GTS NX

Heavy rainfall during deep excavation nearby a river channel
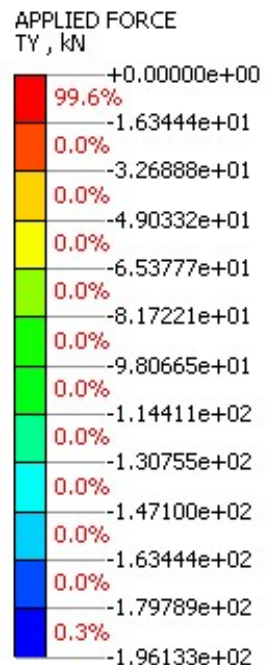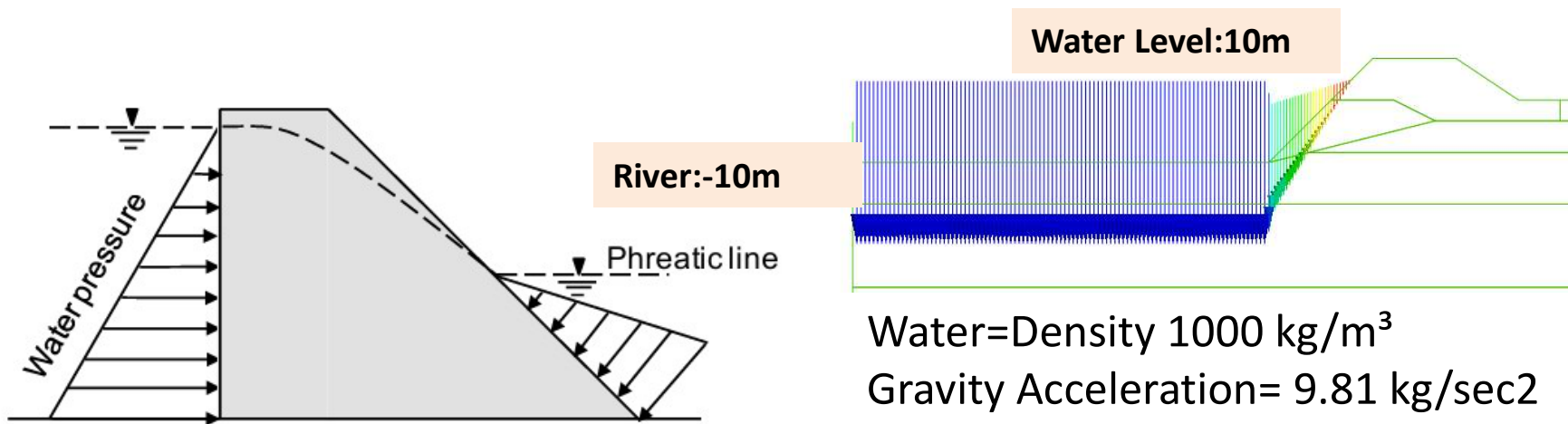
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Water Pressure

GTS NX can consider water pressure that occurs from the defined water level of a model. Water pressure is added as an edge pressure load for 2D problems and as a surface pressure load for 3D problems.

The pressure size needed for calculating the water pressure is determined as follows:

1. Same size as the pore pressure defined on the target edge/surface ($Z_{coordinate}$)
2. Hydrostatic pressure due to user input water level position , ($Z_{water Level}$)

$$P = \rho \times g \times (Z_{water Level} - Z_{coordinate}) = \mathbf{196.2(KPa) = 196.2(KN/m^2)}$$

Water Level:10m

River:-10m

Phreatic line

Water pressure

Water=Density 1000 kg/m³
Gravity Acceleration= 9.81 kg/sec2

APPLIED FORCE
TY , kN

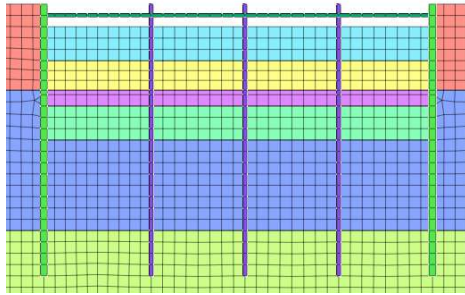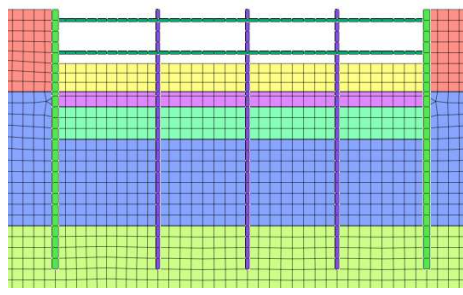|	
99.6%	+0.00000e+00
0.0%	-1.63444e+01
0.0%	-3.26888e+01
0.0%	-4.90332e+01
0.0%	-6.53777e+01
0.0%	-8.17221e+01
0.0%	-9.80665e+01
0.0%	-1.14411e+02
0.0%	-1.30755e+02
0.0%	-1.47100e+02
0.0%	-1.63444e+02
0.0%	-1.79789e+02
0.3%	-1.96133e+02

Reference
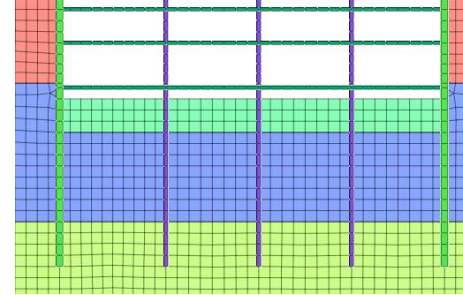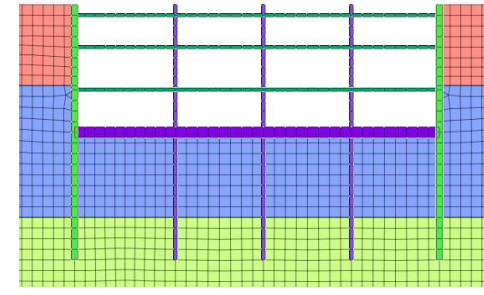GTS NX_Analysis Reference_Chapter6_LoadConstraint
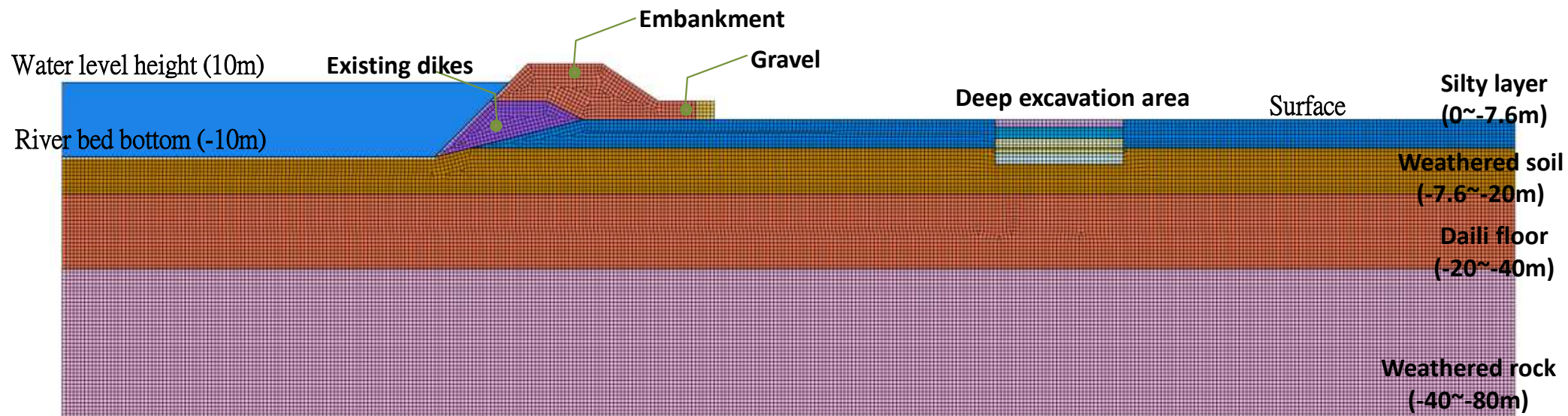
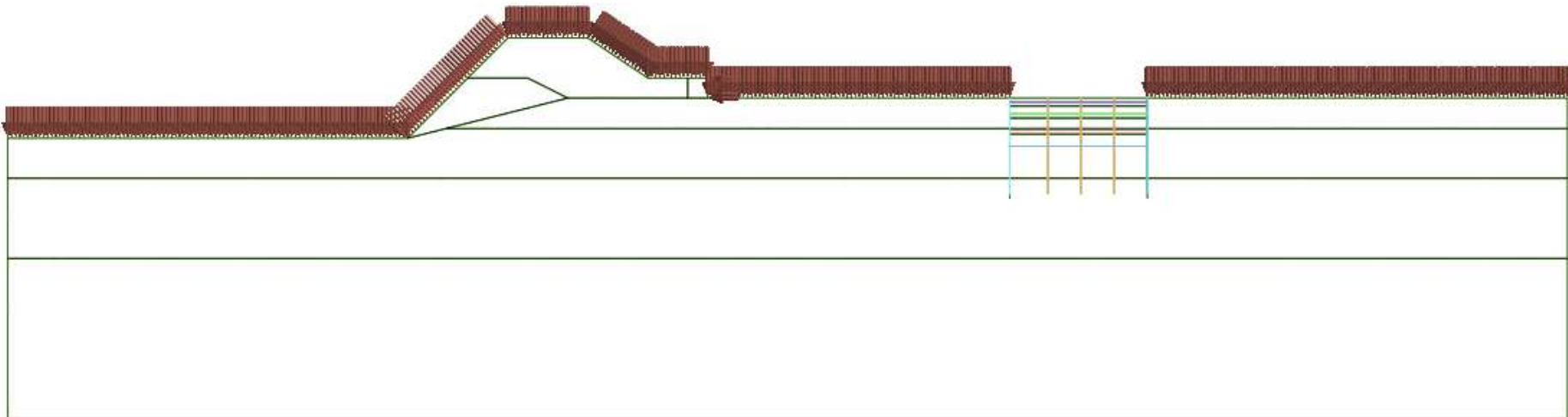# Explanation-1

Stage 1   Stage 2   Stage 3   Stage 4

Water Pressure

Water level height (10m)

Existing dikes

Embankment

Gravel

River bed bottom (-10m)

Deep excavation area   Surface

Silty layer (0~-7.6m)

Weathered soil (-7.6~-20m)
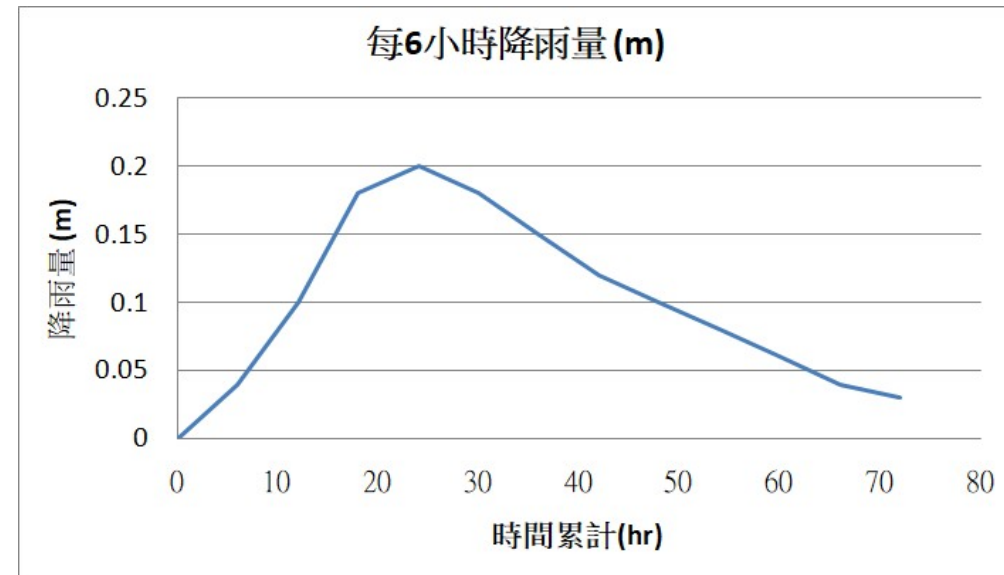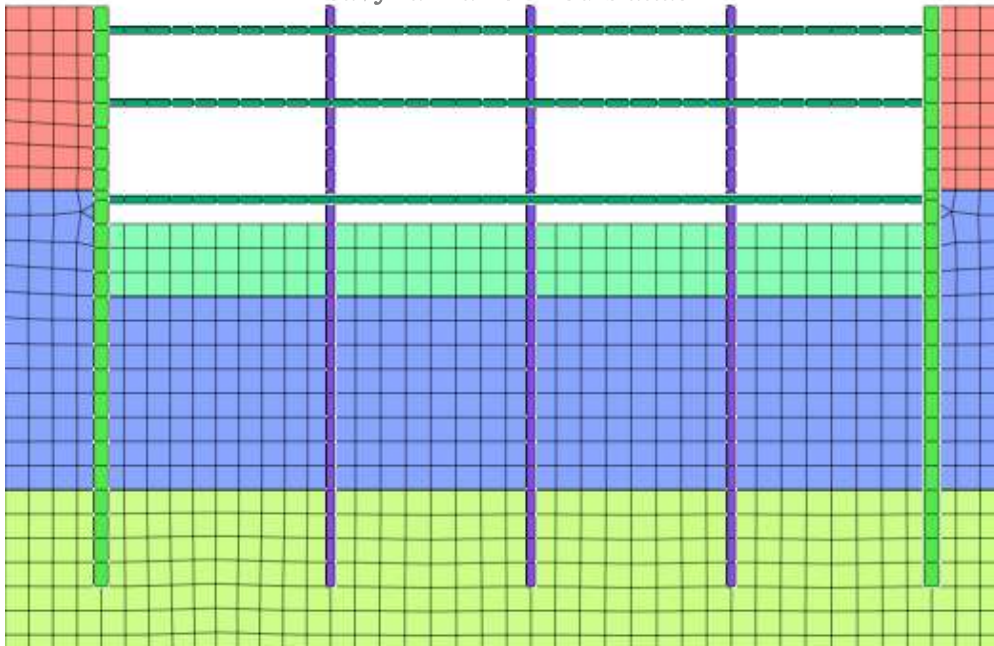
Daili floor (-20~-40m)

Weathered rock (-40~-80m)
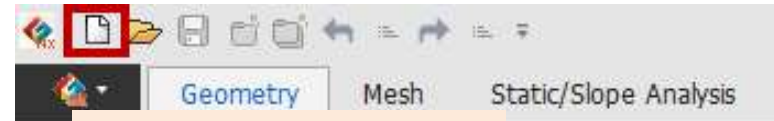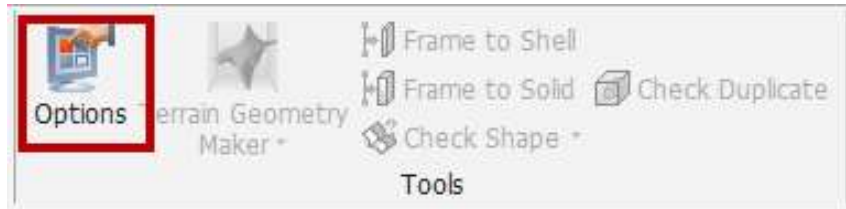
Explanation-2
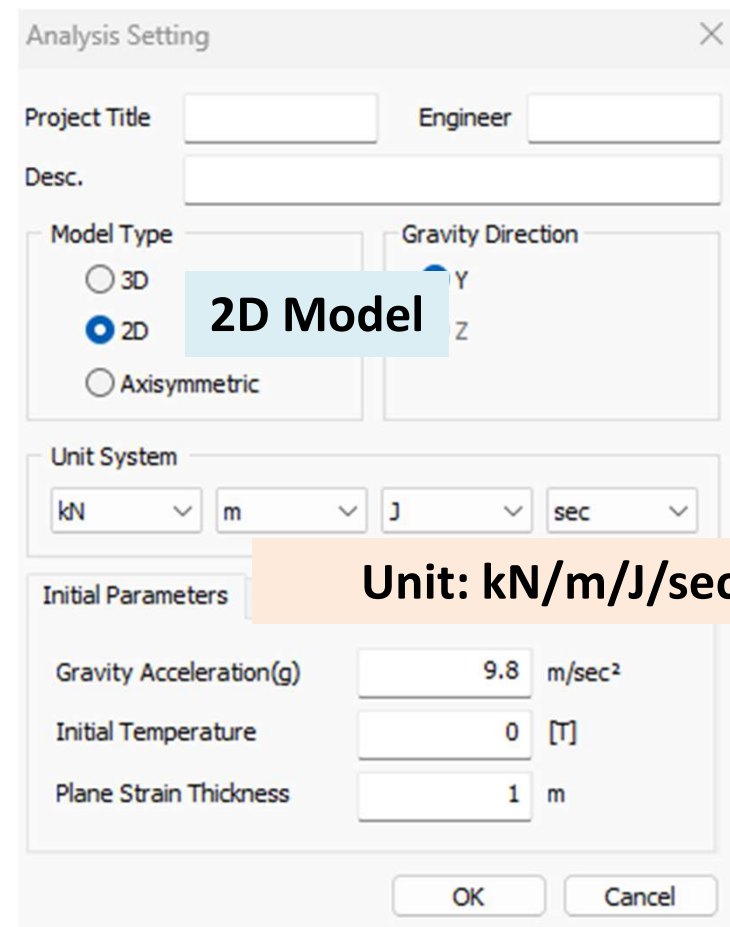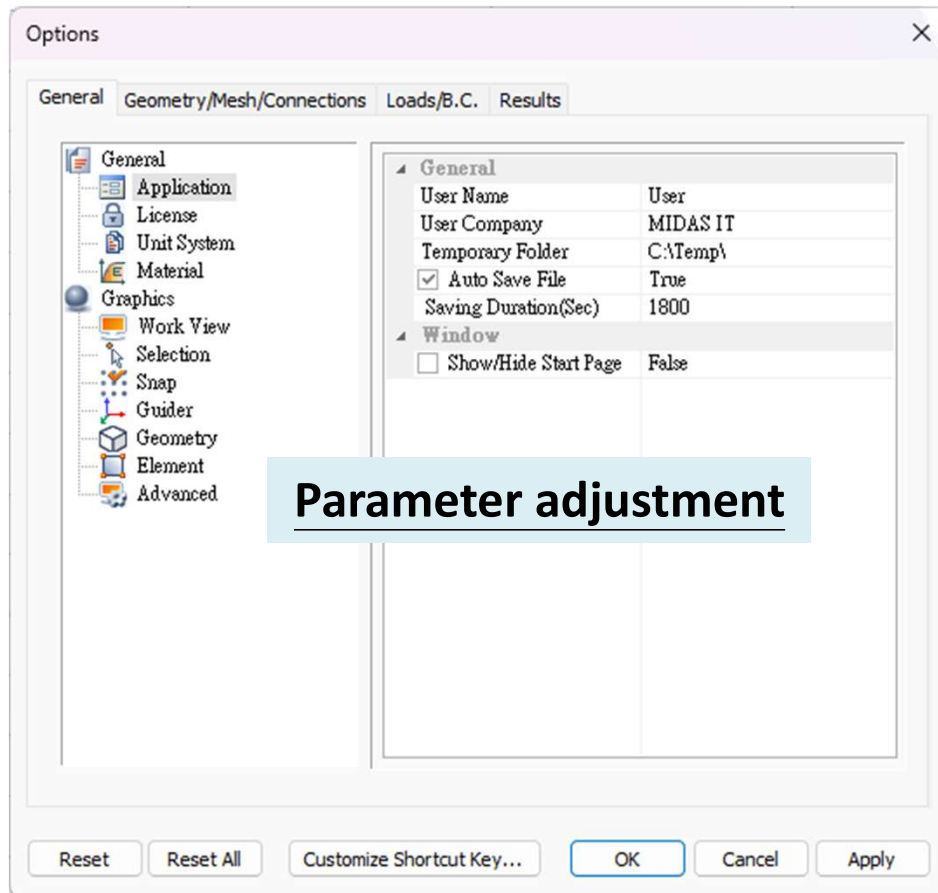
Before stage 3 of excavation

Heavy rainfall 72 hours attack

每6小時降雨量 (m)
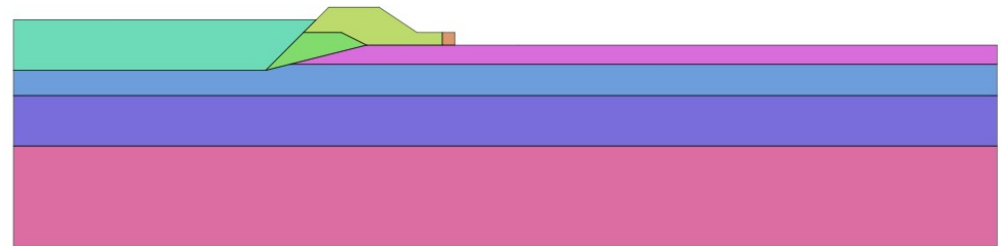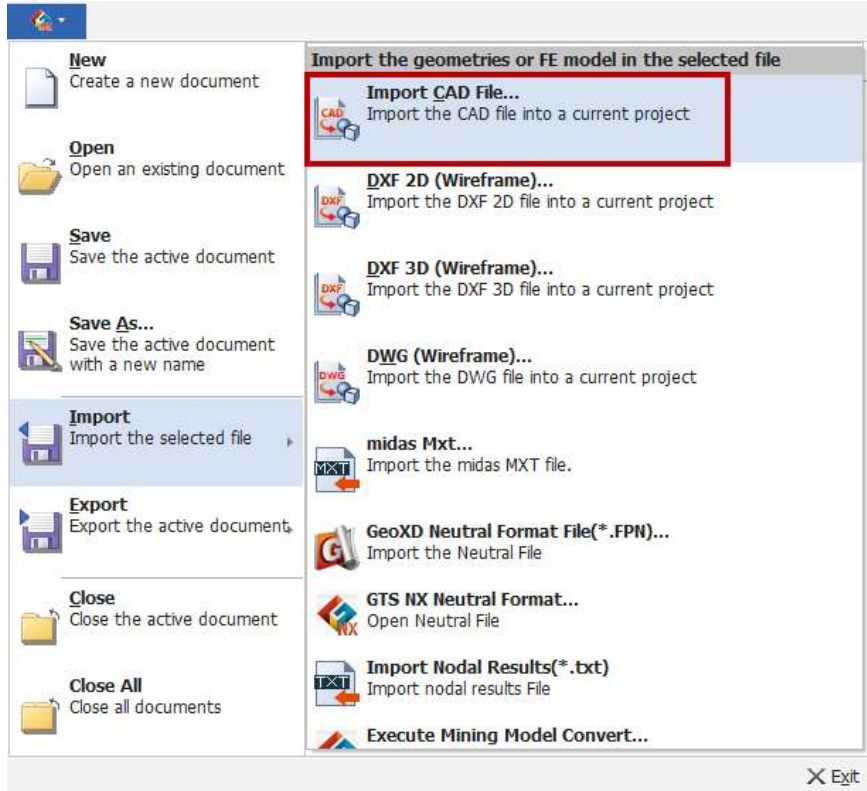
Part1. Geometry

