midas FEA NX

2024/03/29 10:00~11:30

Google會議室 https://meet.google.com/sgo-hhbz-qiy

FEA NX_線上課程

鋼骨結構

線性挫屈和非線性挫屈

台灣邁達斯

MIDAS

註:範例相關參數使用假設條件。

Subject

- MIDAS Design & Simulation
- 基礎觀念介紹
  - 挫曲
  - 後挫曲
  - 線性挫曲&非線性挫曲
- Example1:線性挫曲分析
- Example2:非線性挫曲分析
- Example3:後挫曲分析

挫曲

挫曲(Buckling)

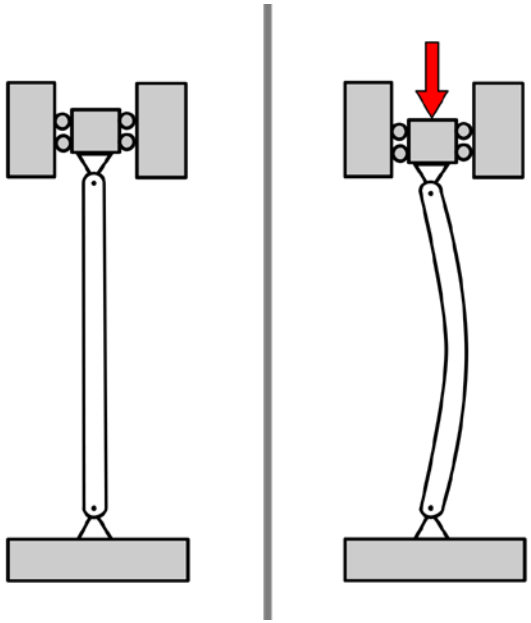
是指細長桿件受到壓力時，發生彎曲變形的一種現象，不穩定造成的結構失效稱為屈曲失效，理想壓桿不穩定後，由原來的直線平衡狀態變為彎曲平衡狀態。

數學家萊昂哈德·歐拉提出了細長理想柱在不挫曲的情形下，可以承受的最大軸向壓縮力。

$$F = \frac{\pi^2 EI}{(KL)^2}$$

F:最大臨界力
E:彈性模數
I:面積慣性矩
L:柱的未支撐長度

K:視柱子兩側的支撐條件而定
K=1,二端都用插銷連接(可以旋轉)
K=0.5,若二端都固定(無法旋轉)
K≈ 0.699,一端固定一端用插銷連接
K=2,一端固定，另一端可以自由移動



Reference

https://zh.wikipedia.org/zh-tw/挫曲

後挫曲

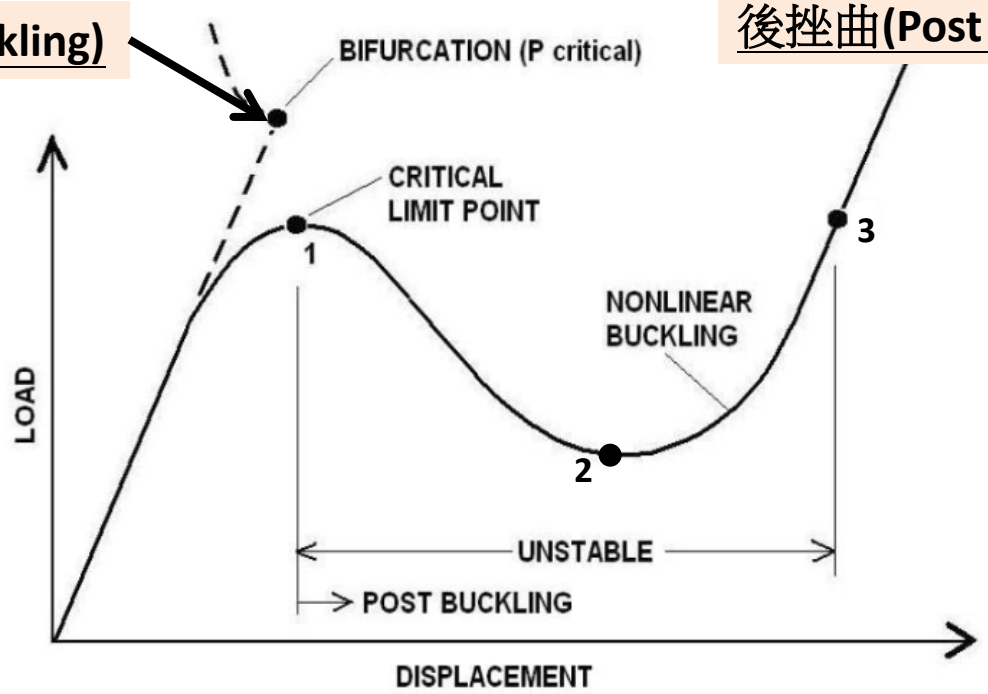
後挫曲(非線性挫曲)分析

載荷較小時分析結果與線性結果一致。當載荷逐步增大，變形逐步增加，結構響應呈現出非線性，力位移曲線開始偏離線性結果，在Point 1點承受外部載荷達到最大。

之後變形繼續變大但是結構能承受的外部載荷變小，結構發生挫曲，變形繼續變大，但是結構承受的載荷繼續變小。達到Point 2位移增加，結構承受的載荷開始增加，Point 3達到之前載荷的極限點。從Point 1到Point 3的過程稱為疾速跳過(snap through)。

線性挫曲(Linear Buckling)

後挫曲(Post Buckling)



Reference

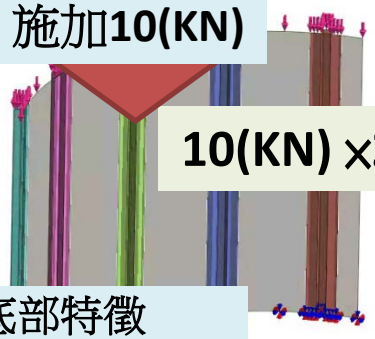
https://www.linkedin.com/pulse/buckling-post-buckling-abraham-imam-muttaqin

線性挫曲&非線性挫曲

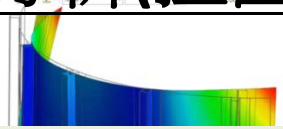
(Linear & Non-Linear Buckling)

FEA NX-線性挫曲分析(挫曲最大臨界力)

施加10(KN)



底部特徵
Tx/Ty/Tz/Rx/Ry/Rz

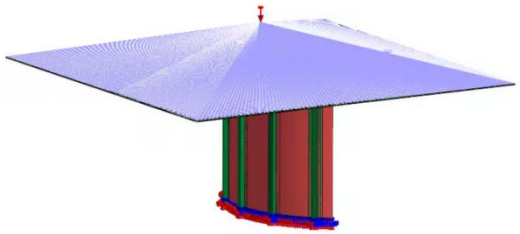


10(KN) ×2902.6(mode 1 (Hz))=29026(KN)-挫曲最大臨界力

Mode 1-變形

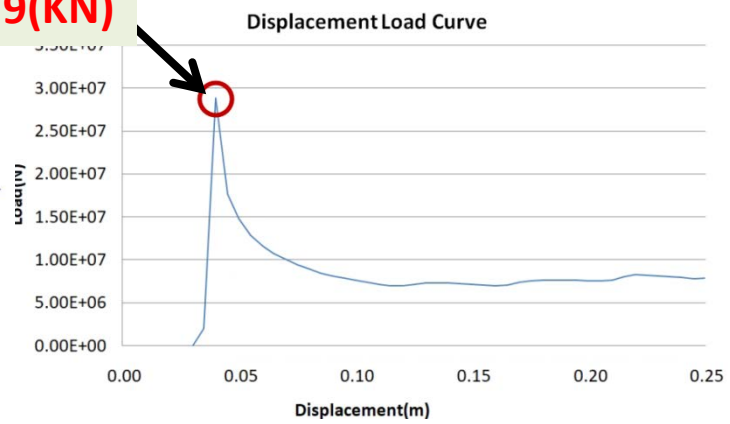
FEA NX-非線性挫曲分析(挫曲過程載荷-位移曲線)

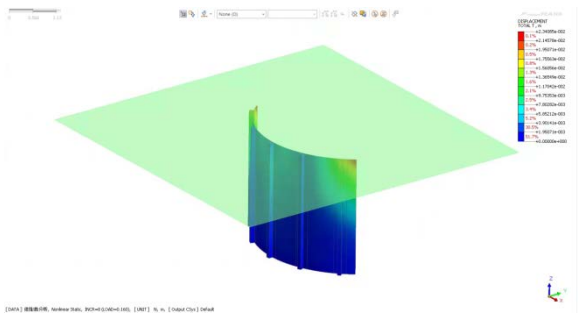
下壓0.25(m)



底部特徵
Tx/Ty/Tz/Rx/Ry/Rz

28832.9(KN)





註:範例相關參數使用假設條件。

應變硬化指數
(Strain Hardening Exponent)

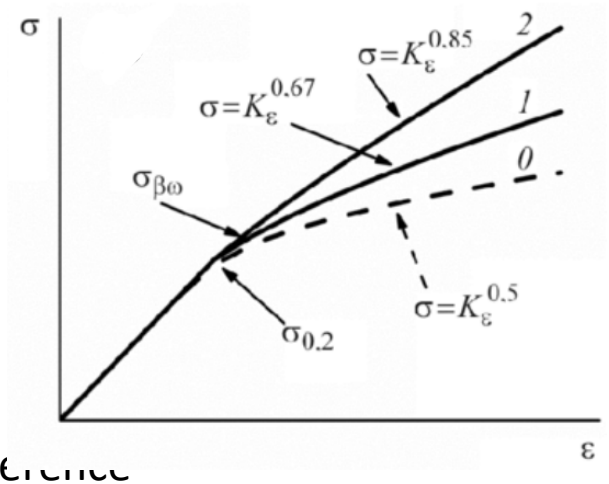
應變硬化指數(Strain Hardening Exponent)

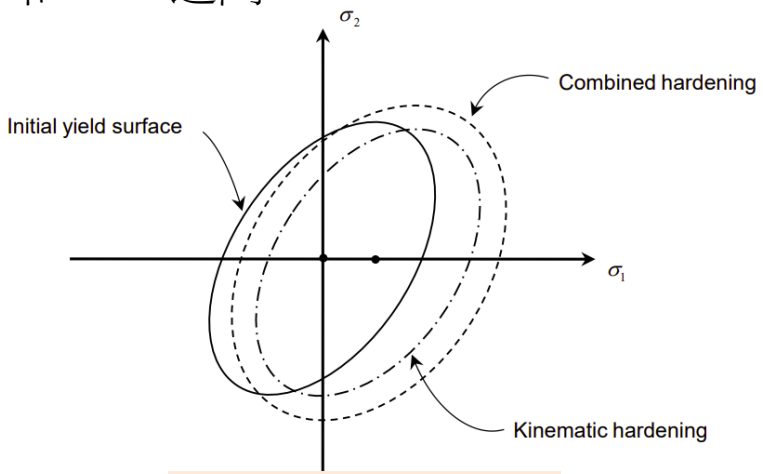
通常表示為 n，常用於與加工硬化中的應力-應變行為相關的計算中的常量。

$$\sigma = K\epsilon^n$$

σ 真實應力
ε 真實應變
K 強度係數
n 應變硬化指數

應變硬化指數(n),值介於 0 和 1 之間，0 表示完全塑性， 1 表示完全彈性，大多數金屬的 n 值介於 0.10 和 0.50 之間。





硬化模型-屈服面

Reference

GTS NX AND FEA NX Manual
https://en.wikipedia.org/wiki/Strain_hardening_exponent

midas FEA NX

FEA NX_標準教學系列

鋼骨結構-線性分析

線性挫曲分析

台灣邁達斯

MIDAS

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NX

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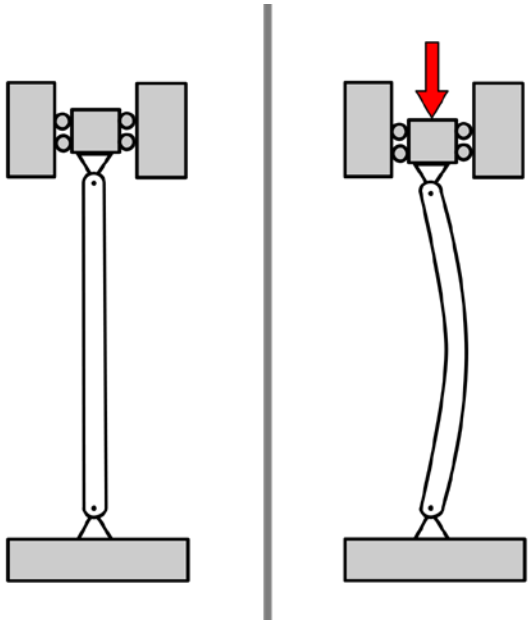


Reference

https://zh.wikipedia.org/zh-tw/挫曲

分析說明

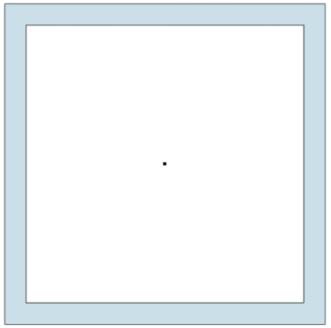
材料

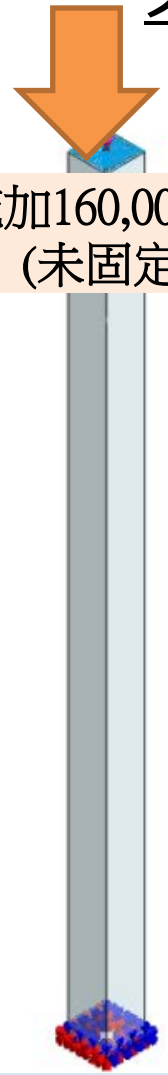
$E = 70GPa$

$\gamma = 0.33$

$\rho = 7.850kg/m^3$

截面0.15(m) ×0.15(m)
厚度(t):0.01(m)
長度(L):3 (m)





施加160,000(N)
(未固定)

拘束條件
底部面特徵Tx/Ty/Tz/Rx/Ry/Rz

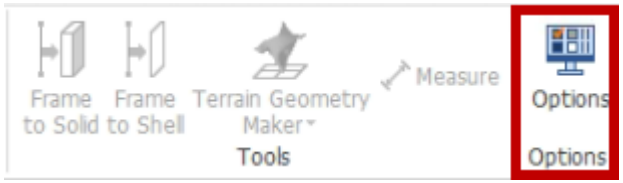
F最大臨界力:352.86(KN)

$$F = \frac{\pi^2 EI}{(KL)^2}$$

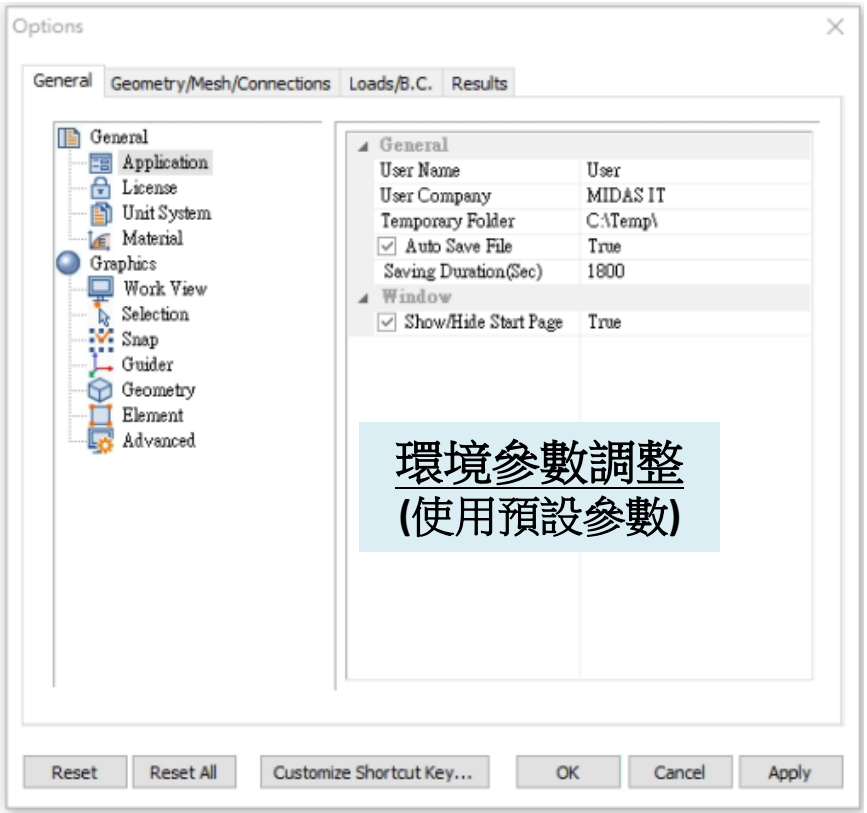
E:70(GPa)
L:3(m)
K=2
I: $\frac{1}{12}((0.15\times0.15^3)-(0.13\times0.13^3))$

線性挫曲分析
計算最大臨界力

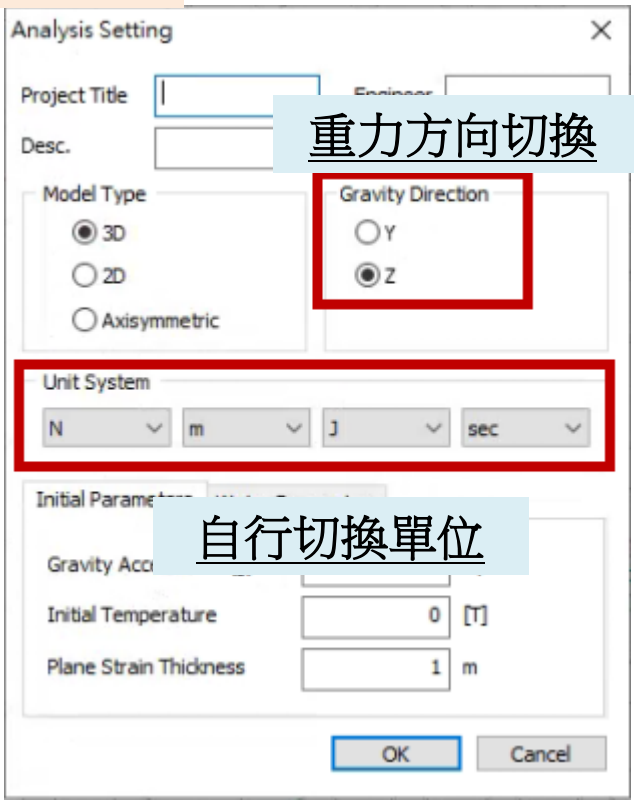
環境



新文件



環境參數調整
(使用預設參數)

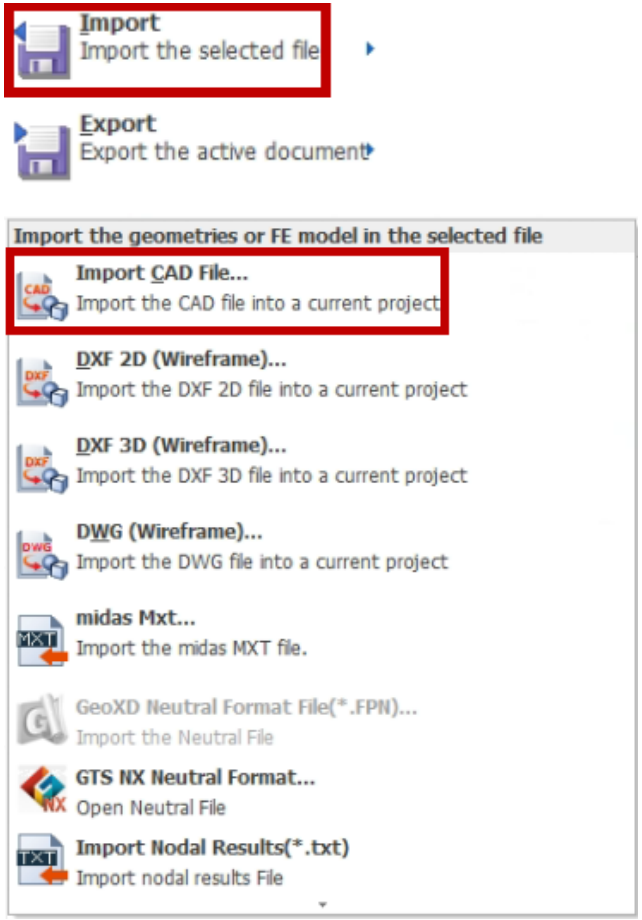


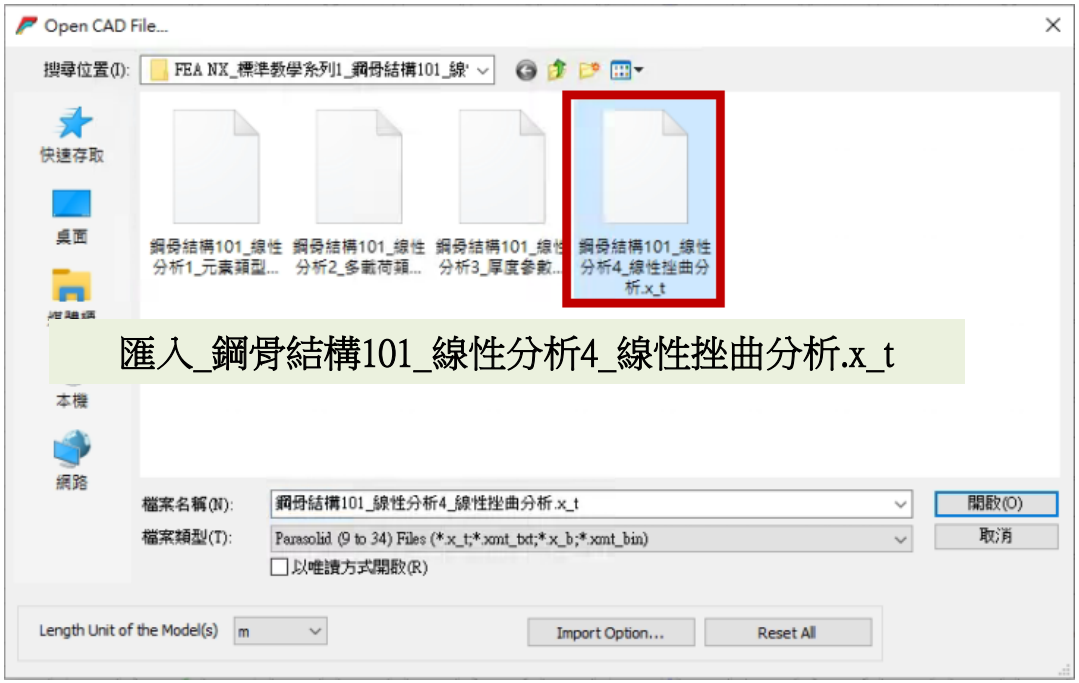
重力方向切換

自行切換單位

單位使用N/m/J/sec

匯入模型

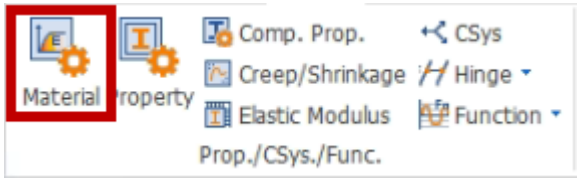


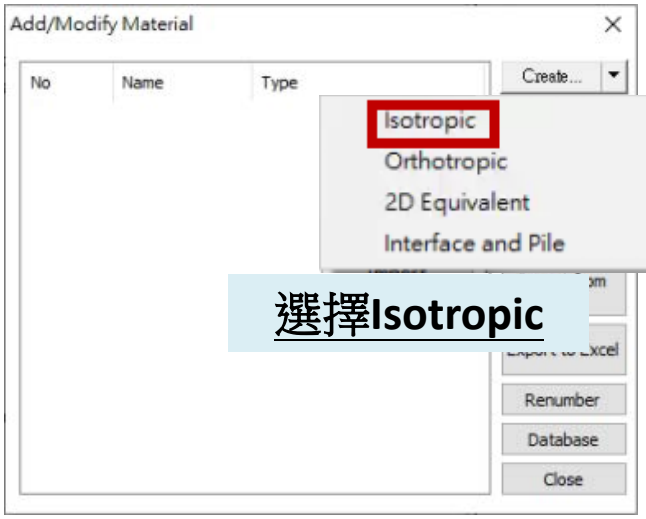


匯入_鋼骨結構101_線性分析4_線性挫曲分析.x_t

鋼構3D模型

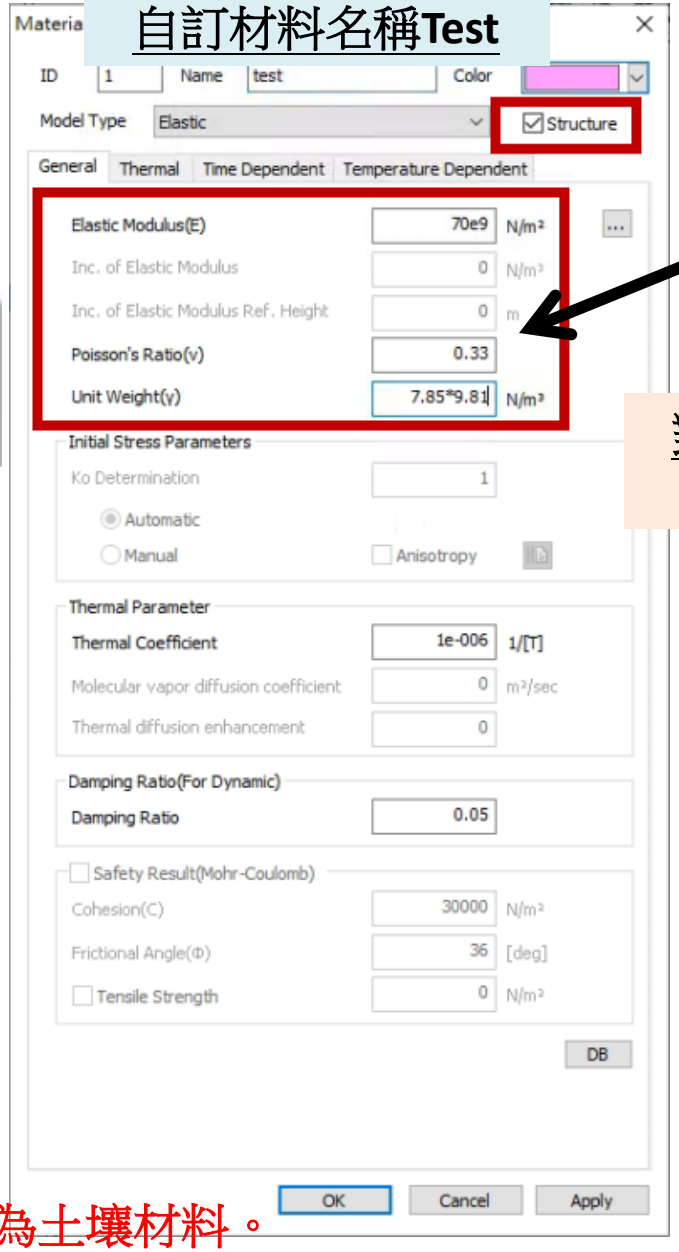
材料





選擇Isotropic

自訂材料名稱Test



勾選Structure

$E = 70GPa$

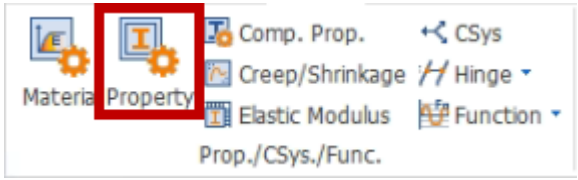
$\gamma = 0.33$

$\rho = 7.850kg/m^3$

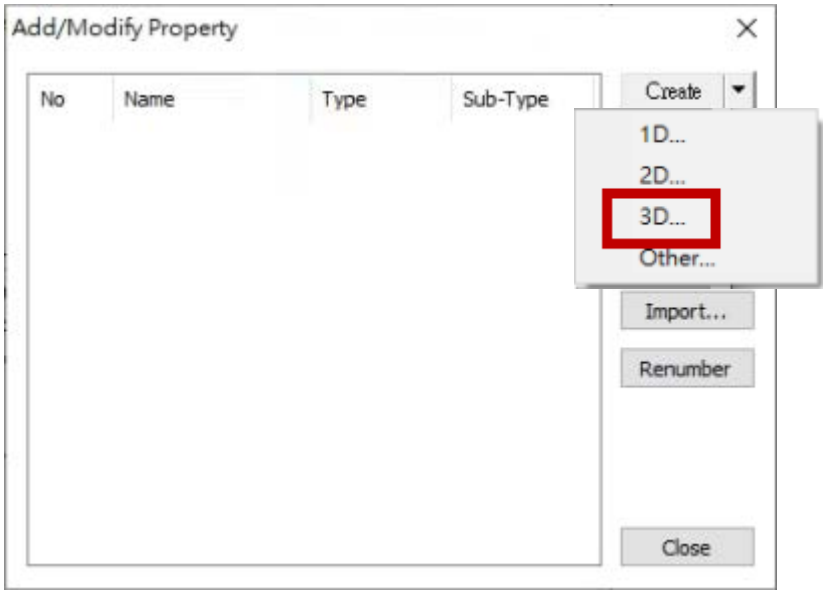
對照輸入材料數據
(密度單位換算)

