

GTS NX

Heavy rainfall during deep excavation
nearby a river channel

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Note: The parameters in the example use assumed conditions.

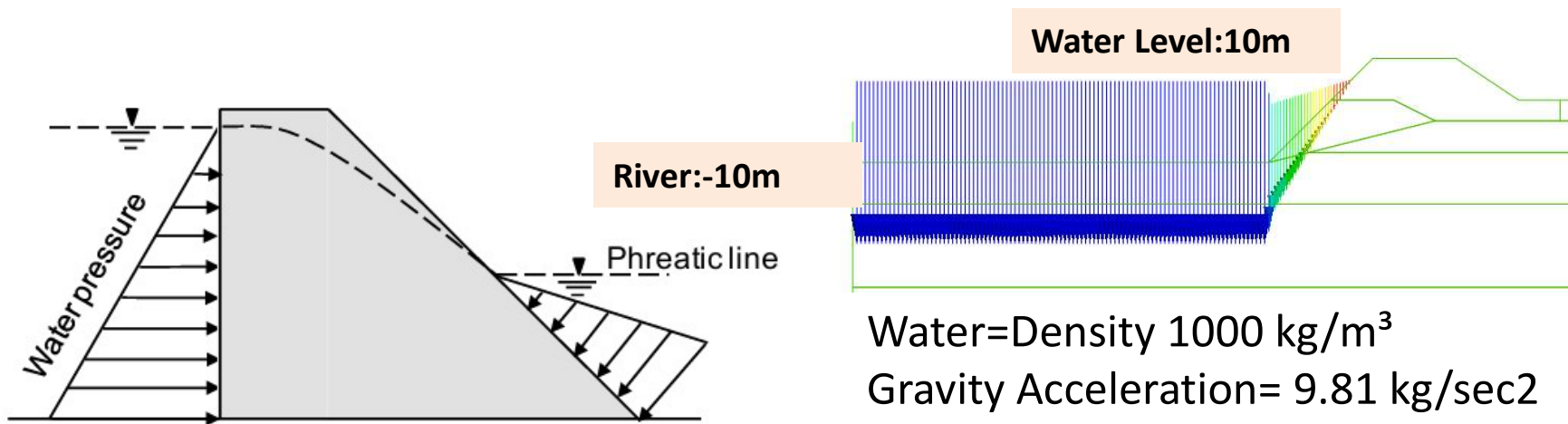
Water Pressure

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 ($Z_{\text{coordinate}}$)
2. Hydrostatic pressure due to user input water level position, ($Z_{\text{water Level}}$)

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



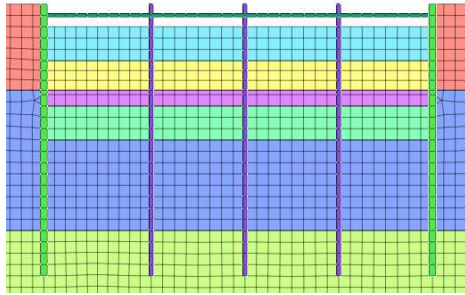
Reference

GTS NX_Analysis Reference_Chapter6_LoadConstraint

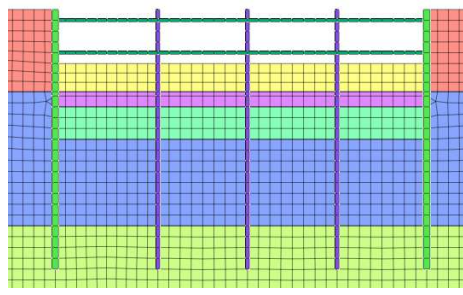


Explanation-1

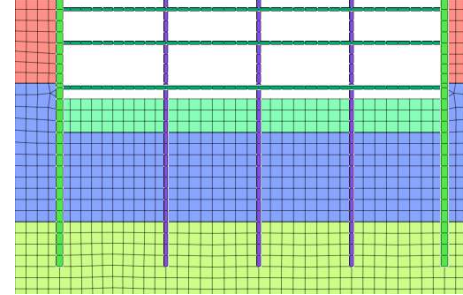
Stage 1



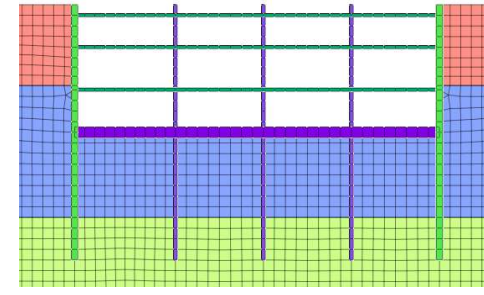
Stage 2



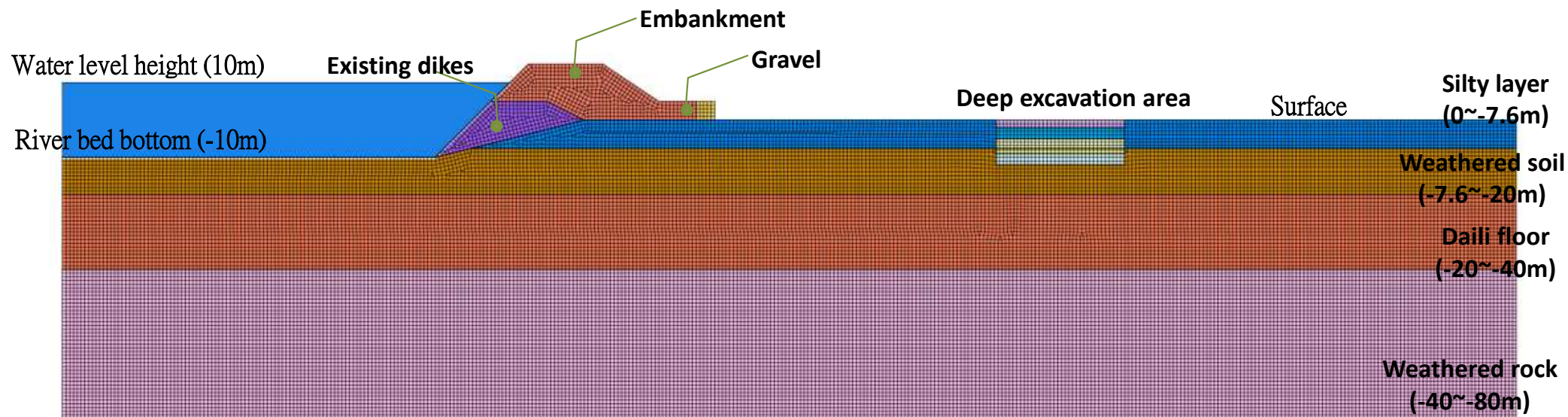
Stage 3



Stage 4

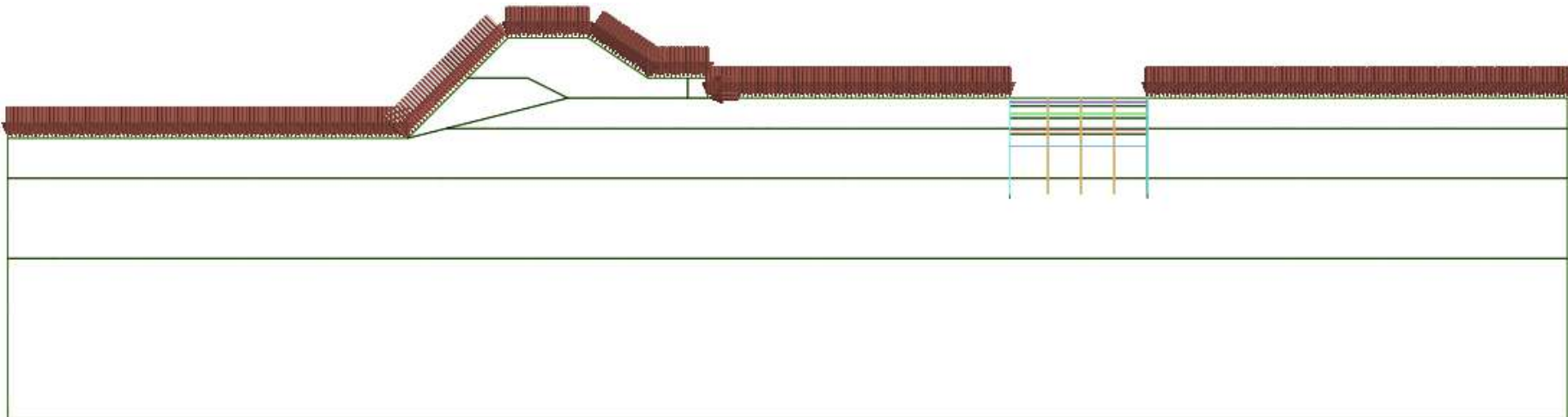
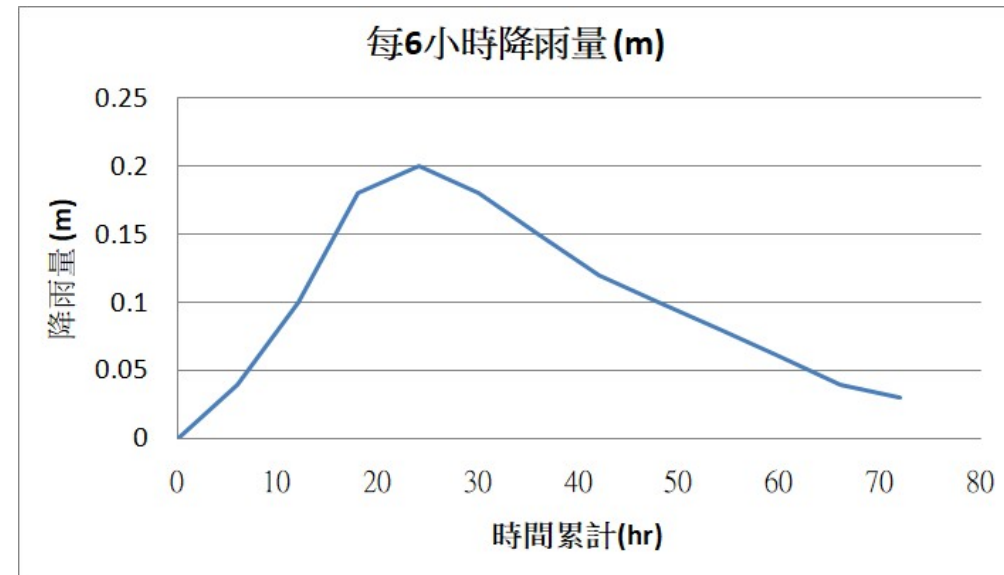
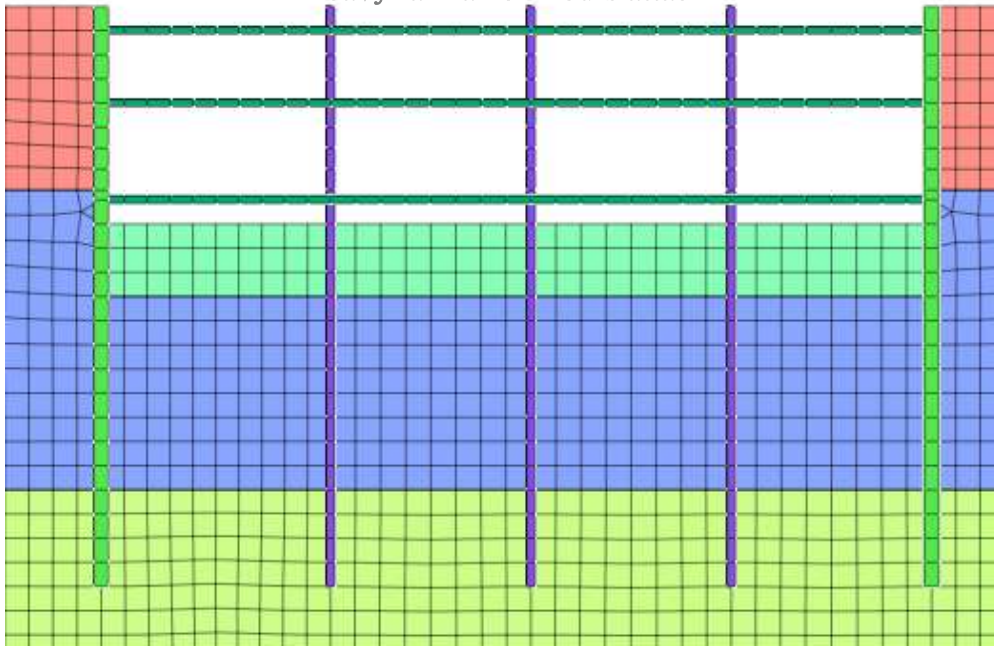


Water Pressure



Explanation-2

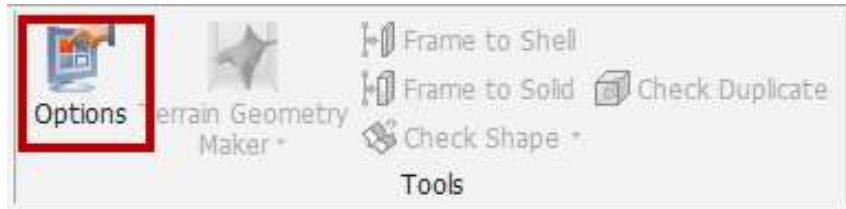
Before stage 3 of excavation
Heavy rainfall 72 hours attack



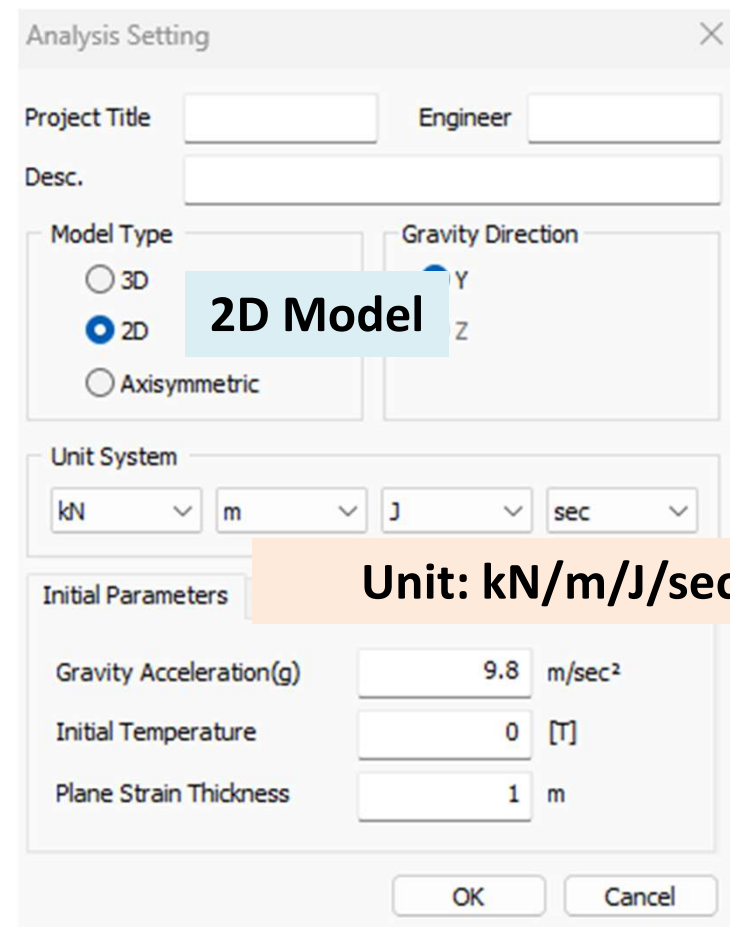
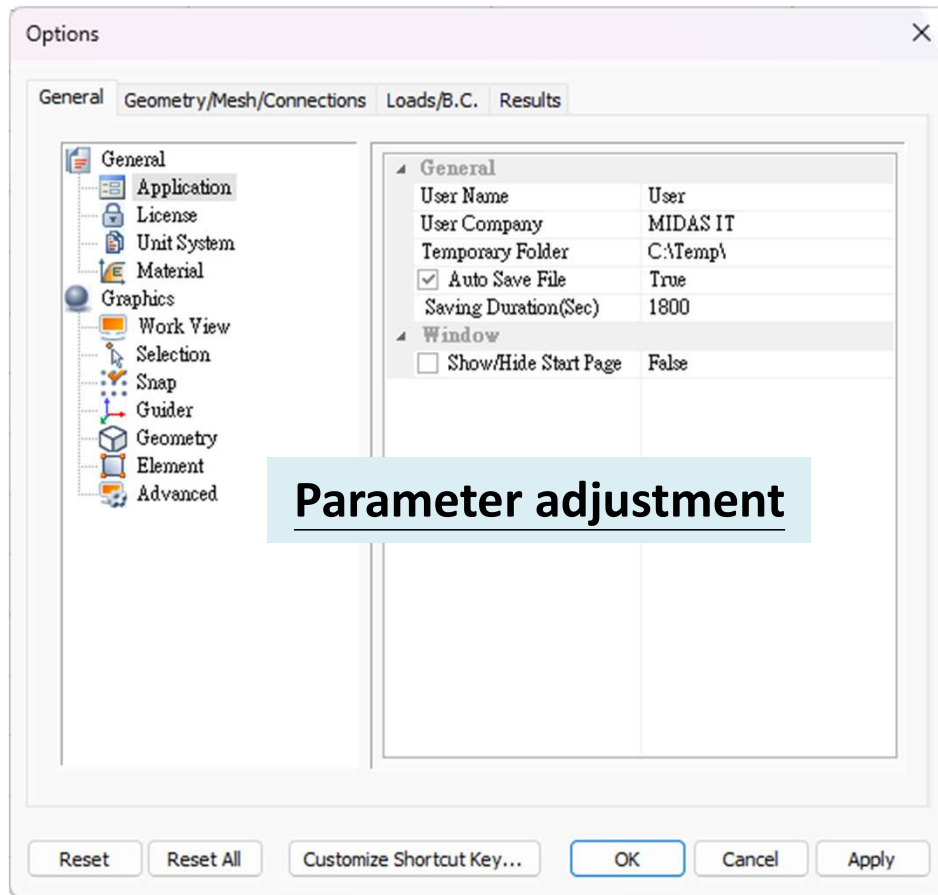
Part1. Geometry

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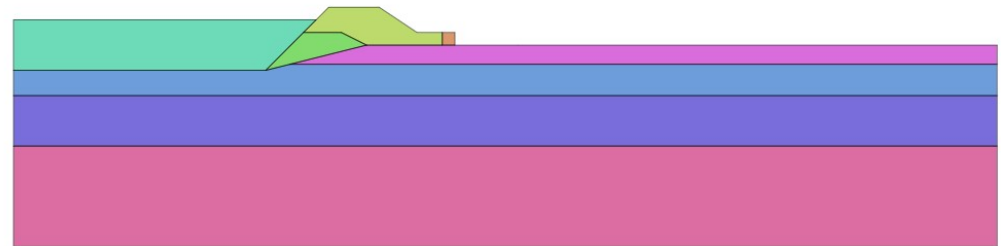
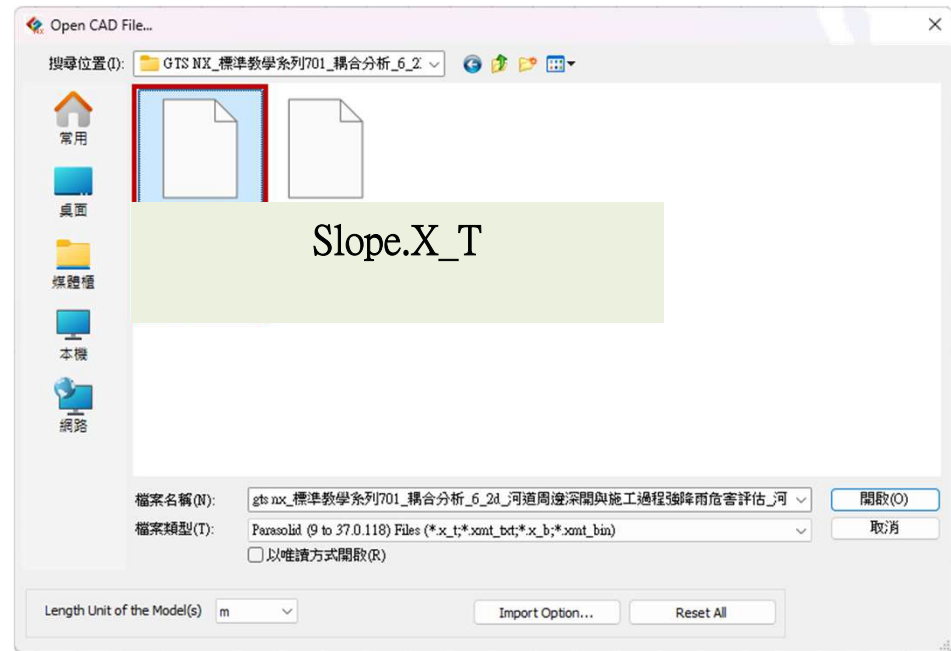
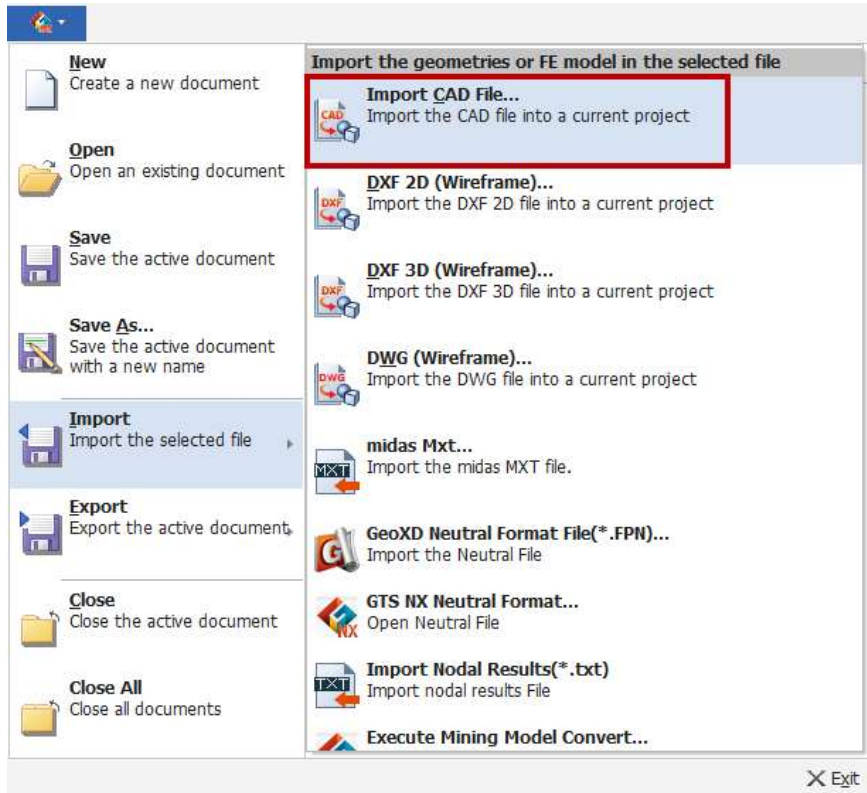
Import



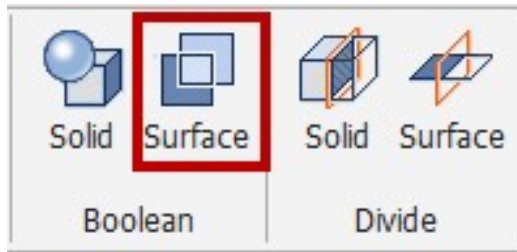
New document



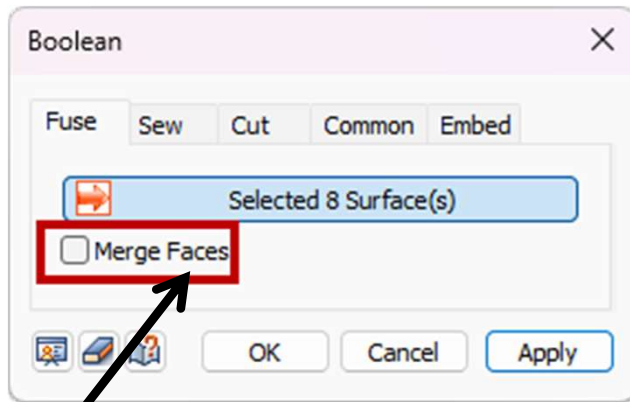
Import



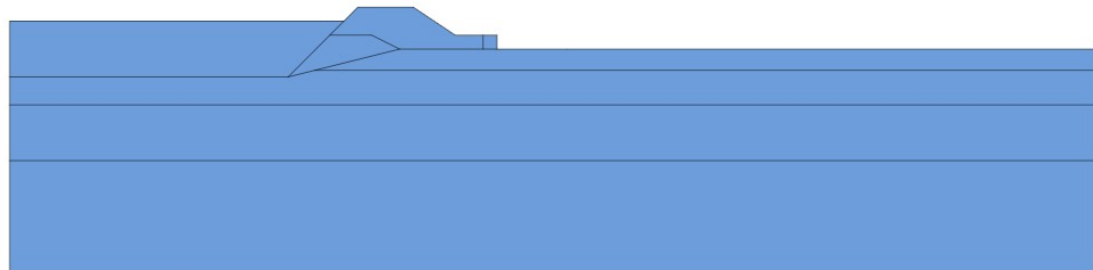
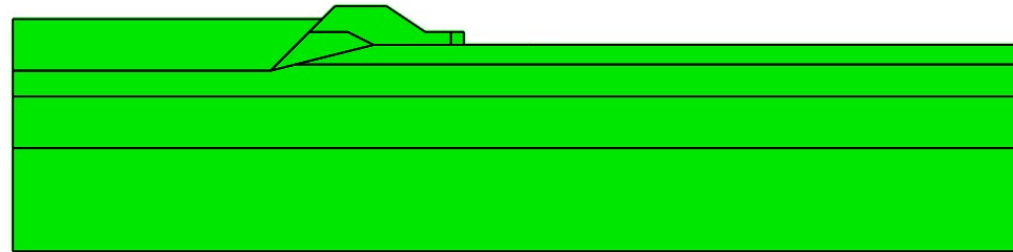
Surface merging



