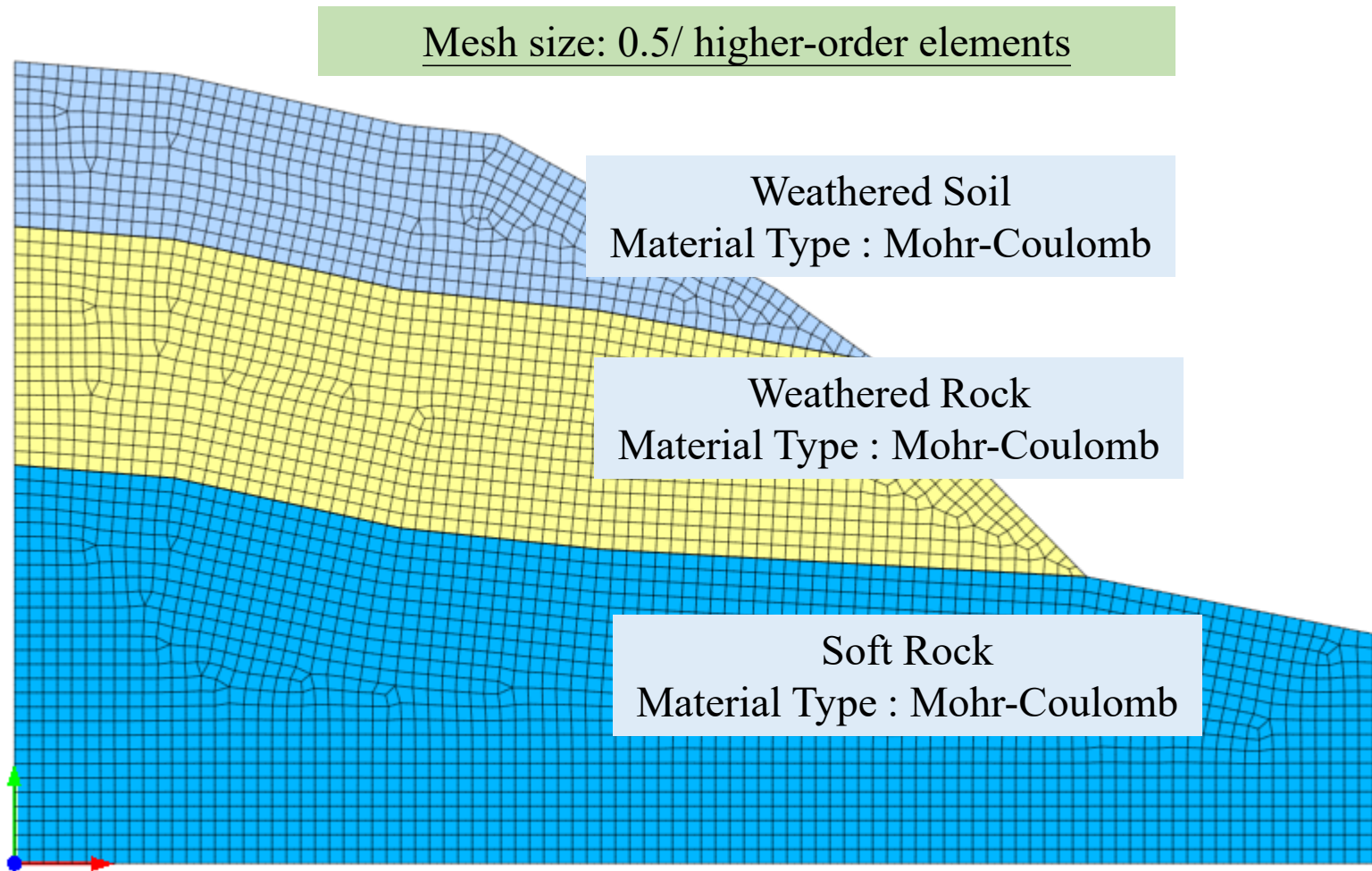
Import Option... Reset All



MATERIAL & PROPERTY

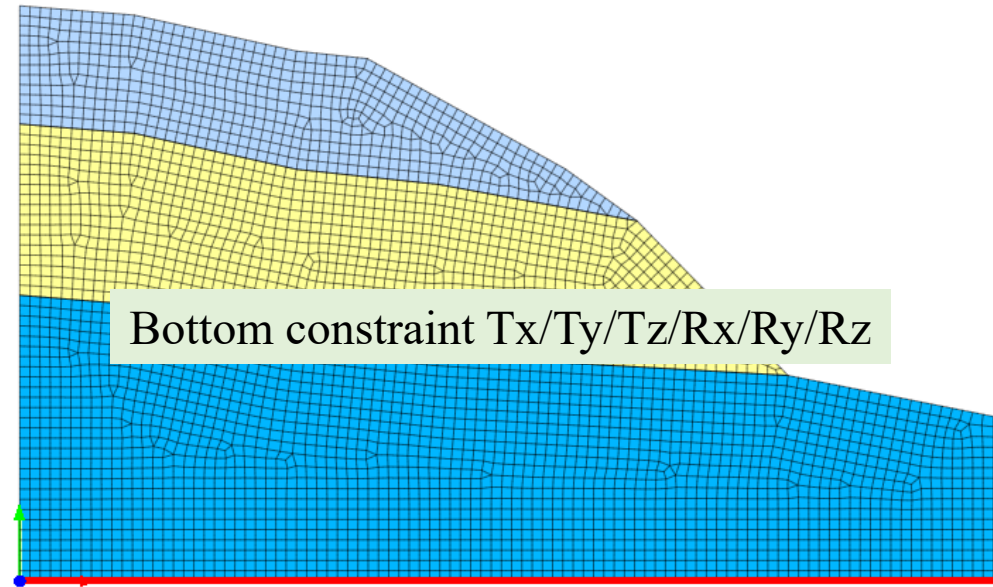
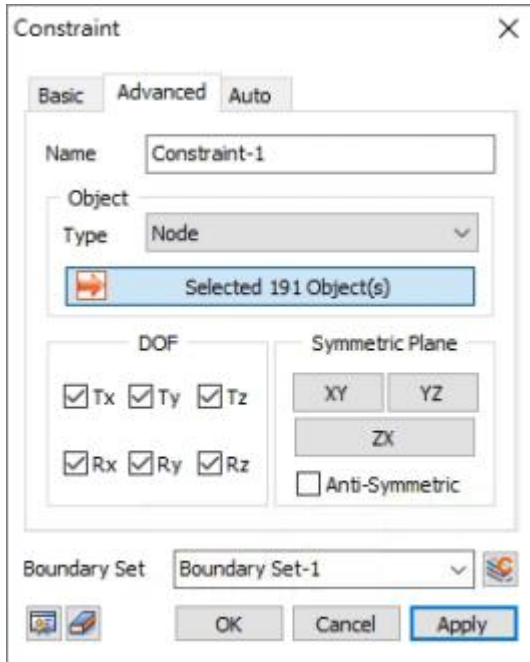
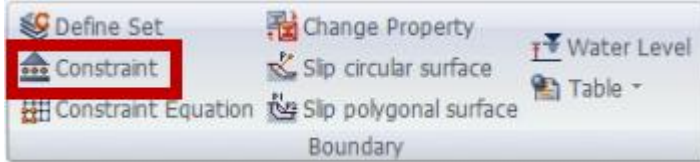


2D MESH GENERATION

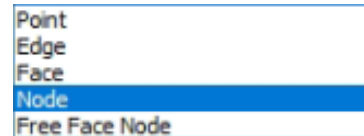
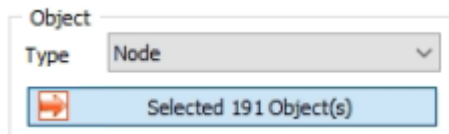


Note: Using higher-order elements and smaller grid sizes for slope analysis

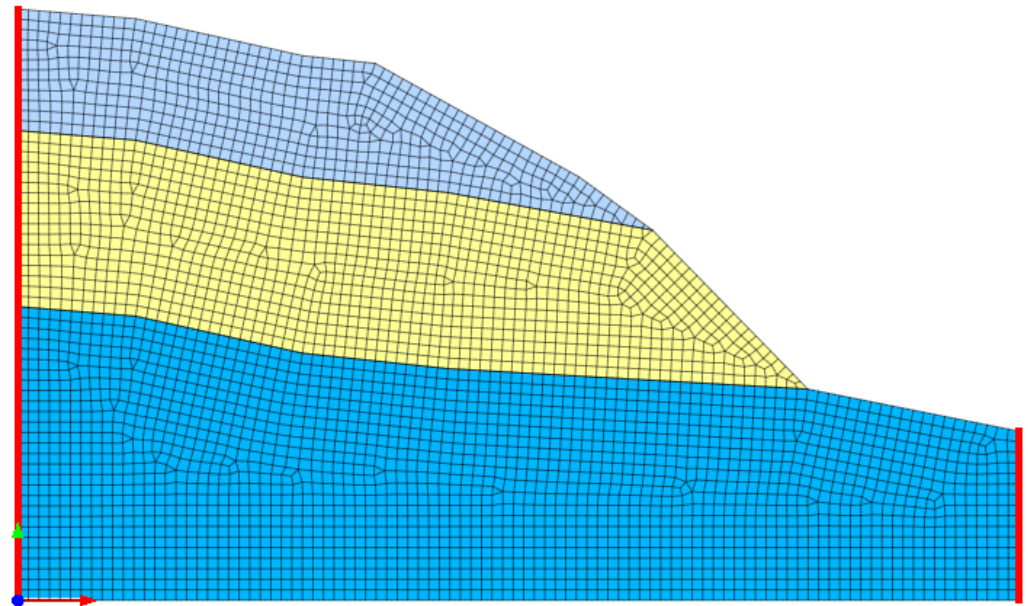
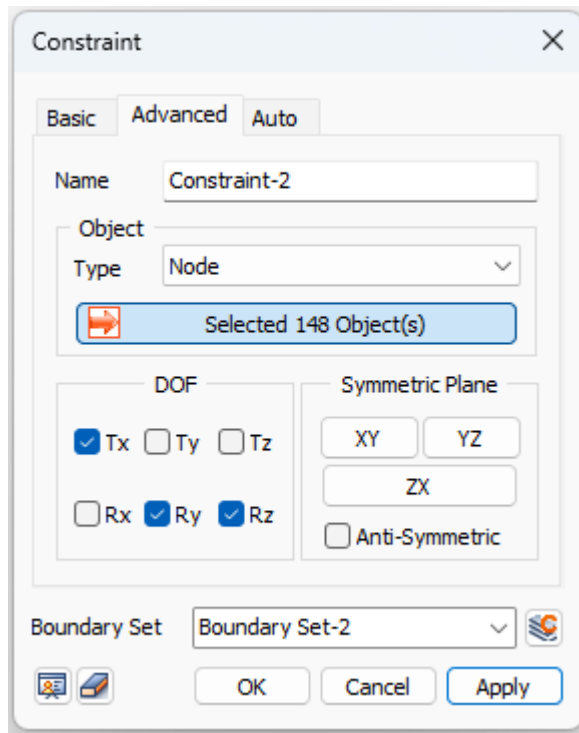
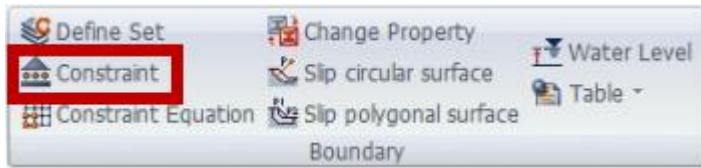
BOTTOM BOUNDARY



