MIDAS TAIWAN
GTS NX STANDARD TEACHING SERIES

2D EXCAVATION WITH SOIL RETAINING SYSTEM

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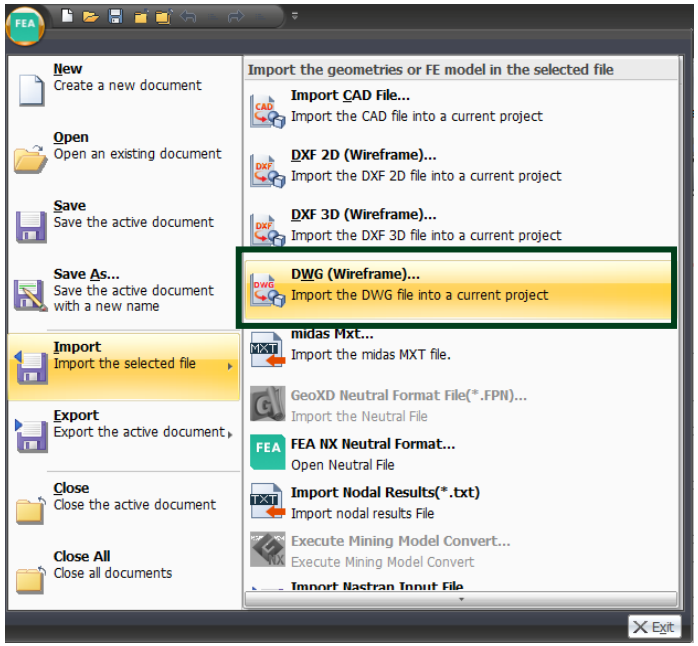
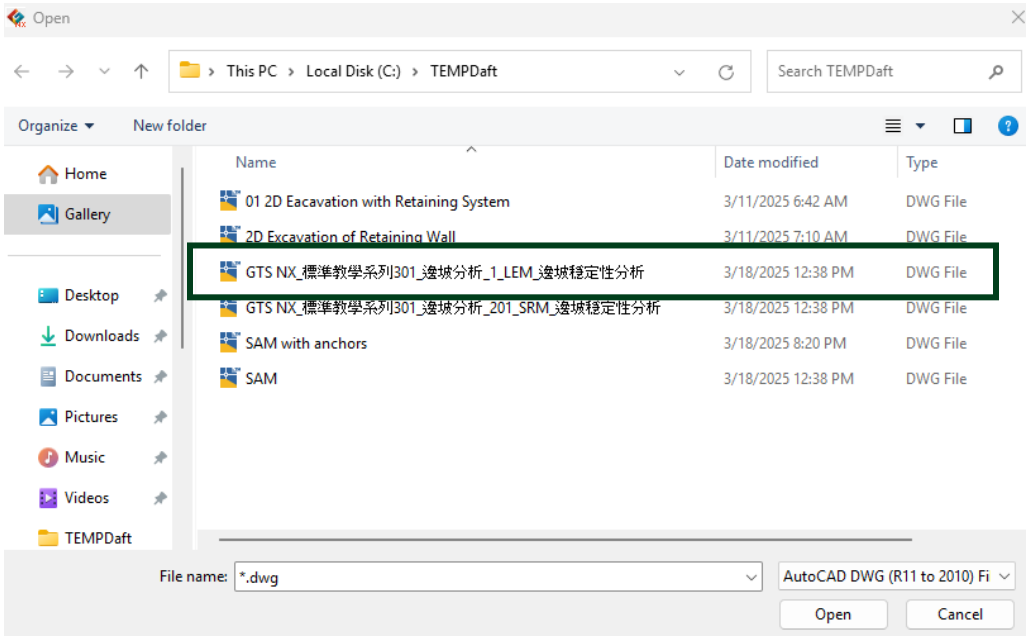
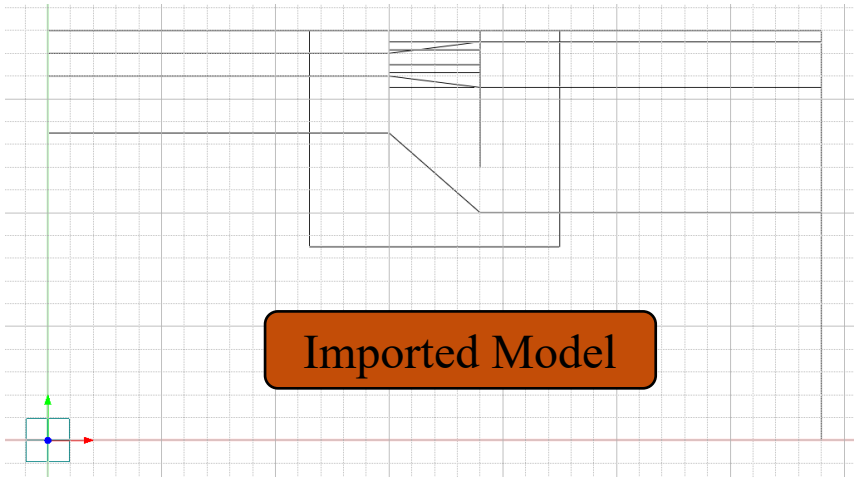
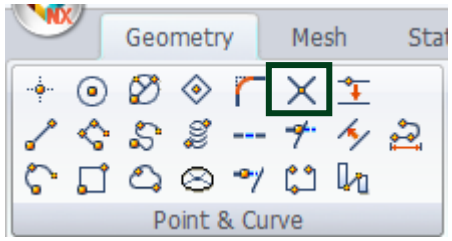
2D MODEL IMPORT

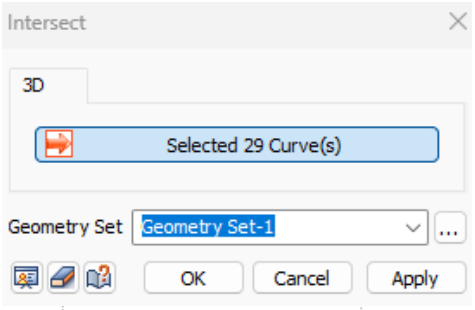


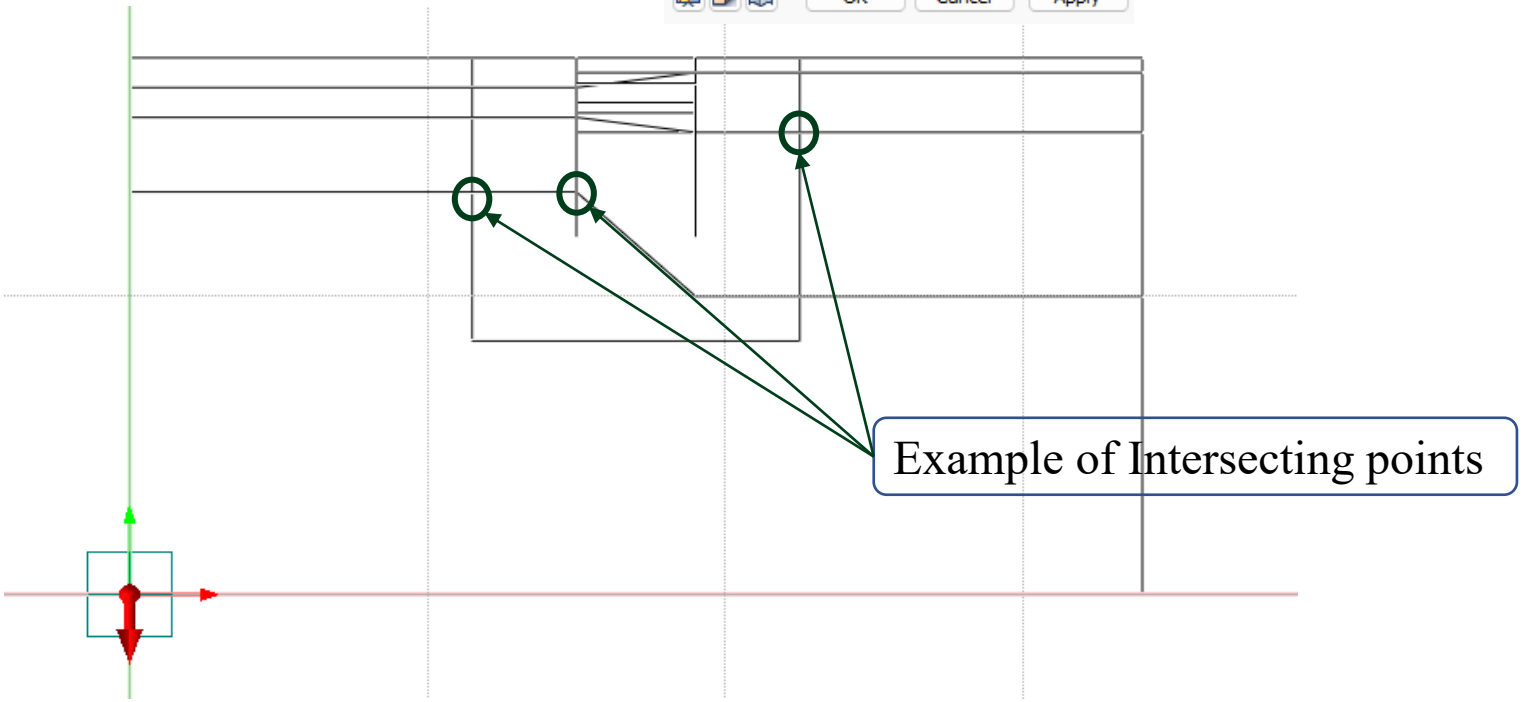




INTERSECT FUNCTION

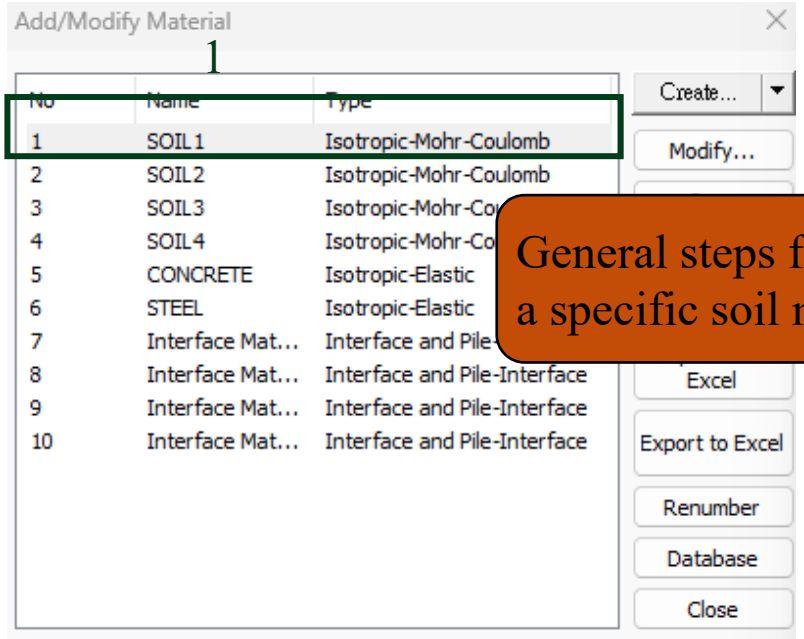




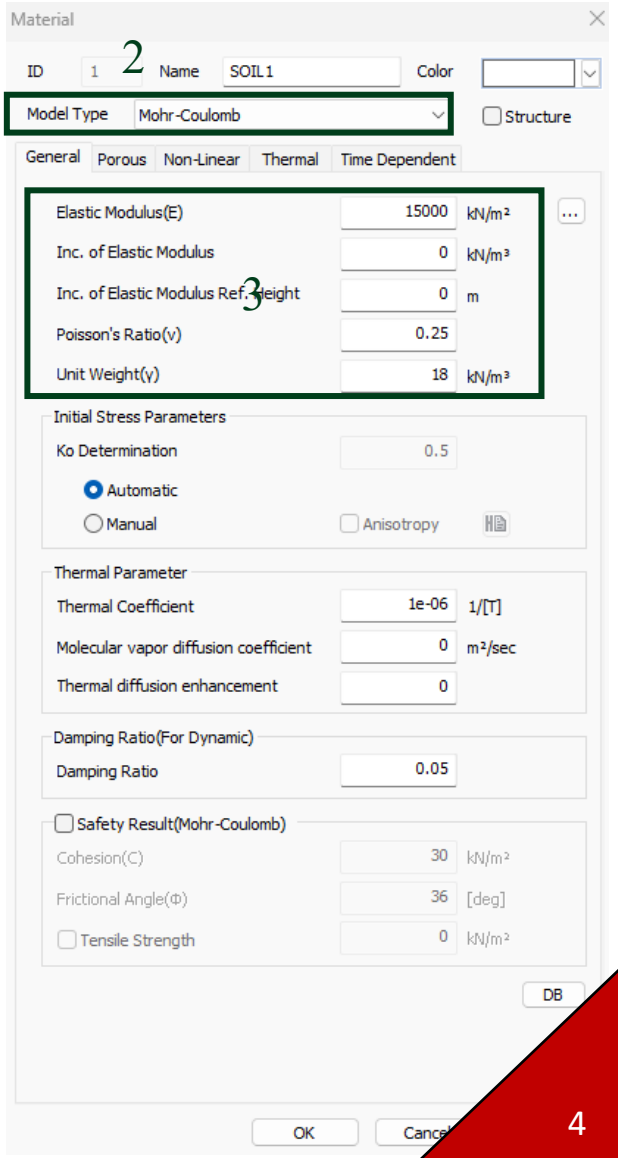


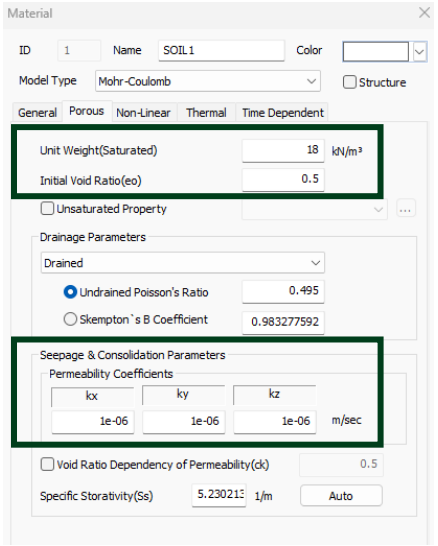
Automatically divides the model into intersecting points

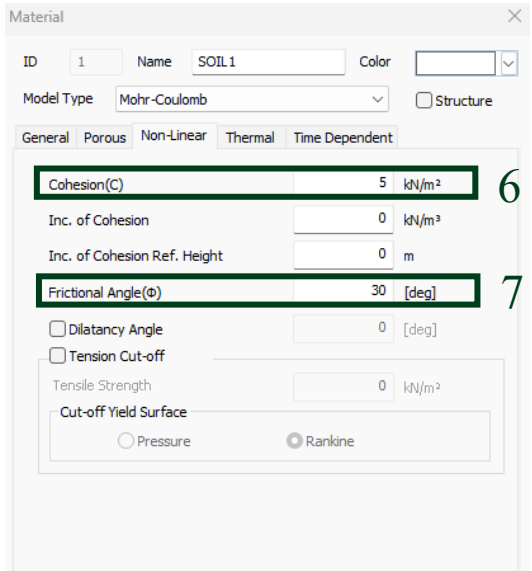
SOIL MATERIAL



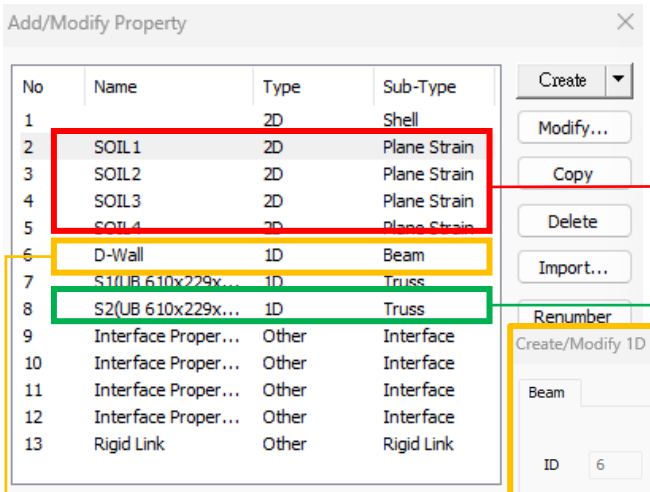
General steps for defining a specific soil material

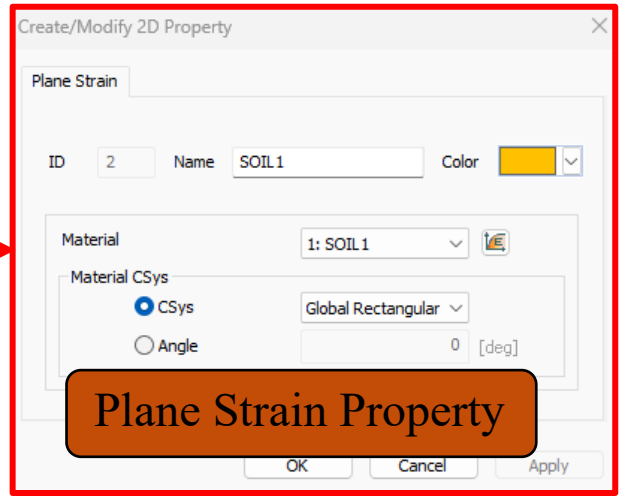


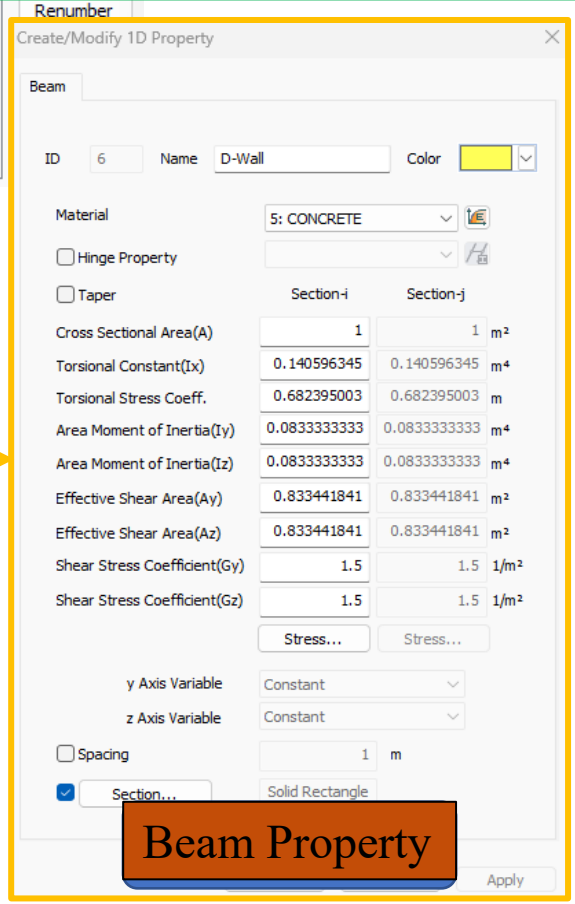


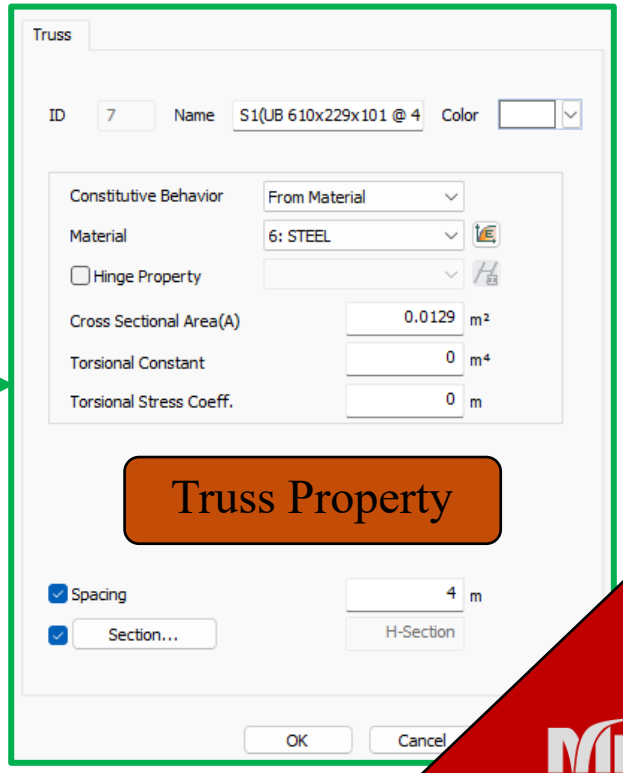


SOIL PROPERTY







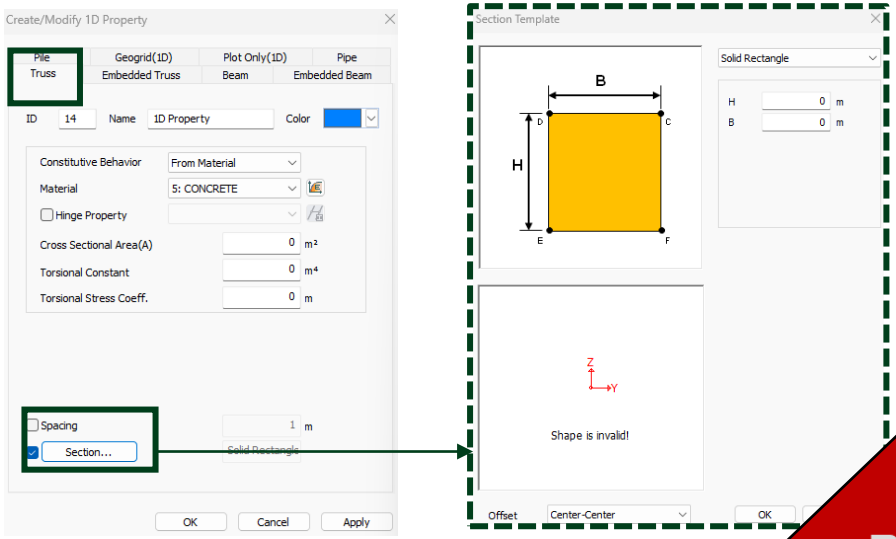


BEAM - TRUSS ELEMENT

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

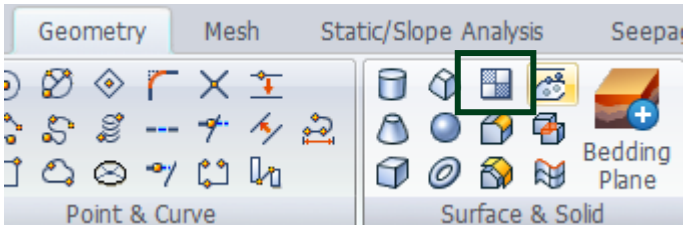
Ground Property

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

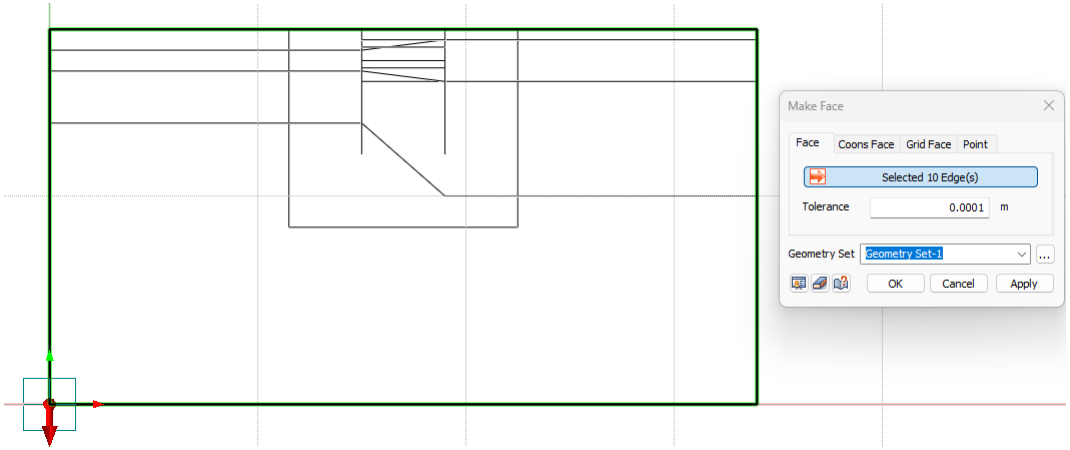
Structural Property

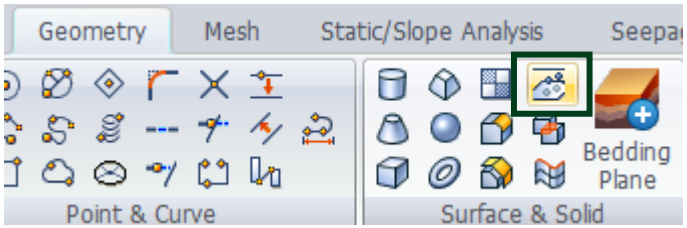
Name	D-Wall	S1	S2
Type	1D	1D	1D
Model Type	Beam	Truss	Truss
Material	CONCRETE	STEEL	STEEL
Section	Solid Rectangle	H-Section	H-Section
Section Size	1x1m @ 1m c/c	UB 610x229x101 @ 4m c/c	UB 610x229x101 @ 4m c/c

GEOMETRIC MODEL

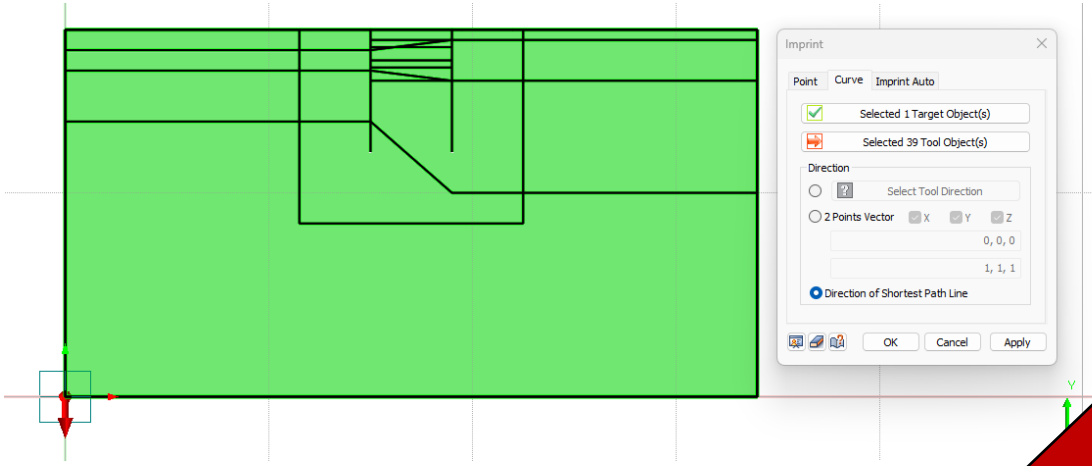


Face Function

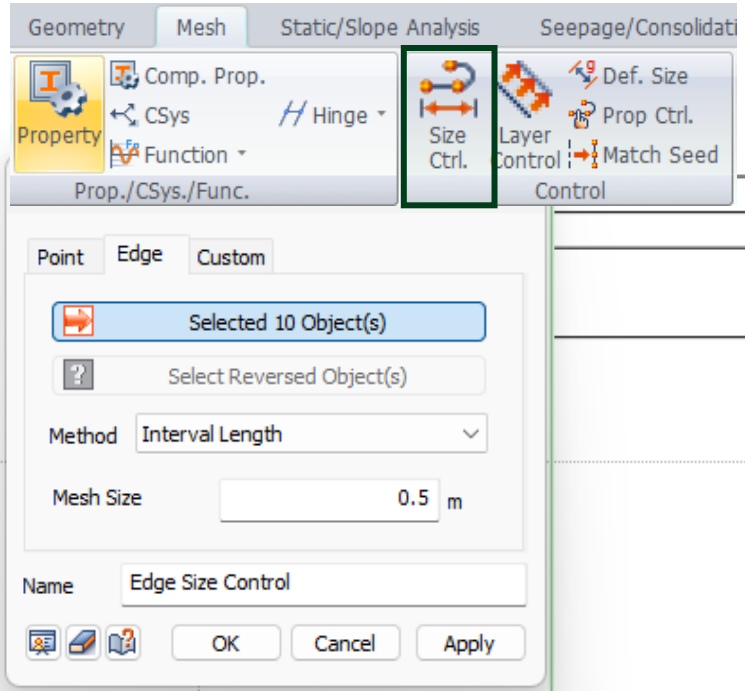




Imprint Function



MESH - SIZE CONTROL

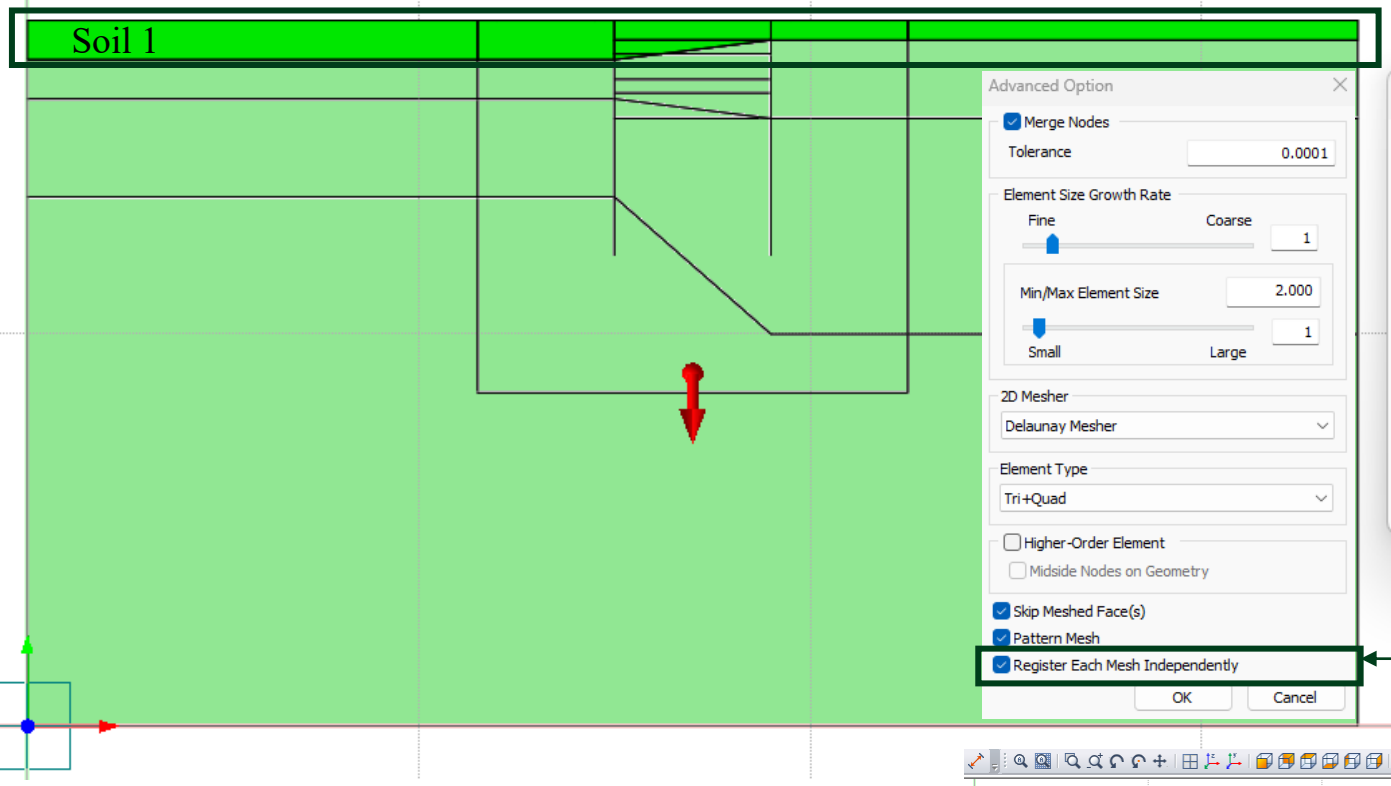


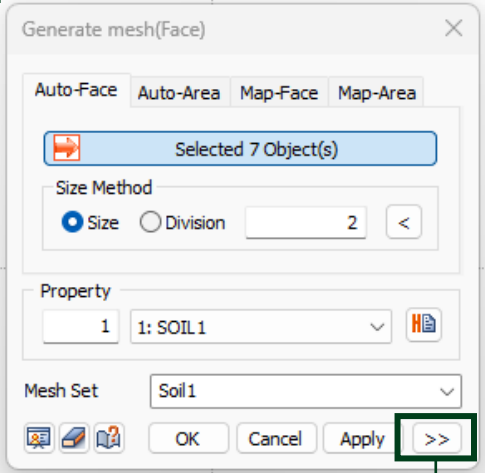
Mesh size control to increase the accuracy in plastic area