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Import

New document

Parameter adjustment

2D Model

Unit: kN/m/J/sec

Import

Surface merging

Solid **Surface** Solid Surface

Boolean | Divide

Selecting all

Boolean ✕

Fuse | Sew | Cut | Common | Embed

Selected 8 Surface(s)

☐ Merge Faces

OK | Cancel | Apply
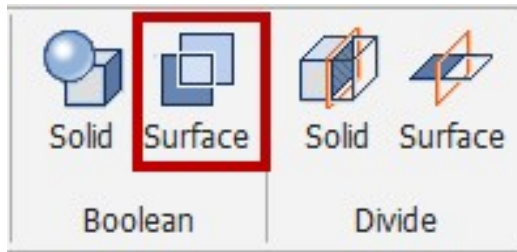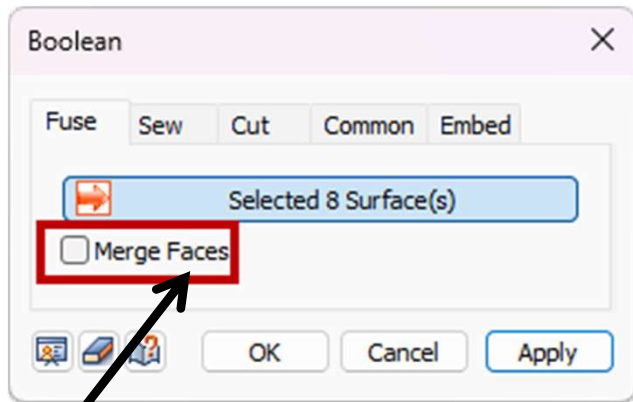
Do not tick
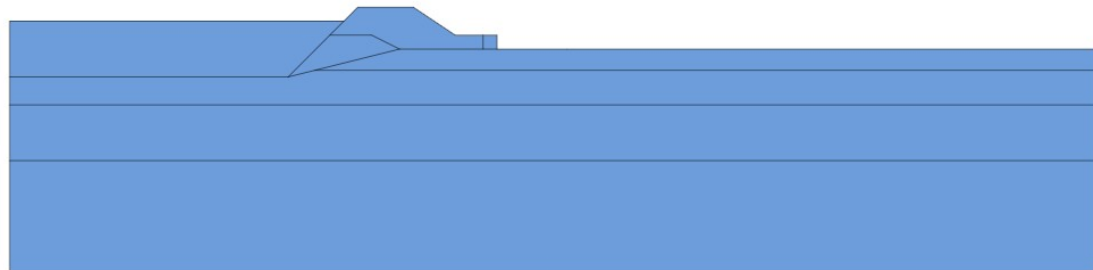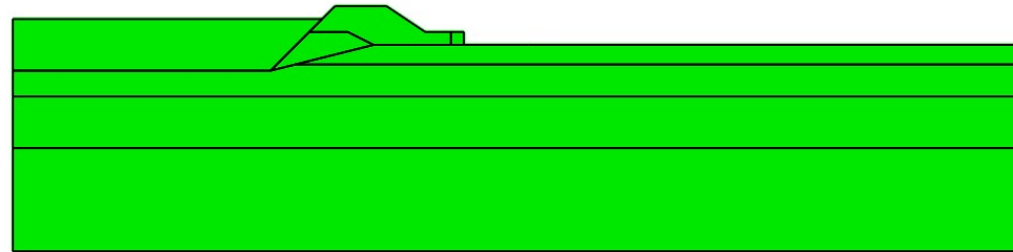
Import excavation area
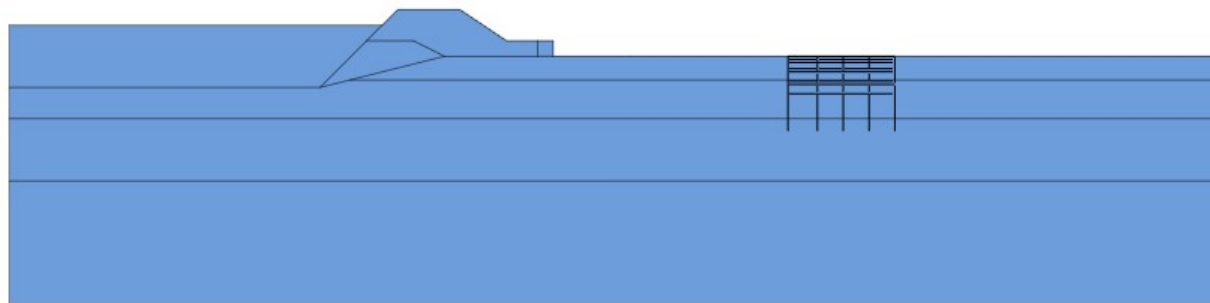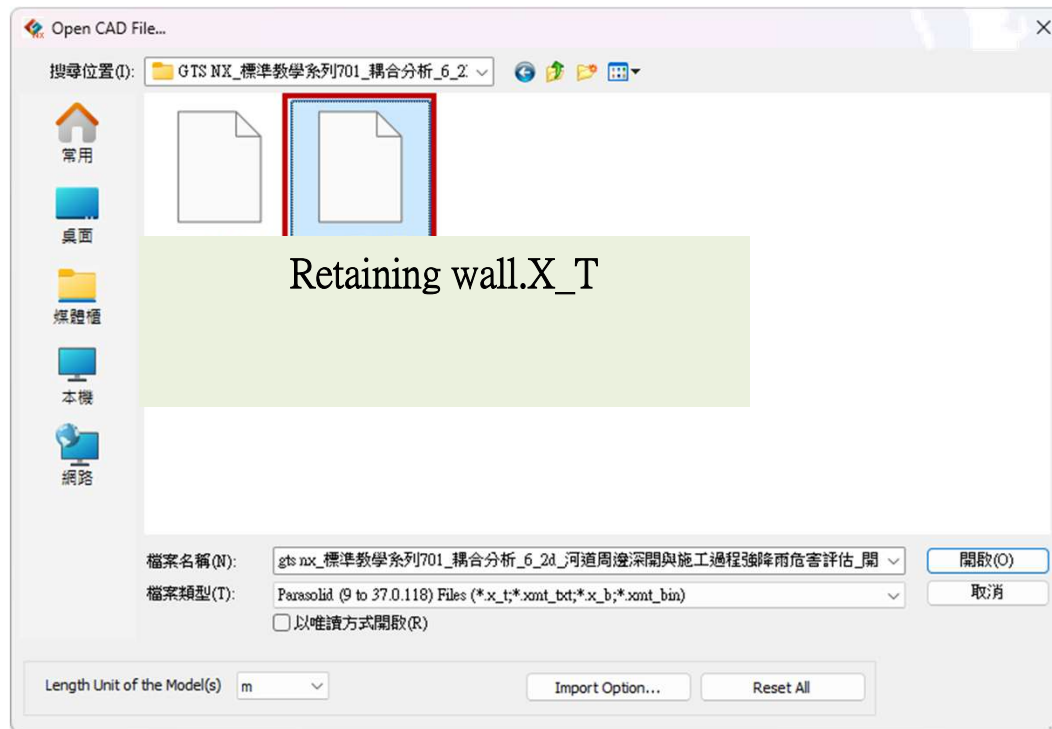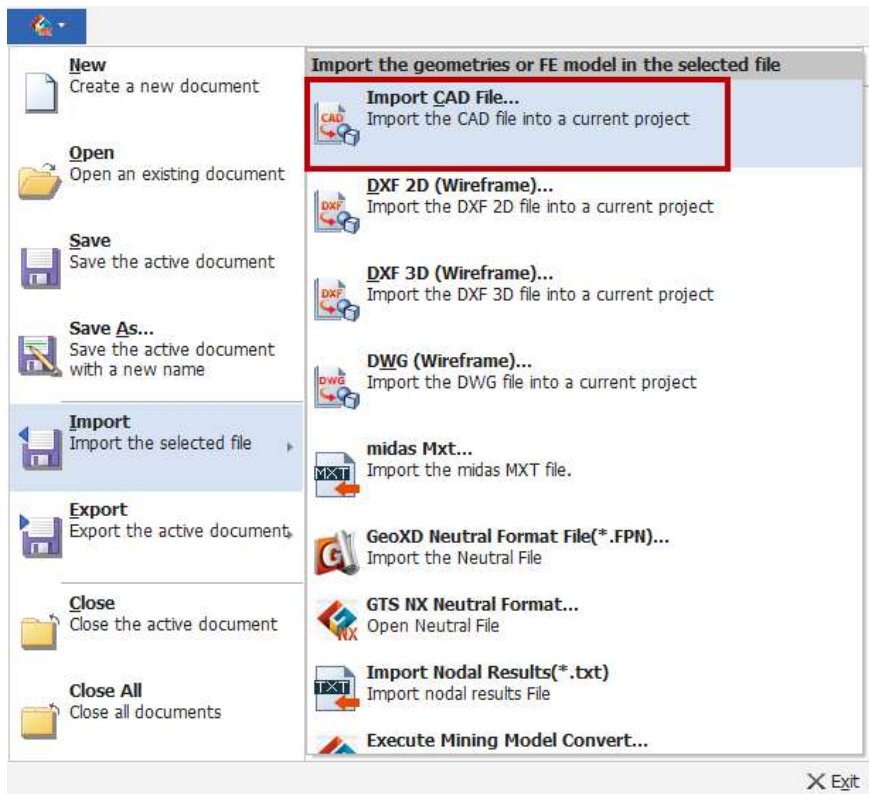
Imprint

Target Object: All surfaces

Tool Object: Excavation zone

Shortest path line selected
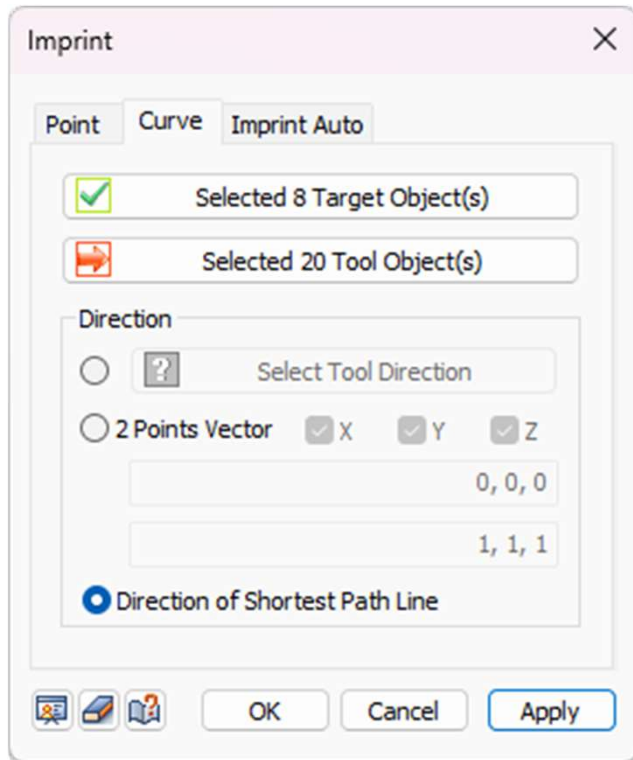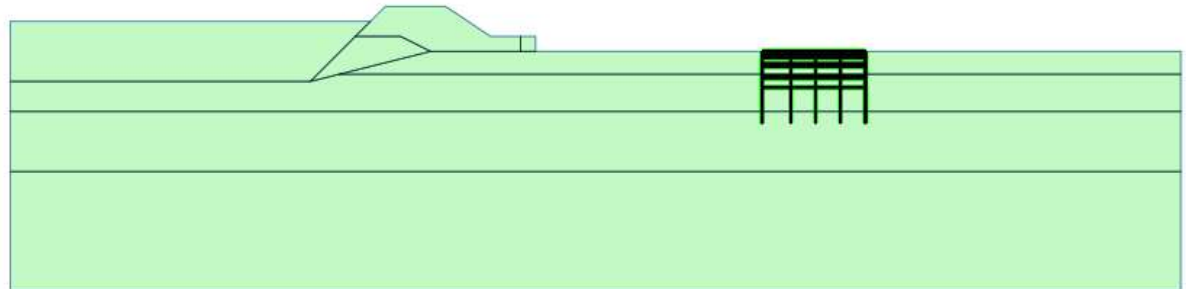
Delete curves
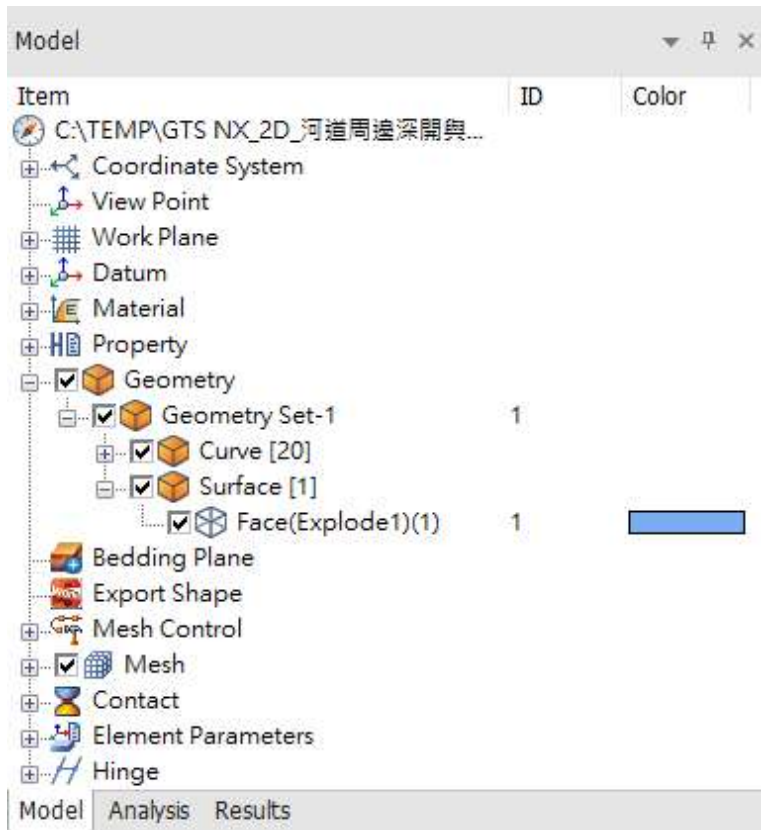
Step1.Excavation curves
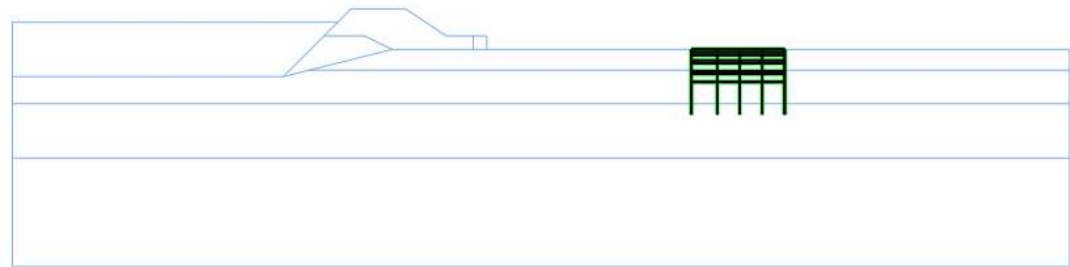
Step2. DELETE
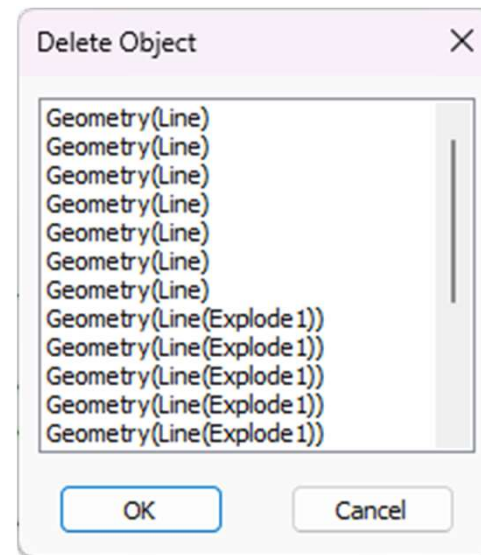
Part2. Soil Property

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Soil Layer Distribution

Water Pressure

Water level height (10m) **Existing dikes** **Embankment**

Gravel

River bed bottom (-10m) **Deep excavation area** Surface **Silty layer (0~-7.6m)**

Weathered soil (-7.6~-20m)

Daili floor (-20~-40m)

Weathered rock (-40~-80m)
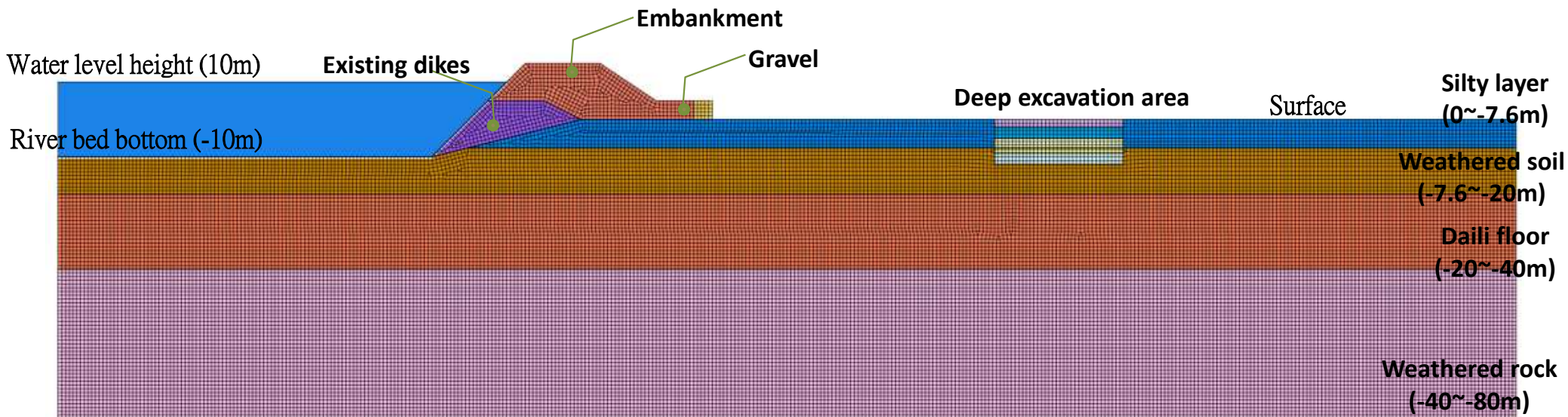
Property Import

Import: 選擇_河道周邊深開與施工過程
強降雨危害評估_MAT&PROP.gts
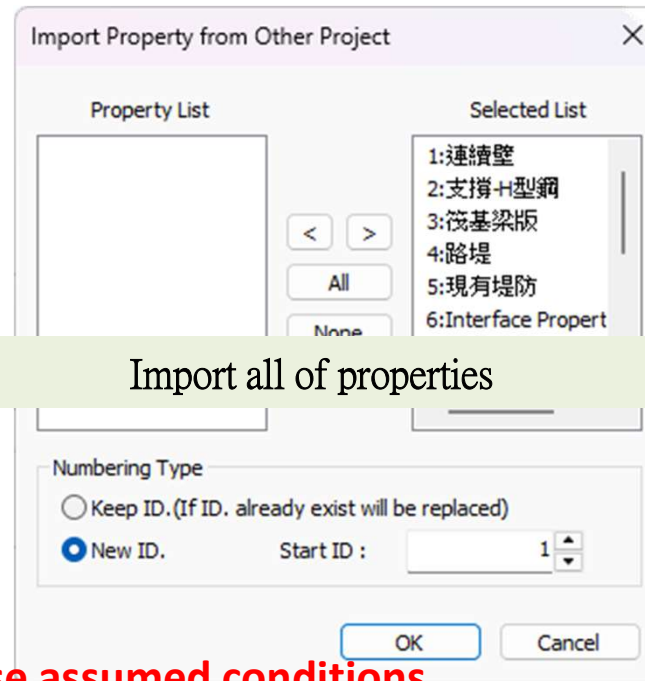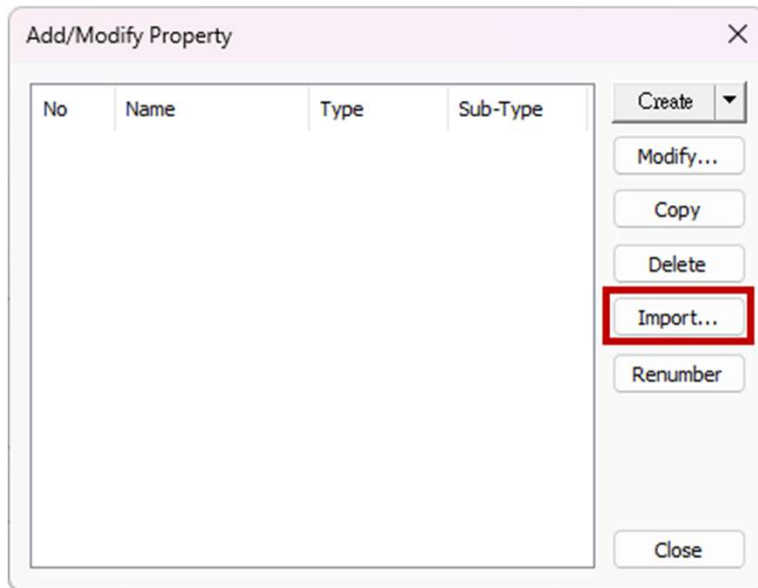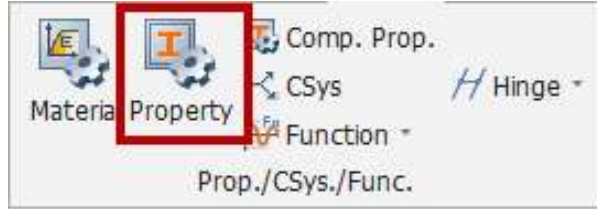
Import all of properties

Excavation area – Stage 1 -1

Mesh size: 1/ Prop: Silty layer

Geometry set: Excav 1_Soil1

Mesh set: Excav1_Soil1
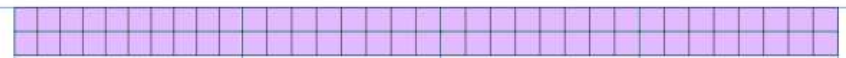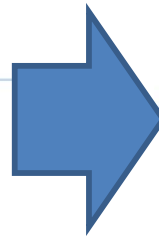
Geometric features are automatically hidden during mesh generation

- ☑ Mesh
  - ☑ Default Mesh Set
  - ☑ 開挖1_soil1

Excavation area –Stage 2 -2

Mesh size: 1/ Prop: Silty sand layer

Geometry set: Excav2_ ▉ Soil 1
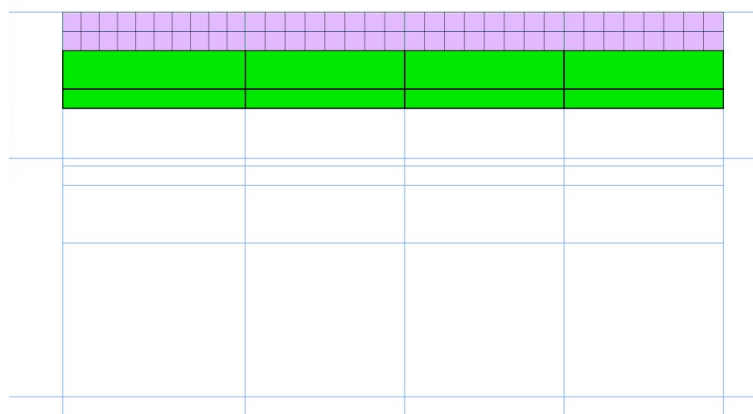
Mesh set: Excav2_ ▉ Soil 1