The geometric features or nodes can be applied to the boundary



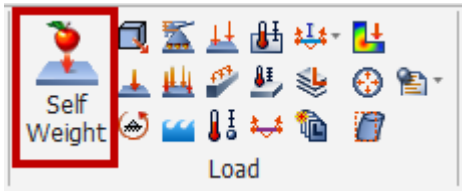
TWO-SIDED BOUNDARY



2-sided constraint Tx/Ry/Rz

It is recommended to set boundary sets for different location

SELF-WEIGHT



Gravity

Gravity

Name: Gravity-1

Reference Object

Type: Coordinate

Ref. CSys: Global Rectangular

Components

Gx: 0

Gy: -1

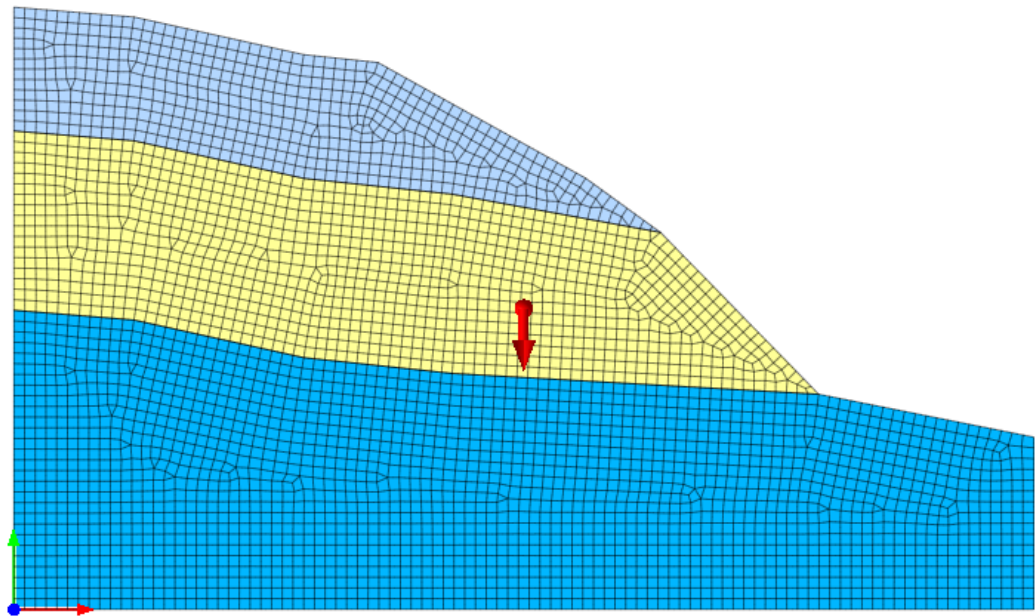
Gz: 0

Spatial Distribution

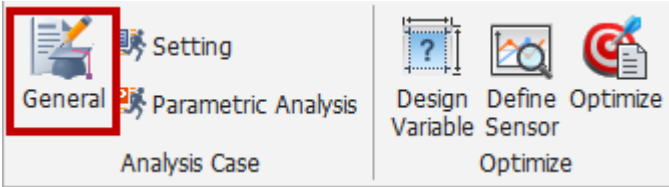
Base Function: None

Load Set: Gravity-1

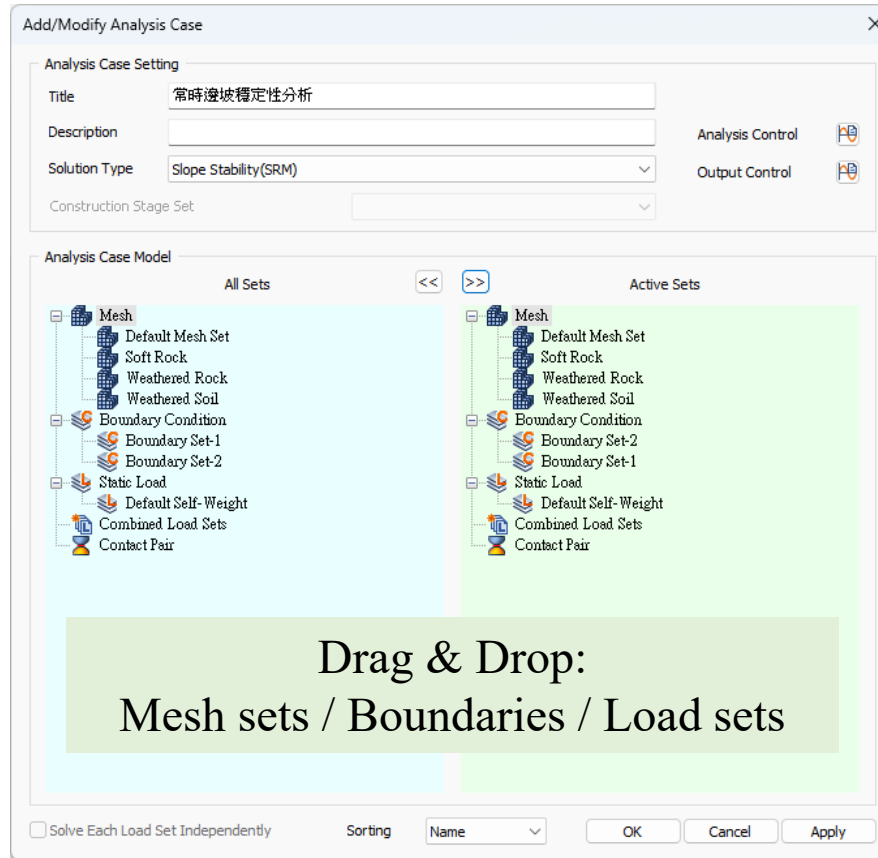
OK Cancel Apply



ANALYSIS 1 |SLOPE STABILITY (SRM) – NORMAL CASE)



Simulation type: Slope Stability(SRM)



ANALYSIS 2 |SLOPE STABILITY (SRM) – NORMAL CASE)

Convergence settings

General Slope Stability(SRM)

Geometry Nonlinearity

Consider Geometric Nonlinear Effects

Nonlinear parameters

Maximum Number of Trials

Maximum Number of Iterations

Stiffness Update Scheme

Intermediate Output Request

Convergence Criteria / Error

Displacement(U)

Load(P)

Work(W)

Safety Factor

Initial Safety Factor

Increment of Safety Factor

Resolution of Safety Factor

Safety Factor Function

Advanced Nonlinear Parameters...

OK Cancel

Output setup

Output=>Strain

Shear strain indicates the failure arc

Output Type Output Option

Write Results of All Active Mesh Sets

Nodal Results

Displacement

Applied Load

Reaction Force

Grid Point Force

Contact

Element Results

Force

Stress

Strain

Status

Damaged Index

Ductility

Output Option

Binary Binary and Text

Element Output Location

Element Corner Results

Shell Mid-Plane Results

Composite Shell Mid-Plane Results

Number of Beam Output Segments

OK Cancel

SRM convergence adjustment

- (1) Initial safety factor 1
- (2) FOS increment by 0.1 each time
- (3) Residual < 0.01, minimum FOS reached

CALCULATION

The screenshot displays the GTS NX software interface. The 'Analysis' ribbon is active, with the 'Perform' button highlighted. A 'GTS NX Solver' dialog box is open, showing a table of analysis cases. The table has three columns: Name, Type, and Description. The first row is checked and contains the text '常時邊坡穩定性分析' (Slope Stability (SRM)).