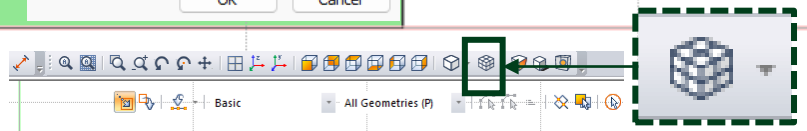
Mesh size of 0.5 m

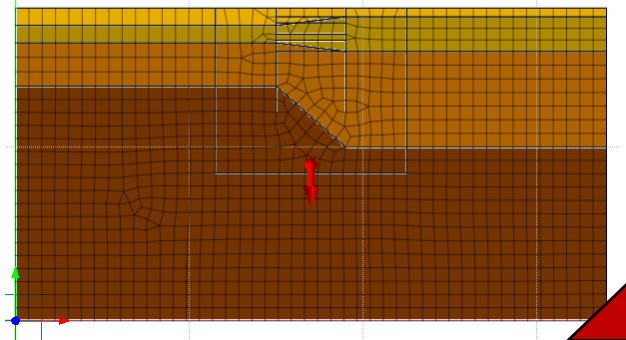
MESH - GENERATE MESH

Generate mesh for soil layer 1



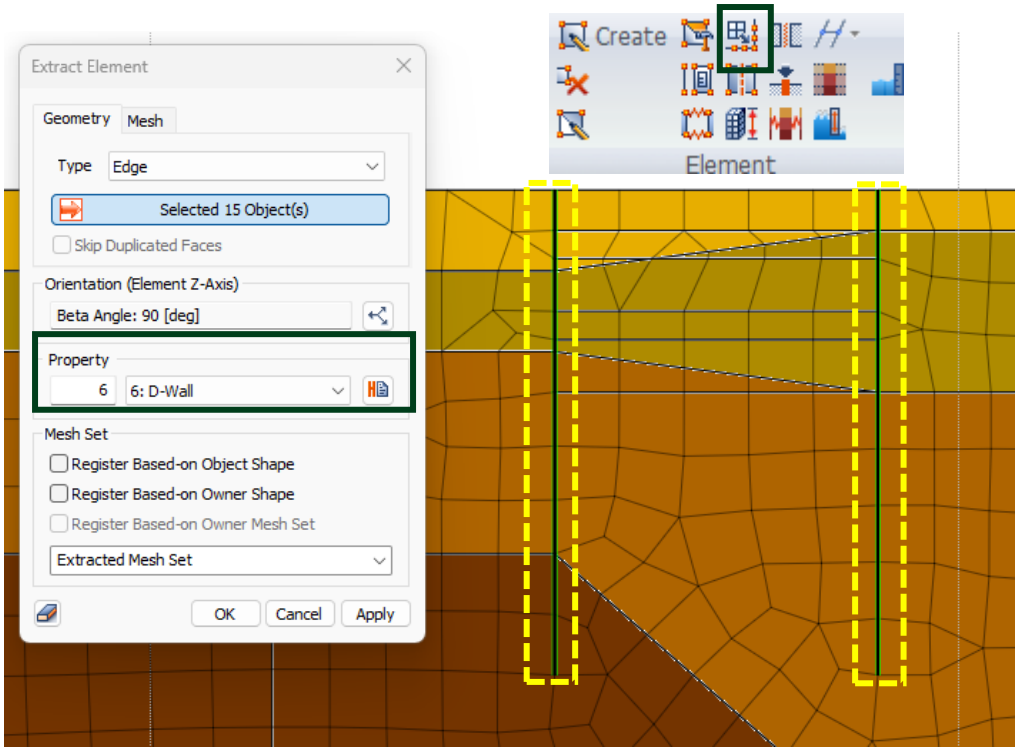




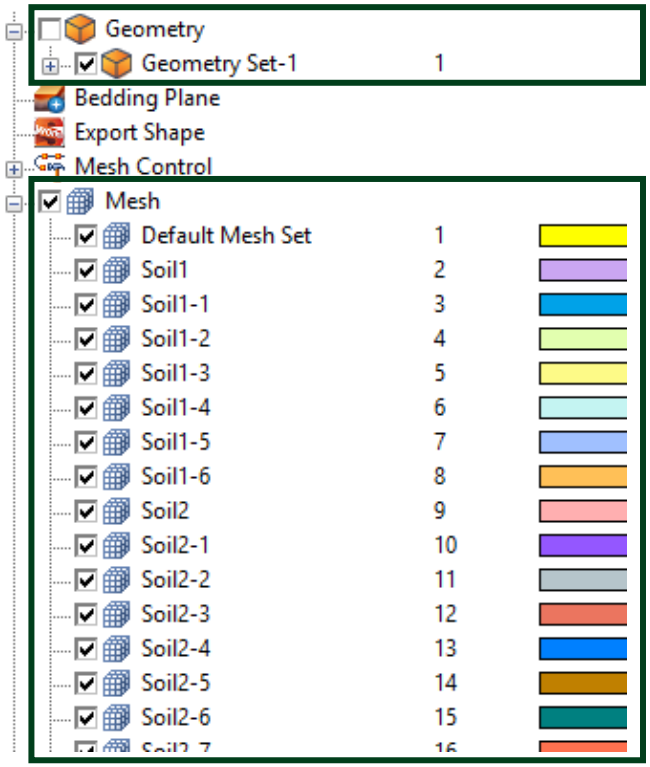


To show ‘Property color’
Display Mode (Mesh) → Property color

MESH - EXTRACT ELEMENT

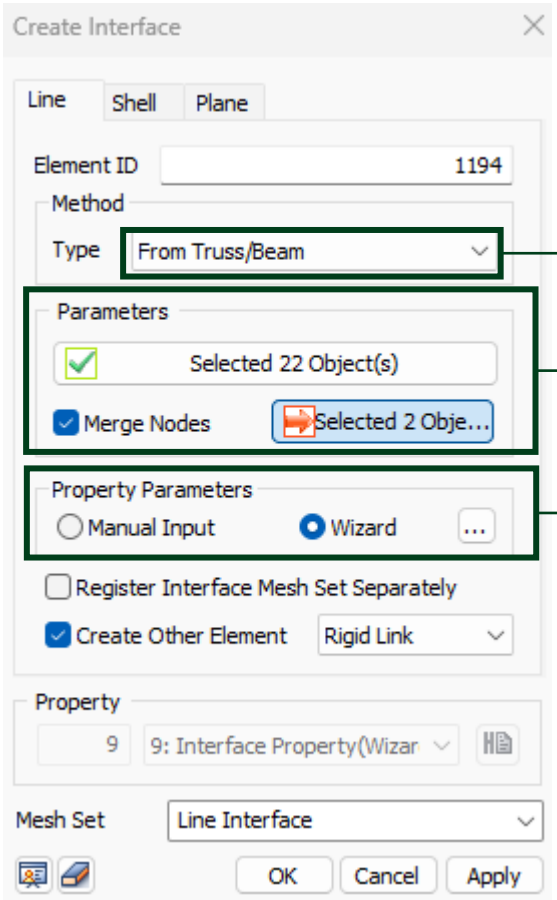


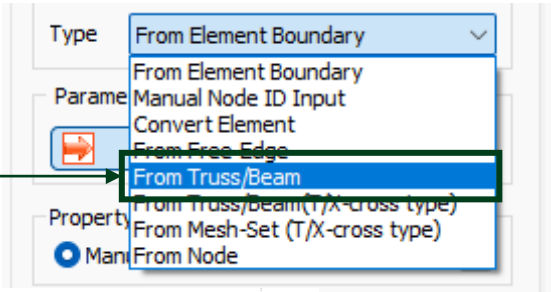
‘Extract elements’ for retaining wall

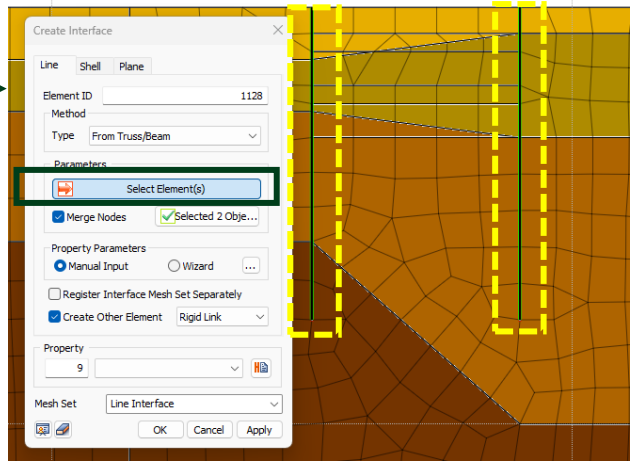


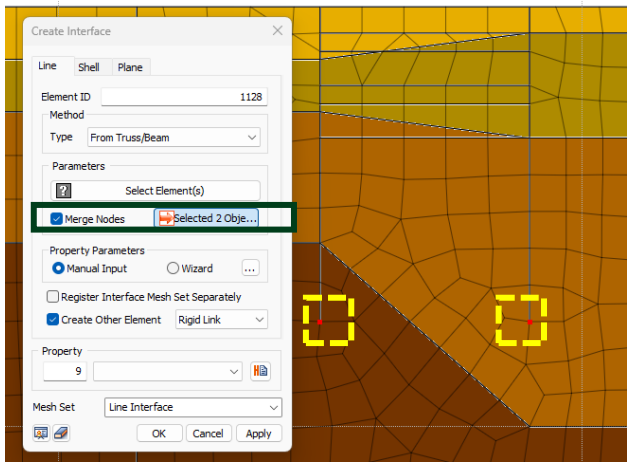
Note: By using the ‘Extract Elements’ function, it is needed to open geometry and corresponding mesh set

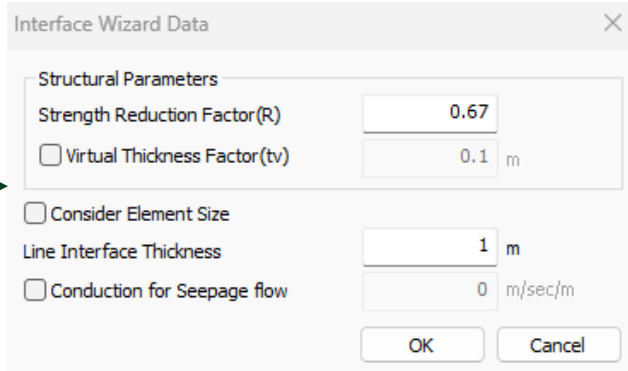
INTERFACE


Create Interface
Line
Shell
Plane
Element ID
1194
Method
Type
From Truss/Beam
Parameters
Selected 22 Object(s)
Merge Nodes
Selected 2 Obje...
Property Parameters
Manual Input
Wizard
Register Interface Mesh Set Separately
Create Other Element
Rigid Link
Property
9
9: Interface Property(Wizar
Mesh Set
Line Interface
OK
Cancel
Apply


Type
From Element Boundary
From Element Boundary
Manual Node ID Input
Convert Element
From Free Edge
From Truss/Beam
From Truss/Beam(T/X-cross type)
From Mesh-Set (T/X-cross type)
From Node

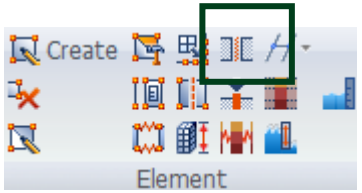

Create Interface
Line
Shell
Plane
Element ID
1128
Method
Type
From Truss/Beam
Parameters
Select Element(s)
Merge Nodes
Selected 2 Obje...
Property Parameters
Manual Input
Wizard
Register Interface Mesh Set Separately
Create Other Element
Rigid Link
Property
9
Mesh Set
Line Interface
OK
Cancel
Apply


Create Interface
Line
Shell
Plane
Element ID
1128
Method
Type
From Truss/Beam
Parameters
Select Element(s)
Merge Nodes
Selected 2 Obje...
Property Parameters
Manual Input
Wizard
Register Interface Mesh Set Separately
Create Other Element
Rigid Link
Property
9
Mesh Set
Line Interface
OK
Cancel
Apply


Interface Wizard Data
Structural Parameters
Strength Reduction Factor(R)
0.67
Virtual Thickness Factor(tv)
0.1
m
Consider Element Size
Line Interface Thickness
1
m
Conduction for Seepage flow
0
m/sec/m
OK
Cancel

INTERFACE WIZARD

Interface Wizard equation from Midas GTX NX manual



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

$K_t = G_i / t_v$

$C_i = R \times C_{soil}$

Here,

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

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

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

Where:

K_n: Normal Stiffness Modulus

K_t: Shear Stiffness Modulus

t_v: Virtual Thickness Factor

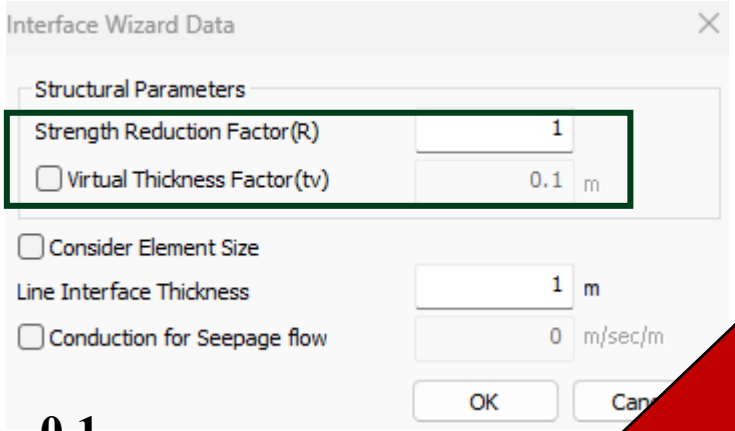
R: Strength Reduction Factor

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

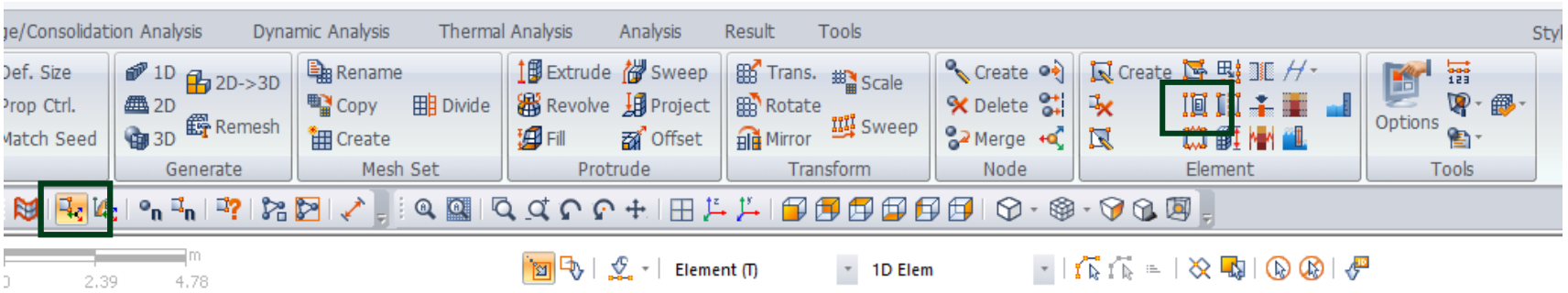
Shear stiffness modulus (Kt) is the elasticity modulus for **slip behavior** in the normal direction to the interface element

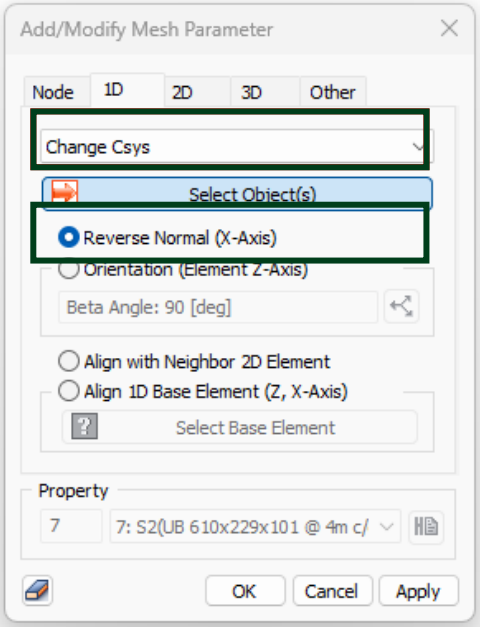
Strength Reduction Factor	R
Sandy Soil/Steel Material	0.6~0.7
Clay/ Steel Material	0.5
Sandy Soil/ Concrete	0.8~1.0
Clay / Concrete	0.7 ~ 1.0

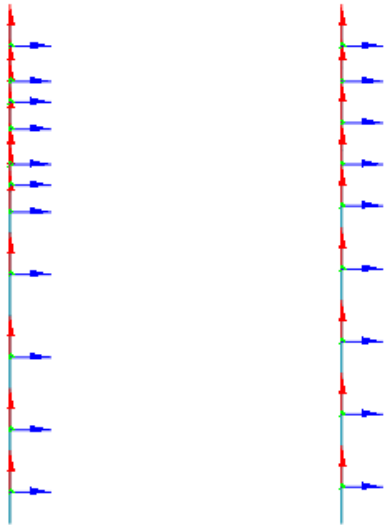


The general **Virtual Thickness Factor range is 0.01 ~ 0.1**
(If the stiffness is high, use a smaller value)

LOCAL AXIS READJUSTMENT

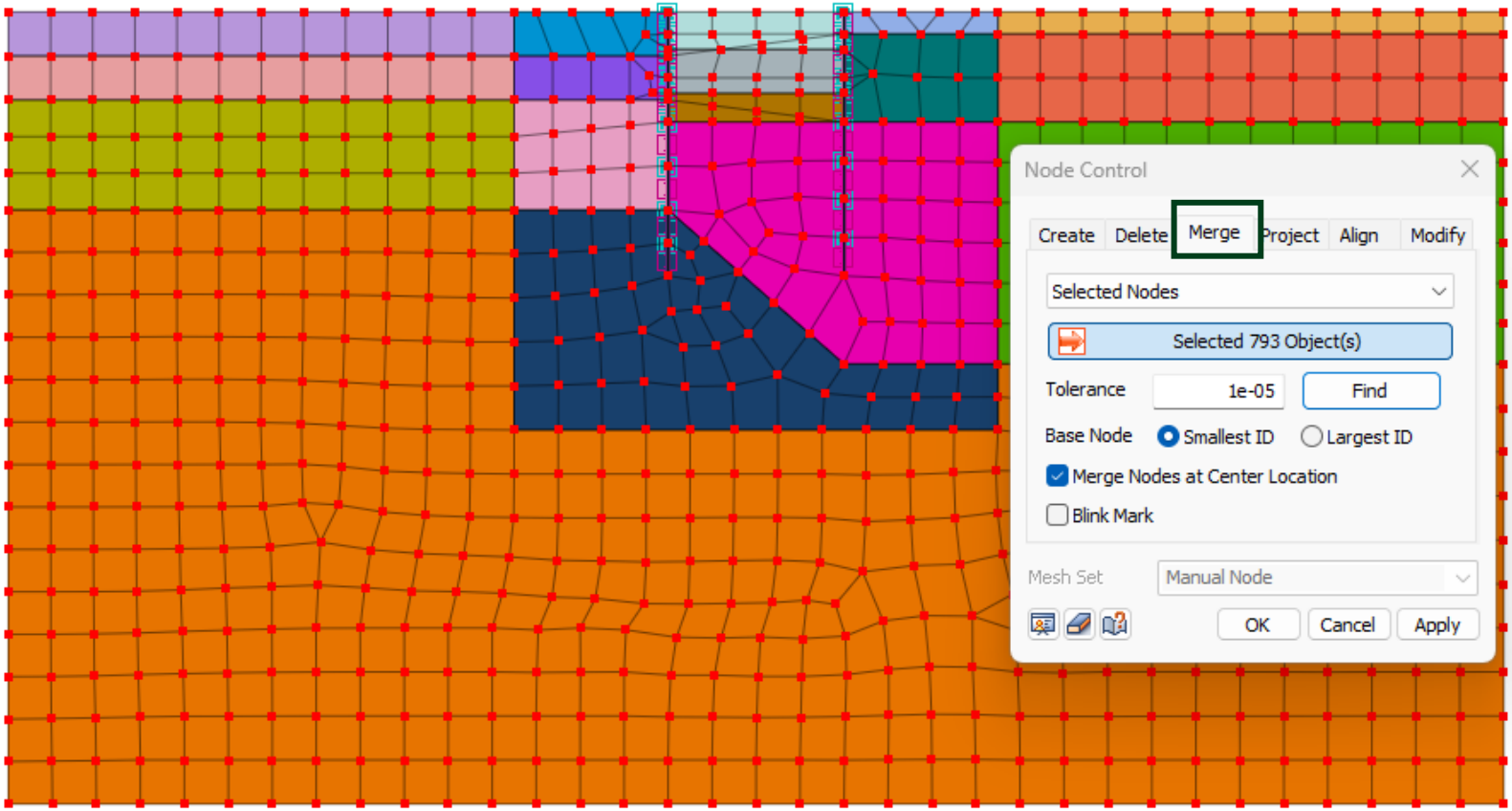






Changing the axis of the local retaining wall axis

MERGE NODE

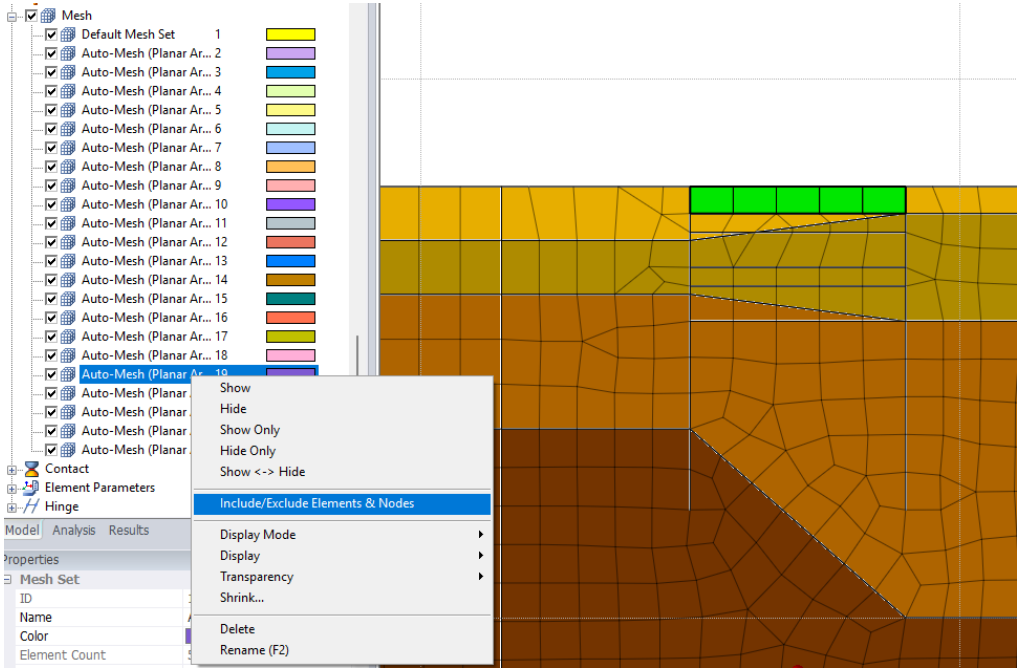


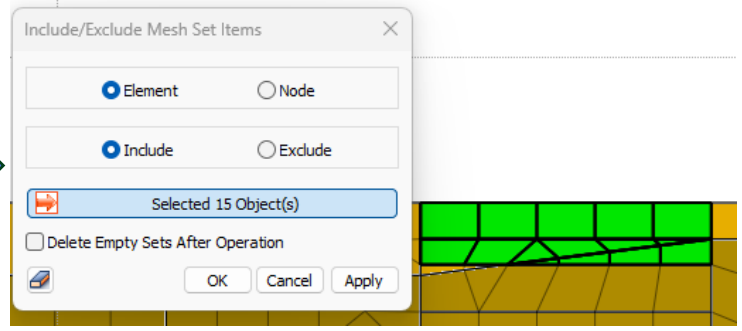
Checking the merge node function for interface

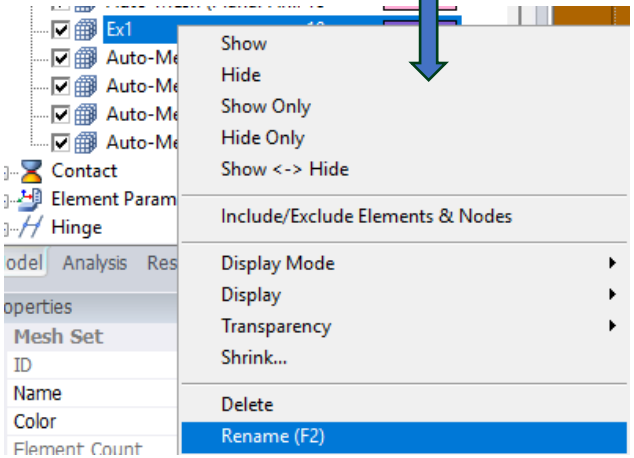
Selecting all nodes → Mesh → Node → Merge → Find