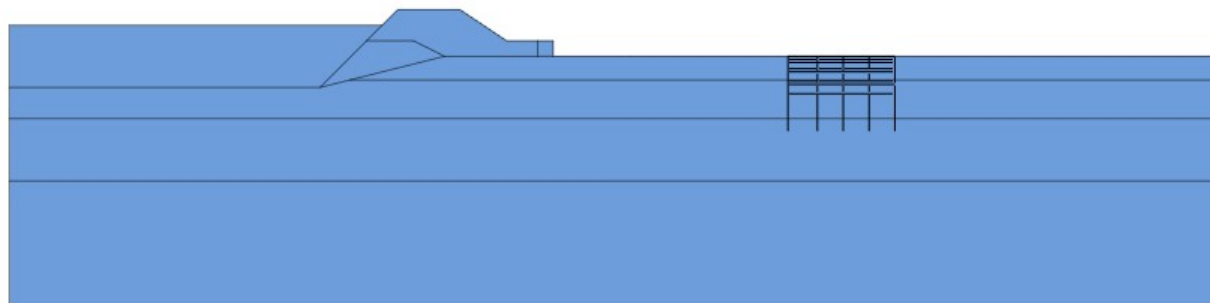
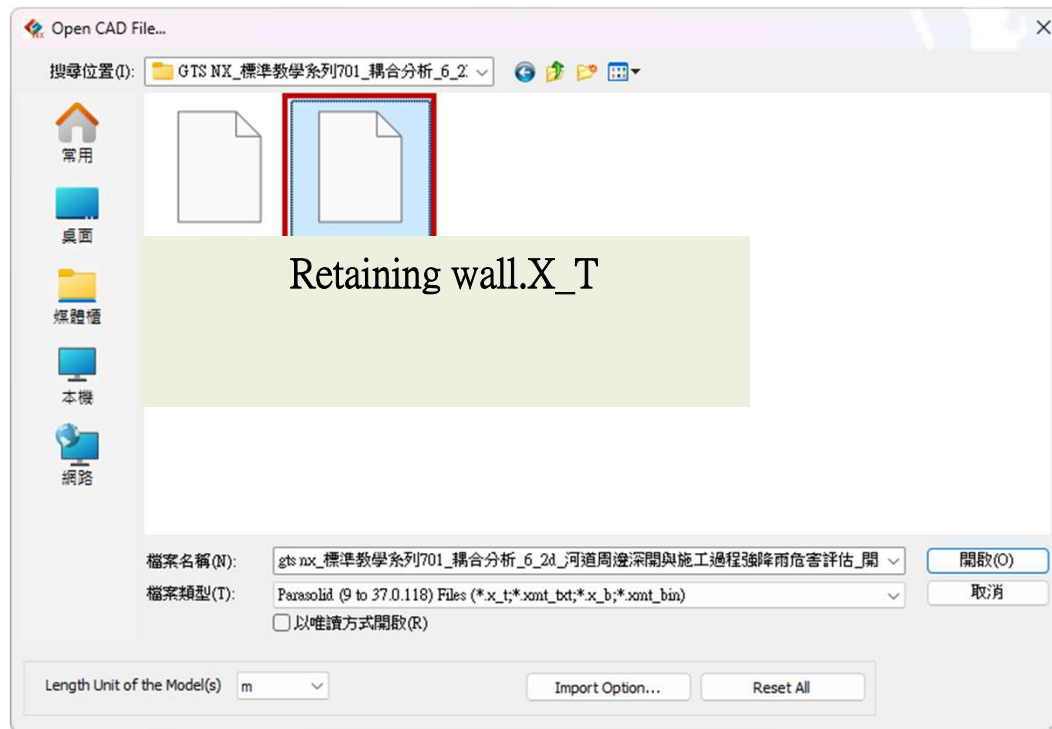
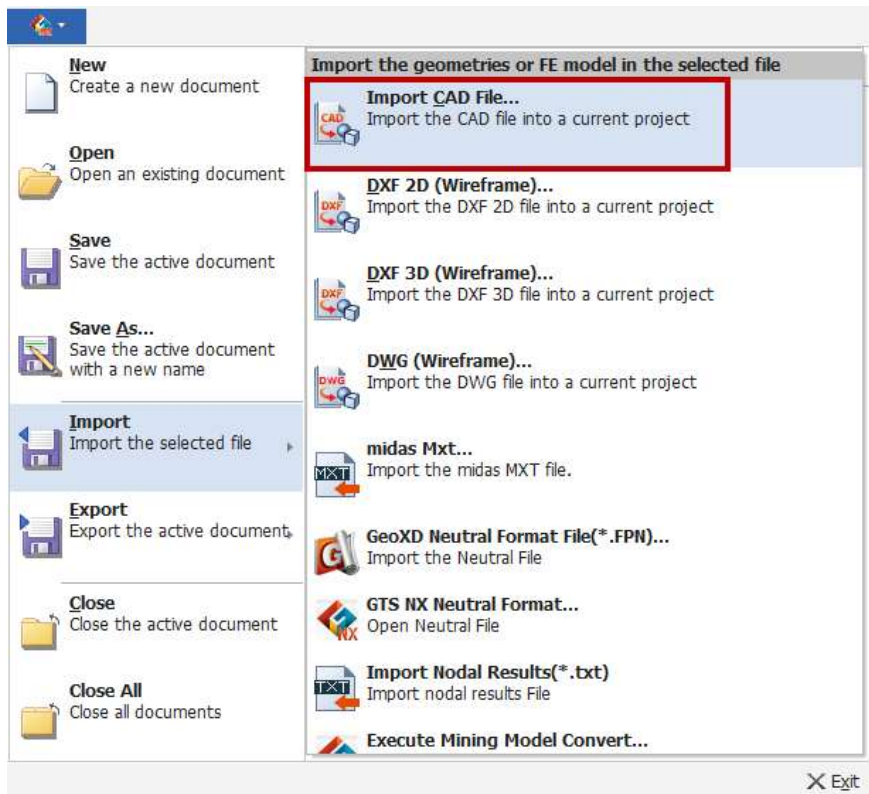
Selecting all



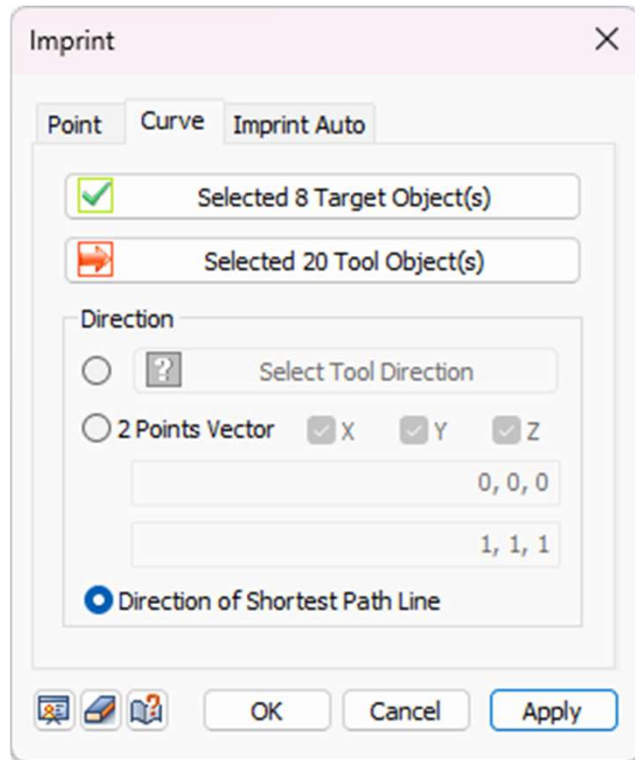
Do not tick



Import excavation area

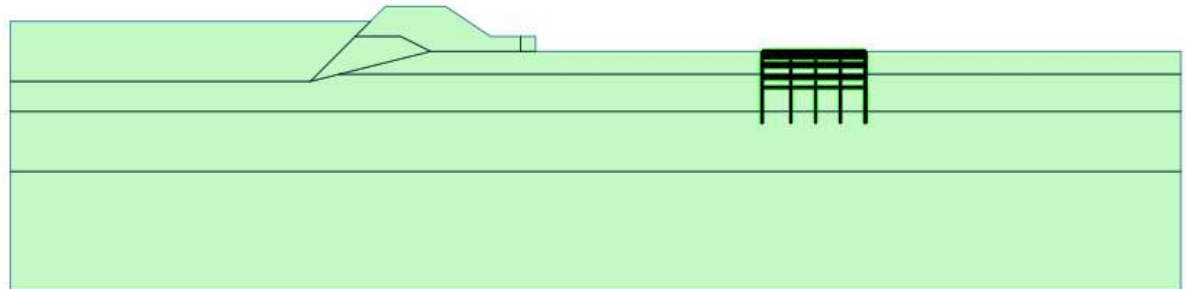


Imprint



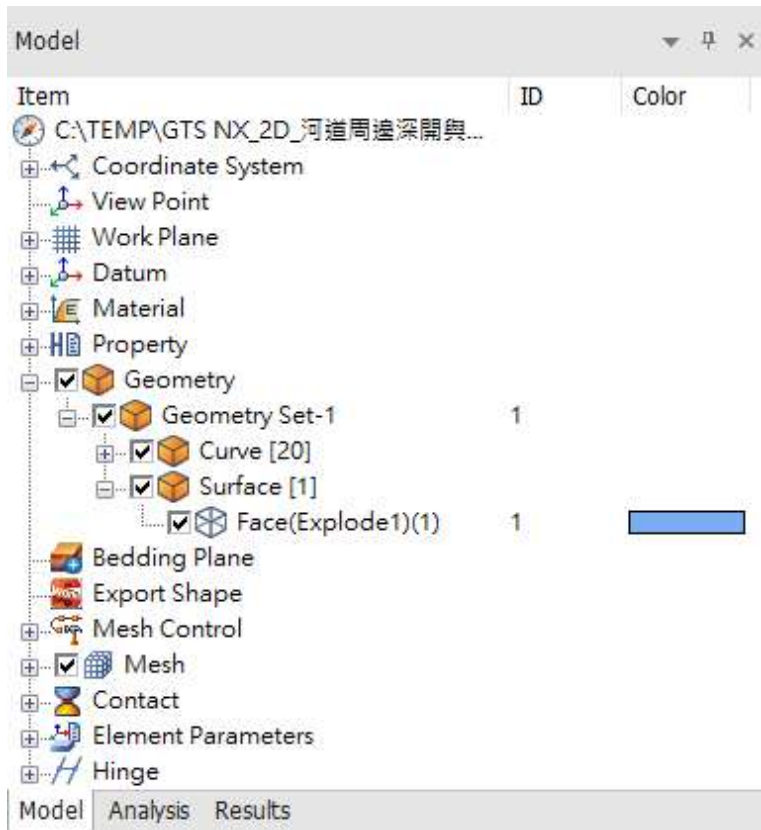
Shortest path line selected

Target Object: All surfaces

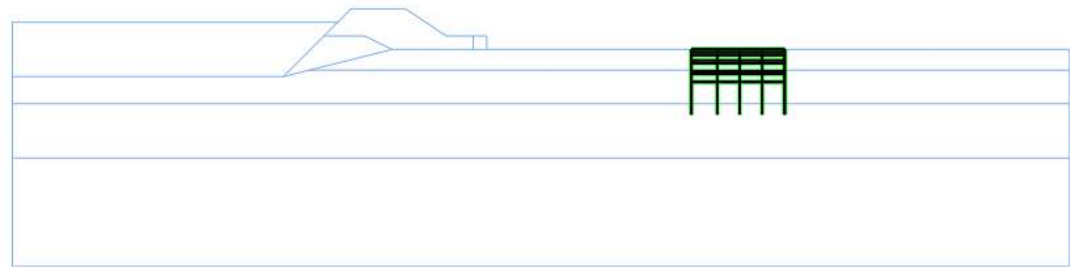


Tool Object: Excavation zone

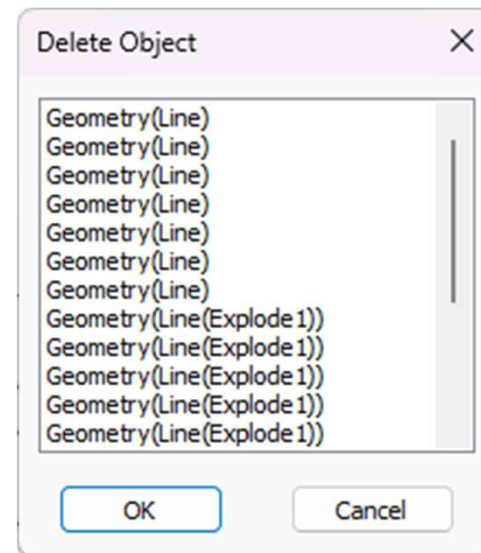
Delete curves



Step1.Excavation curves



Step2. DELETE

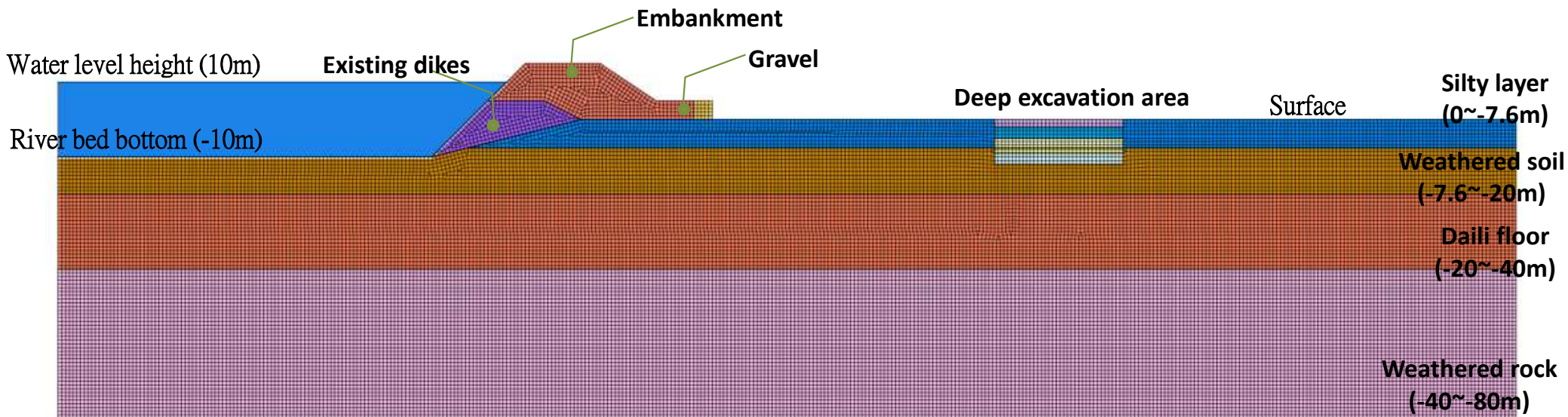


Part2. Soil Property

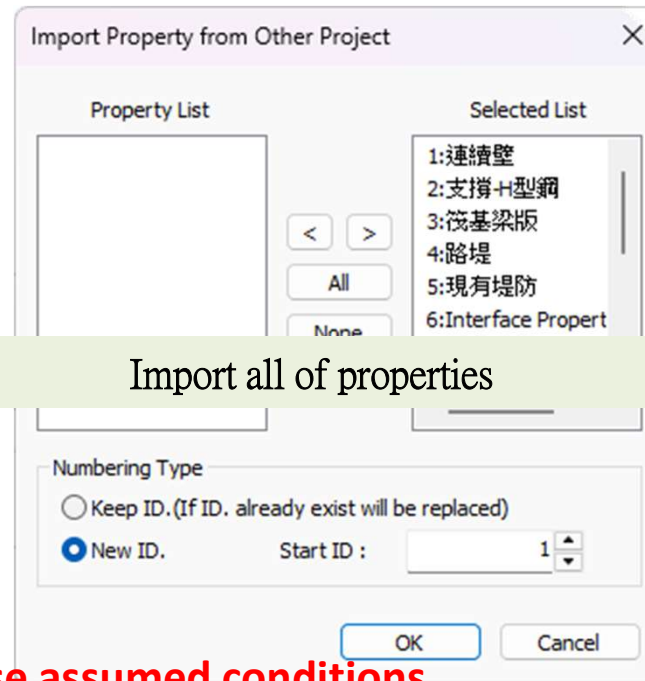
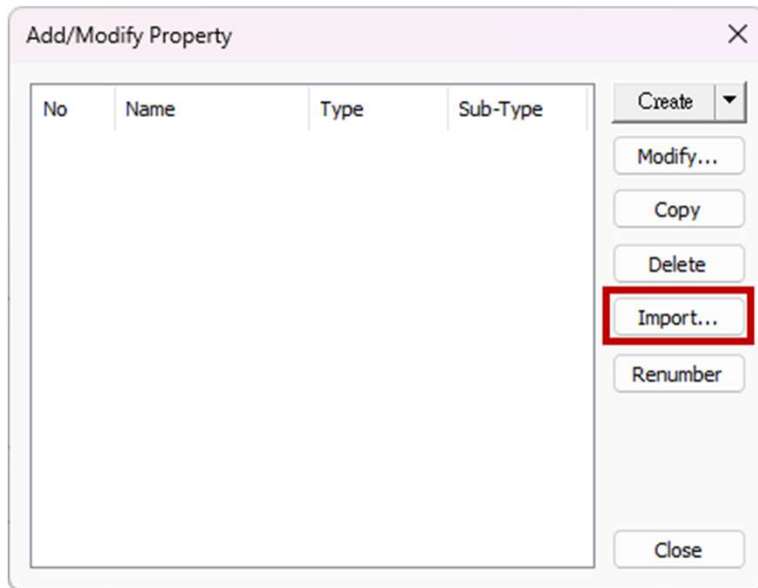
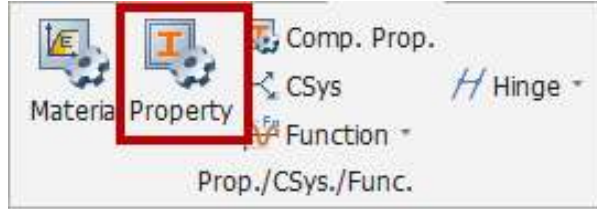
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Soil Layer Distribution

Water Pressure



Property Import



Import all of properties

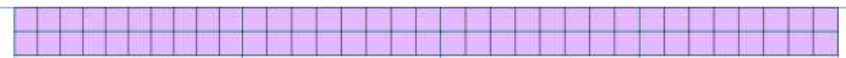
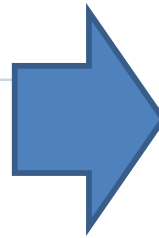
Excavation area – Stage 1 -1



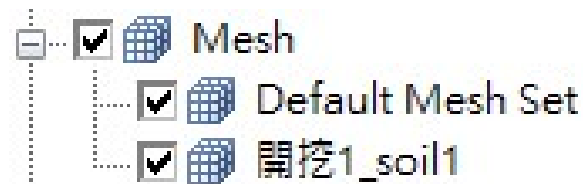
Mesh size: 1/ Prop: Silty layer

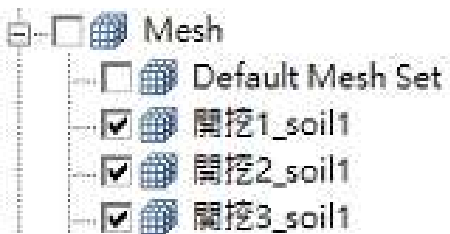
Geometry set: Excav 1_Soil1

Mesh set: Excav1_Soil1



Geometric features are automatically hidden during mesh generation

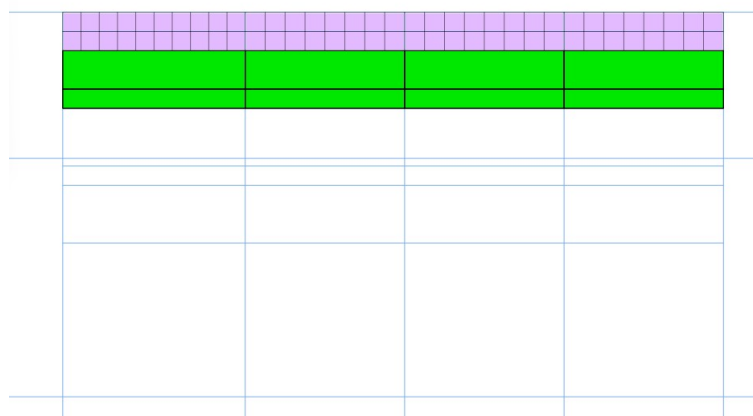




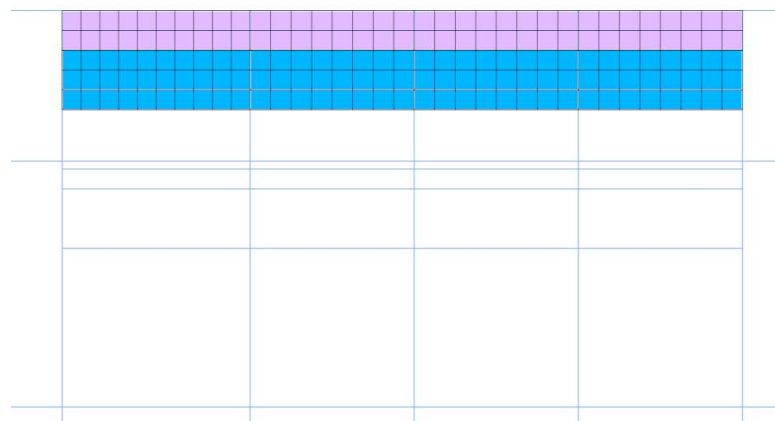
Excavation area –Stage 2 -2

Mesh size: 1/ Prop: Silty sand layer

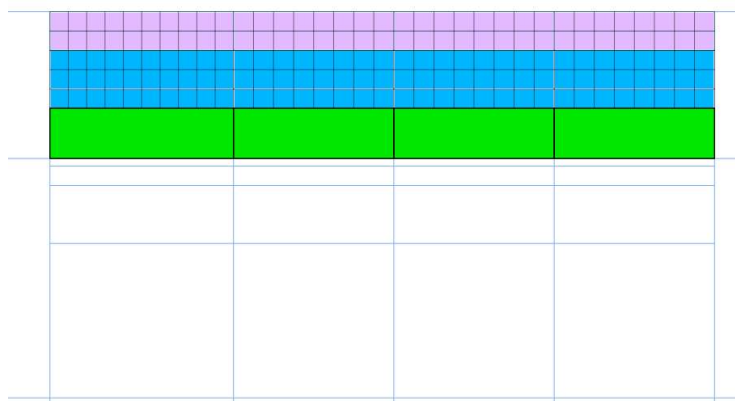
Geometry set: Excav2_Soil2



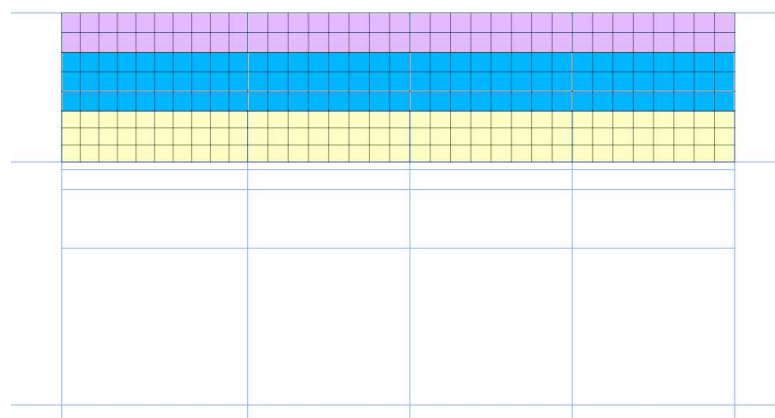
Mesh set: Excav2_Soil2



Geometry set: Excav3_soil3



Mesh set: Excav3_Soil3

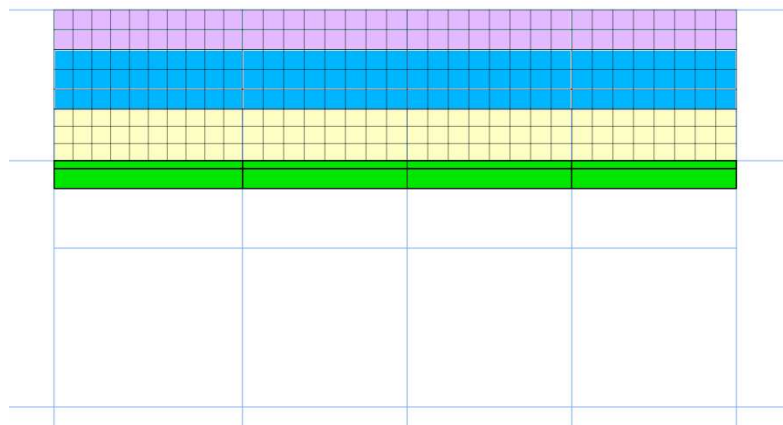


- Mesh
- Default Mesh Set
- ☑ 開挖1_soil1
- ☑ 開挖2_soil1
- ☑ 開挖3_soil1
- ☑ 開挖3_soil2
- ☑ 最終開挖_soil2