Geometry set: Excav3_▉ Soil 1
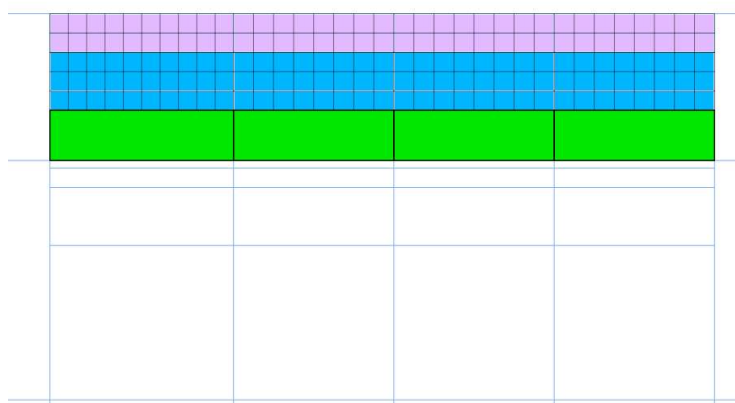
Mesh set: Excav3_▉ Soil 1
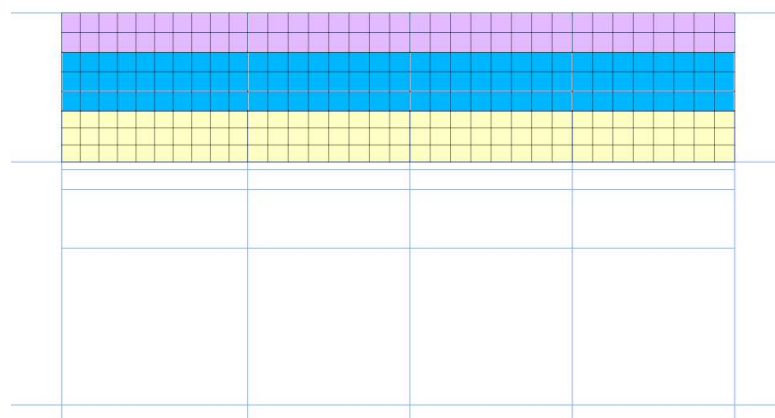
Mesh
Default Mesh Set
☑ 開挖1_soil1
☑ 開挖2_soil1
☑ 開挖3_soil1

Excav area – Stage 3 -3

Mesh size: 1/ Prop: Weathered soil

Geometry set: Excav3_Soil2
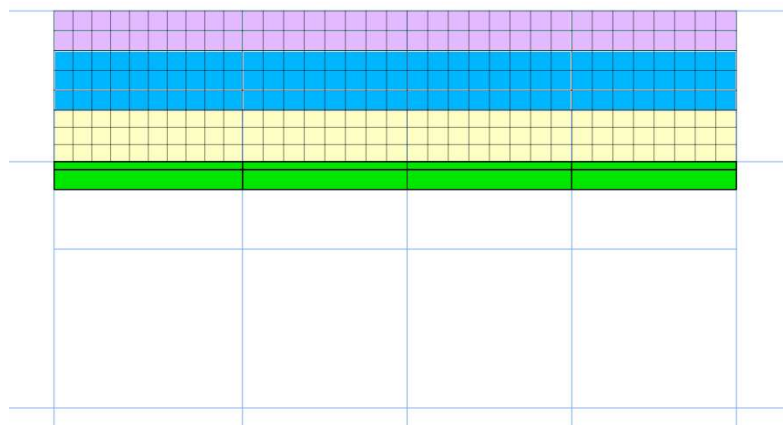
Mesh set: Excav3_Soil2
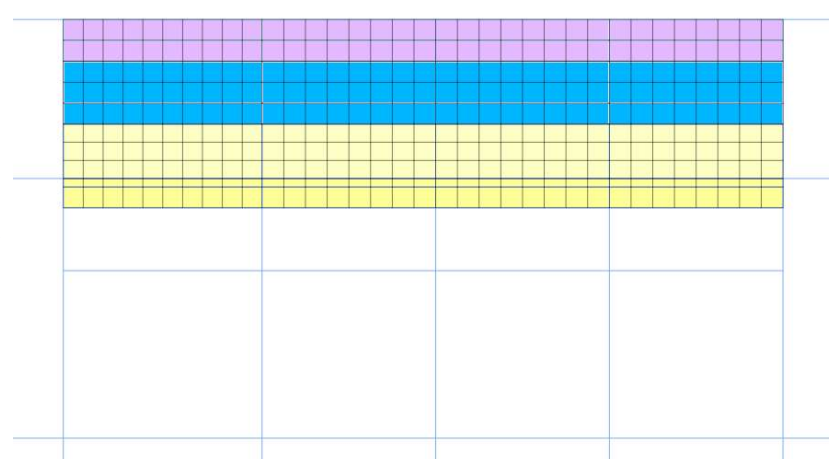
Geometry set: Excav4_Soil2
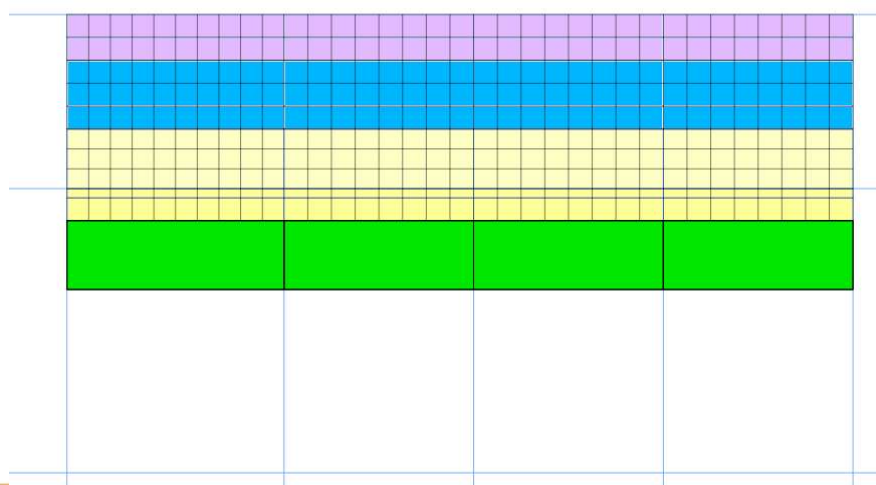
Mesh set: Excav 4_Soil2
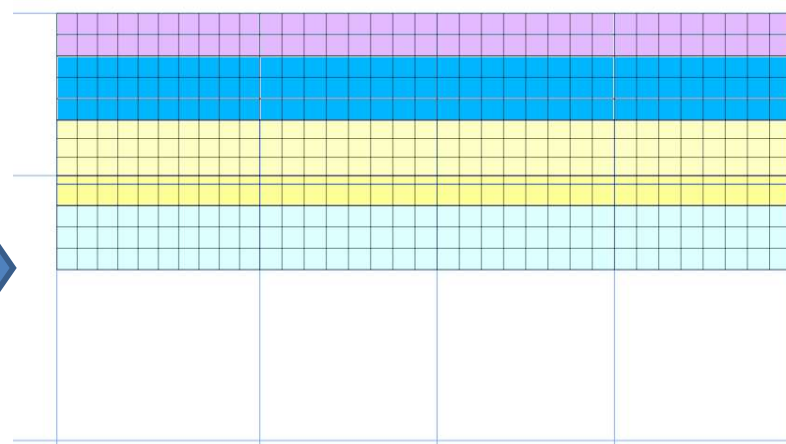
Riverbank area

Separated mesh set

Embankment-mesh size: 1

Gravel-mesh size:1
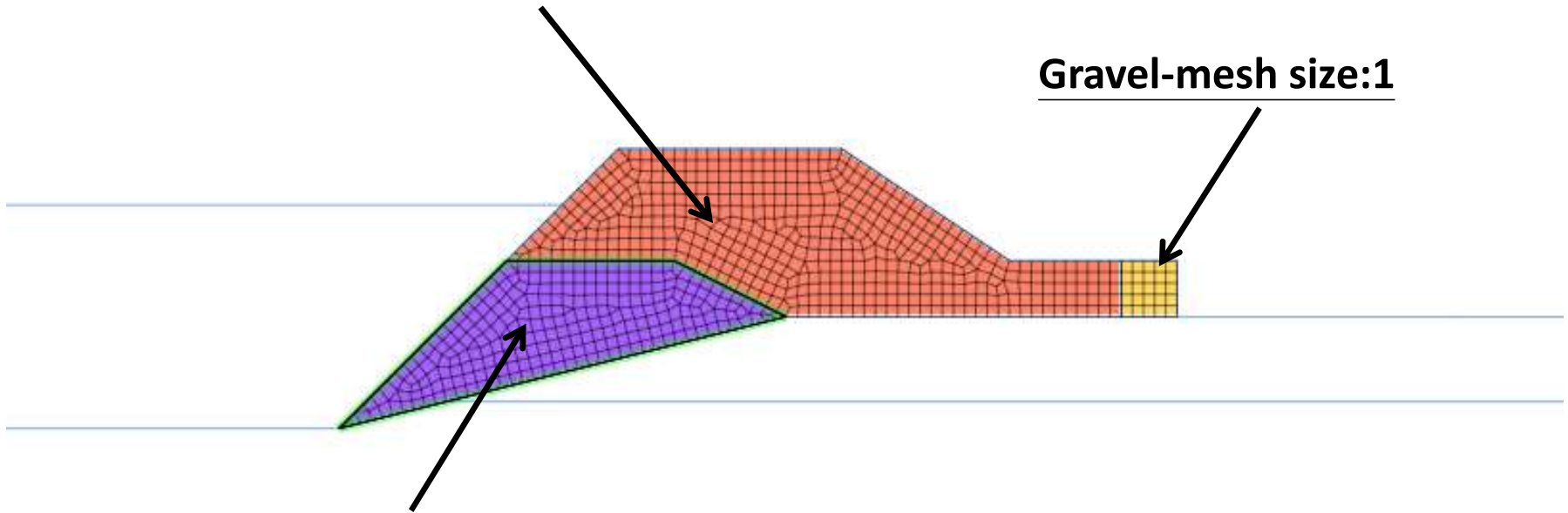
Existing dike-mesh size:1

Soil Layer

Silty layer_Soil1_Mesh size:1

Water Pressure

Weathered soil_Soil2_Mesh size:1

Daliao formation ▮ soil_Soil3_Mesh size:1

Weathered rock_Soil4_Mesh size:1
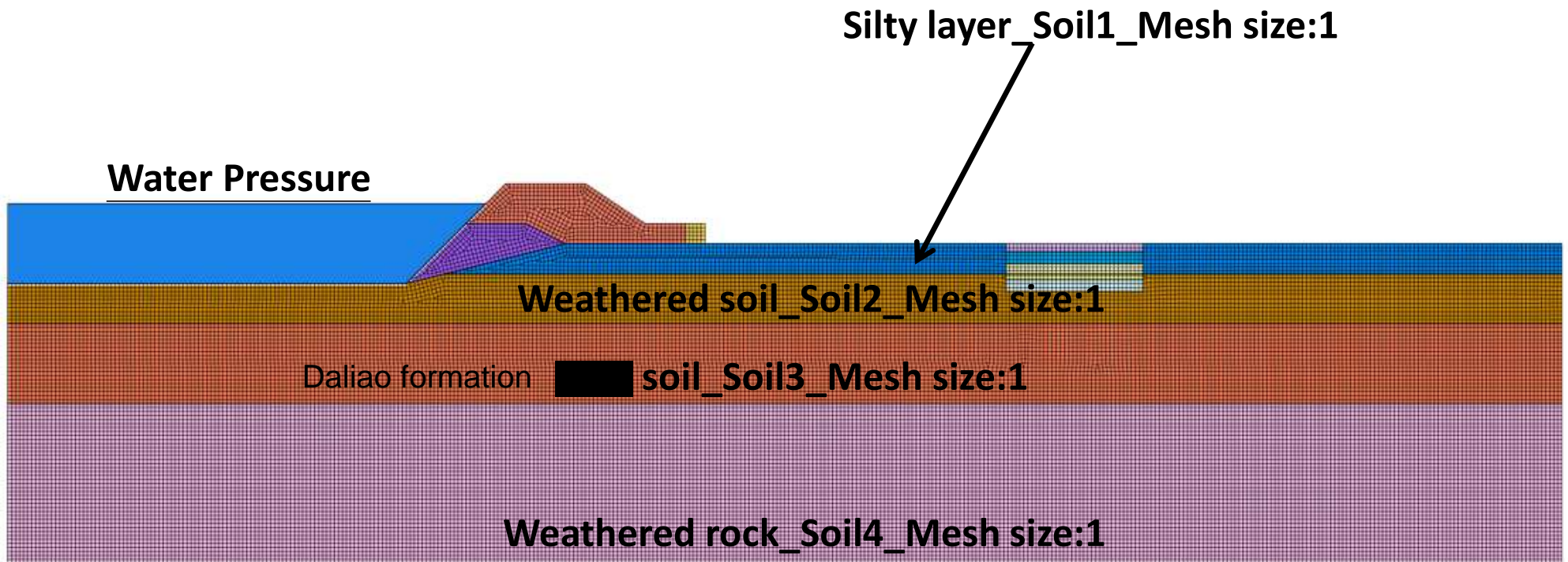
Part3. Mesh

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Retaining Wall-1D Beam

Extracting 1D element to retaining wall
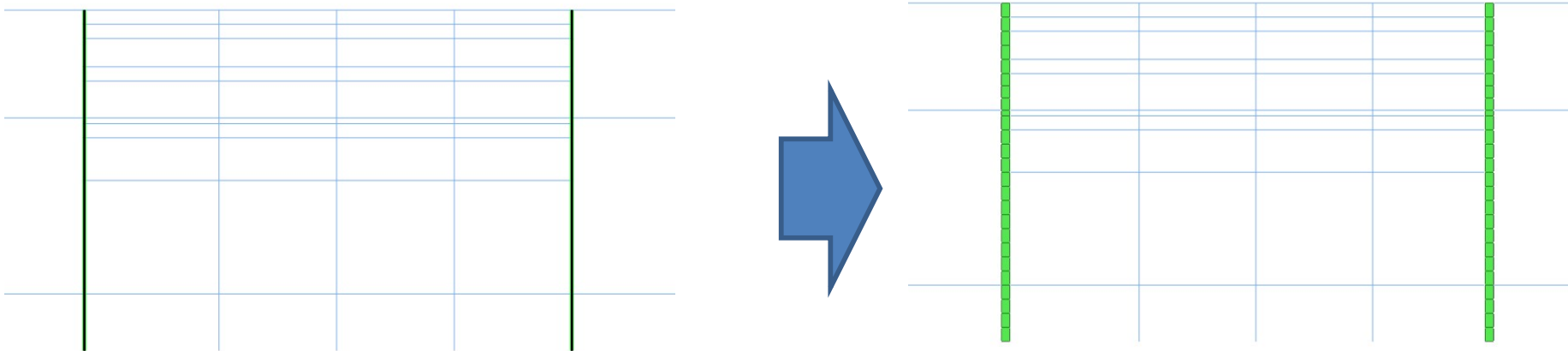
Tick on to view the property shape of BEAM
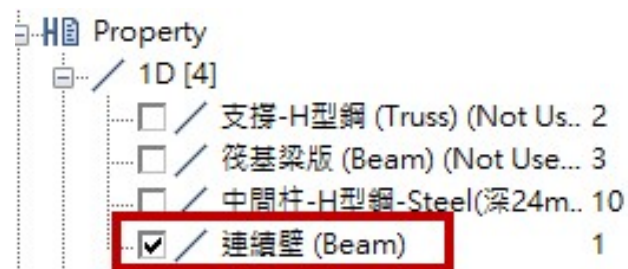
Raft foundation-1D Beam

Extracting 1D element to raft foundation
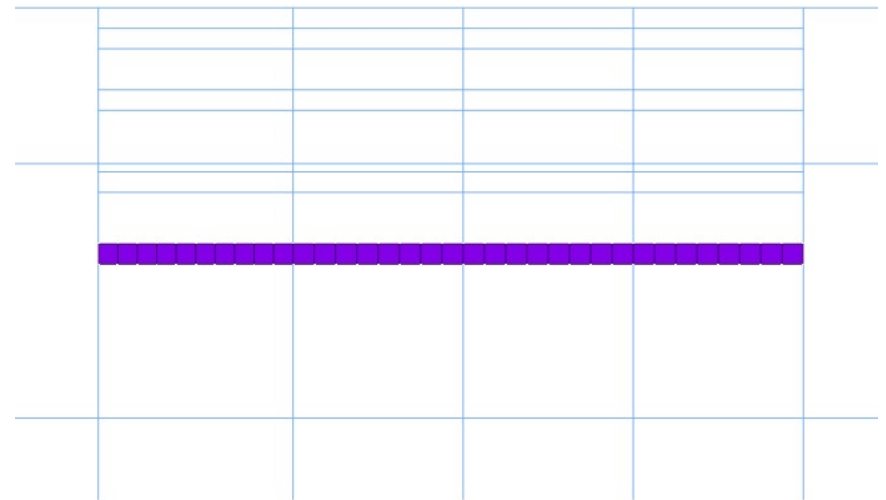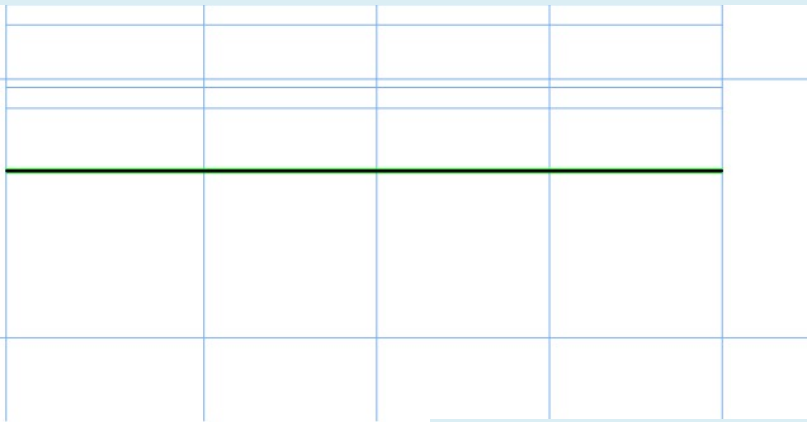
Tick on to view the property shape of BEAM

Center Column-1D Beam

Create   Modify Topo   **Extract**   Interface   Hinge

Delete   Parameters   Divide   Pile/Pile Tip   Infinite   Fluid Boundary

Modify   Connection   Measure   Free Field   Seepage Cut Off
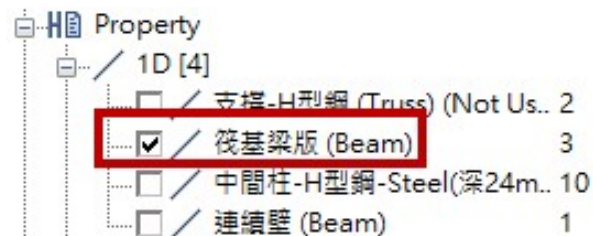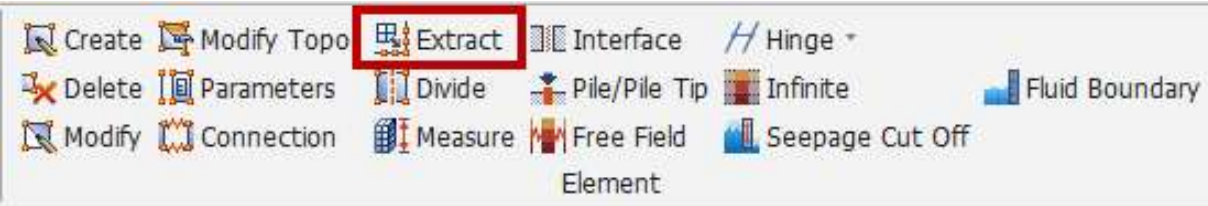
Element

Center column(depth 24m)
(H350 ×250 ×12 ×19)-Beam

Extracting 1D element to center column

Tick on to view the property shape of BEAM

HB Property
    1D [4]
       ☐ 支撐-H型鋼 (Truss) (Not Us..   2
       ☐ 筏基梁版 (Beam)   3
       ☑ 中間柱-H型鋼-Steel(深24m..   10
       ☐ 連續壁 (Beam)   1

MIDAS
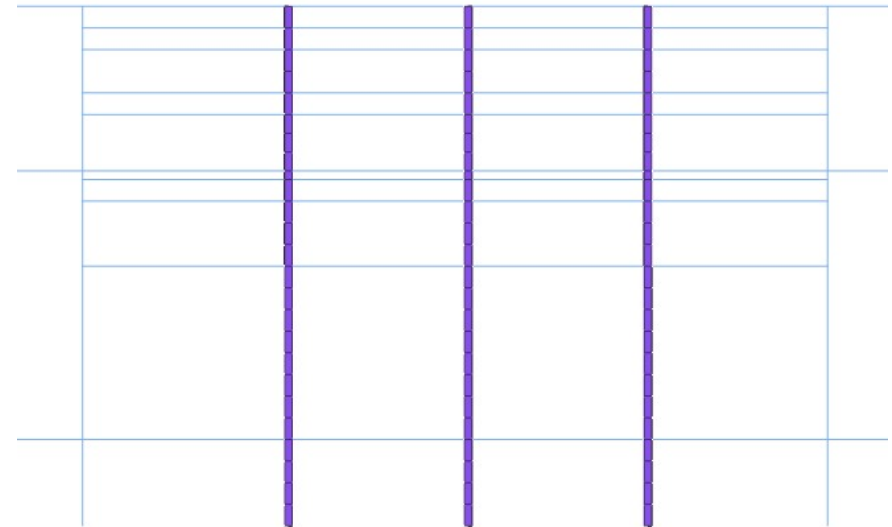
Strut Layer1-1D Truss

Extracting 1D element to strut_Layer1

Strut Layer1-H Beam-Steel
(H300 ×300 ×13 ×21)-Truss
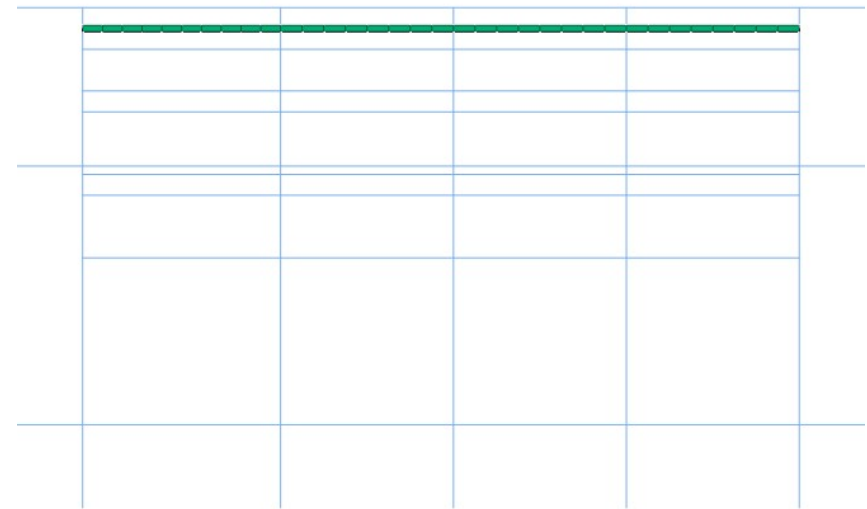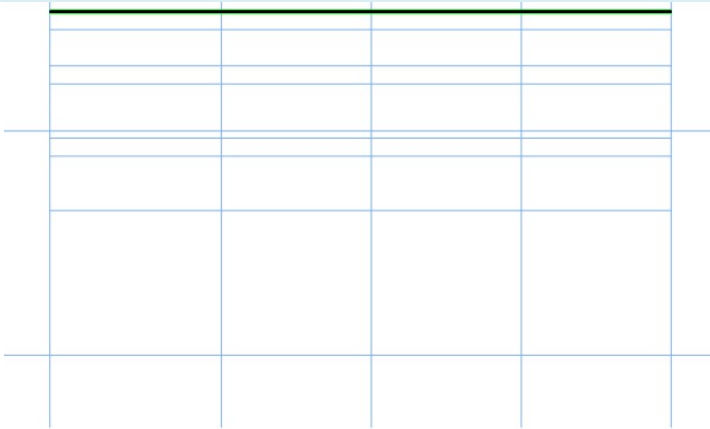
Tick on to view the property shape of STRUSS