MESH GROUPING

Model Tree

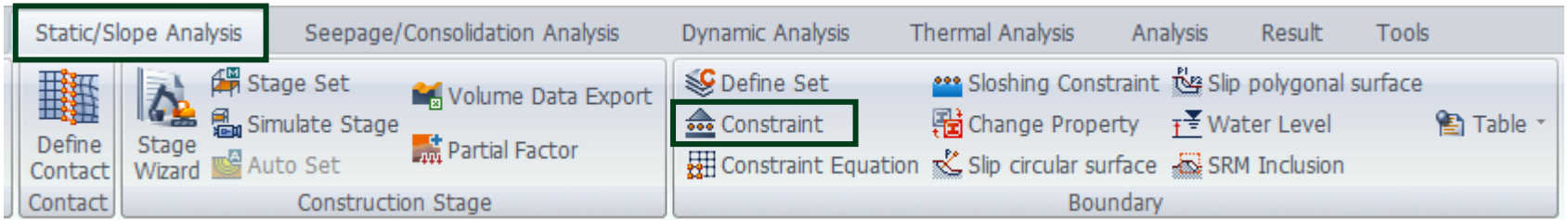


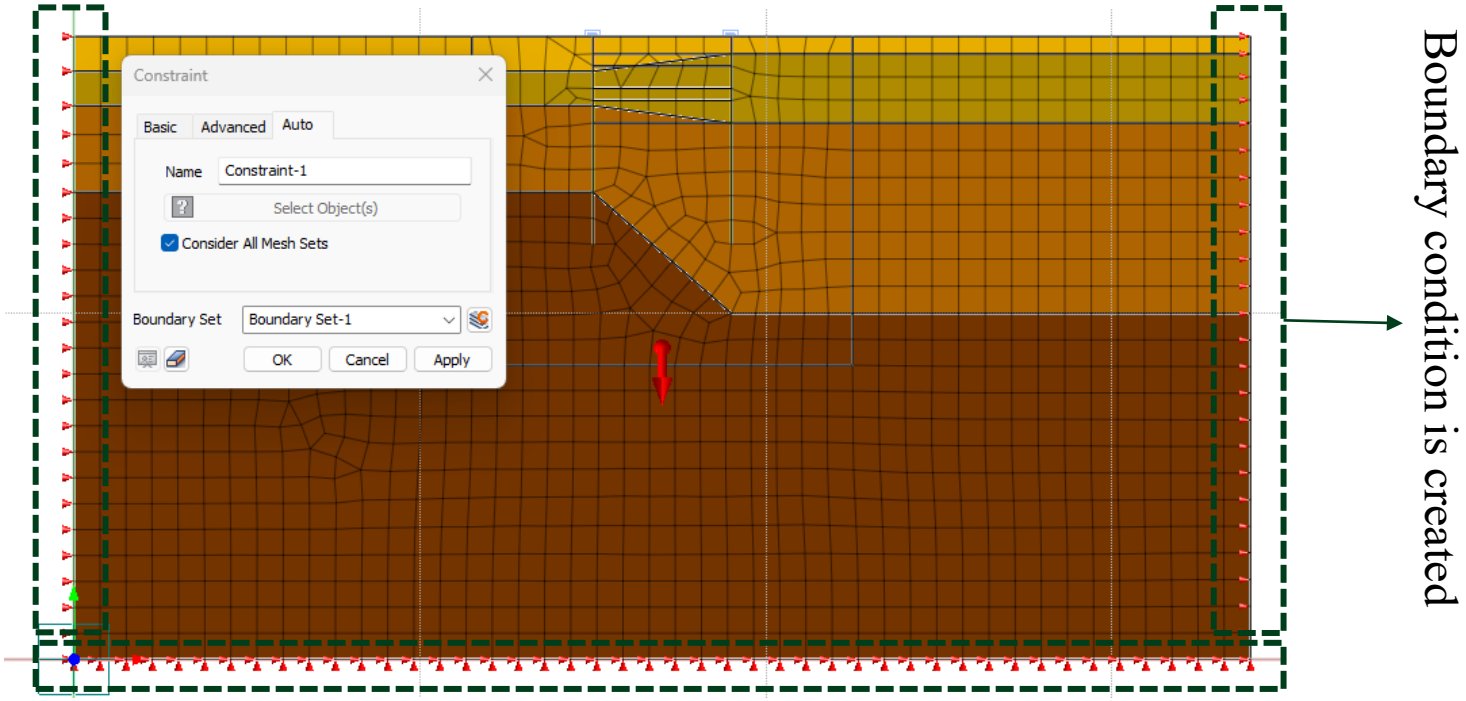




NOTE: Step is generally done for organizing meshes

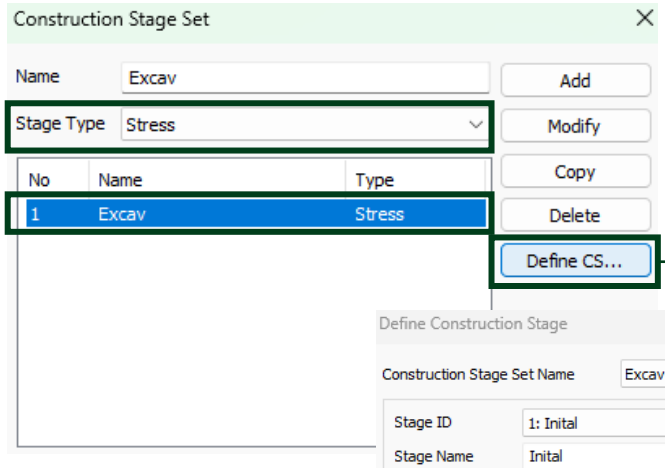
BOUNDARY CONDITION



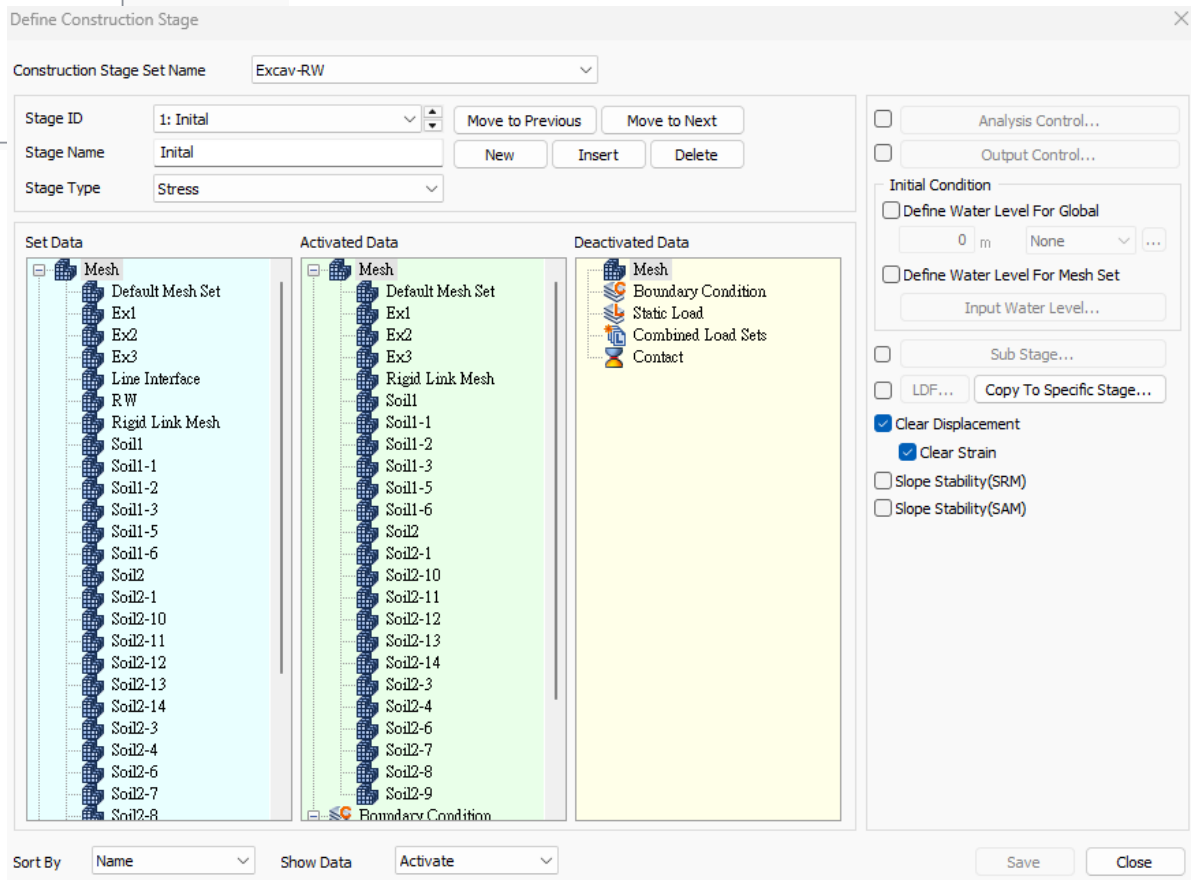


NOTE: Automatic constraint creates a fix restrictions (restrained x and y axes) on the bottom part of soil model, and pin restriction on the sides (restrained y axis).

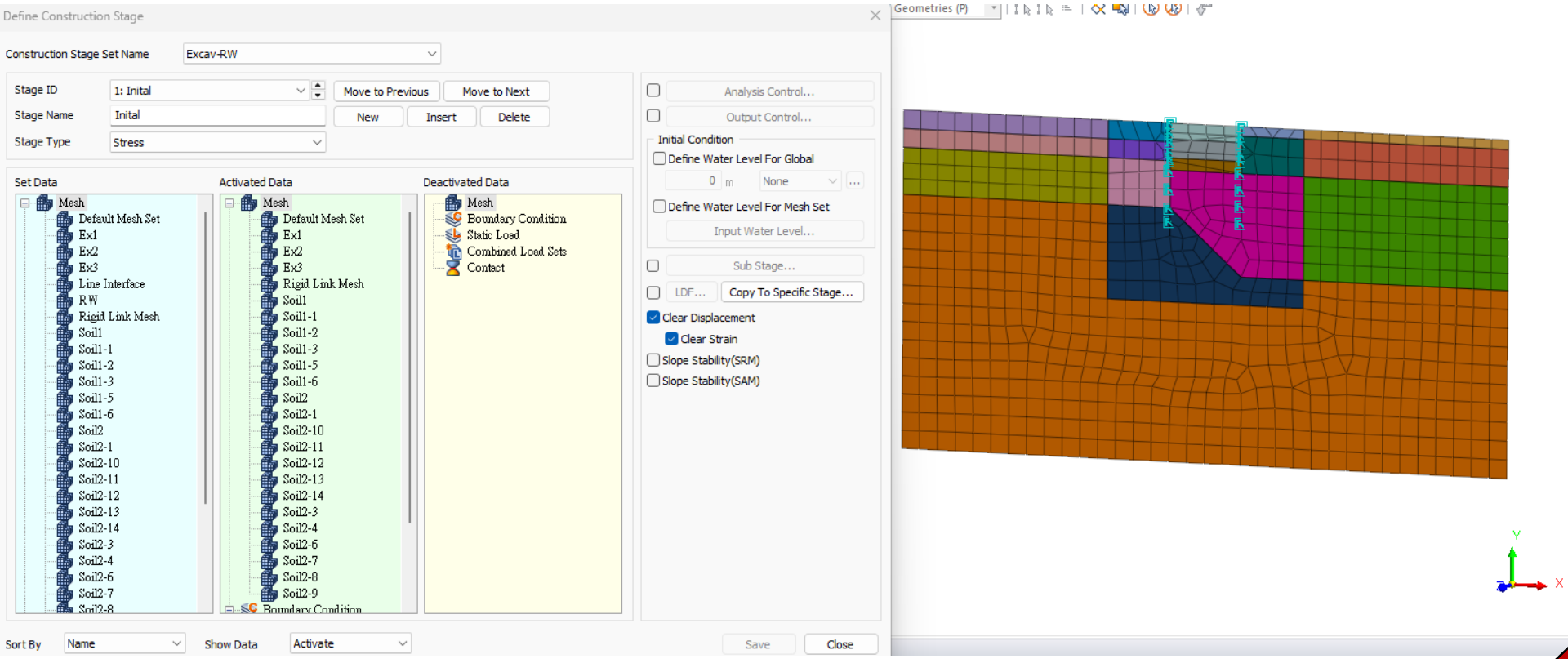
CONSTRUCTION STAGE



Define construction stage:
Stage Name → Set Data → Initial condition → Save → New