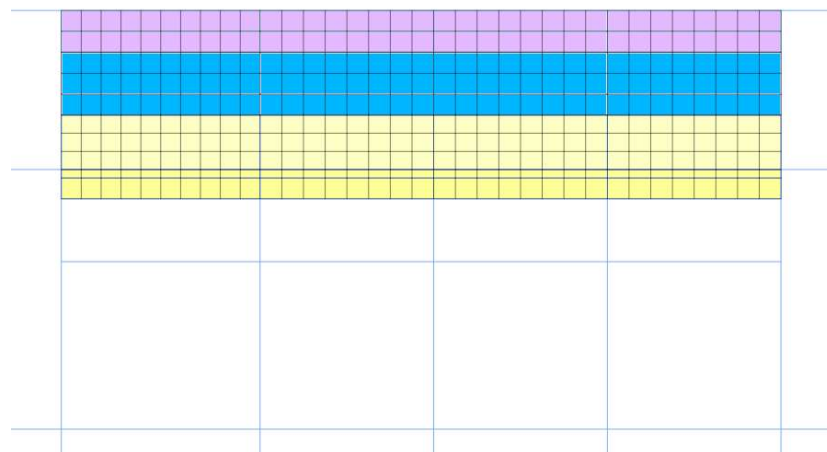
Excav area – Stage 3 -3

Mesh size: 1/ Prop: Weathered soil

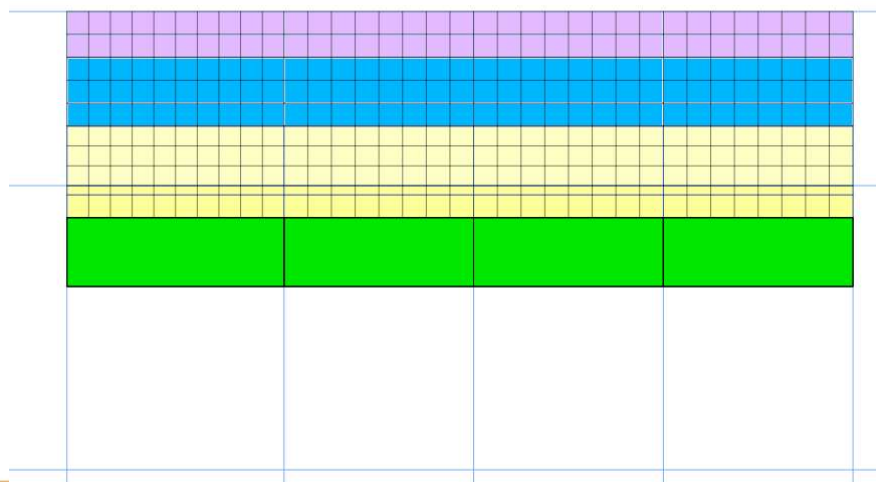
Geometry set: Excav3_Soil2



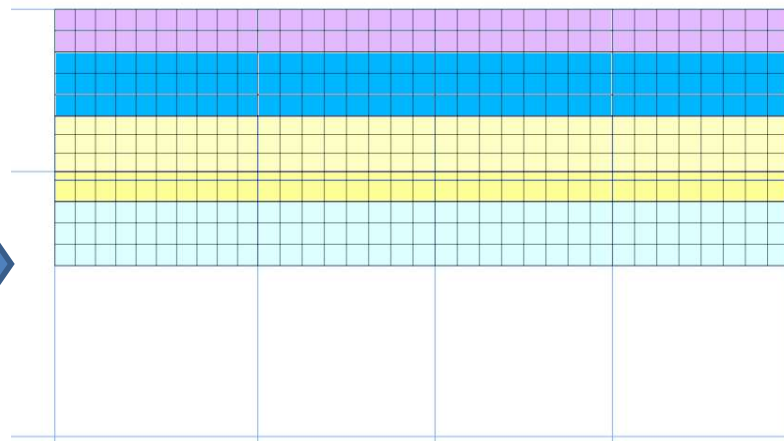
Mesh set: Excav3_Soil2



Geometry set: Excav4_Soil2



Mesh set: Excav 4_Soil2

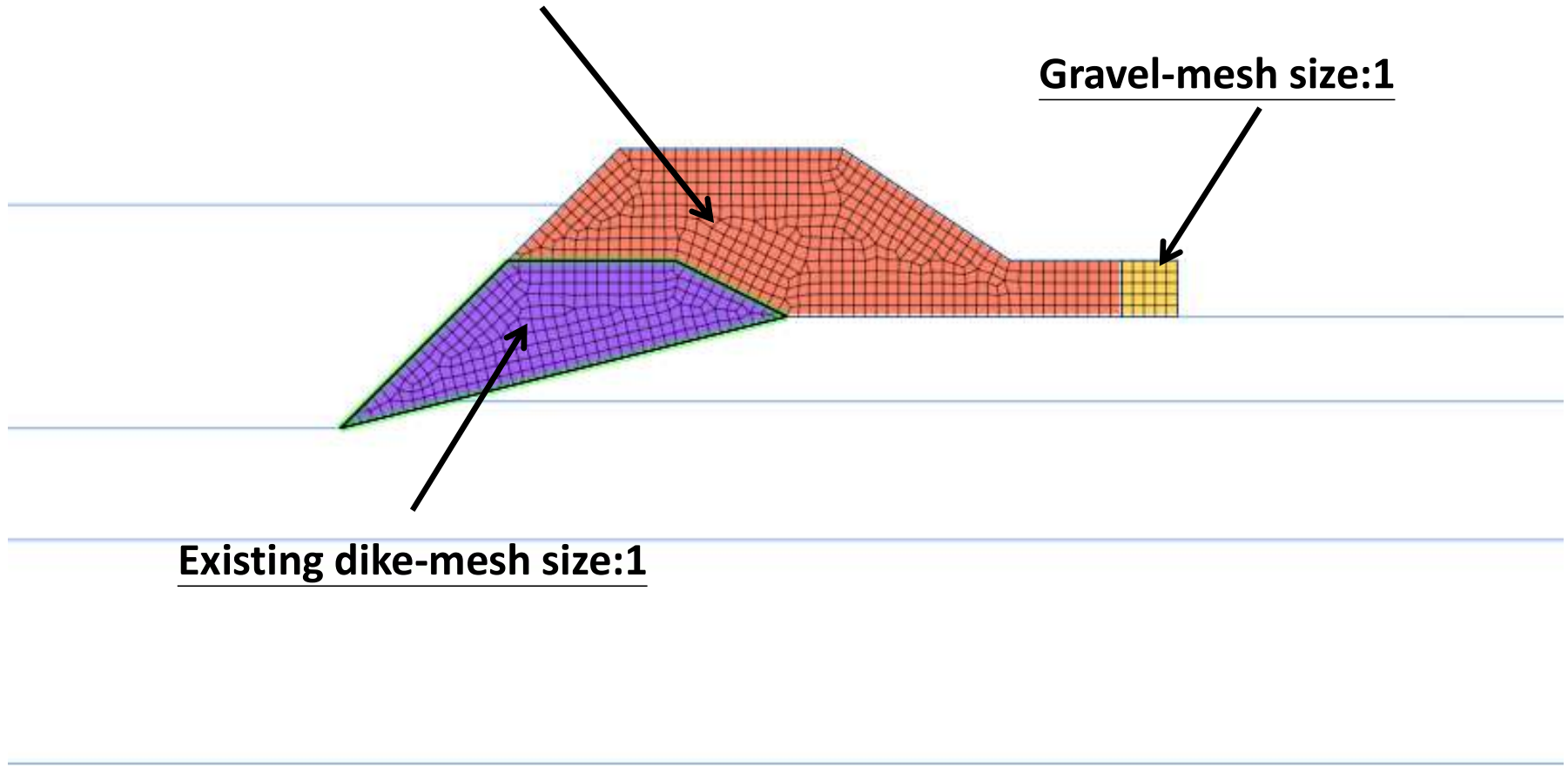


Riverbank area

Separated mesh set

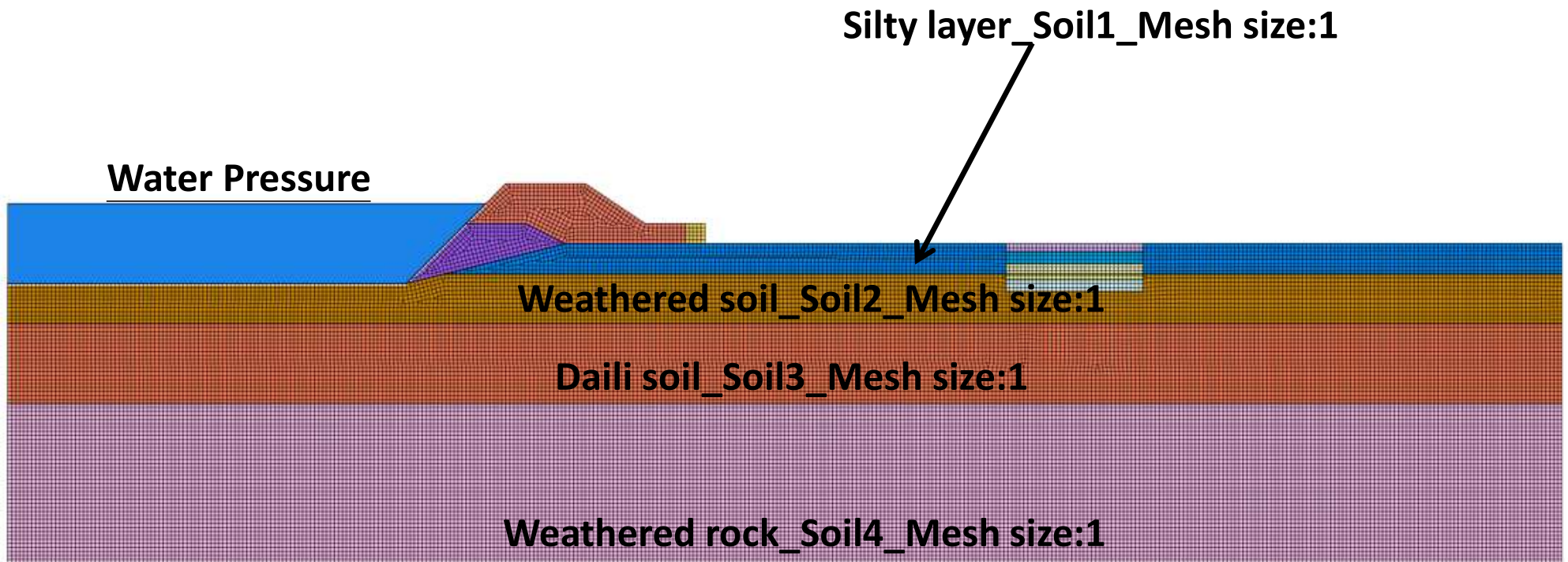
Embankment-mesh size: 1

Gravel-mesh size:1



Existing dike-mesh size:1

Soil Layer



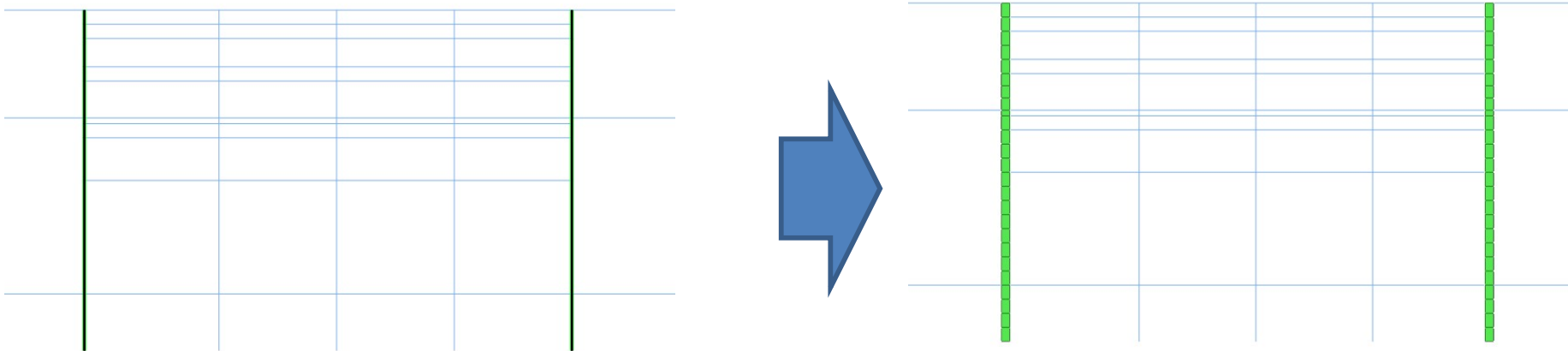
Part3. Mesh

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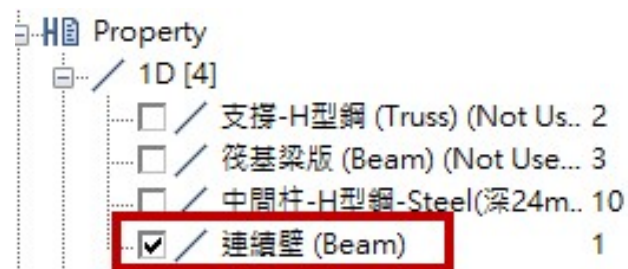
Retaining Wall-1D Beam



Extracting 1D element to retaining wall



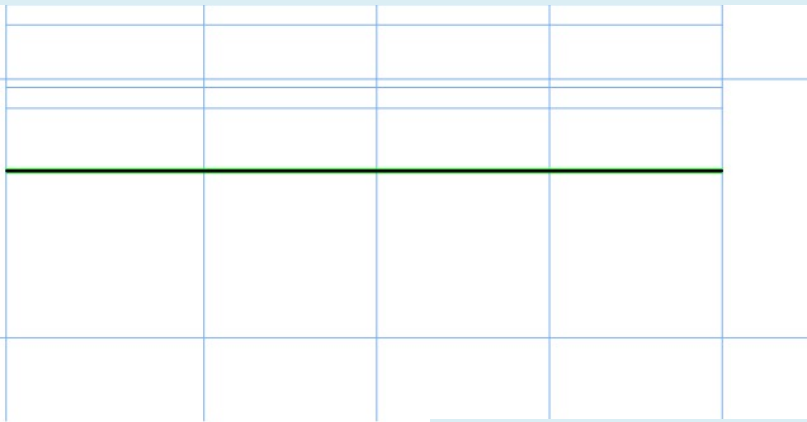
Tick on to view the property shape of BEAM



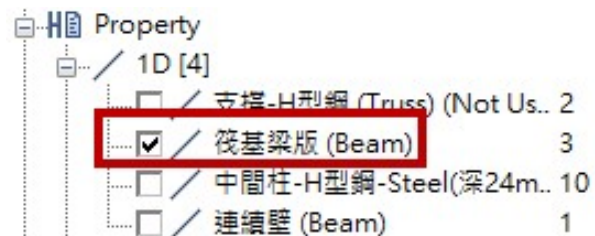
Raft foundation-1D Beam



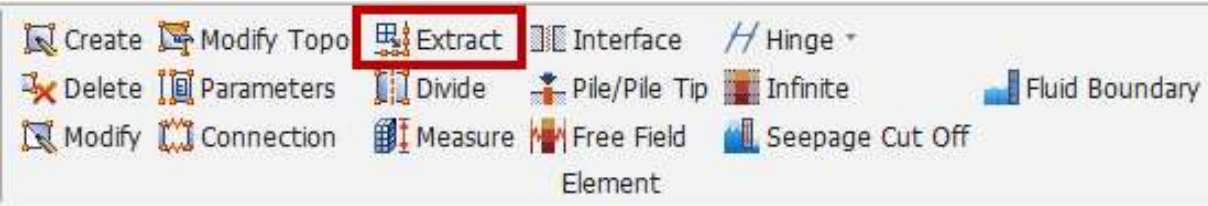
Extracting 1D element to raft foundation



Tick on to view the property shape of BEAM

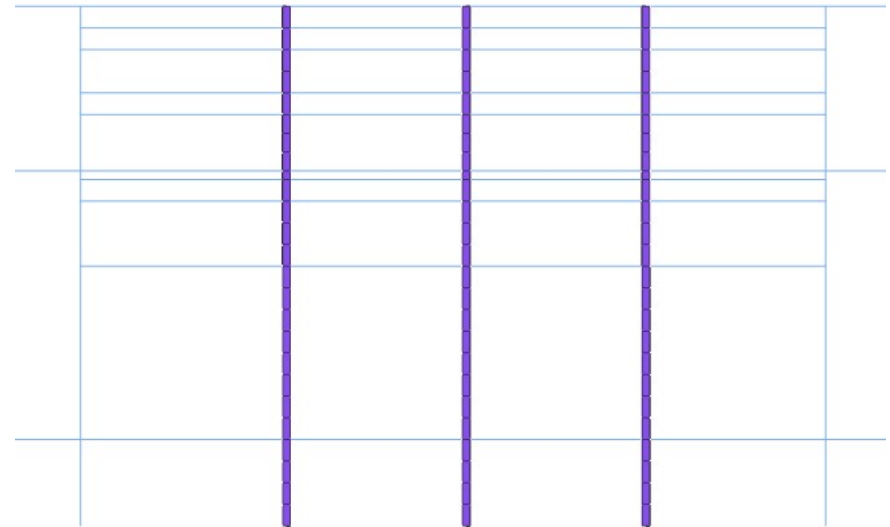
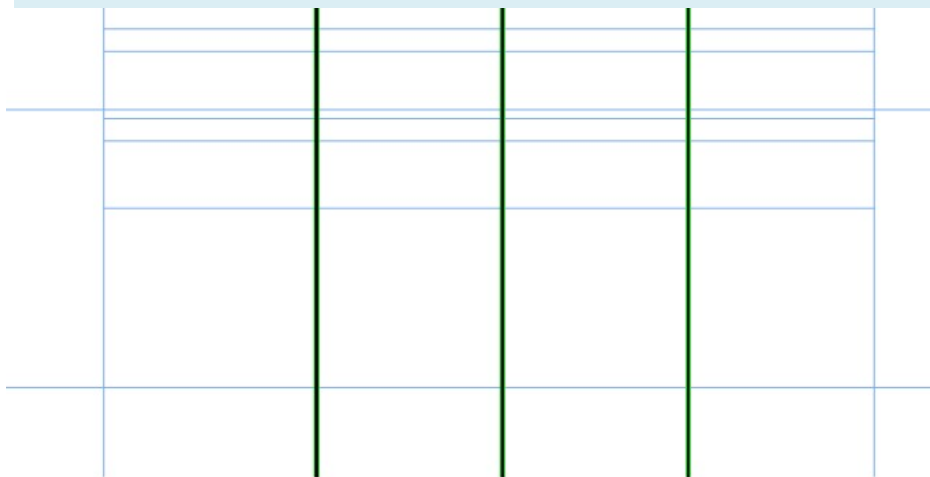


Center Column-1D Beam

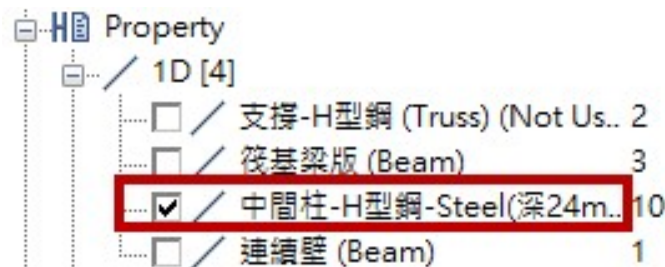


**Center column(depth 24m)
(H350 ×250 ×12 ×19)-Beam**

Extracting 1D element to center column



Tick on to view the property shape of BEAM

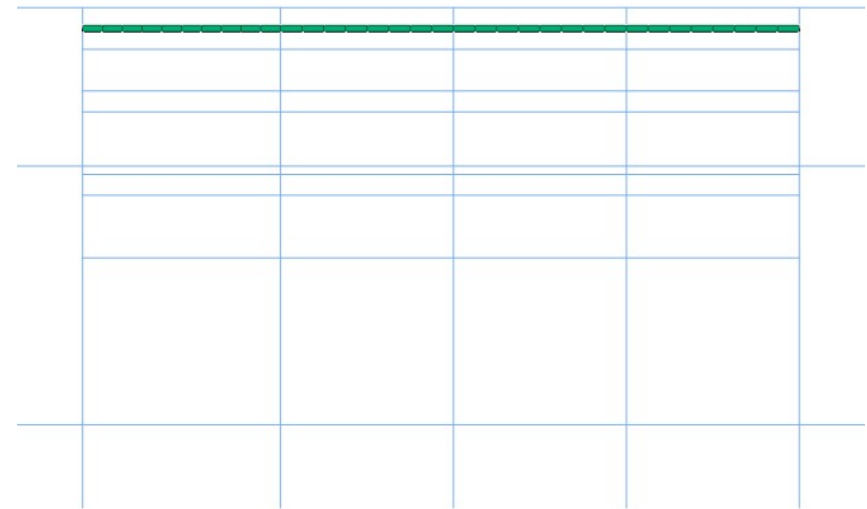
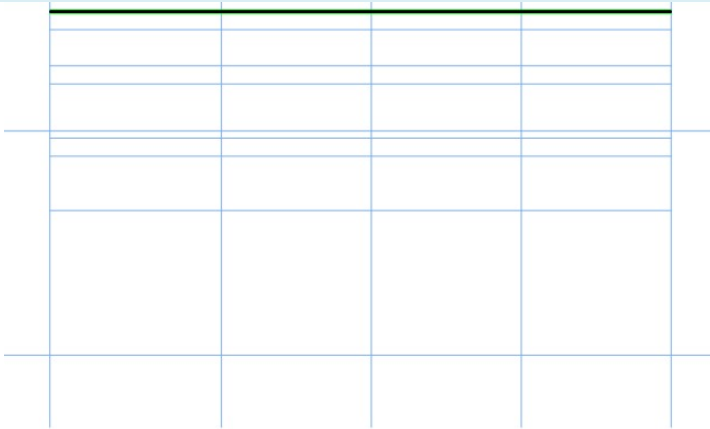