Strut Layer2&3-1D Truss

Strut Layer2-H Beam-Steel
(H300 ×300 ×13 ×21)-Truss

Strut Layer3-H Beam-Steel
(H300 ×300 ×13 ×21)-Truss
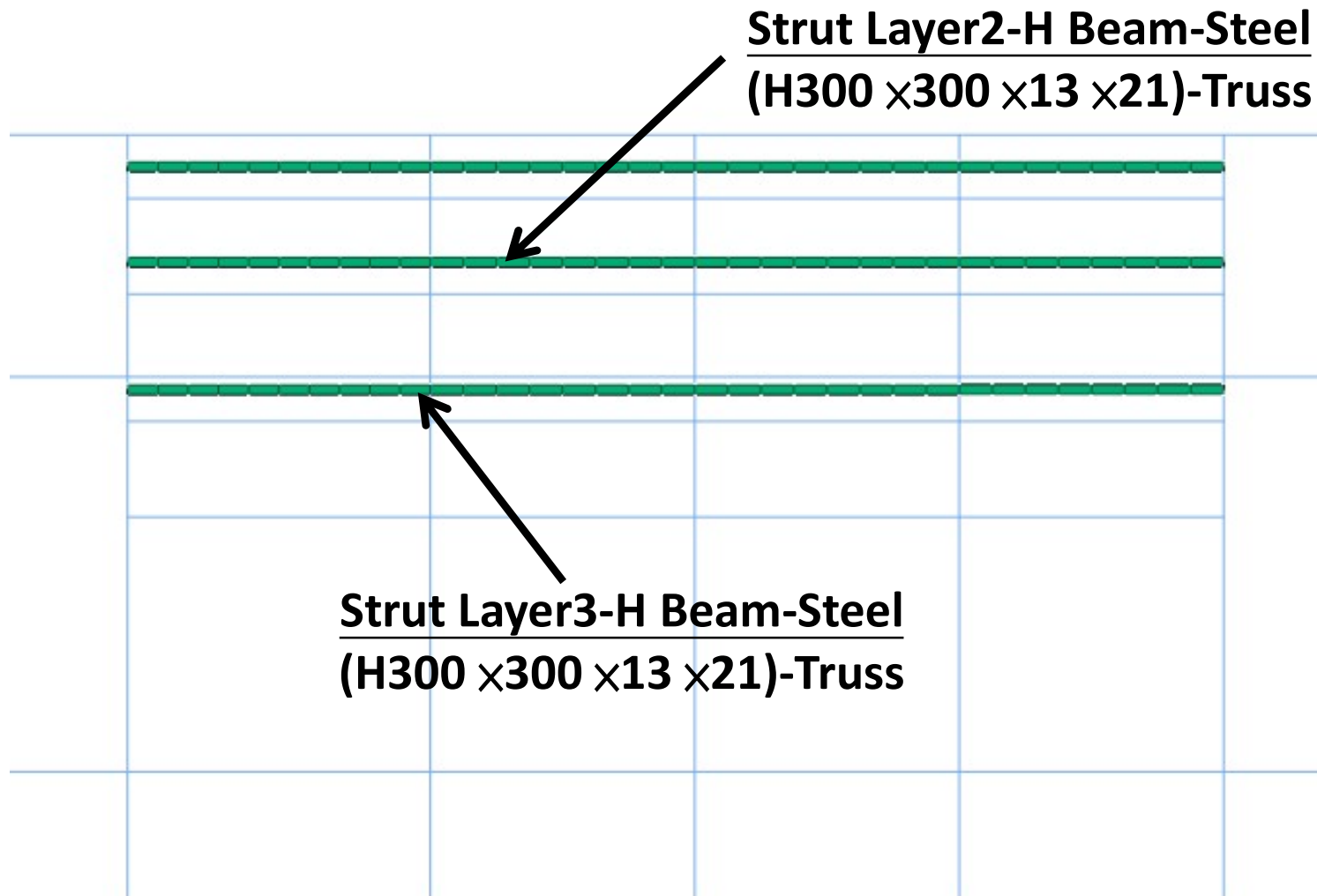
Element Local Orientation
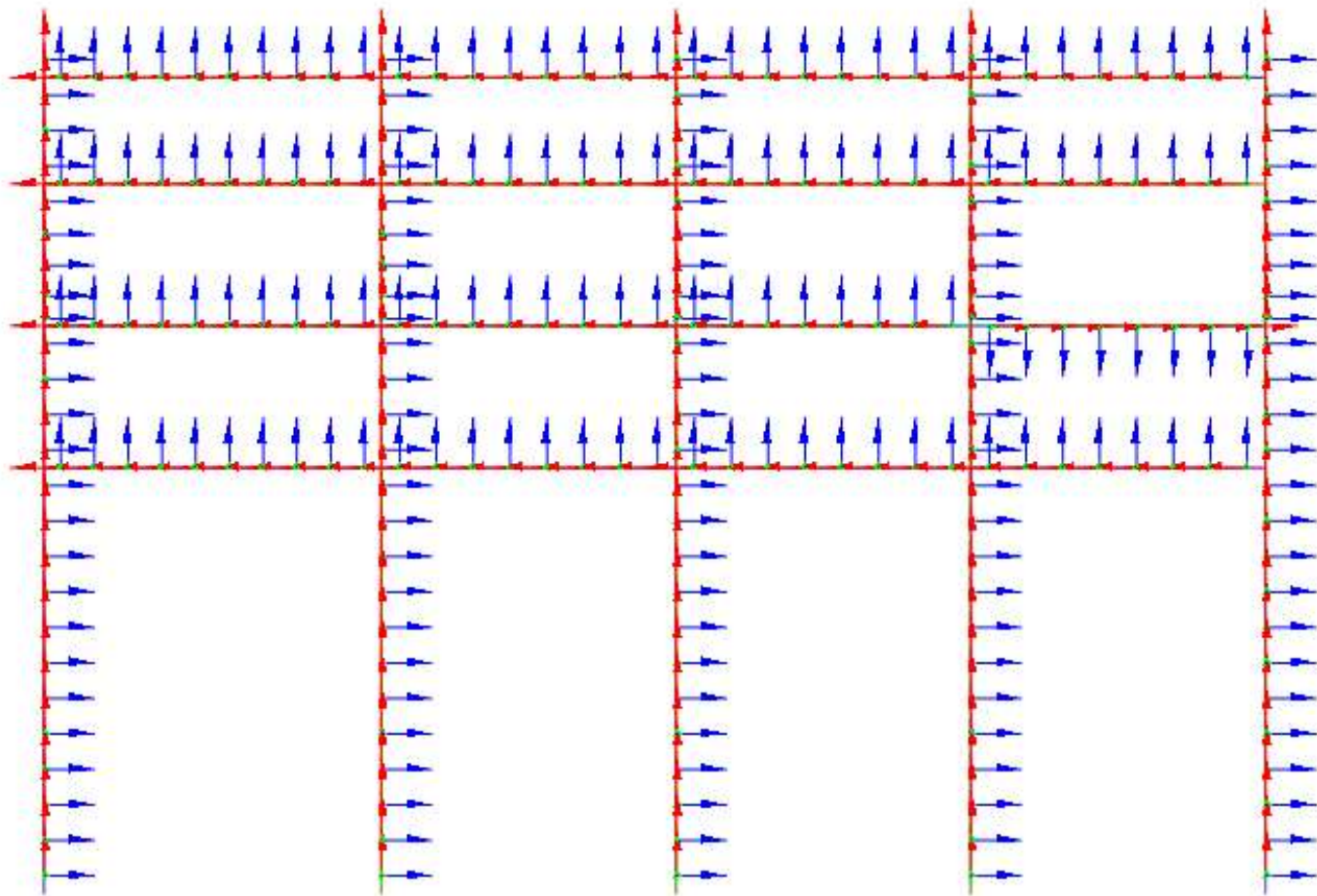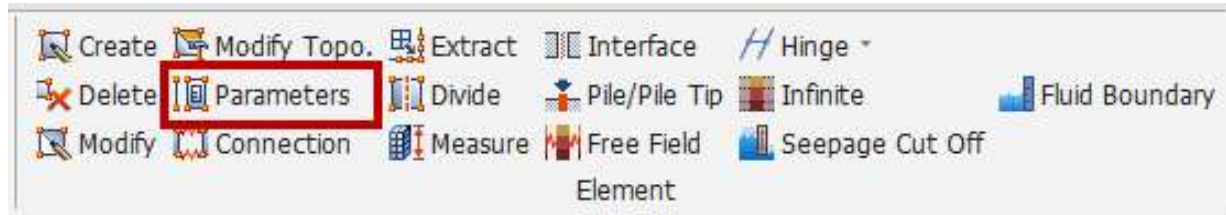
Part4.Boundary Conditions

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Boundary Conditions

Boundary toolbar showing: Define Set, Constraint, Constraint Equation, Sloshing Constraint, Change Property, Slip circular surface, Slip polygonal surface, Water Level, SRM Inclusion, Table

Edge (E)

Constraint Ry for center column

Initial Water Head Level
(Nodal Head ,Pressure=0 m)

Boundary toolbar:
- Define Set
- Constraint
- Constraint Equation
- Change Property
- Review
- Water Level
- **Nodal Head**
- Nodal Flux
- Surface Flux
- Draining Condition
- Non ConSolidation
- From Results
- Table

Boundary

Seepage Boundary ✕

Tabs: **Nodal Head** | Review

Name: Nodal Head-1

Object
- Type: Node
- → Selected 410 Object(s)

Value: 0 m

Type: ○ Total   ● Pressure

☐ Function None

Direction: Global Y

☐ if Total Head < Potential Head, then Q = 0

Boundary Set: 初始水頭位置

OK   Cancel   Apply

Selecting line features

Edge features selected

Edge (E)

MIDAS
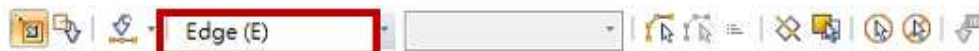
Initial Seepage Surface

Selecting line features

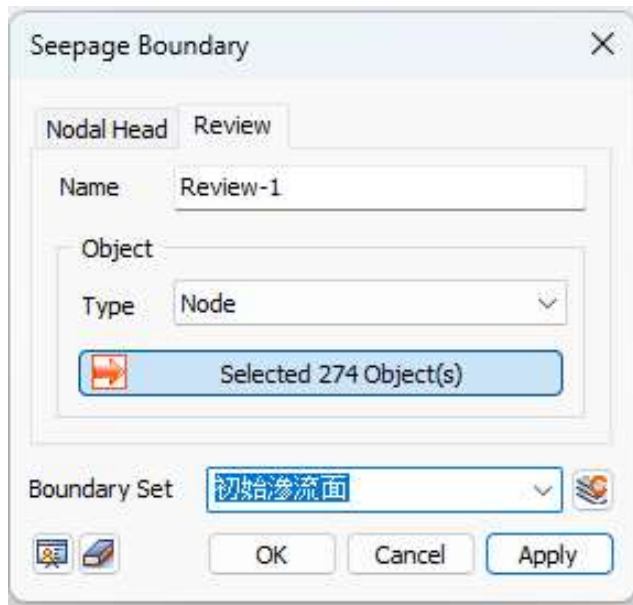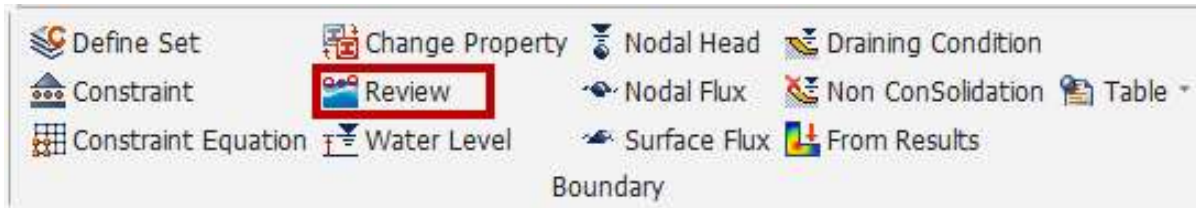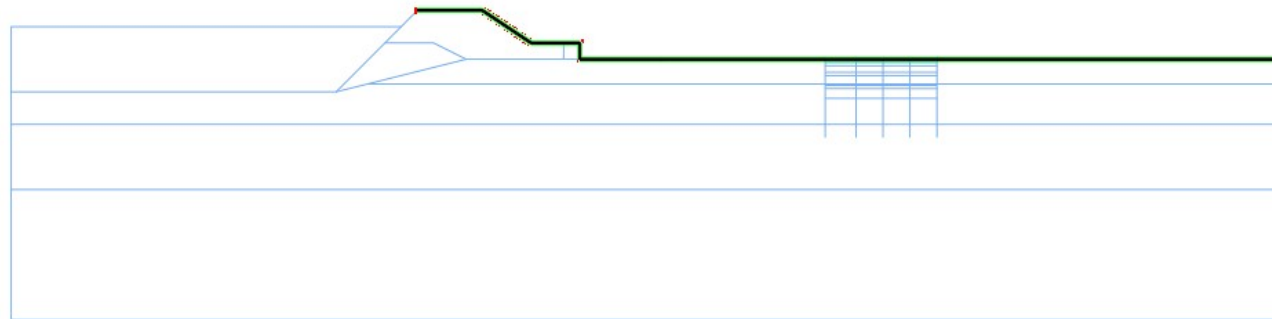# Excav Stage1_Seepage Surface

Boundary toolbar: Define Set, Change Property, Nodal Head, Draining Condition, Constraint, **Review**, Nodal Flux, Non ConSolidation, Table, Constraint Equation, Water Level, Surface Flux, From Results

Seepage Boundary dialog:
- Nodal Head | Review tabs
- Name: Nodal Head-2
- Object
  - Type: Node
  - Selected 276 Object(s)
- Boundary Set: 第一次開挖滲流面
- OK | Cancel | Apply

Selecting line features
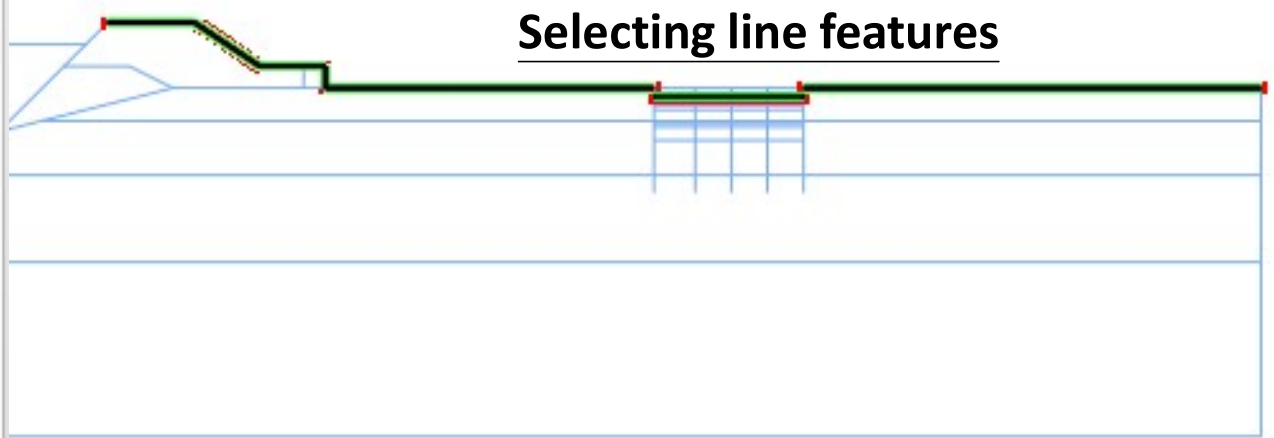
Excav Stage2_Seepage Surface

Selecting line features
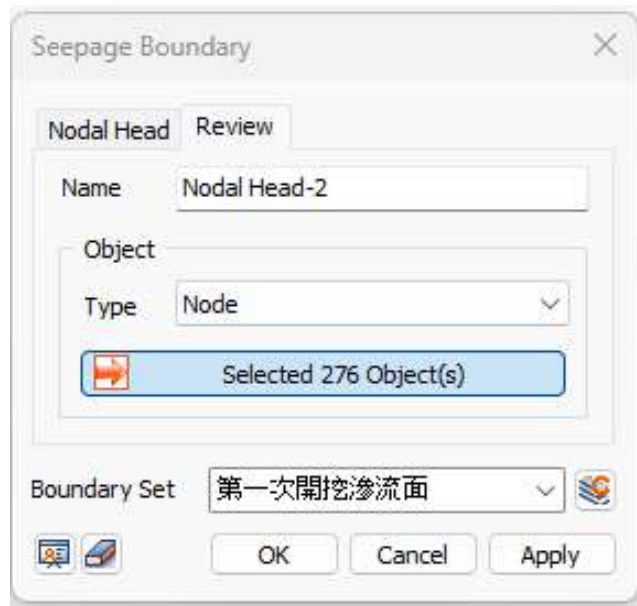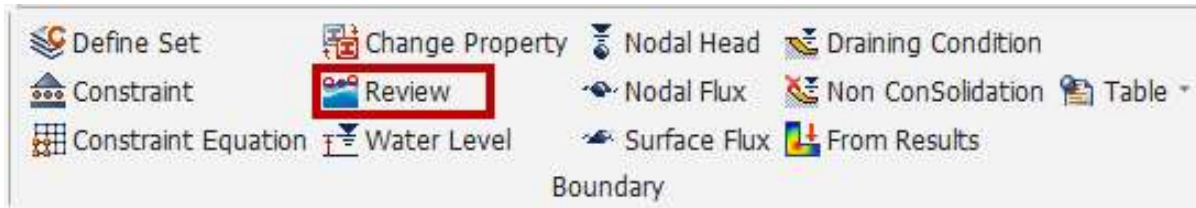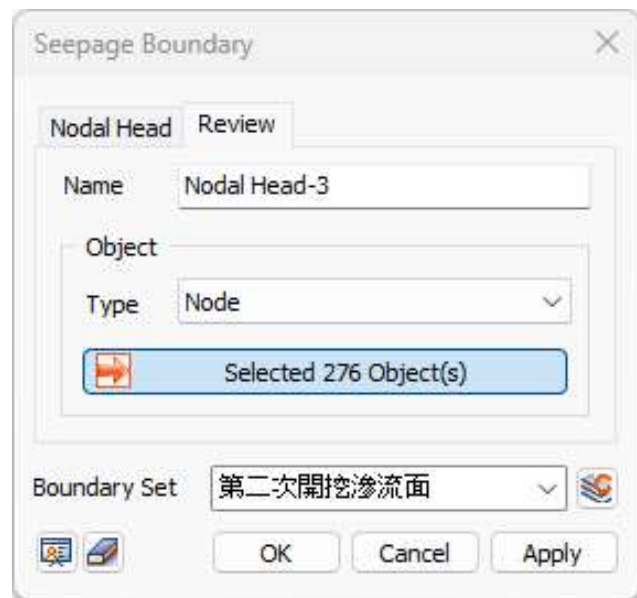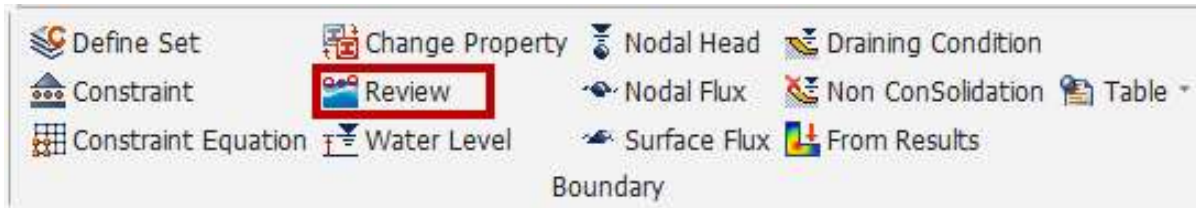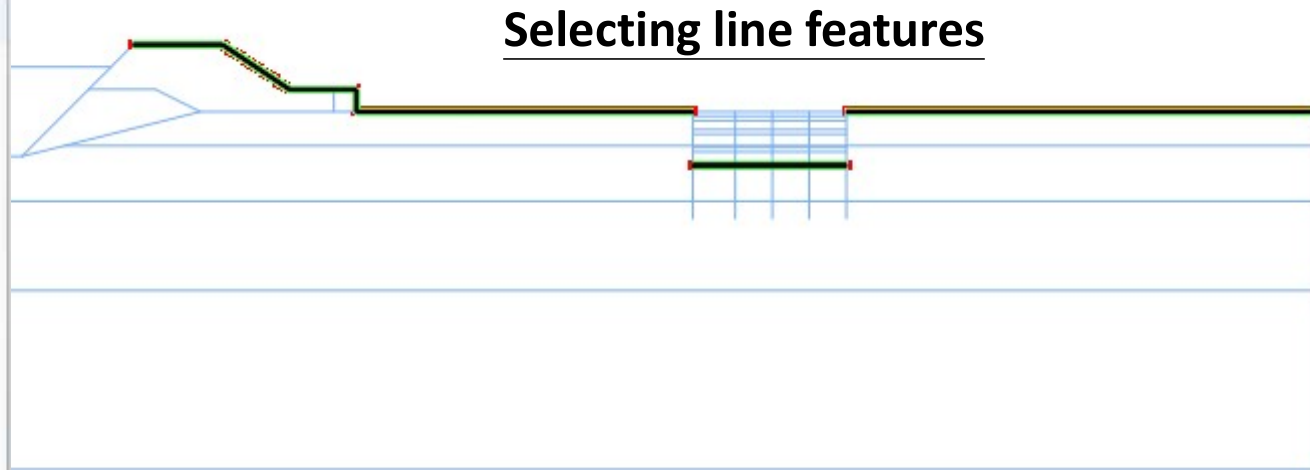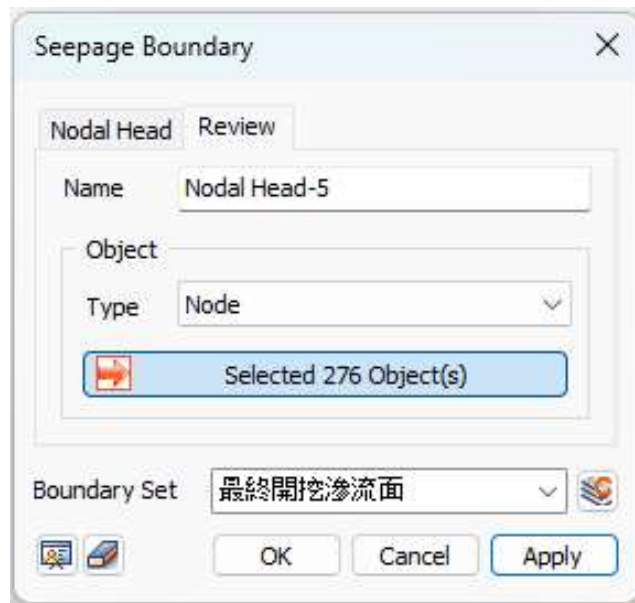
Excav Stage 3_Seepage Surface
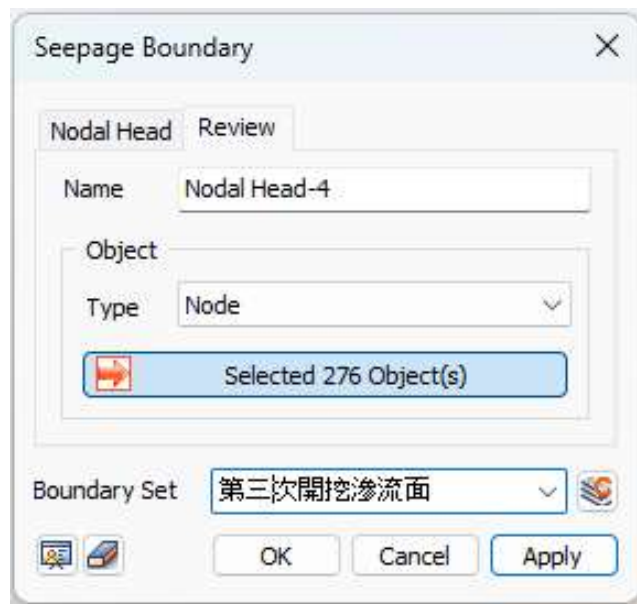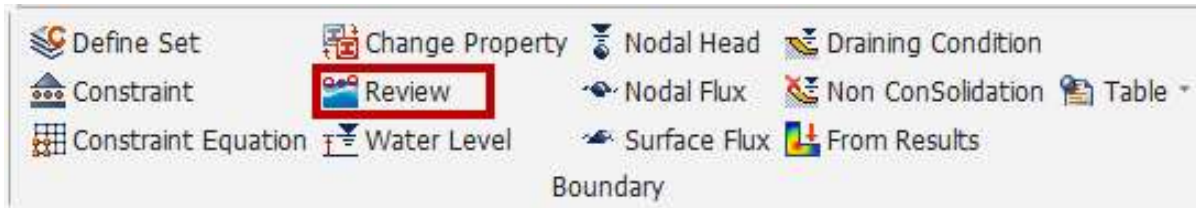
Selecting line features
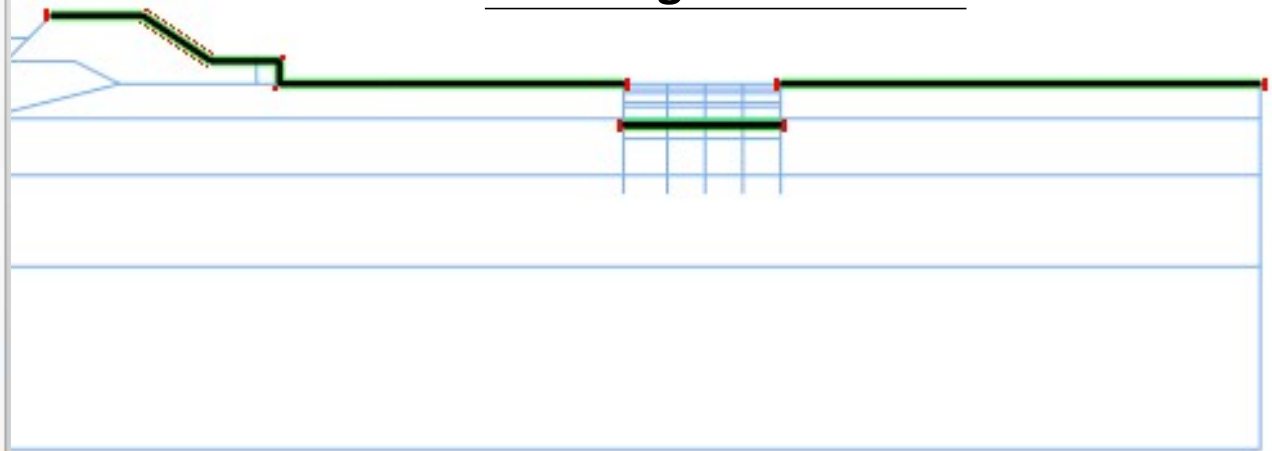
Excav Stage4_Seepage surface