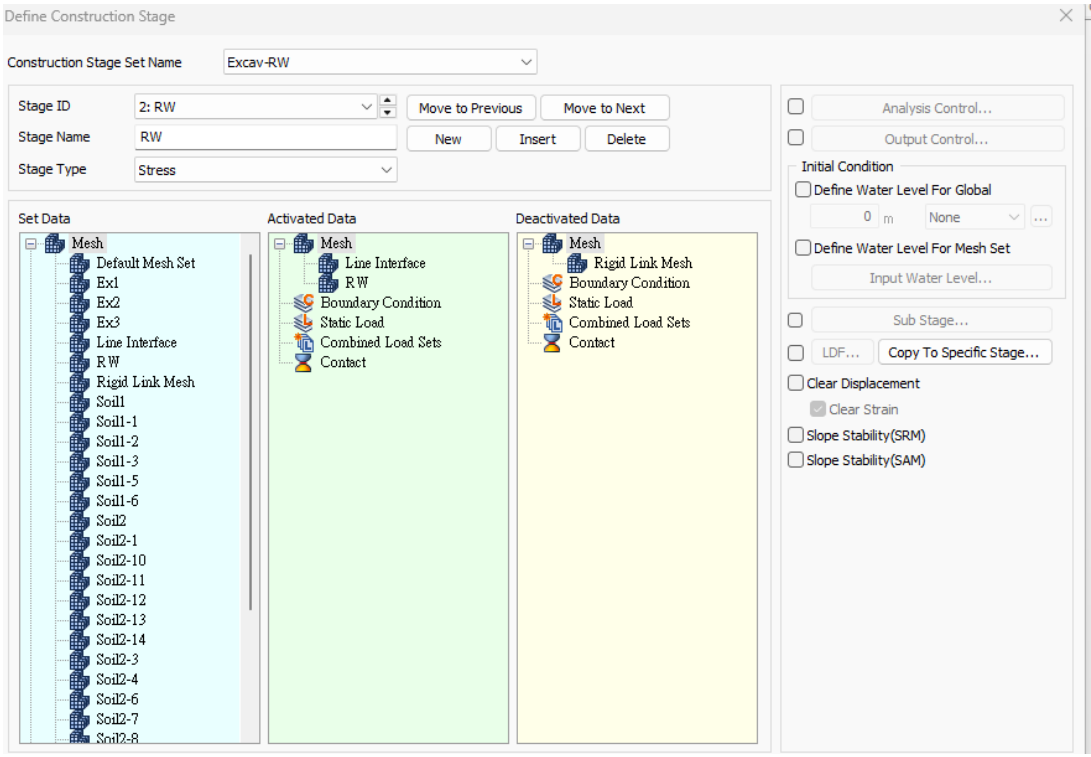


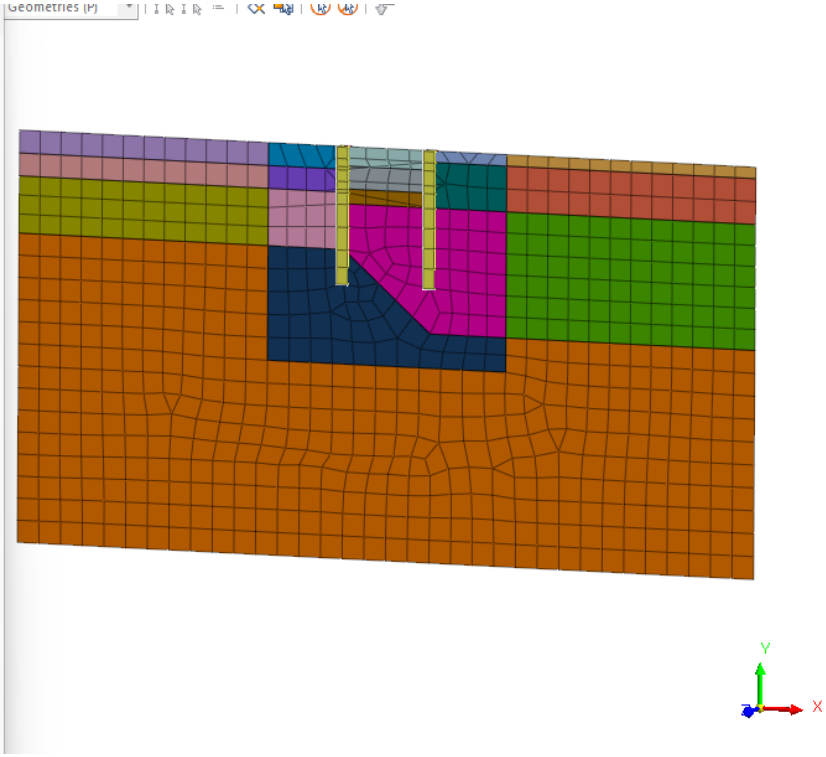
CONSTRUCTION STAGE 1



Stage 1: Initial Conditions

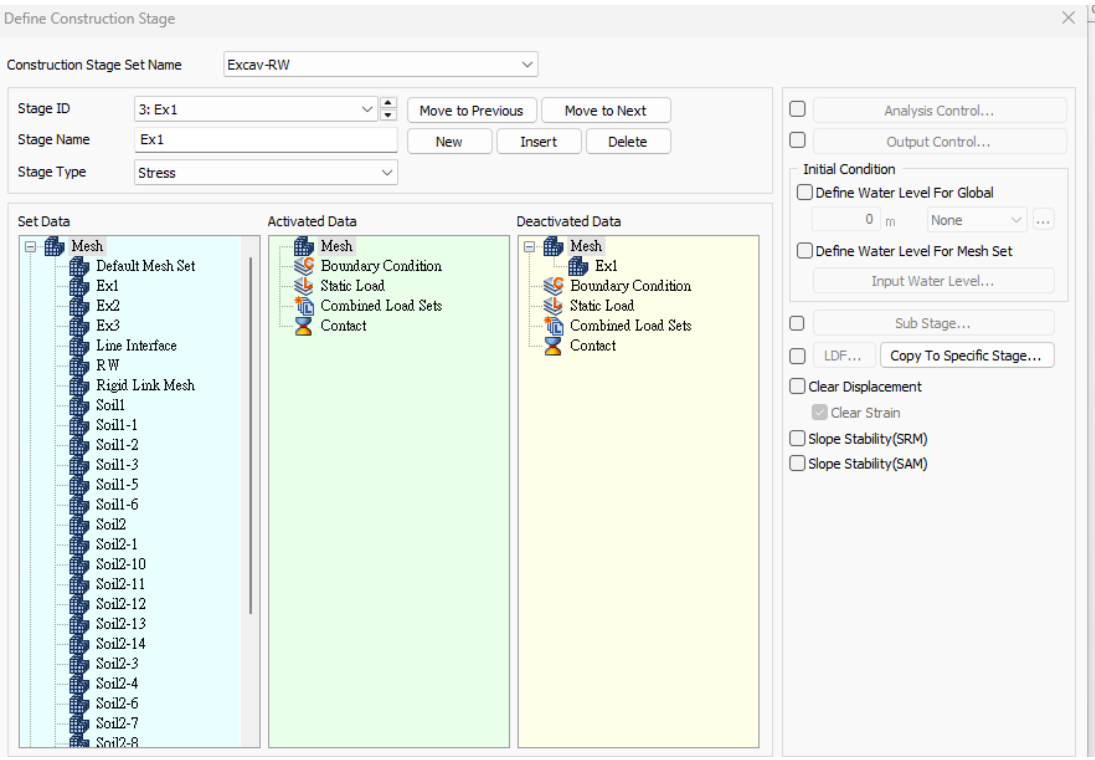
CONSTRUCTION STAGE 2

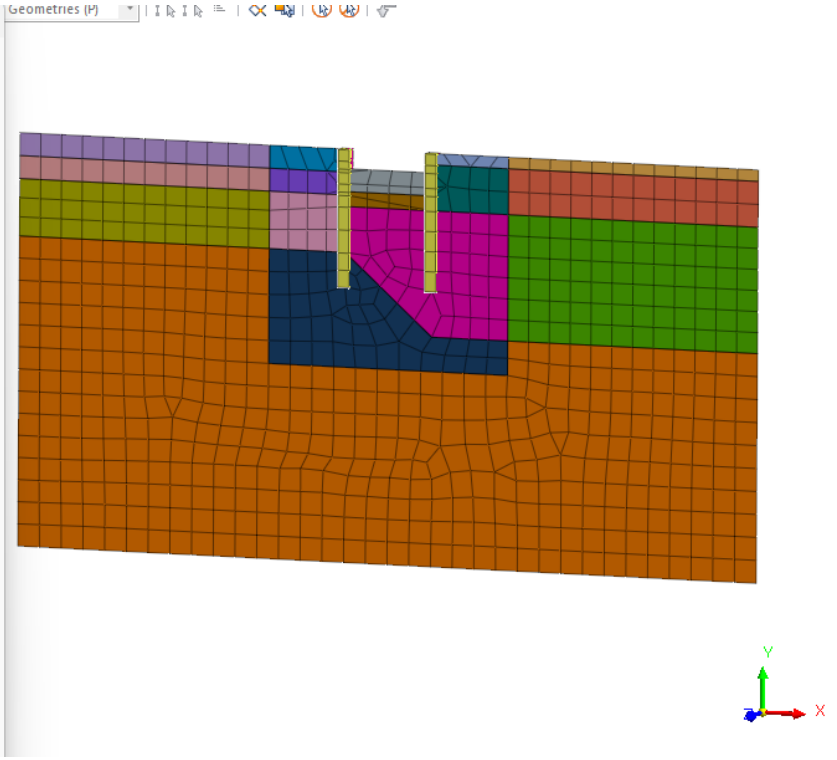




Stage 2: Retaining Wall

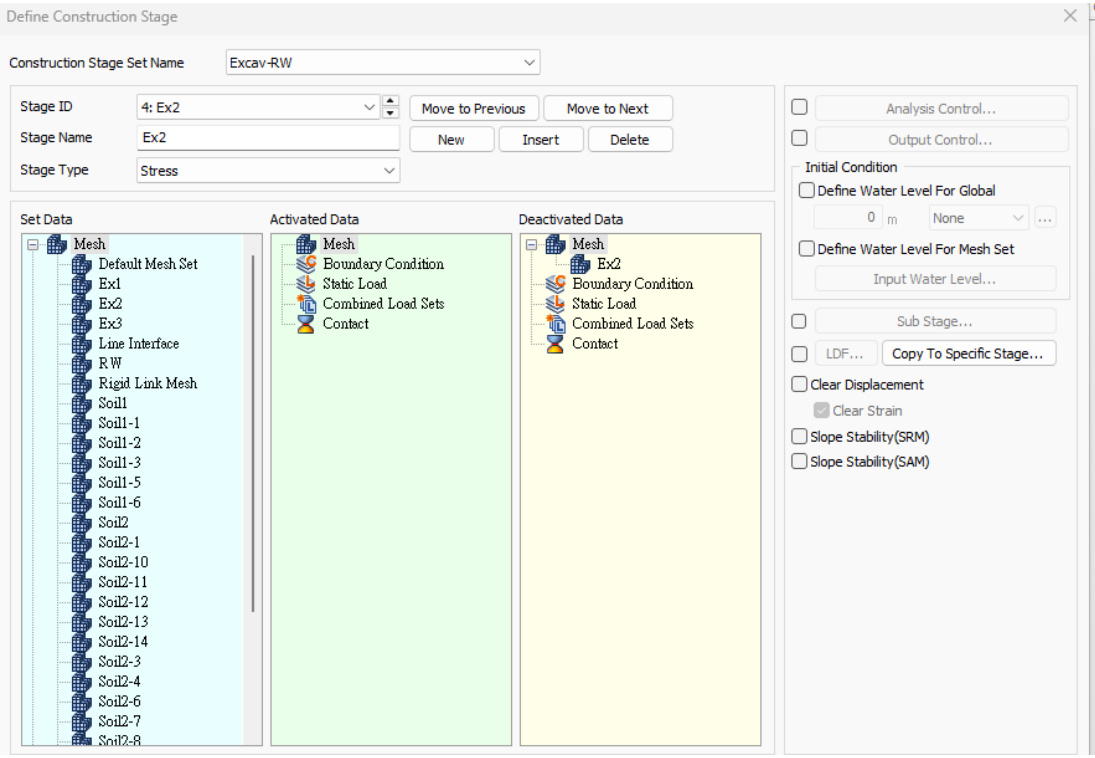
CONSTRUCTION STAGE 3

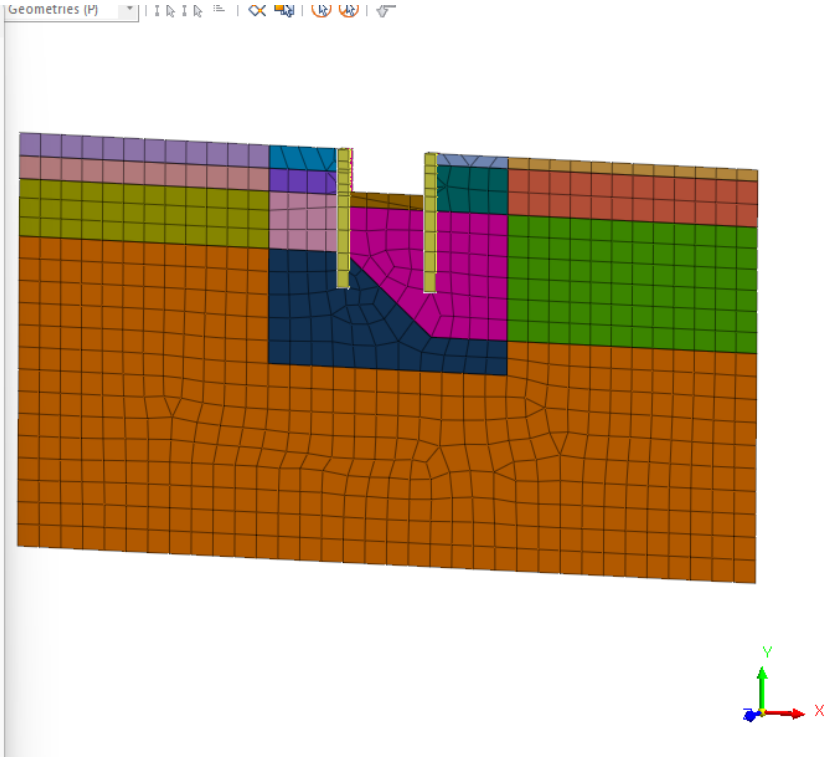




Stage 3: Excavation Layer 1

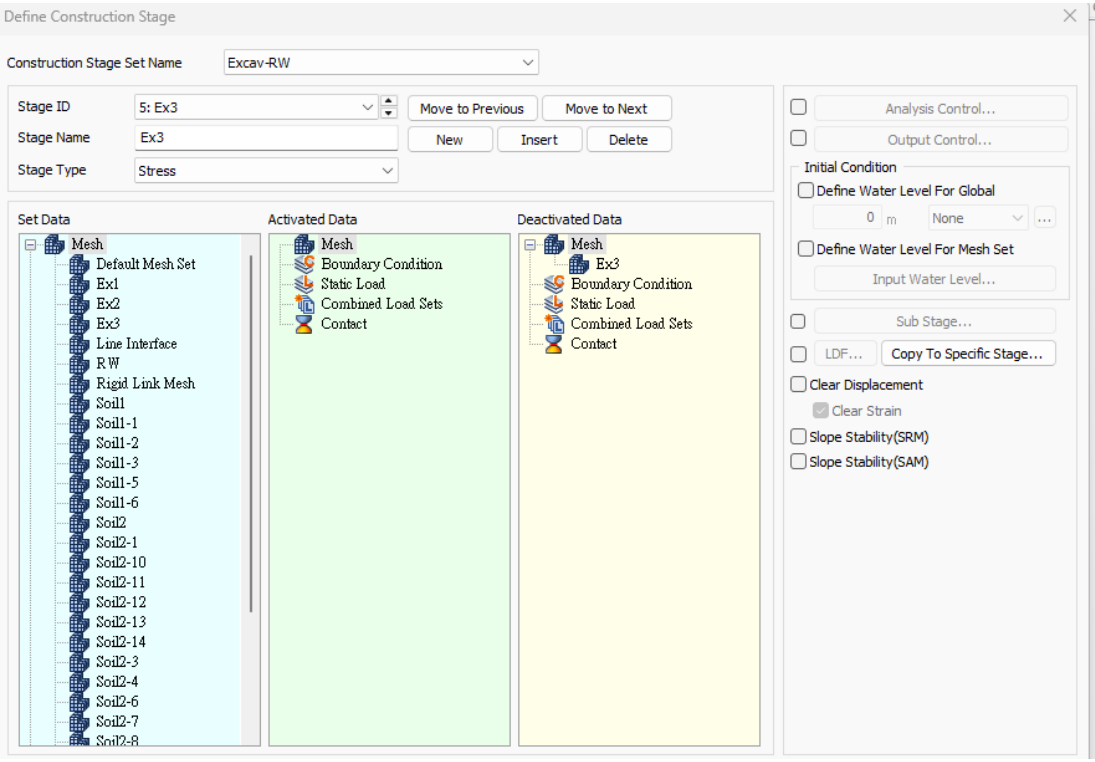
CONSTRUCTION STAGE 4

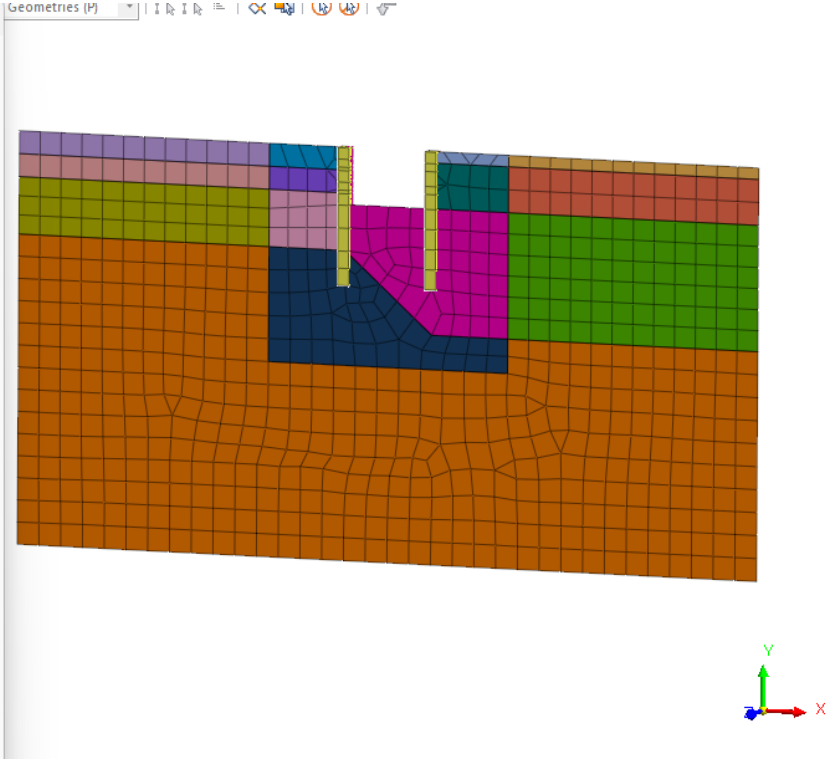




Stage 4: Excavation Layer 2

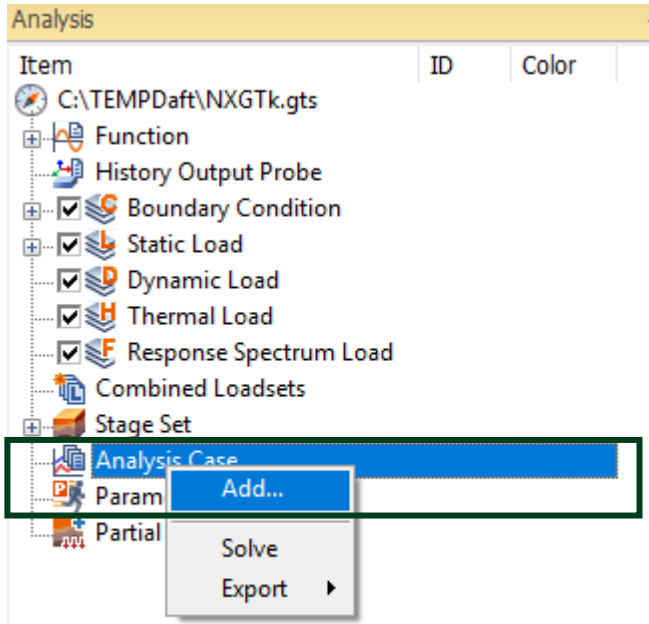
CONSTRUCTION STAGE 4

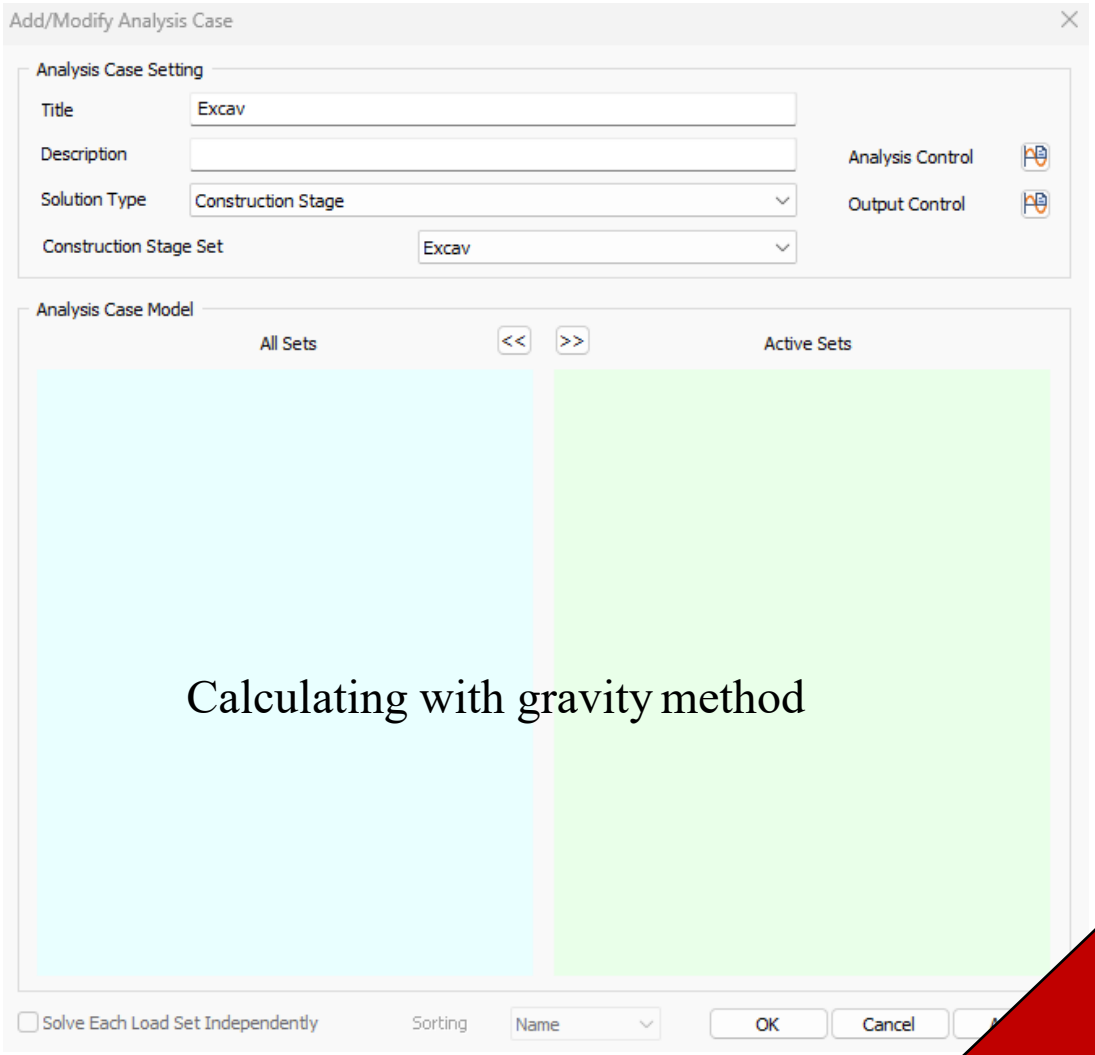




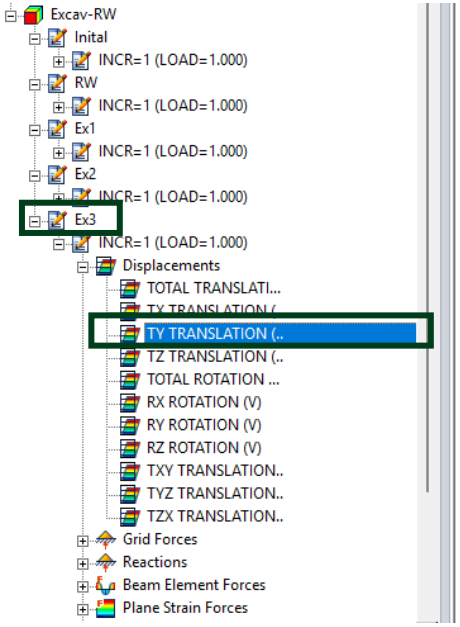
Stage 4: Excavation Layer 3

ANALYSIS CONTROL

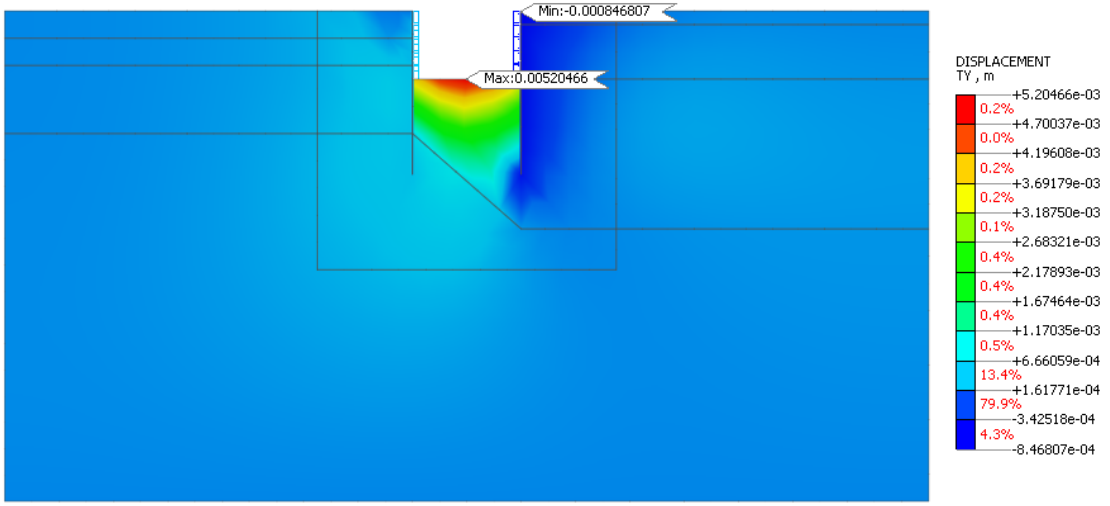


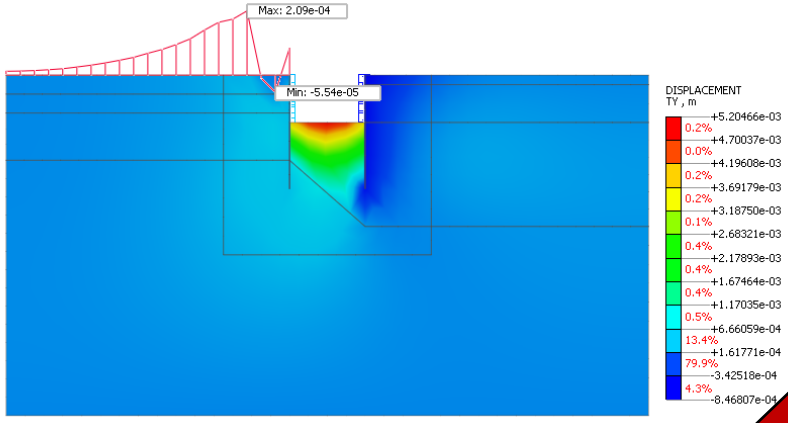


RESULT - VERTICAL DISPLACEMENT

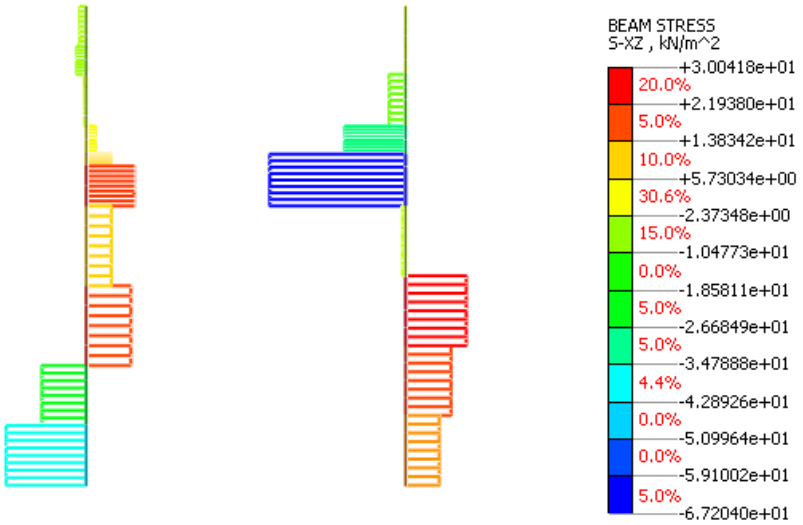


Result → Advanced → Cutting Diagram

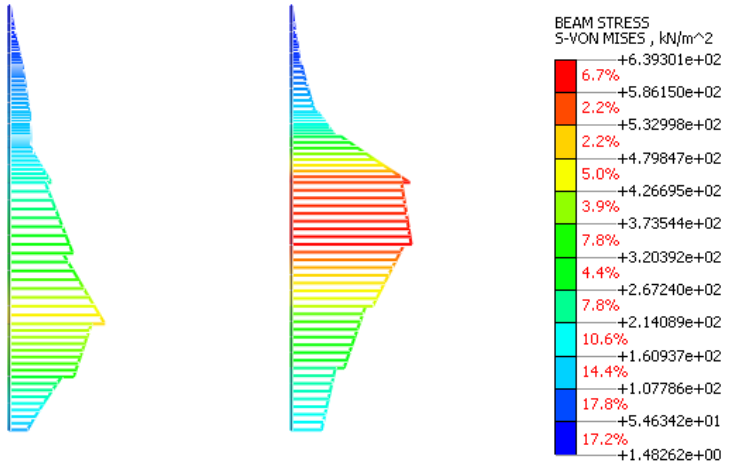




RESULT - BEAM STRESSES



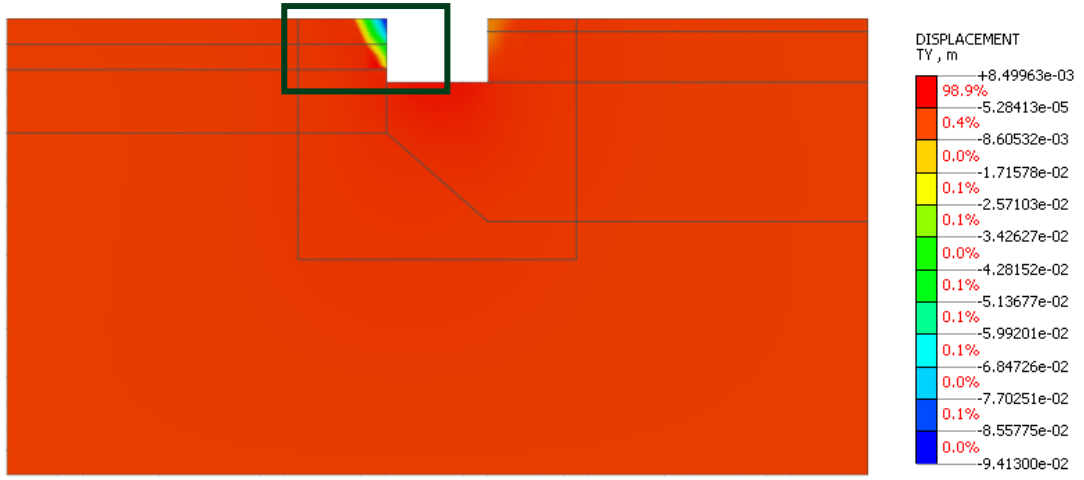
Shear force
Retaining Wall



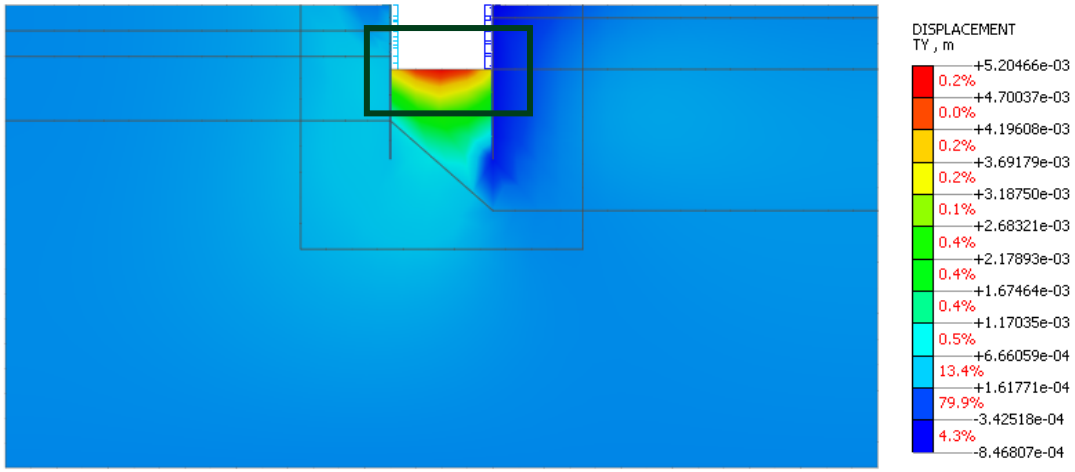
Bending moment
Retaining Wall

RESULT - COMPARISON

Total Displacement Without RW



Total Displacement With RW



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

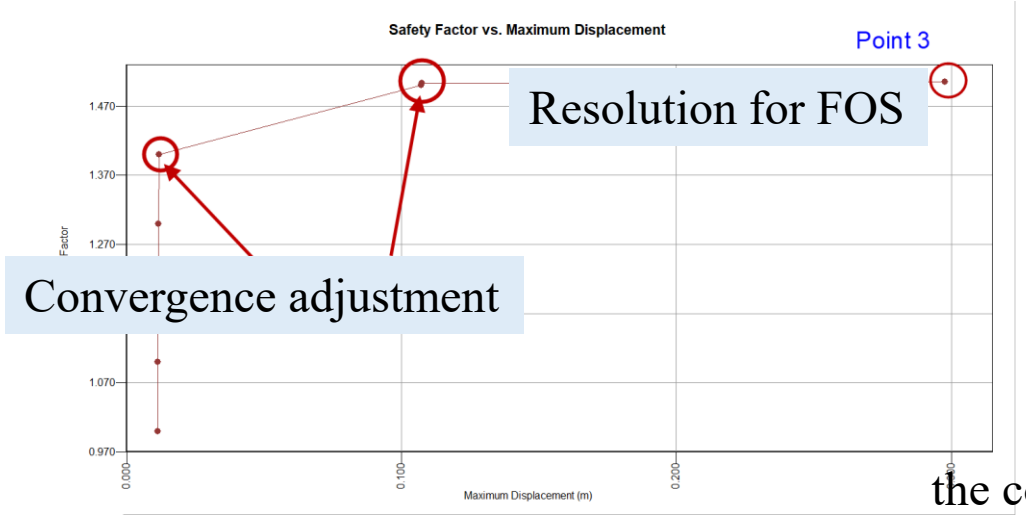
MIDAS TAIWAN
GTS NX STANDARD TEACHING SERIES

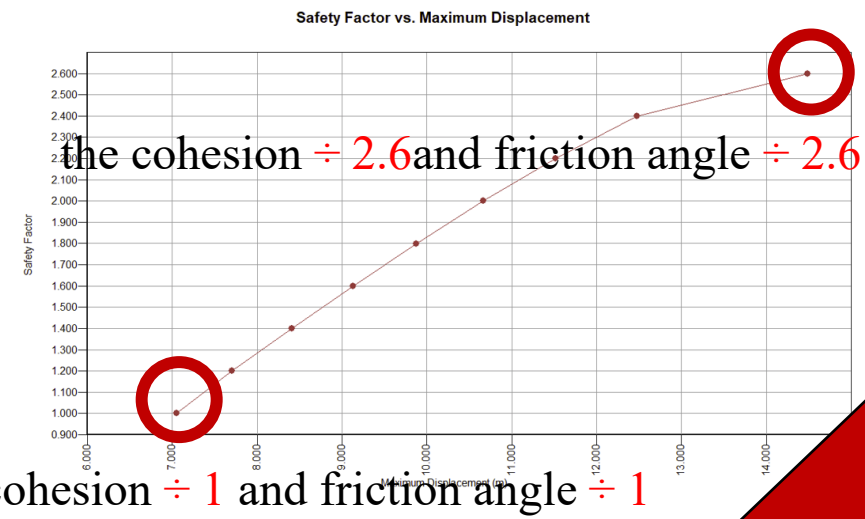
DIFFERENT HAZARD CONDITIONS IN SLOPE STABILITY

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

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

Where:

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

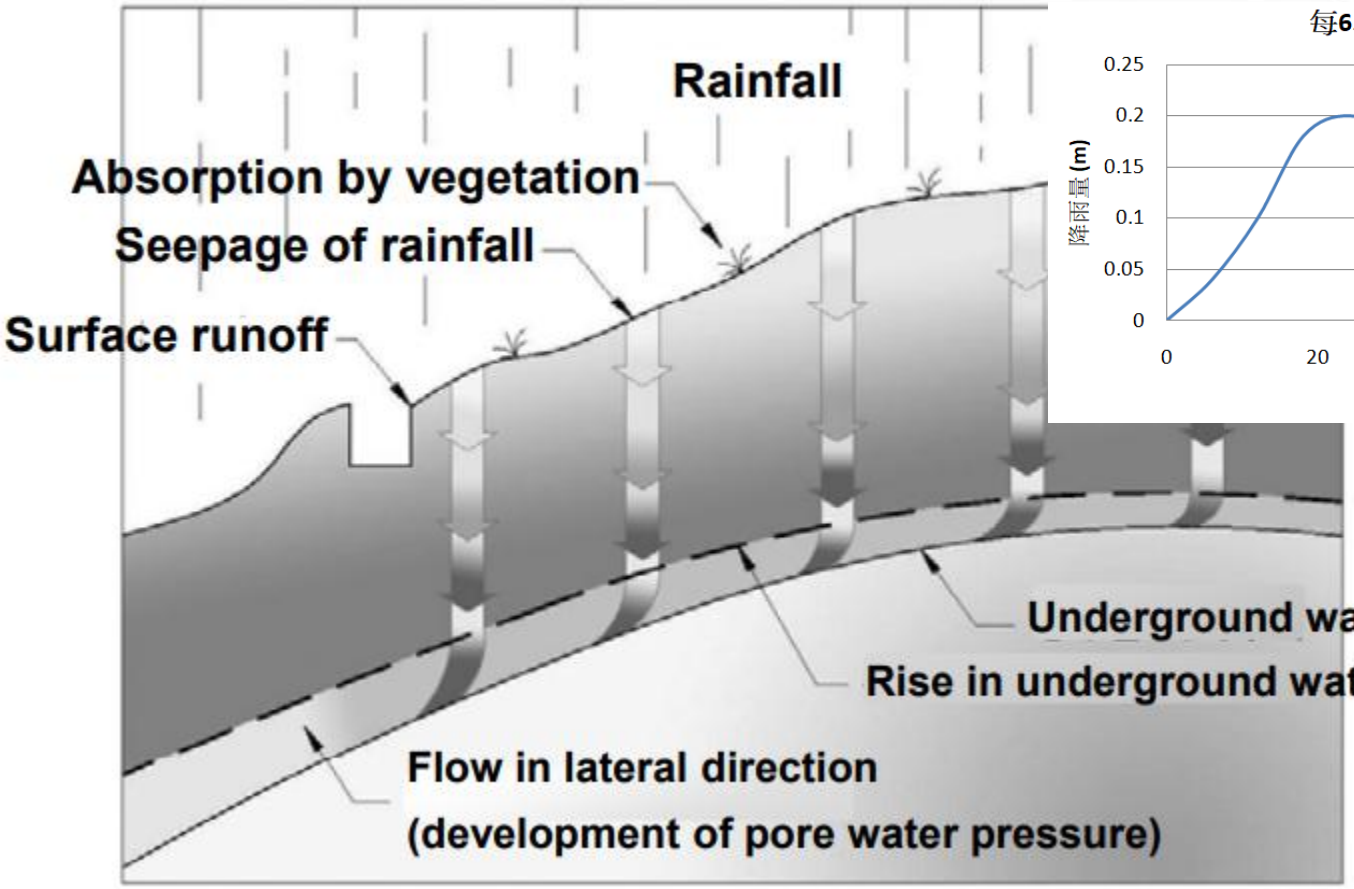
These forces are applied **uniformly to the entire soil mass.**