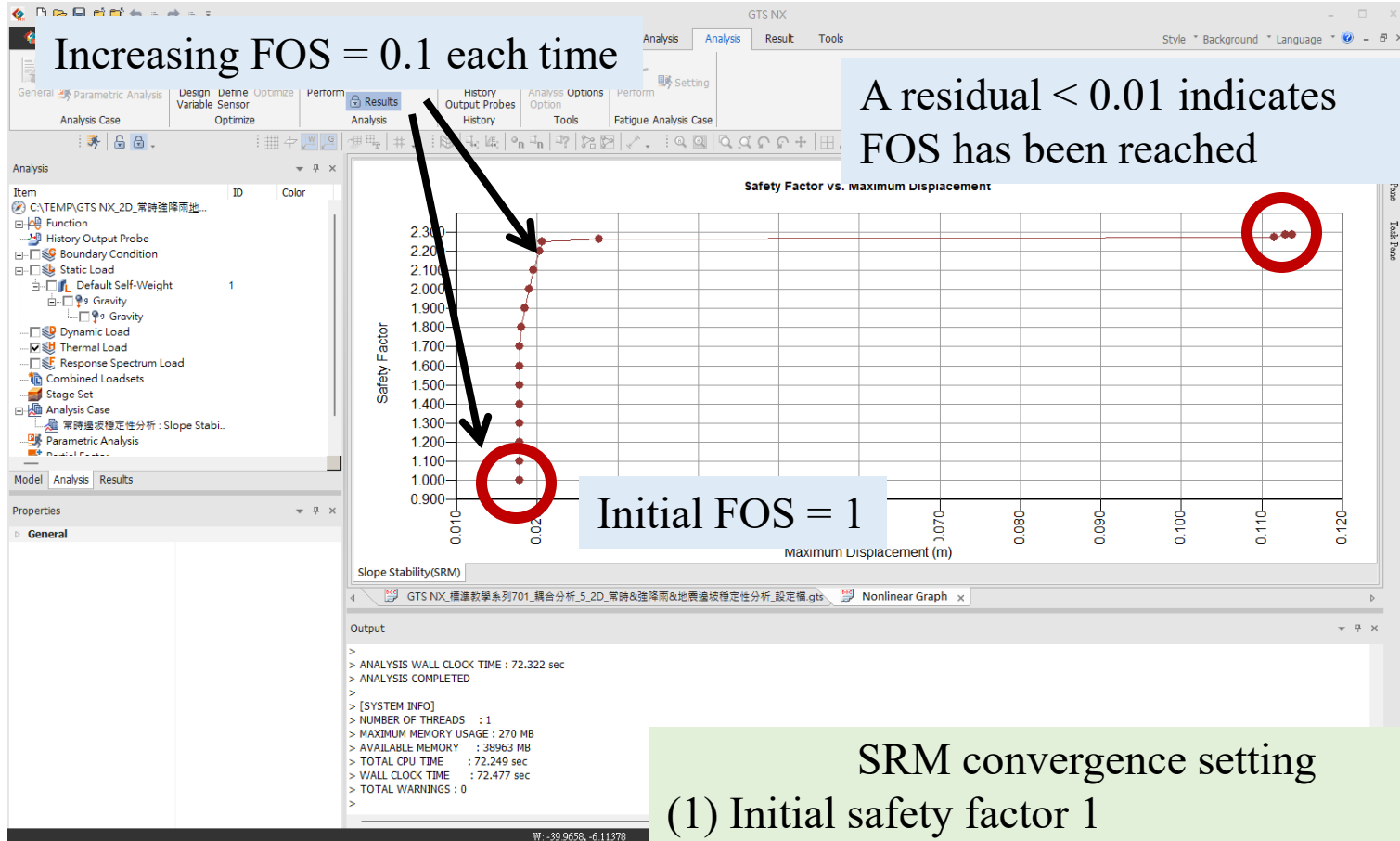
Name	Type	Description
<input checked="" type="checkbox"/>	常時邊坡穩定性分析	Slope Stability (SRM)

Below the dialog box, the text 'Execute the analysis case' is overlaid. The output window at the bottom shows the following text:

```
> GTS NX 2026 (v1.1) (64bit)
> Copyright (C) SINCE 1989 MIDAS Information Technology Co., Ltd. ALL RIGHTS RESERVED.
> Geometry is successfully imported. [GTS NX_標準教學系列701_耦合分析_5_2D_常時&強降雨&地震邊坡穩定性分析_CAD.X_T]
> A mesh set[Soft Rock] which has 6466 nodes and 2081 elements has been created.
> A mesh set[Weathered Rock] which has 3456 nodes and 1097 elements has been created.
> A mesh set[Weathered Soil] which has 1759 nodes and 544 elements has been created.
> Work project is being saved by auto-save function.
```

The status bar at the bottom shows coordinates: W: 48.0042, 39.1112 X: 0-47.4337 Y: 0-27.9872 Z: 0-0 G: [1] M: [11407] E: [3722]

SAFETY FACTOR INDICATION | CONVERGENCE CRITERIA



- SRM convergence setting
- (1) Initial safety factor 1
 - (2) FOS increment by 0.1 each time
 - (3) Residual < 0.01, minimum FOS reached

RESULTS | NORMAL CASE

Results

Self-weight analysis, FOS = 2.2883

- INCR=6 (FOS=1.5000)
- INCR=7 (FOS=1.6000)
- INCR=8 (FOS=1.7000)
- INCR=9 (FOS=1.8000)
- INCR=10 (FOS=1.9000)
- INCR=11 (FOS=2.0000)
- INCR=12 (FOS=2.1000)
- INCR=13 (FOS=2.2000)
- INCR=14 (FOS=2.2500)
- INCR=15 (FOS=2.2625)
- INCR=16 (FOS=2.2750)
- INCR=17 (FOS=2.2875)

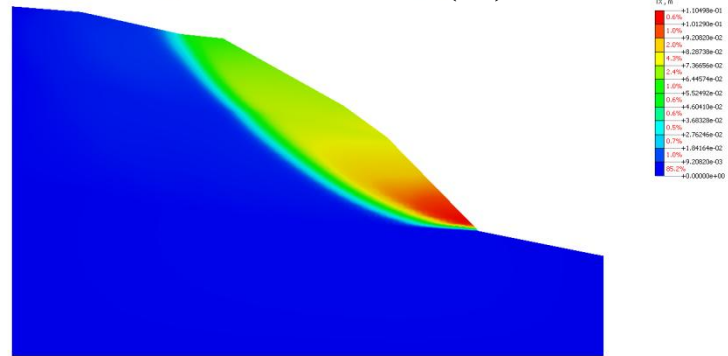
- INCR=18 (FOS=2.2883)
 - Displacements
 - Grid Forces
 - Plane Strain Forces
 - Plane Strain Stresses
 - Plane Strain Strains

Model Analysis Results

SRM for safety factor calculation

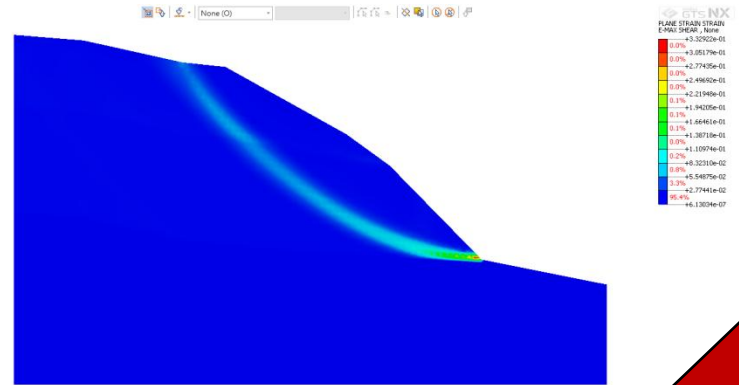
Failure surface indicated by horizontal displacement & maximum shear strain

Tx Translation(m)



[DATA] 常時運転穩定性分析, Slope Stability(SRM), INCR=18 (FOS=2.2883), [LIMIT] 変位, m

Maximum Shear Strain



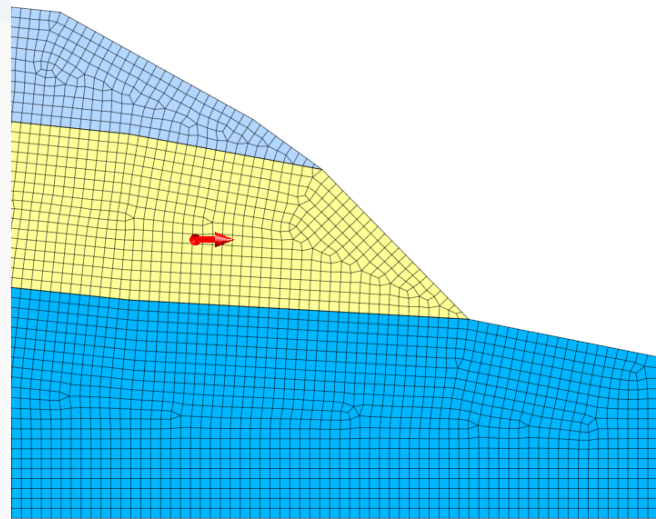
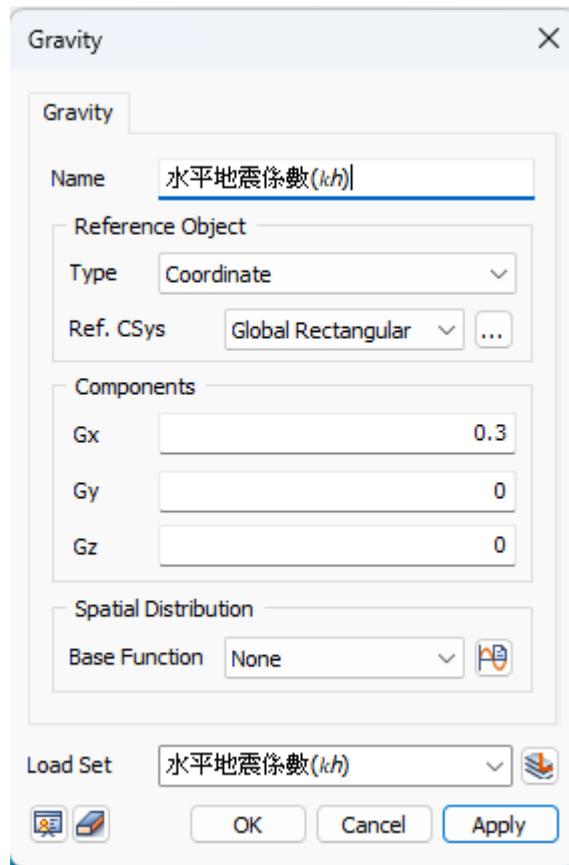
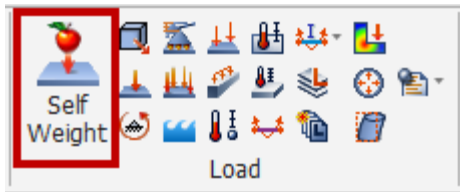
[DATA] 常時運転穩定性分析, Slope Stability(SRM), INCR=18 (FOS=2.2883), [LIMIT] 変位, m