Selecting line features
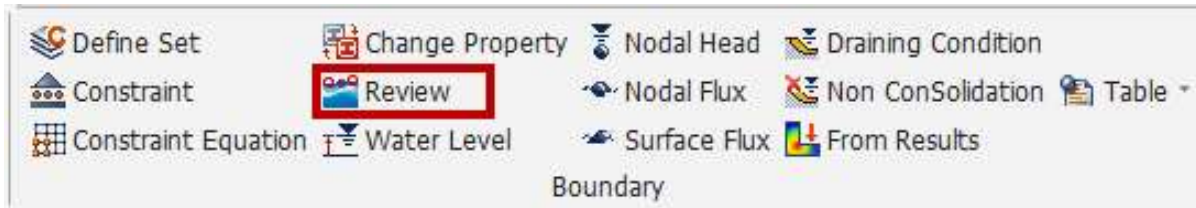
Water Pressure

(Pressure to represent for river reservoir pressure)
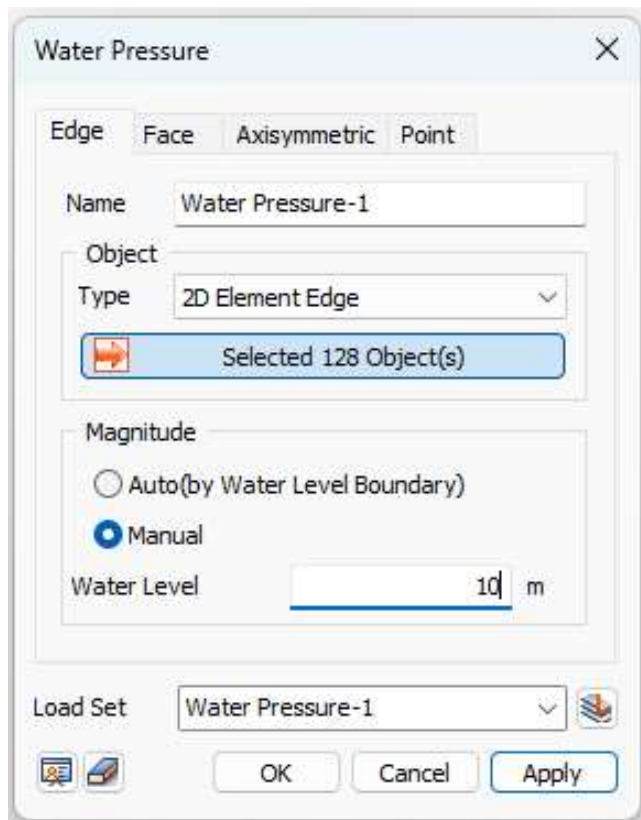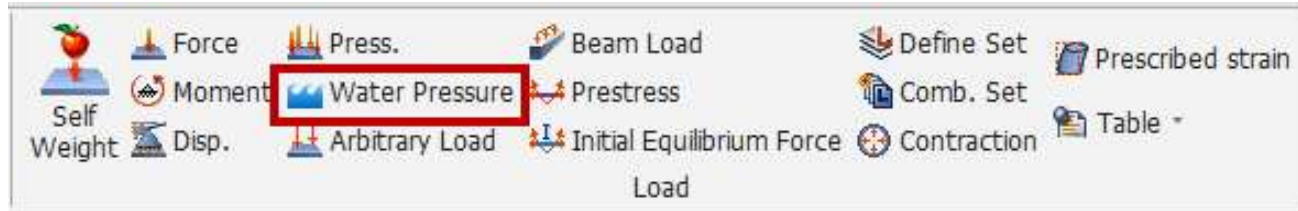
Water level (10m)

Selecting line features
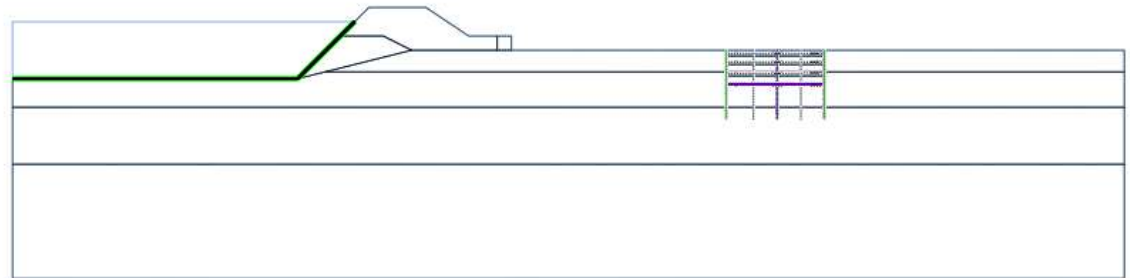
Part5.Interface Elements
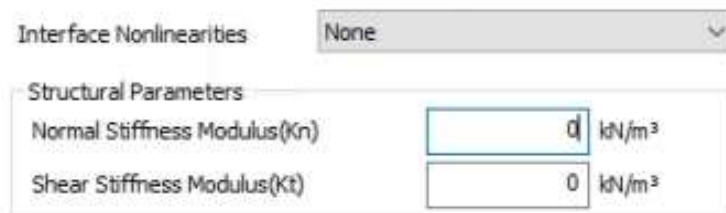
MIDAS Taiwan

Interface Element-1

GTS NX Interface Element Wizard

- Automatic calculation of normal stiffness (Kn) & tangential stiffness (Kt)

- **Virtual Thickness Factor (tv)**
  - Range from 0.01 ~ 0.1 。
  - Use smaller values for higher stiffness 。

- **Strength Reduction Factor (R)**
  - Sandy soil/Steel material = R : 0.6~0.7
  - Clay/Steel material = R : 0.5
  - Sandy soil/Concrete = R : 1.0~0.8
  - Clay/Concrete = R : 1.0~0.7

Manual definition
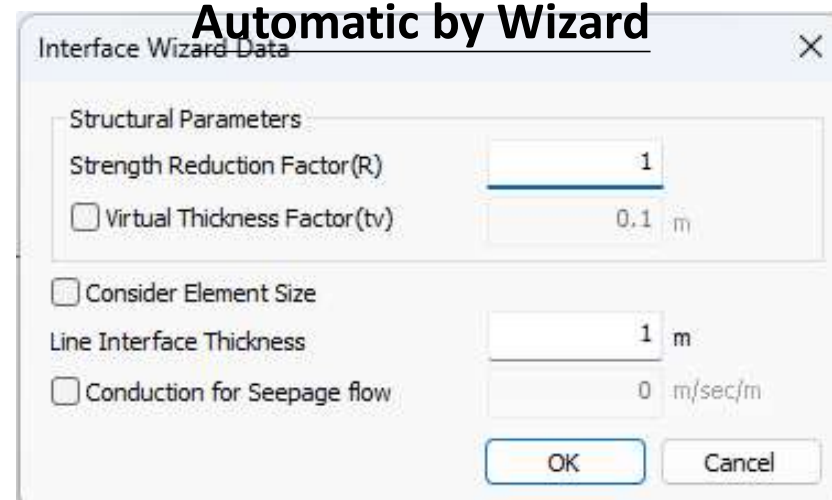
Automatic by Wizard

Interface Element-2
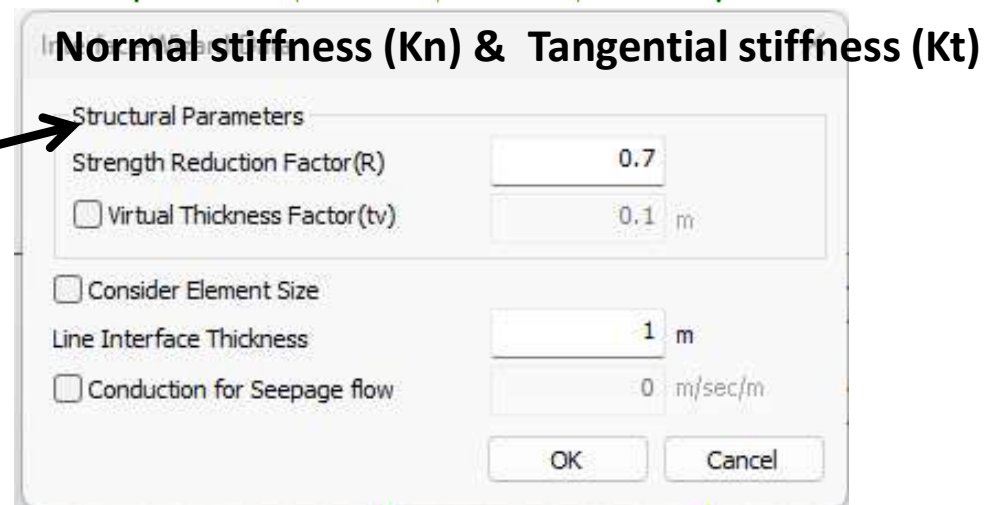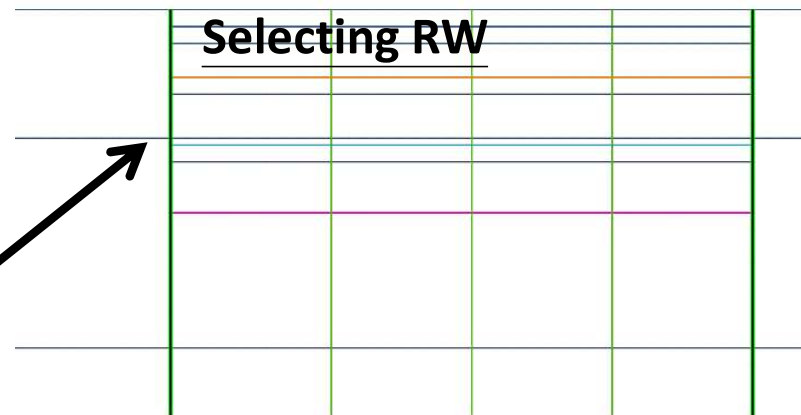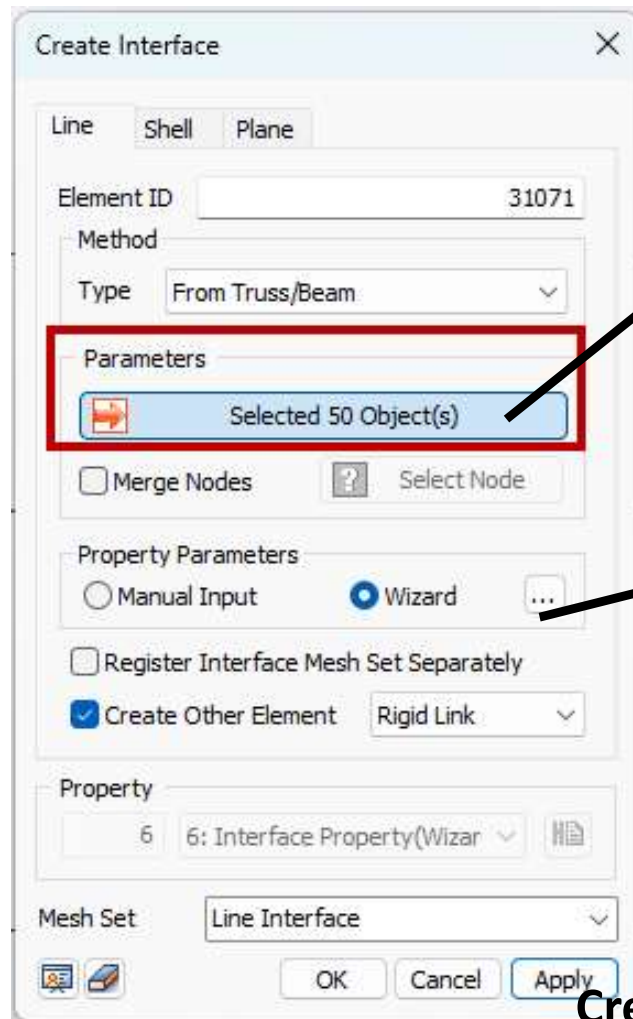
Creating Rigid link for soil and retaining wall before RW is constructed

Interface Element-3

Normal stiffness (Kn) & Tangential stiffness (Kt)

☑ 水平支撐1-H型鋼-Steel
☑ 水平支撐2-H型鋼-Steel
☑ 水平支撐3-H型鋼-Steel
☑ **Line Interface**
☑ **Rigid Link Mesh**

⊟ Others [7]
☐ Rigid Link (Rigid Link)
☐ Interface Property(Wizard)..
☐ Interface Property(Wizard)..
☐ Interface Property(Wizard)..
☐ Interface Property(Wizard)..
☐ Interface Property(Wizard)..
☐ Interface Property(Wizard)..

Line Interface
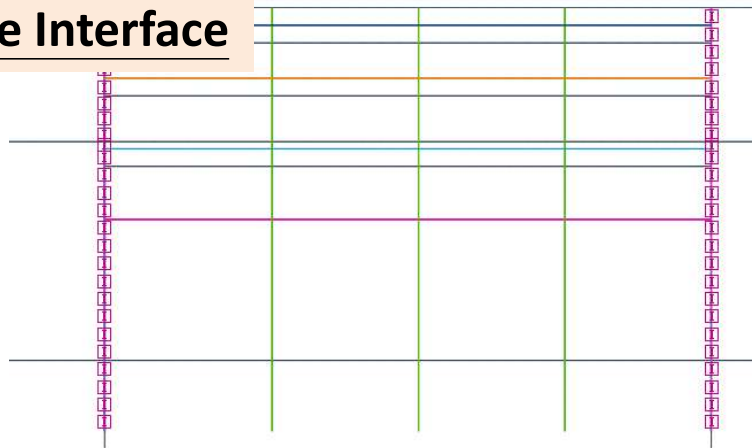
Rigid Link
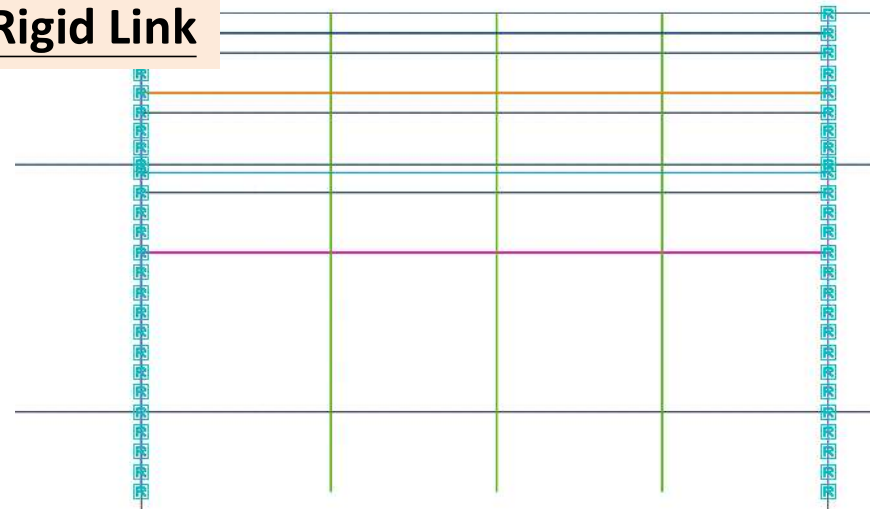
Part6.Construction Stage

MIDAS Taiwan

Construction Stage-1
(Selecting type of simulation)

GTS NX Type of simulation

Stress Seepage Slope
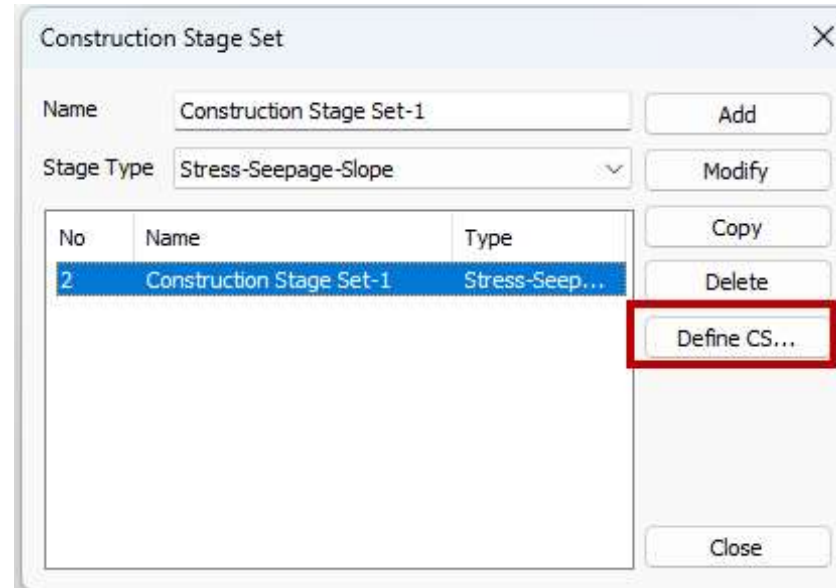
Step1.New

Step2.Define CS
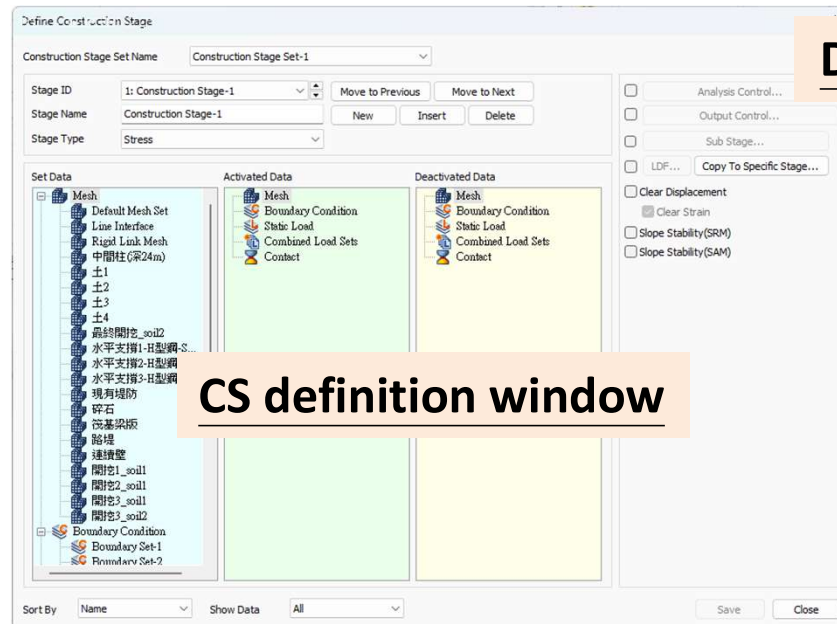
Displaying all mesh sets/ BCs/ Geometry sets