Reference

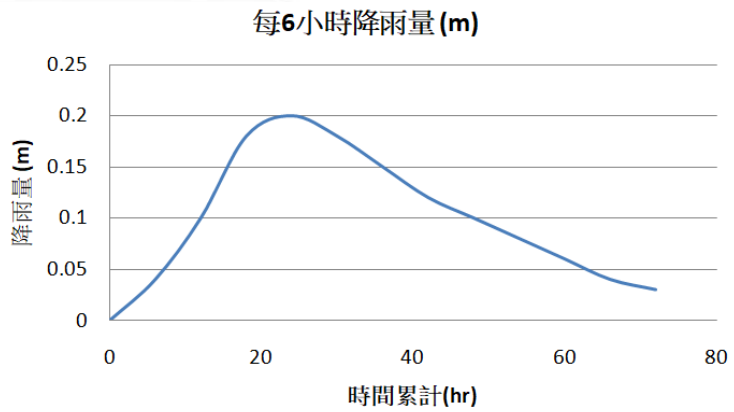
GTS NX/FEA NX/Soilworks Manual

SEEPAGE THROUGH UNSATURATED SLOPE

SEEPAGE INDUCED BY RAINFALL

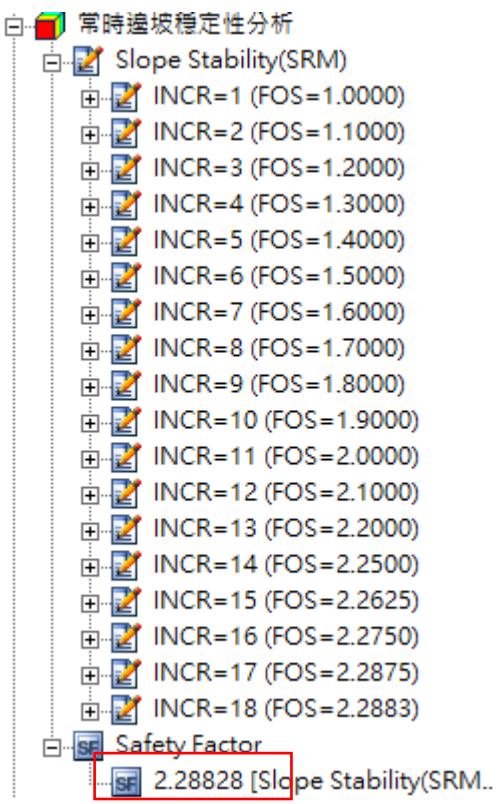


SURFACE RAINFALL OVER 72 HOURS



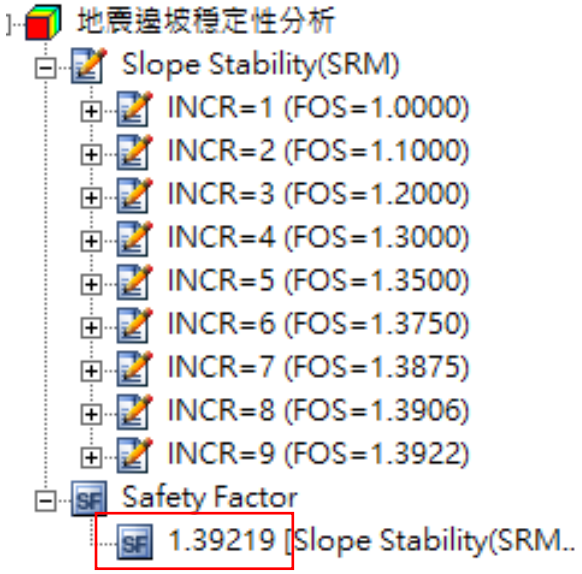
COMPARISON FOR DIFFERENT CASES

Normal case



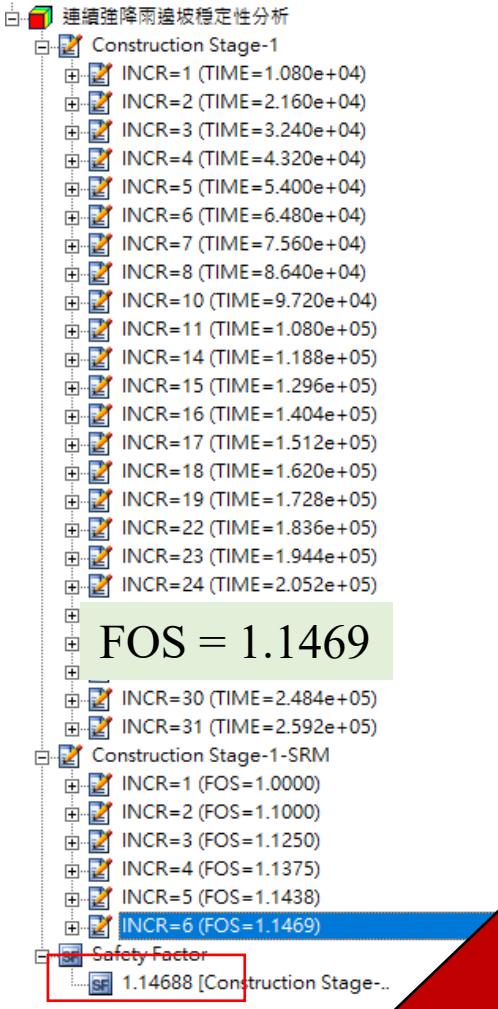
FOS = 2.2883

Pseudo-static seismic



FOS = 1.3922

Heavy rainfall case

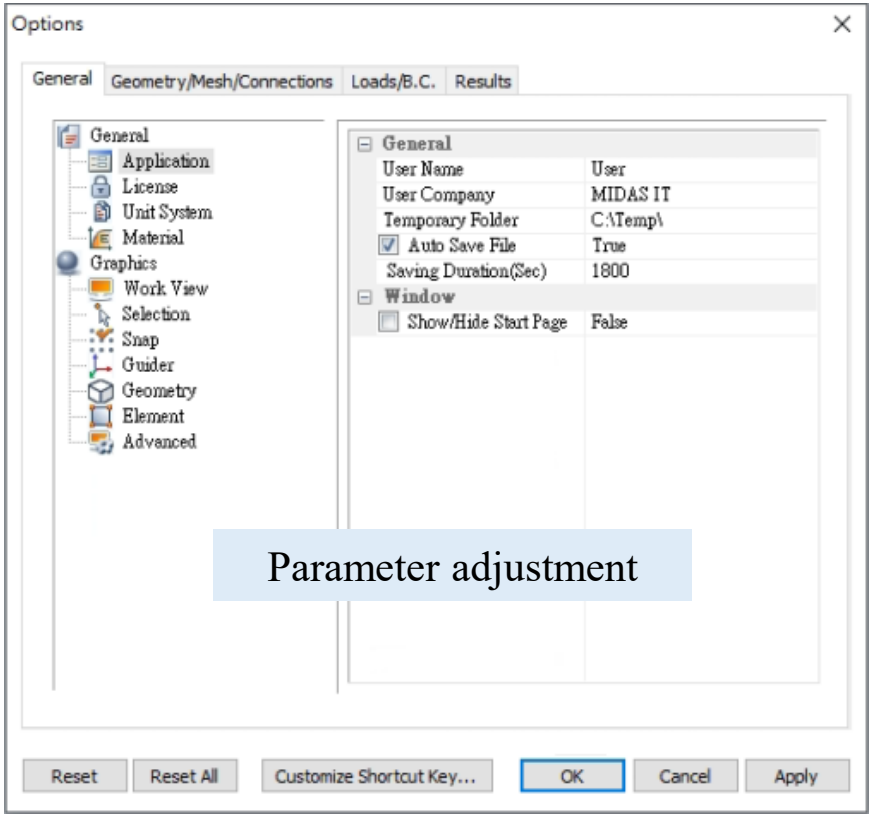


FOS = 1.1469

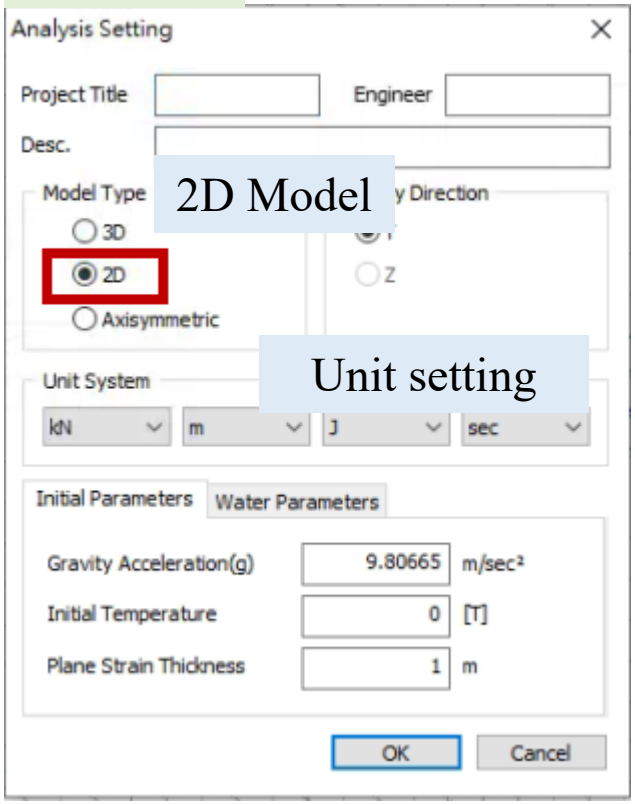
Part 1
NORMAL CONDITION

IMPORT

New file



Parameter adjustment

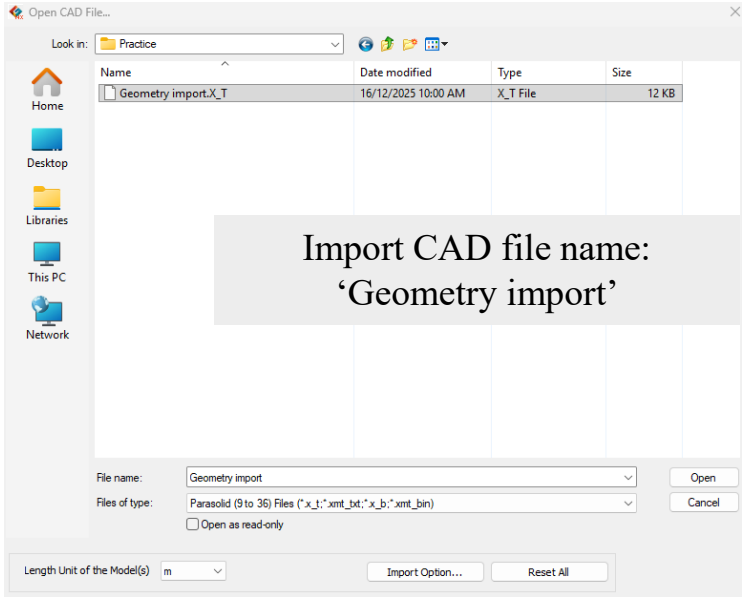


2D Model

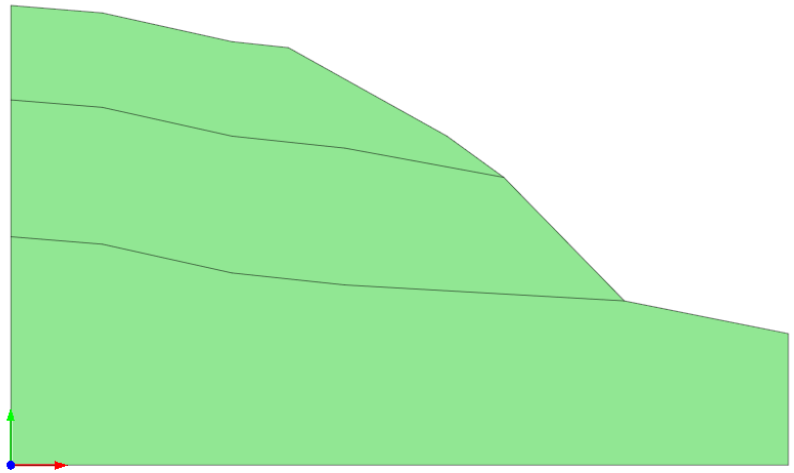
Unit setting

Unit setting: KN/m/J/sec

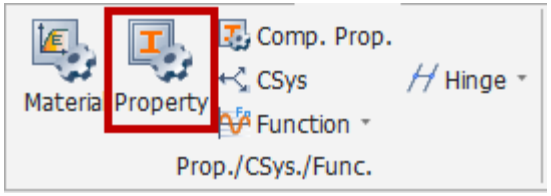
2D MODEL IMPORT

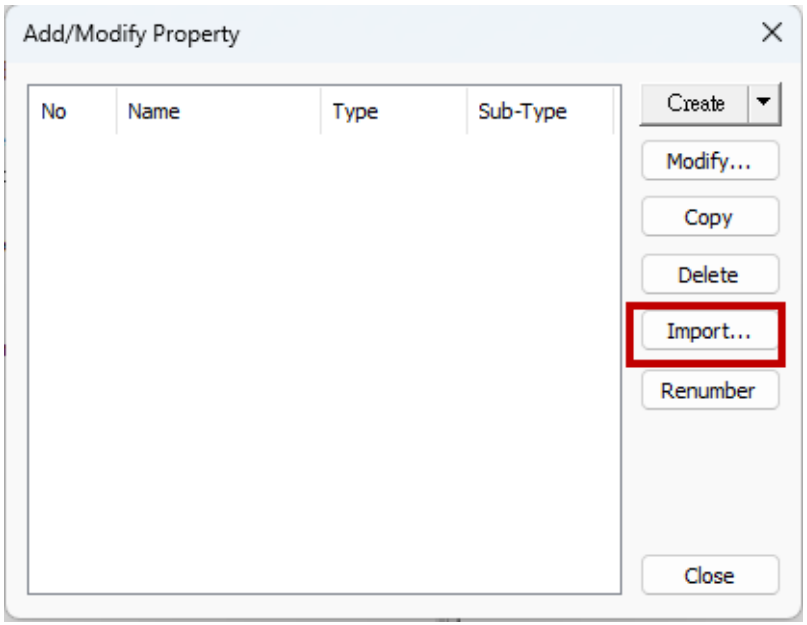


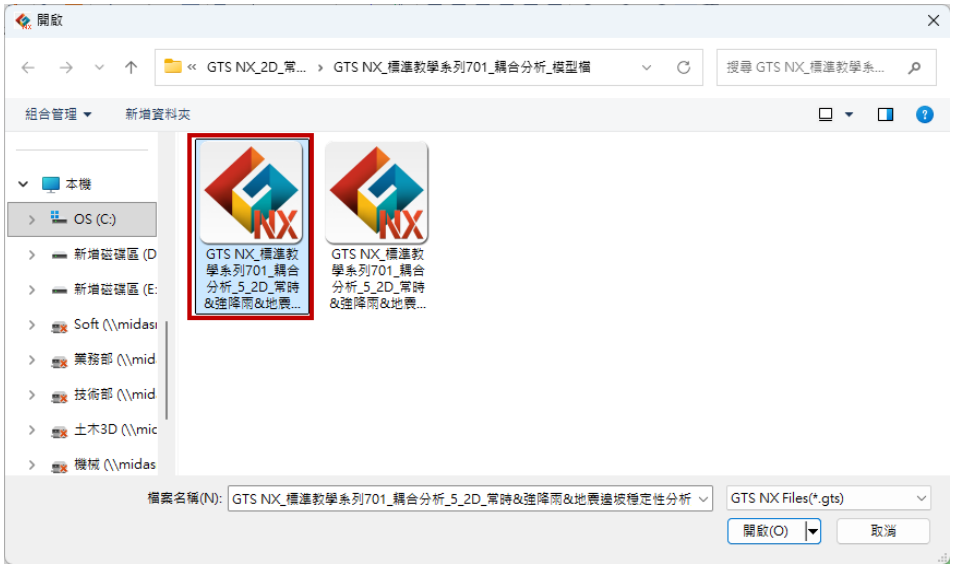
Import CAD file name:
'Geometry import'

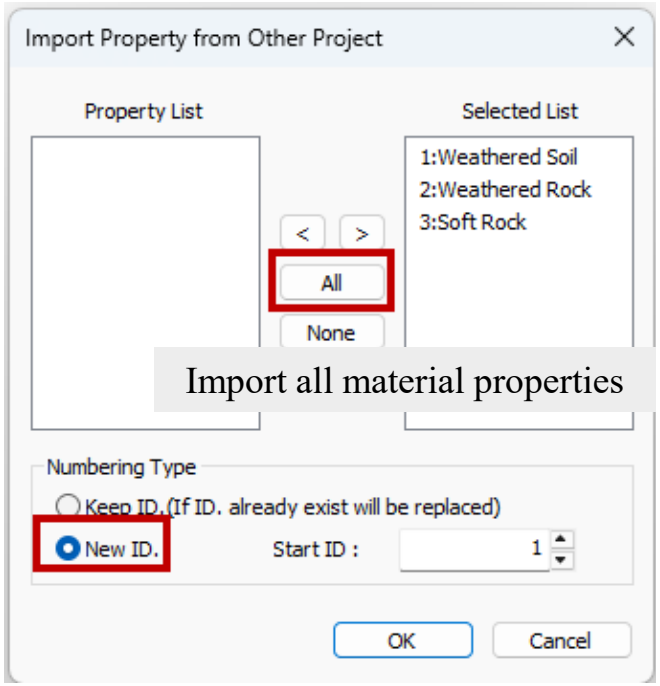


MATERIAL & PROPERTY





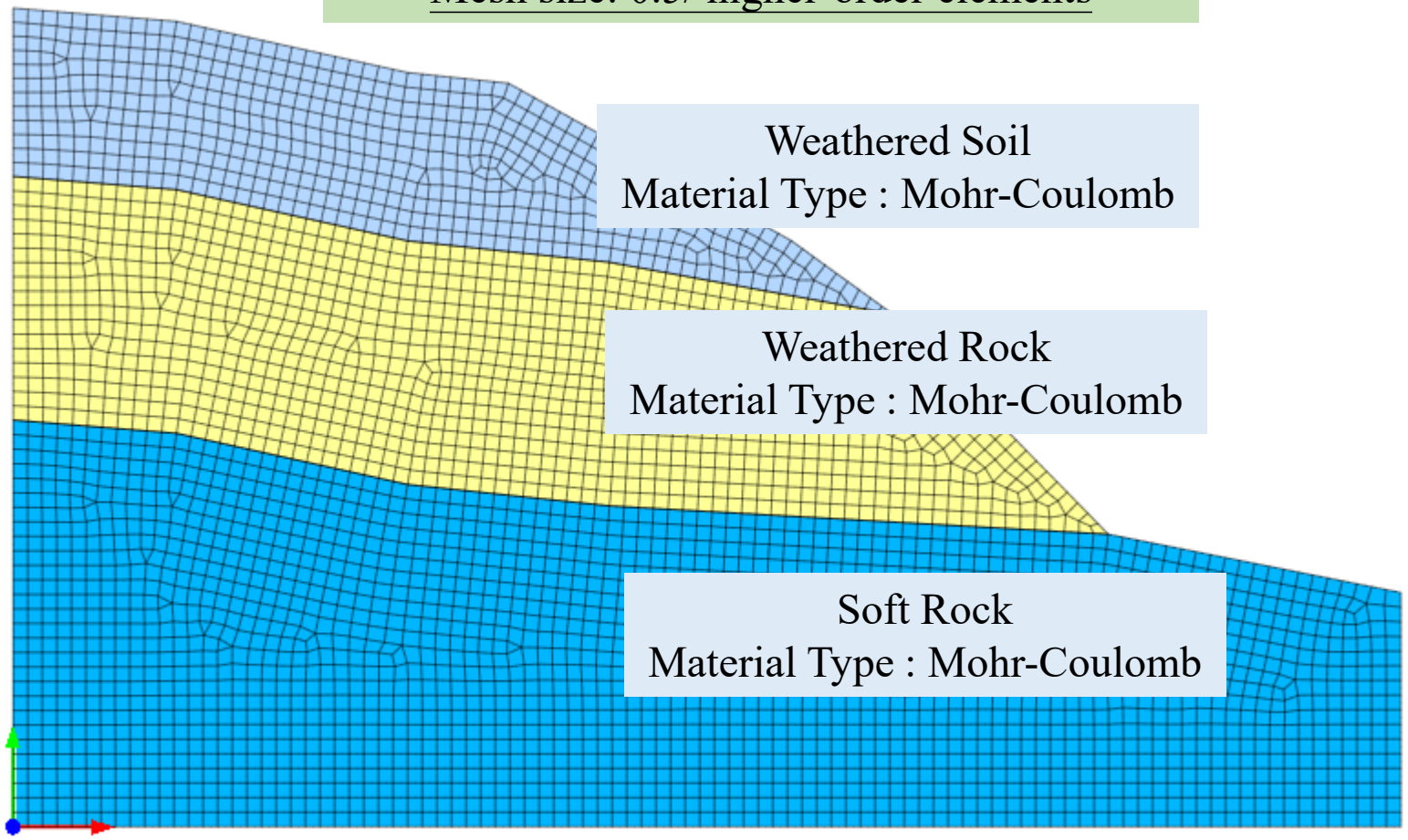




Import all material properties

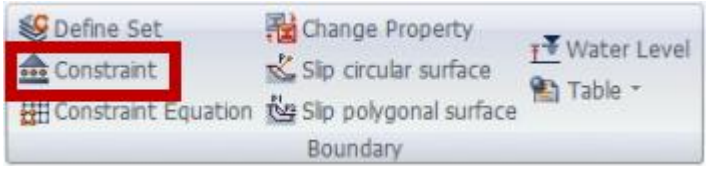
2D MESH GENERATION

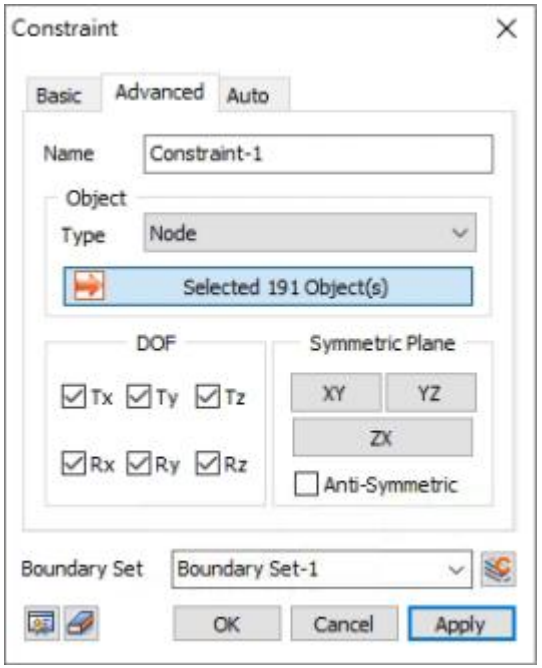
Mesh size: 0.5/ higher-order elements

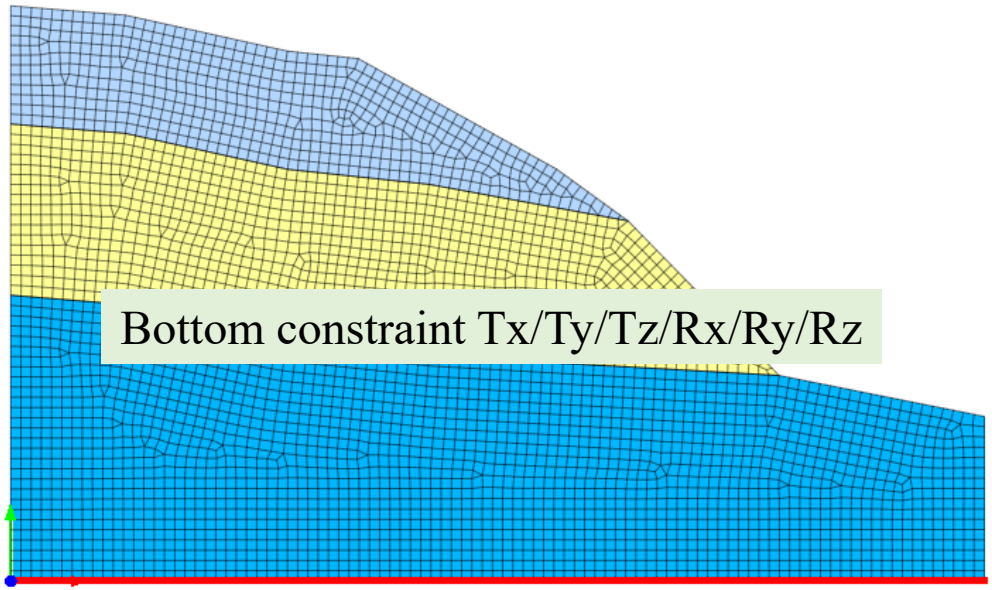


Note: Using higher-order elements and smaller grid sizes for slope analysis

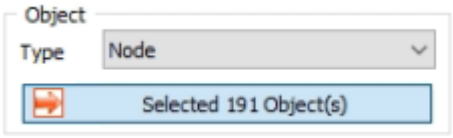
BOTTOM BOUNDARY

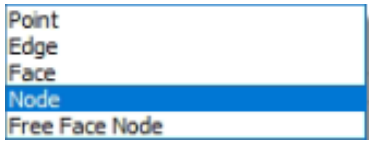




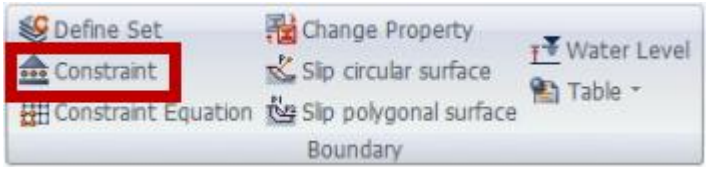


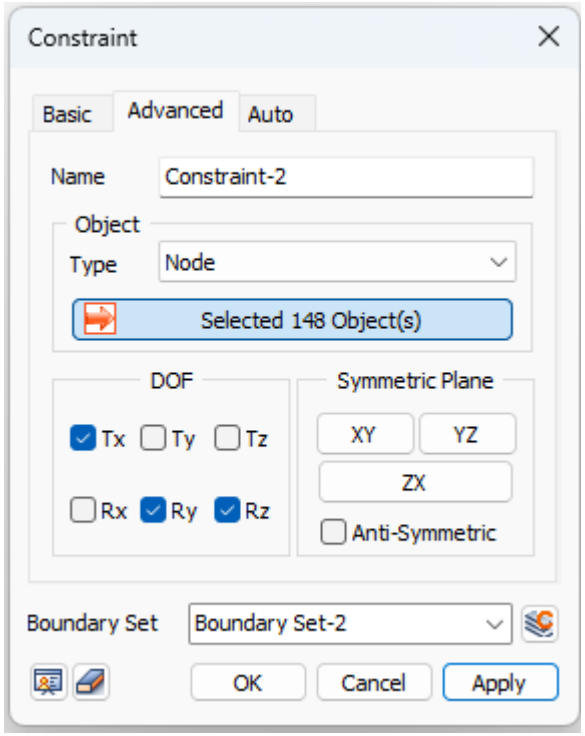
The geometric features or nodes can be applied to the boundary

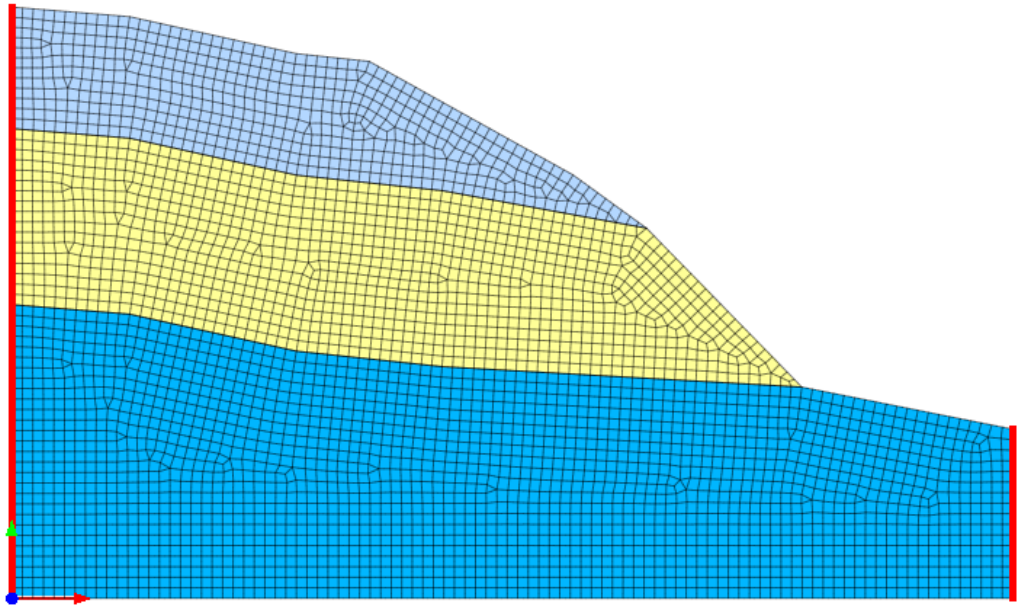




TWO-SIDED BOUNDARY



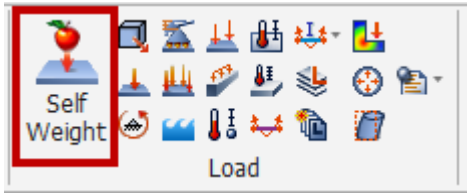


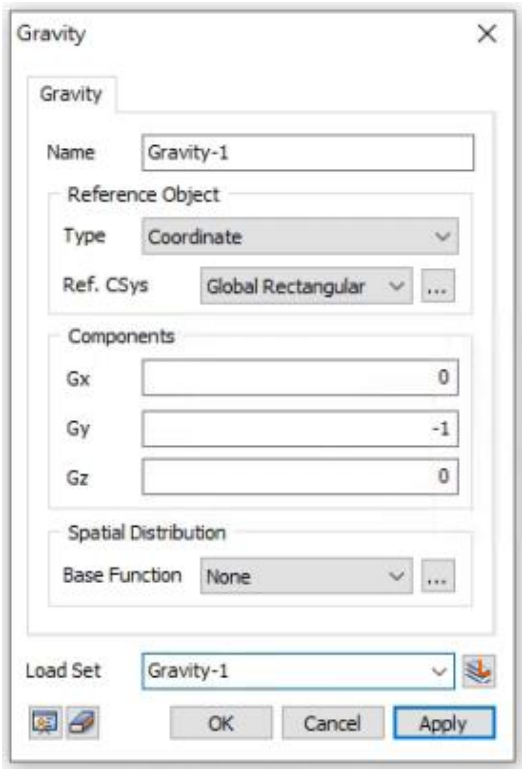


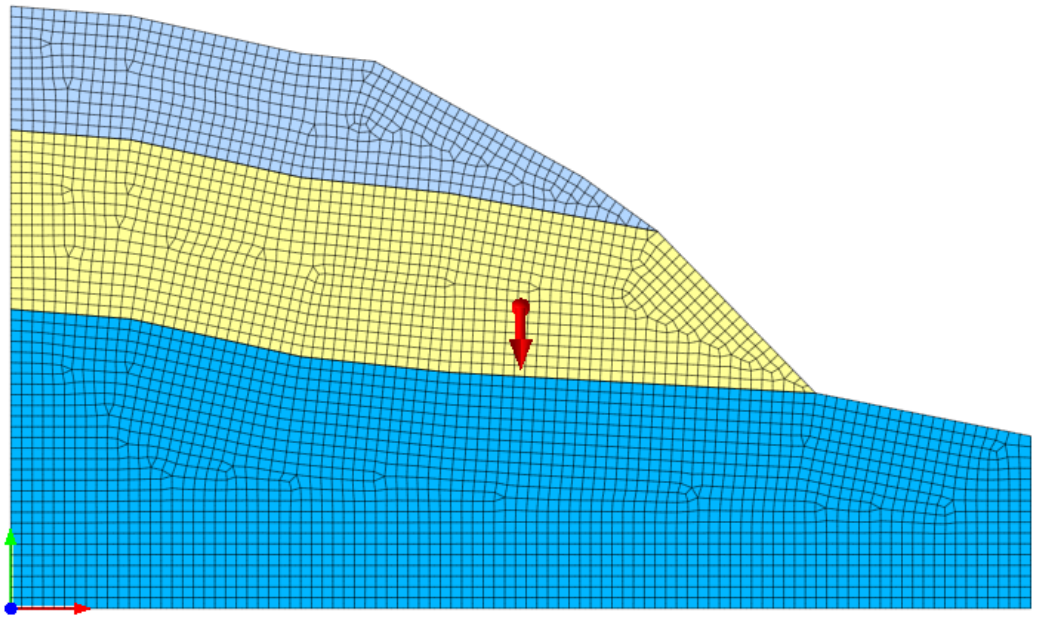
2-sided constraint Tx/Ry/Rz

It is recommended to set boundary sets for different location

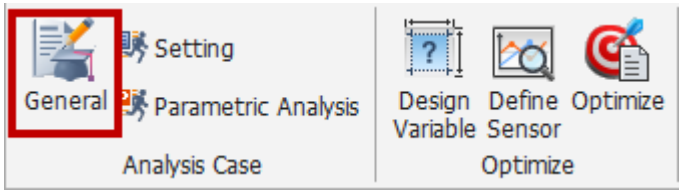
SELF-WEIGHT


Self
Weight
Load

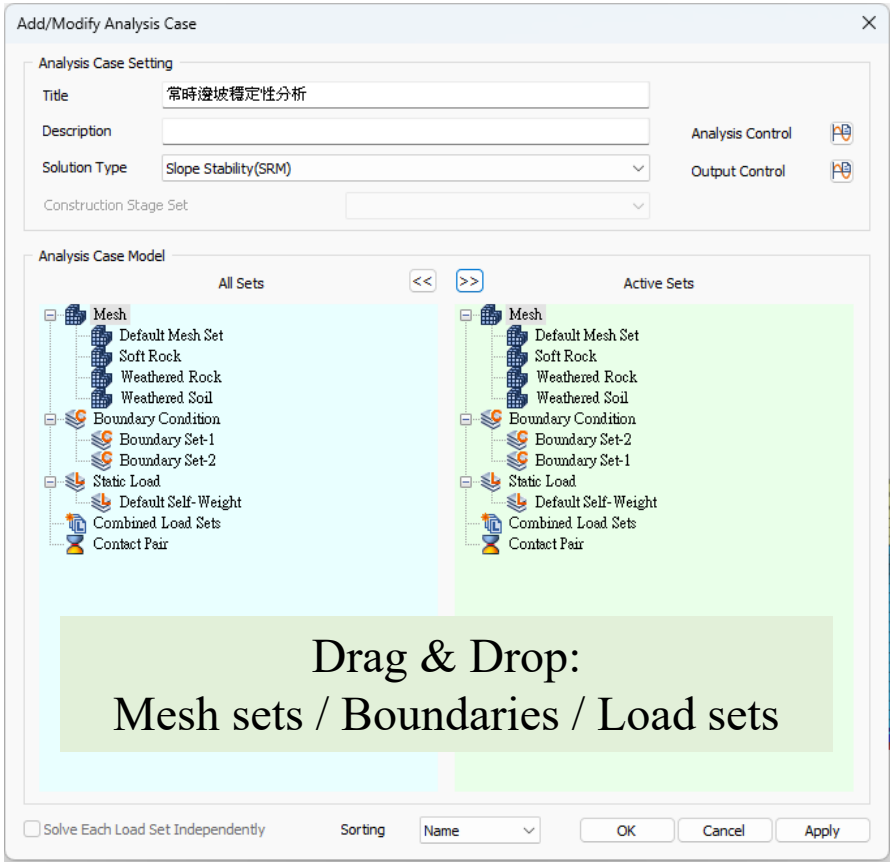

Gravity
Gravity
Name
Gravity-1
Reference Object
Type
Coordinate
Ref. CSys
Global Rectangular
...
Components
Gx
0
Gy
-1
Gz
0
Spatial Distribution
Base Function
None
...
Load Set
Gravity-1
OK
Cancel
Apply