Strut Layer1-1D Truss



Strut Layer1-H Beam-Steel (H300 ×300 ×13 ×21)-Truss

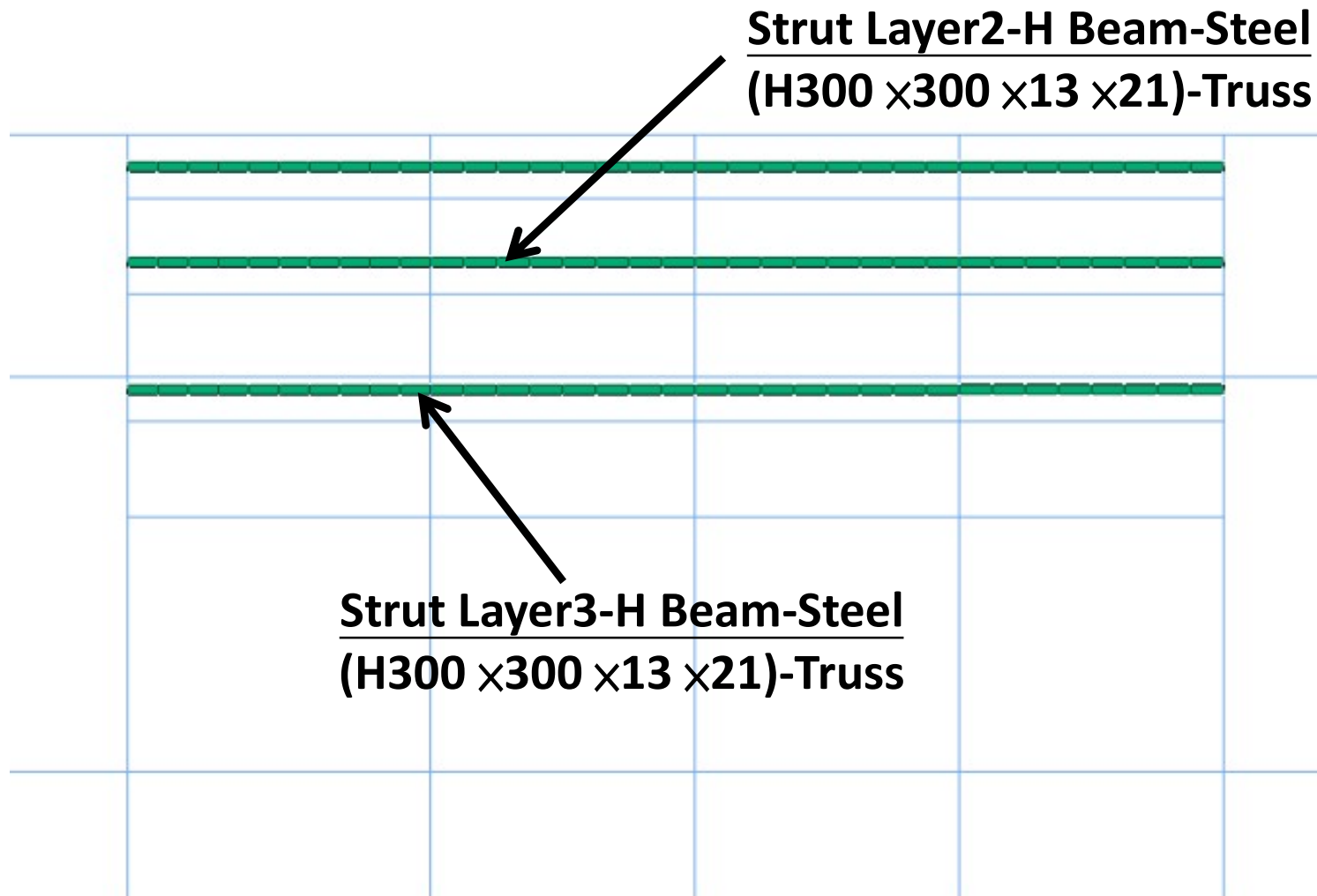
Extracting 1D element to strut_Layer1



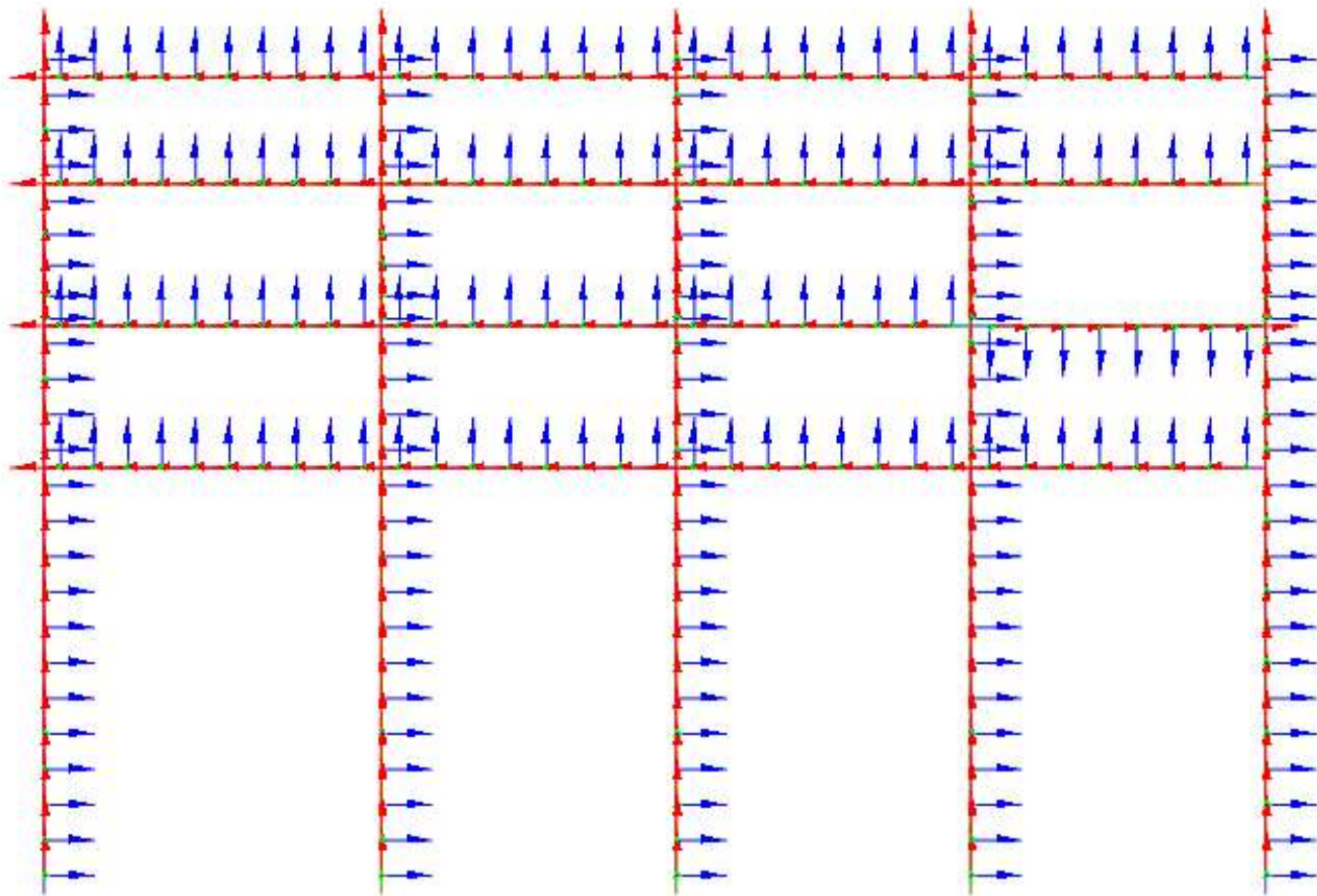
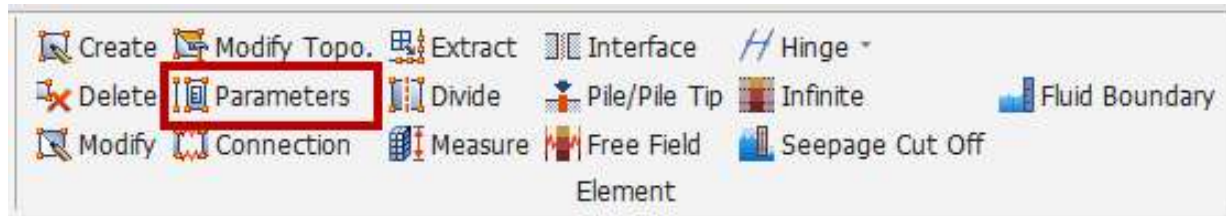
Tick on to view the property shape of STRUSS



Strut Layer2&3-1D Truss



Element Local Orientation

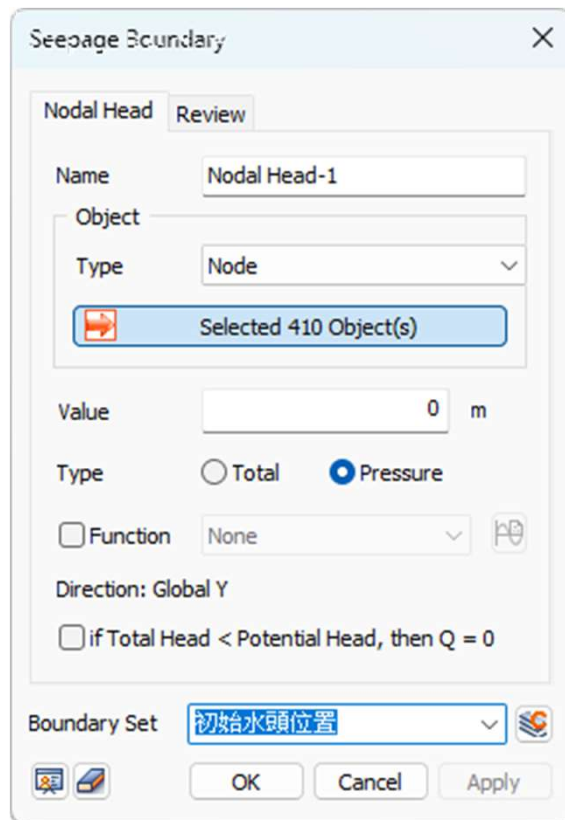


Part4.Boundary Conditions

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Initial Water Head Level

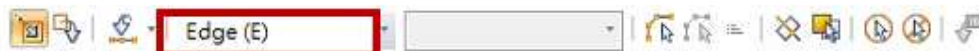
(Nodal Head ,Pressure=0 m)



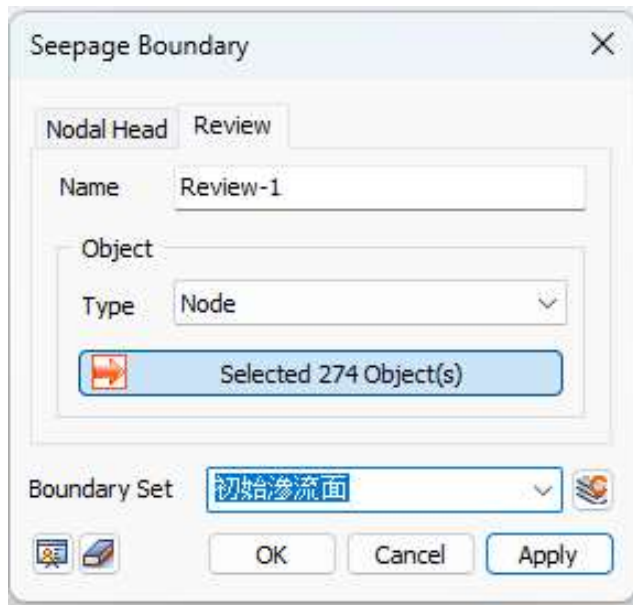
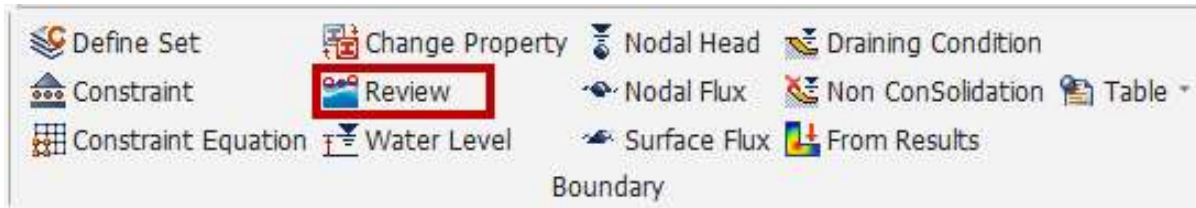
Selecting line features



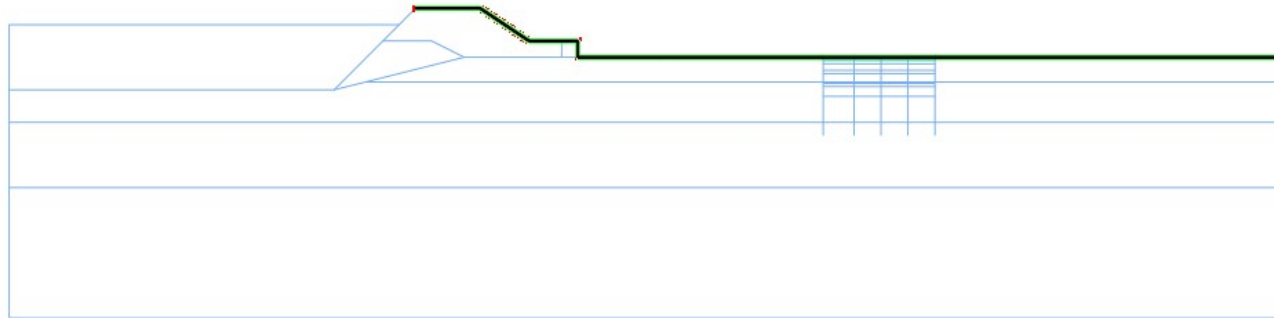
Edge features selected



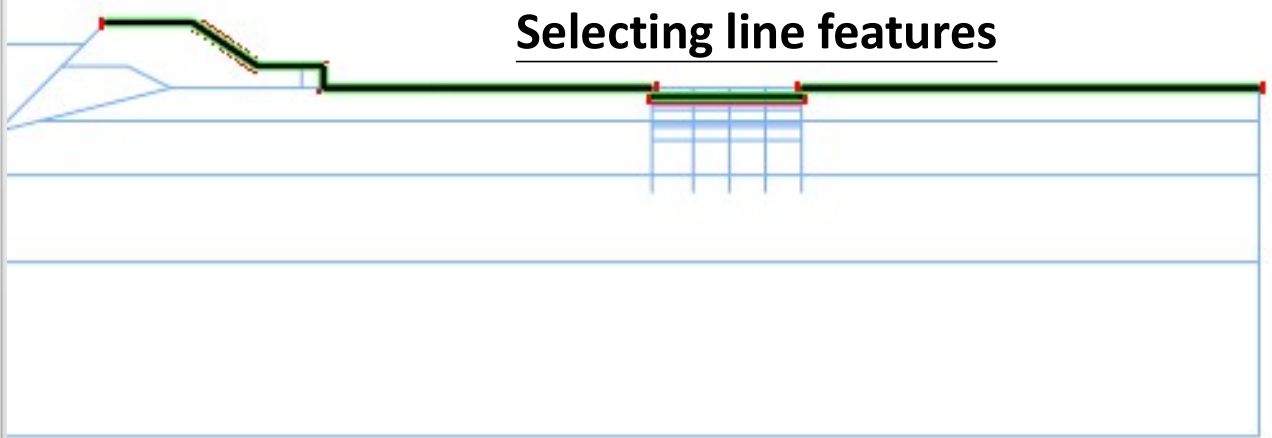
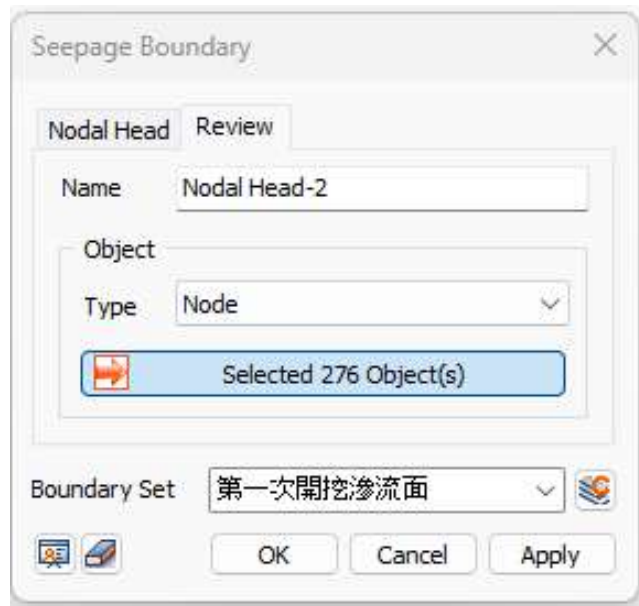
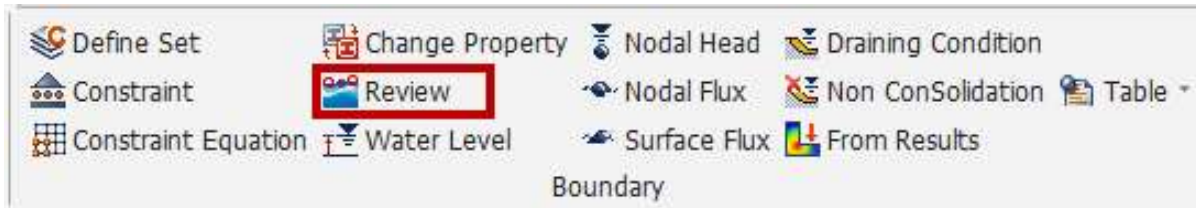
Initial Seepage Surface



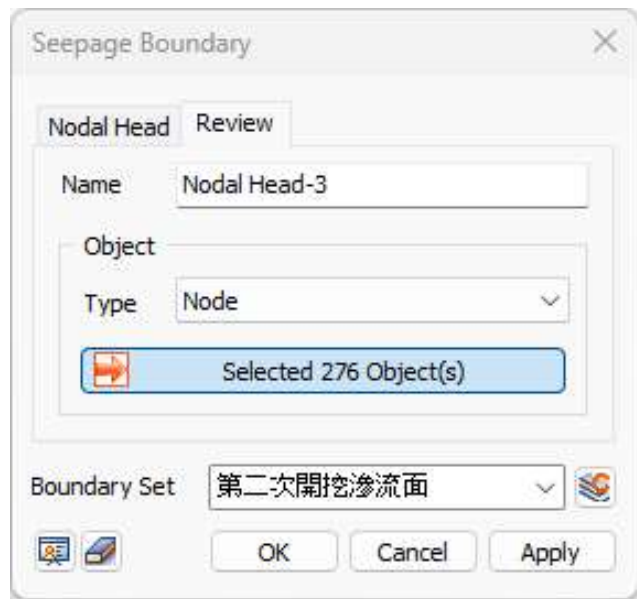
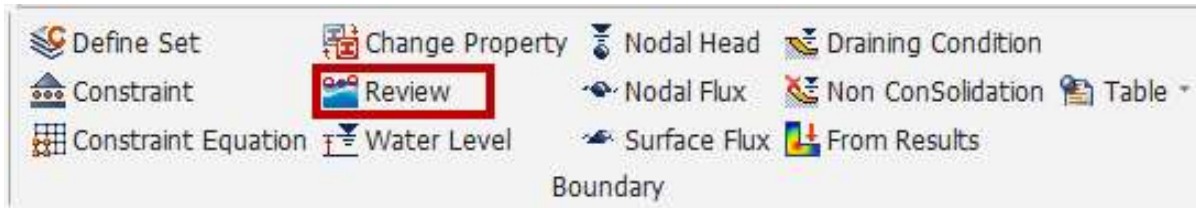
Selecting line features



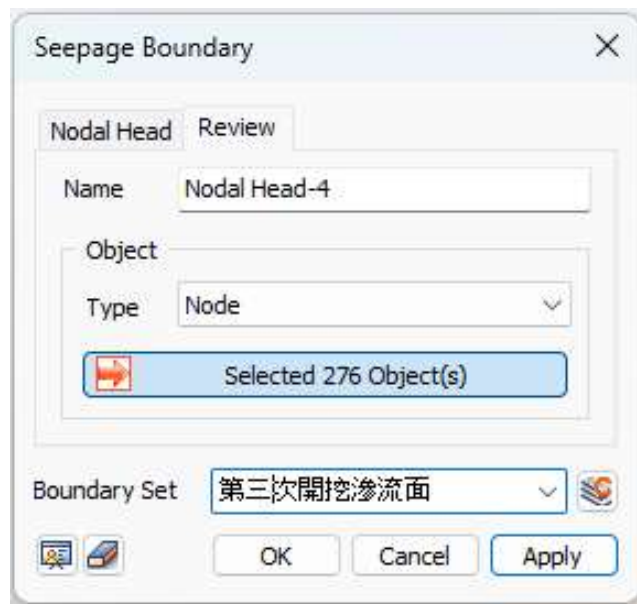
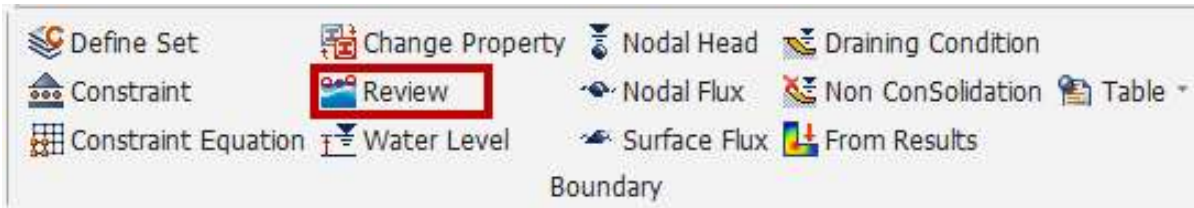
Excav Stage1_Seepage Surface



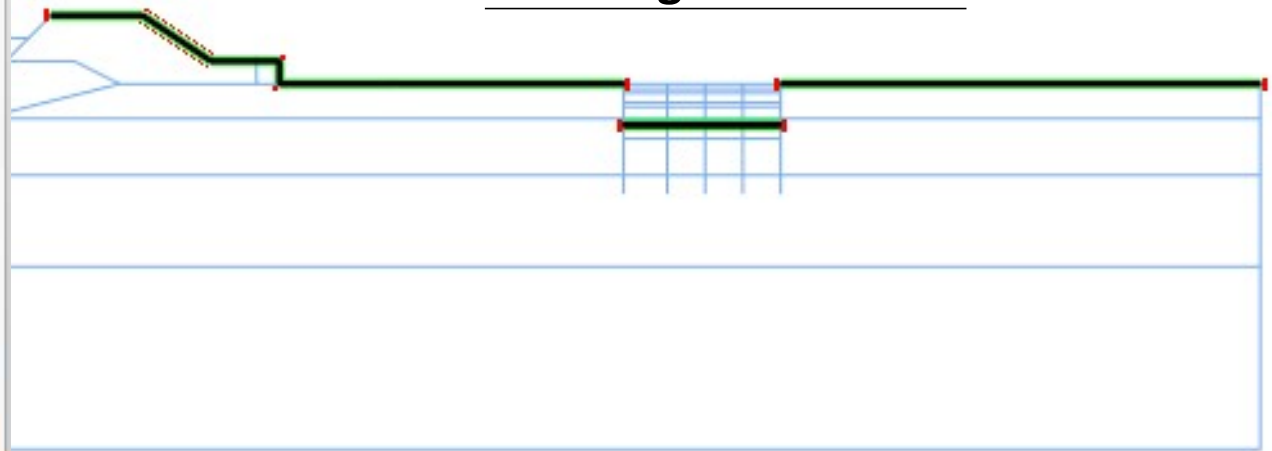
Excav Stage2_Seepage Surface



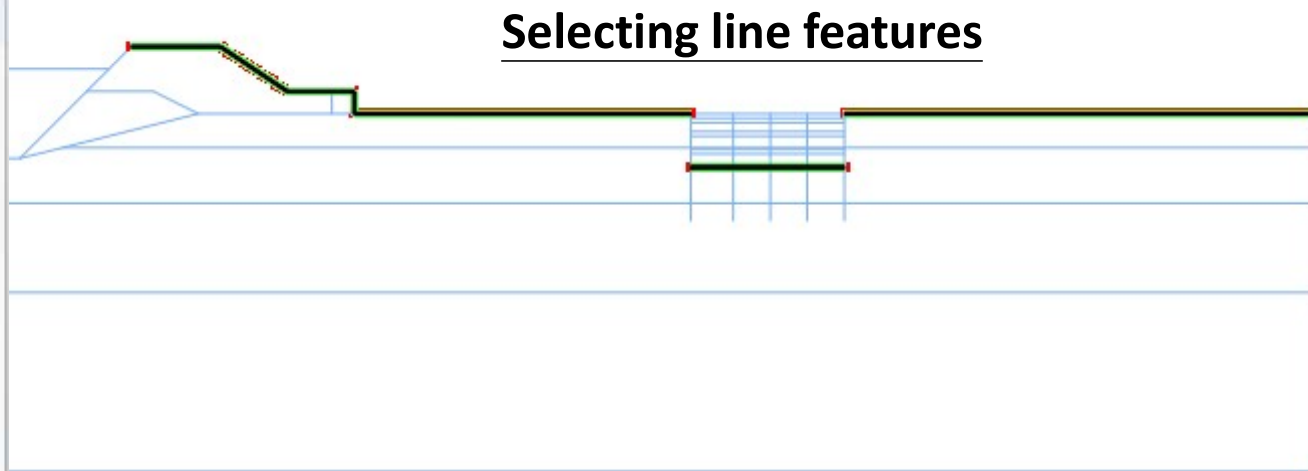
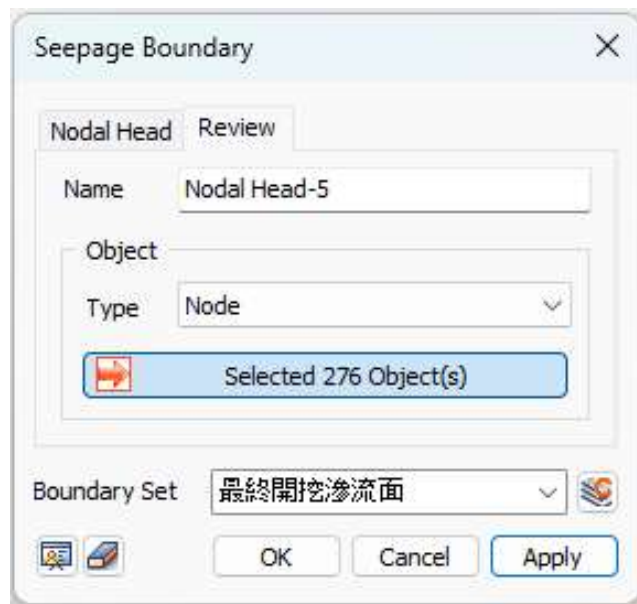
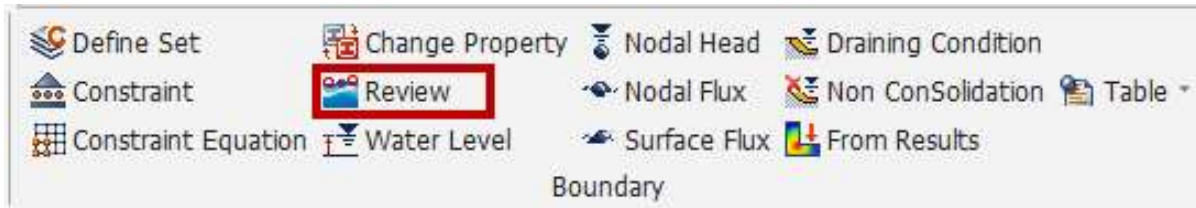
Excav Stage 3_Seepage Surface