CS definition window

Construction Stage-2

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)
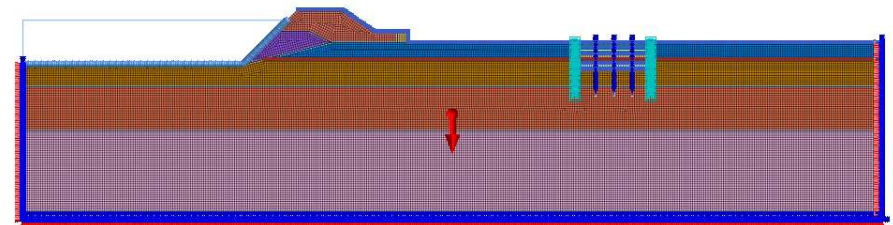
Construction Stage-3

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	2: Stage1.連續壁(24m)和中間柱施
Stage Name	Stage1.連續壁(24m)和中間柱施
Stage Type	Stress Seepage

- ☑ Clear Displacement
- ☐ Clear Strain
- ☐ Slope Stability(SRM)
- ☐ Slope Stability(SAM)

Activated Data
- Mesh
  - 連續壁
  - 中間柱(深24m)
  - Line Interface
- Boundary Condition
  - 中間柱旋轉自由度Ry
- Static Load
- Combined Load Sets
- Contact

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

Construction Stage-4

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	3: Stage2.開挖1(開挖深度-2m)
Stage Name	Stage2.開挖1(開挖深度-2m)
Stage Type	Stress Seepage

Activated Data
- Mesh
- Boundary Condition
  - 第一次開挖滲流面
- Static Load
- Combined Load Sets
- Contact

Deactivated Data
- Mesh
  - 開挖1_soil1
- Boundary Condition
  - 初始滲流面
- Static Load
- Combined Load Sets
- Contact

Construction Stage-5

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	4: Stage3.水平支撐1(位置-1m)
Stage Name	Stage3.水平支撐1(位置-1m)
Stage Type	Stress Seepage

Activated Data
- Mesh
  - 水平支撐1-H型鋼-Steel
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

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

Construction Stage-6

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Construction Stage-7

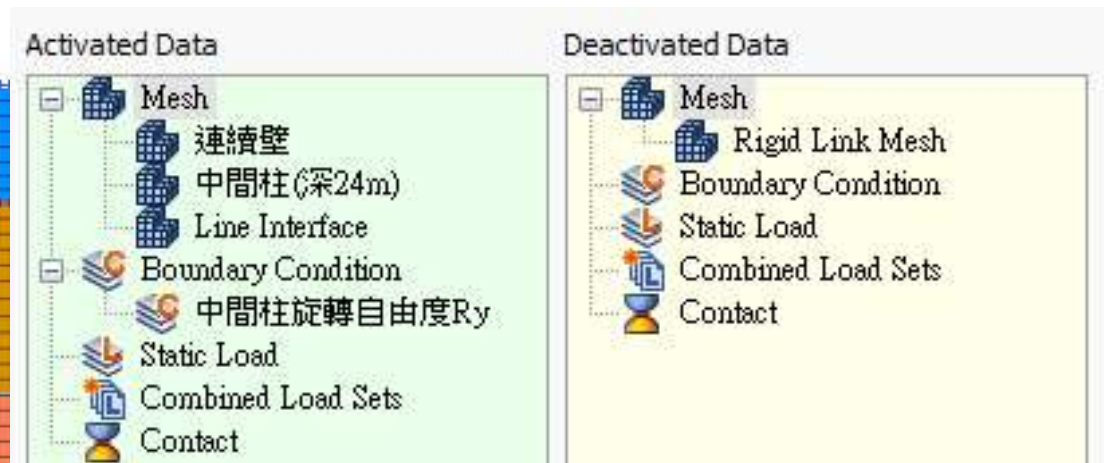Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	6: Stage5.水平支撑2(位置-4m)
Stage Name	Stage5.水平支撑2(位置-4m)
Stage Type	Stress Seepage

Activated Data
- Mesh
  - 水平支撐2-H型鋼-Steel
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

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

Construction Stage-8

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
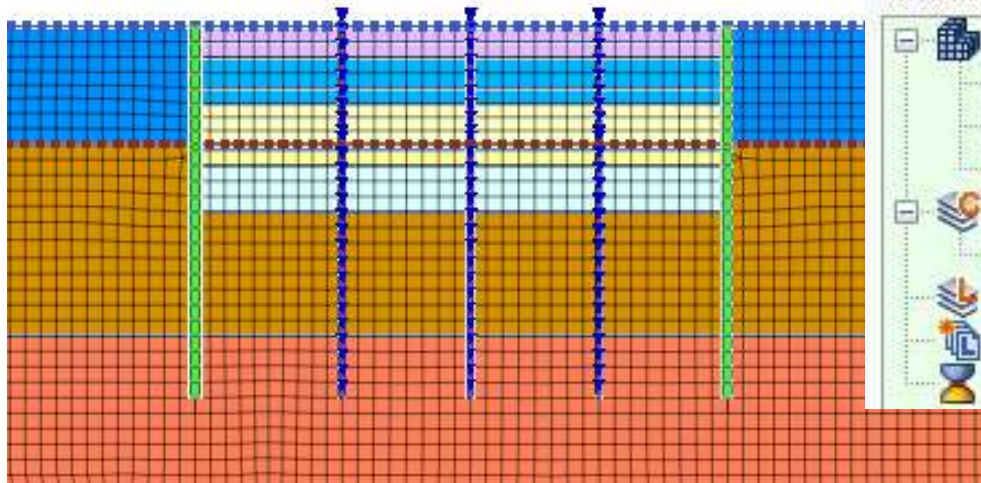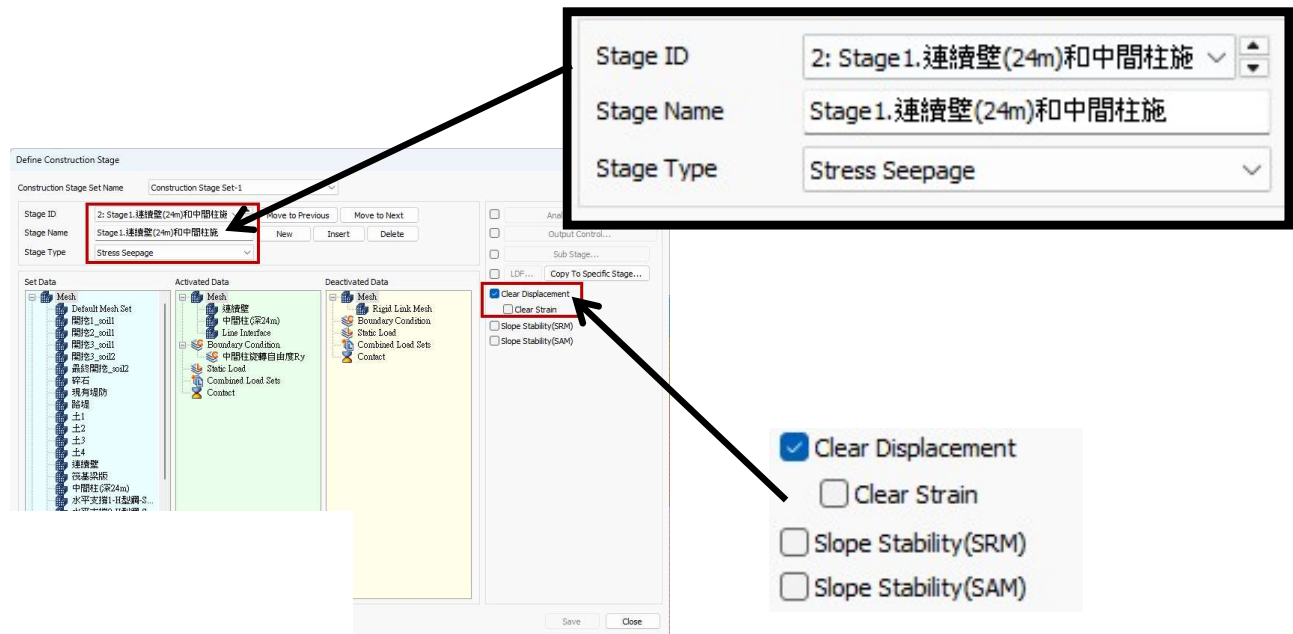Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Construction Stage-9

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
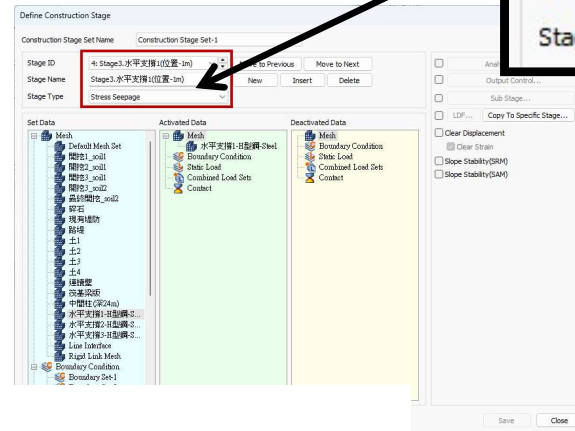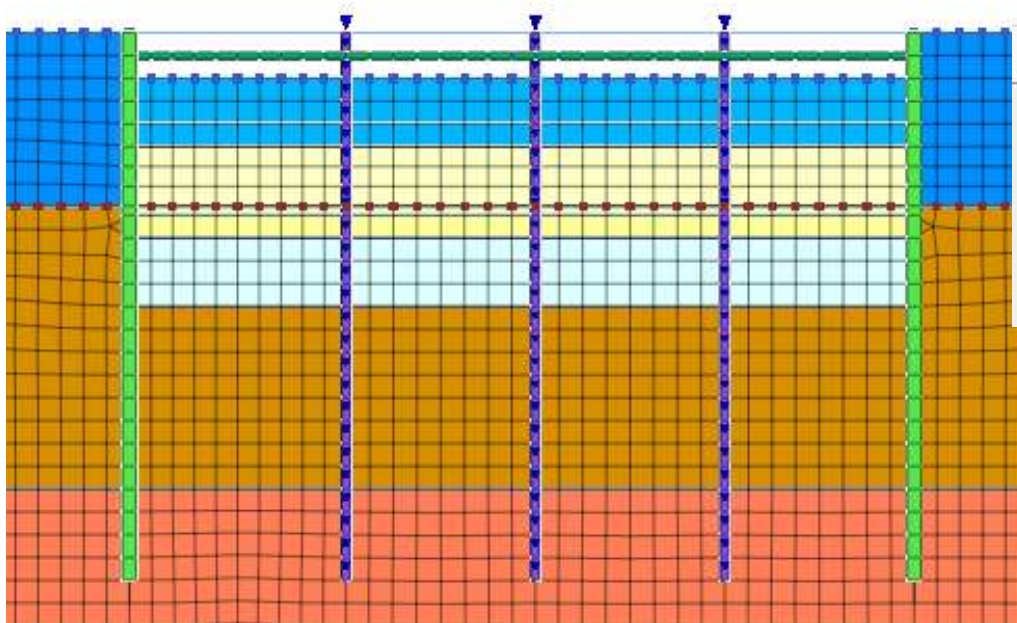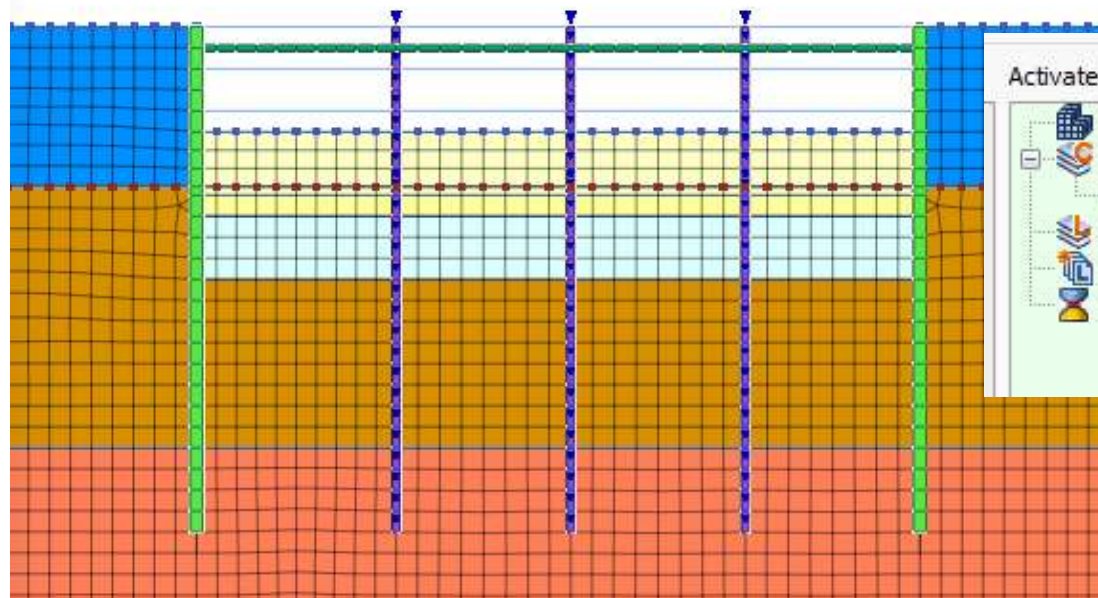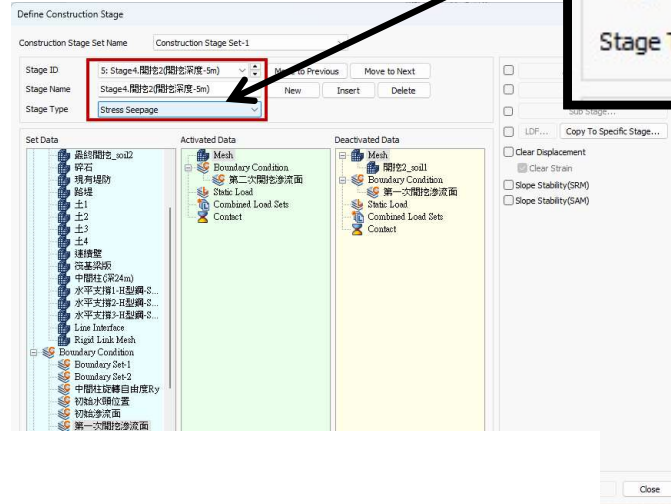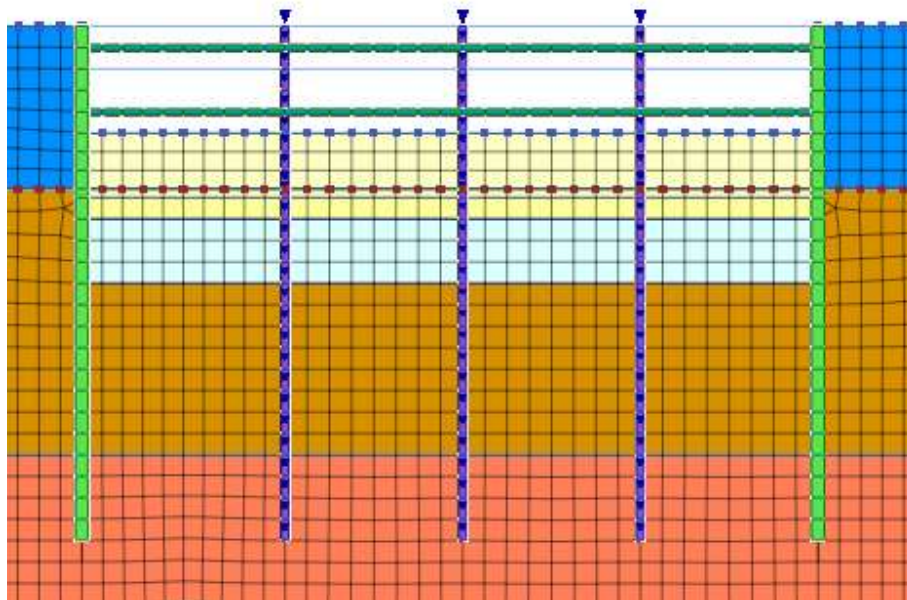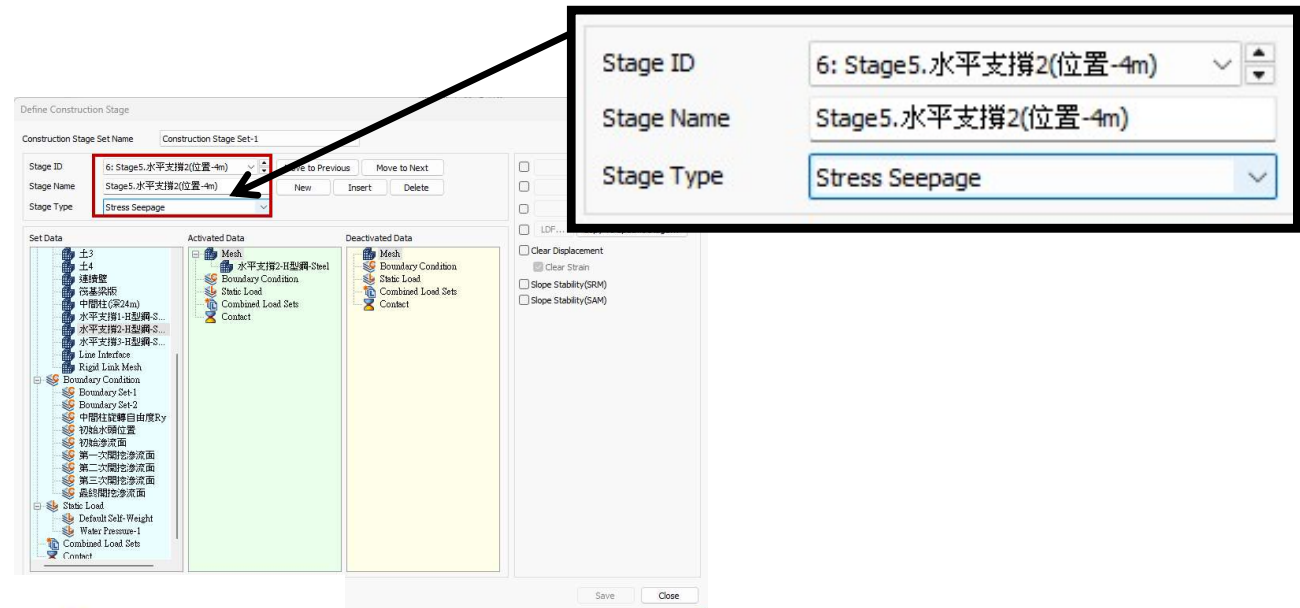Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	8: Stage7.水平支撑3(位置-8m)
Stage Name	Stage7.水平支撑3(位置-8m)
Stage Type	Stress Seepage

Activated Data
- Mesh
  - 水平支撑3-H型鋼-Steel
- Boundary Condition
- Static Load
- Combined Load Sets
- Contact

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

Construction Stage-10

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
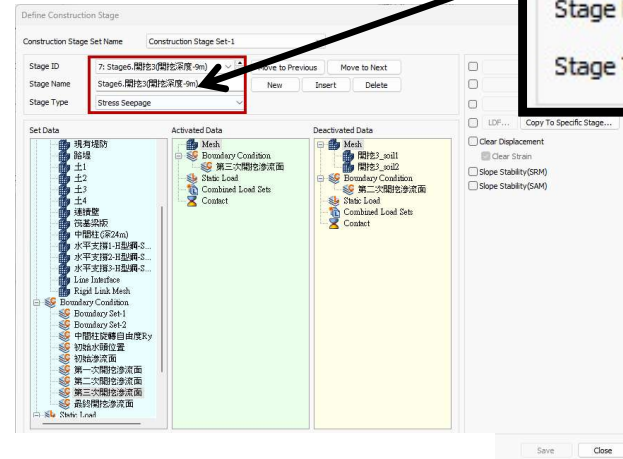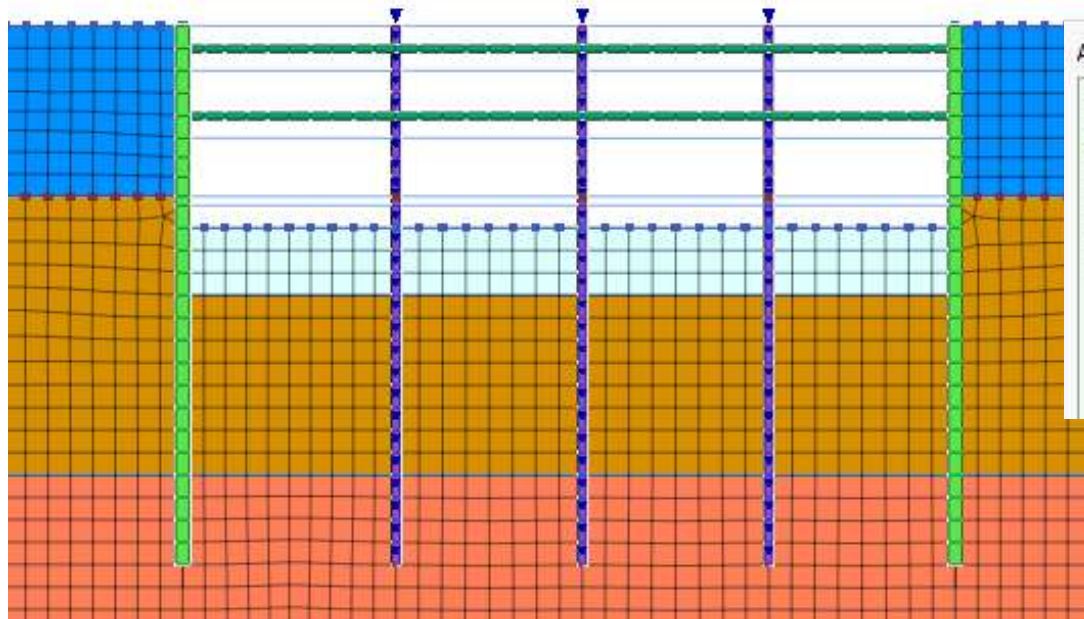Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	9: Stage8.最終開挖 (-12m)
Stage Name	Stage8.最終開挖 (-12m)
Stage Type	Stress Seepage

Activated Data	Deactivated Data
Mesh	Mesh
Boundary Condition	最終開挖_soil2
最終開挖滲流面	Boundary Condition
Static Load	第三次開挖滲流面
Combined Load Sets	Static Load
Contact	Combined Load Sets
	Contact