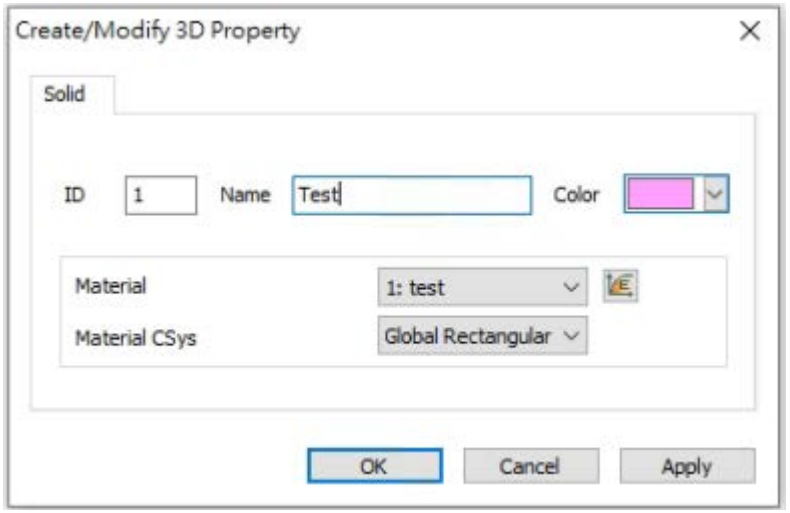
註:未勾選Structure則視為土壤材料。

屬性

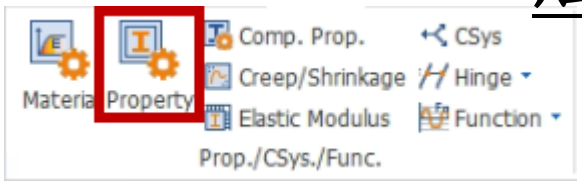


新增Test Property

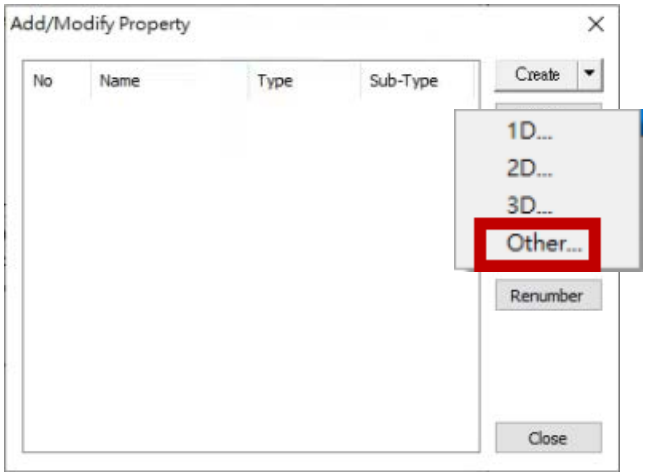




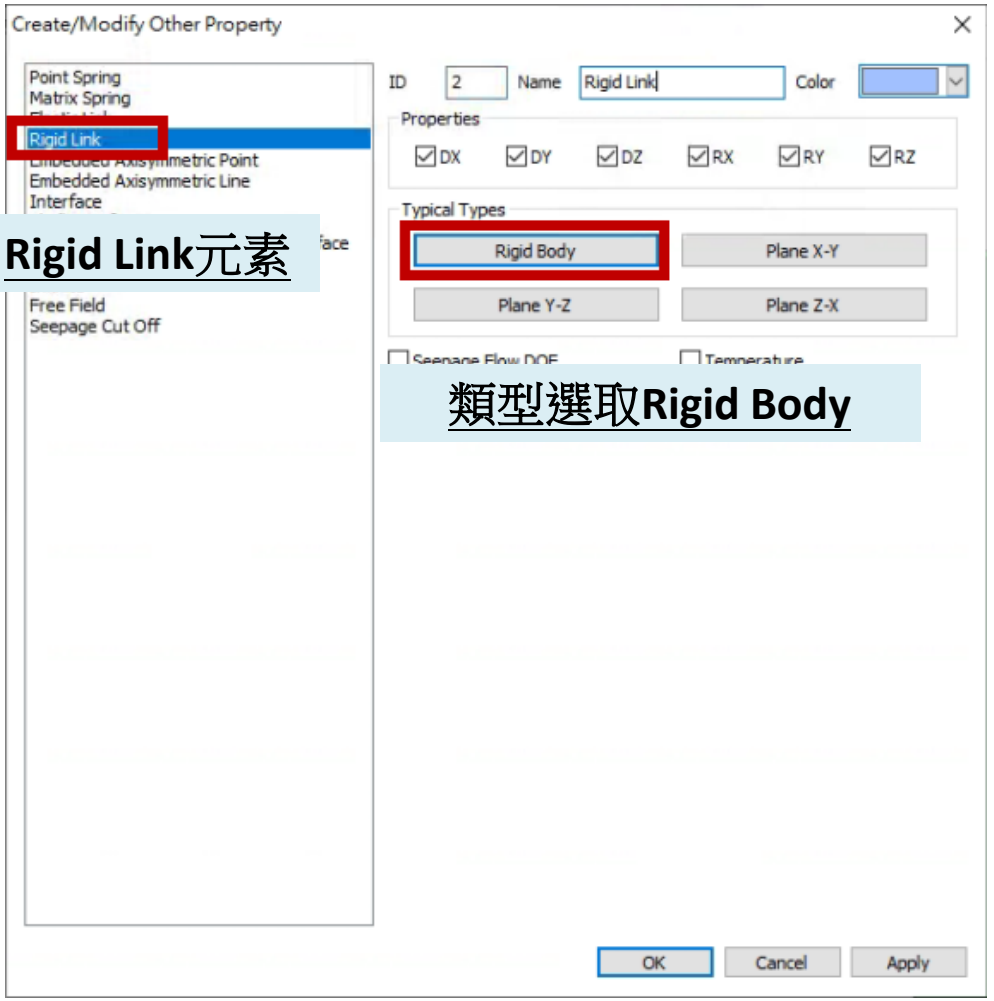
屬性-Rigid Link



新增Rigid Link Property



Rigid Link元素



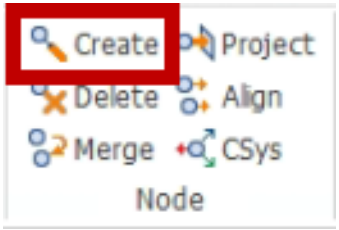
類型選取Rigid Body

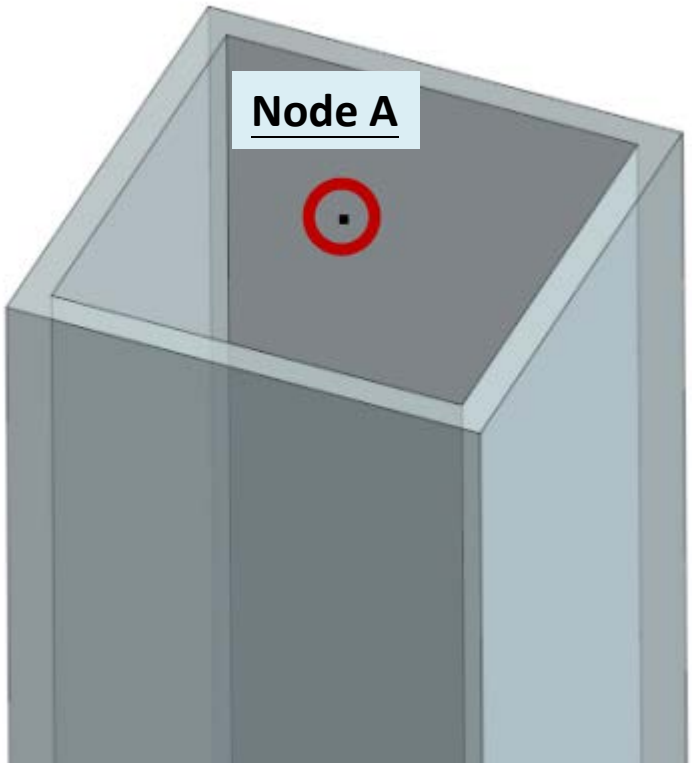
3D網格-四面體網格

Tetra Mesher(四面體網格)/網格尺寸0.01 (m)/2階元素

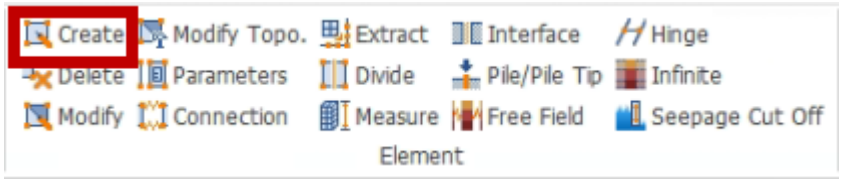
主控節點建立

(剛性連接主控點)

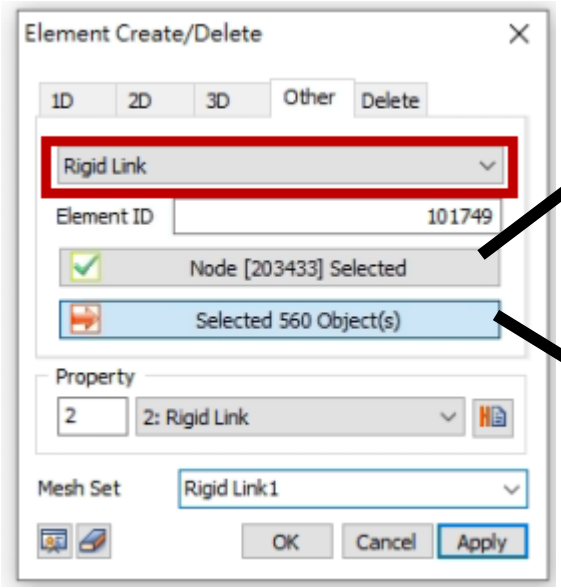




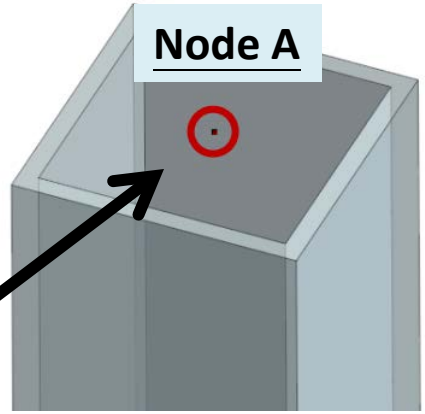
剛性連接



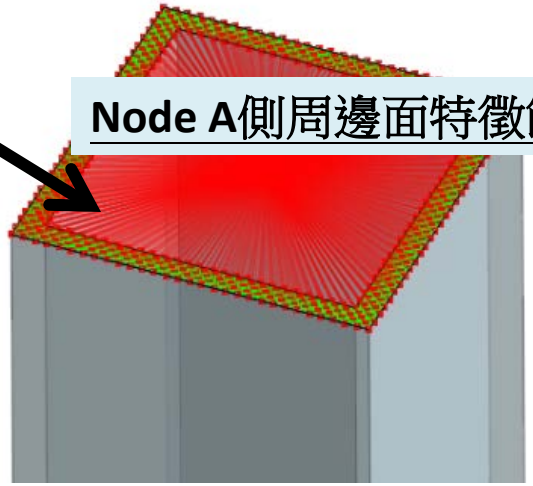
元素類型選取**Rigid Link**



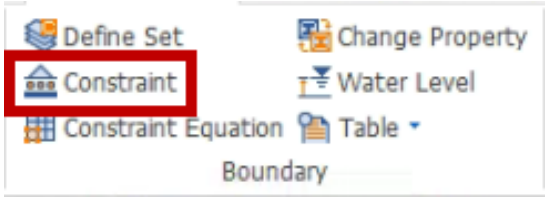
自訂網格集**Rigid Link1**

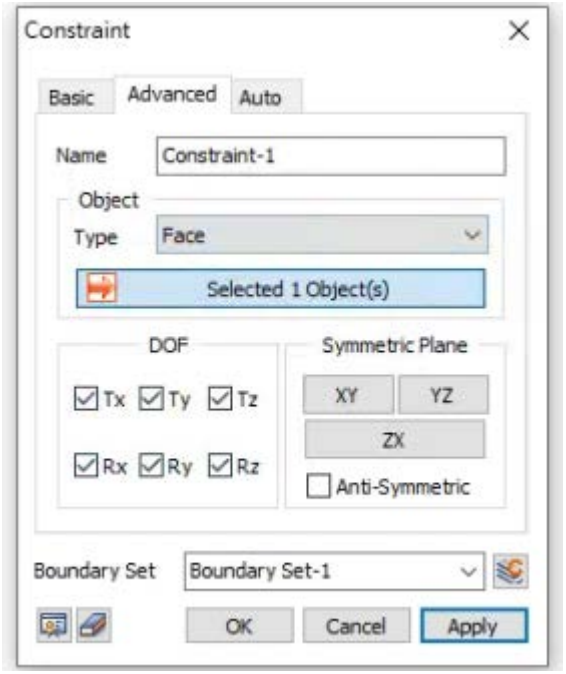


切換使用面特徵選取節點

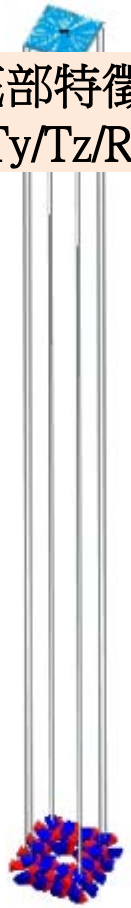


邊界

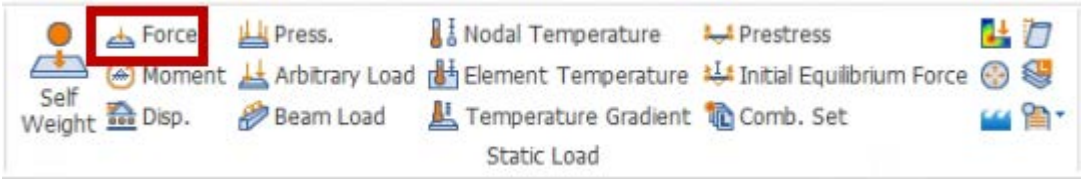


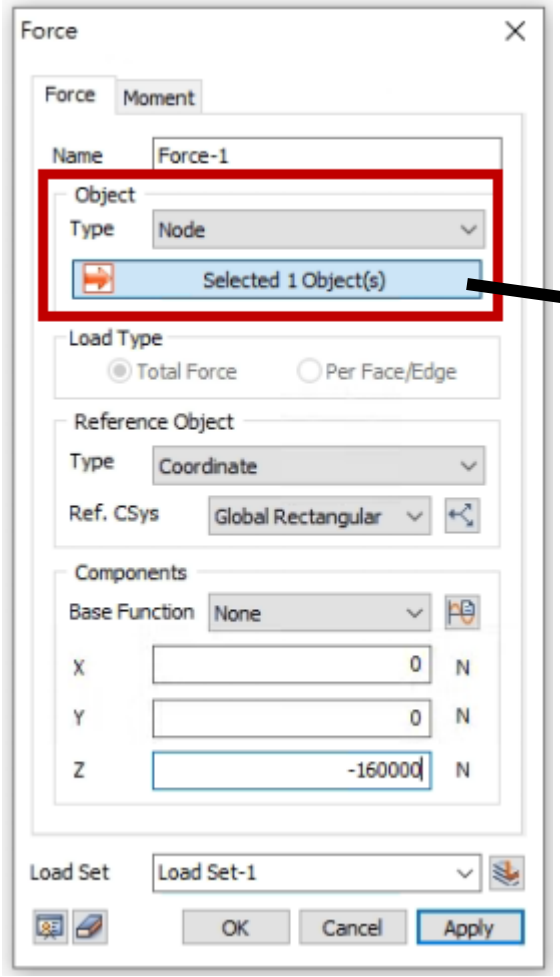


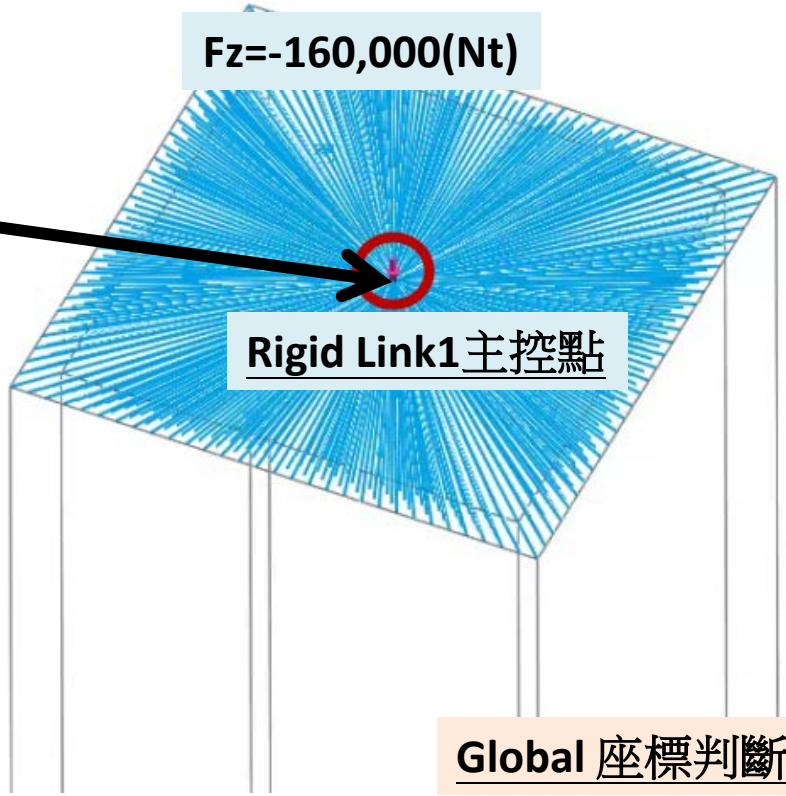
底部特徵拘束
Tx/Ty/Tz/Rx/Ry/Rz



載荷

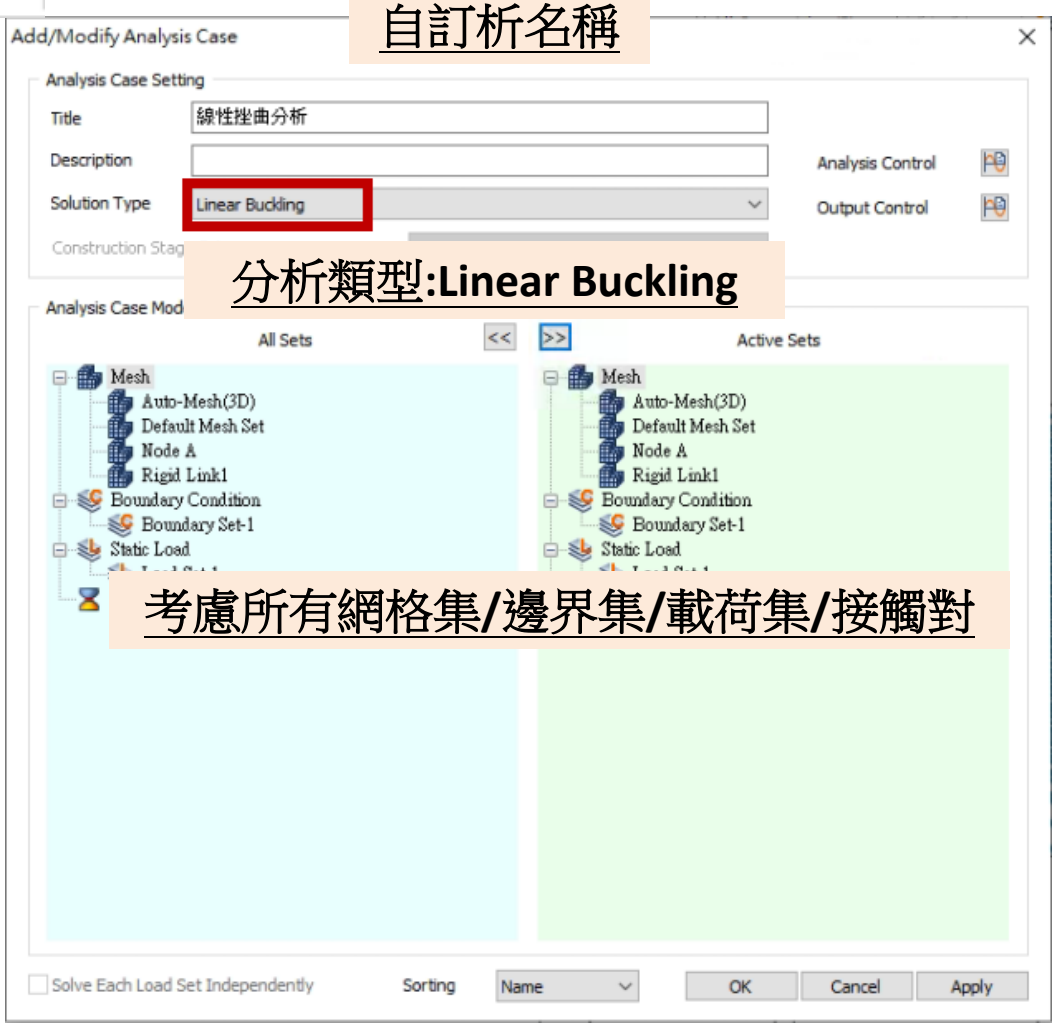

Force
Press.
Nodal Temperature
Prestress
Self Weight
Moment
Arbitrary Load
Element Temperature
Initial Equilibrium Force
Disp.
Beam Load
Temperature Gradient
Comb. Set
Static Load


Force
Force
Moment
Name
Force-1
Object
Type
Node
Selected 1 Object(s)
Load Type
Total Force
Per Face/Edge
Reference Object
Type
Coordinate
Ref. CSys
Global Rectangular
Components
Base Function
None
X
0
N
Y
0
N
Z
-160000
N
Load Set
Load Set-1
OK
Cancel
Apply


Fz=-160,000(Nt)
Rigid Link1主控點
Global 座標判斷方向

線性挫曲分析-1

自訂析名稱



分析類型:Linear Buckling

考慮所有網格集/邊界集/載荷集/接觸對

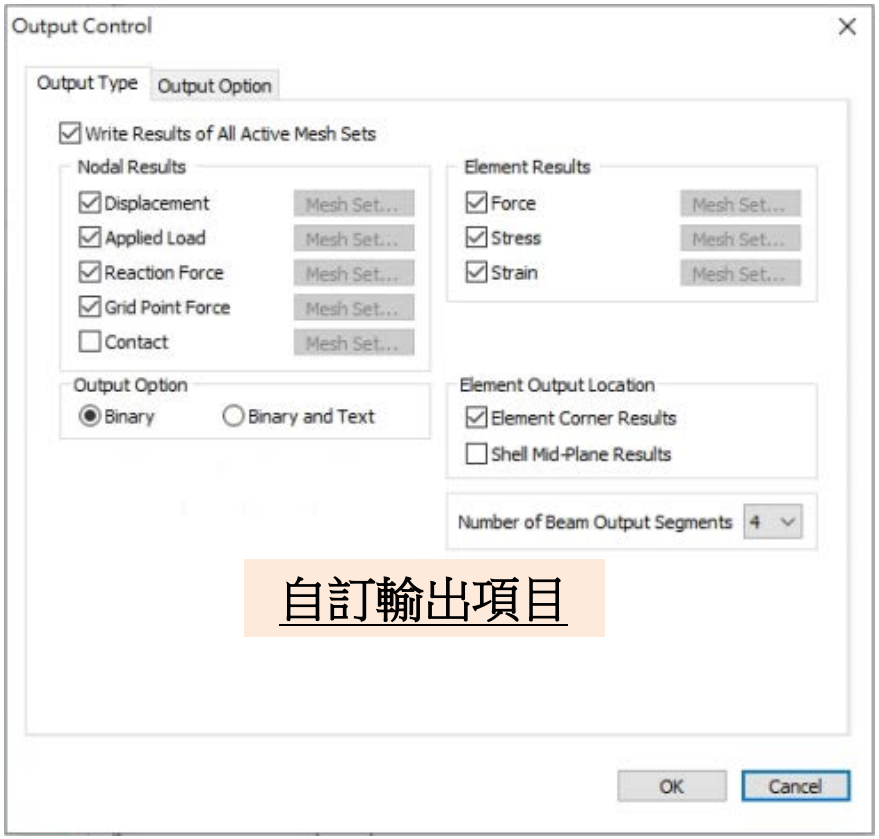
註:建議分析名稱不要使用空格

線性挫曲分析-2

分析控制

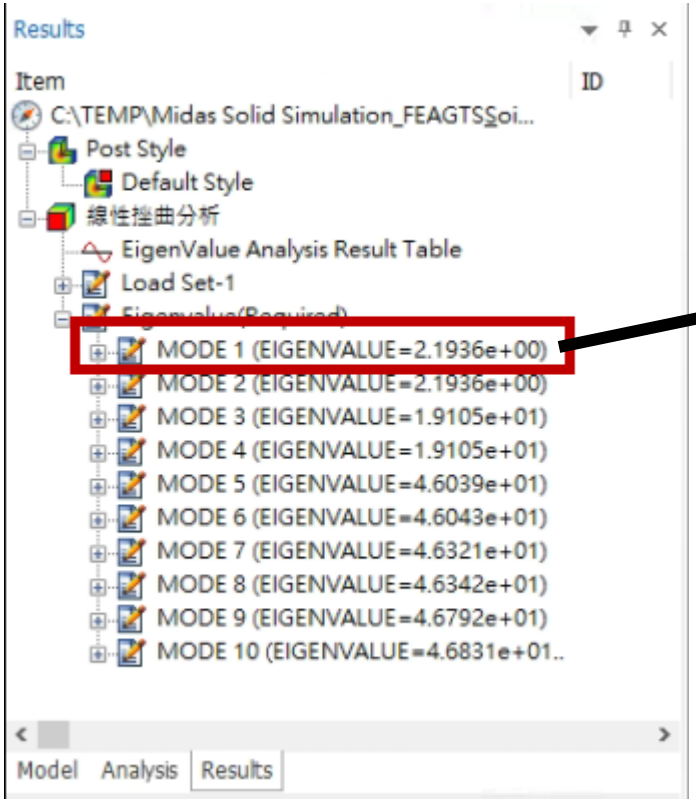
輸出10組結果

輸出控制



自訂輸出項目

挫曲計算



線性挫曲分析

n=1

160(KN) ×**2.1936**=**350.976**(KN)

F最大臨界力:352.86(KN)

$$F = \frac{\pi^2 EI}{(KL)^2}$$

E:70(GPa)

L:3(m)

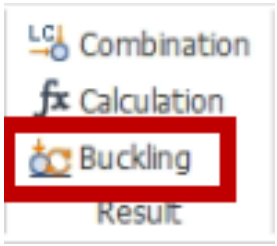
K=2

I: $\frac{1}{12}((0.15\times0.15^3)-(0.13\times0.13^3))$

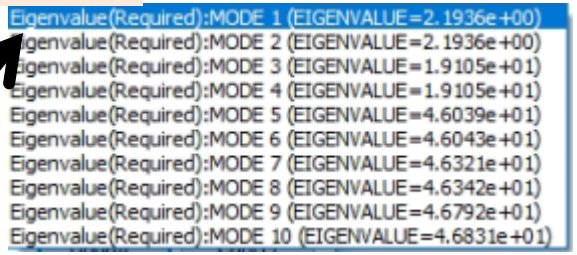
Reference

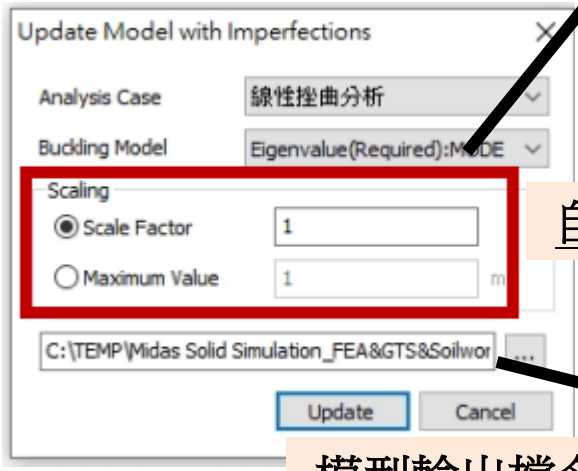
NFX Analysis Reference

挫曲變形模型



選取結果





自訂變形比例

模型輸出檔名

midas FEA NX

FEA NX_標準教學系列

鋼骨結構-非線性分析
挫曲計算

台灣邁達斯

MIDAS

註:範例相關參數使用假設條件。

挫曲

挫曲(Buckling)