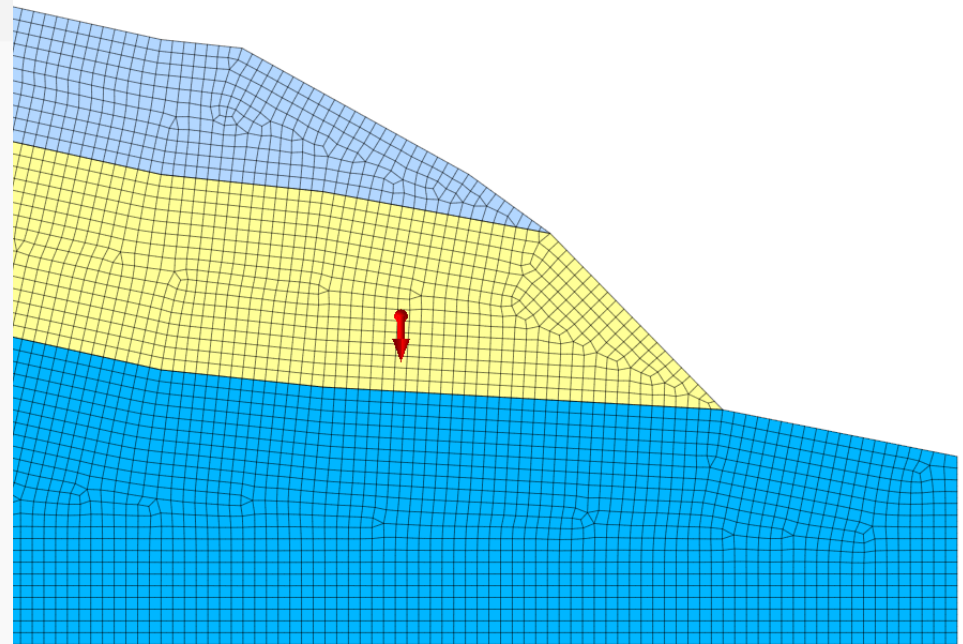
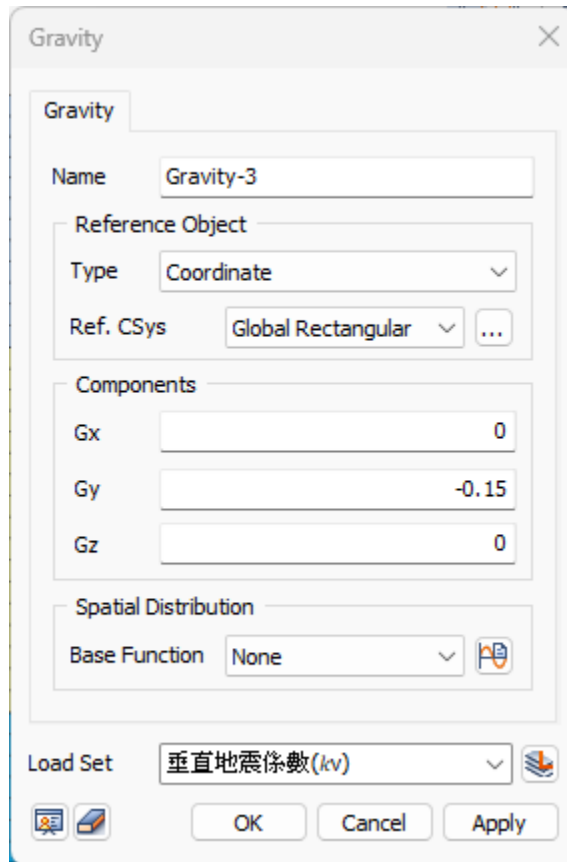
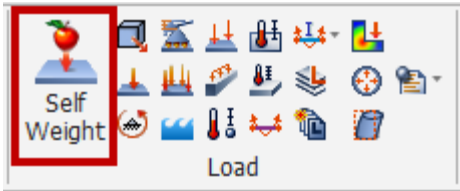
Part 2

PSEUDO-STATIC SEISMIC CASE

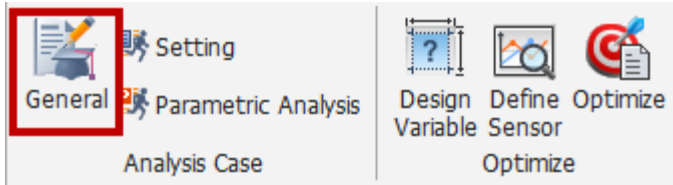
HORIZONTAL SEISMIC COEFFICIENT (K_H)



VERTICAL SEISMIC COEFFICIENT (K_v)



ANALYSIS 1 | PSEUDO-STATIC SEISMIC CASE



Add/Modify Analy **Seismic slope stability analysis:
Slope stability(SRM)**

Analysis Case Set
Title
Description
Solution Type: Slope Stability(SRM)
Construction Stage Set

Analysis Case Model

All Sets	Active Sets
<ul style="list-style-type: none">Mesh<ul style="list-style-type: none">Default Mesh SetSoft RockWeathered RockWeathered SoilBoundary Condition<ul style="list-style-type: none">Boundary Set-1Boundary Set-2Static Load<ul style="list-style-type: none">Default Self-Weight垂直地震係數 (k_v)水平地震係數 (k_h)Combined Load SetsContact Pair	<ul style="list-style-type: none">Mesh<ul style="list-style-type: none">Default Mesh SetSoft RockWeathered RockWeathered SoilBoundary Condition<ul style="list-style-type: none">Boundary Set-1Boundary Set-2Static Load<ul style="list-style-type: none">Default Self-Weight水平地震係數 (k_h)垂直地震係數 (k_v)Combined Load SetsContact Pair

Drag and drop: mesh set/boundary set/load set

Solve Each Load Set Independently Sorting: Name OK Cancel Apply

ANALYSIS 2 | PSEUDO-STATIC SEISMIC CASE

Convergence settings

General Slope Stability(SRM)

Geometry Nonlinearity

Consider Geometric Nonlinear Effects

Nonlinear parameters

Maximum Number of Trials 50

Maximum Number of Iterations 50

Stiffness Update Scheme Full Newton-Raphson

Intermediate Output Request **Every Iteration**

Convergence Criteria / Error

Displacement(U)

Load(P) 0.01

Work(W) 0.0001

Safety Factor

Initial Safety Factor **1**

Increment of Safety Factor 0.1

Resolution of Safety Factor **0.01**

Safety Factor Function

Advanced Nonlinear Parameters...

OK Cancel

Output setup

Output: Strain

(Shear strain indicates the failure arc)

Output Control

Output Type Output Option

Write Results of All Active Mesh Sets

Nodal Results

Displacement Mesh Set...

Applied Load Mesh Set...

Reaction Force Mesh Set...

Grid Point Force Mesh Set...

Contact Mesh Set...

Element Results

Force Mesh Set...

Stress Mesh Set...

Strain Mesh Set...

Status Mesh Set...

Damaged Index Mesh Set...

Ductility Mesh Set...

Output Option

Binary Binary and Text

Element Output Location

Element Corner Results

Shell Mid-Plane Results

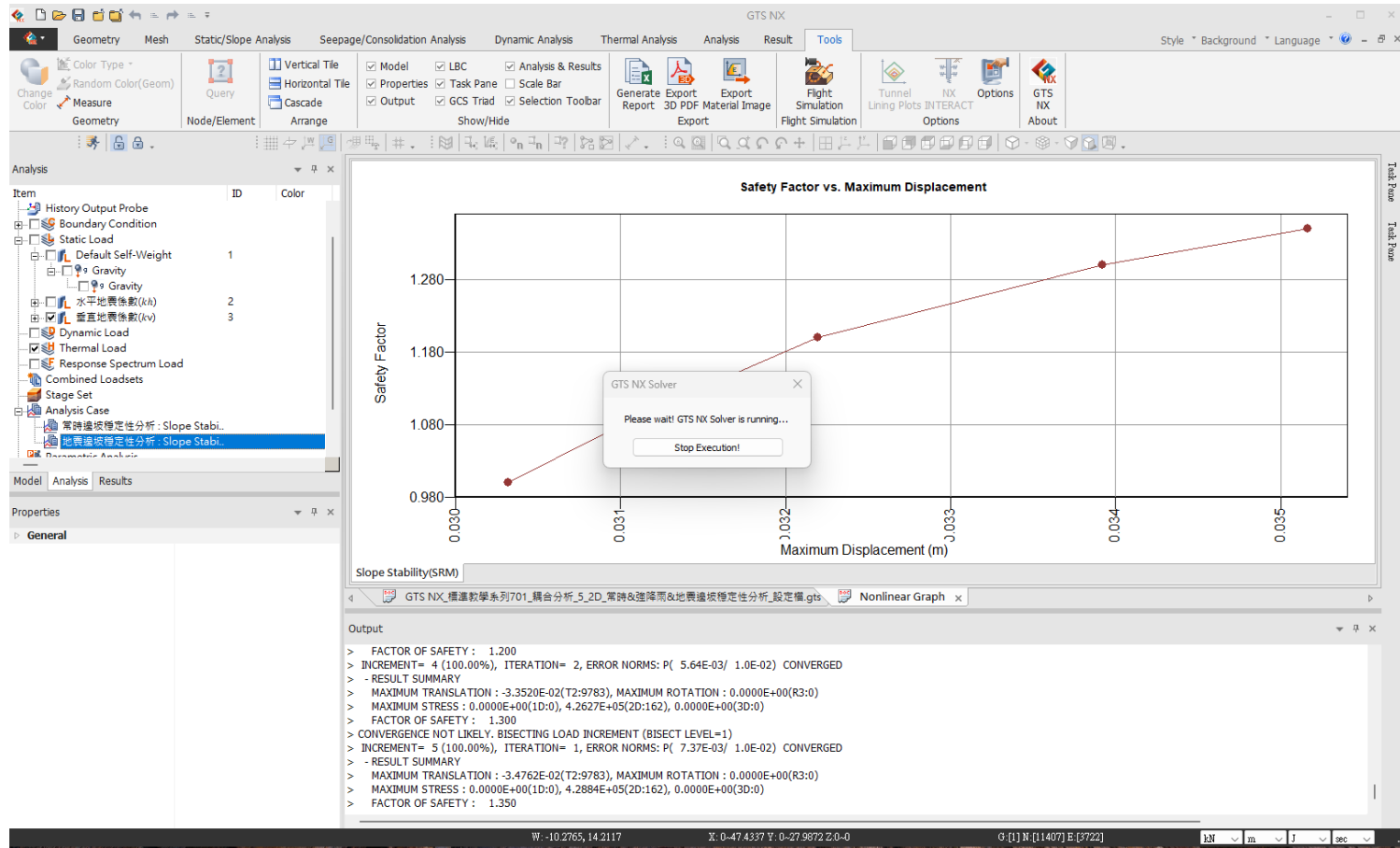
Composite Shell Mid-Plane Results

Number of Beam Output Segments 4

SRM convergence adjustment

- (1) Initial safety factor 1
- (2) FOS increment by 0.1 each time
- (3) Residual < 0.01 , minimum FOS reached