Construction Stage-11

Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
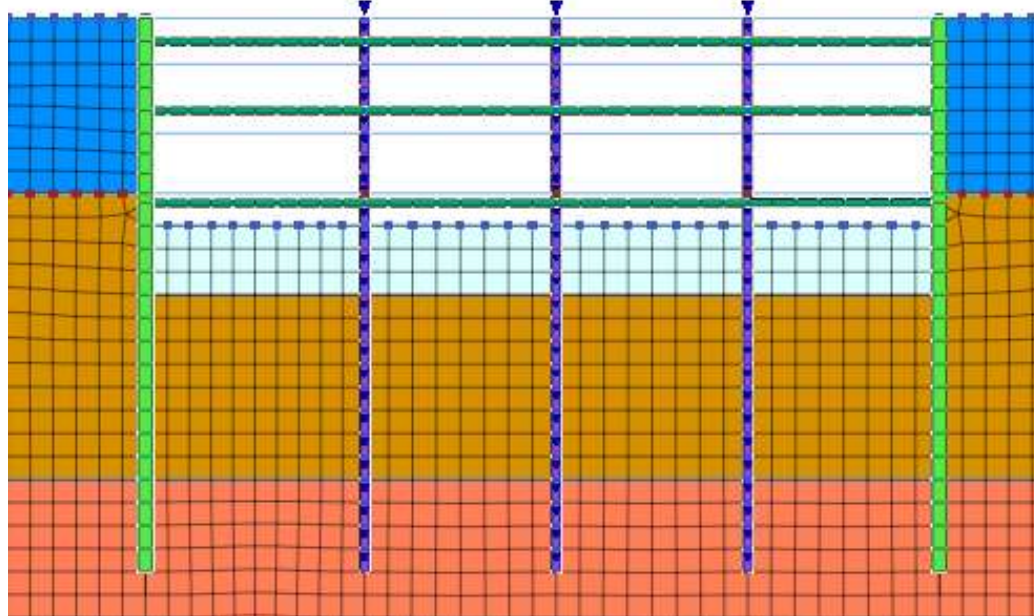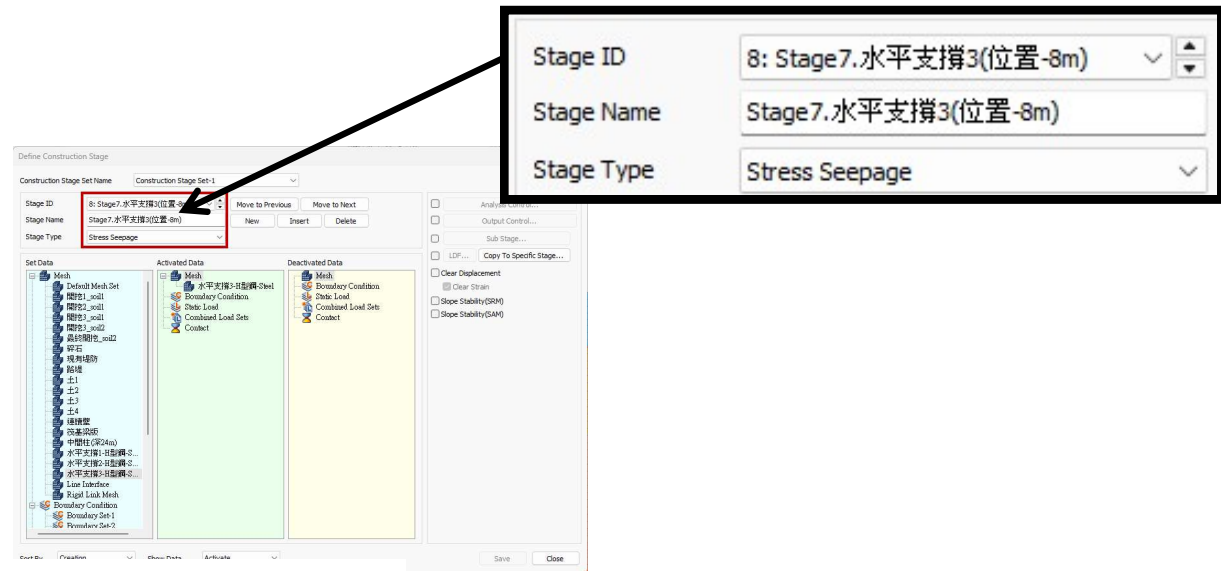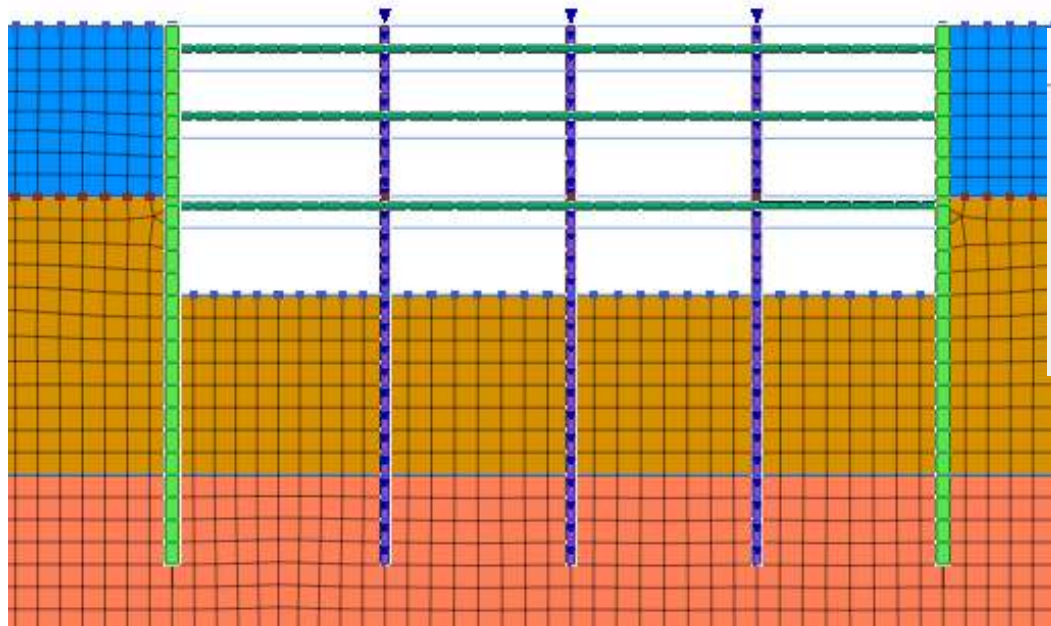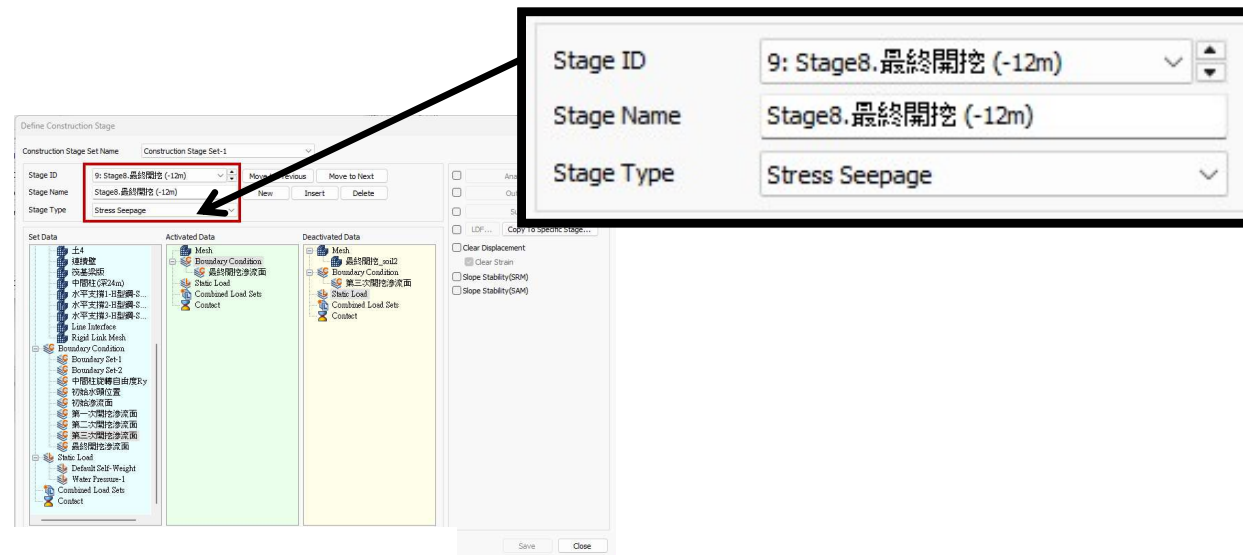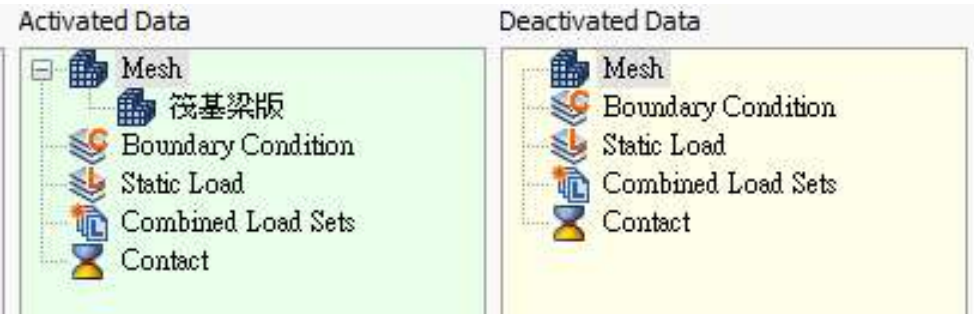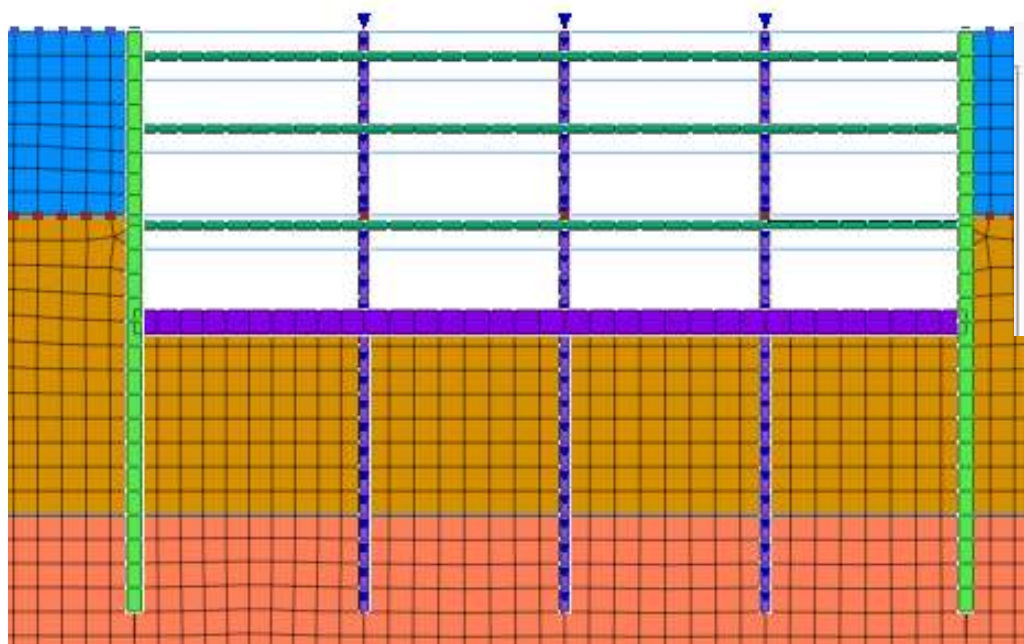Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)

Stage ID	10: Construction Stage-1
Stage Name	Stage9.筏基梁版(t=1m)
Stage Type	Stress Seepage

Part7.Analysis & Calculation

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Analysis
(Deep excavation nearby river channel)

Analysis type: Construction Stage

Construction Stage

Selecting the previous CS setup for calculation

Calculation
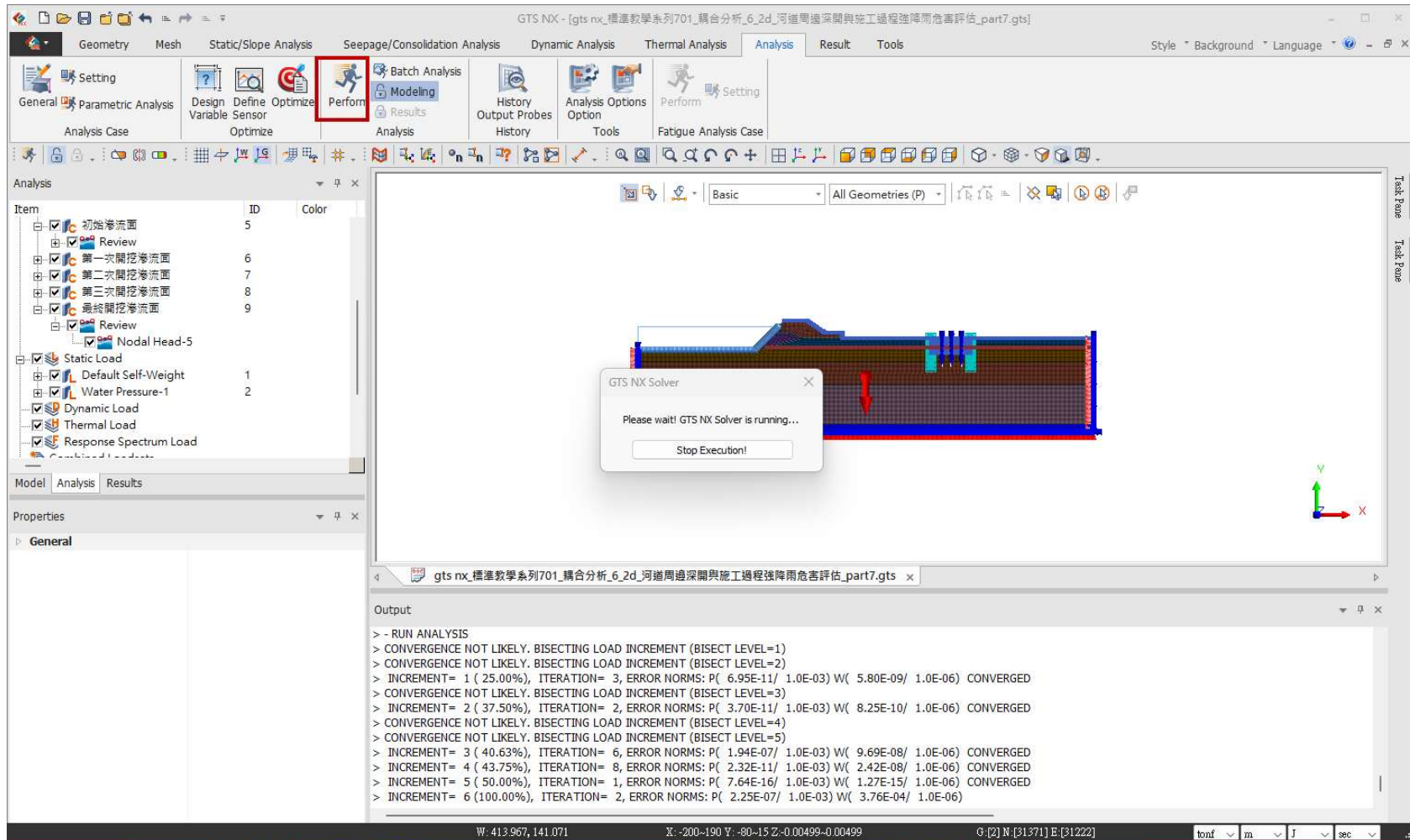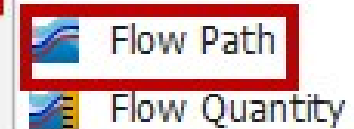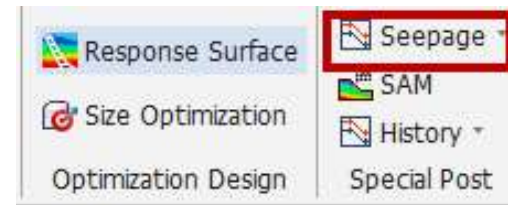
Results-1

Sequence of analysis in CS

河道周邊深開挖
- Stage0.未施工前-Seepage
- Stage0.未施工前-Stress
- Stage1.連續壁(24m)和中間柱施-Seepage
- Stage1.連續壁(24m)和中間柱施-Stress
- Stage2.開挖1(開挖深度-2m)-Seepage
- Stage2.開挖1(開挖深度-2m)-Stress
- Stage3.水平支撐1(位置-1m)-Seepage
- Stage3.水平支撐1(位置-1m)-Stress
- Stage4.開挖2(開挖深度-5m)-Seepage
- Stage4.開挖2(開挖深度-5m)-Stress
- Stage5.水平支撐2(位置-4m)-Seepage
- Stage5.水平支撐2(位置-4m)-Stress
- Stage6.開挖3(開挖深度-9m)-Seepage
- Stage6.開挖3(開挖深度-9m)-Stress
- Stage7.水平支撐3(位置-8m)-Seepage
- Stage7.水平支撐3(位置-8m)-Stress
- Stage8.最終開挖 (-12m)-Seepage
- Stage8.最終開挖 (-12m)-Stress
- Stage9.筏基梁版(t=1m)-Seepage
- Stage9.筏基梁版(t=1m)-Stress

施工階段0_Flow Path
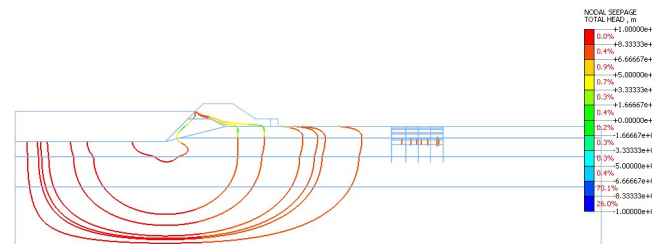
施工階段9_Flow Path
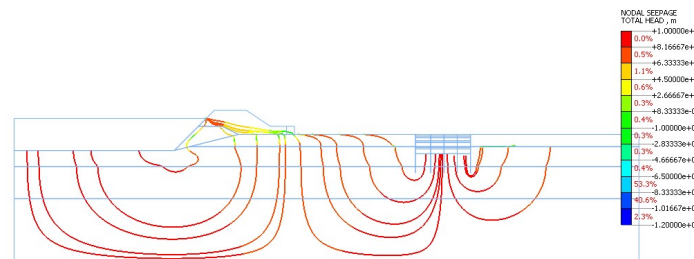
Results-2
(Total Translation(m))

Stage2
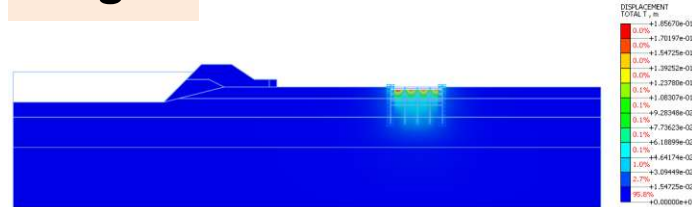
Stage0.Intial condition
Stage1.RW (24m) & center column
Stage2.Ex1_-2m
Stage3.Strut1_-1m
Stage4.Ex2_-5m
Stage5.Strut2_-4m
Stage6.Ex3_-9m
Stage7.Strut3_-8m
Stage8.Ex4_-12m
Stage9.Raft foundation (t= 1m)
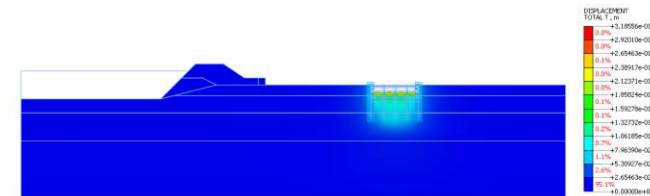
Stage4

Stage6

Stage6

Part8. Heavy rainfall assessment

MIDAS Taiwan

Bofore Excav Stage 3

Heavy rainfall struck 72 hours continuously

Rainfall Recording
(Hours)

| kN ⌄ | m ⌄ | J ⌄ | hr ⌄ |

Material Property
CSys
Function
Hinge
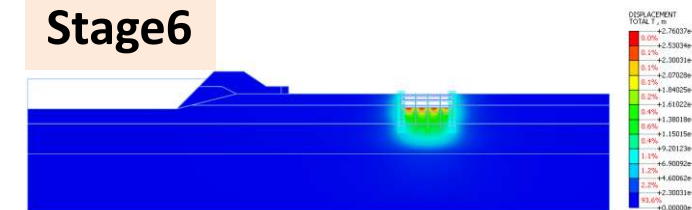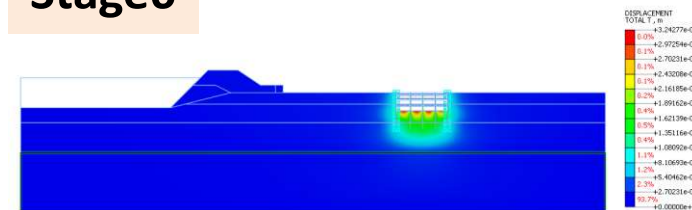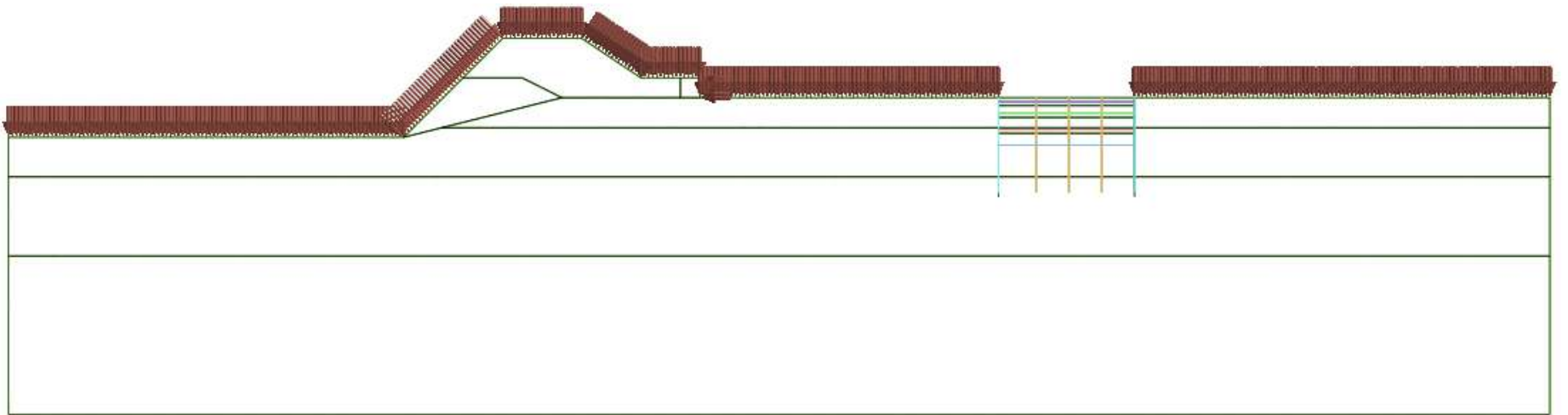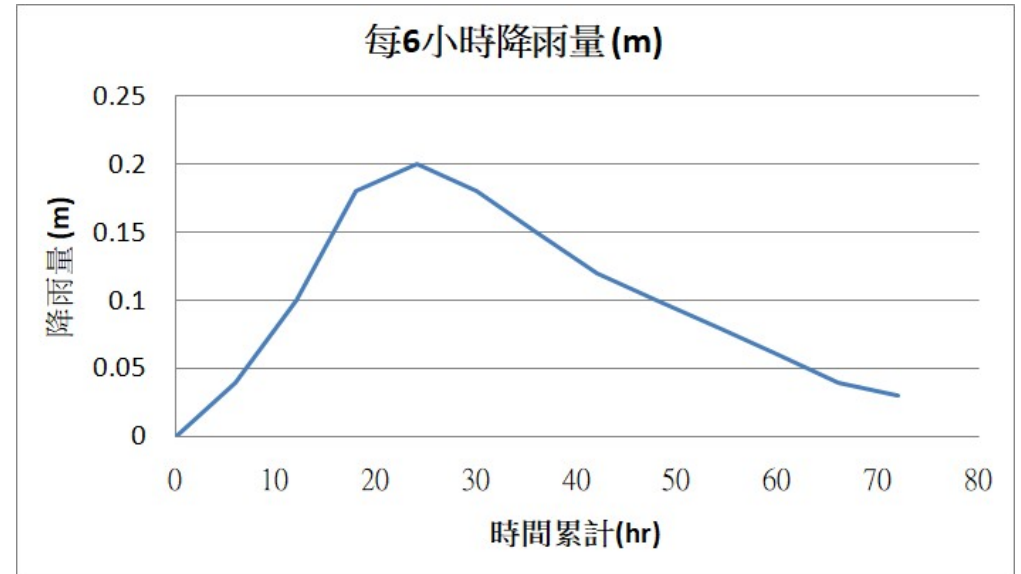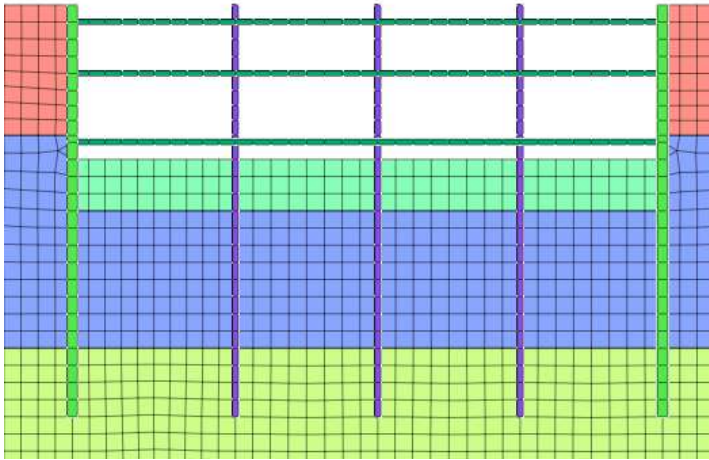Prop./CSys./Func.