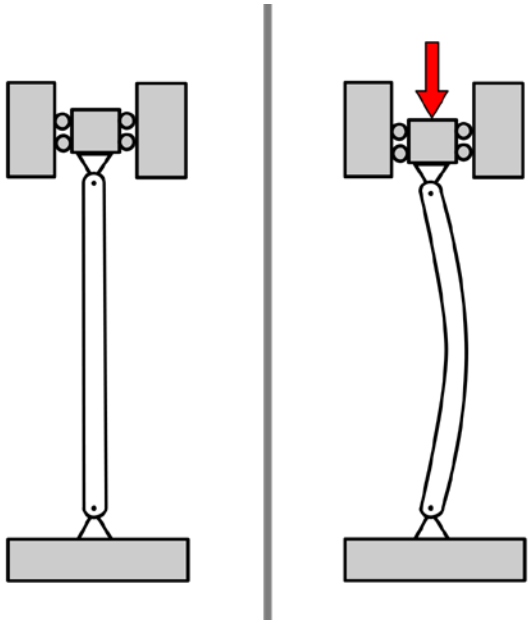
是指細長桿件受到壓力時，發生彎曲變形的一種現象，不穩定造成的結構失效稱為屈曲失效，理想壓桿不穩定後，由原來的直線平衡狀態變為彎曲平衡狀態。

數學家萊昂哈德·歐拉提出了細長理想柱在不挫曲的情形下，可以承受的最大軸向壓縮力。

$$F = \frac{\pi^2 EI}{(KL)^2}$$

F:最大臨界力
E:彈性模數
I:面積慣性矩
L:柱的未支撐長度

K:視柱子兩側的支撐條件而定
K=1,二端都用插銷連接(可以旋轉)
K=0.5,若二端都固定(無法旋轉)
K≈ 0.699,一端固定一端用插銷連接
K=2,一端固定，另一端可以自由移動



Reference

https://zh.wikipedia.org/zh-tw/挫曲

後挫曲

範例探討內容

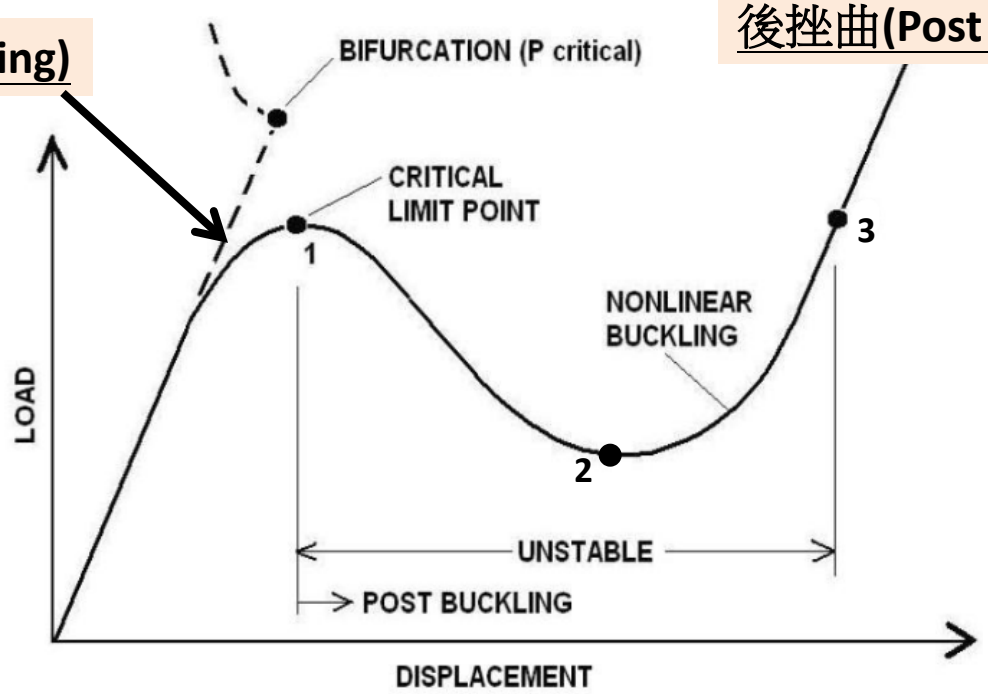
後挫曲(非線性挫曲)分析

載荷較小時分析結果與線性結果一致。當載荷逐步增大，變形逐步增加，結構響應呈現出非線性，力位移曲線開始偏離線性結果，在Point 1點承受外部載荷達到最大。

之後變形繼續變大但是結構能承受的外部載荷變小，結構發生挫曲，變形繼續變大，但是結構承受的載荷繼續變小。達到Point 2位移增加，結構承受的載荷開始增加，Point 3達到之前載荷的極限點。從Point 1到Point 3的過程稱為疾速跳過(snap through)。

挫曲(Buckling)

後挫曲(Post Buckling)



Reference

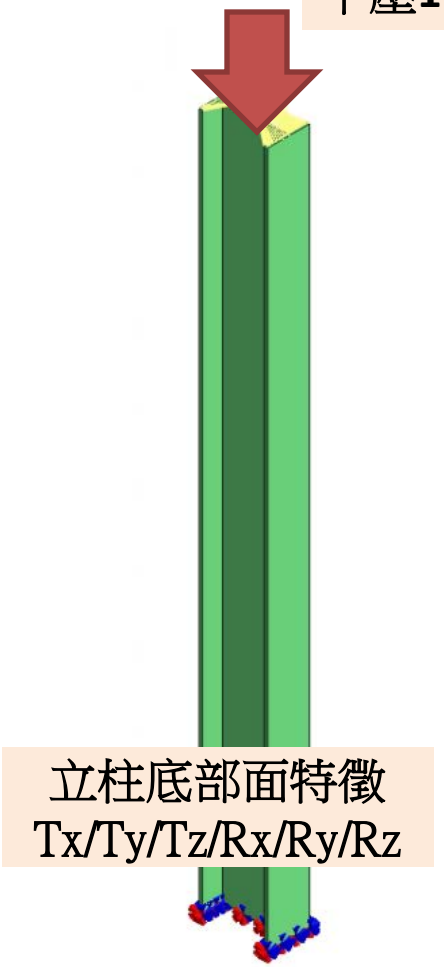
https://www.linkedin.com/pulse/buckling-post-buckling-abraham-imam-muttaqin

分析說明

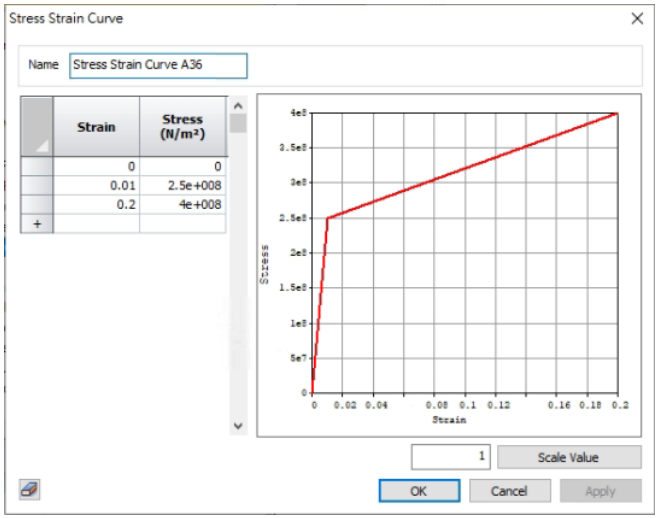
計算立柱下壓過程位移過程所需載荷!!

材料Steel/ASTM A36

下壓1(m)



立柱底部面特徵
Tx/Ty/Tz/Rx/Ry/Rz



ASTM A36 Steel, plate

Categories:	Metal; Ferrous Metal; ASTM Steel; Carbon Steel; Low Carbon Steel
Material Notes:	Steel for general structural purposes including bridges and buildings. Minimum Cu content when copper steel is specified. Tests performed in transverse direction for plates wider than 590 mm.
Key Words:	UNS K02600
Vendors:	No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this material.

Printer friendly version | Download as PDF | Download to Excel (requires Excel and Windows)
Export data to your CAD/FEA program

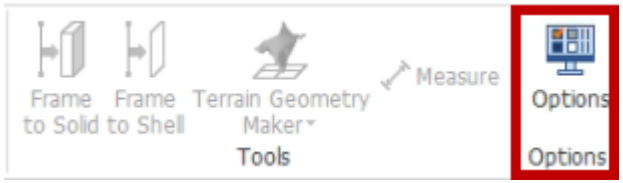
Physical Properties	Metric	English
Density	7.80 g/cc	0.282 lb/in³

Mechanical Properties	Metric	English
Tensile Strength, Ultimate	400 - 550 MPa	58000 - 79800 psi
Tensile Strength, Yield	250 MPa	36300 psi
Elongation at Break	20 %	20 %
	23 %	23 %
Modulus of Elasticity	200 GPa	29000 ksi
Bulk Modulus	160 GPa	23200 ksi
Poissons Ratio	0.26	0.26
Shear Modulus	79.3 GPa	11500 ksi

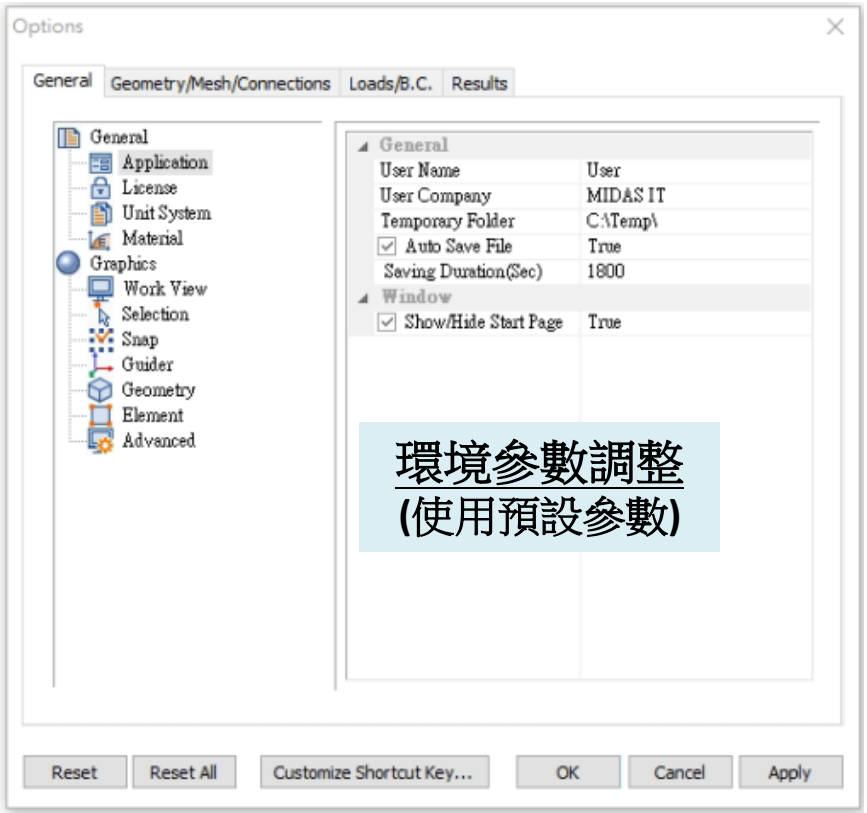
Component Elements Properties	Metric	English
Carbon, C	0.25 - 0.29 %	0.25 - 0.29 %
Copper, Cu	0.20 %	0.20 %
Iron, Fe	98 %	98 %
Manganese, Mn	1.03 %	1.03 %
Phosphorus, P	<= 0.040 %	<= 0.040 %
Silicon, Si	0.28 %	0.28 %
Sulfur, S	<= 0.050 %	<= 0.050 %

註:材料數據參考 www.matweb.com

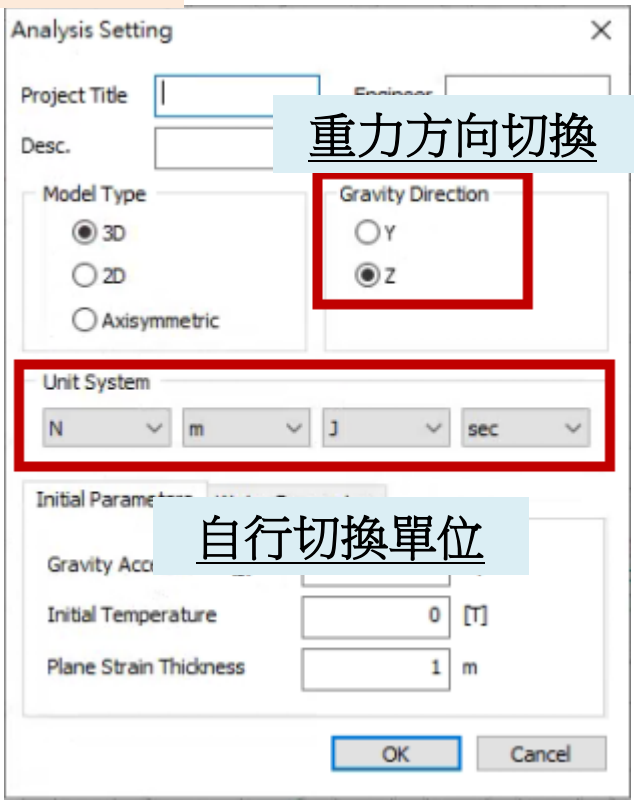
環境



新文件



環境參數調整
(使用預設參數)

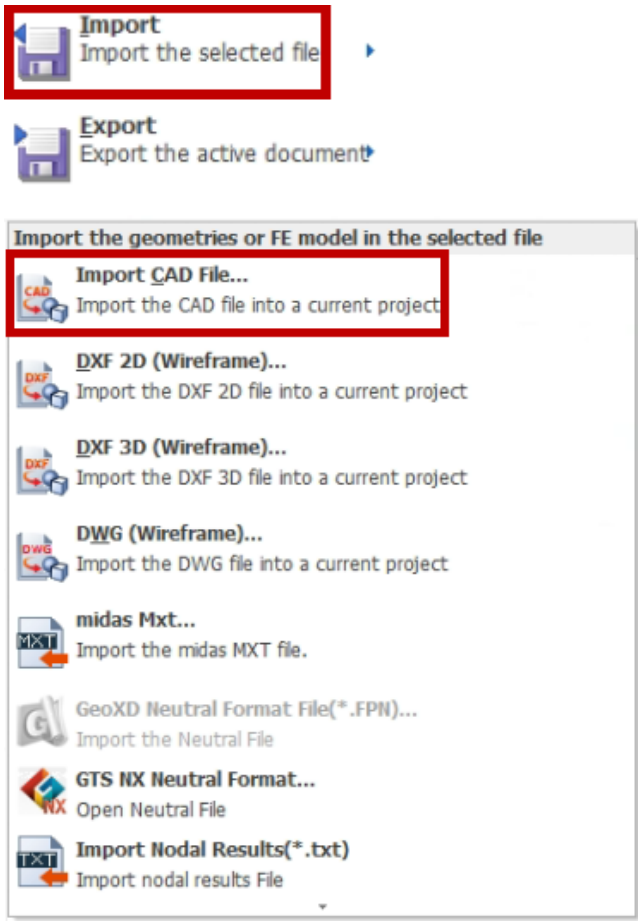


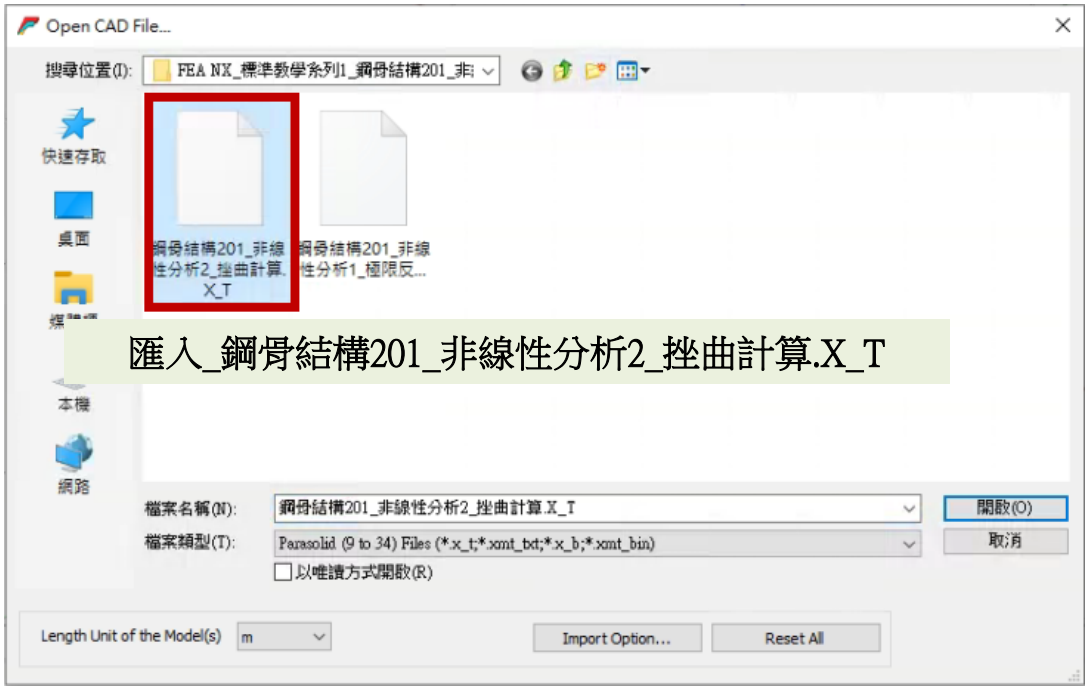
重力方向切換

自行切換單位

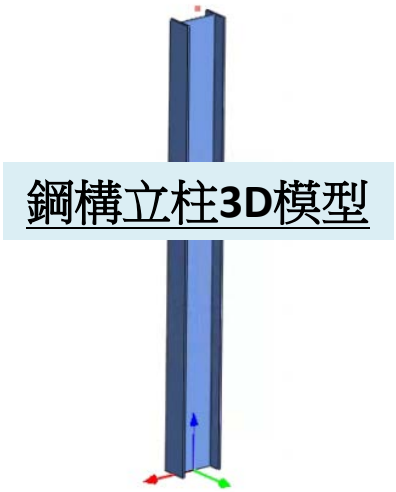
單位使用N/m/J/sec

匯入模型

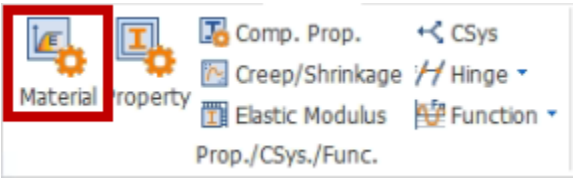




匯入_鋼骨結構201_非線性分析2_挫曲計算.X_T



鋼構立柱3D模型

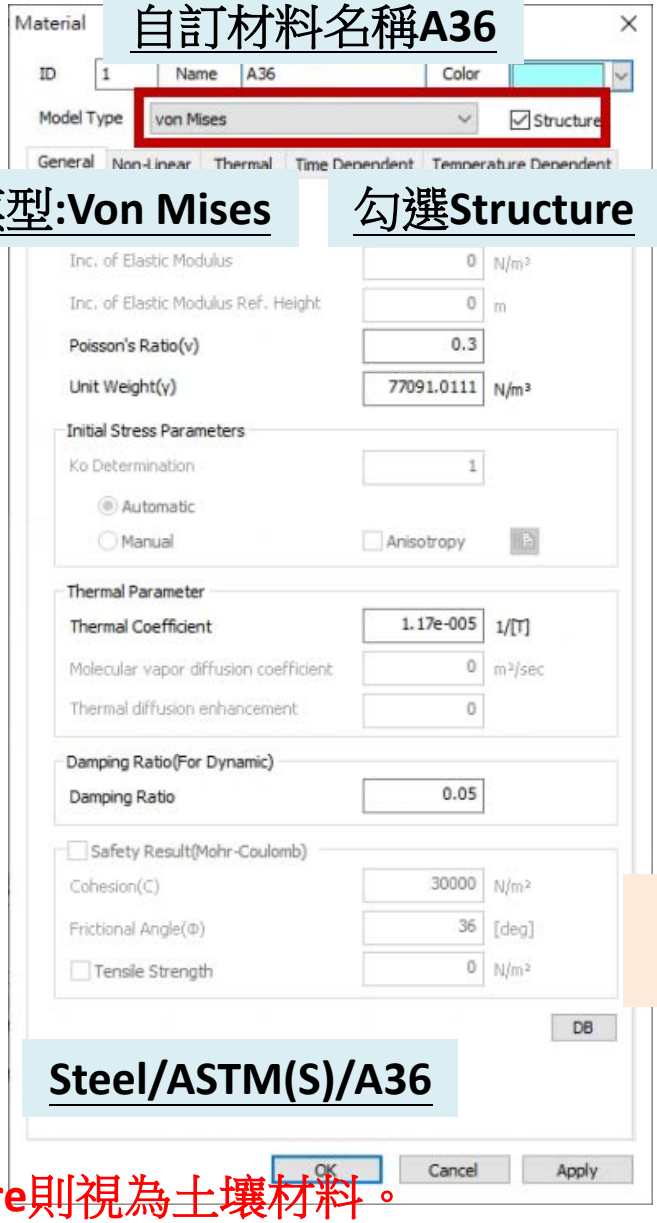


材料

自訂材料名稱A36

材料模型:Von Mises

勾選Structure



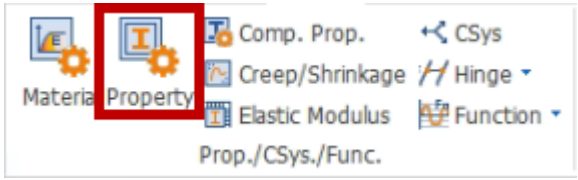
Steel/ASTM(S)/A36

選擇Stress-Strain Curve

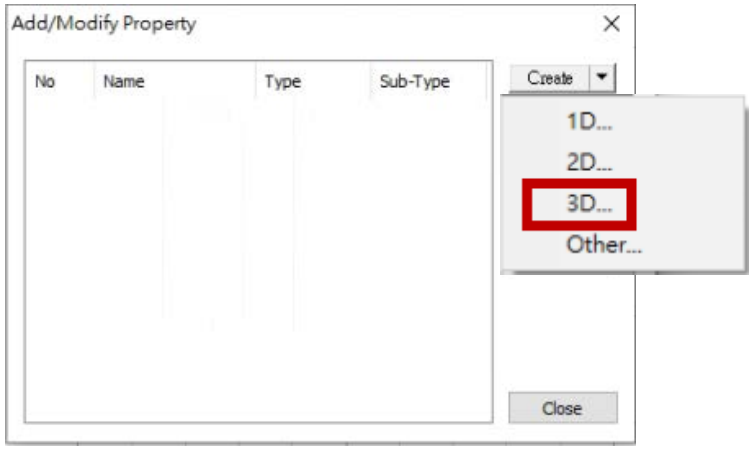
Stress Strain Curve A36
(0,0)(0.01,2.5e8)(0.2,4e8)

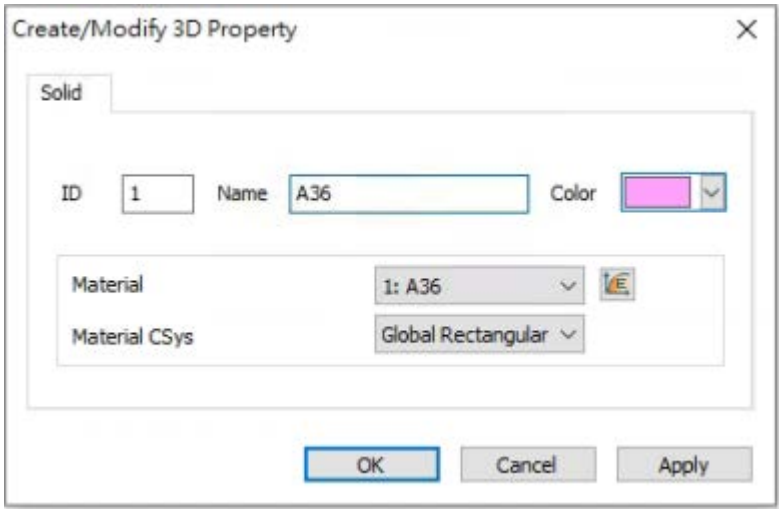
註:未勾選Structure則視為土壤材料。

屬性

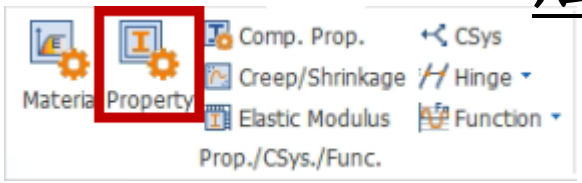


新增A36 Property

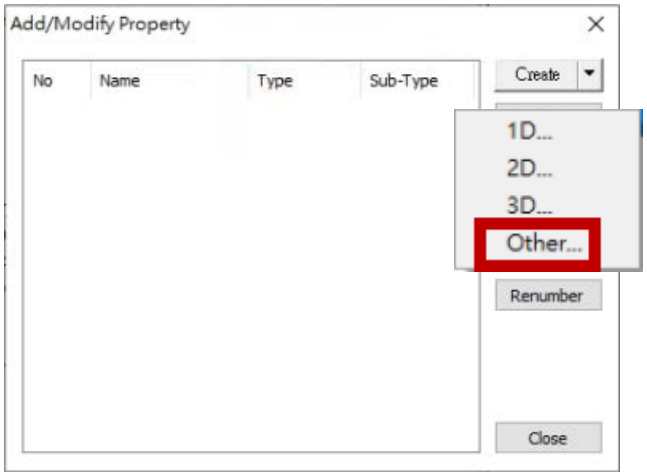




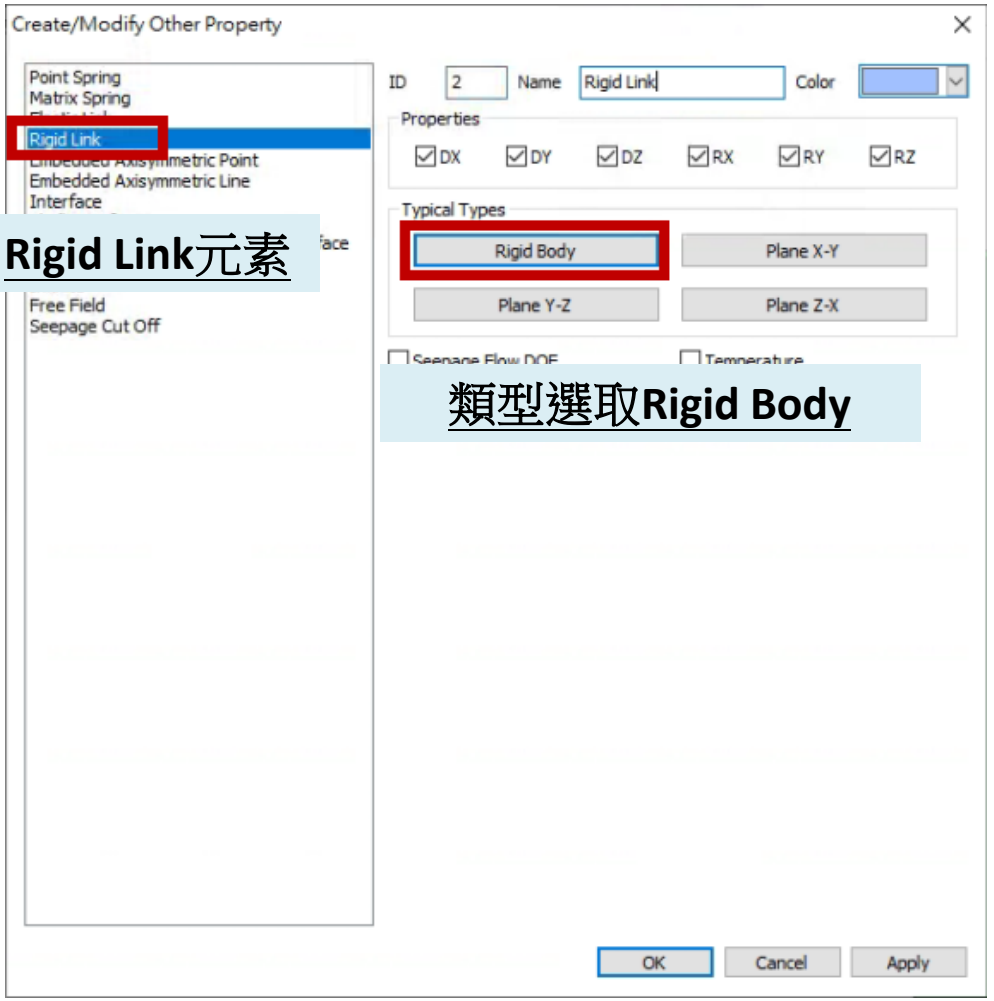
屬性-Rigid Link



新增Rigid Link Property



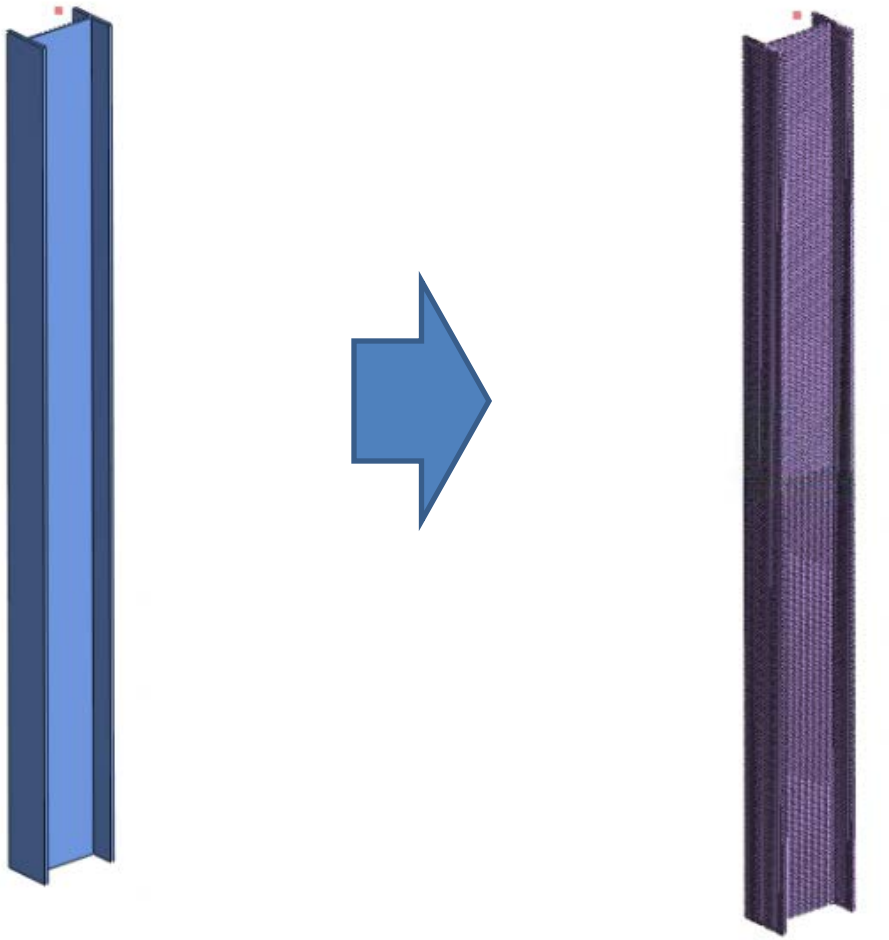
Rigid Link元素



類型選取Rigid Body

3D網格-混合網格

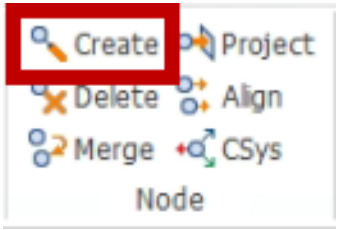
Hybrid Mesher(混合網格)/網格尺寸0.015 (m)