CALCULATION



RESULTS | PSEUDO-STATIC SEISMIC CASE

Pseudo-static seismic by k_h & k_v ,
FOS = 1.3922

地震遠坡穩定性分析

Slope Stability(SRM)

- INCR=1 (FOS=1.0000)
- INCR=2 (FOS=1.1000)
- INCR=3 (FOS=1.2000)
- INCR=4 (FOS=1.3000)
- INCR=5 (FOS=1.3500)
- INCR=6 (FOS=1.3750)
- INCR=7 (FOS=1.3875)
- INCR=8 (FOS=1.3906)
- INCR=9 (FOS=1.3922)

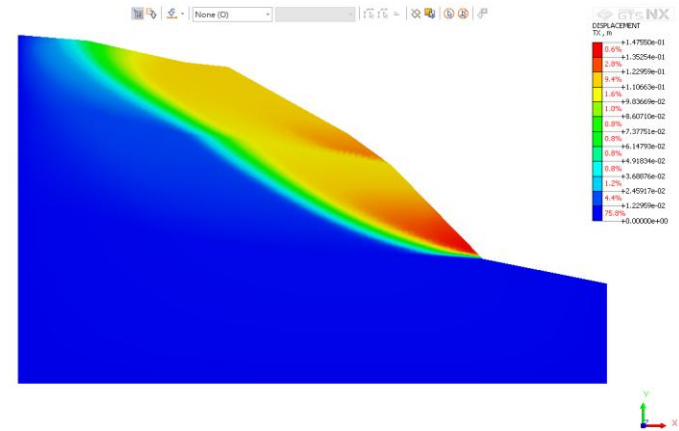
Safety Factor

1.39219 [Slope Stability(SRM..

SRM for safety factor calculation

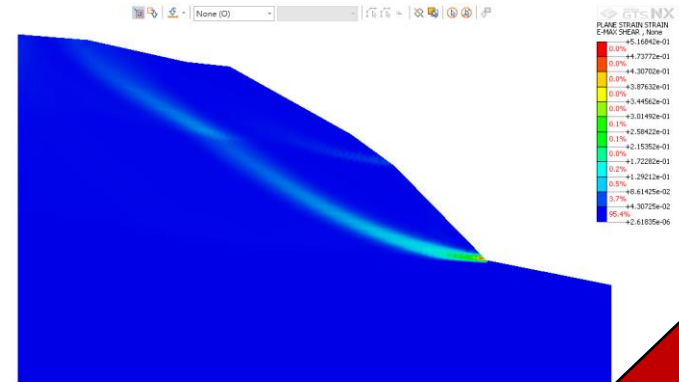
Failure surface indicated by horizontal displacement and maximum shear strain

Tx Translation(m)



[DATA] 地震遠坡穩定性分析, Slope Stability(SRM), INCR=9 (FOS=1.3922), [UNIT] MN, m

Maximum Shear Strain



[DATA] 地震遠坡穩定性分析, Slope Stability(SRM), INCR=9 (FOS=1.3922), [UNIT] MN, m



Part 3

HEAVY RAINFALL

CASE

POROUS MATERIAL 1 | WEATHERED SOIL

Weathered Soil

Material ID: 1 Name: weathered Soil Color: [Light Blue]

Model Type: Mohr-Coulomb Structure

General Porous Non-Linear Thermal Time Dependent

Unit Weight(Saturated): 19.5 kN/m³

Initial Void Ratio(eo): 0.5

Unsatrated Property **Loam**

Drainage Parameters: Drained

Undrained Poisson's Ratio: 0.495

Skempton's B Coefficient: 0.97383435

Seepage & Consolidation Parameters

Permeability Coefficients: kx: 0.001, ky: 0.001, kz: 0.001 m/sec

Void Ratio Dependency of Permeability(ck): 0.5

Specific Storativity(Ss): 0.001 1/m Auto

Add/Modify Unsatrated Function

Name	Type

Buttons: Add, Modify, Delete, Database, Close

Material database in GTS NX

Unsatrated Function Database

Database: Van Genuchten data(Carsel and Parrish, 1988)

No	Soil	Ks (m/sec)	Os(m ² /m ²)	Or(m ² /m ²)	a (1/m)	n	Select
1	Sand	8.25e-05	0.43	0.045	14.5	2.68	<input type="checkbox"/>
2	Loamy Sand	4.05324e-05	0.41	0.057	12.4	2.28	<input type="checkbox"/>
3	Sandy Loam	1.22801e-05	0.41	0.065	7.5	1.89	<input type="checkbox"/>
4	Loam	2.88889e-06	0.43	0.078	3.6	1.56	<input checked="" type="checkbox"/>
5	Silt	6.94444e-07	0.46	0.034	1.6	1.37	<input type="checkbox"/>
6	Silt Loam	1.25e-06	0.45	0.067	2	1.41	<input type="checkbox"/>
7	Sandy Clay Loam	3.63889e-06	0.39	0.1	5.9	1.48	<input type="checkbox"/>
8	Clay Loam	7.22222e-07	0.41	0.095	1.9	1.31	<input type="checkbox"/>
9	Silt Clay Loam	1.94444e-07	0.43	0.089	1	1.23	<input type="checkbox"/>
10	Sandy Clay	3.33333e-07	0.38	0.1	2.7	1.23	<input type="checkbox"/>
11	Silty Clay	5.55556e-08	0.36	0.07	0.5	1.09	<input type="checkbox"/>
12	Clay	5.55556e-07	0.38	0.068	0.8	1.09	<input type="checkbox"/>

Loam Data

Reference: Van Genuchten data (Carsel and Parrish, 1988)

	Coefficient of permeability(K) (m/sec)	Specific Storativity(Ss) (1/m)
Weathered Soil	10 ⁻⁵ - 10 ⁻³	10 ⁻⁶ - 10 ⁻³

Note 1: The relevant parameters use assumed conditions.

Note 2: Unsatrated parameters are not defined in the seepage calculation process; the soil is treated as saturated.

POROUS MATERIAL 2 | WEATHERED ROCK

Weathered Rock

Material ID: 2 Name: weathered Rock Color:

Model Type: Mohr-Coulomb Structure

General Porous Non-Linear Thermal Time Dependent

Unit Weight(Saturated): 22 kN/m³

Initial Void Ratio(eo): 0.5

Unsaturated Property Sandstone(Hygiene) ...

Drainage Parameters: Drained Undrained Poisson's Ratio: 0.495 Skempton's B Coefficient: 0.97826087

Seepage & Consolidation Parameters

Permeability Coefficients: kx: 0.0001 ky: 0.0001 kz: 0.0001 m/sec

Void Ratio Dependency of Permeability(ck): 0.5

Specific Storativity(Ss): 0.001 1/m Auto

Add/Modify Unsaturated Function

Name	Type
Silt	Individual
Sandstone(Hygi...	Individual

Buttons: Add, Modify, Delete, Database, Close

Material database in GTS NX

Unsaturated Function Database

Database: Van Genuchten data(1980)

No	Soil	Ks (m/sec)	Os(m ³ /m ³)	Or(m ³ /m ³)	a (1/m)	n	Select
1	Sandstone(Hygiene)	1.25e-05	0.25	0.153	0.79	10.4	<input checked="" type="checkbox"/>
2	Silt Loam(touchy)	3.50694e-05	0.469	0.19	0.5	7.09	<input type="checkbox"/>
3	Silt Loam	5.74074e-07	0.396	0.131	0.423	2.06	<input type="checkbox"/>
4	Loam(Guelph_drying)	3.65741e-06	0.52	0.218	1.15	2.03	<input type="checkbox"/>
5	Loam(Guelph_wetting)	0	0.434	0.218	2	2.76	<input type="checkbox"/>
6	Clay(Best Nietofa)	9.49074e-09	0.446	0	0.152	1.17	<input type="checkbox"/>

**Van Genuchten data (1980)
Sandstone (Hygiene)**

Reference - A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils M. TH. VAN GENUCHTEN, 1980

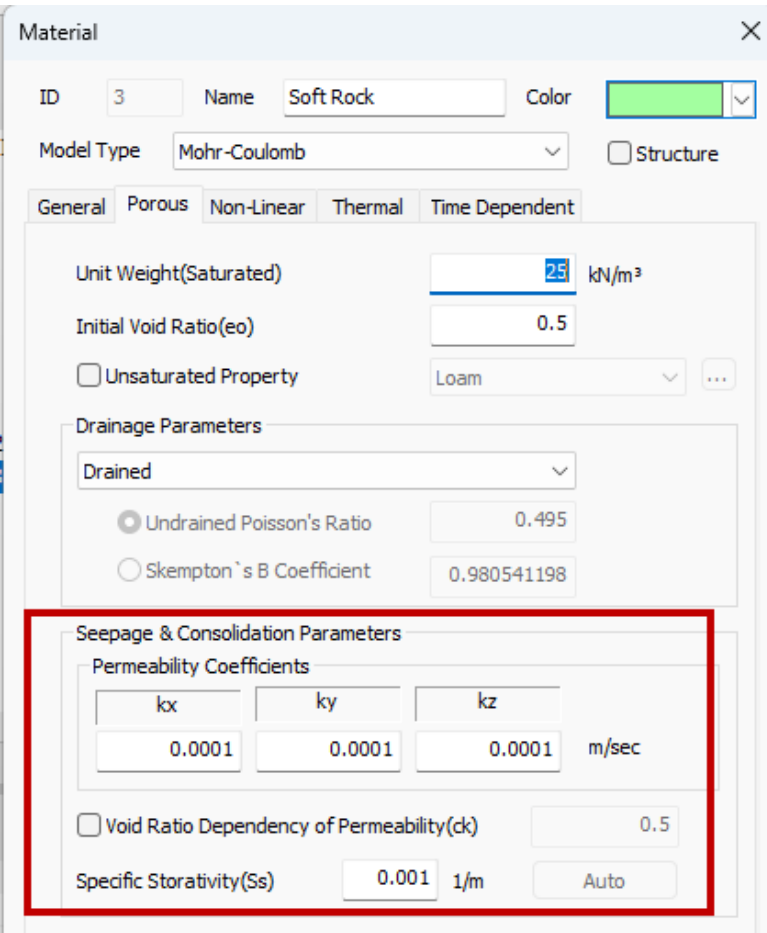
	Coefficient of permeability(K) (m/sec)	Specific Storativity(Ss) (1/m)
Weathered Rock	10 ⁻⁶ ~10 ⁻⁴	10 ⁻⁶ ~10 ⁻³

Note 1: The relevant parameters use assumed conditions.