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

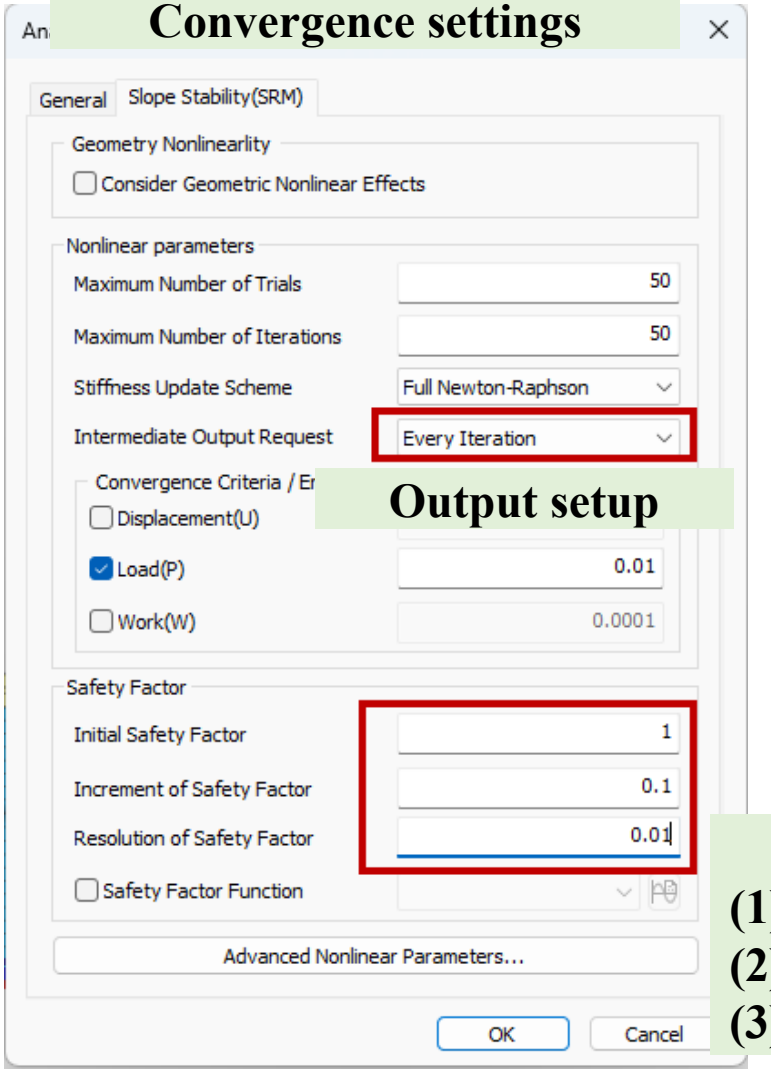


Simulation type: Slope Stability(SRM)



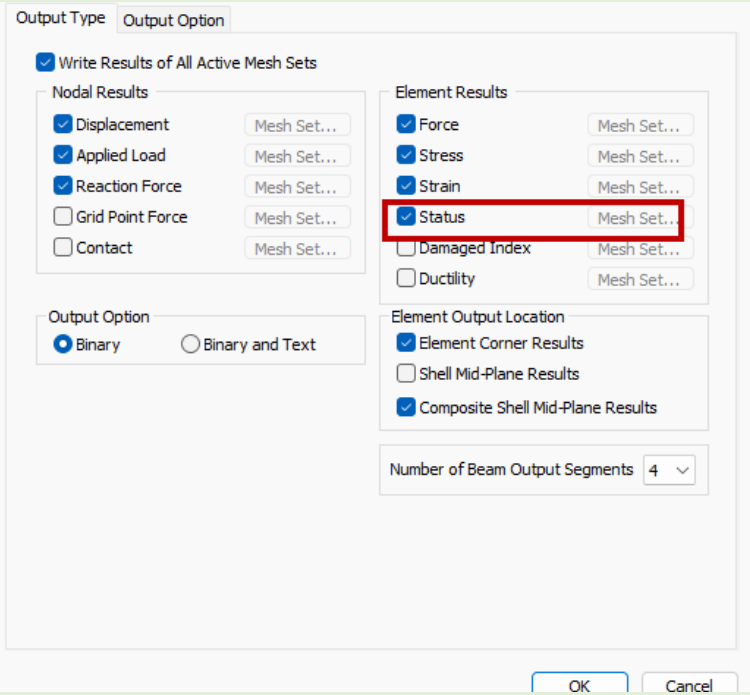
ANALYSIS 2 |SLOPE STABILITY (SRM) – NORMAL CASE)

Convergence settings



Output setup

Output=>Strain
Shear strain indicates the failure arc



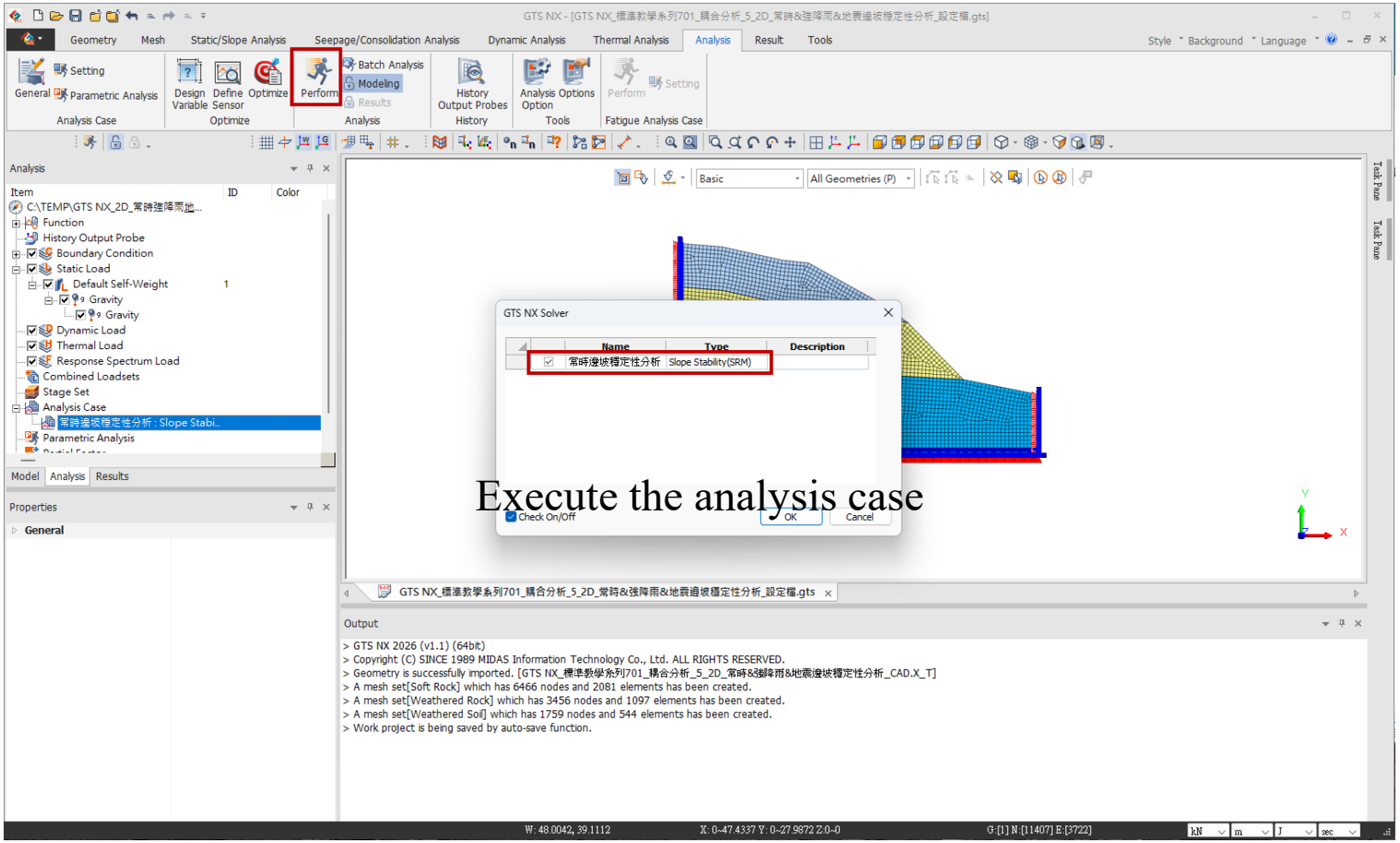
SRM convergence adjustment

(1) Initial safety factor 1

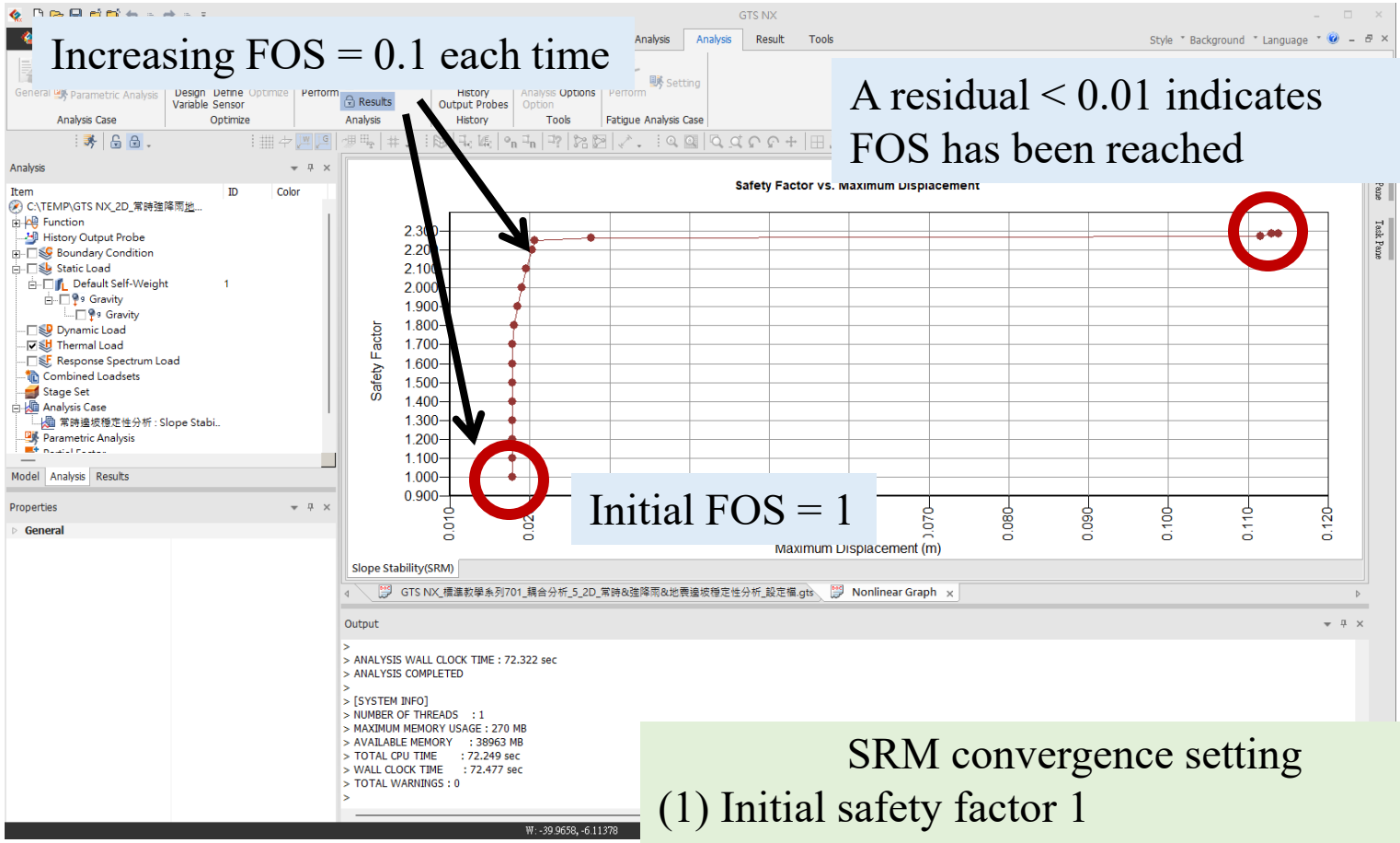
(2) FOS increment by 0.1 each time

(3) Residual < 0.01, minimum FOS reached

CALCULATION



SAFETY FACTOR INDICATION | CONVERGENCE CRITERIA



SRM convergence setting

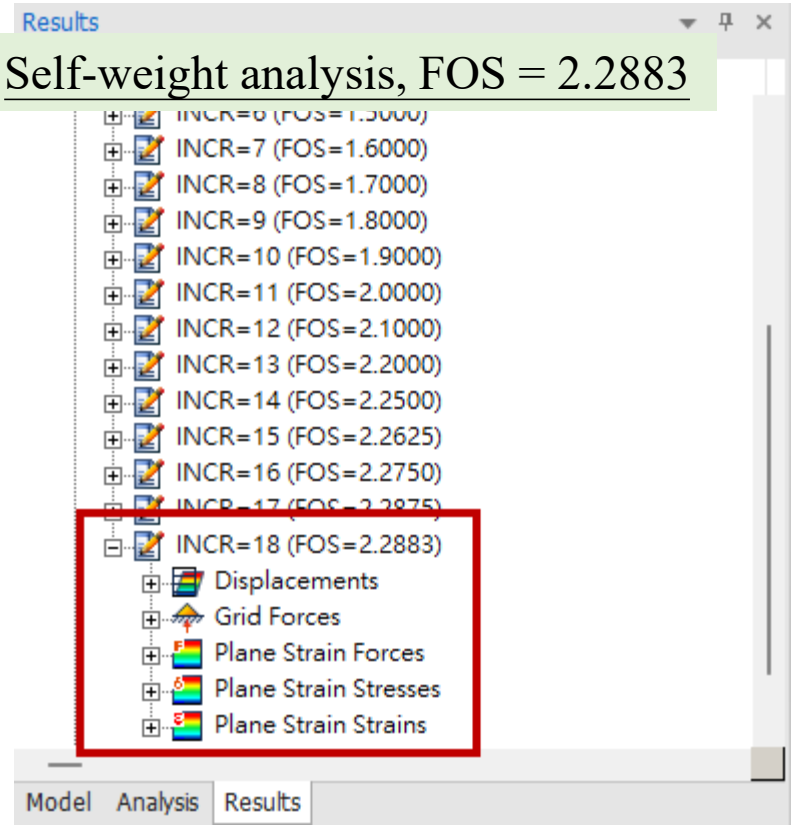
(1) Initial safety factor 1

(2) FOS increment by 0.1 each time

(3) Residual < 0.01, minimum FOS reached

RESULTS | NORMAL CASE

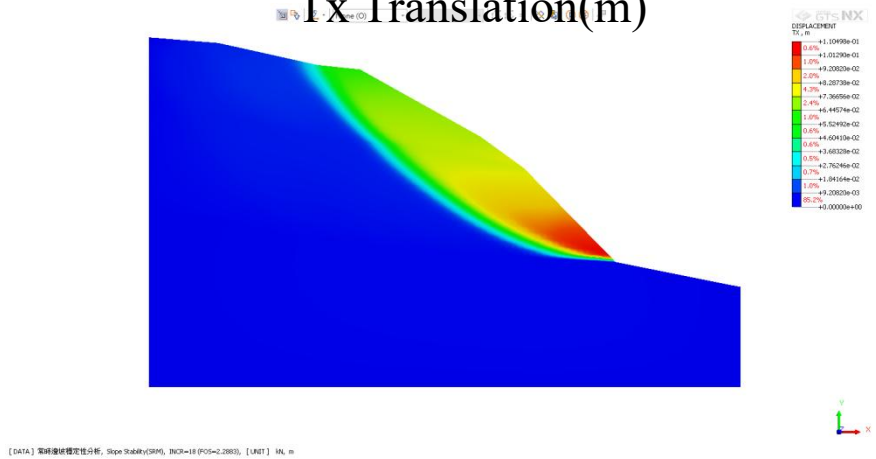
Self-weight analysis, FOS = 2.2883



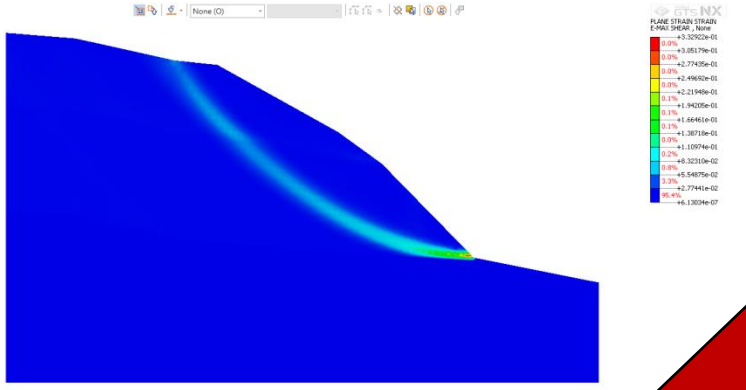
SRM for safety factor calculation

Failure surface indicated by horizontal displacement & maximum shear strain

Tx Translation(m)

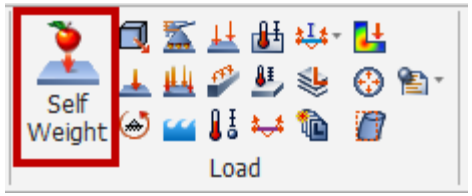


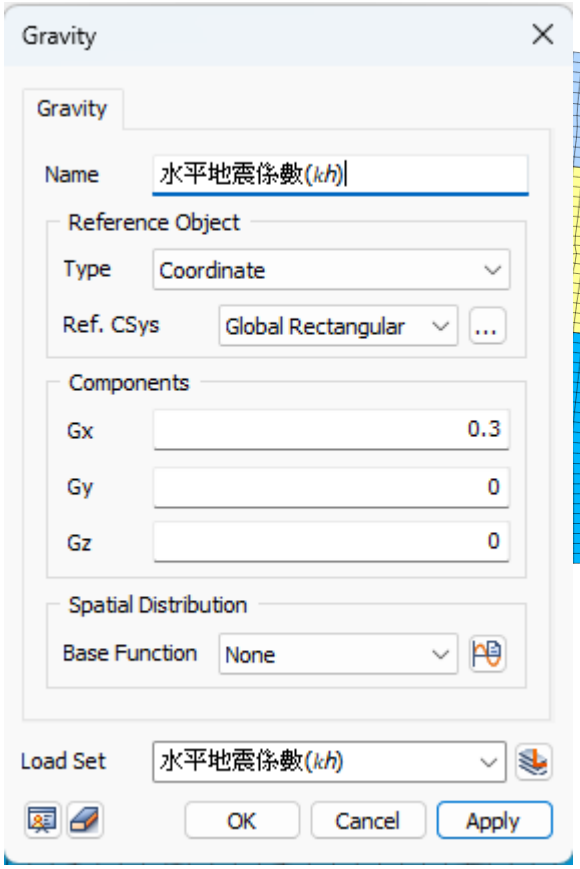
Maximum Shear Strain

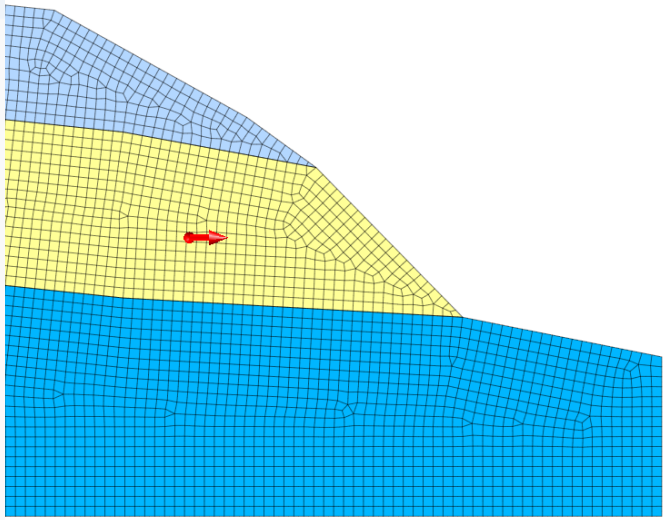


Part 2
PSEUDO-STATIC SEISMIC CASE

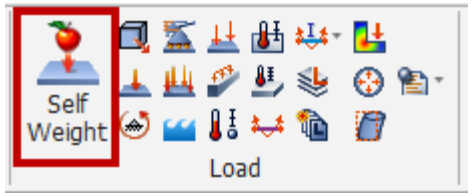
HORIZONTAL SEISMIC COEFFICIENT (K_H)

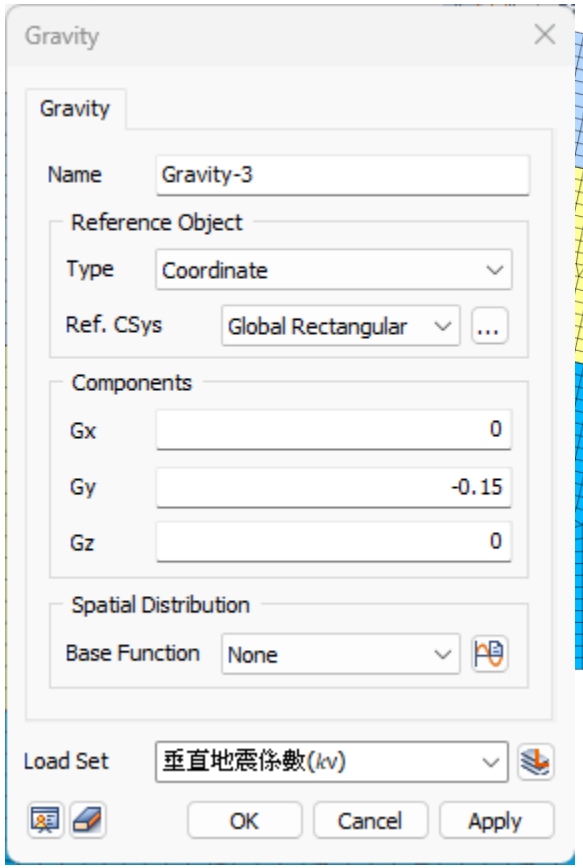


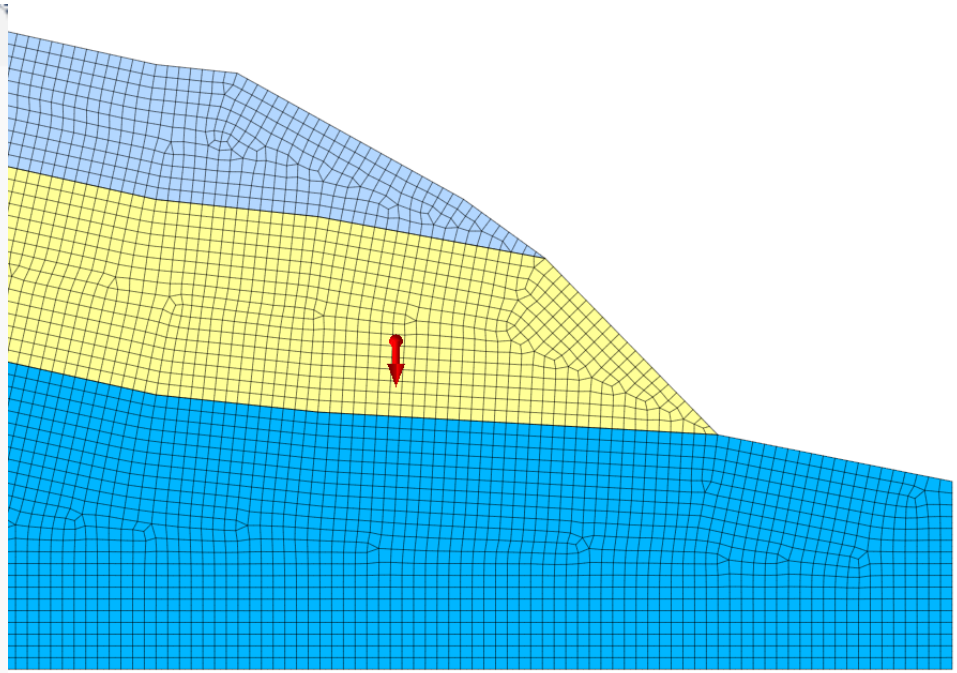




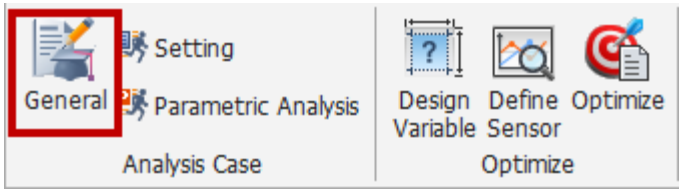
VERTICAL SEISMIC COEFFICIENT (K_V)



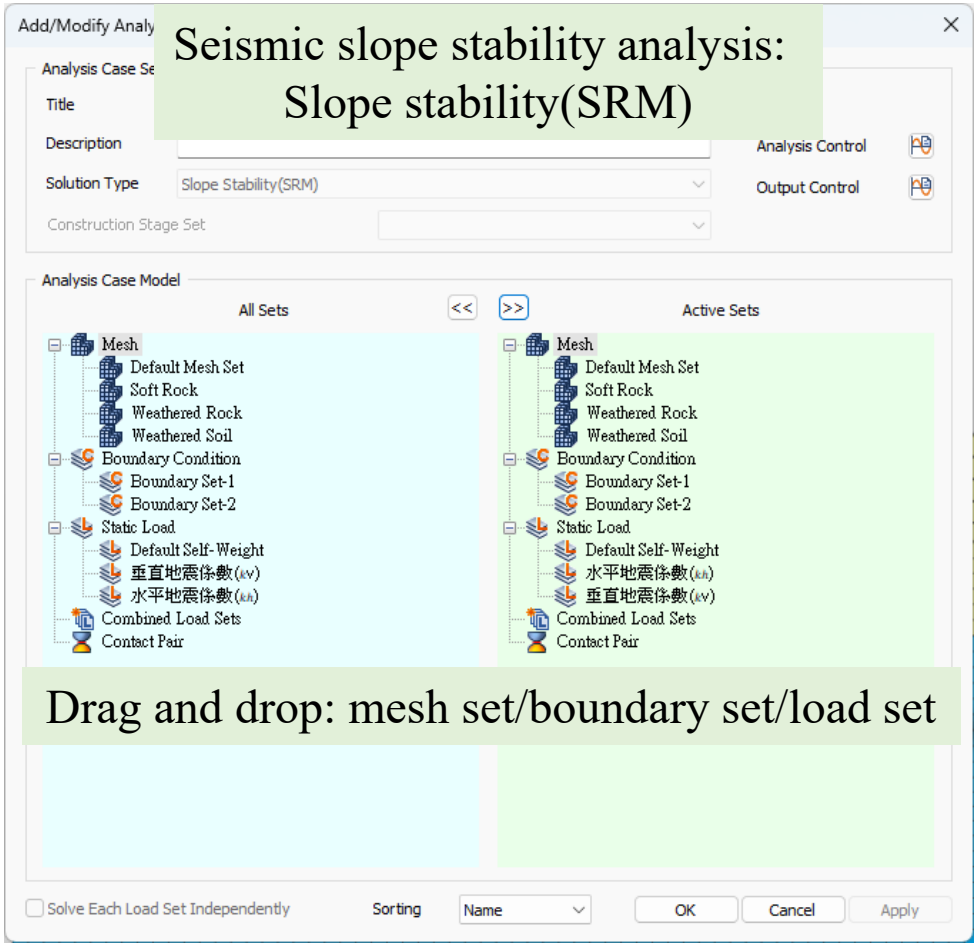




ANALYSIS 1 | PSEUDO-STATIC SEISMIC CASE



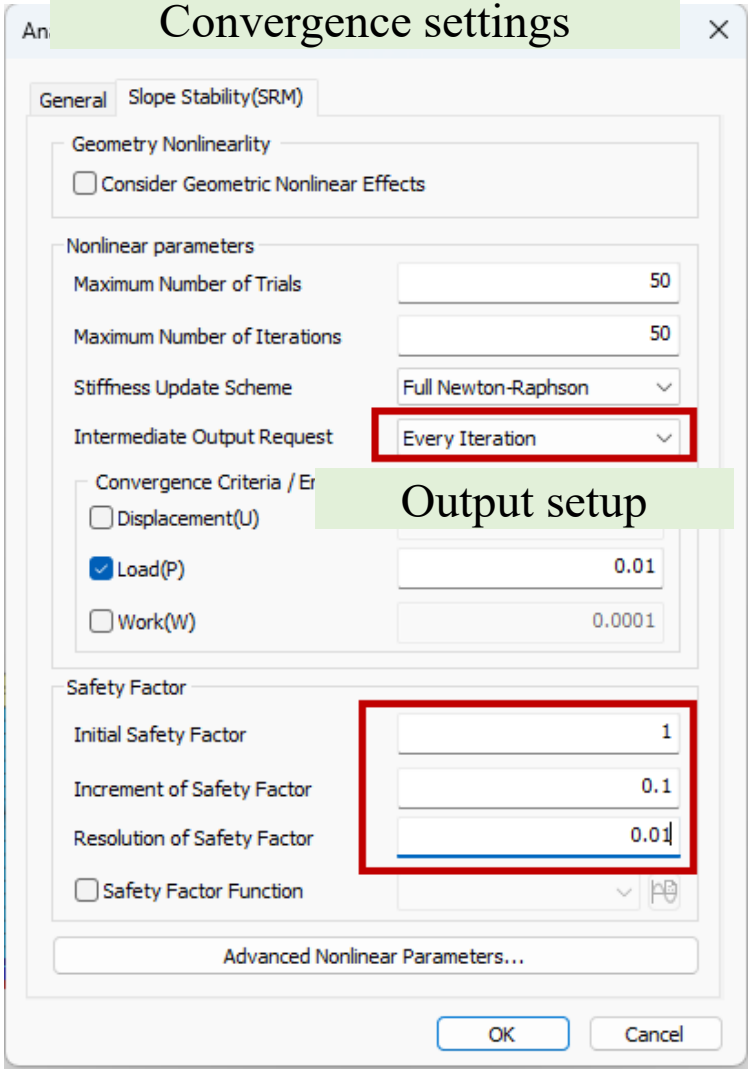
Seismic slope stability analysis:
Slope stability(SRM)