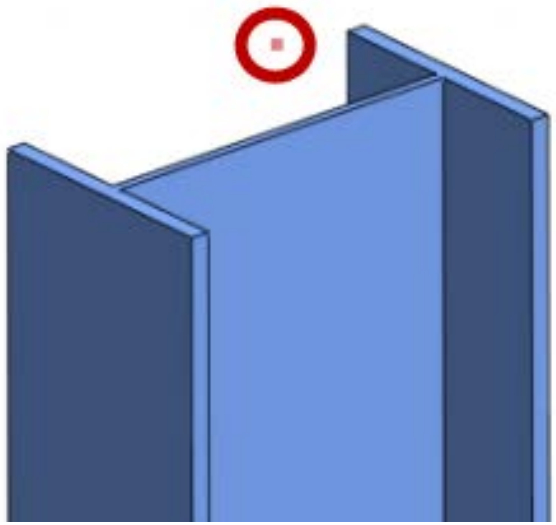
註:元素類型和階數會影響分析結果。

主控節點建立

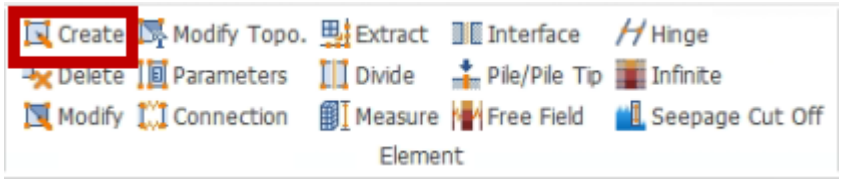
(剛性連接主控點)



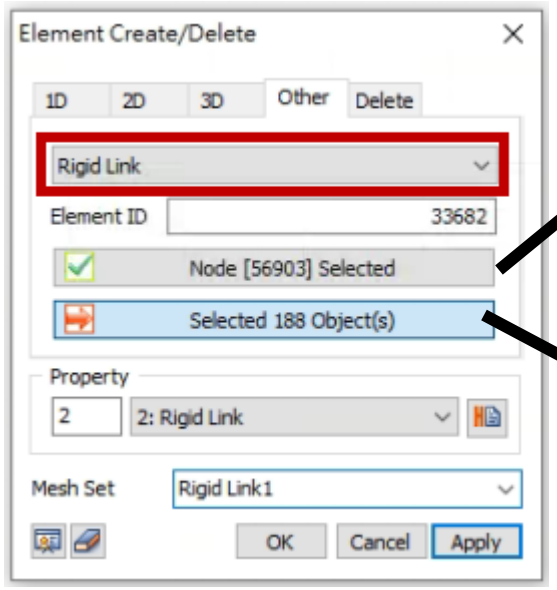
Node A



剛性連接

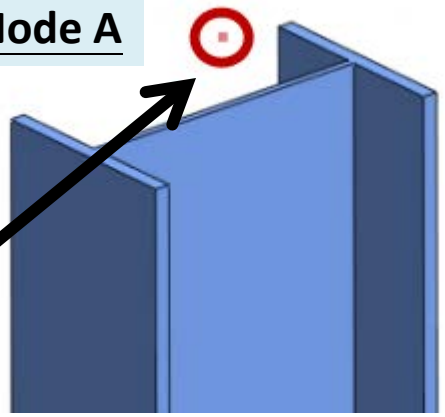


元素類型選取**Rigid Link**



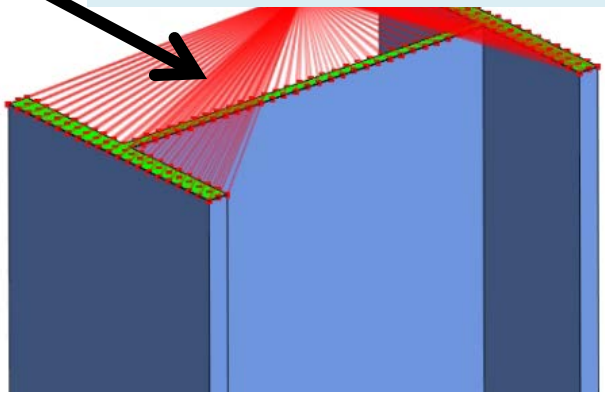
自訂網格集**Rigid Link1**

Node A

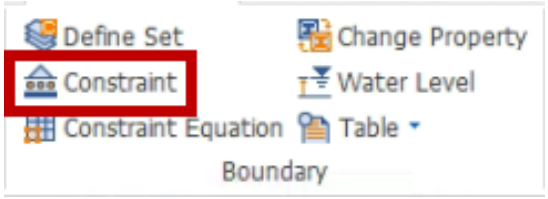


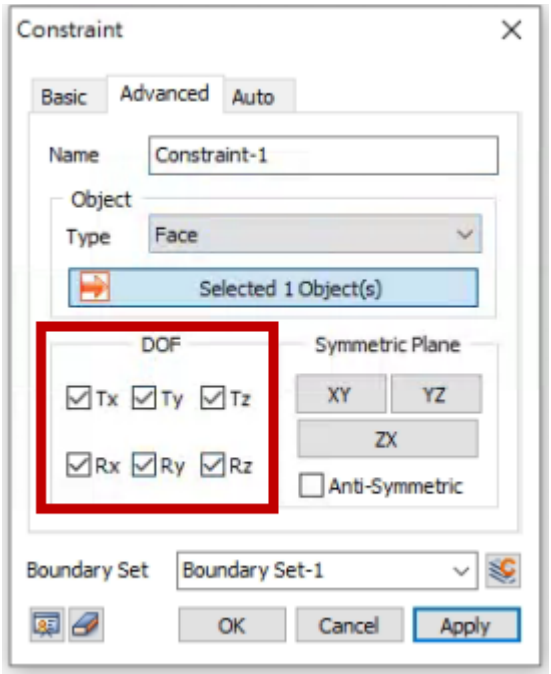
切換使用面特徵選取節點

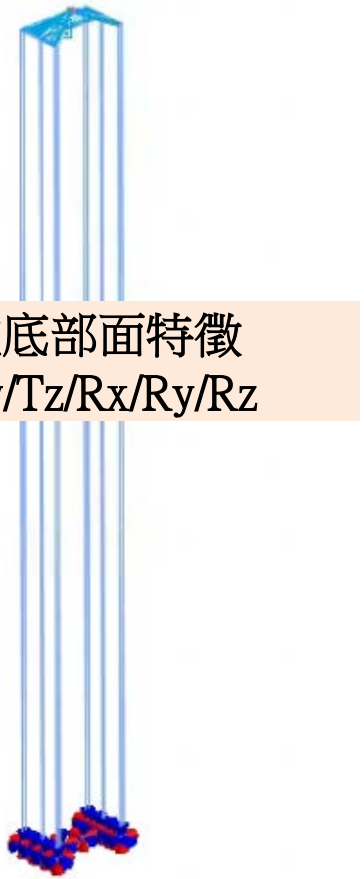
Node A側周邊面特徵節點



邊界



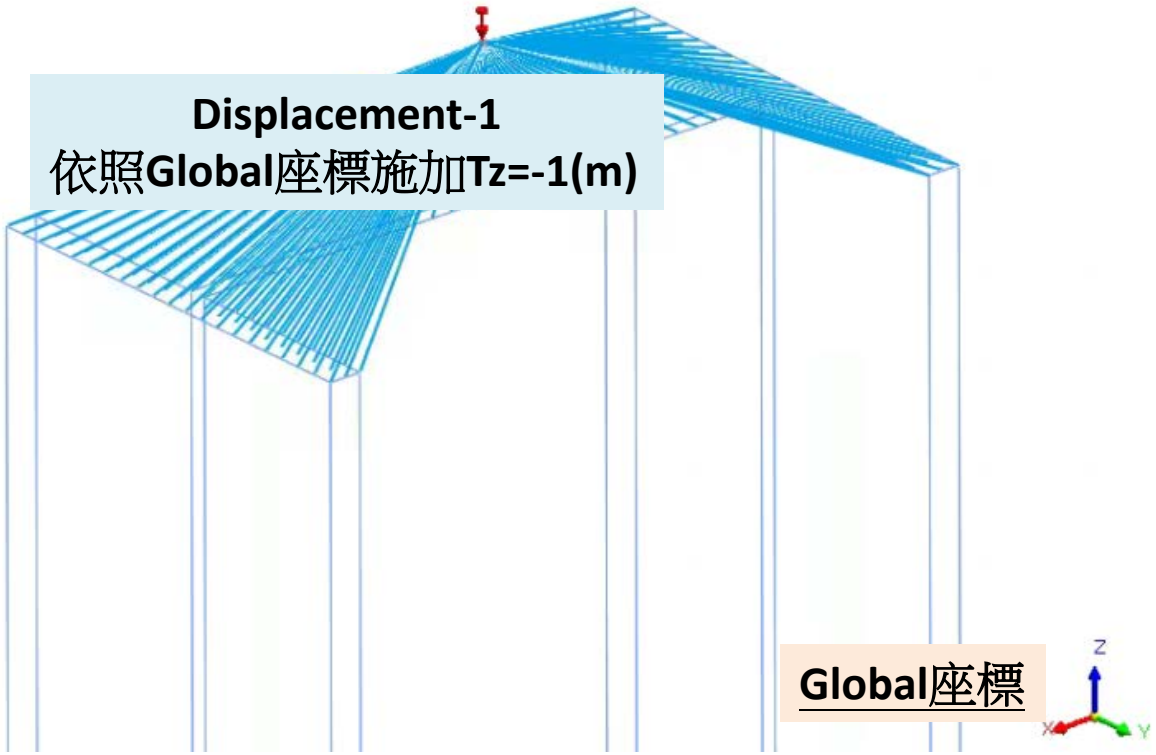




立柱底部面特徵
Tx/Ty/Tz/Rx/Ry/Rz

位移


Force
Press.
Nodal Temperature
Prestress
Moment
Arbitrary Load
Element Temperature
Initial Equilibrium Force
Self Weigh
Disp.
Beam Load
Temperature Gradient
Comb. Set
Static Load

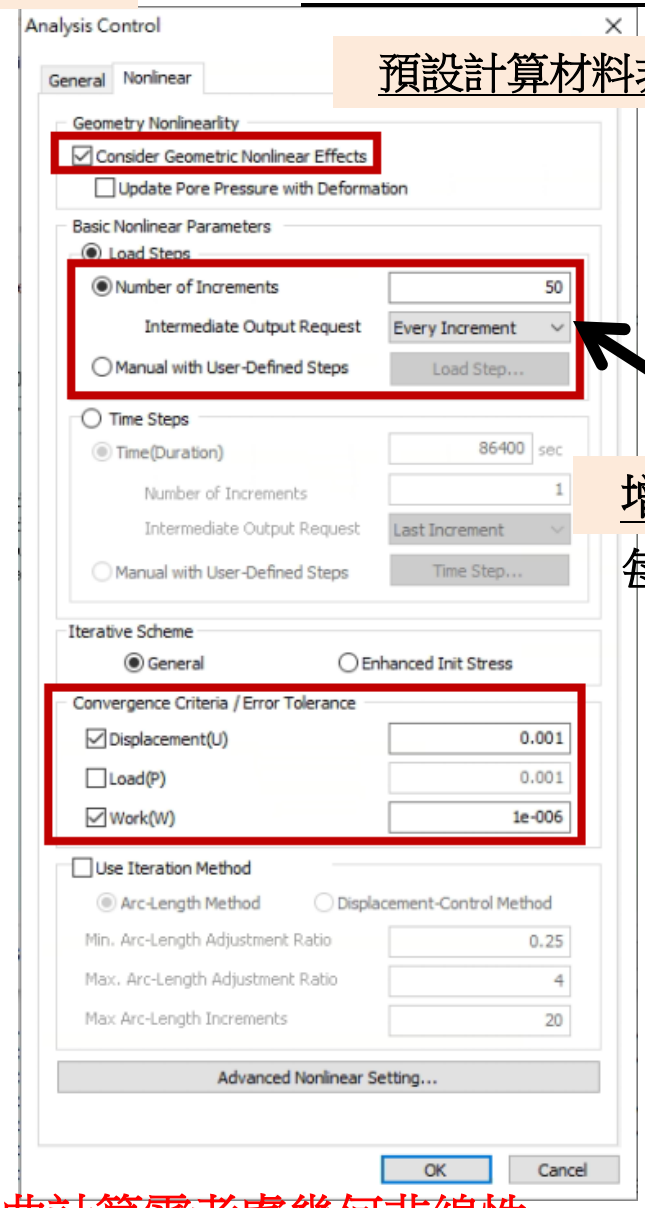

Displacement-1
依照Global座標施加Tz=-1(m)
Global座標
Z
X
Y

非線性分析-1

註:建議分析名稱不要使用空格

非線性分析-2

非線性控制



預設計算材料非線性,勾選才計算幾何&邊界(接觸)非線性

增量數分成50等份/輸出每次增量結果

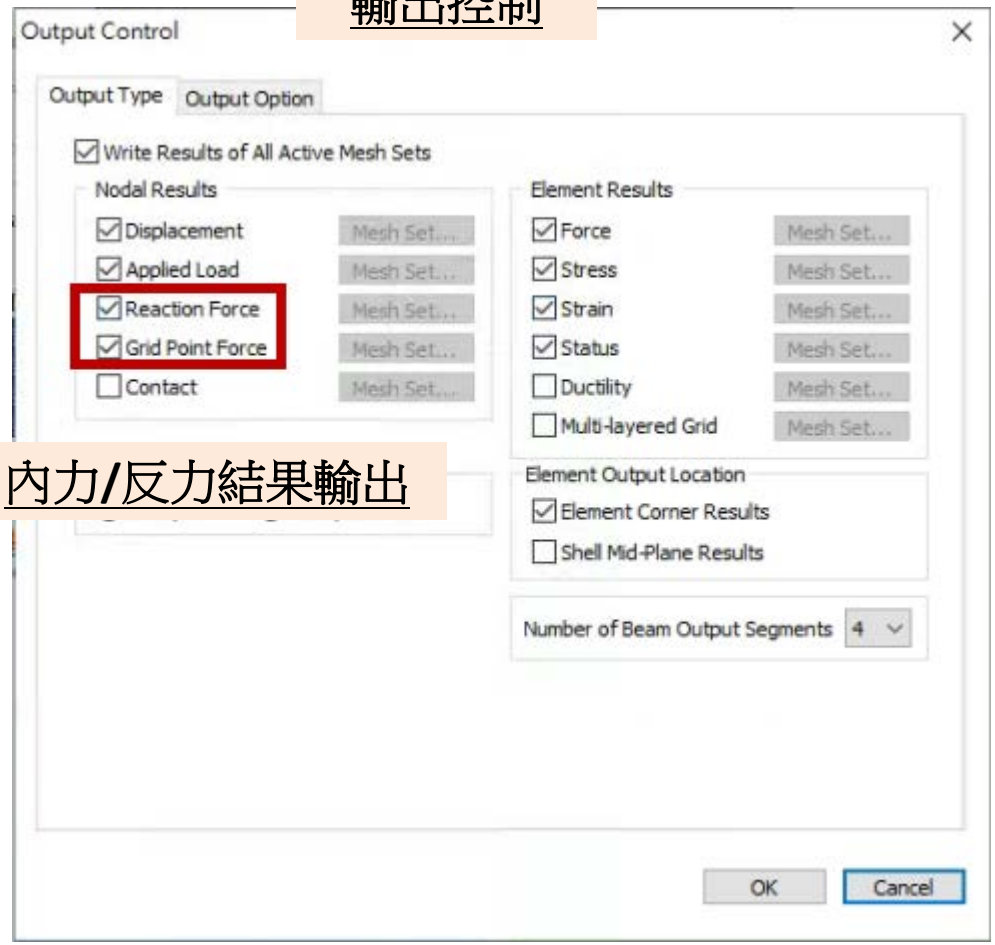
每一增量增加變形量1(m)/50=0.02(m)

收斂判斷採Displacement/Work

註:後挫曲計算需考慮幾何非線性。

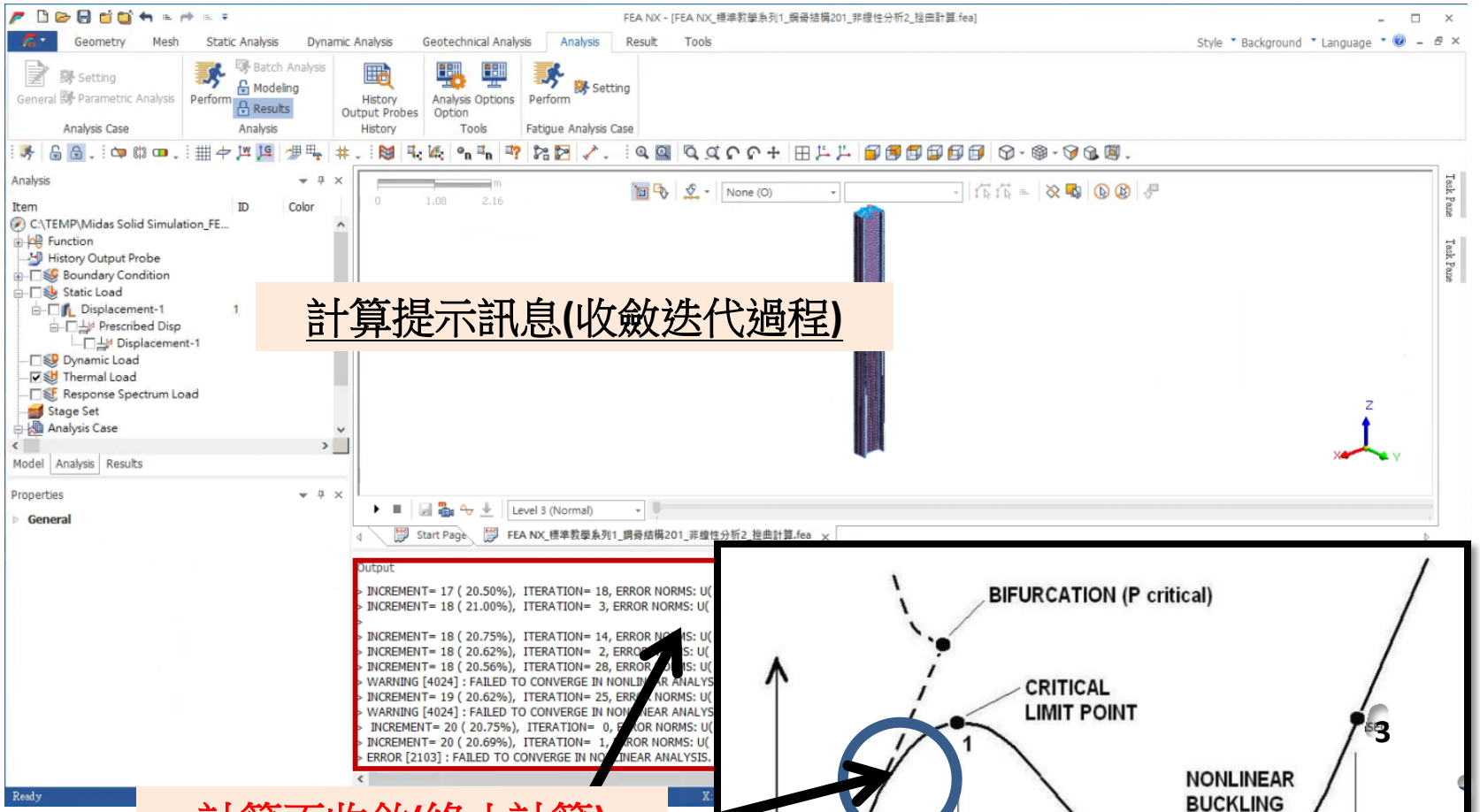
非線性分析-3

輸出控制



內力/反力結果輸出

執行分析



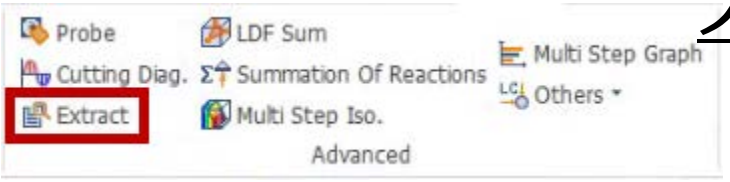
計算提示訊息(收斂迭代過程)

計算不收斂(終止計算)

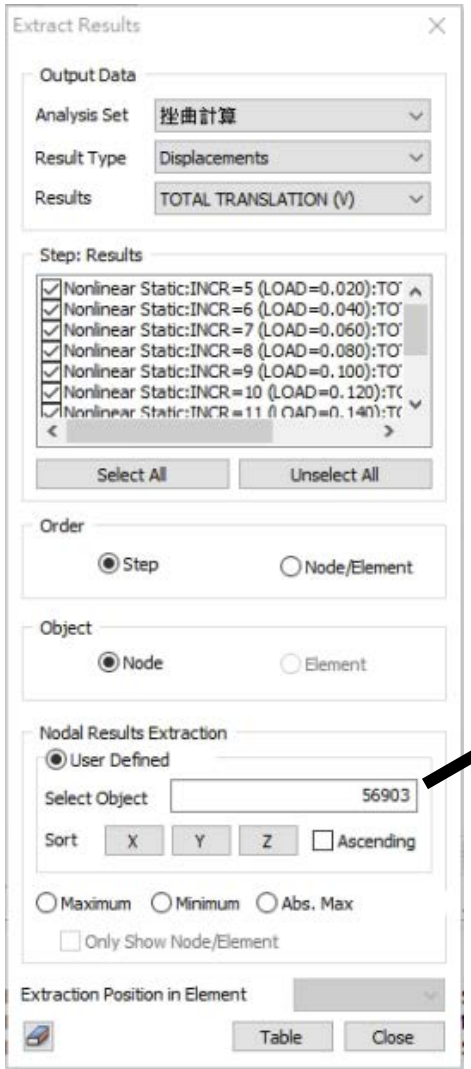
對照挫曲位移-載荷曲線

提取-迭代過程結果

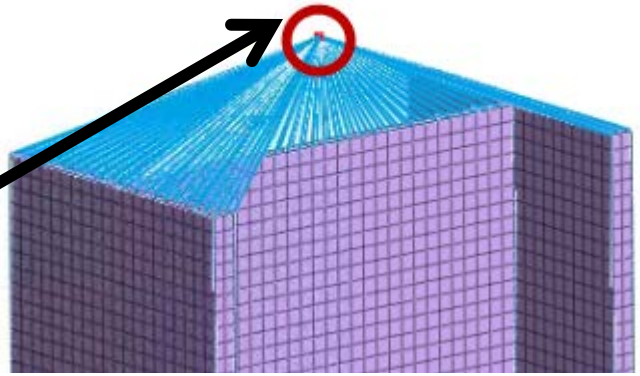
分析結果-1



迭代過程剛性中心點位移結果

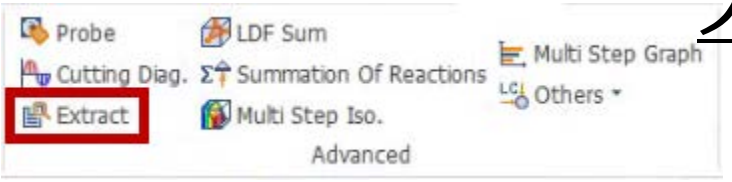


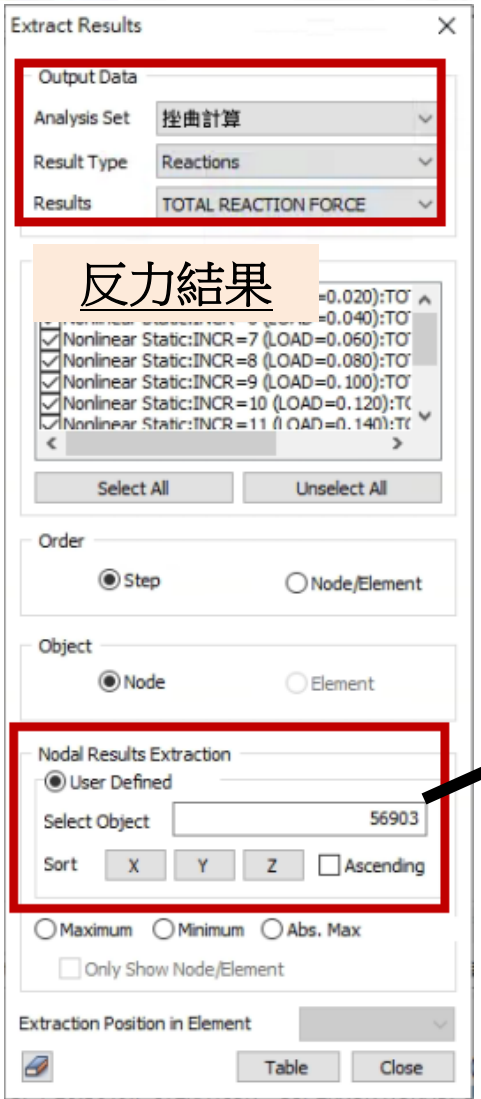
No	Step	Step Value	Node:56903 TOTAL TRANSLATION (V) (m)
1	Nonlinear Static:INCR=5 (LOAD=0.020)	2.000000e-002	2.000000e-002
2	Nonlinear Static:INCR=6 (LOAD=0.040)	4.000000e-002	4.000000e-002
3	Nonlinear Static:INCR=7 (LOAD=0.060)	6.000000e-002	6.000000e-002
4	Nonlinear Static:INCR=8 (LOAD=0.080)	8.000000e-002	8.000000e-002
5	Nonlinear Static:INCR=9 (LOAD=0.100)	1.000000e-001	1.000000e-001
6	Nonlinear Static:INCR=10 (LOAD=0.120)	1.200000e-001	1.200000e-001
7	Nonlinear Static:INCR=11 (LOAD=0.140)	1.400000e-001	1.400000e-001
8	Nonlinear Static:INCR=12 (LOAD=0.160)	1.600000e-001	1.600001e-001
9	Nonlinear Static:INCR=13 (LOAD=0.180)	1.800000e-001	1.800003e-001
10	Nonlinear Static:INCR=14 (LOAD=0.200)	2.000000e-001	2.000009e-001