Note 2: Unsaturated parameters are not defined in the seepage calculation process; the soil is treated as saturated.

POROUS MATERIAL 2 | SOFT ROCK

Soft Rock



Material

ID: 3 Name: Soft Rock Color: [Green]

Model Type: Mohr-Coulomb Structure

General Porous Non-Linear Thermal Time Dependent

Unit Weight(Saturated): 25 kN/m³

Initial Void Ratio(eo): 0.5

Unsaturated Property Loam

Drainage Parameters

Drained

Undrained Poisson's Ratio: 0.495

Skempton's B Coefficient: 0.980541198

Seepage & Consolidation Parameters

Permeability Coefficients

kx	ky	kz	
0.0001	0.0001	0.0001	m/sec

Void Ratio Dependency of Permeability(ck): 0.5

Specific Storativity(Ss): 0.001 1/m Auto

Flow of rainfall case does not calculate as saturated

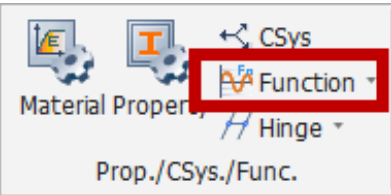
	Coefficient of permeability(K) (m/sec)	Specific Storativity(Ss) (1/m)
Soft Rock	$10^{-6} \sim 10^{-4}$	$10^{-6} \sim 10^{-3}$

Note 1: The relevant parameters use assumed conditions.

Note 2: Unsaturated parameters are not defined in the seepage calculation process; the soil is treated as saturated.

IN-SITU RECORDED RAINFALL | HOURLY RAINFALL

kN m J hr



Unit (kn/m/J/hr)

Seepage Boundary

- Seepage Boundary
- Nonlinear Elastic-Truss
- Nonlinear Elastic-Point Spring/Elastic Link
- Unsaturated Property
- Strain Compatible

Excel data



時間累計(hr)	每6小時降雨量 (m)
0	0
6	0.04
12	0.1
18	0.18
24	0.2
30	0.18
36	0.15
42	0.12
48	0.1
54	0.08
60	0.06
66	0.04
72	0.03

Copy & paste the data

Seepage Boundc

72 hours rainfall variation

Name: 72hr降雨量變化

Time (hr)	Value
0	0
6	0.04
12	0.1
18	0.18
24	0.2
30	0.18
36	0.15
42	0.12
48	0.1
54	0.08
60	0.06
66	0.04
72	0.03

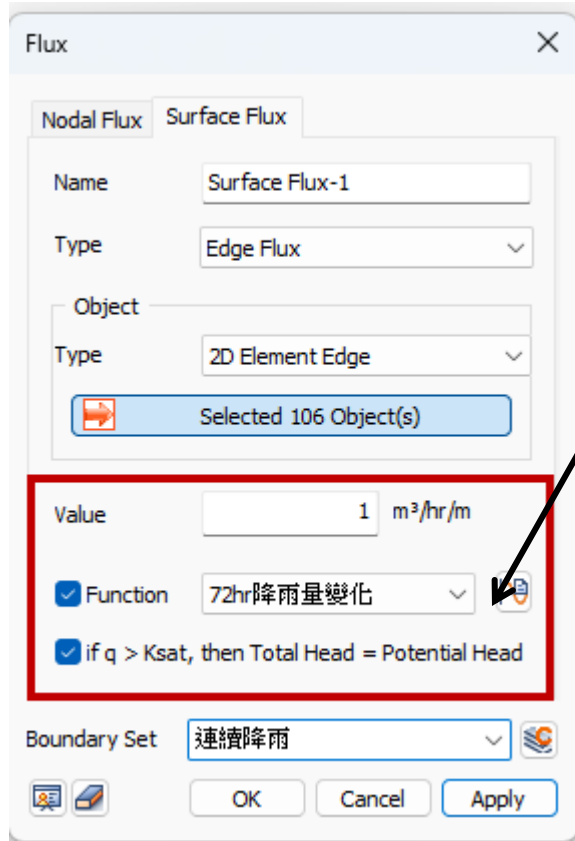
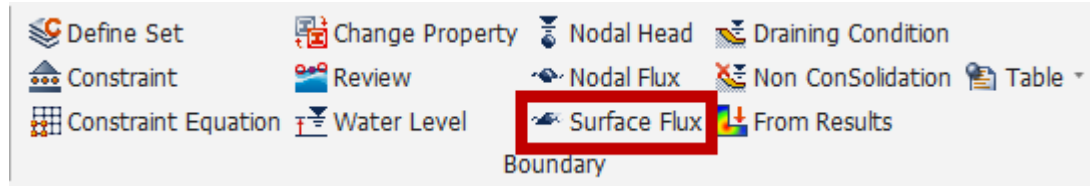
Description

OK Cancel Apply

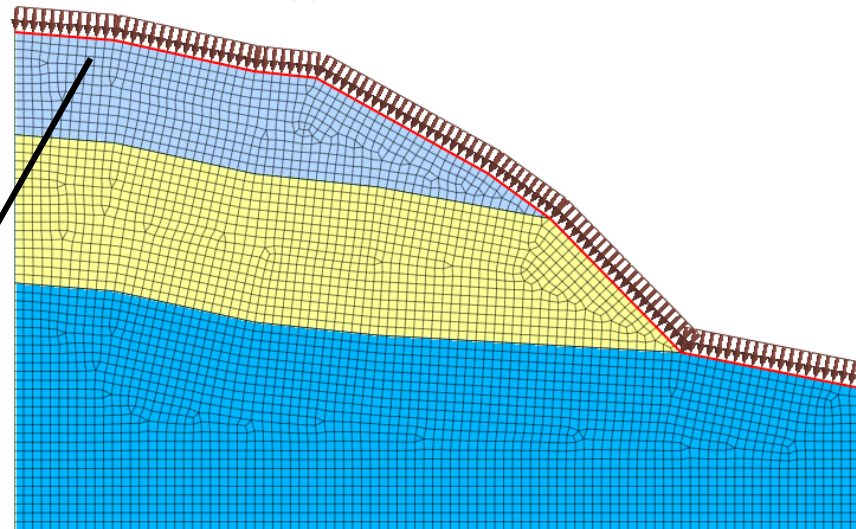
註:GTS NX不支援Y軸單位切換。

SURFACE FLUX

Seepage/Consolidation Analysis



Flux = Value × Function

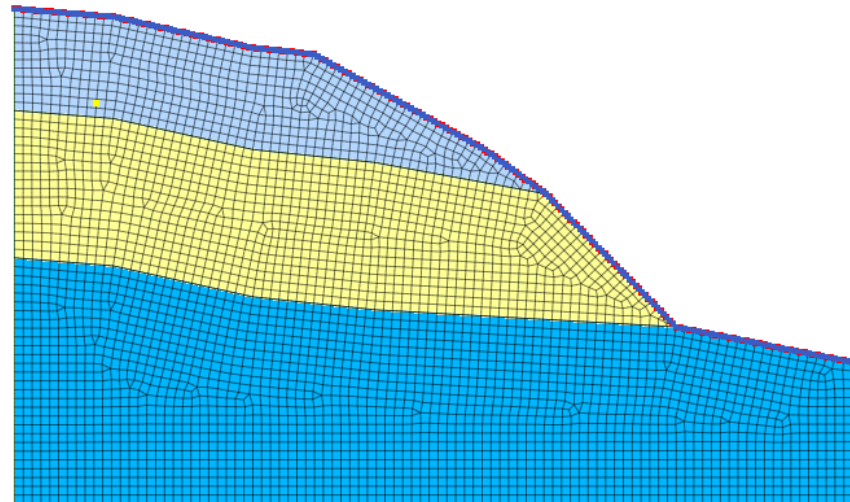
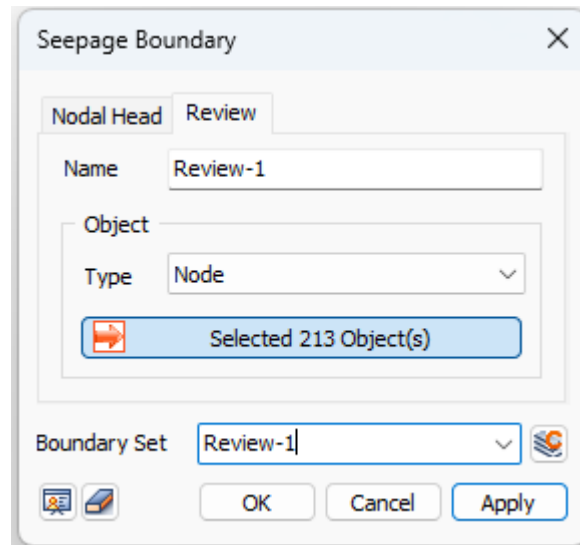


Setting:

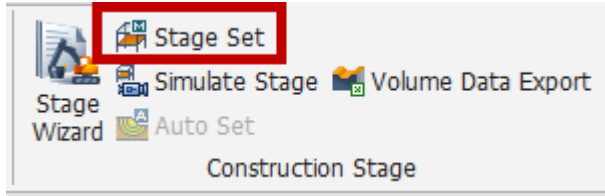
if surface flux > coefficient of permeability
total head = potential head