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

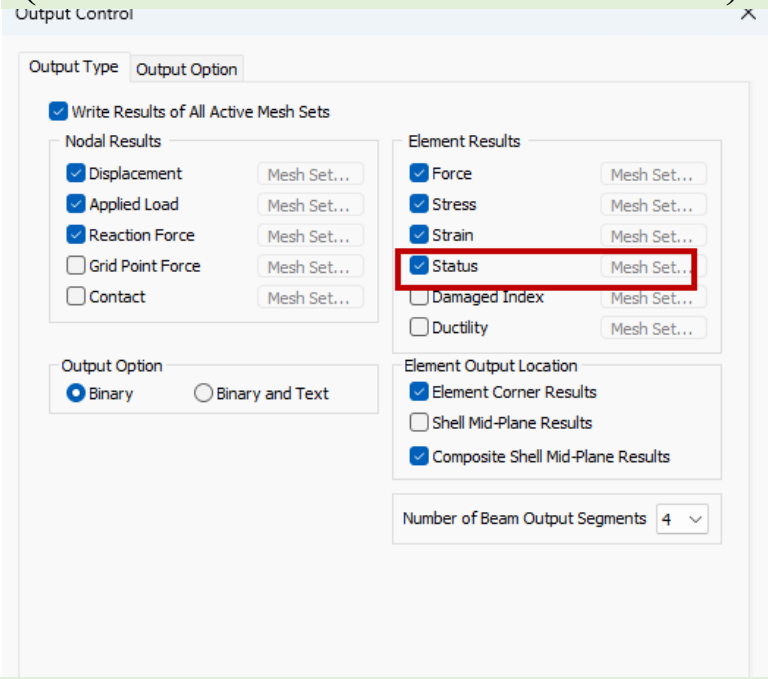
ANALYSIS 2 | PSEUDO-STATIC SEISMIC CASE

Convergence settings



Output setup

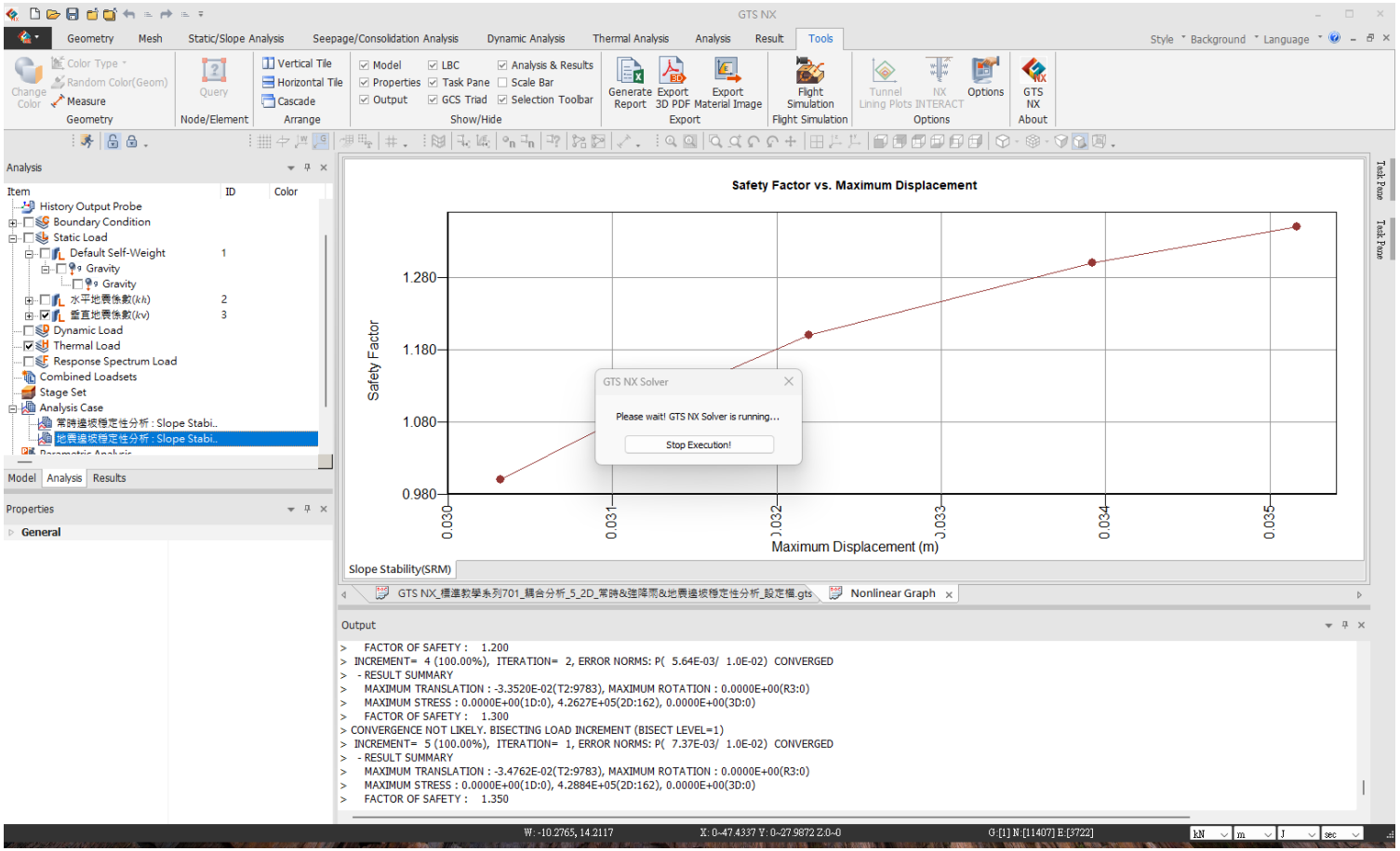
Output: Strain
(Shear strain indicates the failure arc)



SRM convergence adjustment

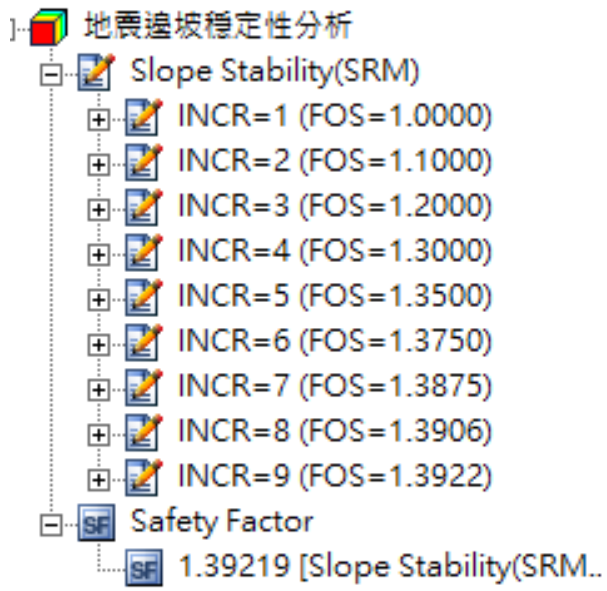
(1) Initial safety factor 1
(2) FOS increment by 0.1 each time
(3) Residual < 0.01, minimum FOS reached

CALCULATION



RESULTS | PSEUDO-STATIC SEISMIC CASE

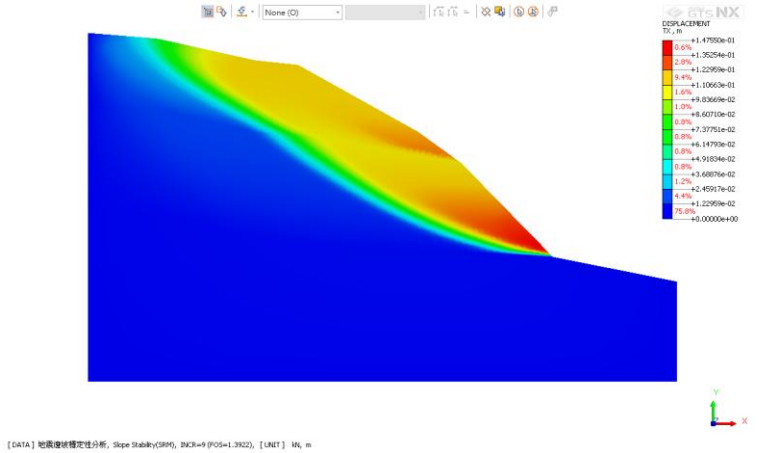
Pseudo-static seismic by k_h & k_v, FOS = 1.3922



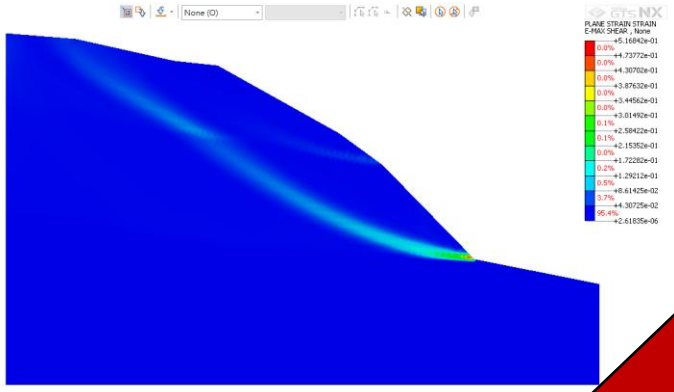
SRM for safety factor calculation

Failure surface indicated by horizontal displacement and maximum shear strain

Tx Translation(m)

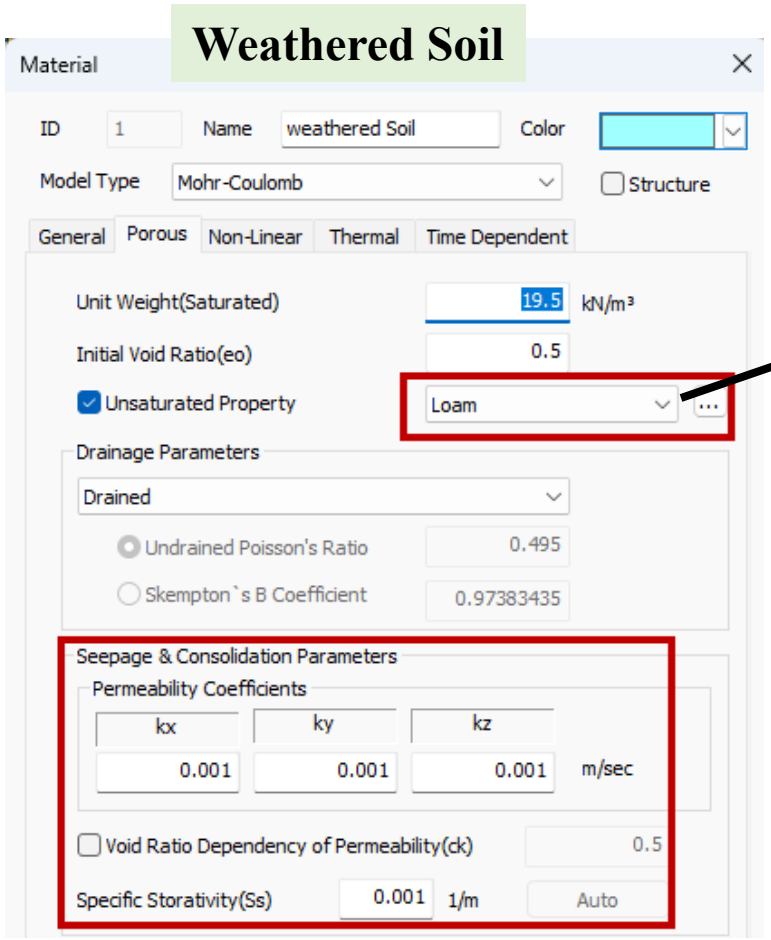


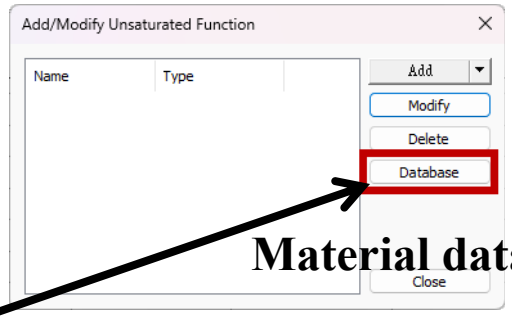
Maximum Shear Strain



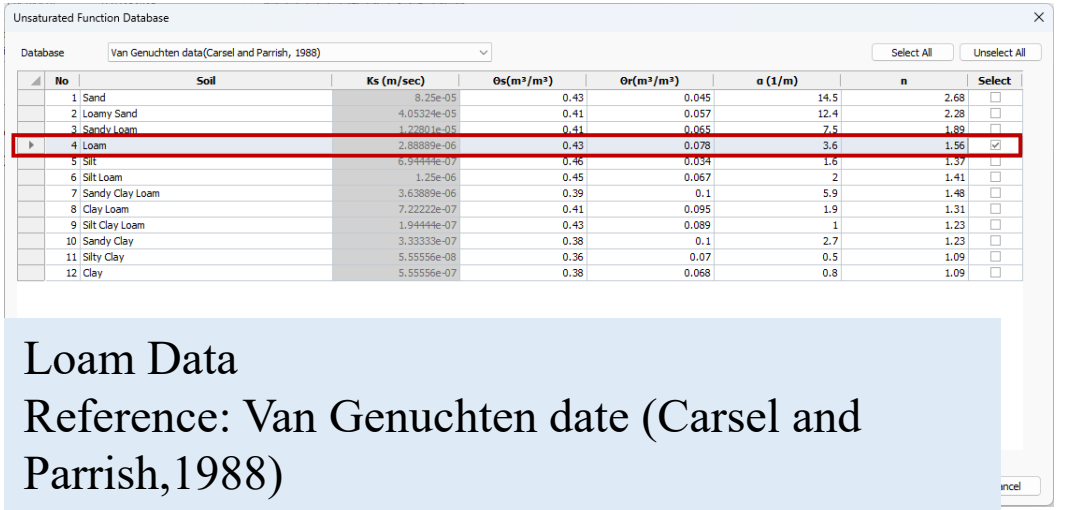
Part 3
HEAVY RAINFALL CASE

POROUS MATERIAL 1 | WEATHERED SOIL





Material database in GTS NX



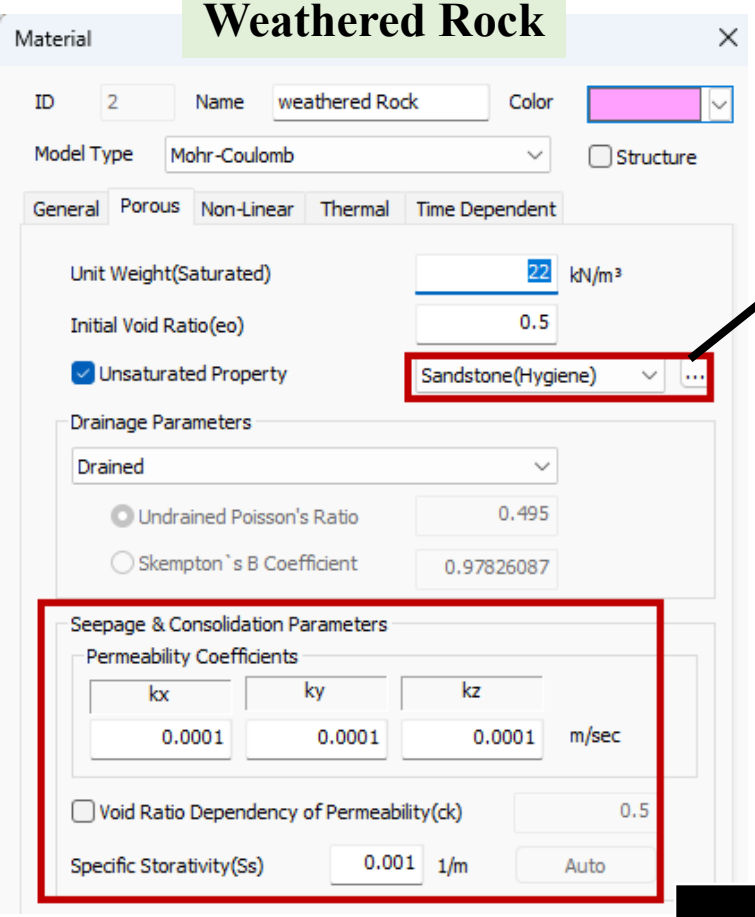
Loam Data
Reference: Van Genuchten date (Carsel and Parrish,1988)

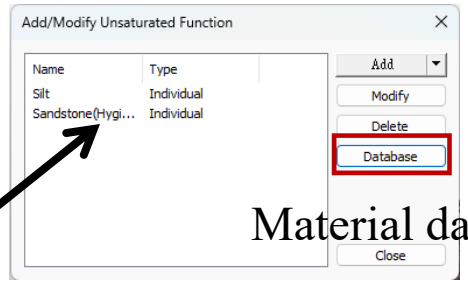
	Coefficient of permeability(K) (m/sec)	Specific Storativity(Ss) (1/m)
Weathered Soil	10^{-5} - 10^{-3}	10^{-6} - 10^{-3}

Note 1: The relevant parameters use assumed conditions.
Note 2: Unsaturated parameters are not defined in the seepage calculation process; the soil is treated as saturated.

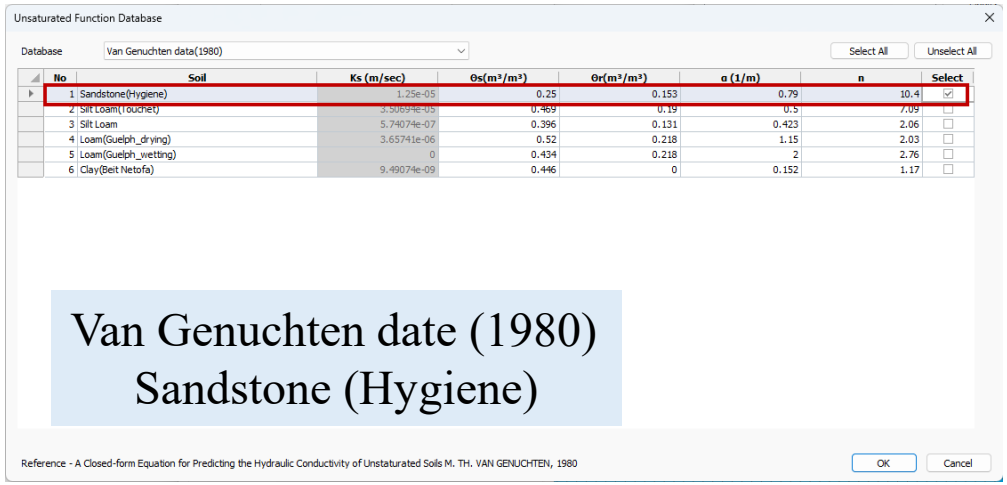
POROUS MATERIAL 2 | WEATHERED ROCK

Weathered Rock





Material database in GTS NX



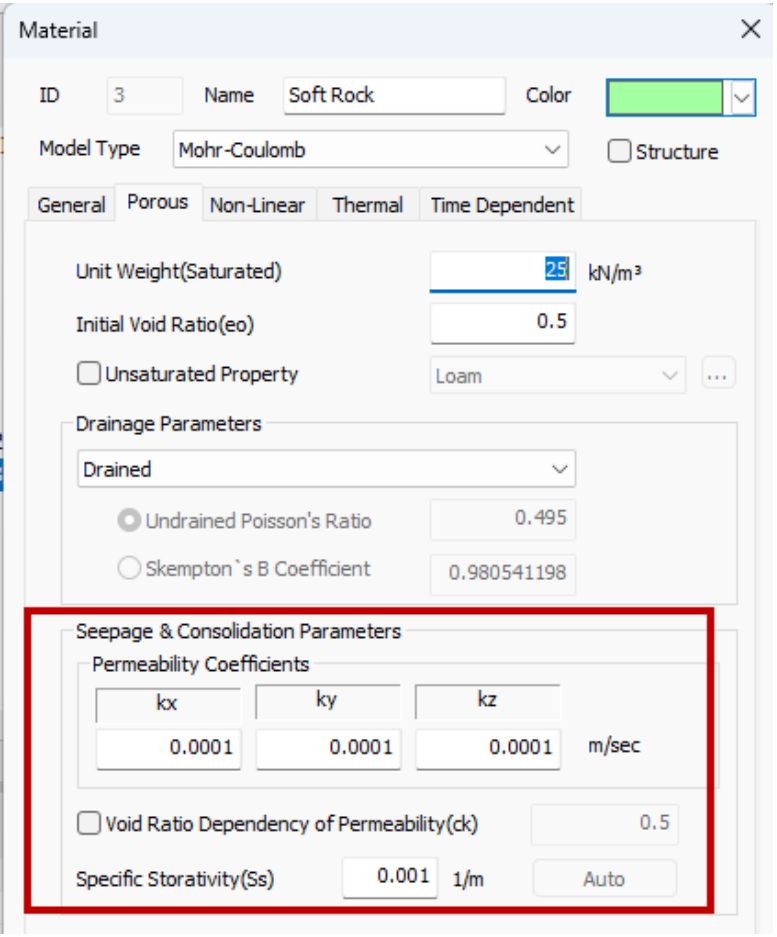
Van Genuchten date (1980)
Sandstone (Hygiene)

	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

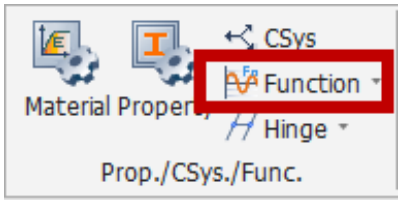


Flow of rainfall case does not calculate as saturated

	Coefficient of permeability(K) (m/sec)	Specific Storativity(Ss) (1/m)
Soft 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.

IN-SITU RECORDED RAINFALL | HOURLY RAINFALL



Unit (kn/m/J/hr)

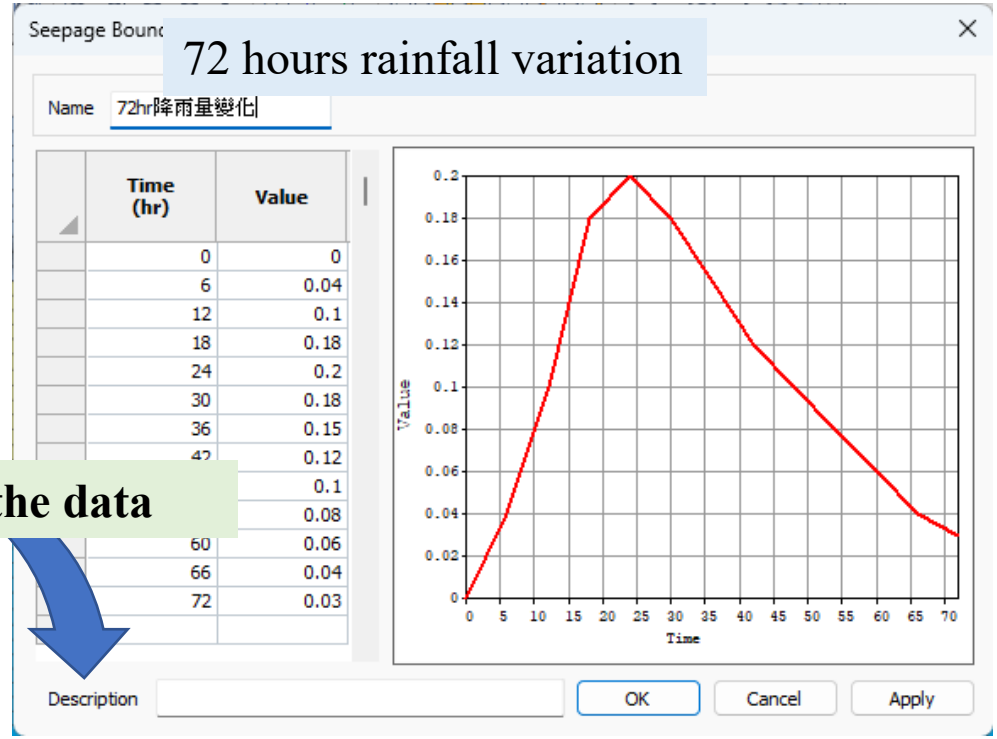
Seepage Boundary

Excel data

時間累計(hr)	每6小時降雨量 (m)
0	
6	
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

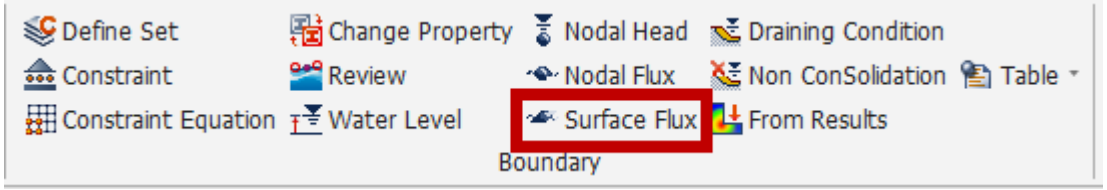
72 hours rainfall variation

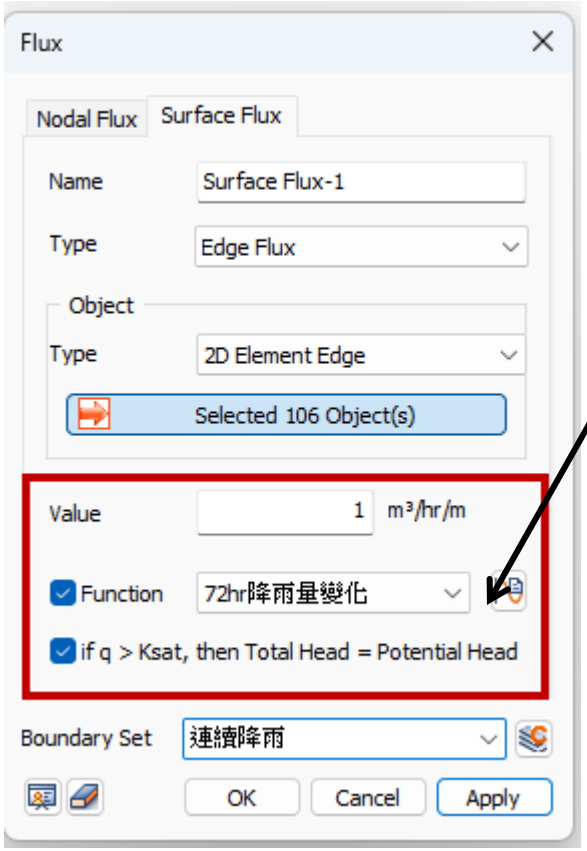


註:GTS NX不支援Y軸單位切換。

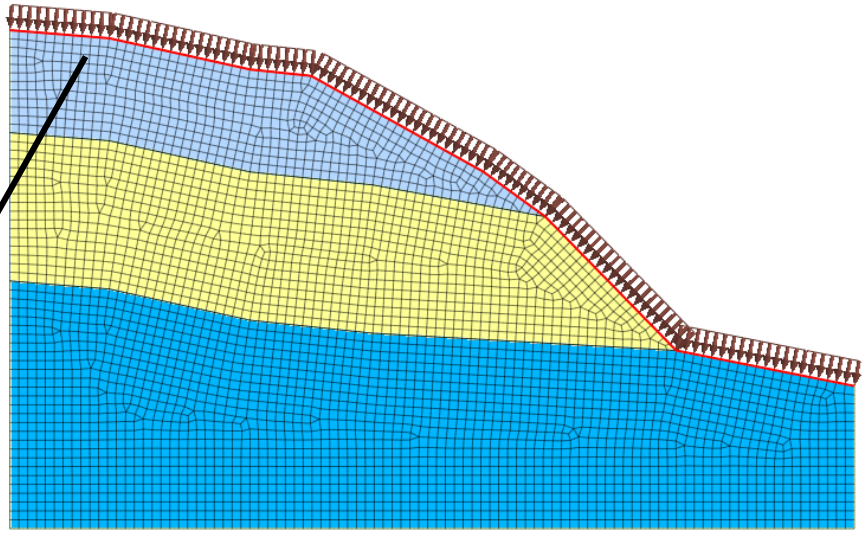
SURFACE FLUX

Seepage/Consolidation Analysis





Flux = Value × Function



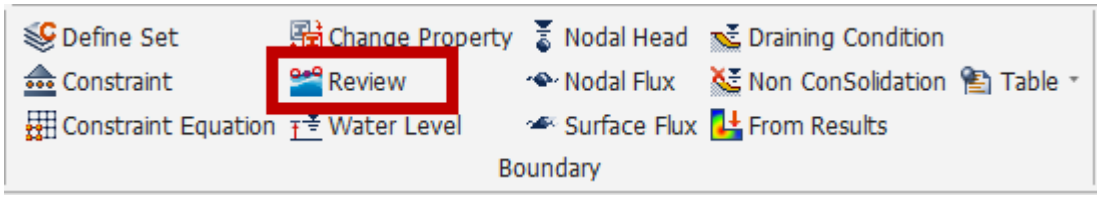
Setting:

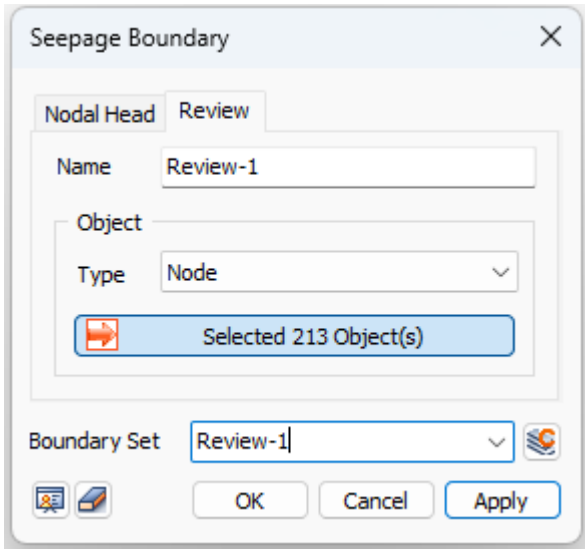
if surface flux > coefficient of permeability

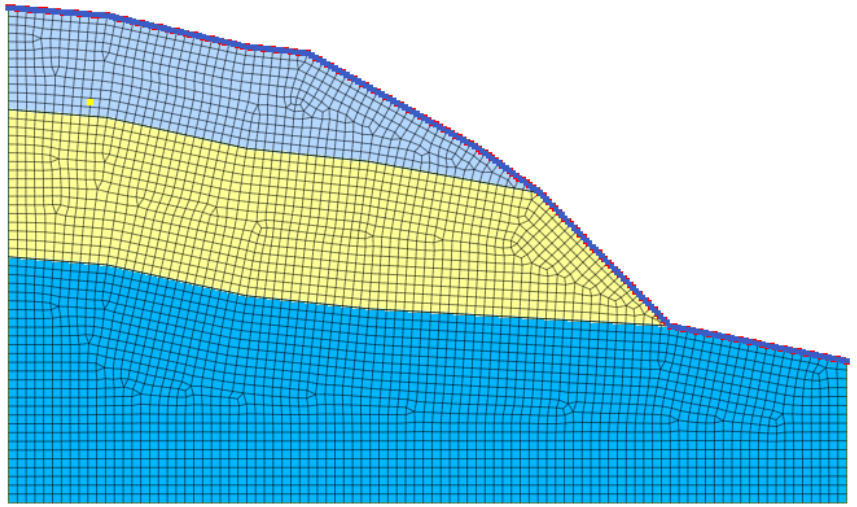
total head = potential head

REVIEW / SEEPAGE

Seepage/Consolidation Analysis







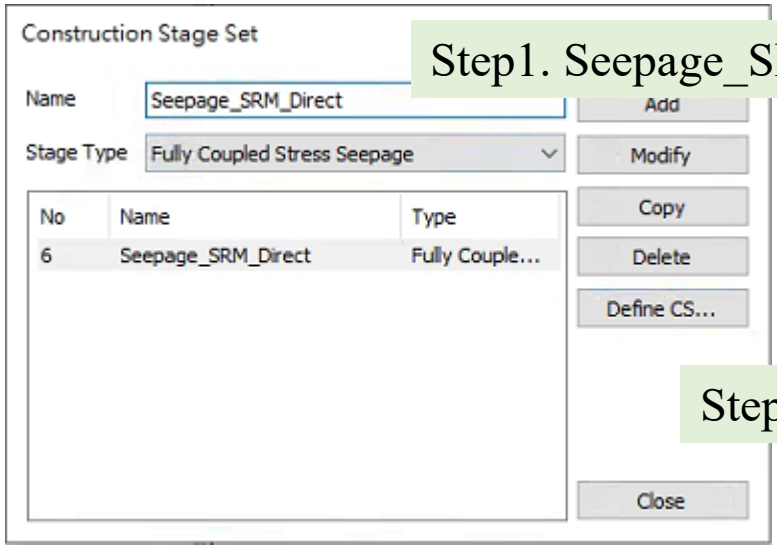
CONSTRUCTION STAGE 1 | PSEUDO-STATIC SEISMIC CASE

Construction phase types in GTS NX

Stress

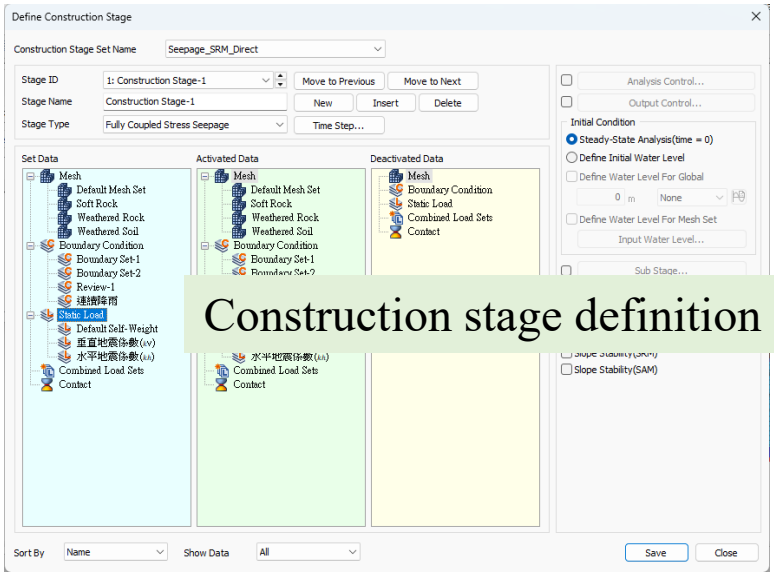
Fully Coupled Stress Seepage

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



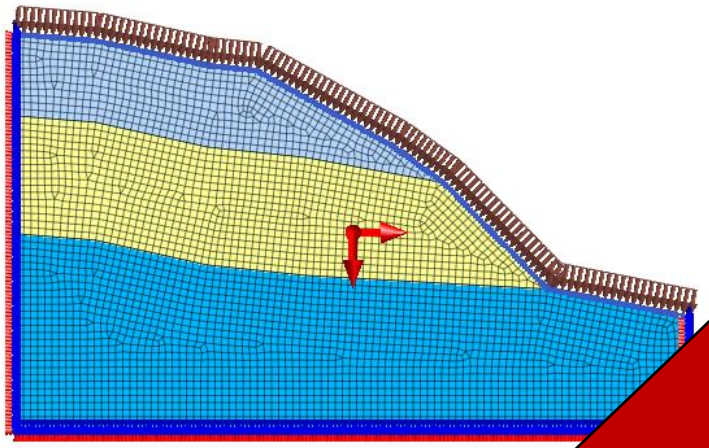
Step1. Seepage_SRM_Direct

Step2.Define CS

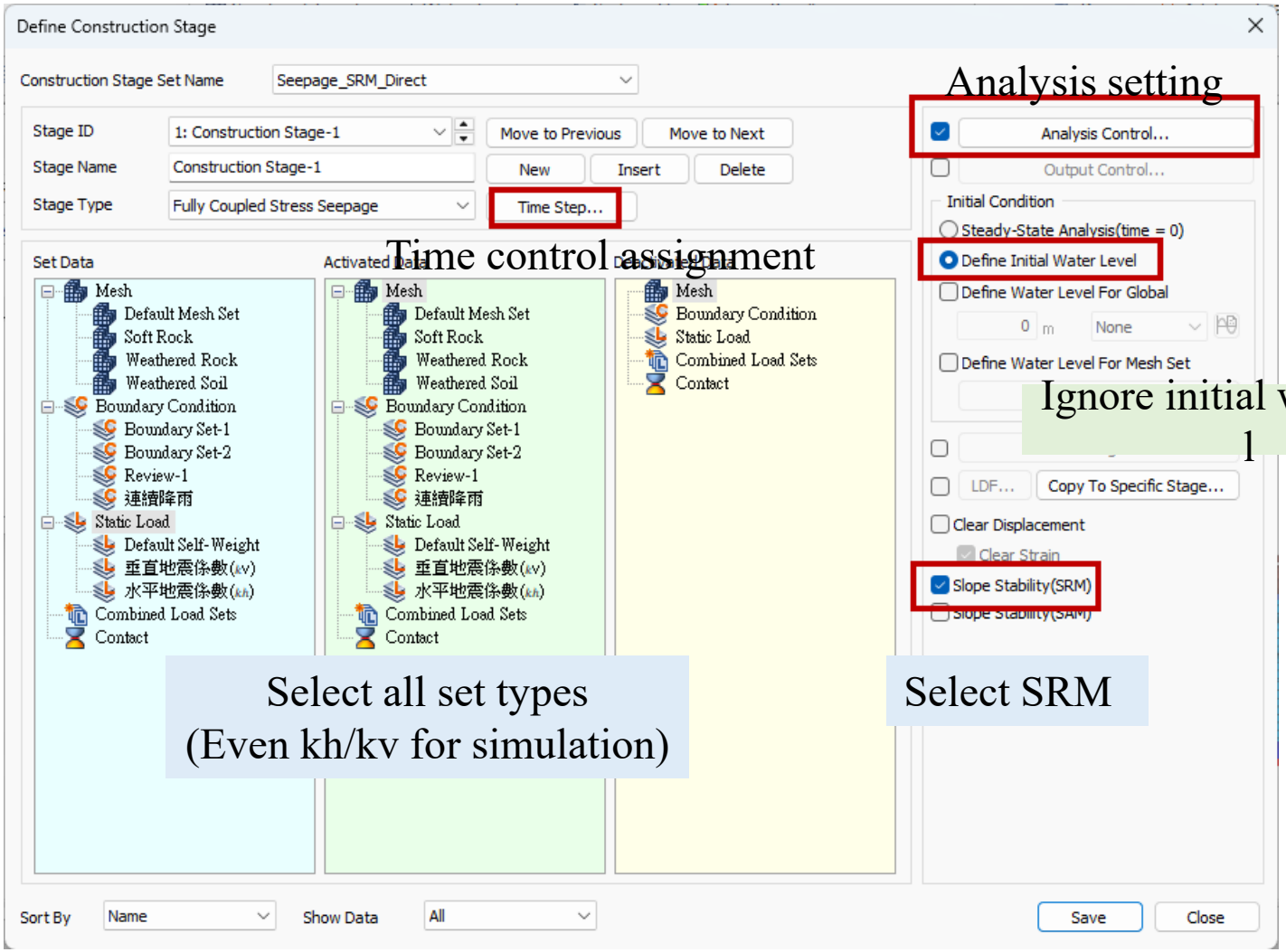


Construction stage definition

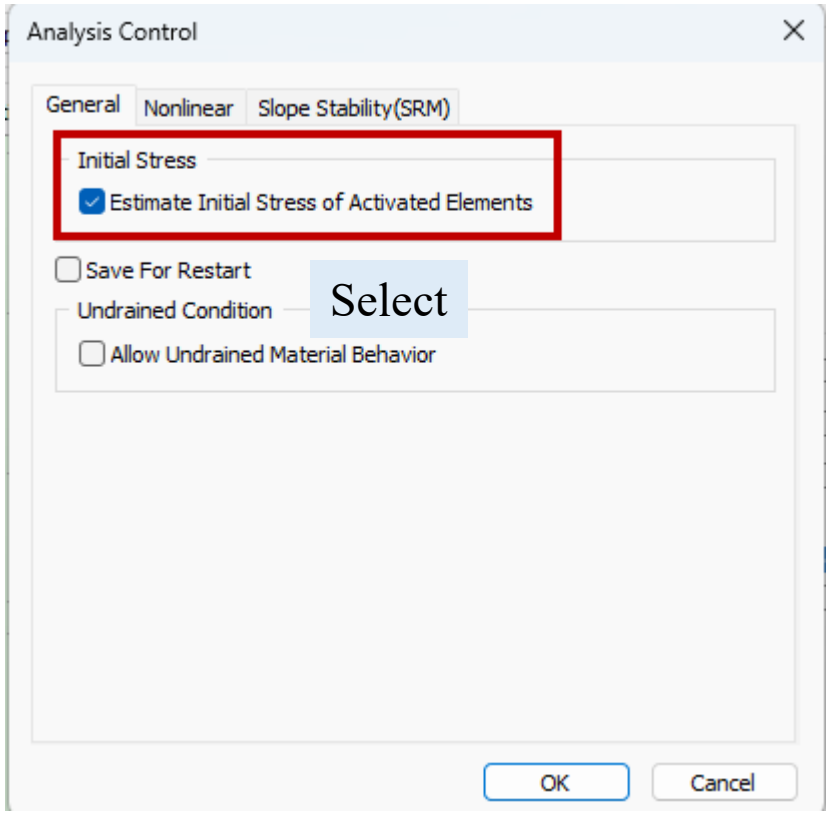
Activate all mesh sets/boundary sets

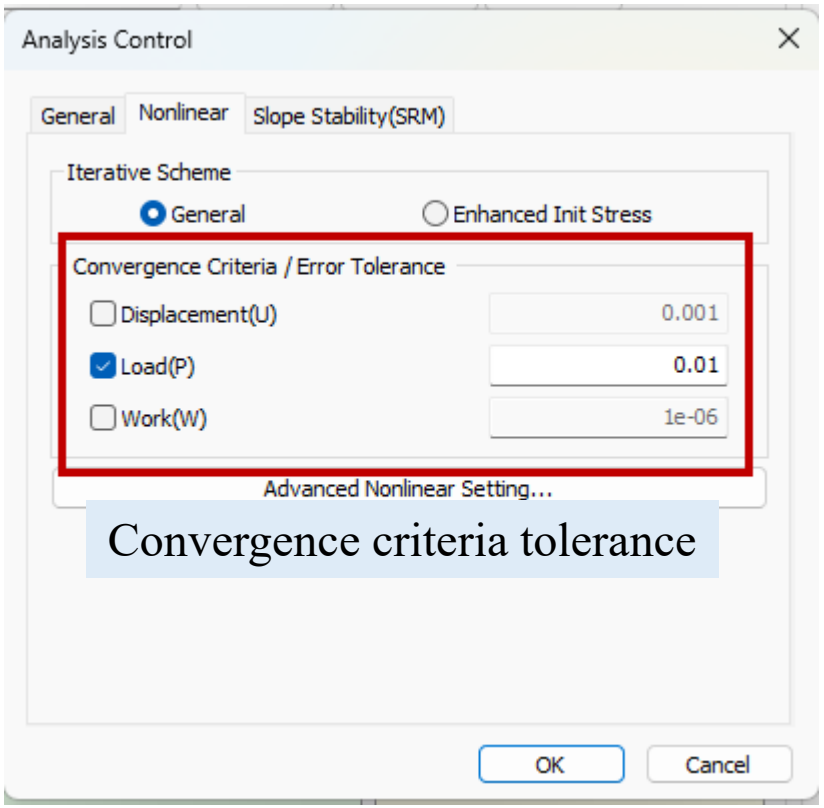


CONSTRUCTION STAGE 2 | FULLY COUPLED STRESS SEEPAGE



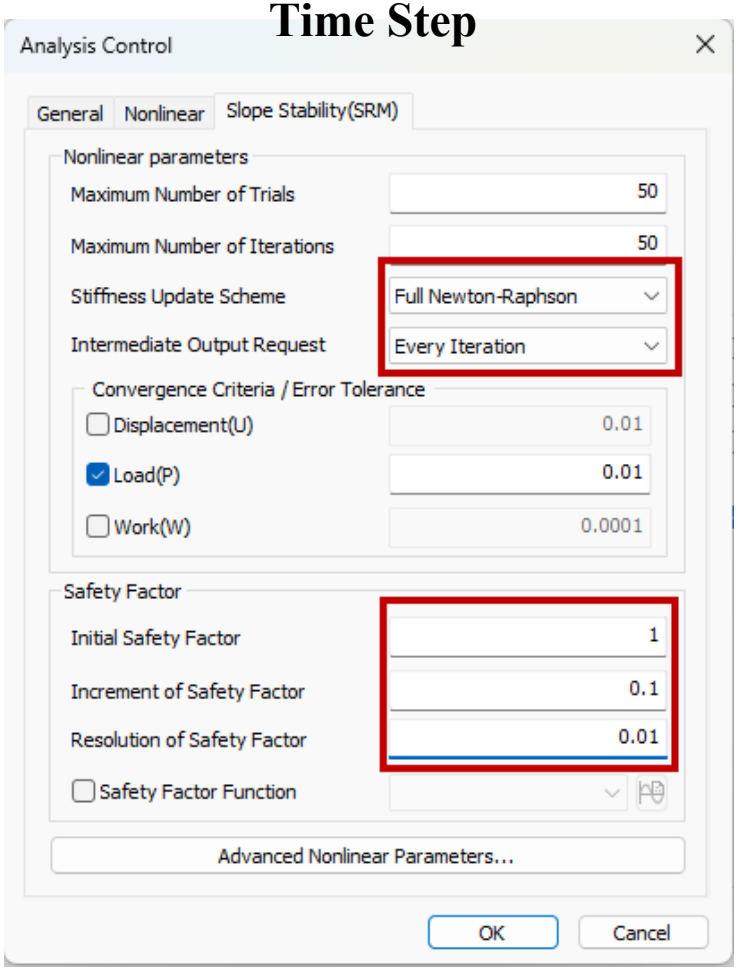
CONSTRUCTION STAGE 3 | ANALYSIS & CONTROL





CONSTRUCTION STAGE 4 | ANALYSIS CONTROL/ TIME CONTROL

Time Step

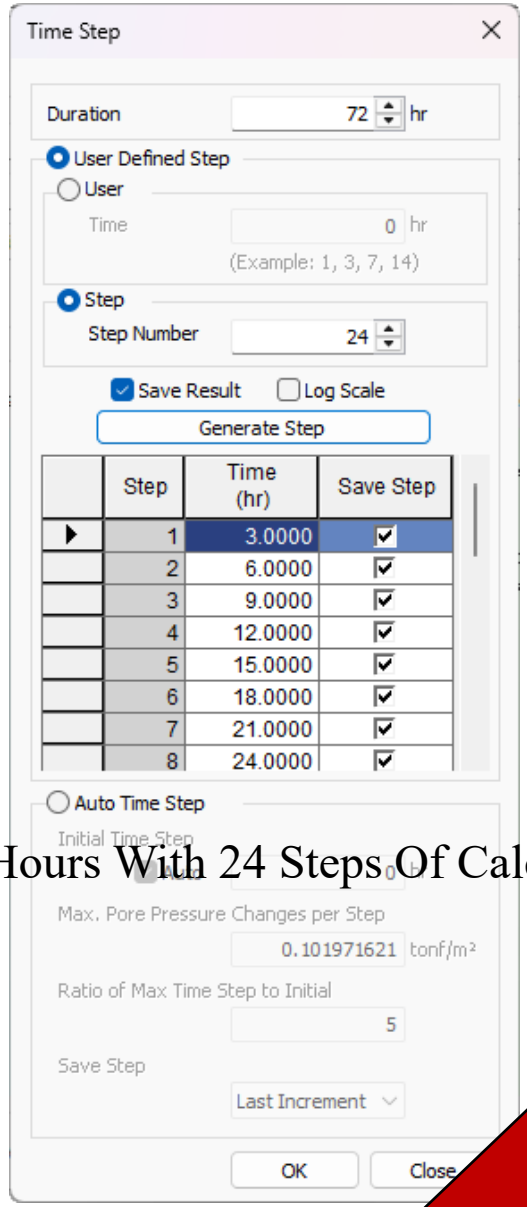


SRM convergence adjustment

(1) Initial safety factor 1

(2) FOS increment by 0.1 each time

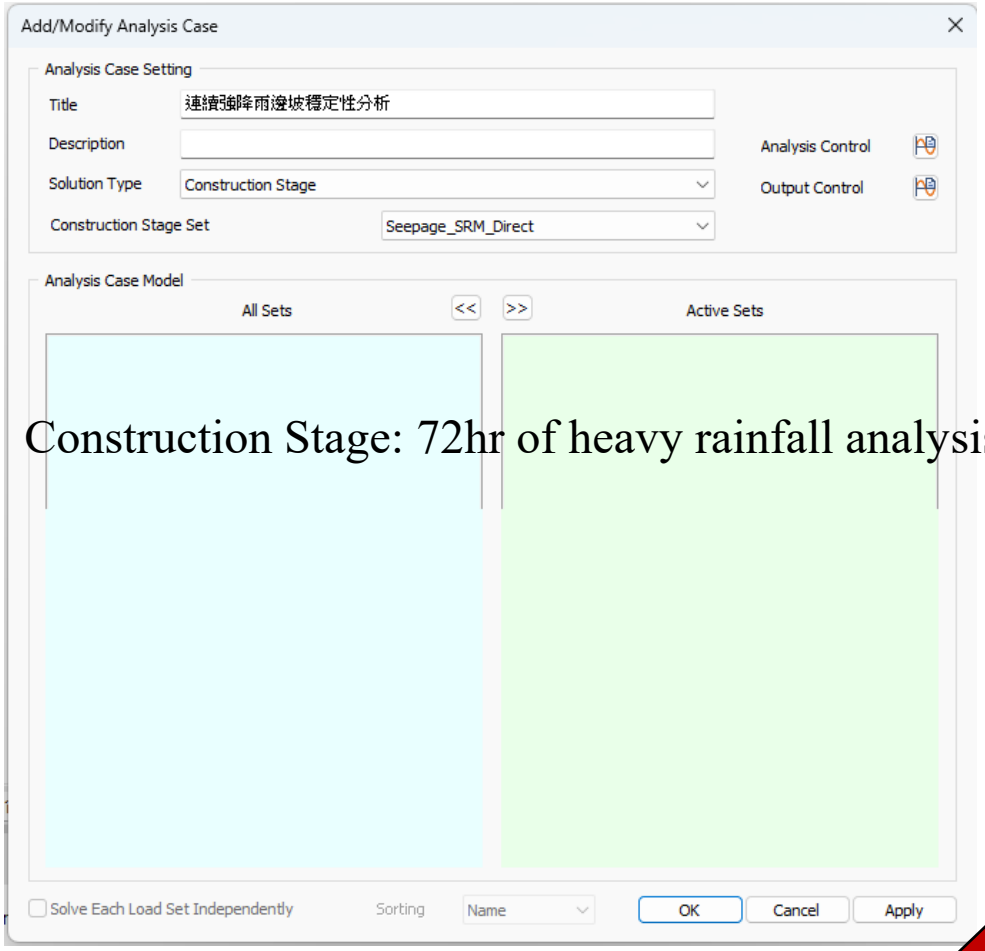
(3) Residual < 0.01, minimum FOS reached



72 Hours With 24 Steps Of Calculation

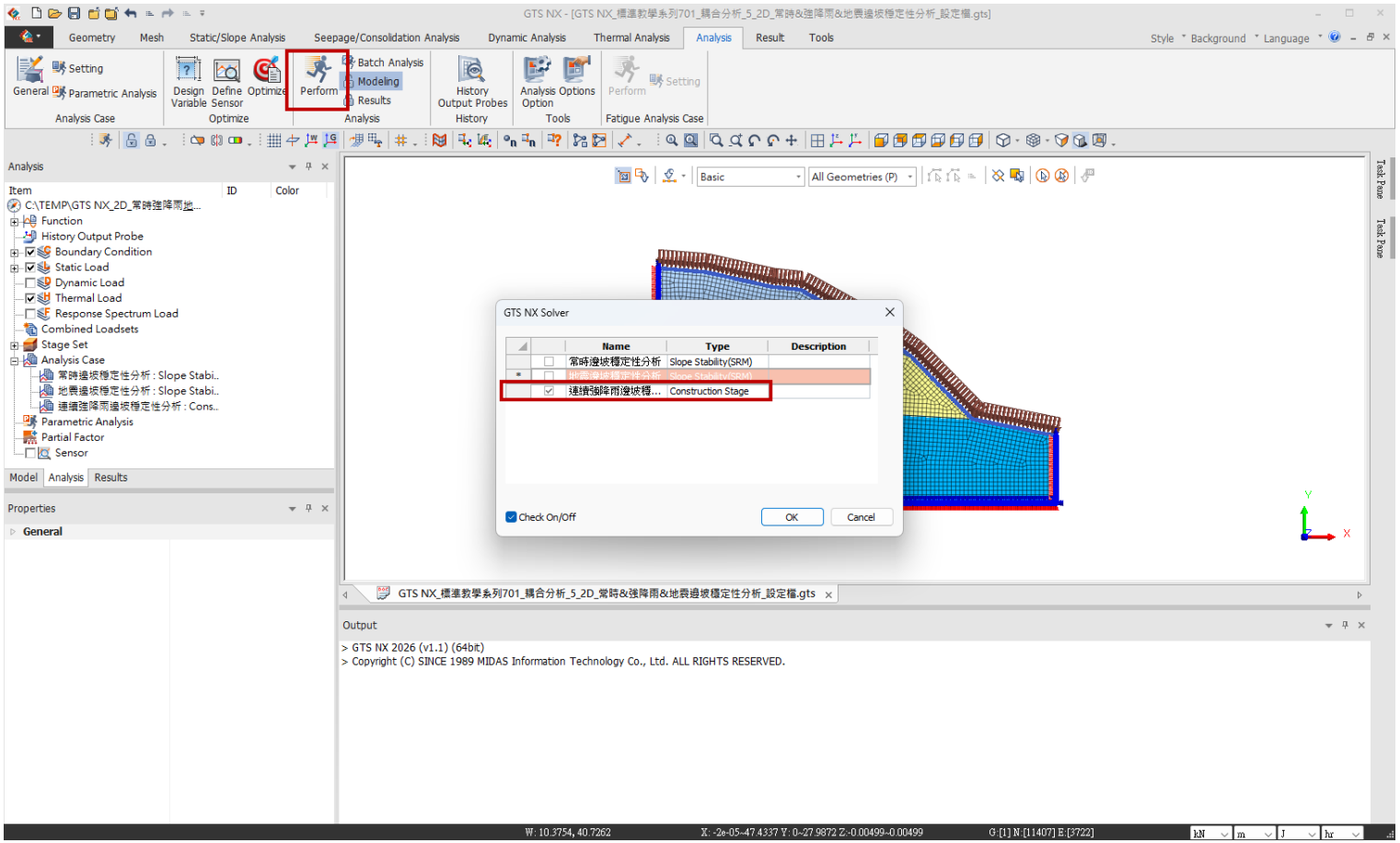
ANALYSIS | HEAVY RAINFALL CASE

Construction Stage



Construction Stage: 72hr of heavy rainfall analysis

CALCULATION



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

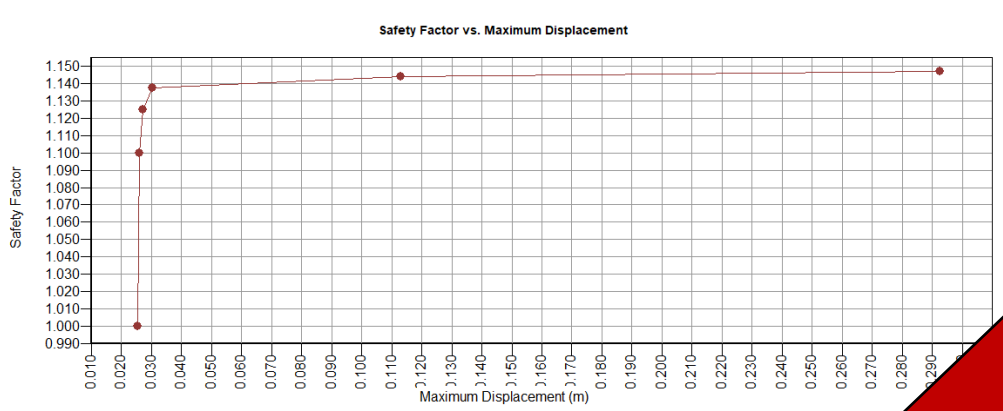
Each time step of calculation

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

- 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)

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)
- Safety Factor
  - 1.14688 [Construction



SRM analysis results

ANALYSIS RESULTS | HEAVY RAINFALL CASE

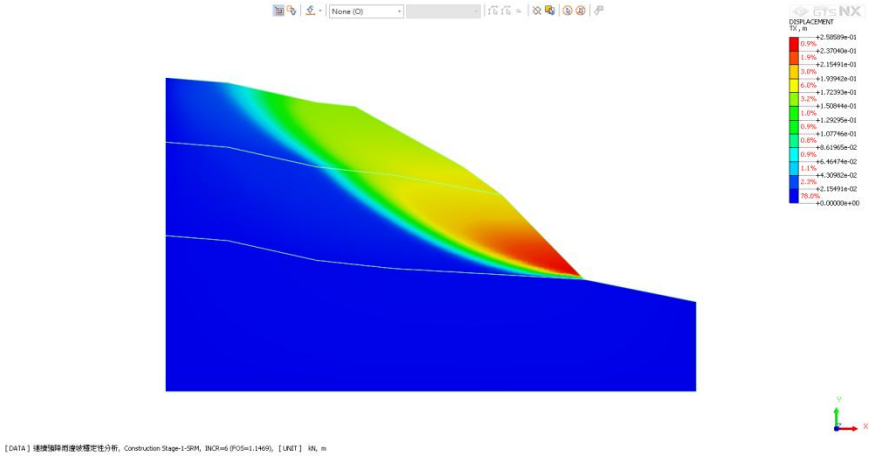
Heavy rainfall simulation, FOS = 1.1469

- 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

Failure surface indicated by horizontal displacement & maximum shear strain

Tx Translation(m)



Maximum Shear Strain