提取-迭代過程結果

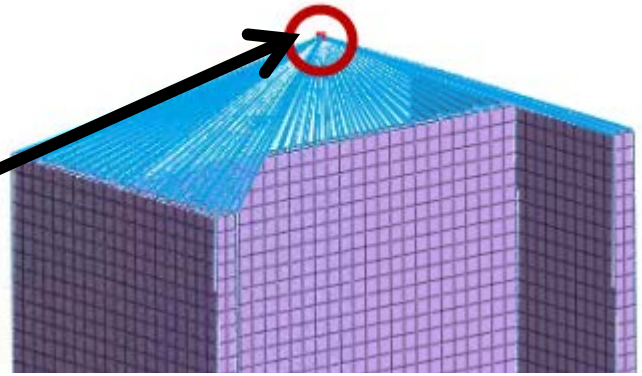
分析結果-2



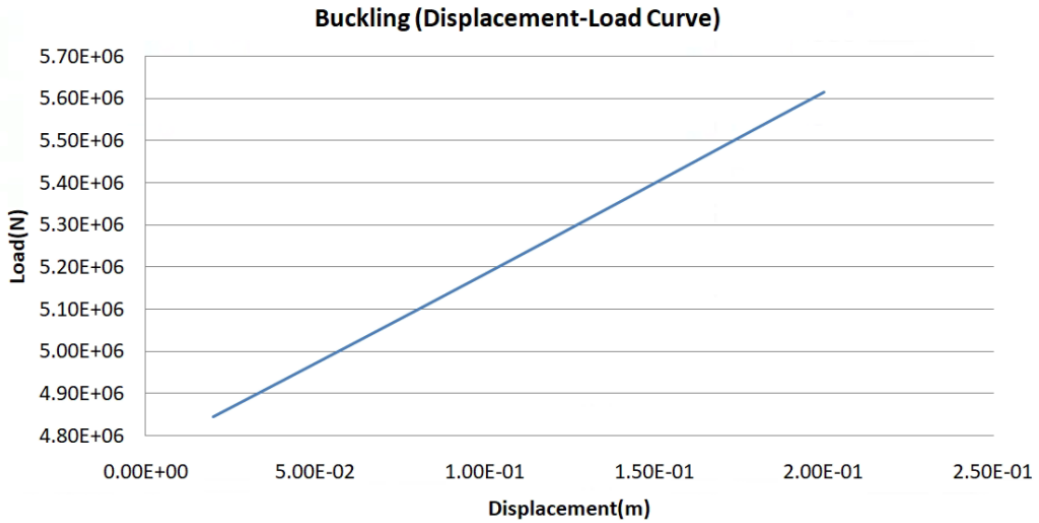


迭代過程剛性中心點反力結果

No	Step	Step Value	Node:56903 TOTAL REACTION FORCE (N)
1	Nonlinear Static:INCR=5 (LOAD=0.020)	2.000000e-002	4.844010e+006
2	Nonlinear Static:INCR=6 (LOAD=0.040)	4.000000e-002	4.928154e+006
3	Nonlinear Static:INCR=7 (LOAD=0.060)	6.000000e-002	5.012475e+006
4	Nonlinear Static:INCR=8 (LOAD=0.080)	8.000000e-002	5.097251e+006
5	Nonlinear Static:INCR=9 (LOAD=0.100)	1.000000e-001	5.182576e+006
6	Nonlinear Static:INCR=10 (LOAD=0.120)	1.200000e-001	5.268476e+006
7	Nonlinear Static:INCR=11 (LOAD=0.140)	1.400000e-001	5.354899e+006
8	Nonlinear Static:INCR=12 (LOAD=0.160)	1.600000e-001	5.441698e+006
9	Nonlinear Static:INCR=13 (LOAD=0.180)	1.800000e-001	5.528546e+006
10	Nonlinear Static:INCR=14 (LOAD=0.200)	2.000000e-001	5.614708e+006



分析結果-3



No	Step	Step Value	Node:56903 TOTAL TRANSLATION (V) (m)
1	Nonlinear Static:INCR=5 (LOAD=0.020)	2.000000e-002	2.000000e-002
2	Nonlinear Static:INCR=6 (LOAD=0.040)	4.000000e-002	4.000000e-002
3	Nonlinear Static:INCR=7 (LOAD=0.060)	6.000000e-002	6.000000e-002
4	Nonlinear Static:INCR=8 (LOAD=0.080)	8.000000e-002	8.000000e-002
5	Nonlinear Static:INCR=9 (LOAD=0.100)	1.000000e-001	1.000000e-001
6	Nonlinear Static:INCR=10 (LOAD=0.120)	1.200000e-001	01
7	Nonlinear Static:INCR=11 (LOAD=0.140)	1.400000e-001	01
8	Nonlinear Static:INCR=12 (LOAD=0.160)	1.600000e-001	01
9	Nonlinear Static:INCR=13 (LOAD=0.180)	1.800000e-001	1.800003e-001
10	Nonlinear Static:INCR=14 (LOAD=0.200)	2.000000e-001	2.000009e-001

X軸

No	Step	Step Value	Node:56903 TOTAL REACTION FORCE (N)
1	Nonlinear Static:INCR=5 (LOAD=0.020)	2.000000e-002	4.844010e+006
2	Nonlinear Static:INCR=6 (LOAD=0.040)	4.000000e-002	4.928154e+006
3	Nonlinear Static:INCR=7 (LOAD=0.060)	6.000000e-002	5.012475e+006
4	Nonlinear Static:INCR=8 (LOAD=0.080)	8.000000e-002	5.097251e+006
5	Nonlinear Static:INCR=9 (LOAD=0.100)	1.000000e-001	06
6	Nonlinear Static:INCR=10 (LOAD=0.120)	1.200000e-001	06
7	Nonlinear Static:INCR=11 (LOAD=0.140)	1.400000e-001	5.354699e+006
8	Nonlinear Static:INCR=12 (LOAD=0.160)	1.600000e-001	5.441698e+006
9	Nonlinear Static:INCR=13 (LOAD=0.180)	1.800000e-001	5.528546e+006
10	Nonlinear Static:INCR=14 (LOAD=0.200)	2.000000e-001	5.614708e+006

Y軸

midas FEA NX

FEA NX_標準教學系列

鋼骨結構-非線性分析
後挫曲分析

台灣邁達斯

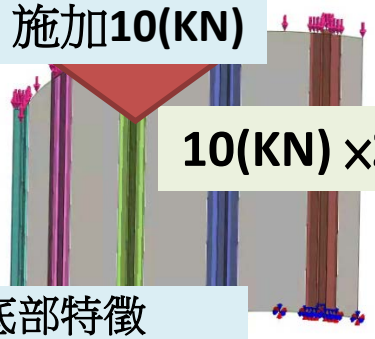
註:範例相關參數使用假設條件。

線性挫曲&非線性挫曲

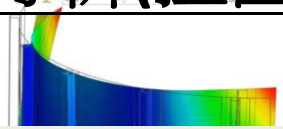
(Linear & Non-Linear Buckling)

FEA NX-線性挫曲分析(挫曲最大臨界力)

施加10(KN)



底部特徵
Tx/Ty/Tz/Rx/Ry/Rz

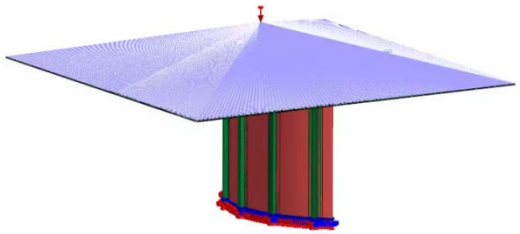


10(KN) ×2902.6(mode 1 (Hz))=29026(KN)-挫曲最大臨界力

Mode 1-變形

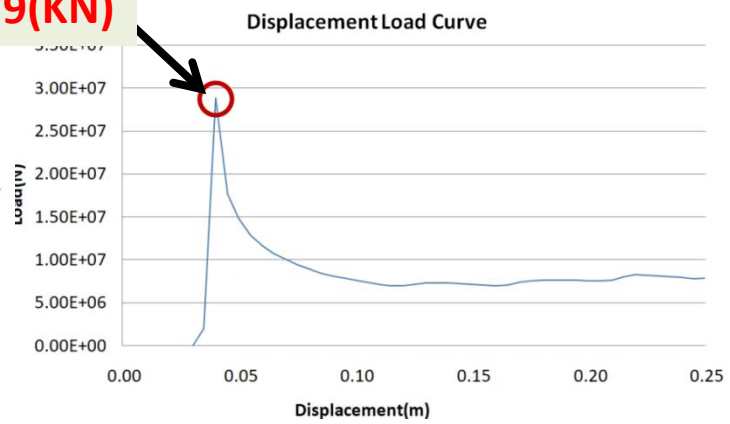
FEA NX-非線性挫曲分析(挫曲過程載荷-位移曲線)

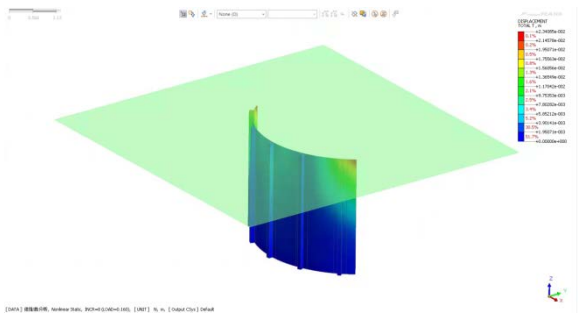
下壓0.25(m)



底部特徵
Tx/Ty/Tz/Rx/Ry/Rz

28832.9(KN)





註:範例相關參數使用假設條件。

後挫曲

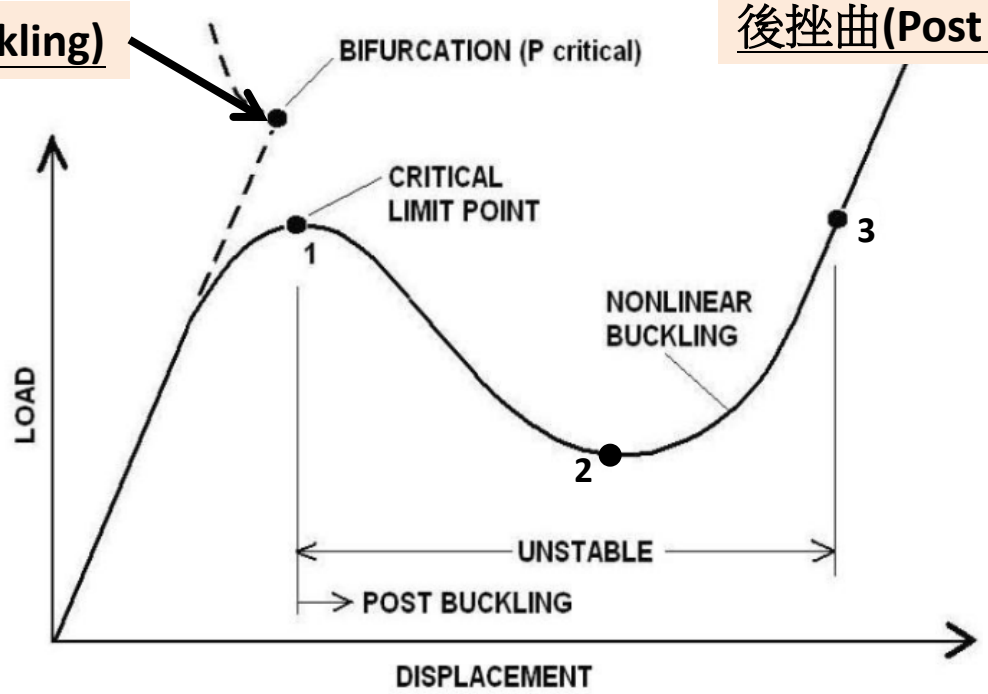
後挫曲(非線性挫曲)分析

載荷較小時分析結果與線性結果一致。當載荷逐步增大，變形逐步增加，結構響應呈現出非線性，力位移曲線開始偏離線性結果，在Point 1點承受外部載荷達到最大。

之後變形繼續變大但是結構能承受的外部載荷變小，結構發生挫曲，變形繼續變大，但是結構承受的載荷繼續變小。達到Point 2位移增加，結構承受的載荷開始增加，Point 3達到之前載荷的極限點。從Point 1到Point 3的過程稱為疾速跳過(snap through)。

線性挫曲(Linear Buckling)

後挫曲(Post Buckling)



Reference

https://www.linkedin.com/pulse/buckling-post-buckling-abraham-imam-muttaqin

應變硬化指數
(Strain Hardening Exponent)

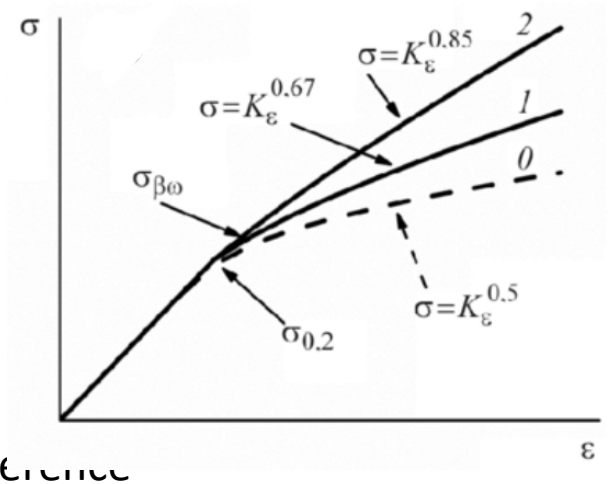
應變硬化指數(Strain Hardening Exponent)

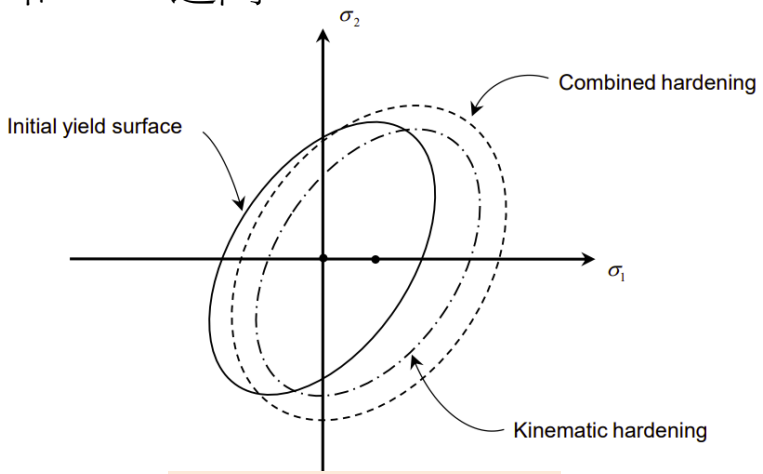
通常表示為 n，常用於與加工硬化中的應力-應變行為相關的計算中的常量。

$$\sigma = K\epsilon^n$$

σ 真實應力
ε 真實應變
K 強度係數
n 應變硬化指數

應變硬化指數(n),值介於 0 和 1 之間，0 表示完全塑性， 1 表示完全彈性，大多數金屬的 n 值介於 0.10 和 0.50 之間。





硬化模型-屈服面

Reference

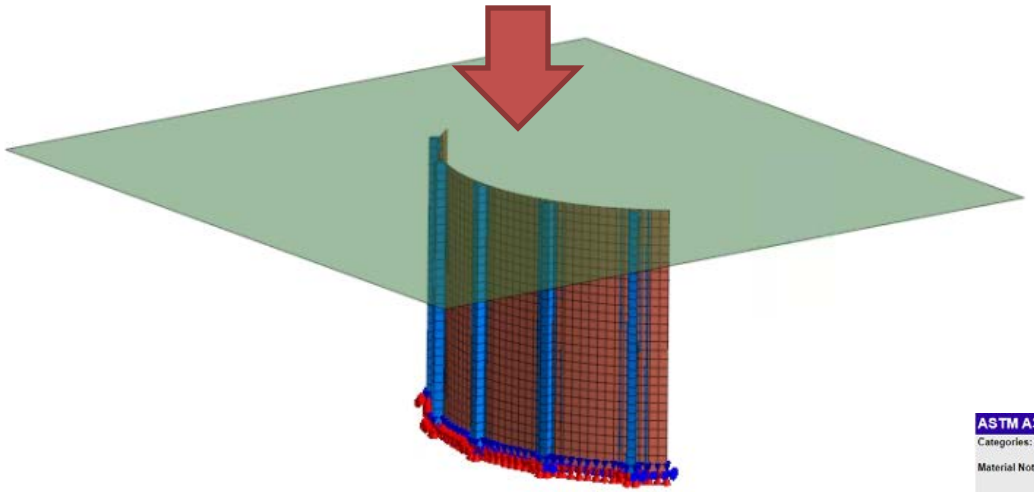
GTS NX AND FEA NX Manual
https://en.wikipedia.org/wiki/Strain_hardening_exponent

分析說明

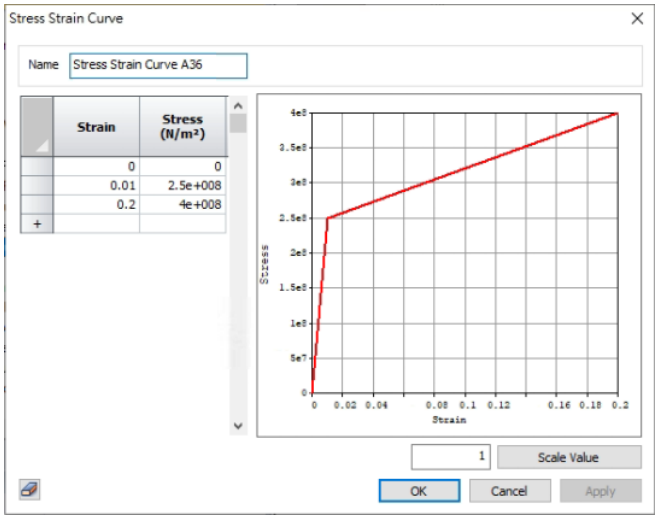
計算下壓過程位移過程所需載荷!!

材料Steel/ASTM A36

鋼板下壓0.2(m)



底部節點
Tx/Ty/Tz/Rx/Ry/Rz



ASTM A36 Steel, plate

Categories: Metal; Ferrous Metal; ASTM Steel; Carbon Steel; Low Carbon Steel

Material Notes: Steel for general structural purposes including bridges and buildings.
Minimum Cu content when copper steel is specified.
Tests performed in transverse direction for plates wider than 590 mm.

Key Words: UNS K02600

Vendors: No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this material.

Printer friendly version | Download as PDF | Download to Excel (requires Excel and Windows)
Export data to your CAD/FEA program

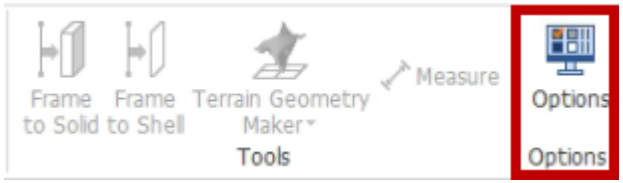
Physical Properties	Metric	English
Density	7.80 g/cc	0.282 lb/in³

Mechanical Properties	Metric	English
Tensile Strength, Ultimate	400 - 550 MPa	58000 - 79800 psi
Tensile Strength, Yield	250 MPa	36300 psi
Elongation at Break	20 %	20 %
	23 %	23 %
Modulus of Elasticity	200 GPa	29000 ksi
Bulk Modulus	160 GPa	23200 ksi
Poissons Ratio	0.26	0.26
Shear Modulus	79.3 GPa	11500 ksi

Component Elements Properties	Metric	English
Carbon, C	0.25 - 0.29 %	0.25 - 0.29 %
Copper, Cu	0.20 %	0.20 %
Iron, Fe	98 %	98 %
Manganese, Mn	1.03 %	1.03 %
Phosphorus, P	<= 0.040 %	<= 0.040 %
Silicon, Si	0.28 %	0.28 %
Sulfur, S	<= 0.050 %	<= 0.050 %

註:材料數據參考 www.matweb.com

環境



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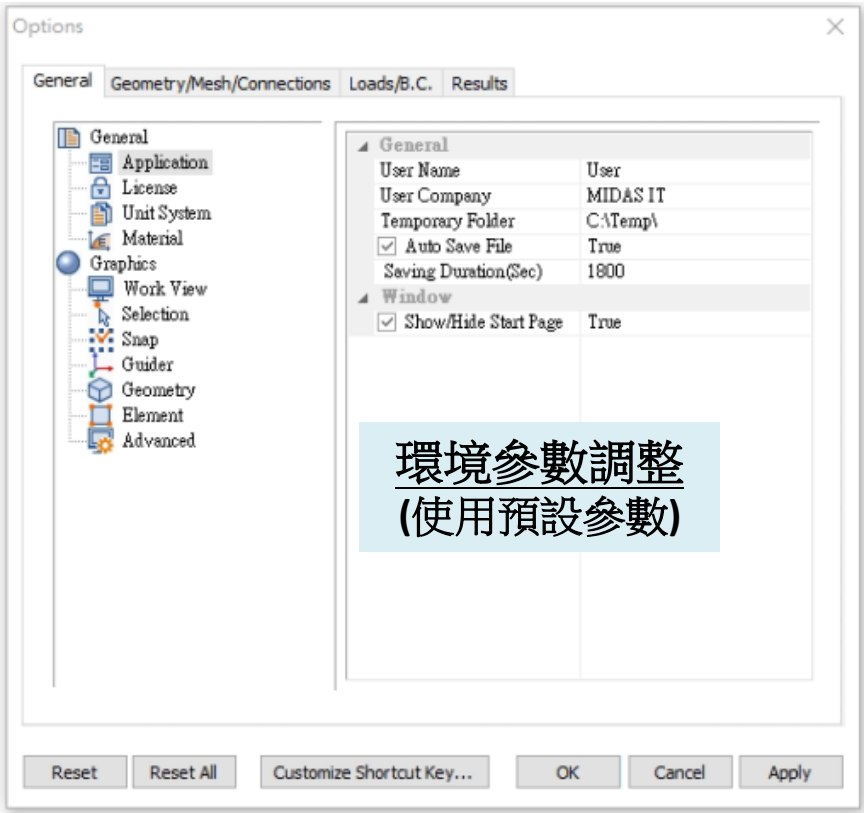
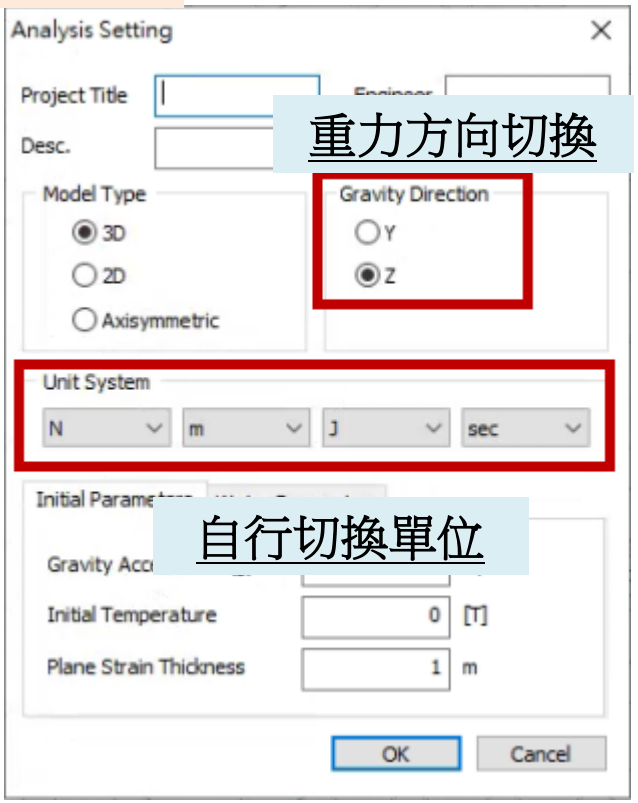


環境參數調整
(使用預設參數)