REVIEW / SEEPAGE

Seepage/Consolidation Analysis



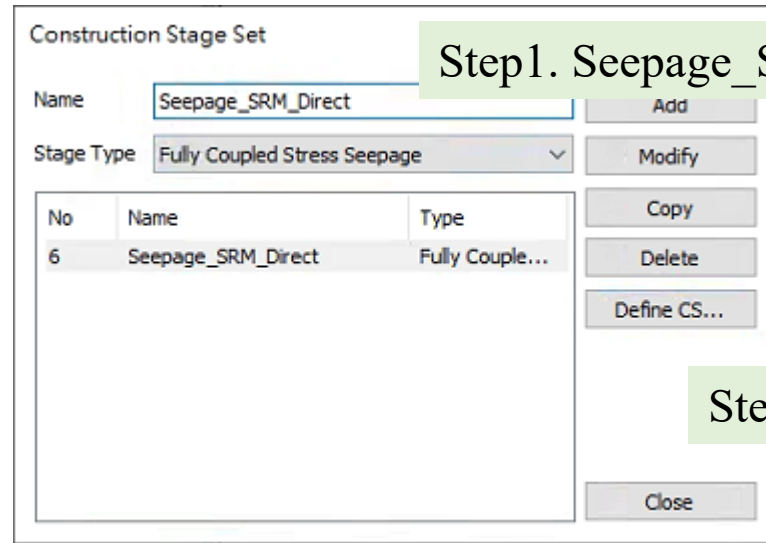
CONSTRUCTION STAGE 1 | PSEUDO-STATIC SEISMIC CASE



Construction phase types in GTS NX

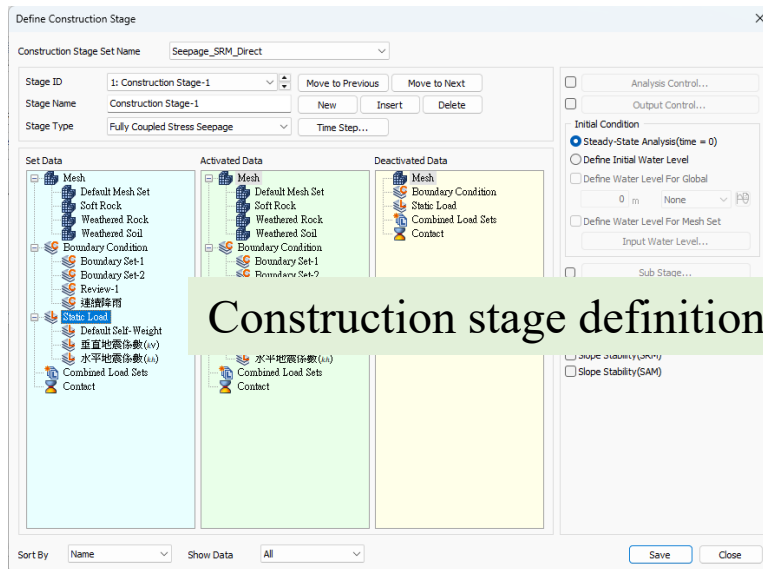
Fully Coupled Stress Seepage

- Fully Coupled Stress Seepage
- Stress-Nonlinear Time History
- Heat Transfer
- Seepage-Thermal Stress
- Heat of Hydration(Thermal Stress)
- Fully Coupled Stress Seepage Heat
- Stress-Seepage-Slope-Nonlinear Time History



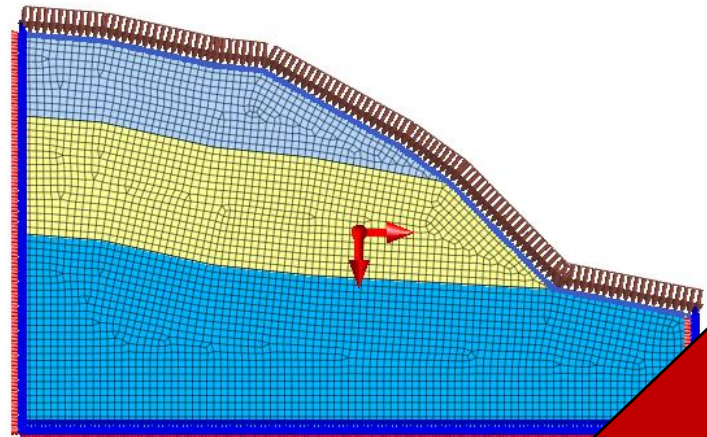
Step1. Seepage_SRM_Direct

Step2. Define CS



Construction stage definition

Activate all mesh sets/boundary sets



CONSTRUCTION STAGE 2 | FULLY COUPLED STRESS SEEPAGE

Analysis setting

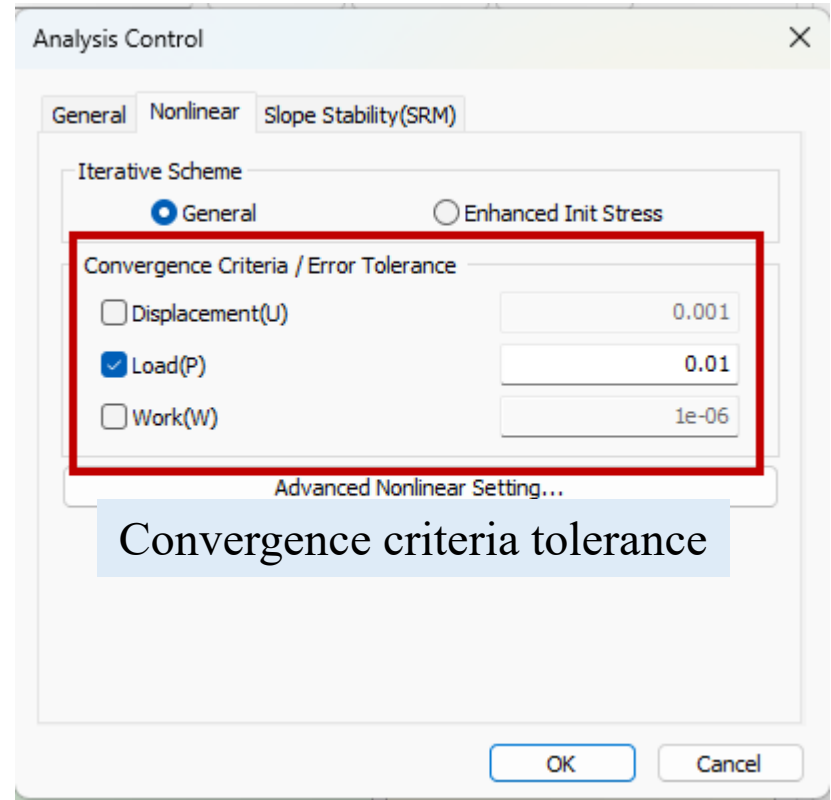
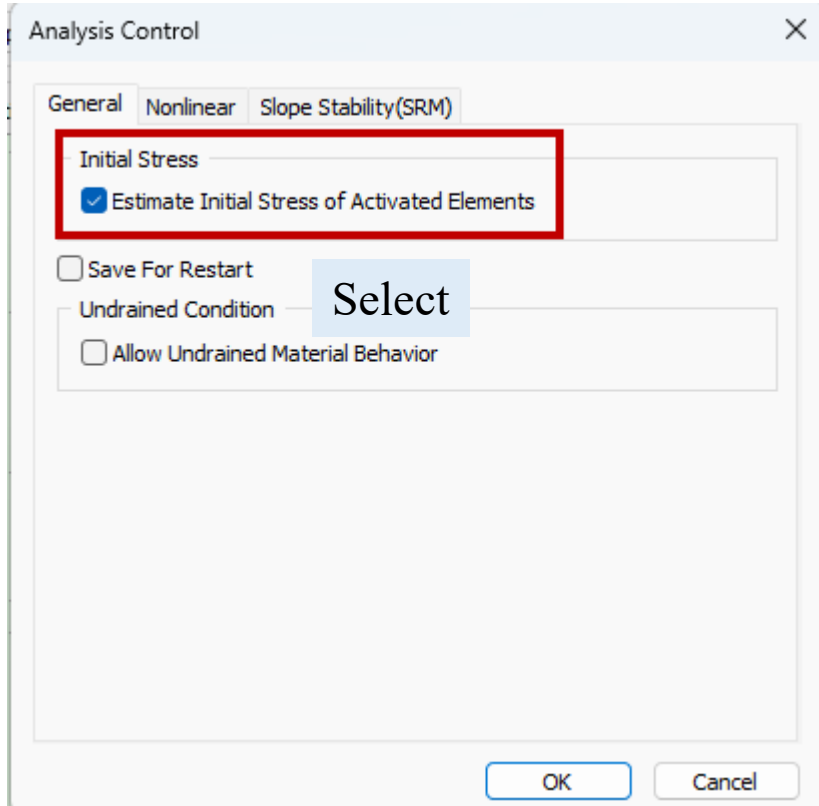
Time control assignment

Ignore initial water level
1

Select all set types
(Even kh/kv for simulation)

Select SRM

CONSTRUCTION STAGE 3 | ANALYSIS & CONTROL



CONSTRUCTION STAGE 4 | ANALYSIS CONTROL/ TIME CONTROL

Time Step

Analysis Control

General Nonlinear Slope Stability(SRM)

Nonlinear parameters

Maximum Number of Trials 50

Maximum Number of Iterations 50

Stiffness Update Scheme Full Newton-Raphson

Intermediate Output Request Every Iteration

Convergence Criteria / Error Tolerance

Displacement(U) 0.01

Load(P) 0.01

Work(W) 0.0001

Safety Factor

Initial Safety Factor 1

Increment of Safety Factor 0.1

Resolution of Safety Factor 0.01

Safety Factor Function

Advanced Nonlinear Parameters...