Seepage Boundary

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

72 hours for heavy rainfall

Seepage Boundary ✕

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
	0.12
	0.1
	0.08
60	0.06
66	0.04
72	0.03

開啓Excel

Copy & paste recording 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

2D_強降雨危害
評估.xls

Description [   ]   OK   Cancel   Apply
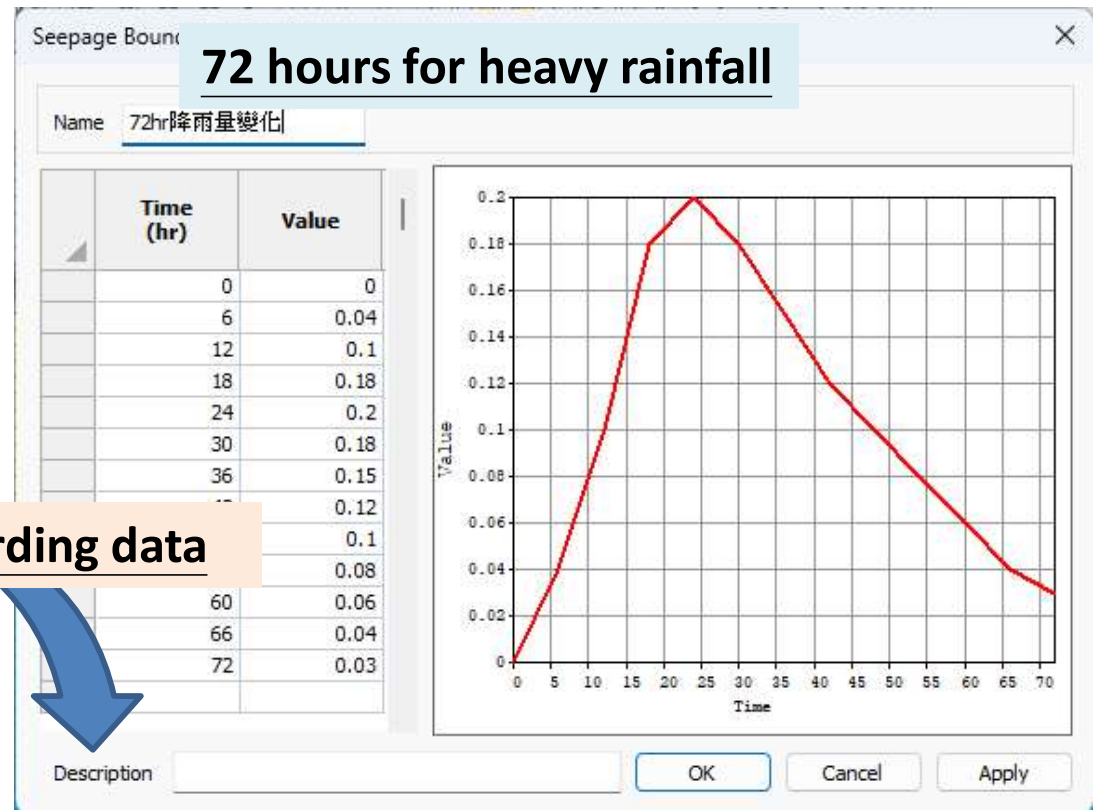
MIDAS 　註:GTS NX不支援Y軸單位切換。

Surface Flux

| kN ∨ | m ∨ | J ∨ | hr ∨ |

Seepage/Consolidation Analysis

Define Set · Change Property · Nodal Head · Draining Condition
Constraint · Review · Nodal Flux · Non ConSolidation · Table ▾
Constraint Equation · Water Level · **Surface Flux** · From Results
Boundary

Selecting line features

Flux = Value × Function

Flux

| Nodal Flux | Surface Flux |

Name: Surface Flux-1

Type: Edge Flux

Object

Type: 2D Element Edge

Selected 442 Object(s)

Value: 1 m³/hr/m

☑ Function: 72hr降雨量變化

☑ if q > Ksat, then Total Head = Potential Head

Boundary Set: 連續降雨

OK   Cancel   Apply

Continuous rainfall curve
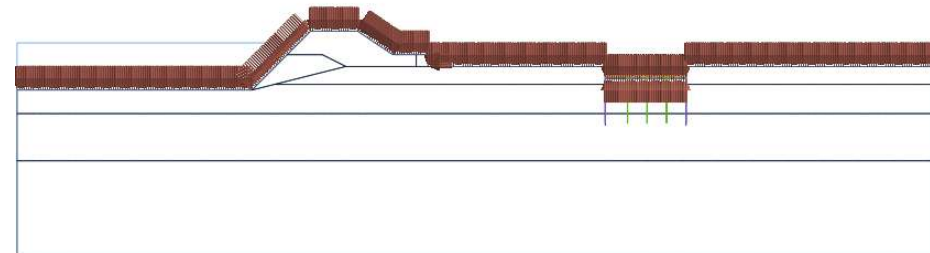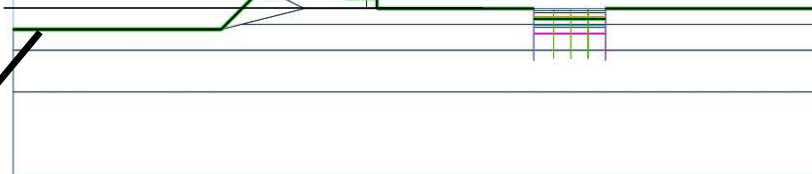
Note:
if surface flux > coefficient of permeability
total head = potential head

(meaning of the velocity is ignore due to the higher of pressure & elevation of flux)

MIDAS   NX

Heavy Rainfall Assessment-1

New CS type: Stress-Seepage-slope

Step1.Select stage6

Step2. Insert

Step3. Select the previous construction stage

Heavy Rainfall Assessment-2
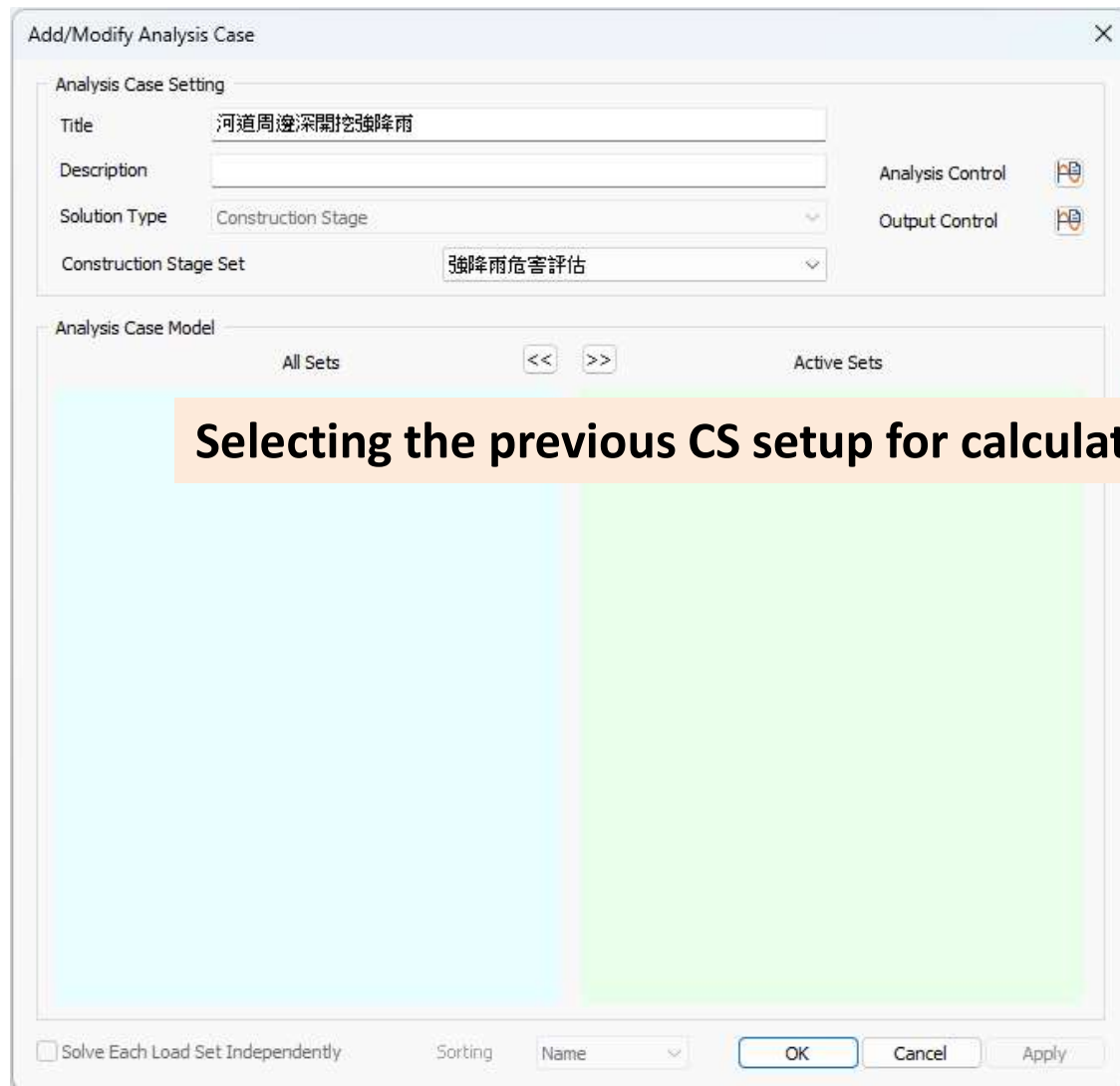

Activated Data
Continuous rainfall condition
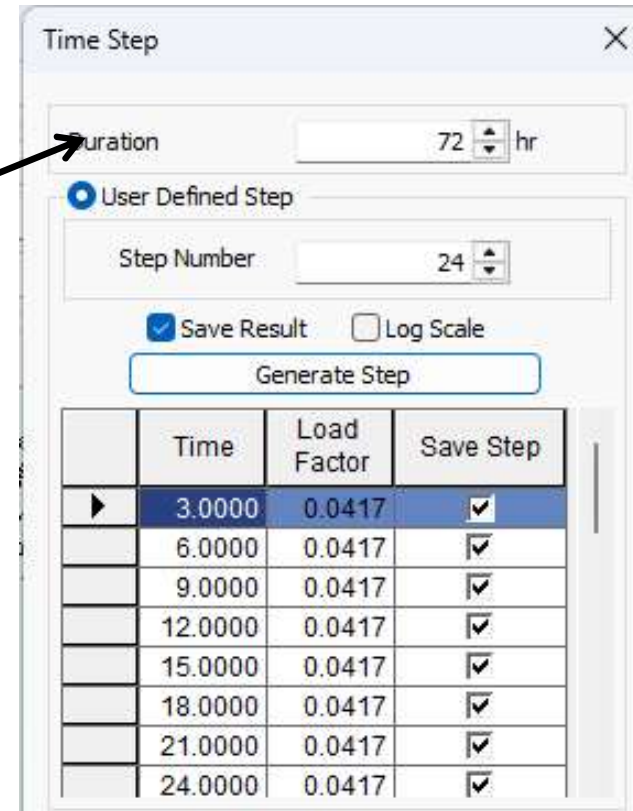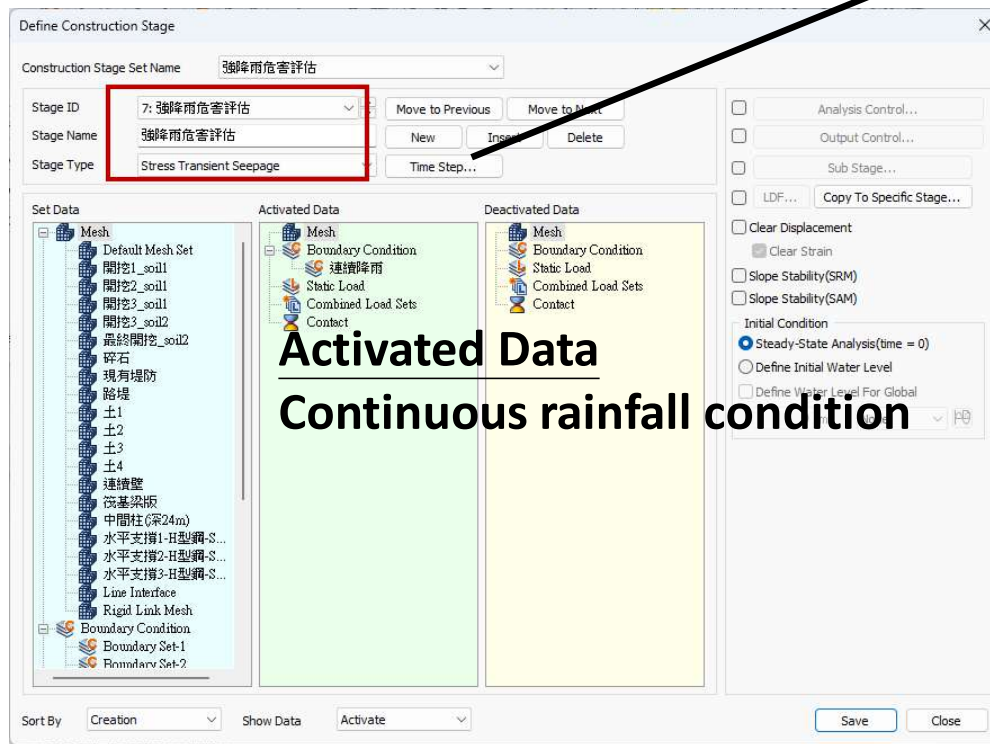
Analysis-1

Analysis type: Construction Stage

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)

Add/Modify Analysis Case

Analysis Case Setting

Title	河道周邊深開挖強降雨
Description	
Solution Type	Construction Stage
Construction Stage Set	強降雨危害評估

Analysis Control
Output Control

Analysis Case Model

All Sets   <<   >>   Active Sets

Selecting the previous CS setup for calculation

☐ Solve Each Load Set Independently   Sorting   Name   OK   Cancel   Apply

Analysis-2
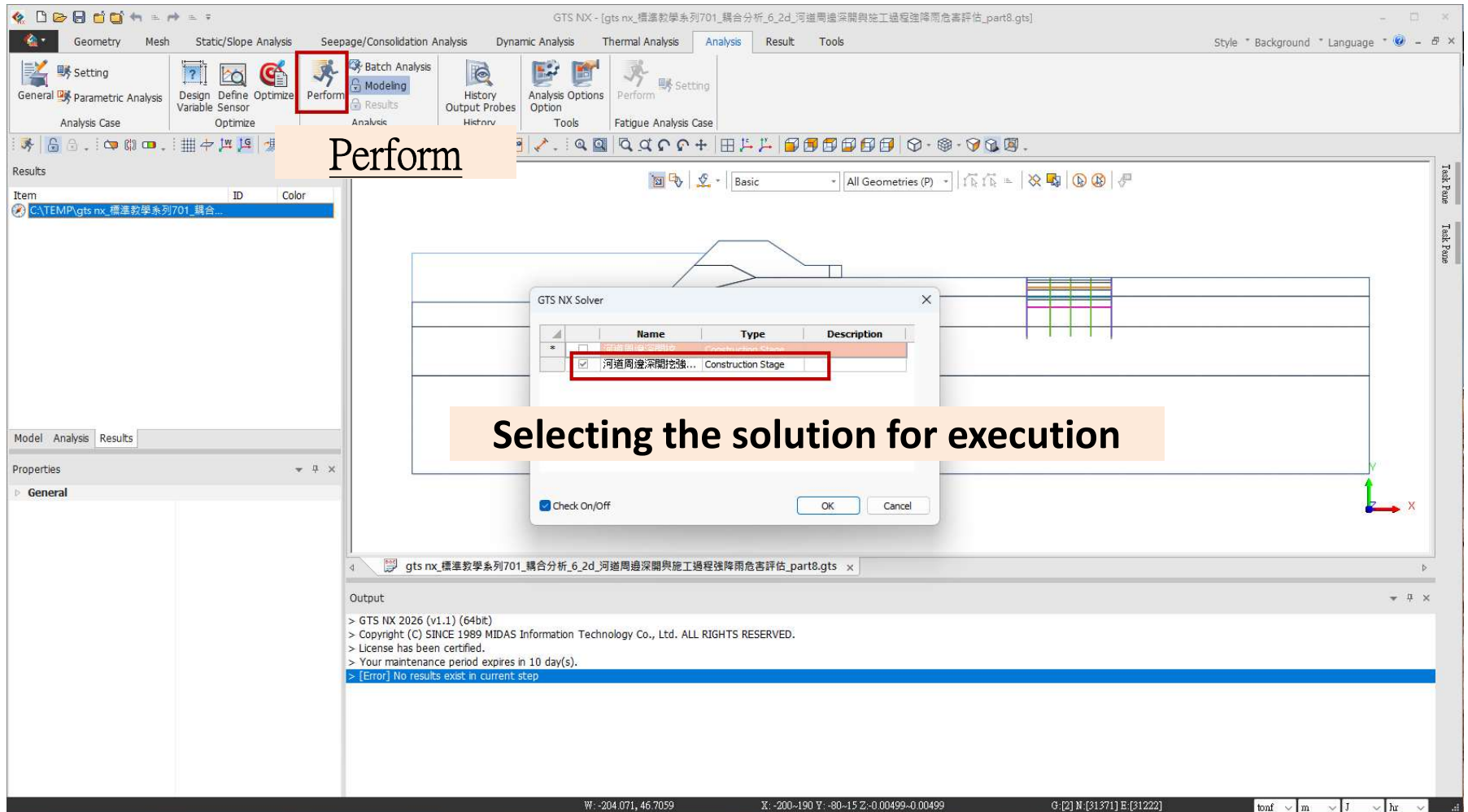

Tick on
Automatically Consider Water Pressure

Tick on
Estimate initial stress of activated elements

Tick on
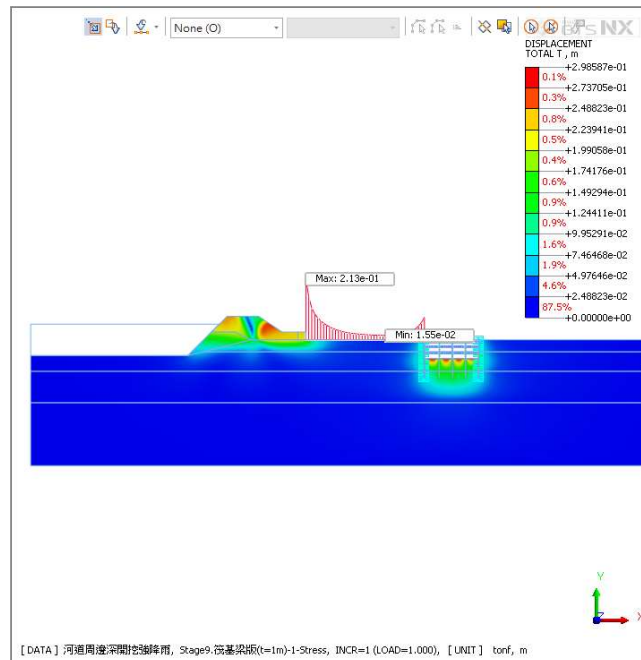Estimate initial Configuration of activated nodes

Calculation

Perform

Selecting the solution for execution

Results
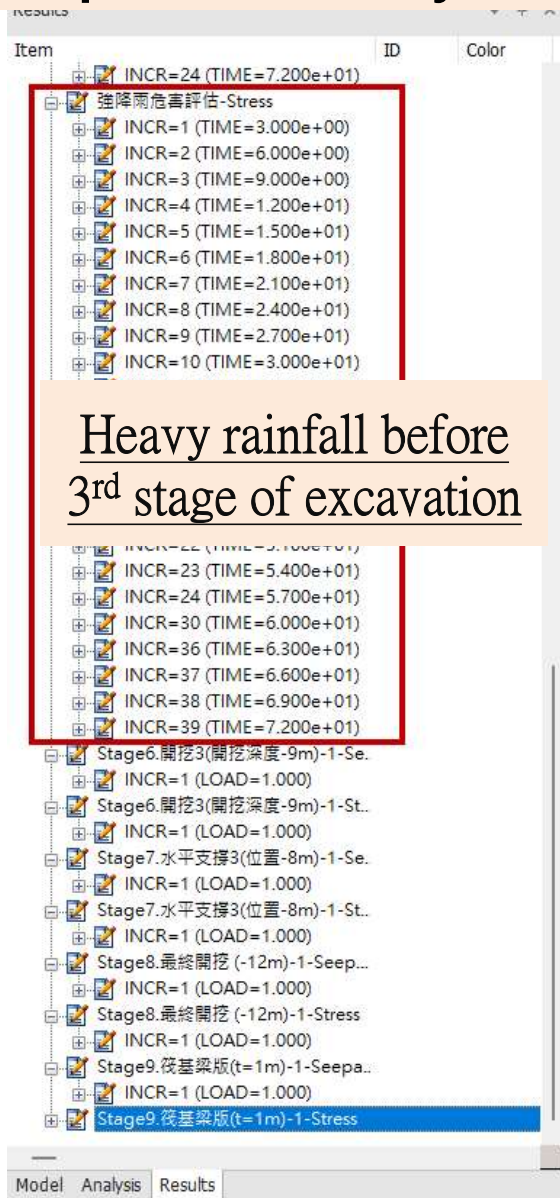
Stage6.Ex3_-9m

Heavy rainfall consideration

No rainfall consideration