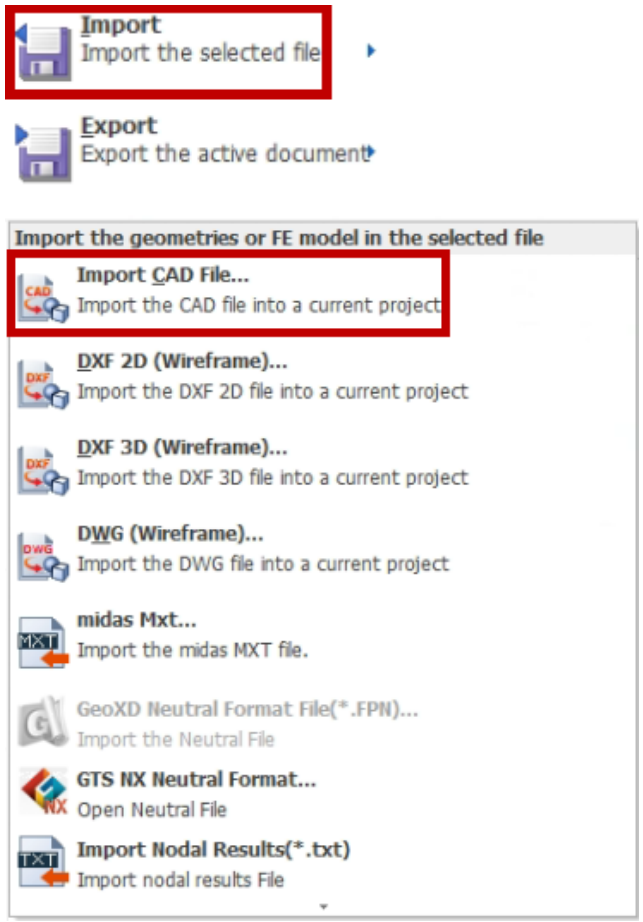


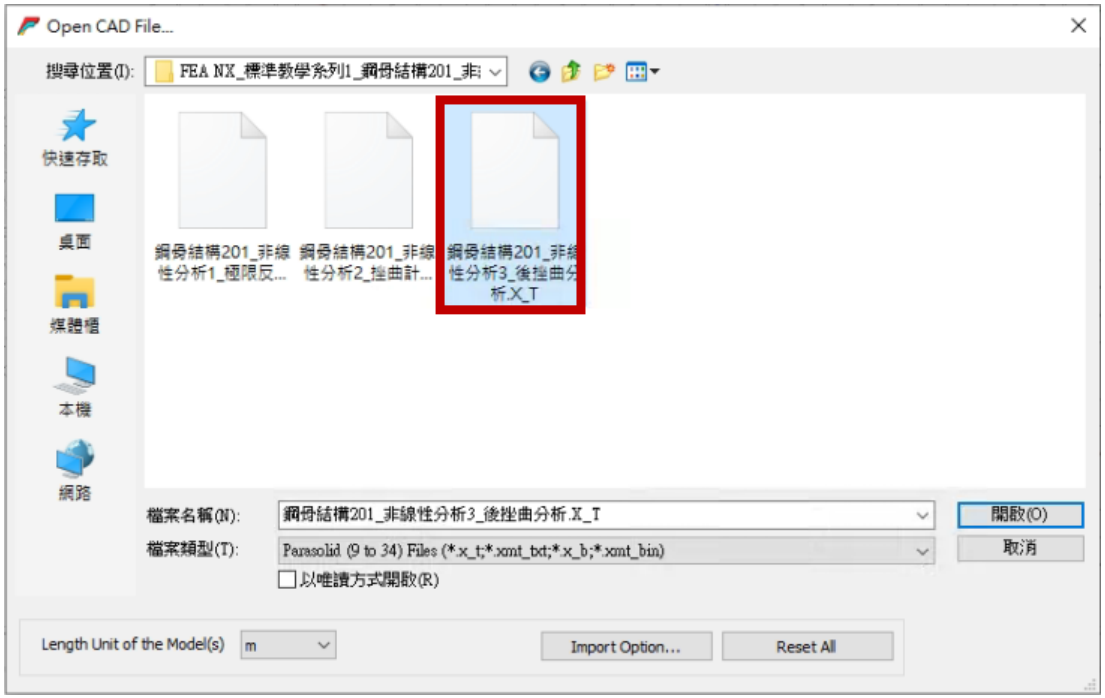
重力方向切換

自行切換單位

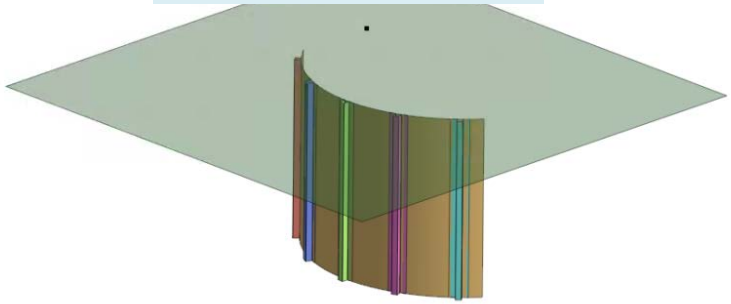
單位使用N/m/J/sec

匯入模型

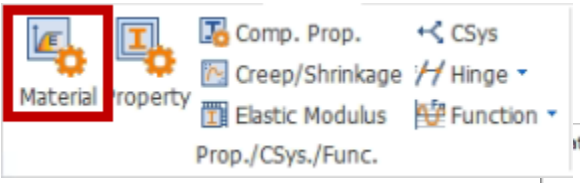




鋼結構3D模型



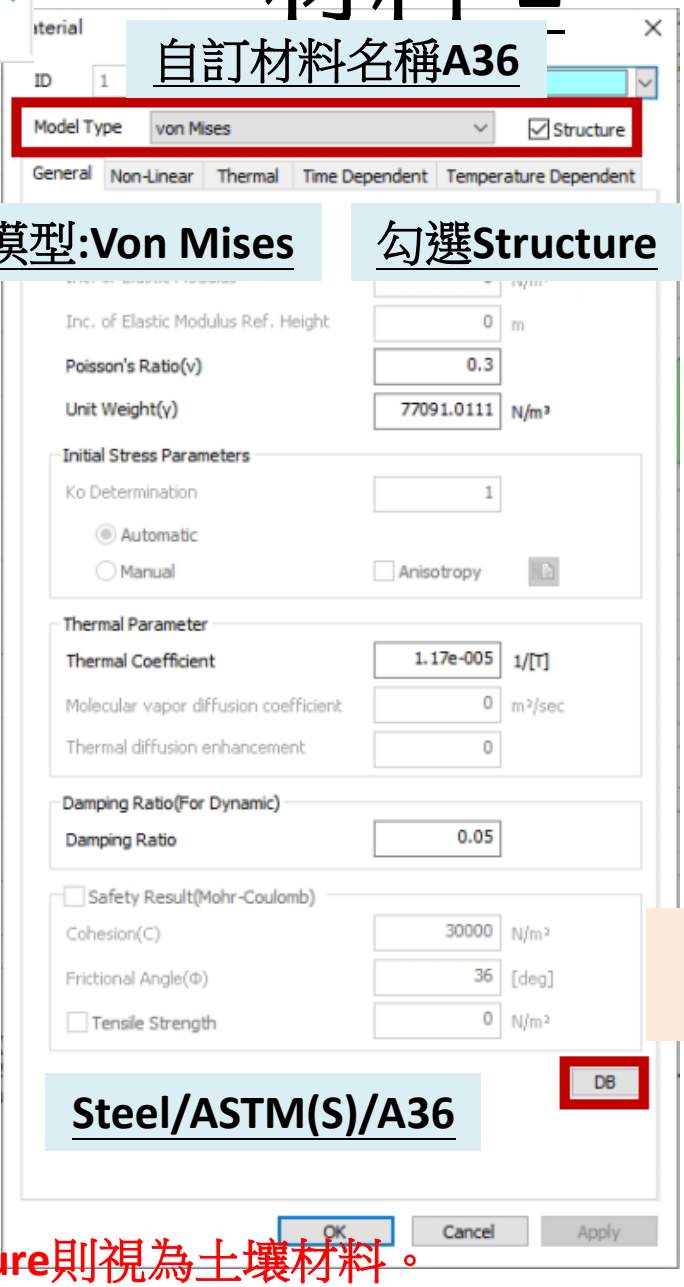
材料-1



自訂材料名稱A36

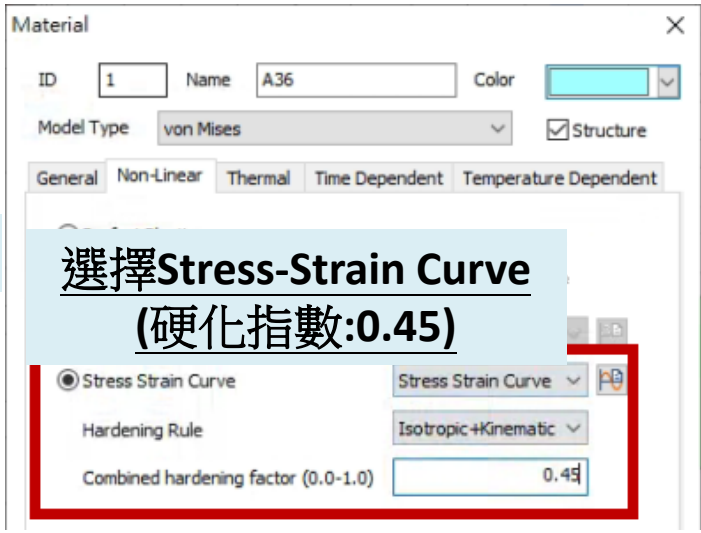
材料模型:Von Mises

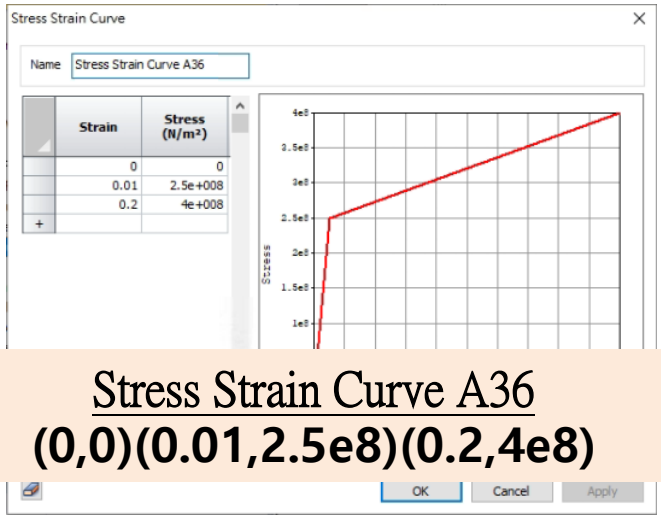
勾選Structure



Steel/ASTM(S)/A36

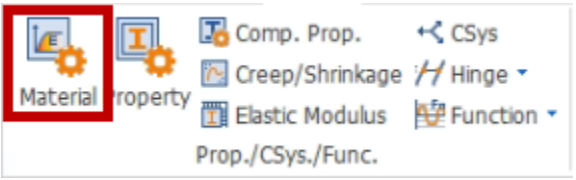
選擇Stress-Strain Curve
(硬化指數:0.45)





Stress Strain Curve A36
(0,0)(0.01,2.5e8)(0.2,4e8)

註:未勾選Structure則視為土壤材料。

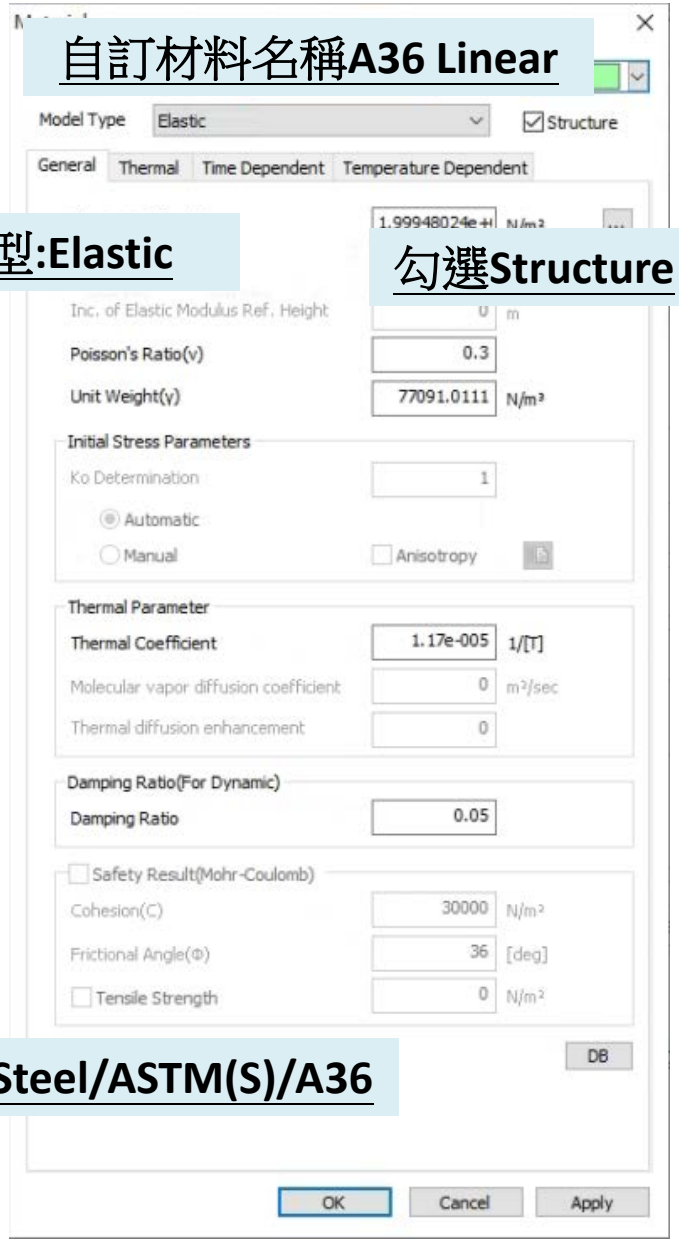


材料-2

自訂材料名稱A36 Linear

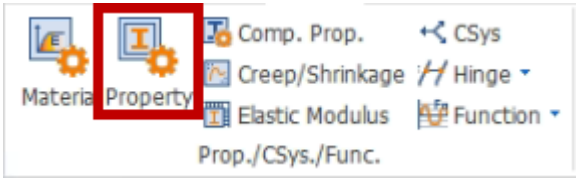
材料模型:Elastic

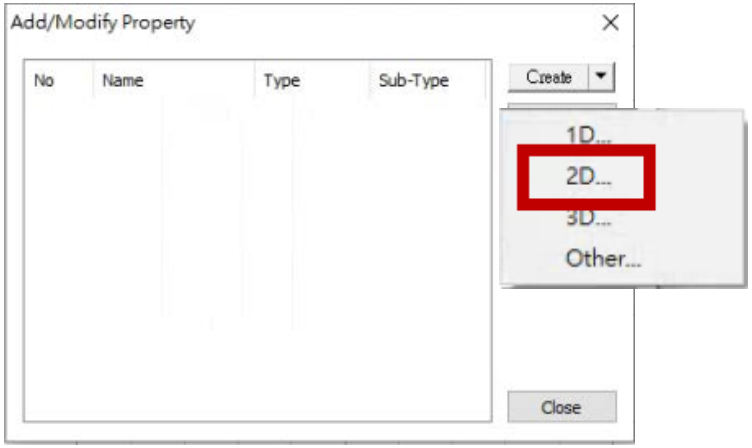
勾選Structure



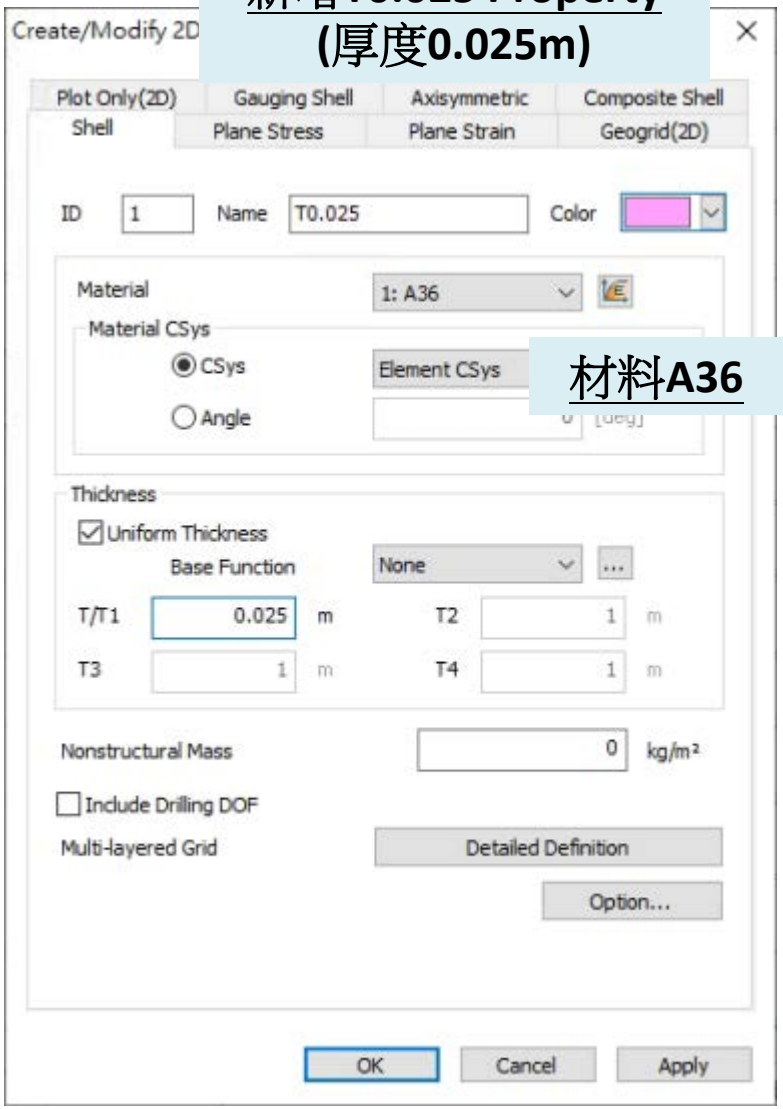
Steel/ASTM(S)/A36

屬性-2D-T0.025



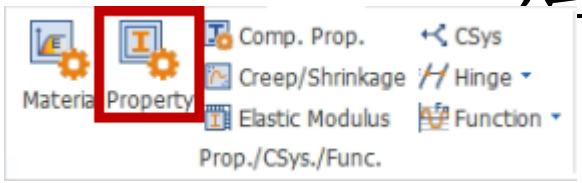


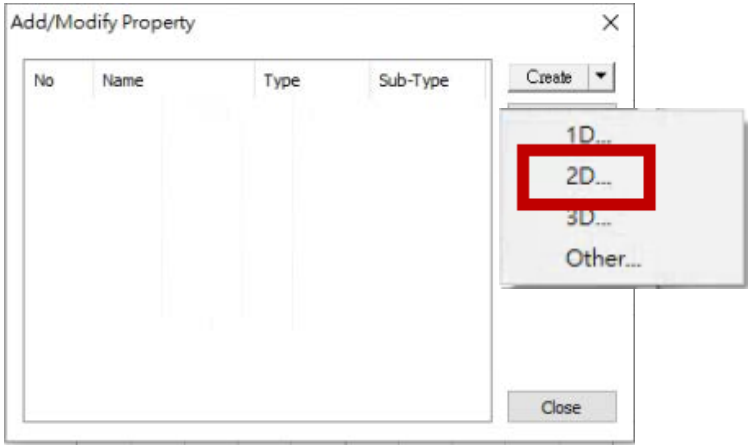
新增T0.025 Property
(厚度0.025m)



材料A36

屬性-2D-T0.012





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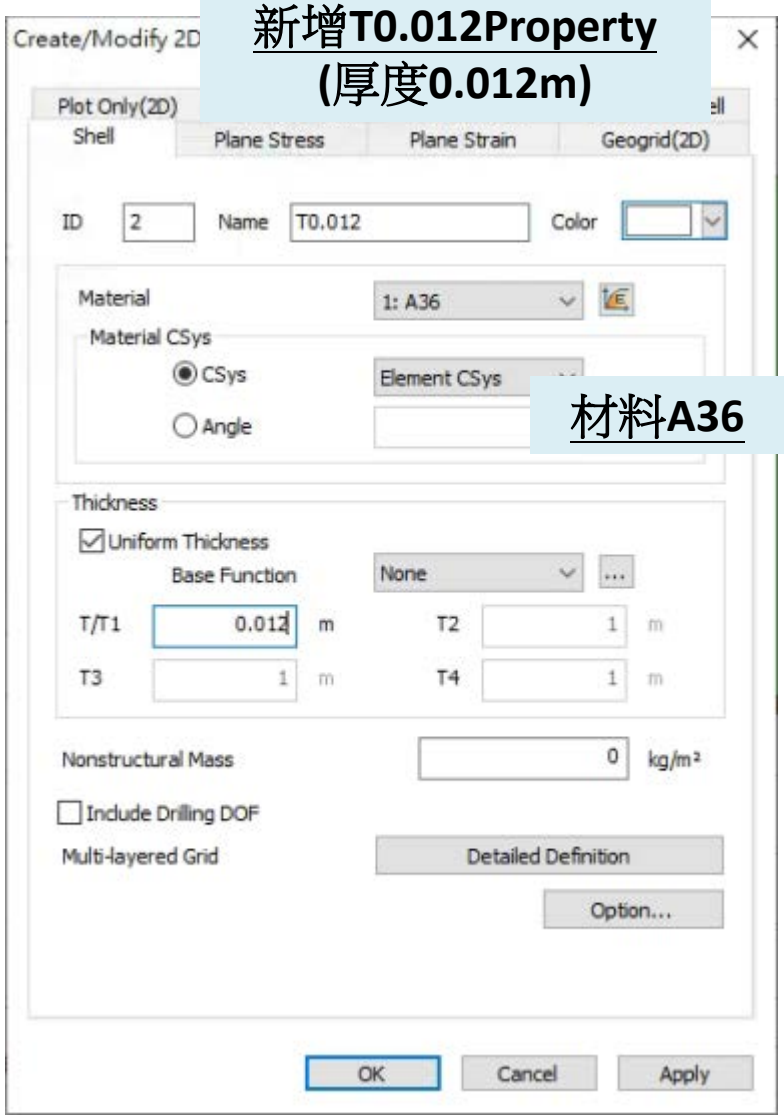
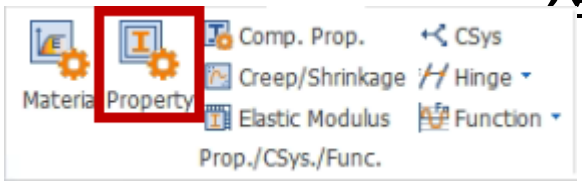
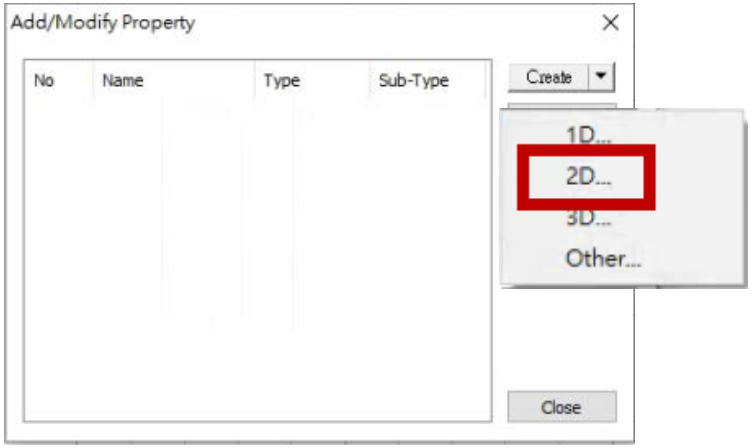


材料A36

屬性-2D-T0.01





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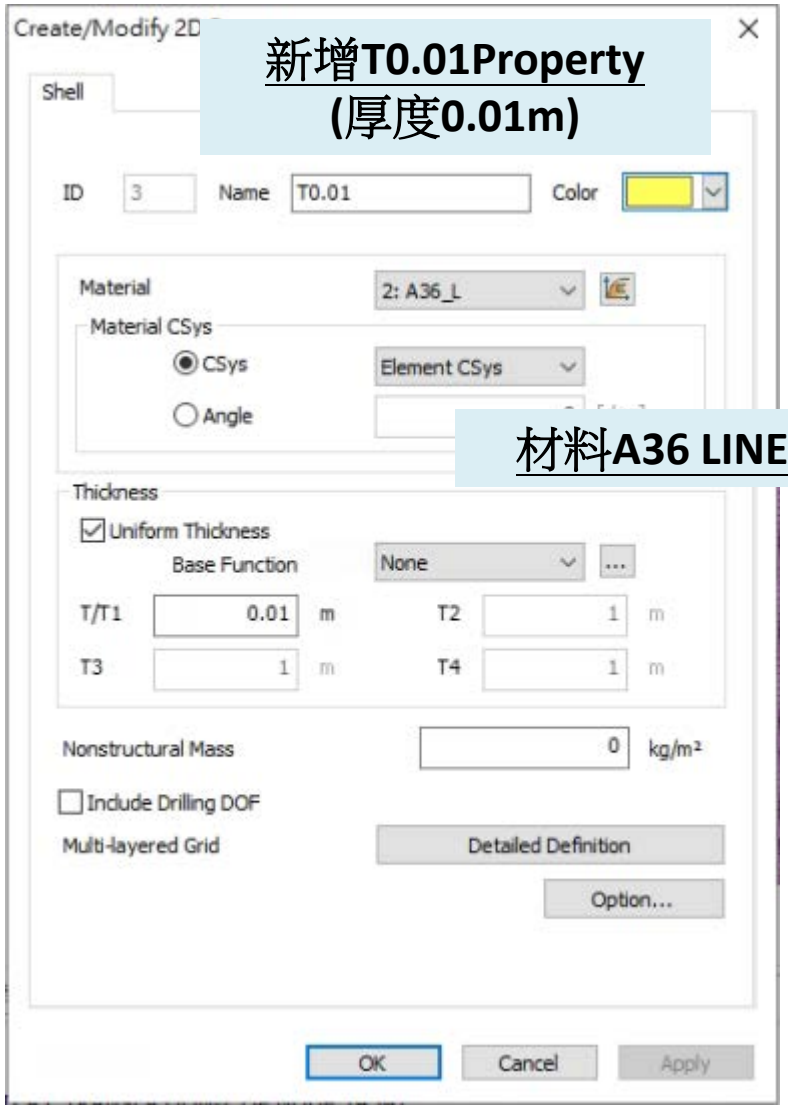
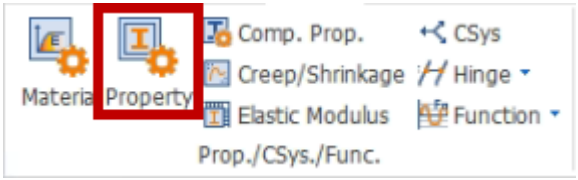
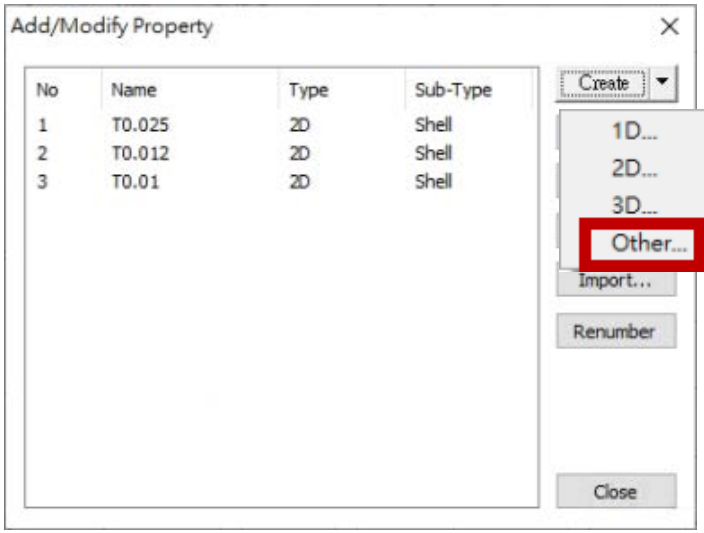
(厚度0.01m)



材料A36 LINEAR

屬性-Rigid Link





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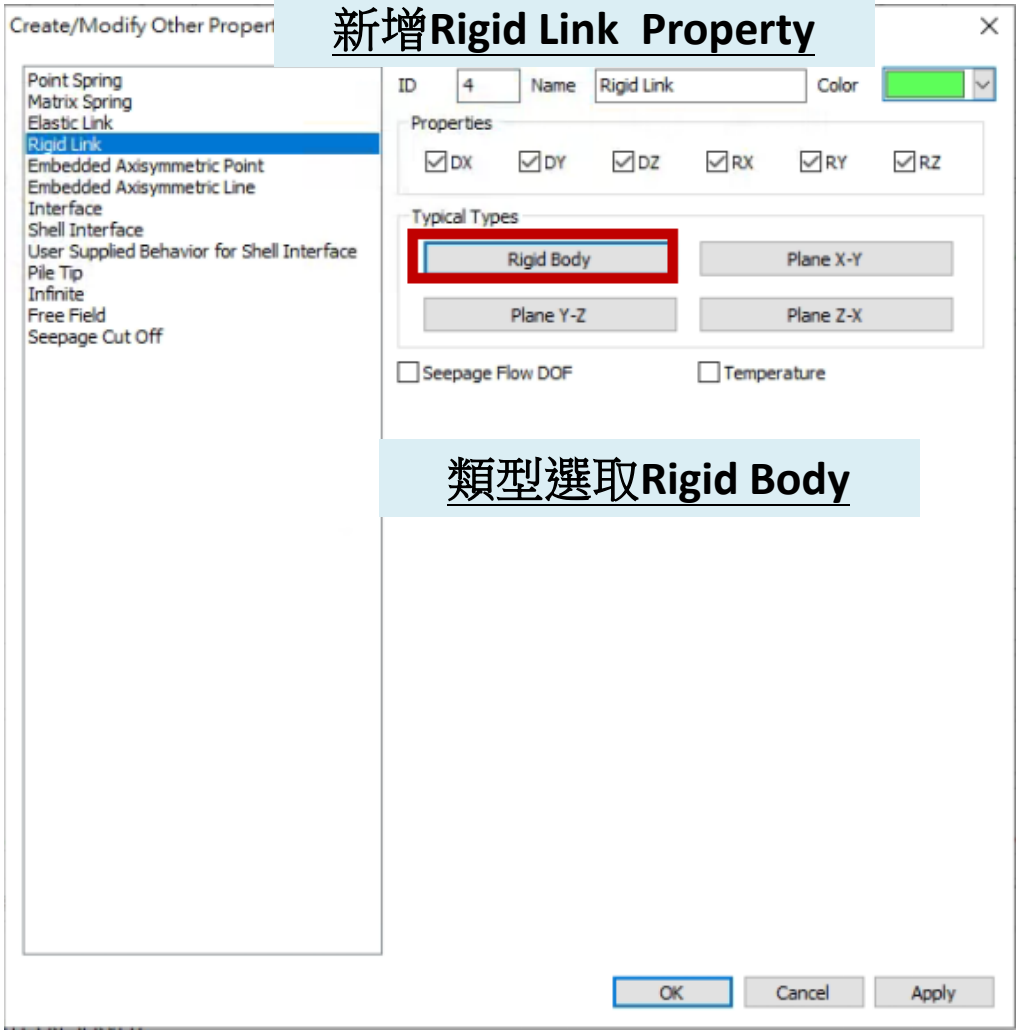
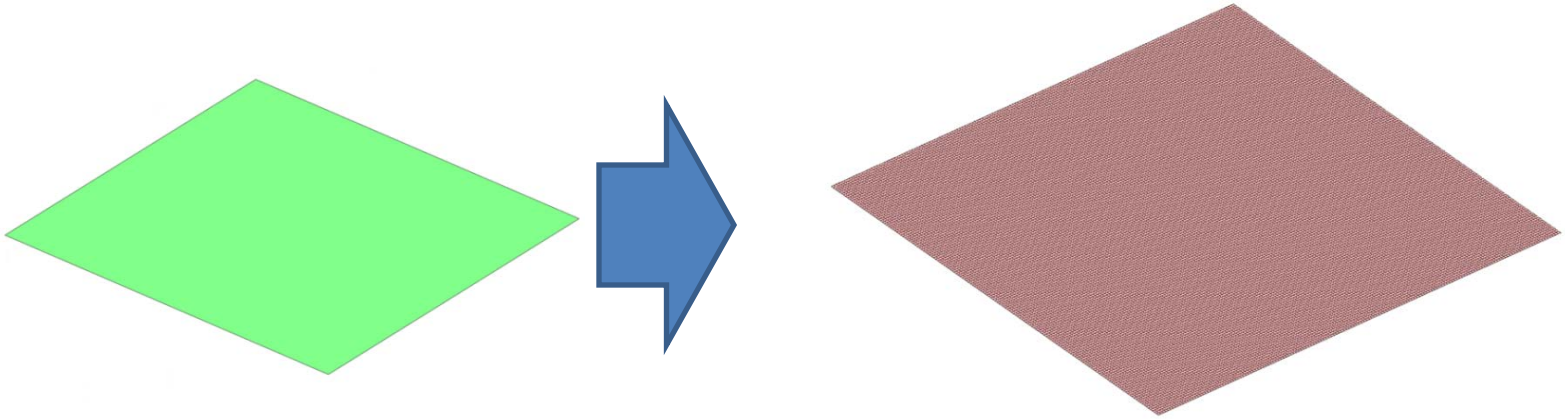