OK Cancel

SRM convergence adjustment

- (1) Initial safety factor 1
- (2) FOS increment by 0.1 each time
- (3) Residual < 0.01, minimum FOS reached

Time Step

Duration 72 hr

User Defined Step

User

Time 0 hr
(Example: 1, 3, 7, 14)

Step

Step Number 24

Save Result Log Scale

Generate Step

	Step	Time (hr)	Save Step
▶	1	3.0000	<input checked="" type="checkbox"/>
	2	6.0000	<input checked="" type="checkbox"/>
	3	9.0000	<input checked="" type="checkbox"/>
	4	12.0000	<input checked="" type="checkbox"/>
	5	15.0000	<input checked="" type="checkbox"/>
	6	18.0000	<input checked="" type="checkbox"/>
	7	21.0000	<input checked="" type="checkbox"/>
	8	24.0000	<input checked="" type="checkbox"/>

Auto Time Step

Initial Time Step

Max. Pore Pressure Changes per Step 0.101971621 tonf/m²

Ratio of Max Time Step to Initial 5

Save Step Last Increment

OK Close

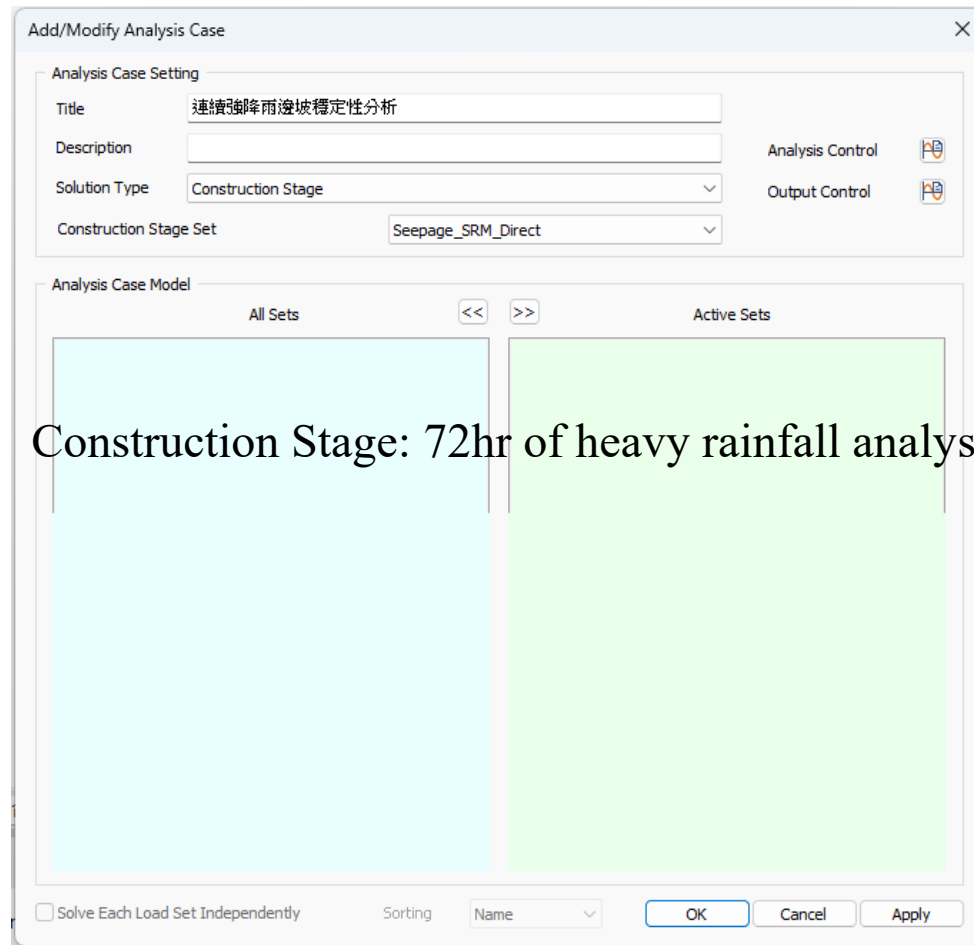
72 Hours With 24 Steps Of Calculation

ANALYSIS | HEAVY RAINFALL CASE



Construction Stage

- Linear Static
- Nonlinear Static
- Construction Stage**
- Eigenvalue
- Response Spectrum
- Linear Time History(Modal)
- Linear Time History(Direct)
- Nonlinear Time History
- Nonlinear Time History + SRM
- 2D Equivalent Linear
- Consolidation
- Fully Coupled Stress Seepage
- Seepage(Steady-state)
- Seepage(Transient)
- Slope Stability(SRM)
- Slope Stability(SAM)



Construction Stage: 72hr of heavy rainfall analysis

CALCULATION

The screenshot displays the GTS NX software interface for a slope stability analysis. The top toolbar features a 'Perform' button, which is highlighted with a red box. Below the toolbar, the 'Analysis' tab is active, showing a list of analysis cases in the left-hand pane. The 'GTS NX Solver' dialog box is open, showing a table of analysis stages. The 'Construction Stage' is selected and highlighted with a red box. The background shows a 3D model of a slope with a mesh and a coordinate system.

Name	Type	Description
常時邊坡穩定性分析	Slope Stability(SRM)	
地震邊坡穩定性分析	Slope Stability(SRM)	
連續降雨邊坡穩定性分析	Construction Stage	

Output

```
> GTS NX 2026 (v1.1) (64bit)
> Copyright (C) SINCE 1989 MIDAS Information Technology Co., Ltd. ALL RIGHTS RESERVED.
```

W: 10.3754, 40.7262 X: -2e-05-47.4337 Y: 0-27.9872 Z: -0.00499-0.00499 G: [1] N: [11407] E: [3722]

DIRECT METHOD ANALYSIS RESULTS

連續強降雨邊坡穩定性分析

Construction Stage-1

- INCR=1 (TIME=1.080e+04)
- INCR=2 (TIME=2.160e+04)
- INCR=3 (TIME=3.240e+04)
- INCR=4 (TIME=4.320e+04)
- INCR=5 (TIME=5.400e+04)
- INCR=6 (TIME=6.480e+04)
- INCR=7 (TIME=7.560e+04)
- INCR=8 (TIME=8.640e+04)
- INCR=10 (TIME=9.720e+04)

Seepage-stress coupling analysis

- INCR=15 (TIME=1.296e+05)
- INCR=16 (TIME=1.404e+05)
- INCR=17 (TIME=1.512e+05)
- INCR=18 (TIME=1.620e+05)
- INCR=19 (TIME=1.728e+05)
- INCR=22 (TIME=1.836e+05)
- INCR=23 (TIME=1.944e+05)
- INCR=24 (TIME=2.052e+05)

Each time step of calculation

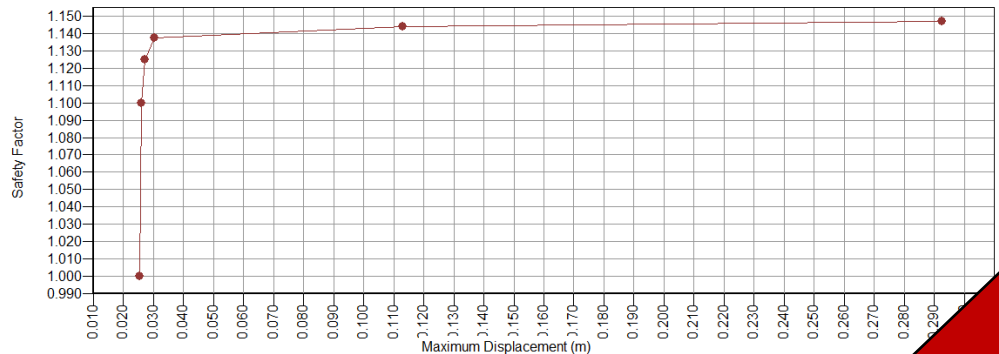
- INCR=11 (TIME=3.300e+01)
- Displacements
- Grid Forces
- Nodal Seepage Results
- Reactions
- Solid Stresses
- Solid Strains
- 3D Elem Seepage Results

SRM is calculated from the last step

- INCR=29 (TIME=2.376e+05)
- INCR=30 (TIME=2.484e+05)
- INCR=31 (TIME=2.592e+05)
- Construction Stage-1-SRM
- INCR=1 (FOS=1.0000)
- INCR=2 (FOS=1.1000)
- INCR=3 (FOS=1.1250)
- INCR=4 (FOS=1.1375)
- INCR=5 (FOS=1.1438)
- INCR=6 (FOS=1.1469)

SRM analysis results

Safety Factor vs. Maximum Displacement



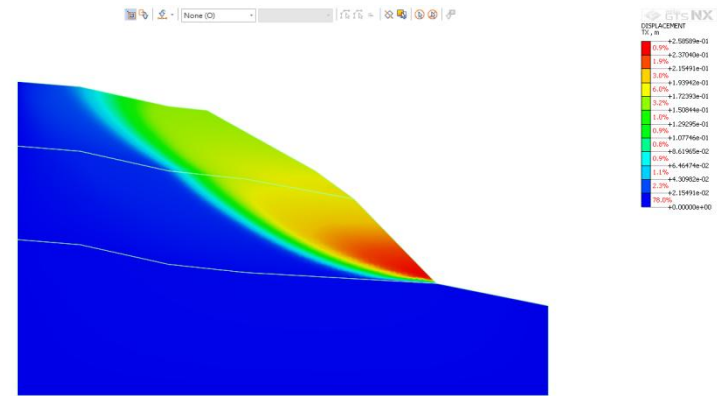
ANALYSIS RESULTS | HEAVY RAINFALL CASE

Failure surface indicated by horizontal displacement & maximum shear strain
Tx Translation(m)

Heavy rainfall simulation, FOS = 1.1469

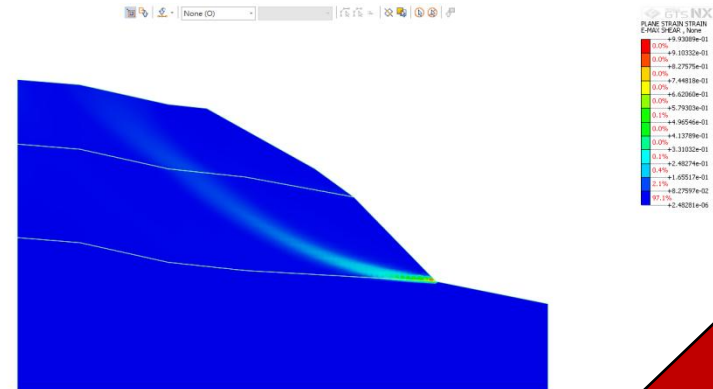
- Construction Stage-1-SRM
 - INCR=1 (FOS=1.0000)
 - INCR=2 (FOS=1.1000)
 - INCR=3 (FOS=1.1250)
 - INCR=4 (FOS=1.1375)
 - INCR=5 (FOS=1.1438)
 - INCR=6 (FOS=1.1469)
- Safety Factor
 - 1.14688 [Construction Stage-..

SRM for safety factor calculation



[DATA] 連續降雨前度穩定性分析, Construction Stage-1-SRM, INCR=6 (FOS=1.1469), [UNIT] M, m

Maximum Shear Strain



[DATA] 連續降雨前度穩定性分析, Construction Stage-1-SRM, INCR=6 (FOS=1.1469), [UNIT] M, m