Selecting line features

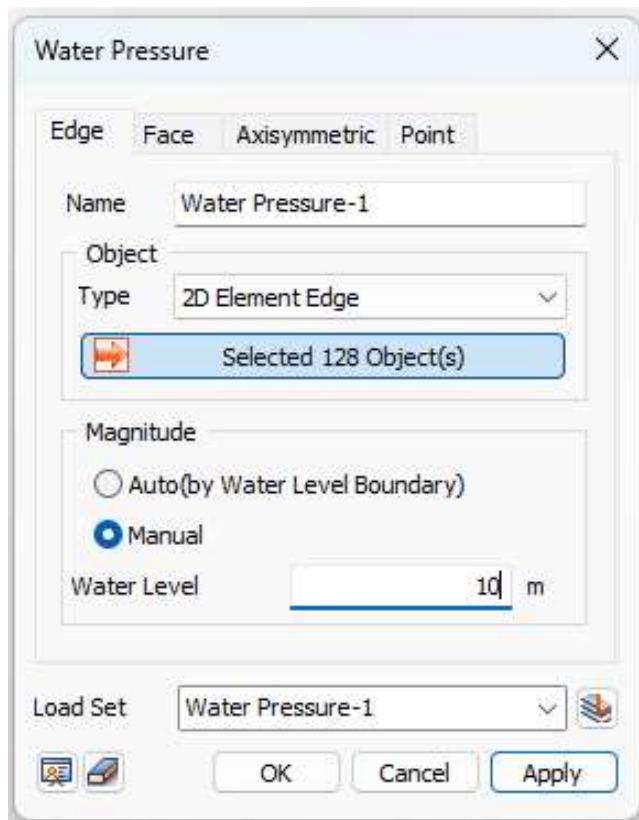
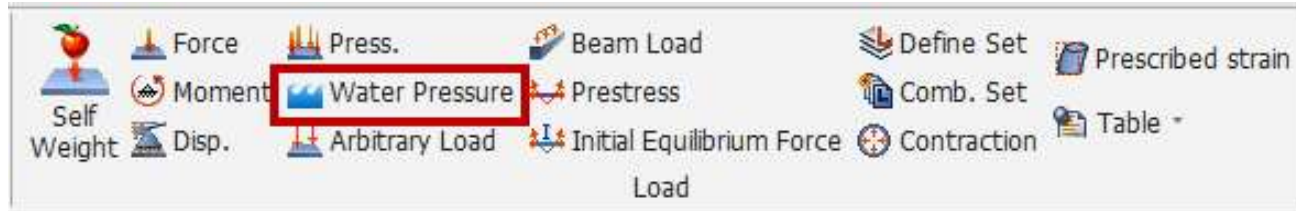


Excav Stage4_Seepage surface



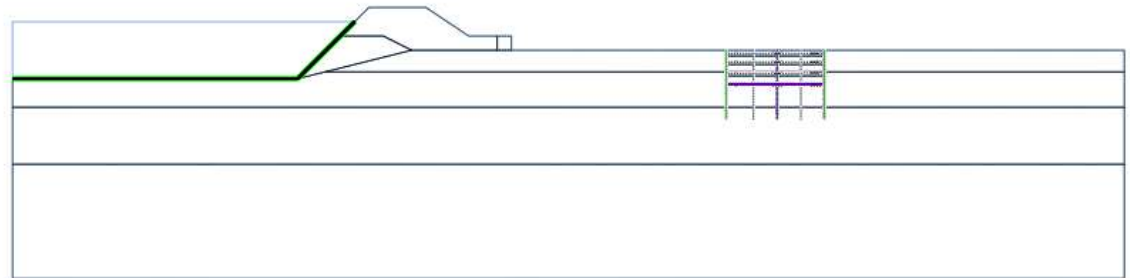
Water Pressure

(Pressure to represent for river reservoir pressure)



Water level (10m)

Selecting line features



Part5.Interface Elements

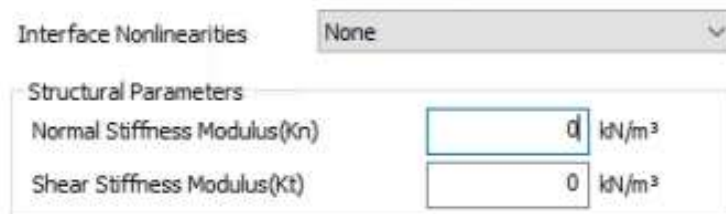
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Interface Element-1

GTS NX Interface Element Wizard

- Automatic calculation of normal stiffness (K_n) & tangential stiffness (K_t)
- **Virtual Thickness Factor (t_v)**
 - 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

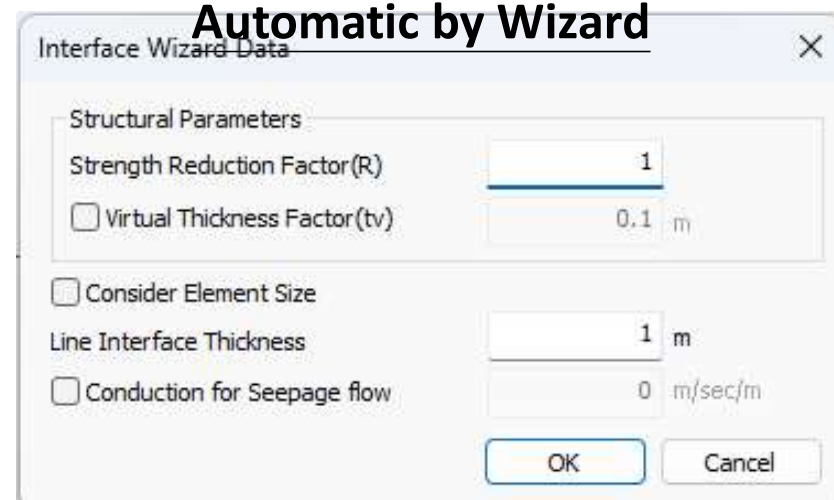


Interface Nonlinearities: None

Structural Parameters

Normal Stiffness Modulus(K_n)	0	kN/m ³
Shear Stiffness Modulus(K_t)	0	kN/m ³

Automatic by Wizard



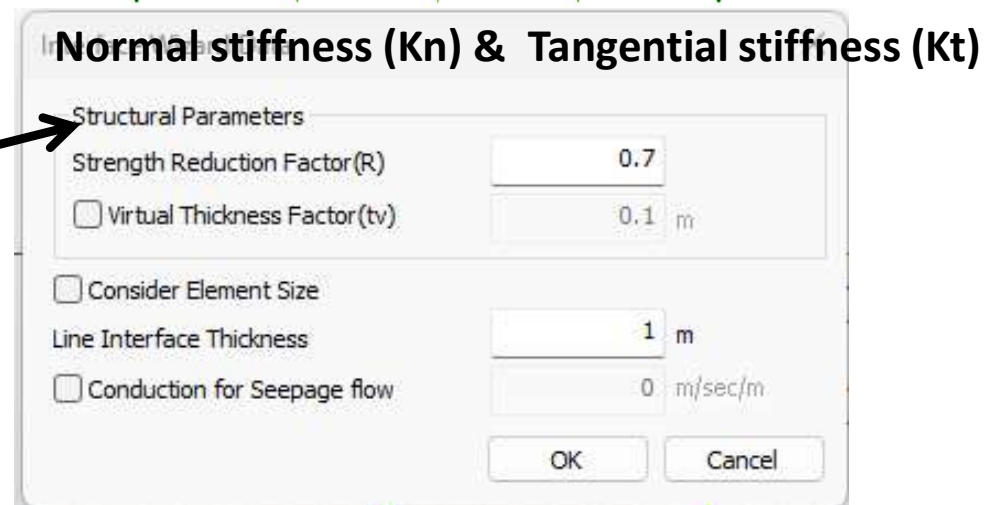
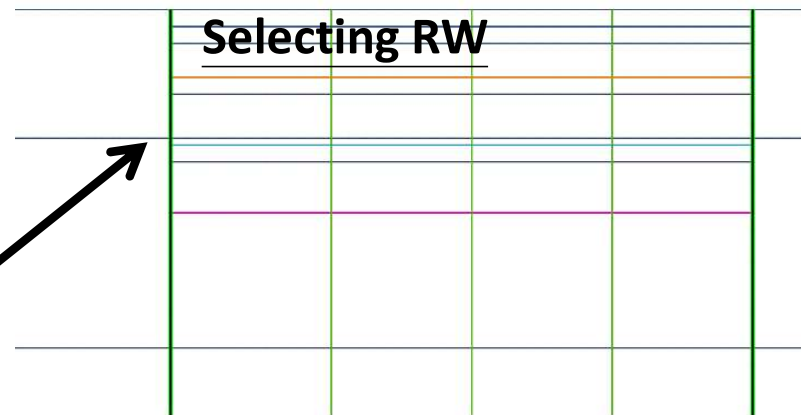
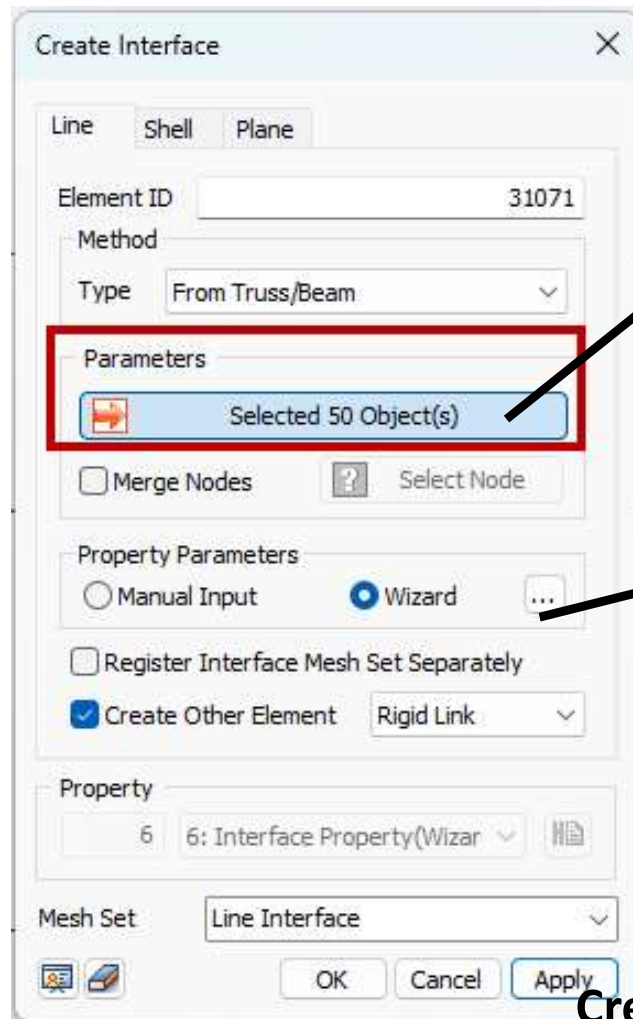
Interface Wizard Data

Structural Parameters

Strength Reduction Factor(R)	1
<input type="checkbox"/> Virtual Thickness Factor(t_v)	0.1 m
<input type="checkbox"/> Consider Element Size	
Line Interface Thickness	1 m
<input type="checkbox"/> Conduction for Seepage flow	0 m/sec/m

OK Cancel














Interface Element-2



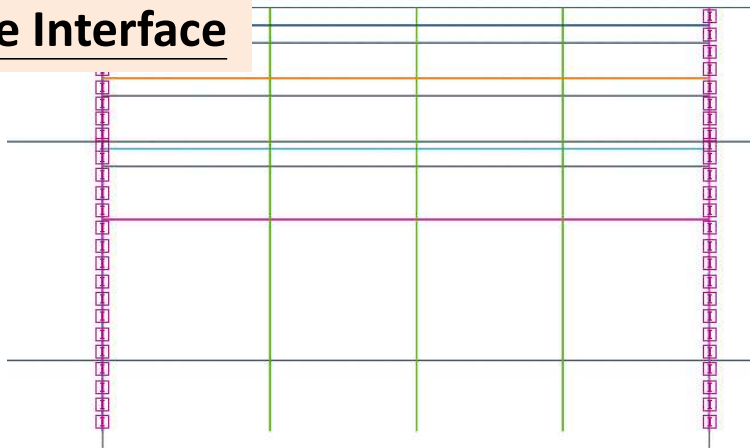
Creating Rigid link for soil and retaining wall before RW is constructed

Interface Element-3

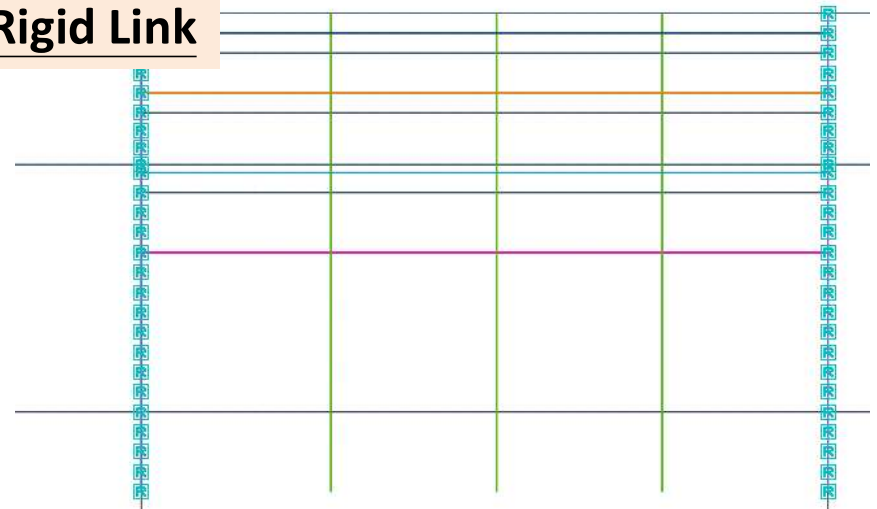
Normal stiffness (Kn) & Tangential stiffness (Kt)

- ☒  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)

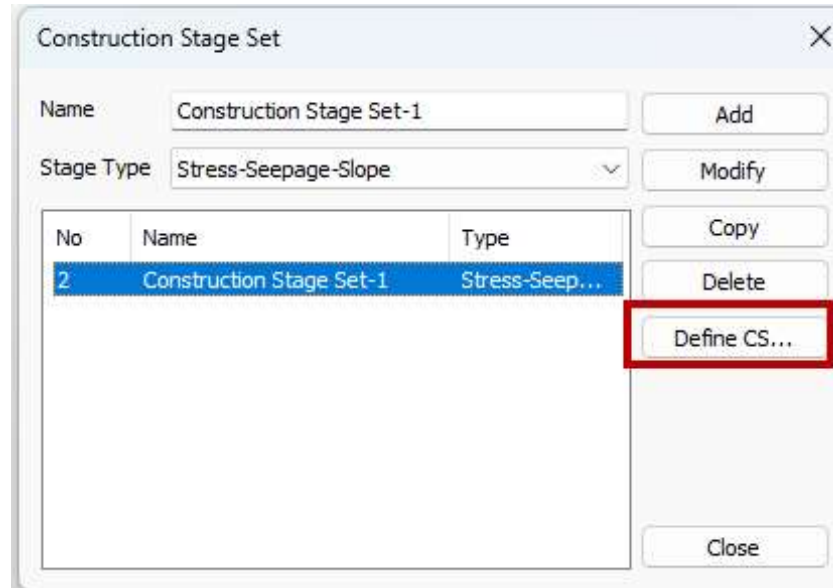


GTS NX Type of simulation

Stress
Seepage
Stress-Seepage-Slope
Consolidation

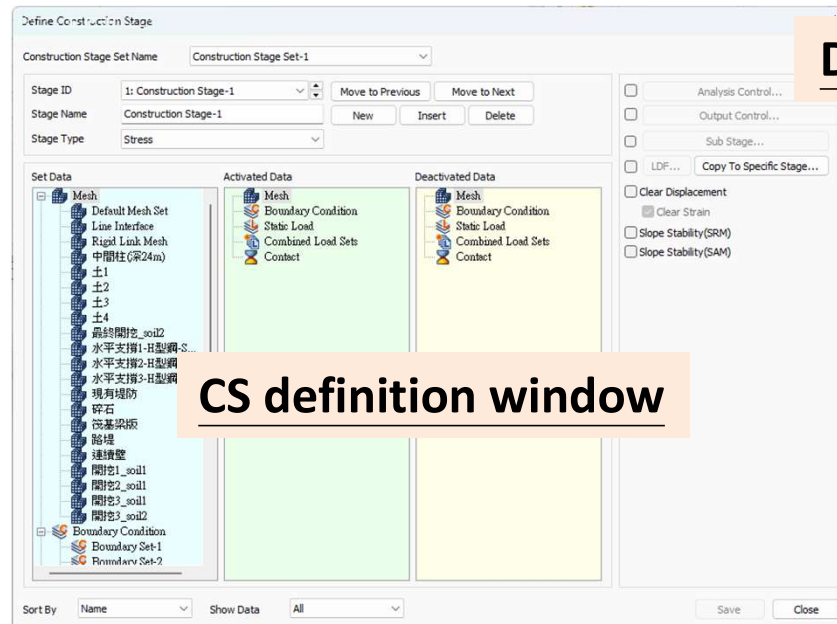
Stress Seepage Slope

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



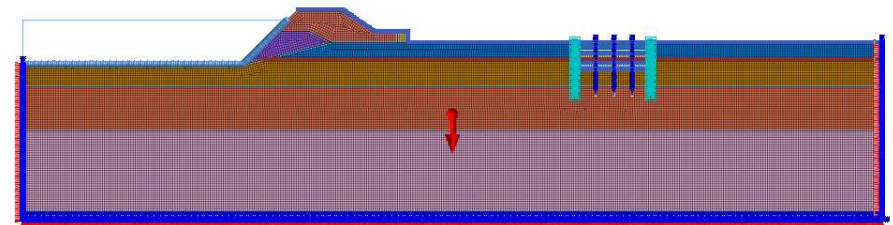
Step1.New

Step2.Define CS



CS definition window

Displaying all mesh sets/ BCs/ Geometry sets



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)

Stage Information

- Stage ID: 1: Construction Stage-1
- Stage Name: Stage0.未施工前
- Stage Type: Stress Seepage

Activated Data

- Mesh
 - 開挖1_soil1
 - 開挖2_soil1
 - 開挖3_soil1
 - 開挖3_soil2
 - 最終開挖_soil2
 - 碎石
 - 現有堤防
 - 路堤
 - 土1
 - 土2
 - 土3
 - 土4
- Rigid Link Mesh
- Boundary Condition
 - Boundary Set-1
 - Boundary Set-2
 - 初始水頭位置
 - 初始滲流面
- Static Load
 - Default Self-Weight
 - Water Pressure-1
- Combined Load Sets
- Contact

Deactivated Data

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

Clear Displacement (checked)

Clear Strain (unchecked)

Slope Stability(SRM) (unchecked)

Slope Stability(SAM) (unchecked)

Construction Stage-3

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

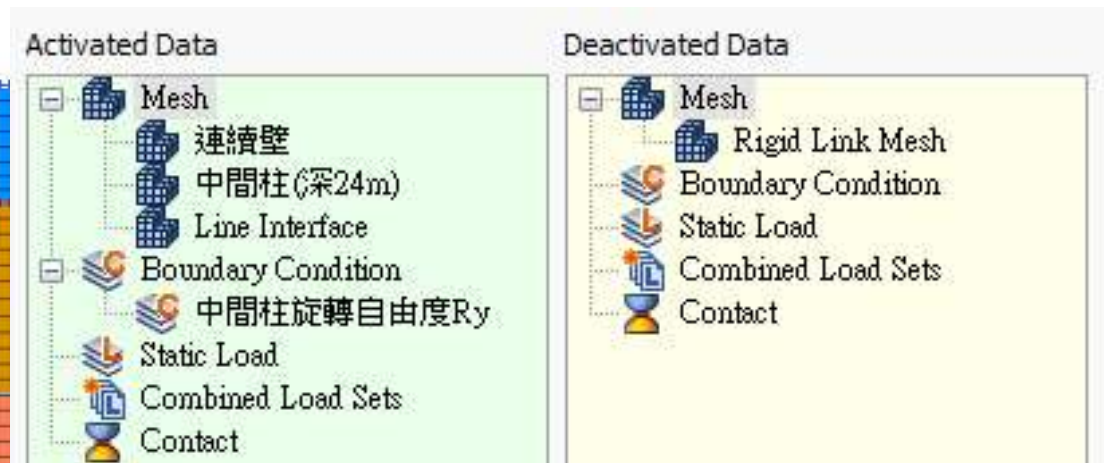
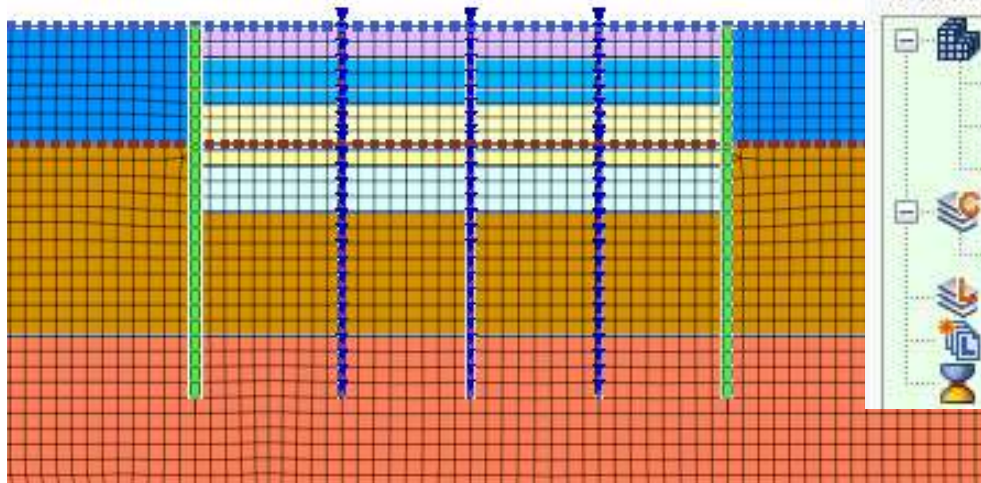
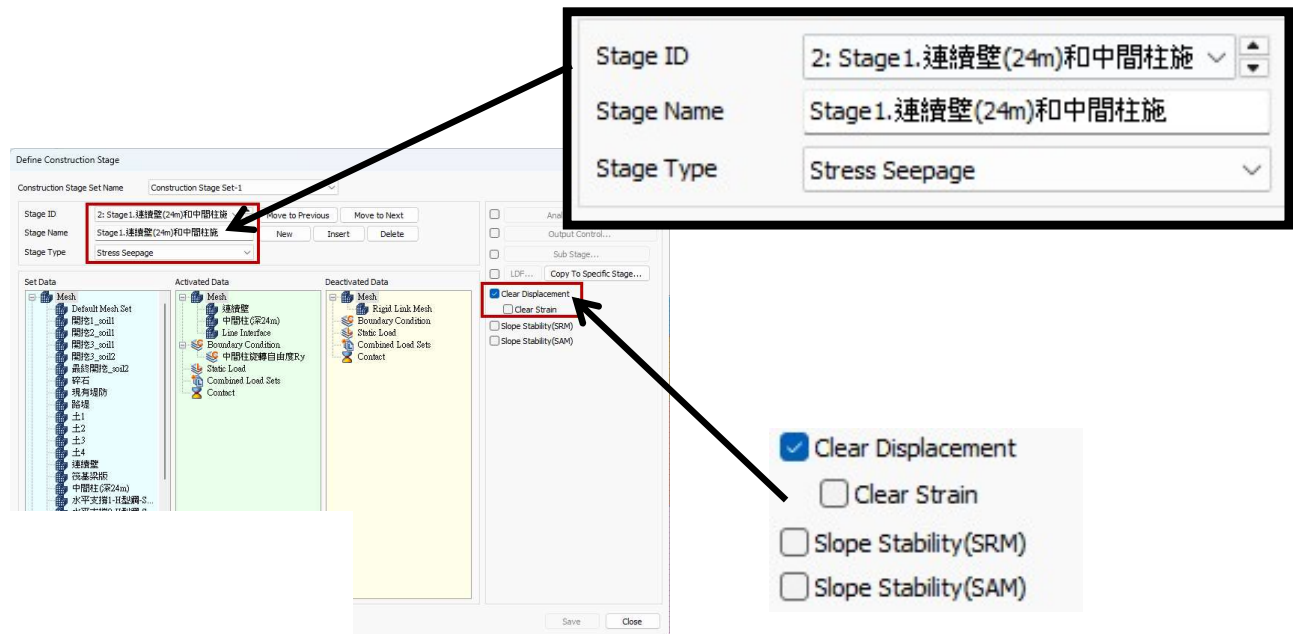
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-4