類型選取Rigid Body

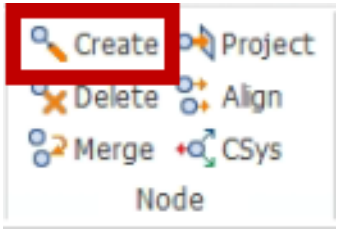
2D網格-下壓板

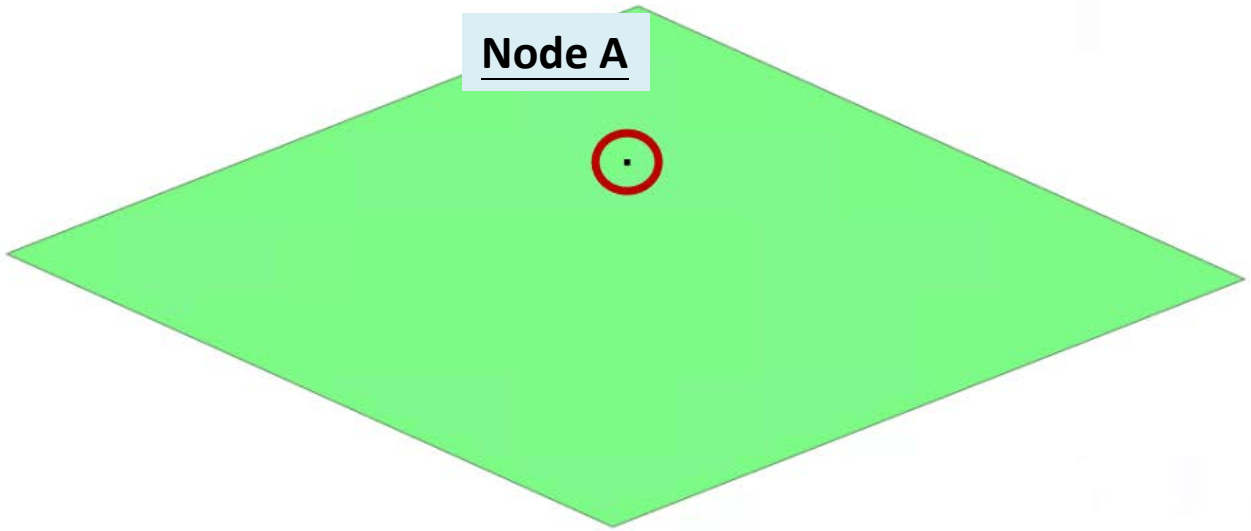
網格尺寸0.1 (m)/屬性T0.01/自訂網格集名稱(下壓板)



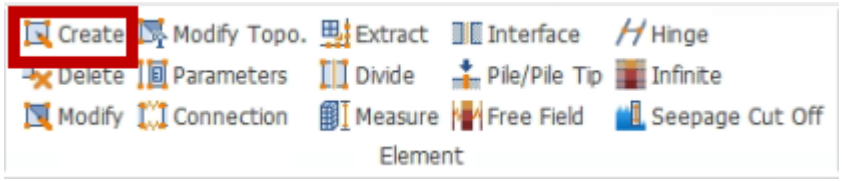
主控節點建立

(剛性連接主控點)

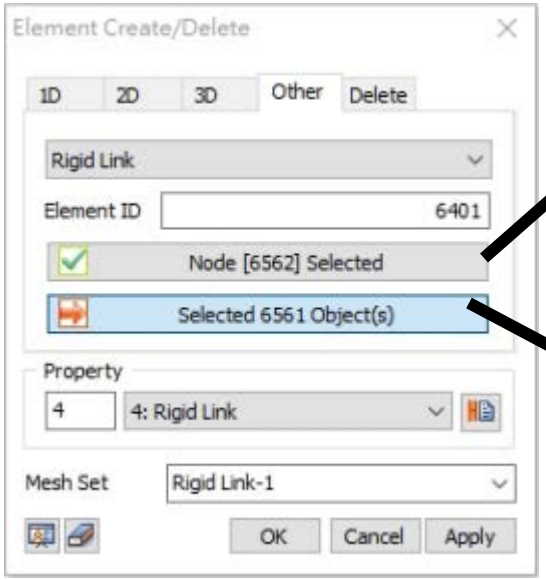




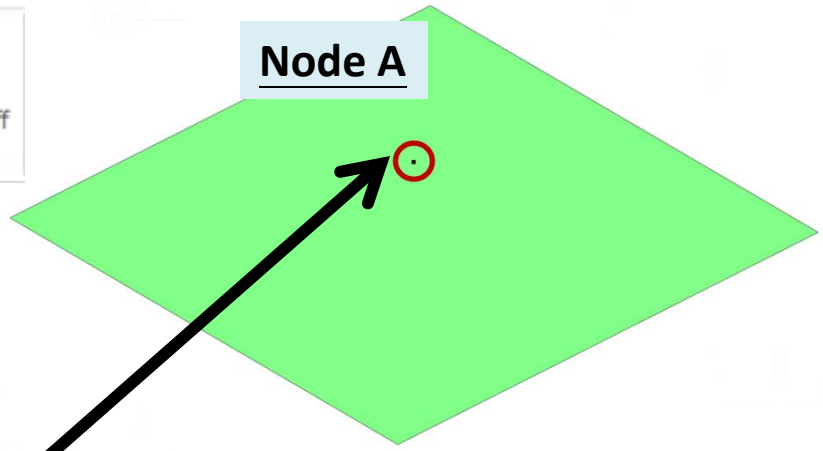
剛性連接



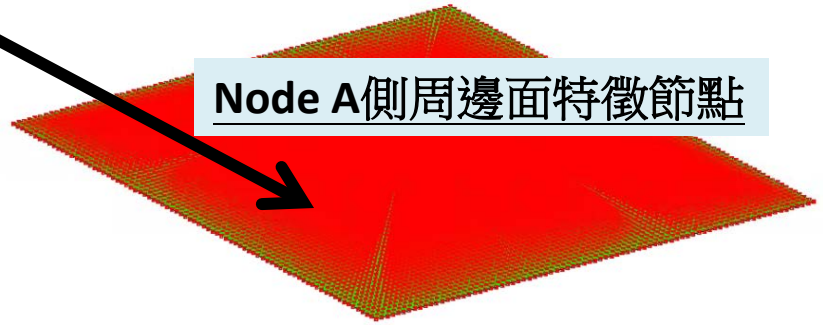
元素類型選取Rigid Link



自訂網格集Rigid Link1

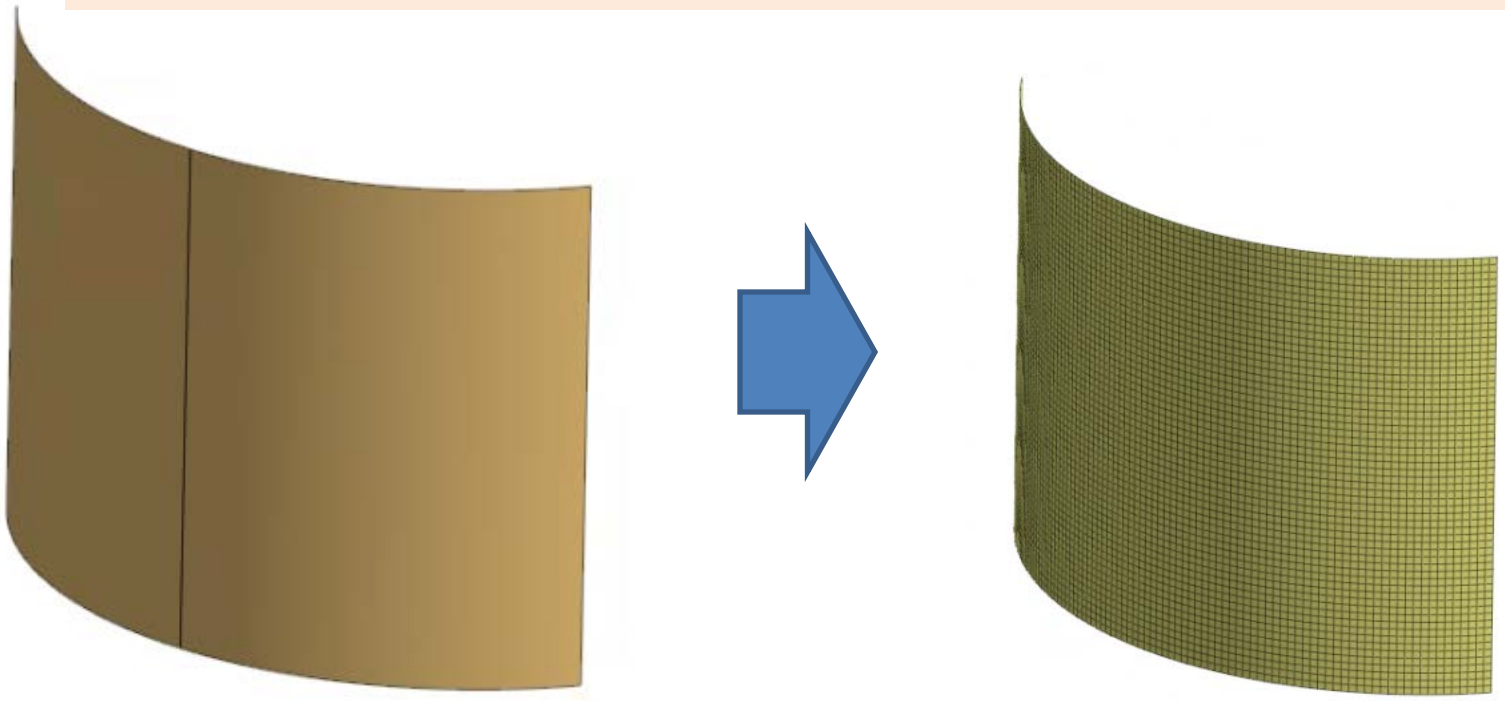


切換使用面特徵選取節點



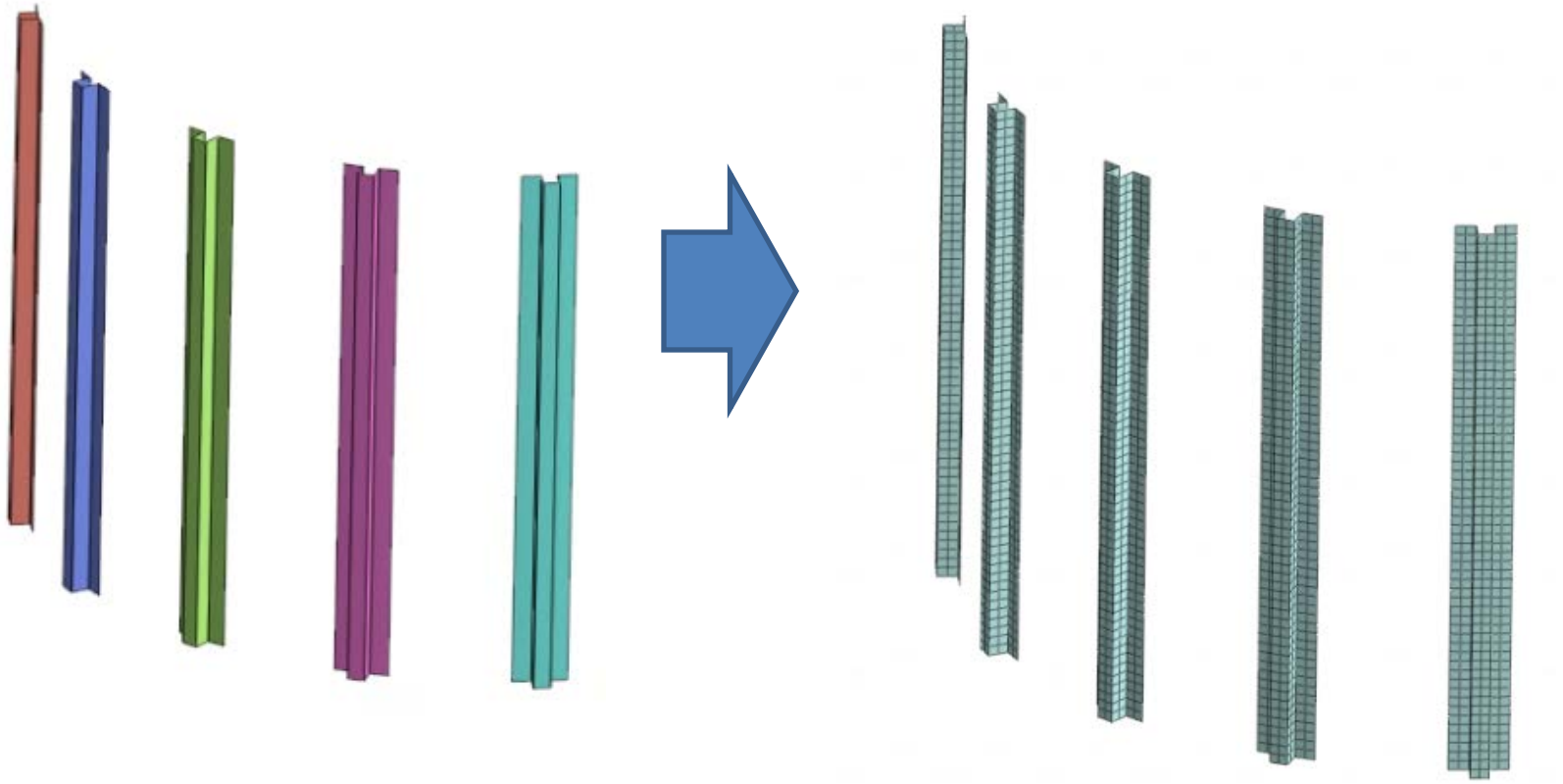
2D網格-鋼板

網格尺寸0.05(m)/屬性T0.025/自訂網格集名稱(鋼板)/合併節點/同一網格集

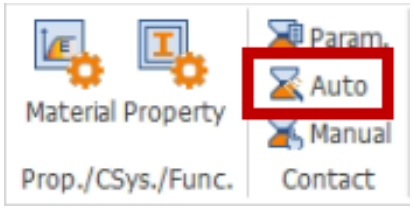


2D網格-立柱

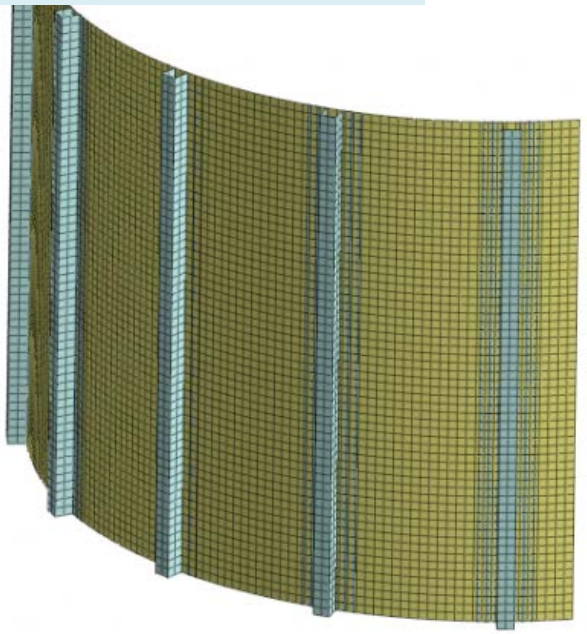
網格尺寸0.05 (m)/屬性T0.012/自訂網格集名稱(立柱)/合併節點/同一網格集



自動焊接接觸

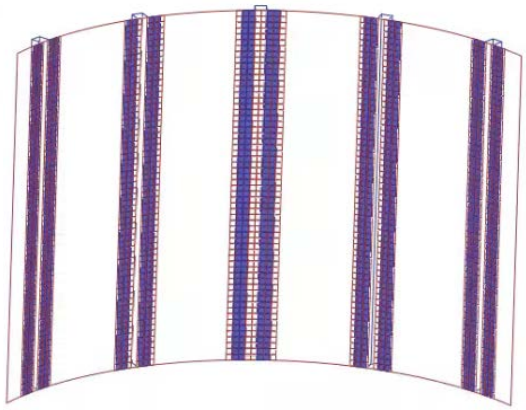


選取鋼板&立柱網格集

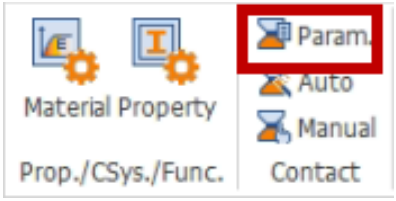


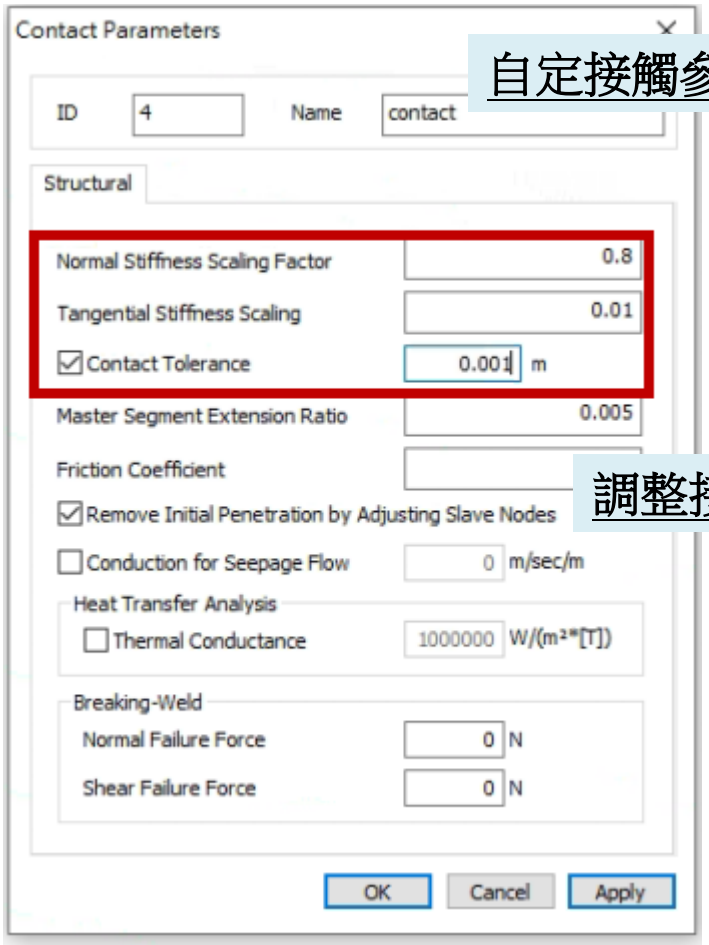
輸入判斷接觸間距0.01(m)

接觸檢視



接觸參數

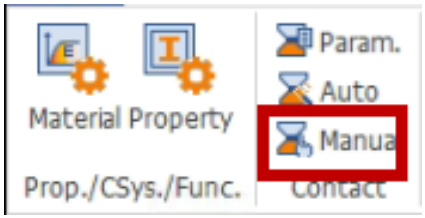




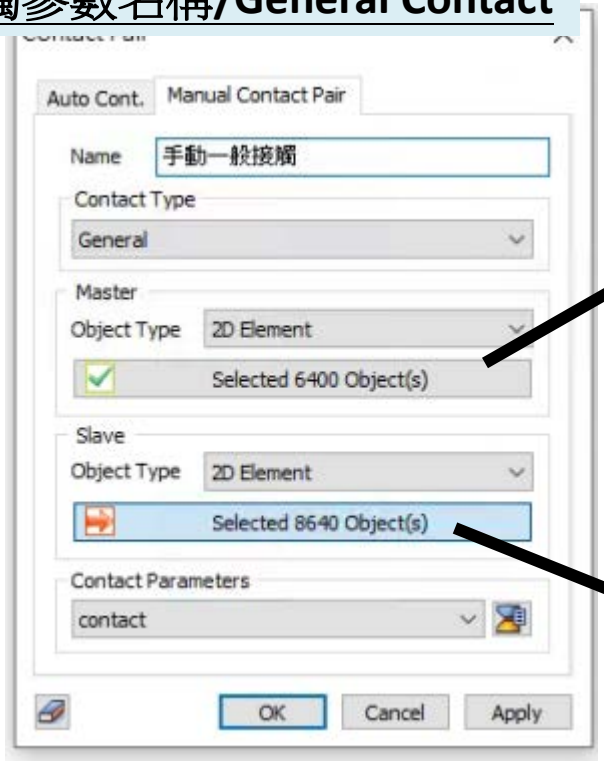
自定接觸參數名稱

調整接觸剛度/定義接觸間隙

手動一般接觸

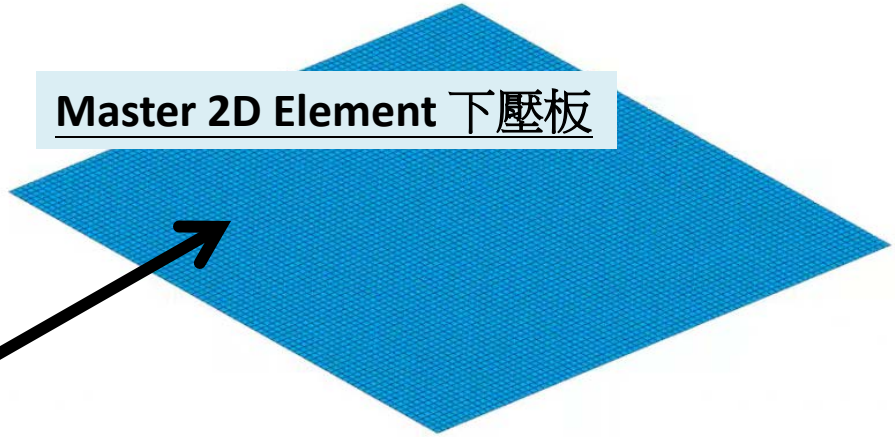


自定接觸參數名稱/General Contact

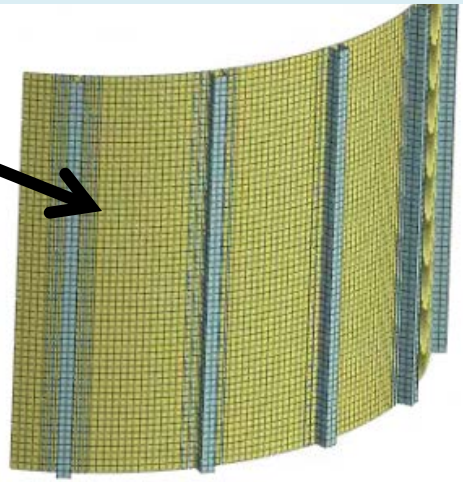


使用上一步驟接觸參數

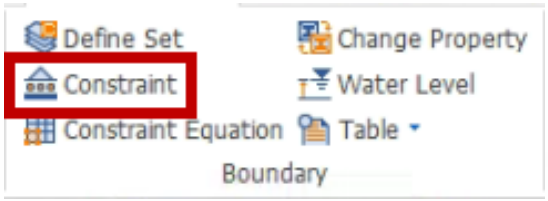
Master 2D Element 下壓板

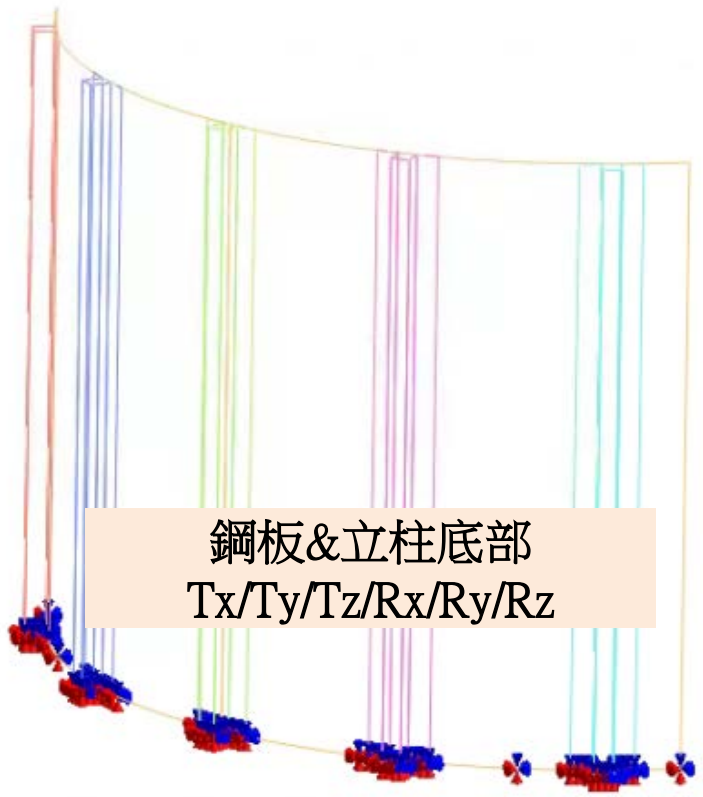


Slave 2D Element 鋼板&立柱

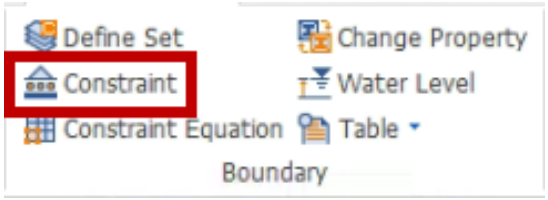


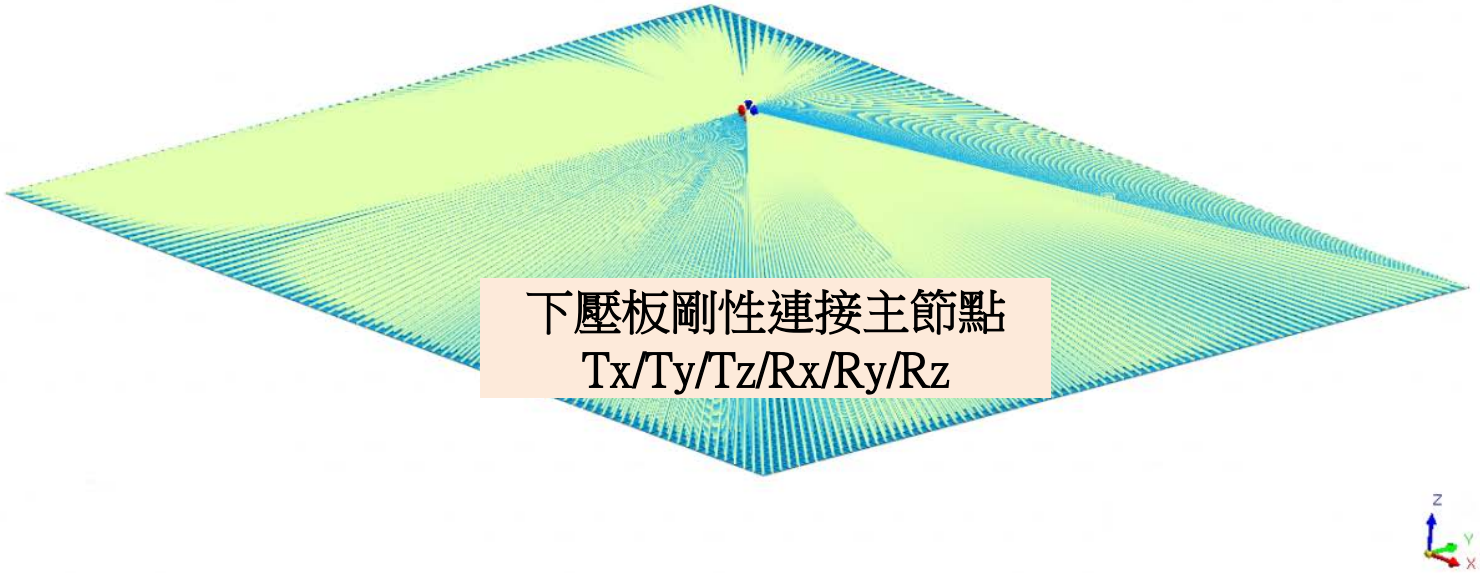
邊界(鋼板&立柱)