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

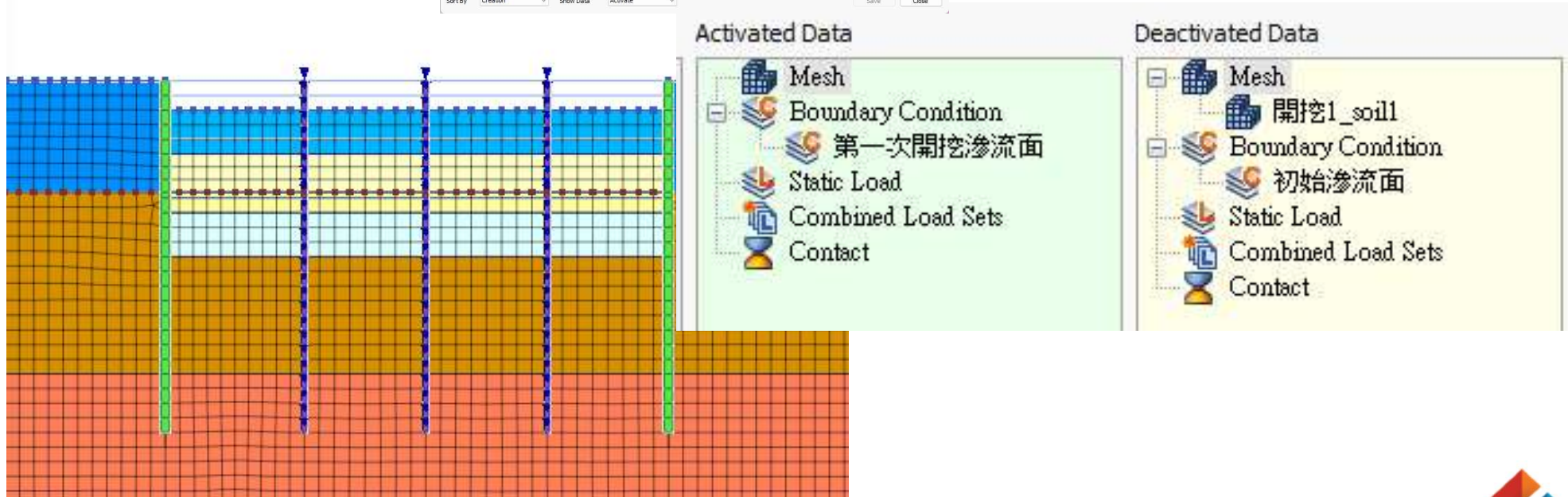
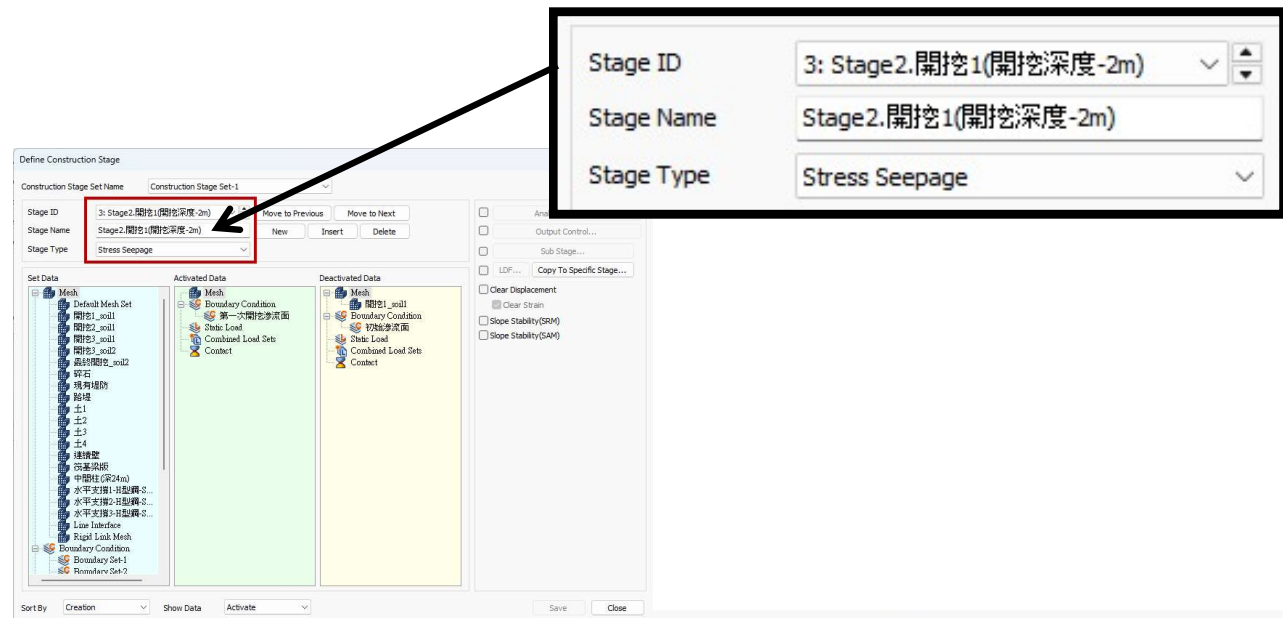
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-5

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

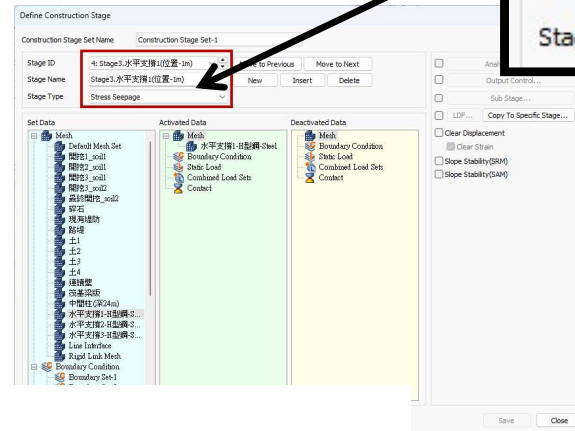
Stage5.Strut2_-4m

Stage6.Ex3_-9m

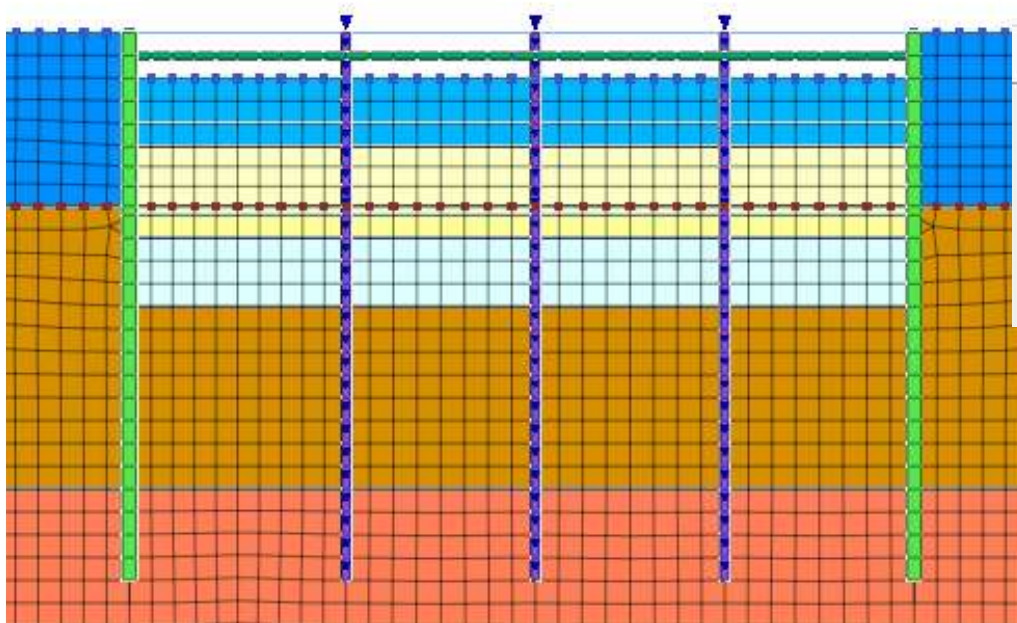
Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



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



Construction Stage-6

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

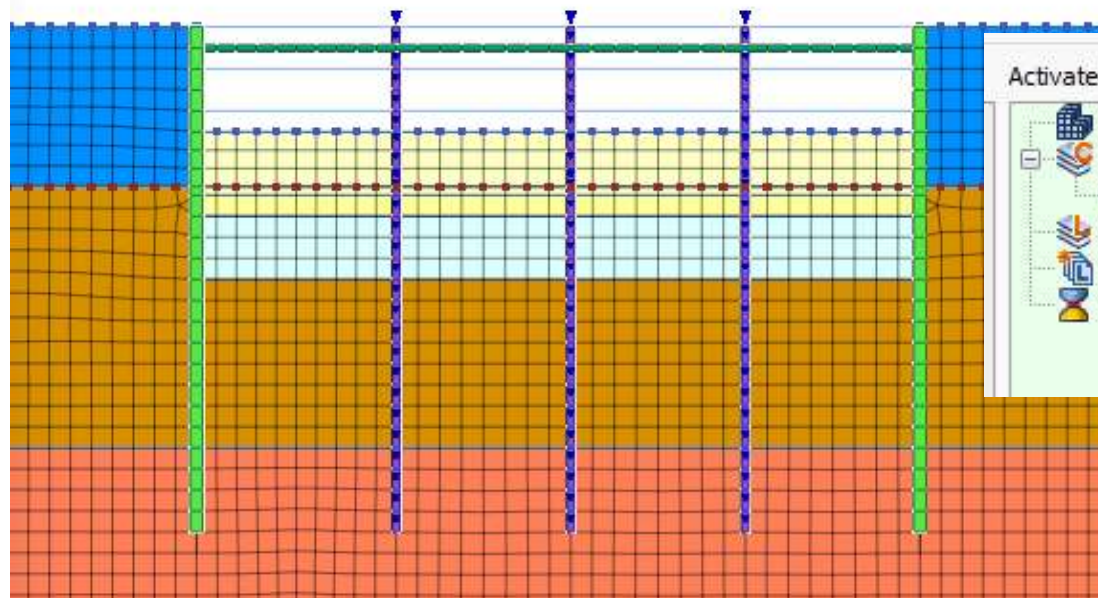
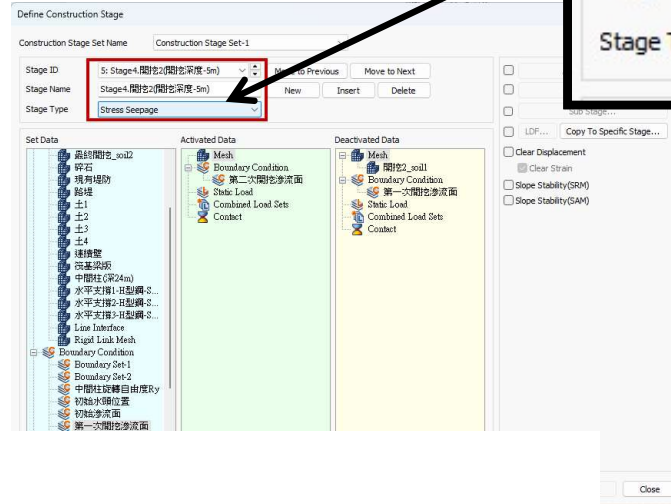
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-7

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

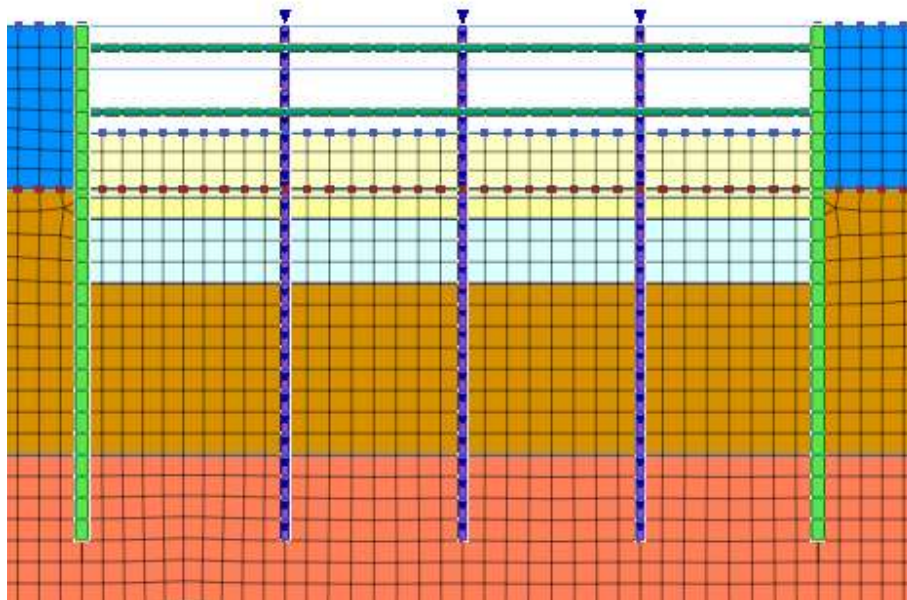
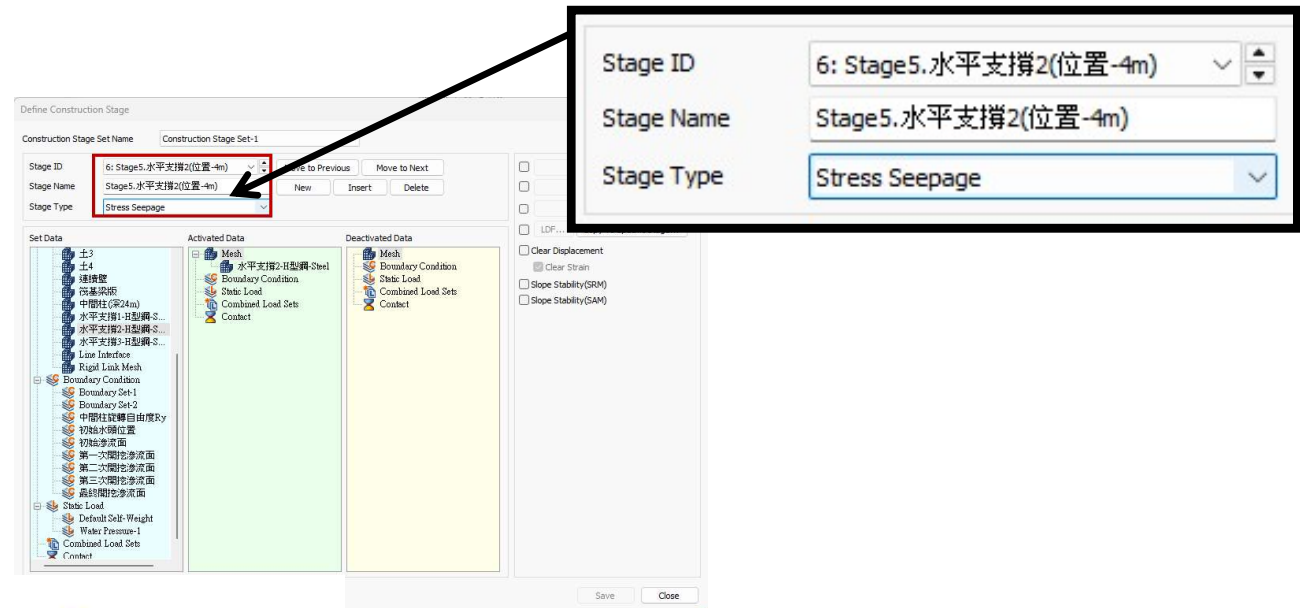
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-8

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

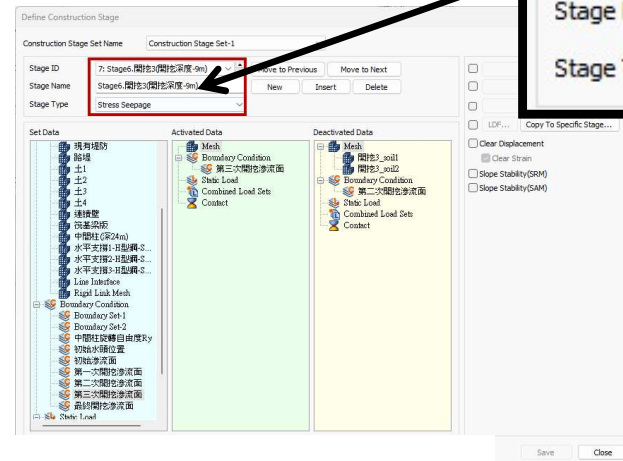
Stage5.Strut2_-4m

Stage6.Ex3_-9m

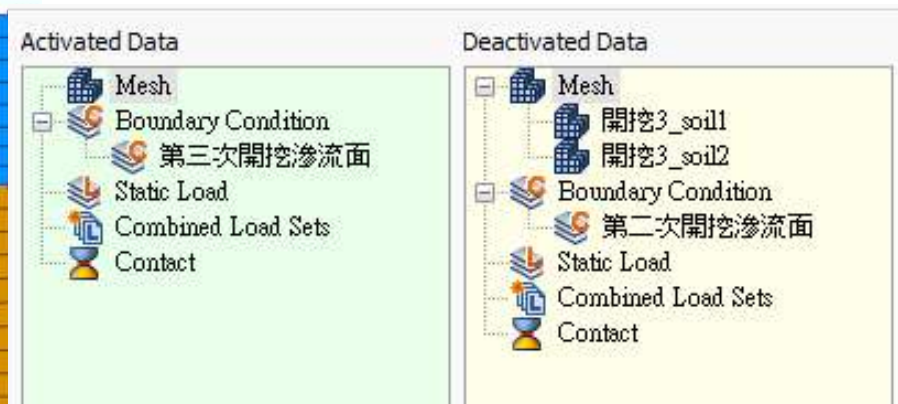
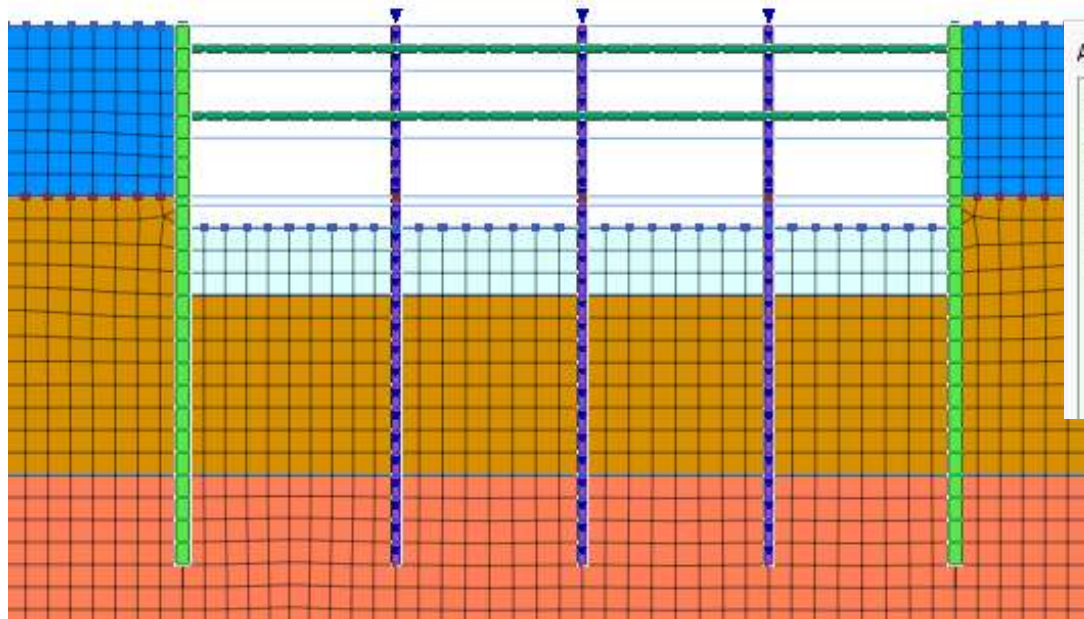
Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Stage ID	7: Stage6.開挖3(開挖深度-9m)
Stage Name	Stage6.開挖3(開挖深度-9m)
Stage Type	Stress Seepage



Construction Stage-9

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

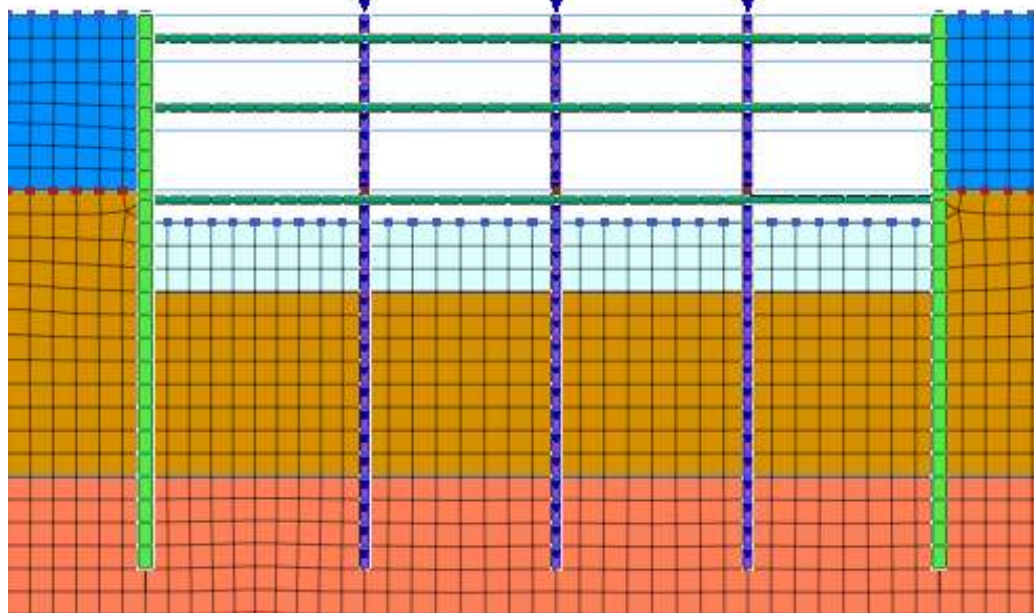
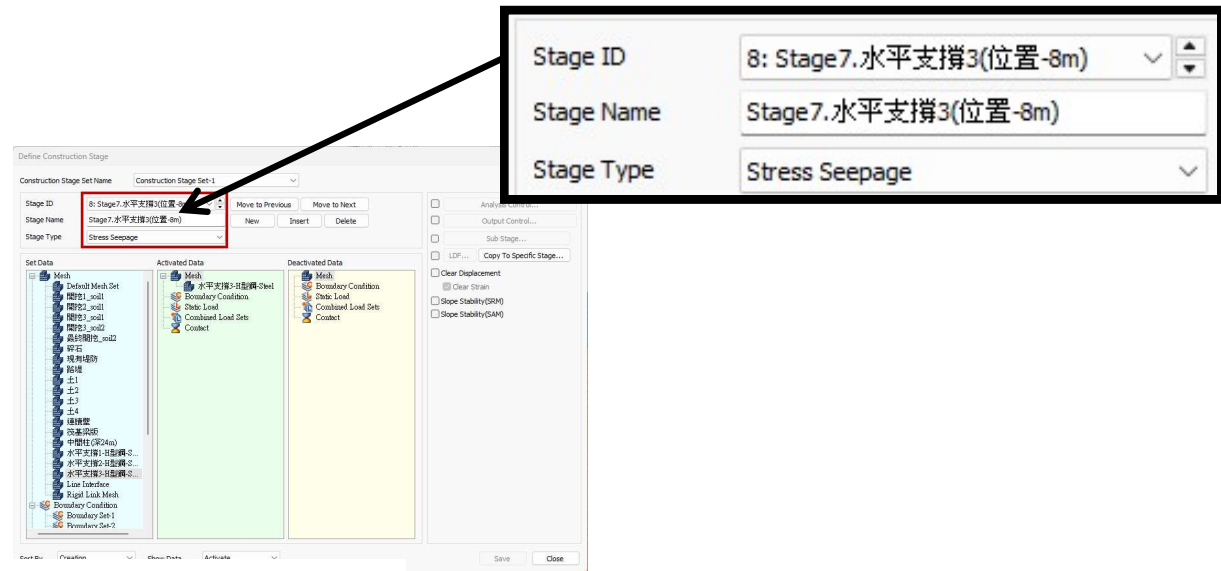
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-10

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

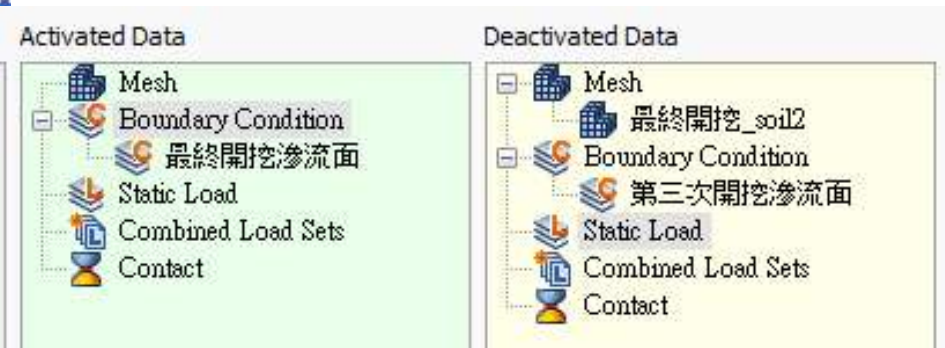
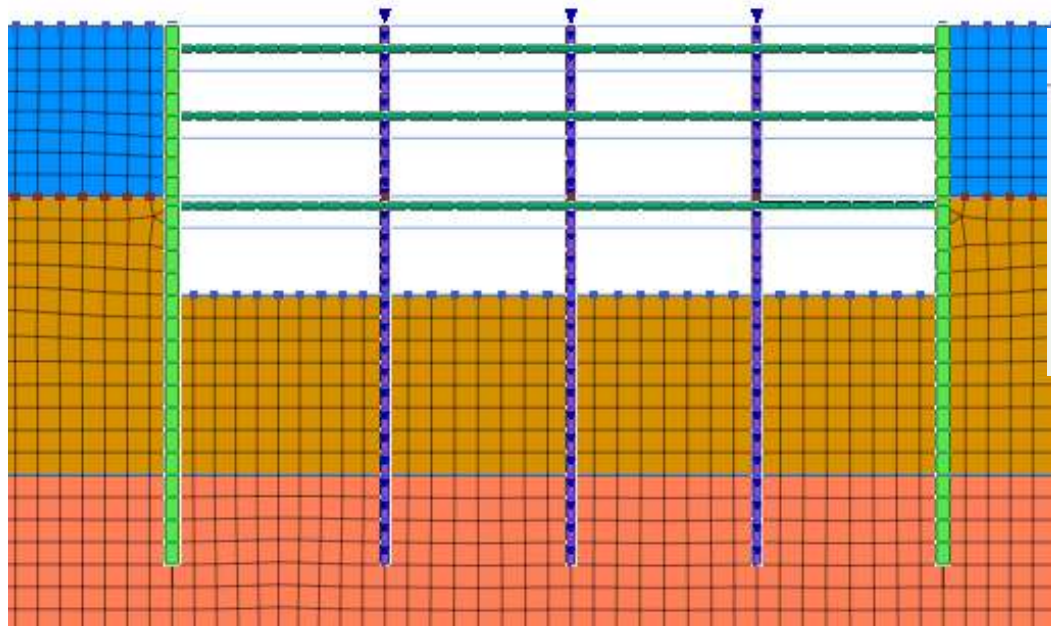
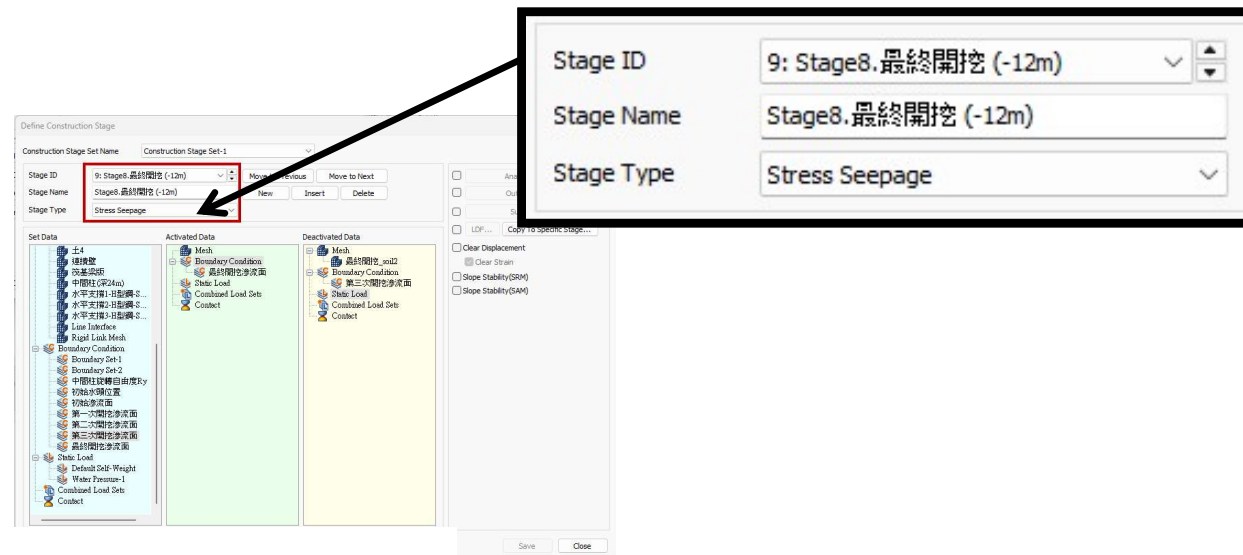
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Construction Stage-11

Stage0.Initial condition

Stage1.RW (24m) & center column

Stage2.Ex1_-2m

Stage3.Strut1_-1m

Stage4.Ex2_-5m

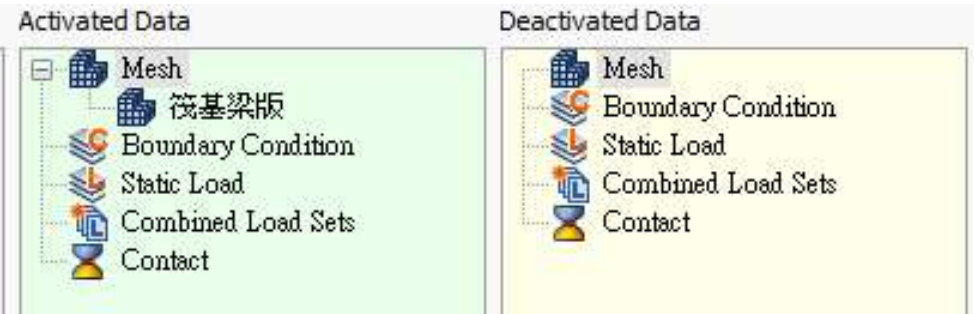
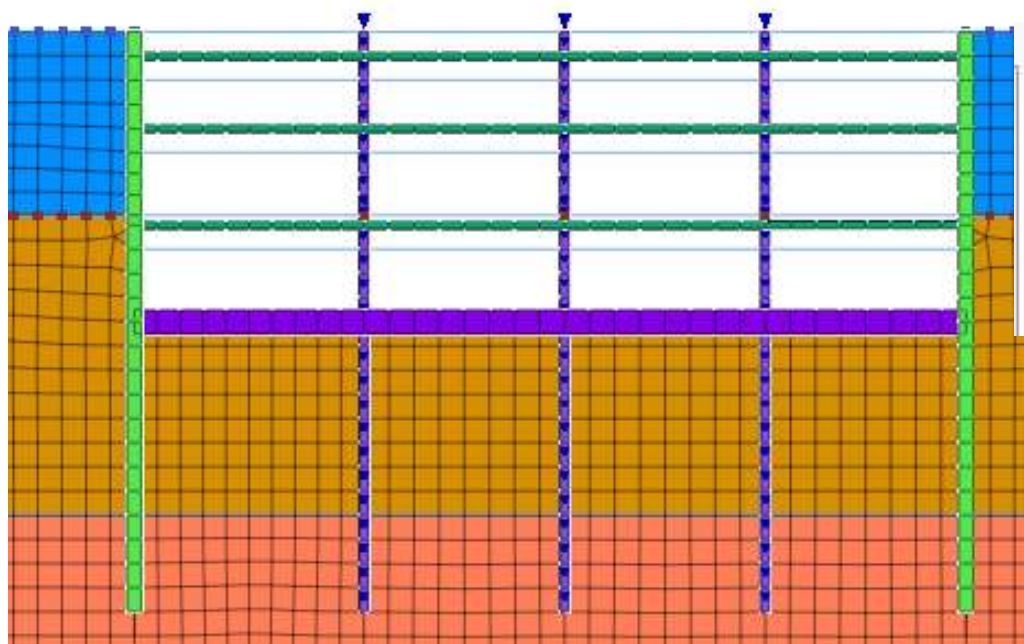
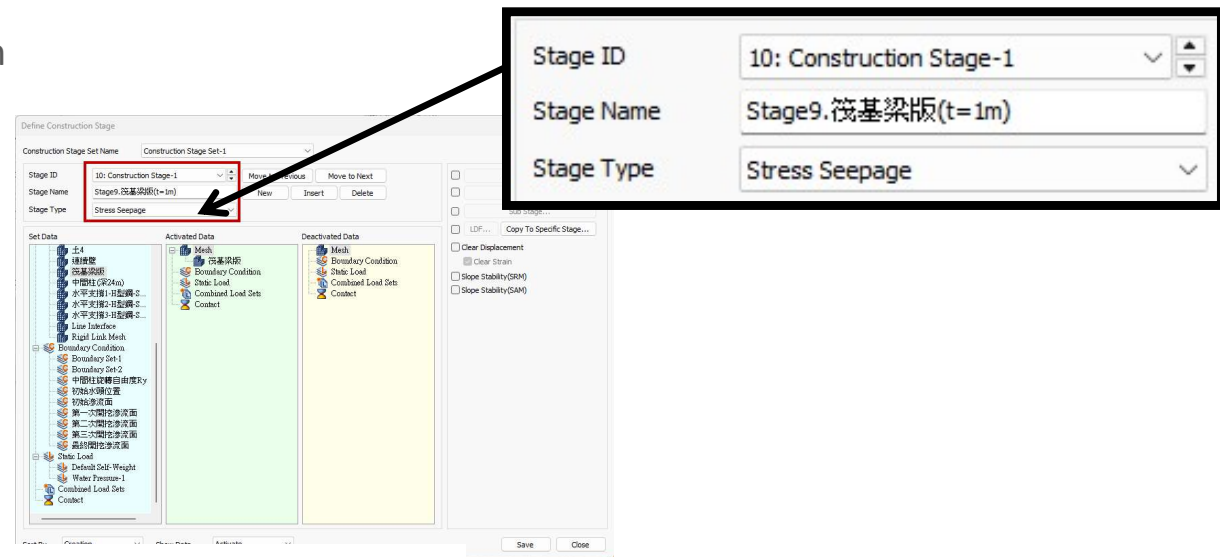
Stage5.Strut2_-4m

Stage6.Ex3_-9m

Stage7.Strut3_-8m

Stage8.Ex4_-12m

Stage9.Raft foundation (t= 1m)



Part7.Analysis & Calculation

MIDAS Taiwan

Analysis

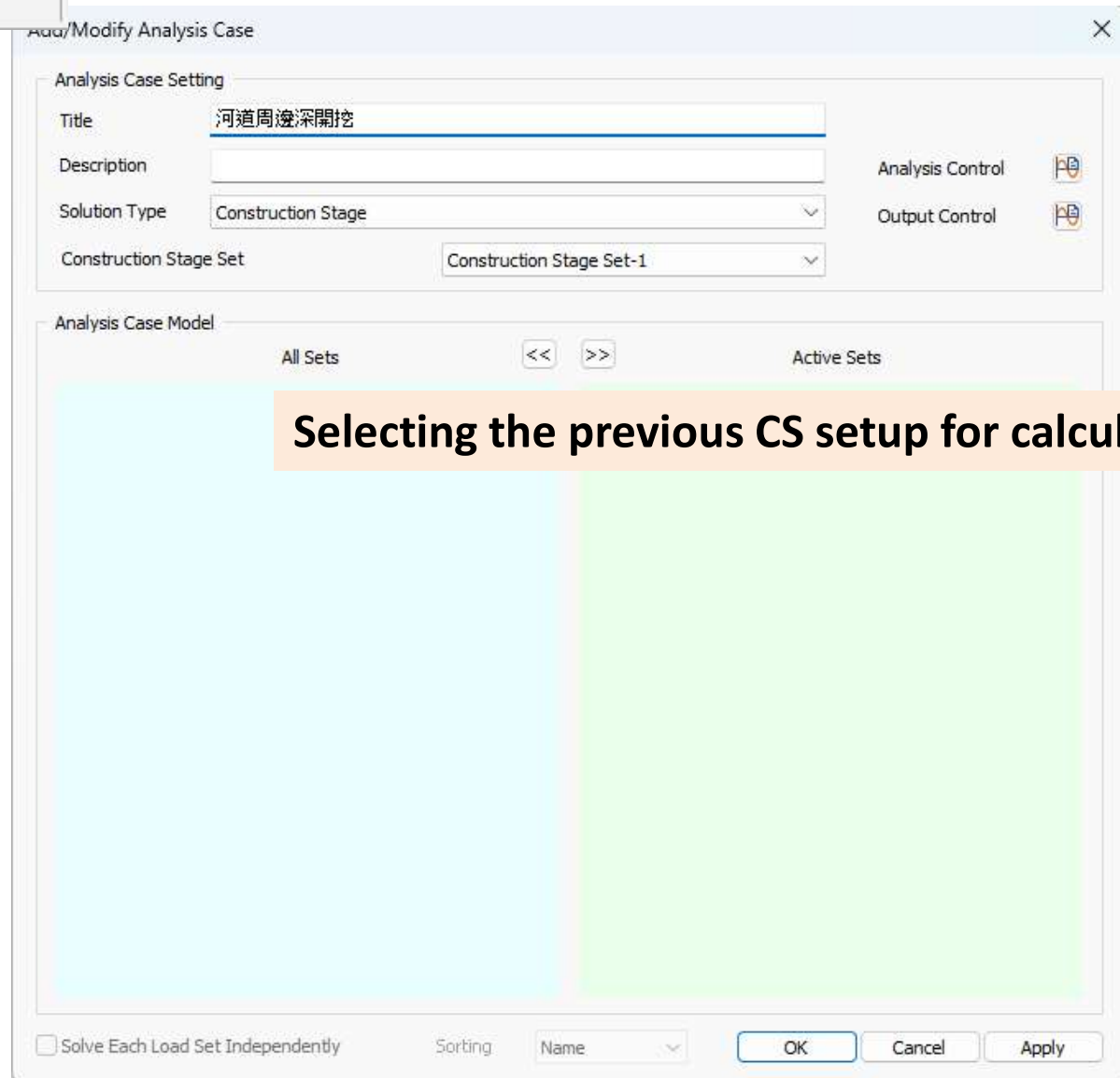
(Deep excavation nearby river channel)



Analysis type: Construction Stage

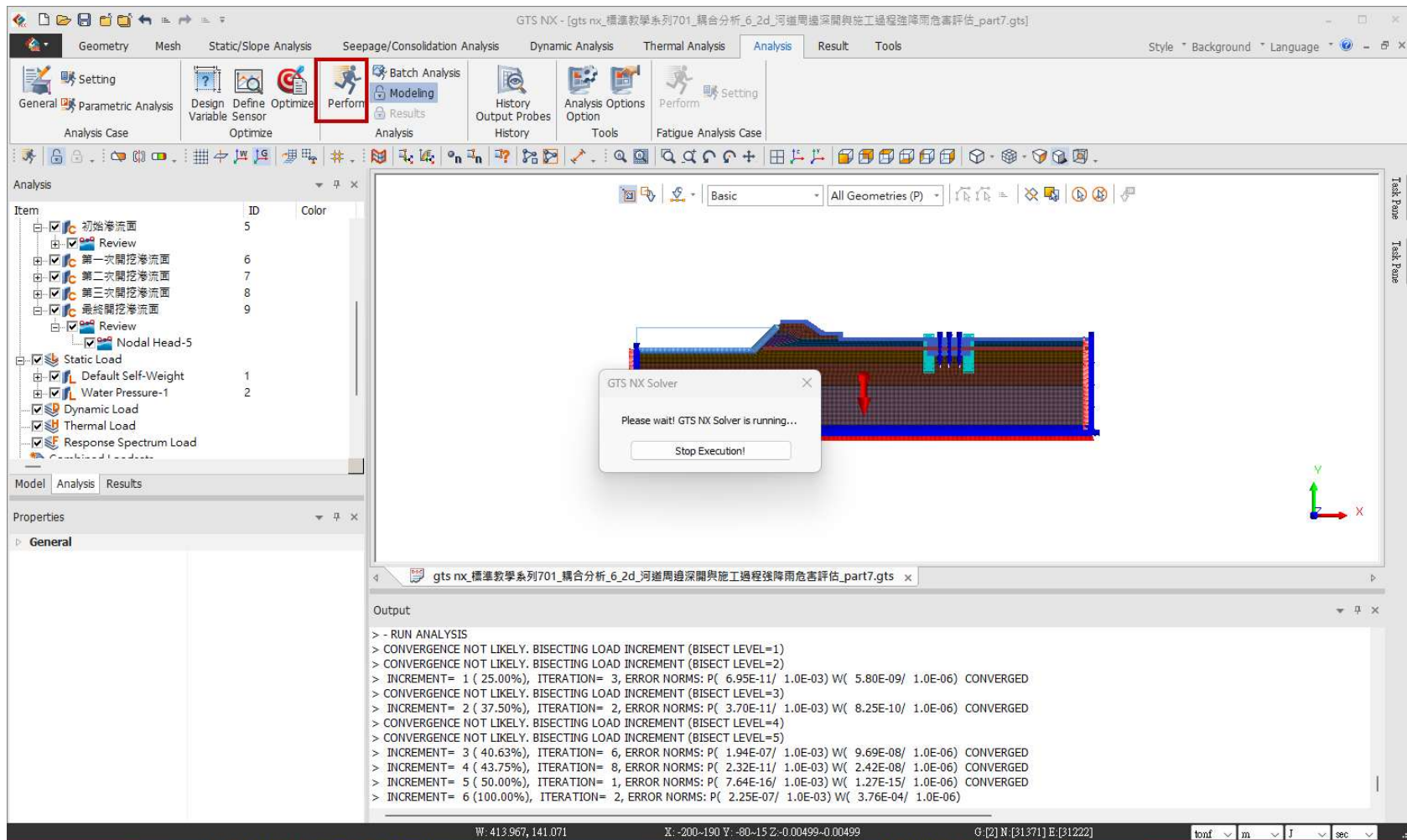
Construction Stage

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)



Selecting the previous CS setup for calculation

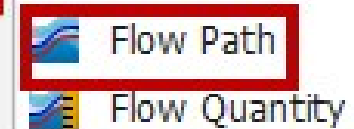
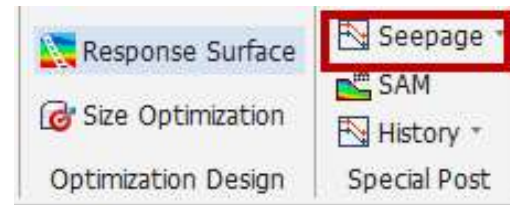
Calculation



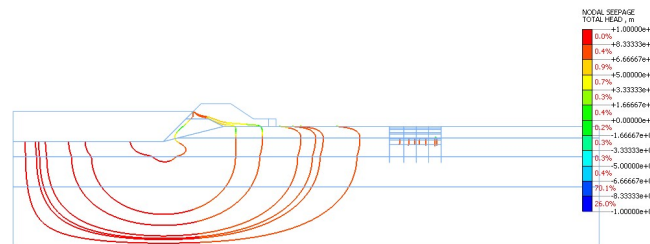
Results-1

Sequence of analysis in CS

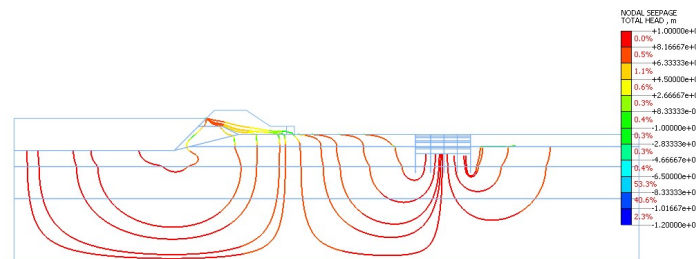
- 河道周邊深開挖
- Stage0.未施工前-Seepage
- Stage0.未施工前-Stress
- Stage1.連續壁(24m)和中間柱施-Seepage
- Stage1.連續壁(24m)和中間柱施-Stress
- Stage2.開挖1(開挖深度-2m)-Seepage
- Stage2.開挖1(開挖深度-2m)-Stress
- Stage3.水平支撐1(位置-1m)-Seepage
- Stage3.水平支撐1(位置-1m)-Stress
- Stage4.開挖2(開挖深度-5m)-Seepage
- Stage4.開挖2(開挖深度-5m)-Stress
- Stage5.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



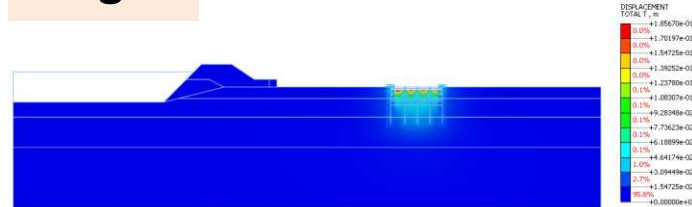
施工階段9_Flow Path



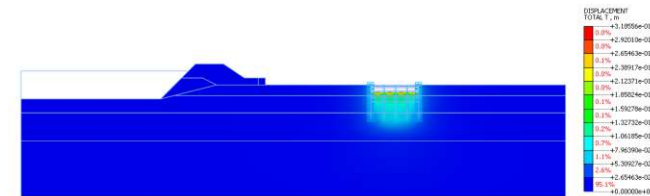
Results-2

(Total Translation(m))

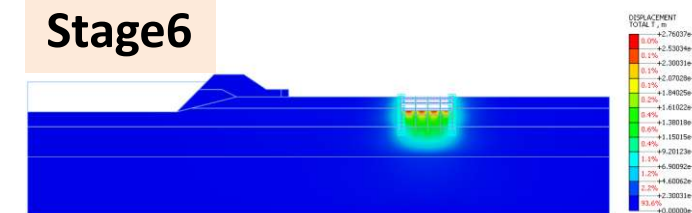
Stage2



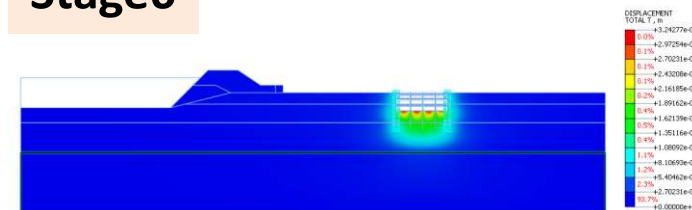
Stage4



Stage6



Stage6



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

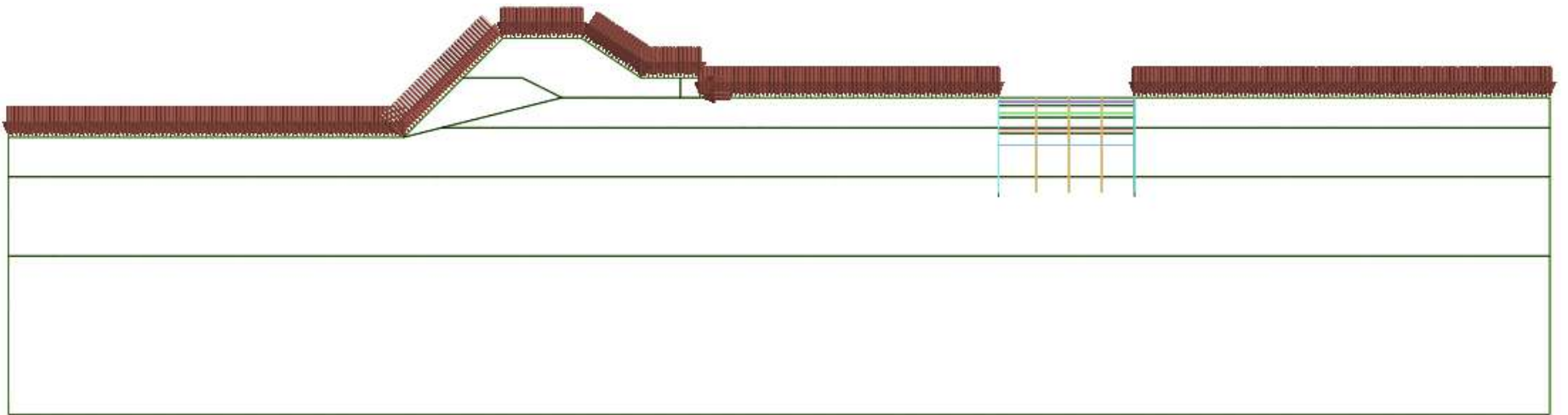
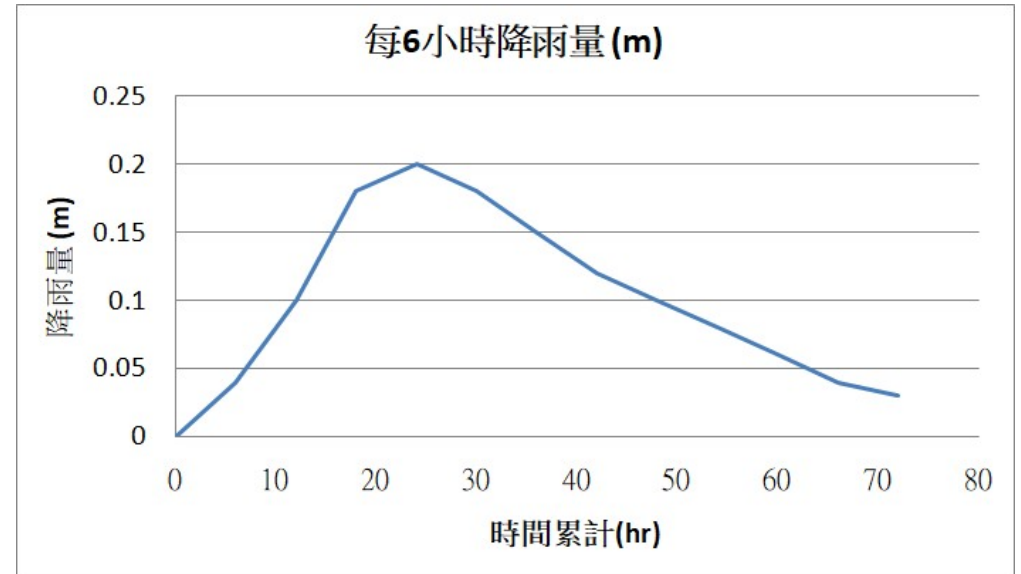
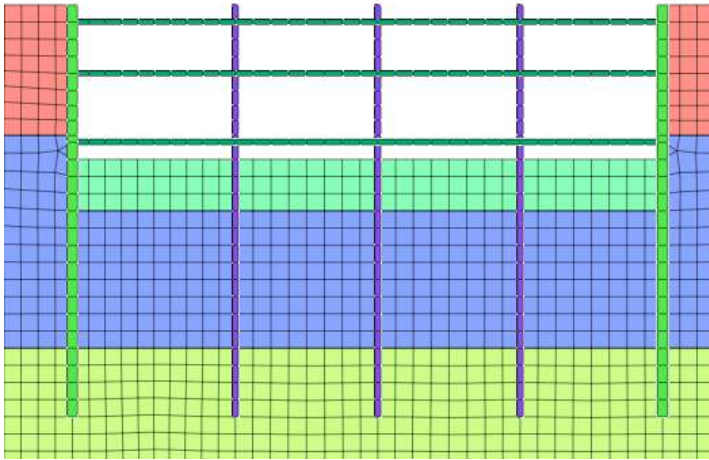
Stage9.Raft foundation (t= 1m)

Part8. Heavy rainfall assessment

MIDAS Taiwan

Bofore Excav Stage 3

Heavy rainfall struck 72 hours continuously



Rainfall Recording (Hours)

Unit (kn/m/J/hr)

kN m J hr



Seepage Boundary

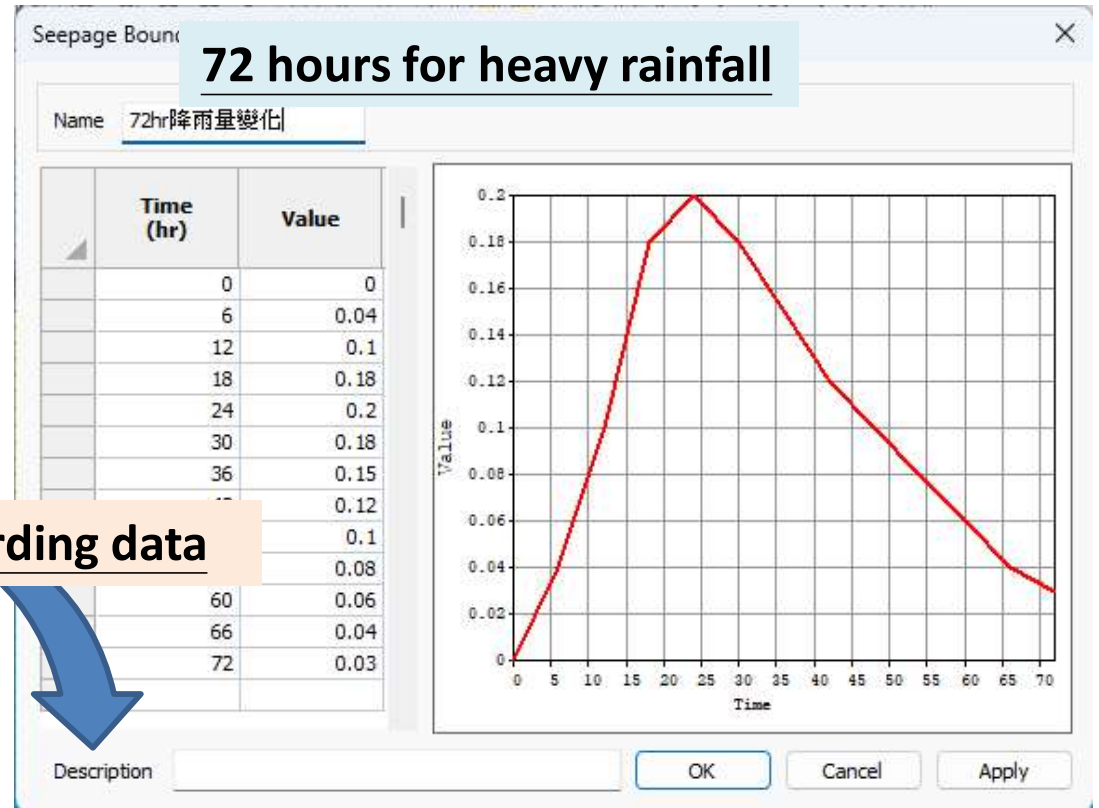


開啓Excel



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 recording data



Surface Flux

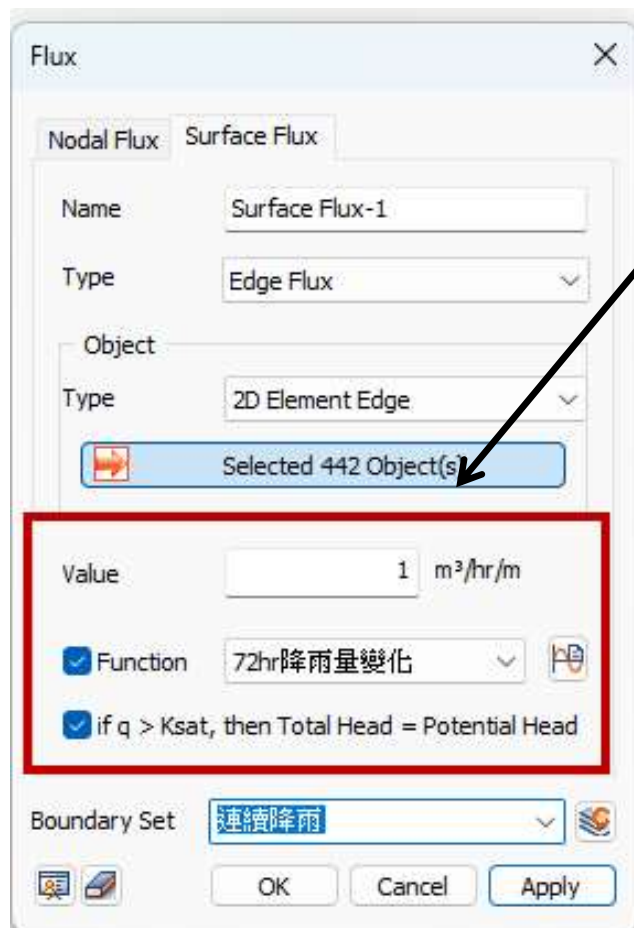
Unit (kN/m/J/hr)

kN m J hr

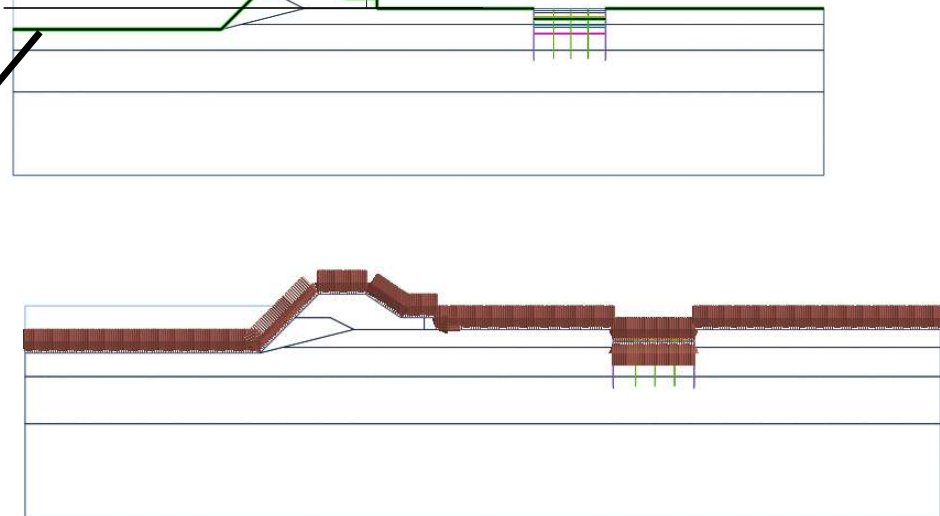
Seepage/Consolidation Analysis



Selecting line features



Flux = Value \times Function



Note:

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

Heavy Rainfall Assessment-1

New CS type: Stress-Seepage-slope

Construction Stage Set

Name: 強降雨危害評估

Stage Type: Stress-Seepage-Slope

No	Name	Type
2	Construction Stage Set-1	Stress-Seep...
3	強降雨危害評估	Stress-Seep...

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

Step1.Select stage6

Step2. Insert

Construction Stage Set Name: 強降雨危害評估

Stage ID: 8: Stage6.開挖3(開挖深度-9m)-1

Stage Name: Stage6.開挖3(開挖深度-9m)-1

Stage Type: Stress Seepage

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

Step3. Select the previous construction stage

Heavy Rainfall Assessment-2

7: 強降雨危害評估

強降雨危害評估

Stress Transient Seepage

Define Construction Stage

Construction Stage Set Name: 強降雨危害評估

Stage ID: 7: 強降雨危害評估

Stage Name: 強降雨危害評估

Stage Type: Stress Transient Seepage

Set Data

Activated Data

Deactivated Data

Analysis Control...

Output Control...

Sub Stage...

LDF...

Copy To Specific Stage...

Clear Displacement

Clear Strain

Slope Stability (SRM)

Slope Stability (SAM)

Initial Condition

Steady-State Analysis (time = 0)

Define Initial Water Level

Define Water Level For Global

Sort By: Creation

Show Data

Activate

Save

Close

Activated Data
Continuous rainfall condition

Time Step

Duration: 72 hr

User Defined Step

Step Number: 24

Save Result ☒ Log Scale ☐

Generate Step

	Time	Load Factor	Save Step
▶	3.0000	0.0417	✓
	6.0000	0.0417	✓
	9.0000	0.0417	✓
	12.0000	0.0417	✓
	15.0000	0.0417	✓
	18.0000	0.0417	✓
	21.0000	0.0417	✓
	24.0000	0.0417	✓

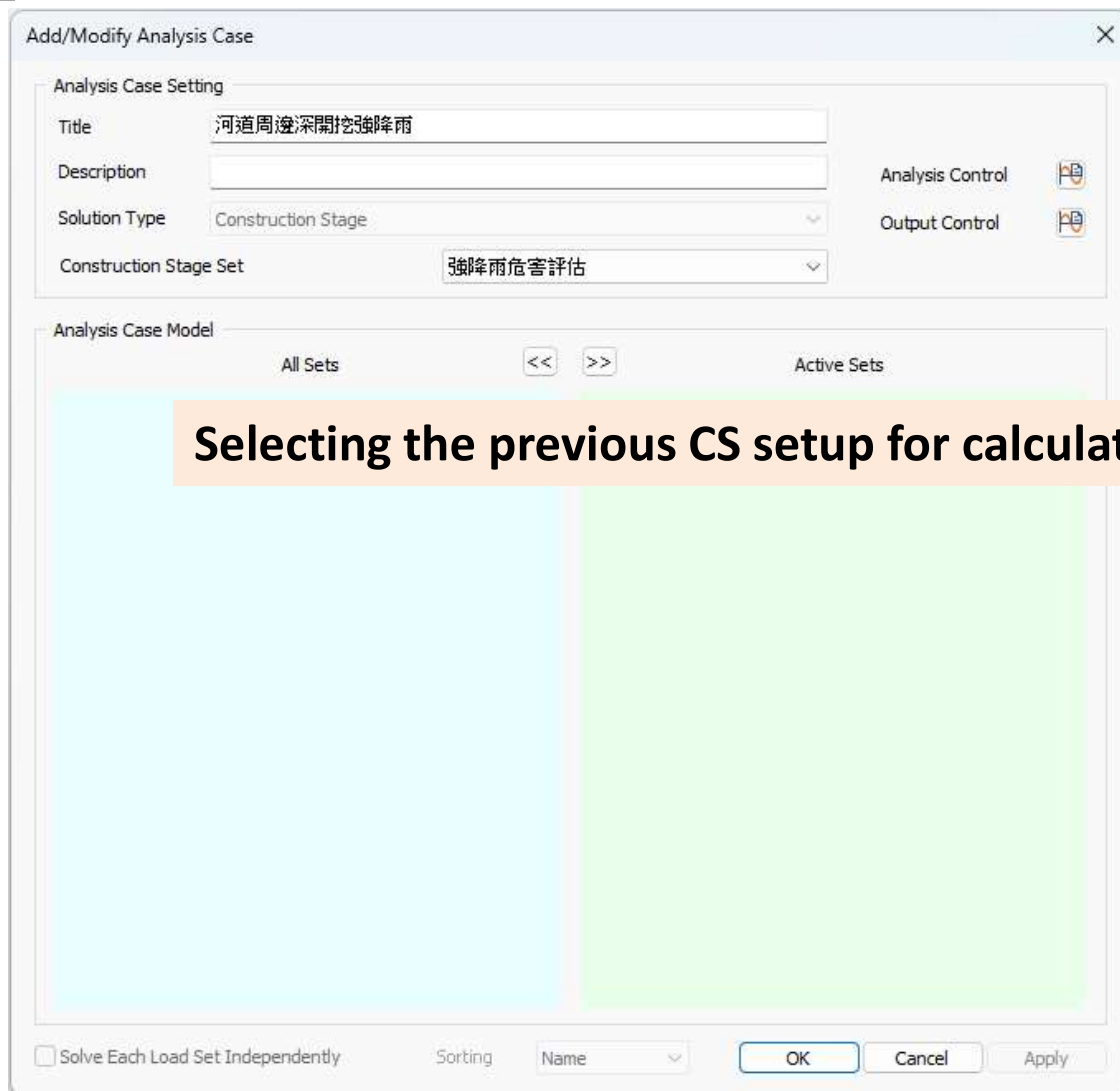
Analysis-1



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)



Analysis-2

The screenshot shows the 'Analysis Control' dialog box with the 'General' tab selected. Four specific settings are highlighted with red rectangular boxes:

- Water Pressure:** The checkbox 'Automatically Consider Water Pressure' is checked.
- Initial Stress:** The checkbox 'Estimate Initial Stress of Activated Elements' is checked.
- Max. Negative Pore Pressure:** The checkbox 'Max. Negative Pore Pressure Limit' is checked, with the value '0 tonf/m²' entered in the adjacent field.
- Initial Configuration:** The checkbox 'Estimate Initial Configuration of Activated Nodes' is checked.

Other visible settings include 'Initial Stage' (1:Stage0.未施工), 'Final Calculation Stage' (End Stage), 'Restart Option' (Save only User Specified Stages), 'Initial Temperature' (0 [T]), 'Saturation Effects' (Consider Partially Saturated Effects for Stress Analysis), 'Undrained Condition' (Allow Undrained Material Behavior), and 'Multiple Shear Mechanism for RO, HD, GHES (with Bowl)' (Number of Mechanisms: 1).

Tick on

Automatically Consider Water Pressure

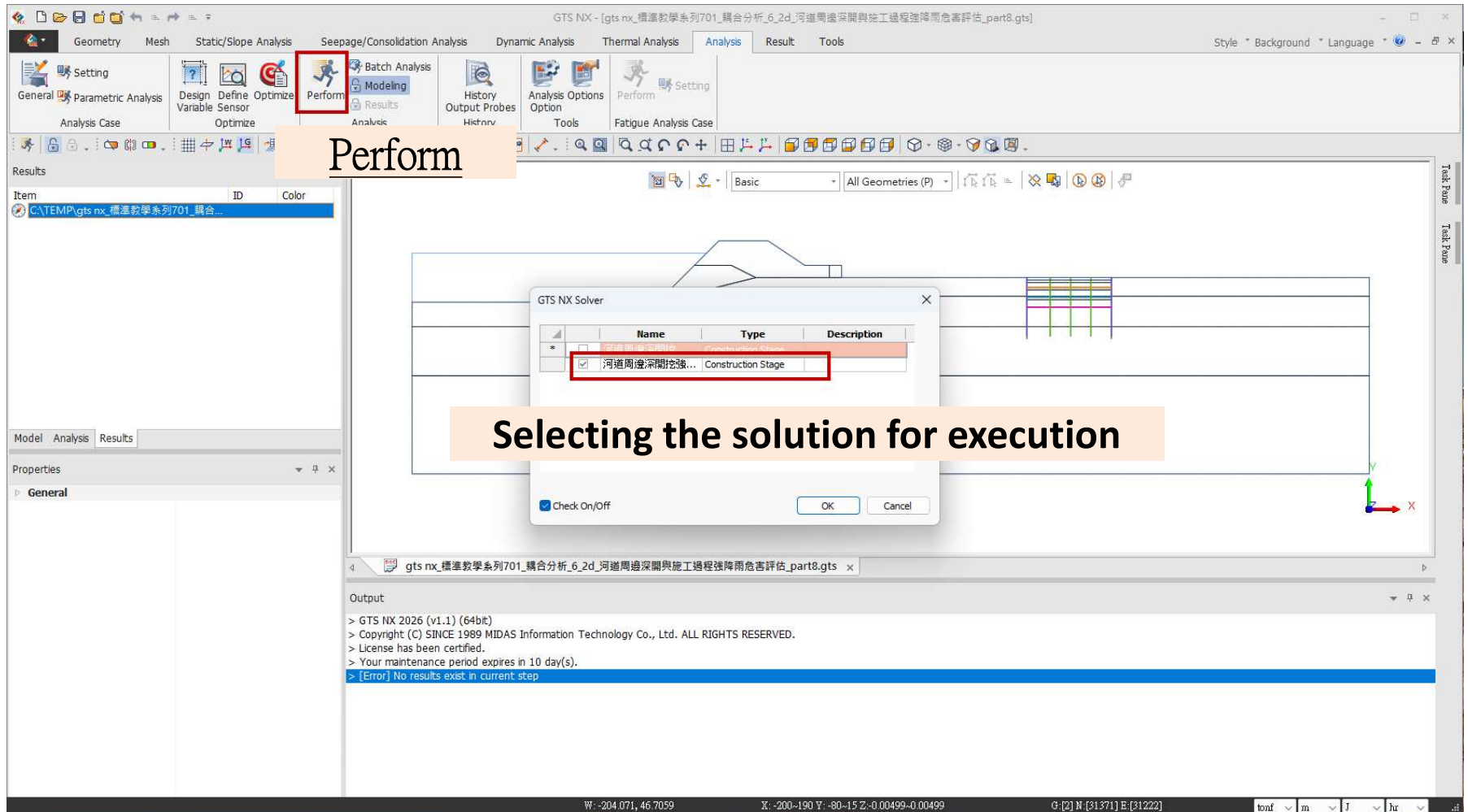
Tick on

Estimate initial stress of activated elements

Tick on

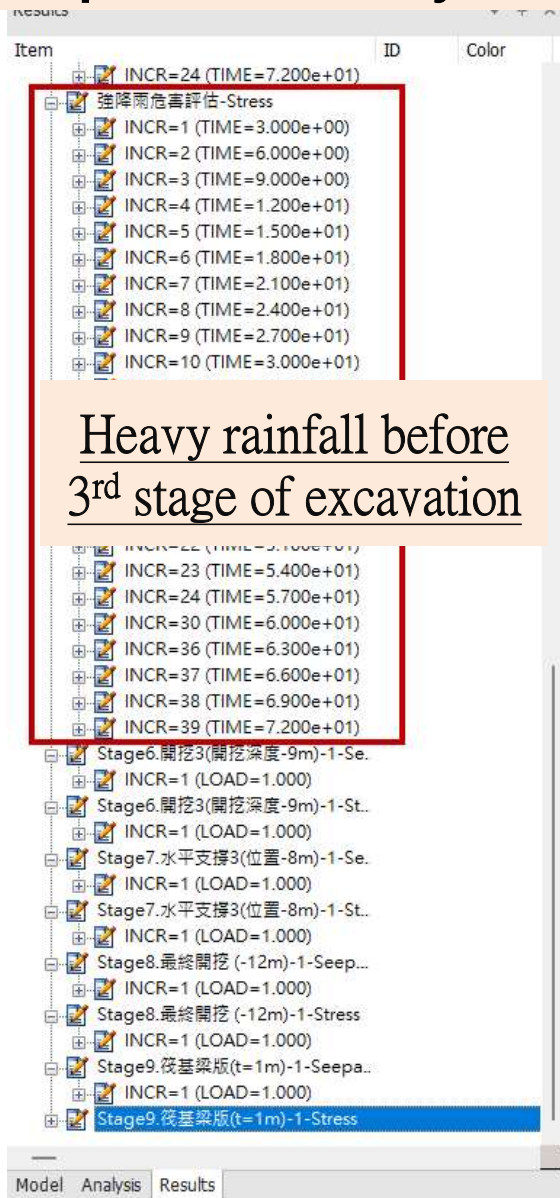
Estimate initial Configuration of activated nodes

Calculation



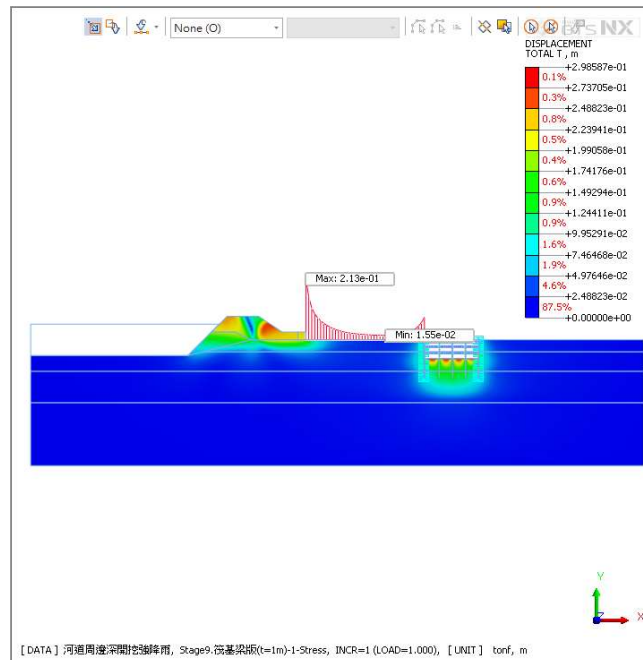
Results

Sequence of analysis in CS



Stage6.Ex3_-9m

Heavy rainfall consideration



No rainfall consideration