Define Set
Change Property
Constraint
Water Level
Constraint Equation
Table
Boundary


鋼板&立柱底部
Tx/Ty/Tz/Rx/Ry/Rz

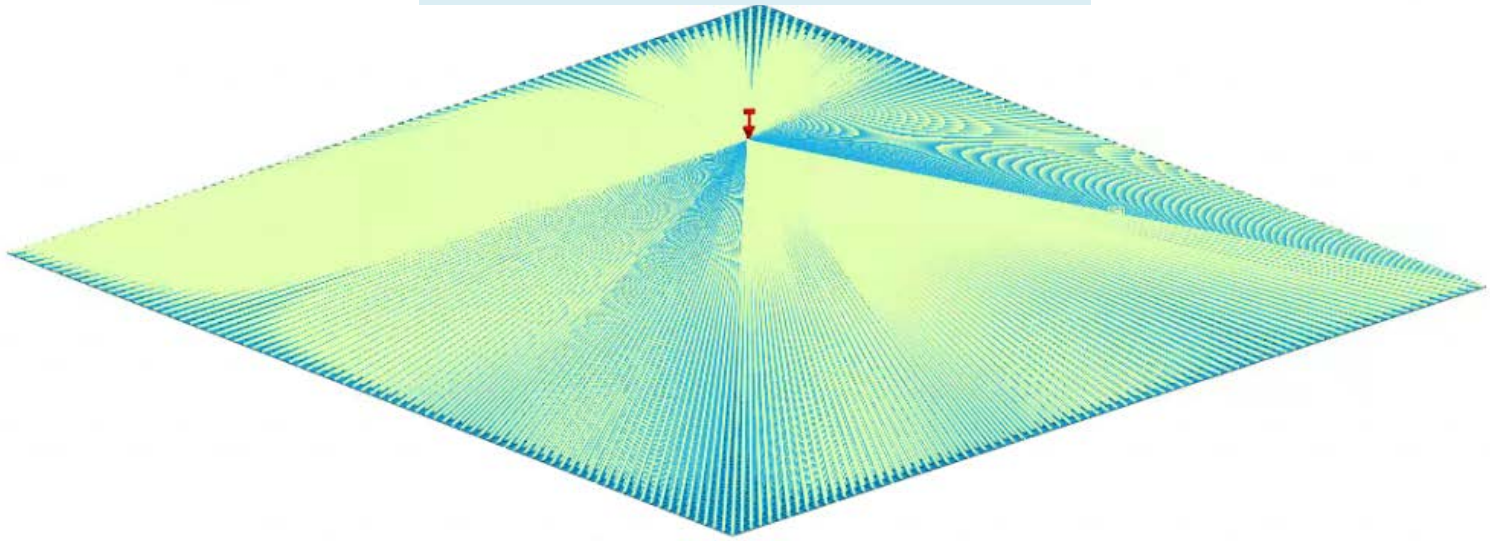
邊界(下壓板剛連接)


Define Set
Change Property
Constraint
Water Level
Constraint Equation
Table
Boundary


下壓板剛性連接主節點
Tx/Ty/Tz/Rx/Ry/Rz
Z
Y
X

位移

依照Global座標施加Tz=-0.2(m)



非線性分析-1

註:建議分析名稱不要使用空格

非線性分析-2

非線性控制

預設計算材料非線性,勾選才計算幾何&邊界(接觸)非線性

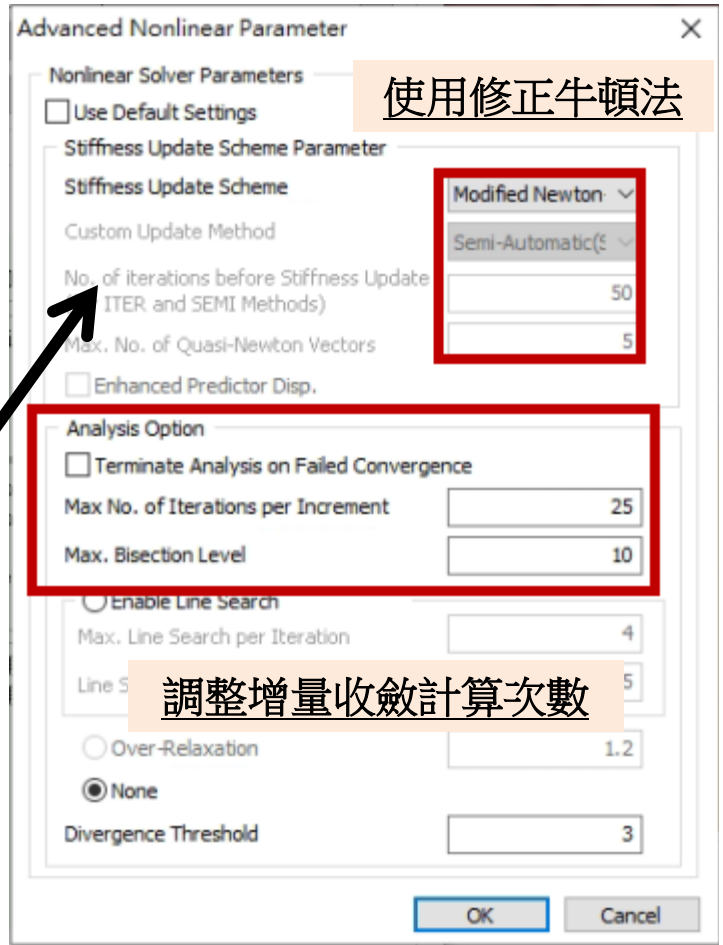
增量數分成50等份/輸出每次增量結果

每一增量增加變形量0.2(m)/50=0.004(m)

收斂判斷採Displacement(放寬收斂標準)

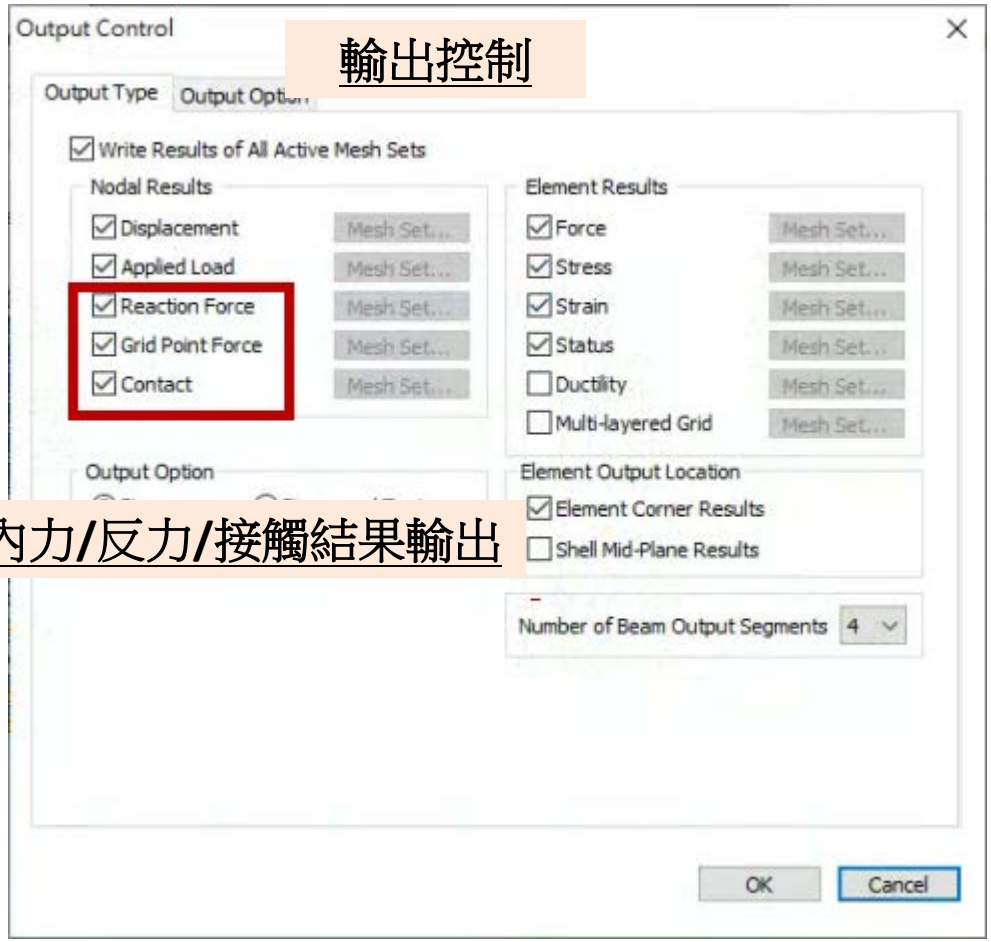
使用修正牛頓法

調整增量收斂計算次數



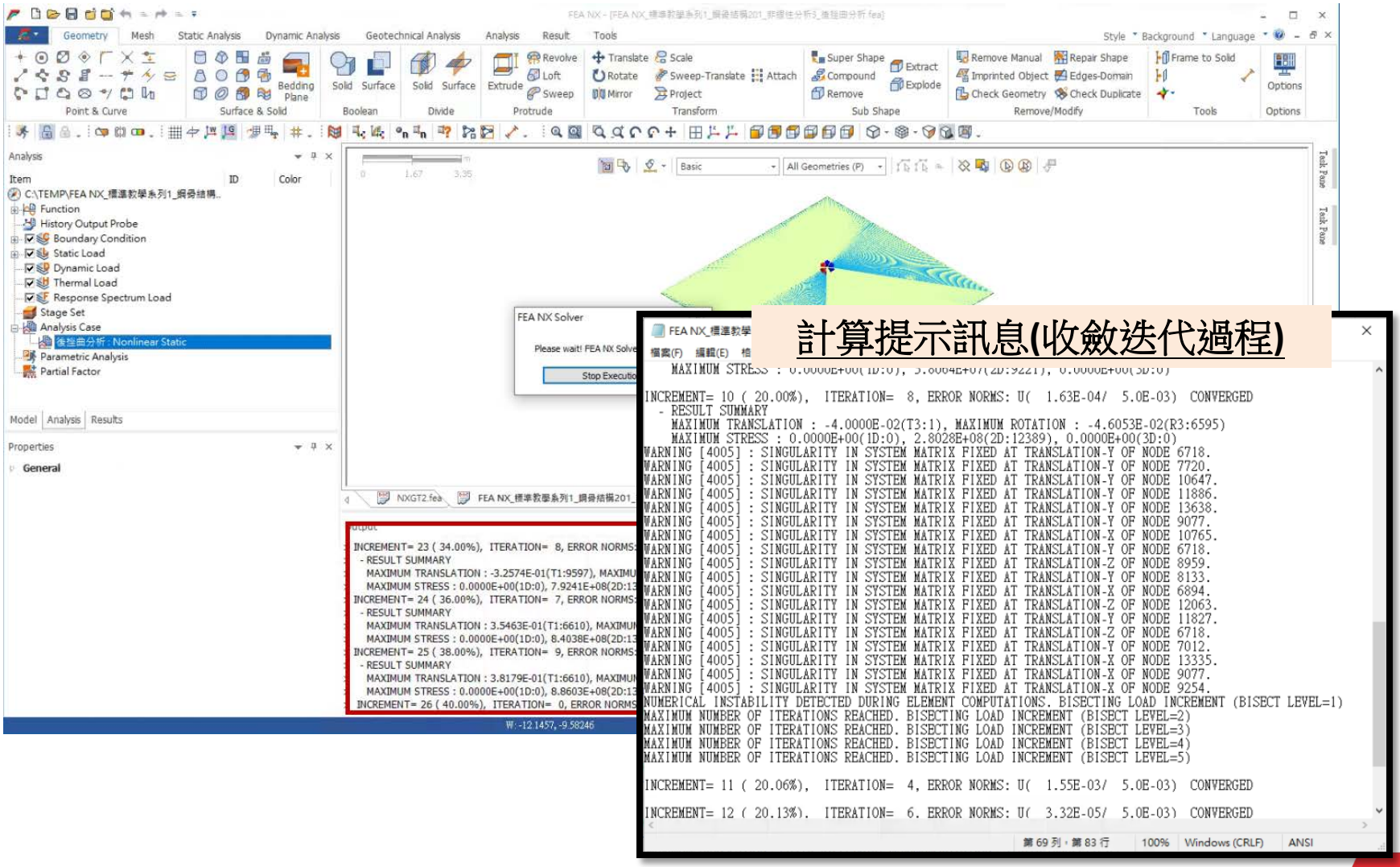
註:後挫曲計算需考慮幾何非線性。

非線性分析-3



内力/反力/接觸結果輸出

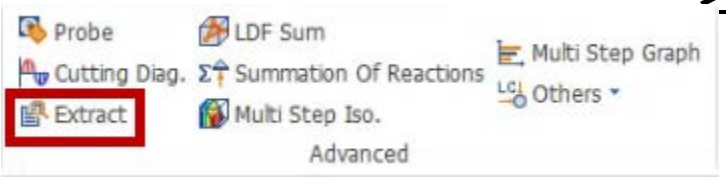
執行分析



註:後挫曲屬於大變形計算,分析過程計算不穩定。

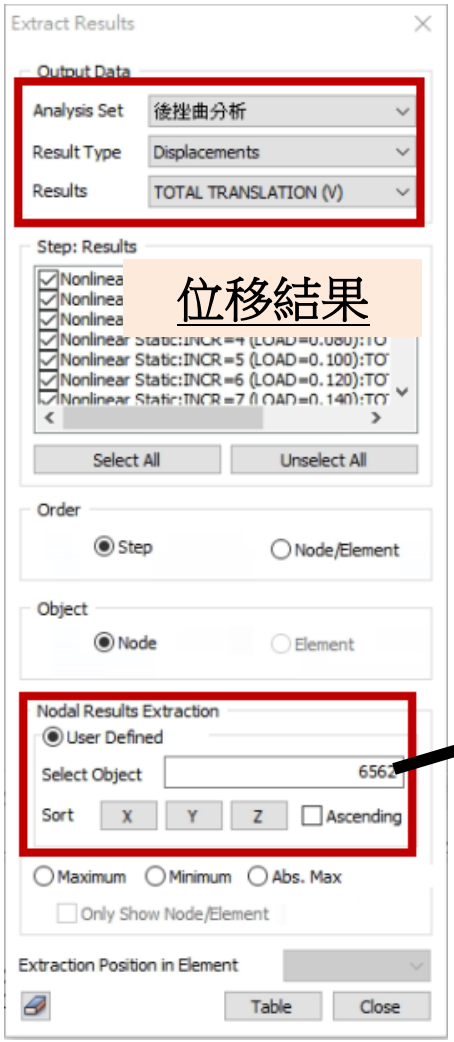
提取-迭代過程結果

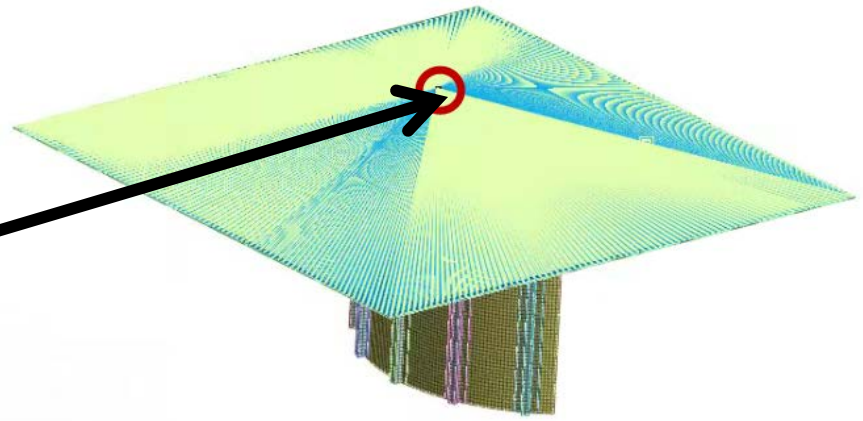
分析結果-1



迭代過程剛性中心點位移結果

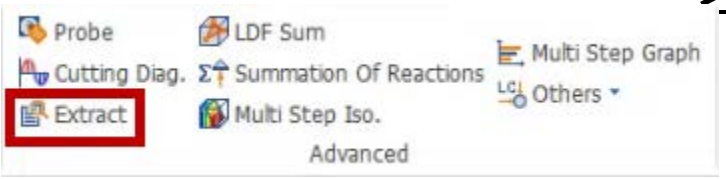
3	Nonlinear Static:INCR=3 (LOAD=0.060)	6.000000e-002	1.200000e-002
4	Nonlinear Static:INCR=4 (LOAD=0.080)	8.000000e-002	1.600000e-002
5	Nonlinear Static:INCR=5 (LOAD=0.100)	1.000000e-001	2.000000e-002
6	Nonlinear Static:INCR=6 (LOAD=0.120)	1.200000e-001	2.400000e-002
7	Nonlinear Static:INCR=7 (LOAD=0.140)	1.400000e-001	2.800000e-002
8	Nonlinear Static:INCR=8 (LOAD=0.160)	1.600000e-001	3.200000e-002
9	Nonlinear Static:INCR=9 (LOAD=0.180)	1.800000e-001	3.600000e-002
10	Nonlinear Static:INCR=10 (LOAD=0.200)	2.000000e-001	4.000000e-002
11	Nonlinear Static:INCR=16 (LOAD=0.220)	2.200000e-001	4.400000e-002
12	Nonlinear Static:INCR=17 (LOAD=0.240)	2.400000e-001	4.800000e-002
13	Nonlinear Static:INCR=19 (LOAD=0.260)	2.600000e-001	5.200000e-002
14	Nonlinear Static:INCR=20 (LOAD=0.280)	2.800000e-001	5.600000e-002
15	Nonlinear Static:INCR=21 (LOAD=0.300)	3.000000e-001	6.000000e-002
16	Nonlinear Static:INCR=22 (LOAD=0.320)	3.200000e-001	6.400000e-002
17	Nonlinear Static:INCR=23 (LOAD=0.340)	3.400000e-001	6.800000e-002
18	Nonlinear Static:INCR=24 (LOAD=0.360)	3.600000e-001	7.200000e-002
19	Nonlinear Static:INCR=25 (LOAD=0.380)	3.800000e-001	7.600000e-002
20	Nonlinear Static:INCR=26 (LOAD=0.400)	4.000000e-001	8.000000e-002
21	Nonlinear Static:INCR=27 (LOAD=0.420)	4.200000e-001	8.400000e-002
22	Nonlinear Static:INCR=28 (LOAD=0.440)	4.400000e-001	8.800000e-002
23	Nonlinear Static:INCR=29 (LOAD=0.460)	4.600000e-001	9.200000e-002
24	Nonlinear Static:INCR=30 (LOAD=0.480)	4.800000e-001	9.600000e-002
25	Nonlinear Static:INCR=31 (LOAD=0.500)	5.000000e-001	1.000000e-001
26	Nonlinear Static:INCR=32 (LOAD=0.520)	5.200000e-001	1.040000e-001
27	Nonlinear Static:INCR=33 (LOAD=0.540)	5.400000e-001	1.080000e-001
28	Nonlinear Static:INCR=34 (LOAD=0.560)	5.600000e-001	1.120000e-001
29	Nonlinear Static:INCR=35 (LOAD=0.580)	5.800000e-001	1.160000e-001





提取-迭代過程結果

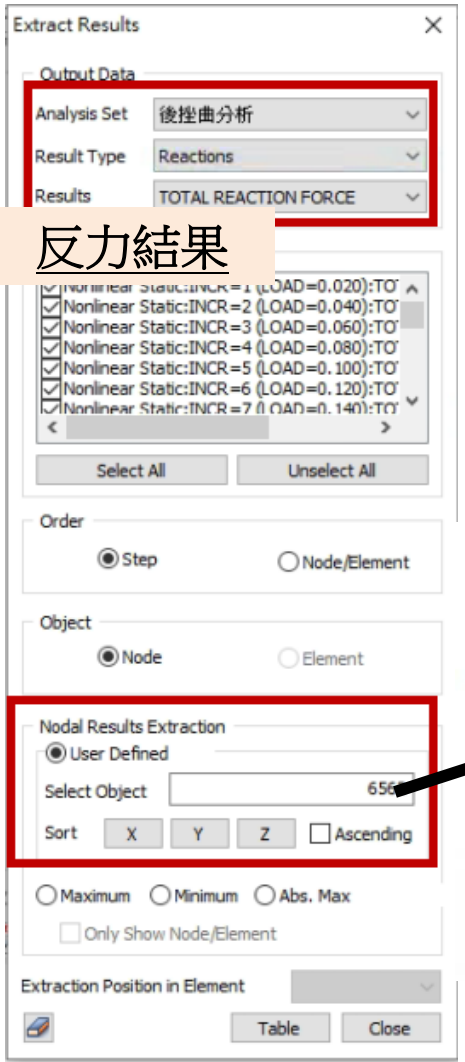
分析結果-2



迭代過程剛性中心點反力結果

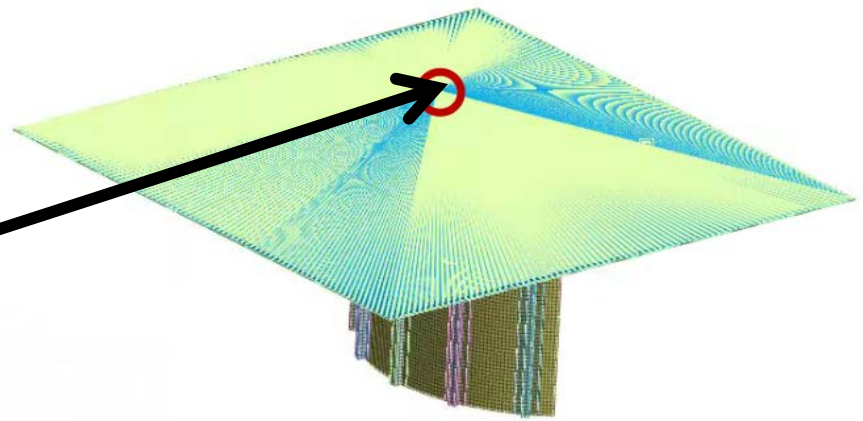
2	Nonlinear Static:INCR=2 (LOAD=0.040)	4.000000e-002	0.000000e+000
3	Nonlinear Static:INCR=3 (LOAD=0.060)	6.000000e-002	0.000000e+000
4	Nonlinear Static:INCR=4 (LOAD=0.080)	8.000000e-002	0.000000e+000
5	Nonlinear Static:INCR=5 (LOAD=0.100)	1.000000e-001	0.000000e+000
6	Nonlinear Static:INCR=6 (LOAD=0.120)	1.200000e-001	0.000000e+000
7	Nonlinear Static:INCR=7 (LOAD=0.140)	1.400000e-001	0.000000e+000
8	Nonlinear Static:INCR=8 (LOAD=0.160)	1.600000e-001	7.642497e+003
9	Nonlinear Static:INCR=9 (LOAD=0.180)	1.800000e-001	4.984495e+006
10	Nonlinear Static:INCR=10 (LOAD=0.200)	2.000000e-001	2.883290e+007
11	Nonlinear Static:INCR=16 (LOAD=0.220)	2.200000e-001	1.842622e+007
12	Nonlinear Static:INCR=17 (LOAD=0.240)	2.400000e-001	1.527795e+007
13	Nonlinear Static:INCR=19 (LOAD=0.260)	2.600000e-001	1.350124e+007
14	Nonlinear Static:INCR=20 (LOAD=0.280)	2.800000e-001	1.232806e+007
15	Nonlinear Static:INCR=21 (LOAD=0.300)	3.000000e-001	1.148340e+007
16	Nonlinear Static:INCR=22 (LOAD=0.320)	3.200000e-001	1.083479e+007
17	Nonlinear Static:INCR=23 (LOAD=0.340)	3.400000e-001	1.029085e+007
18	Nonlinear Static:INCR=24 (LOAD=0.360)	3.600000e-001	9.789326e+006
19	Nonlinear Static:INCR=25 (LOAD=0.380)	3.800000e-001	9.305513e+006
20	Nonlinear Static:INCR=26 (LOAD=0.400)	4.000000e-001	8.898454e+006
21	Nonlinear Static:INCR=27 (LOAD=0.420)	4.200000e-001	8.541397e+006
22	Nonlinear Static:INCR=28 (LOAD=0.440)	4.400000e-001	8.251520e+006
23	Nonlinear Static:INCR=29 (LOAD=0.460)	4.600000e-001	8.023455e+006
24	Nonlinear Static:INCR=30 (LOAD=0.480)	4.800000e-001	7.824082e+006
25	Nonlinear Static:INCR=31 (LOAD=0.500)	5.000000e-001	7.633784e+006
26	Nonlinear Static:INCR=32 (LOAD=0.520)	5.200000e-001	7.451970e+006
27	Nonlinear Static:INCR=33 (LOAD=0.540)	5.400000e-001	7.281841e+006
28	Nonlinear Static:INCR=34 (LOAD=0.560)	5.600000e-001	7.123520e+006
29	Nonlinear Static:INCR=35 (LOAD=0.580)	5.800000e-001	6.984035e+006
30	Nonlinear Static:INCR=36 (LOAD=0.600)	6.000000e-001	7.007681e+006

50 Rows



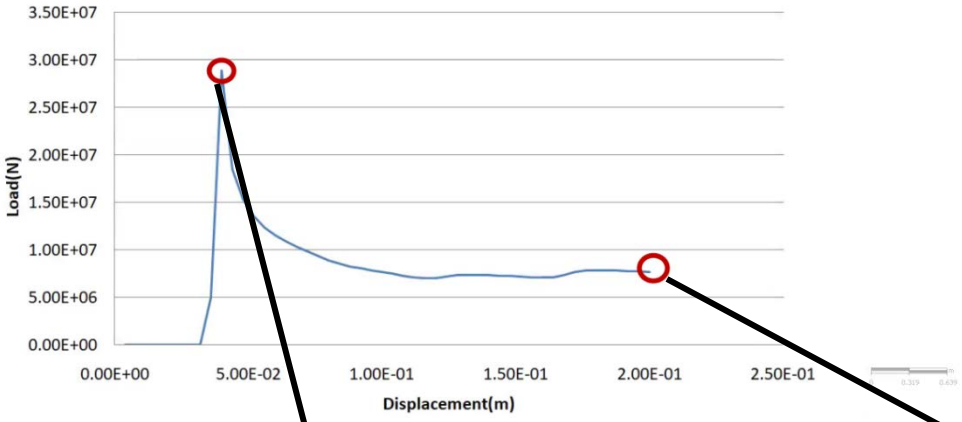
반력결과

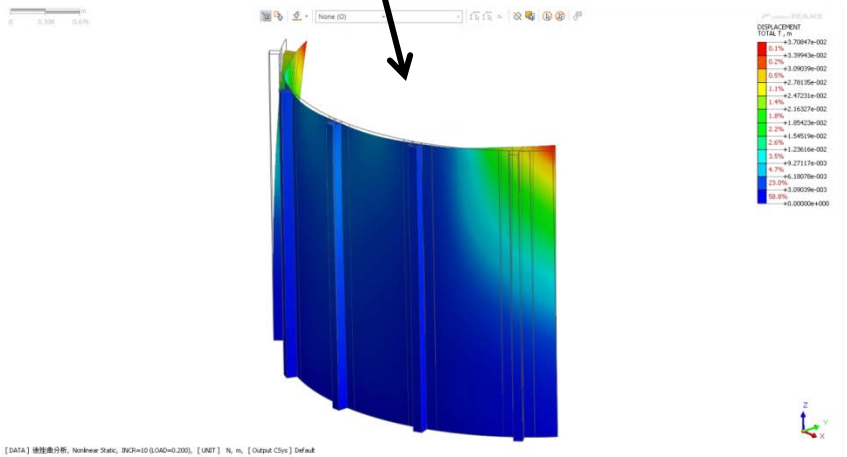
1

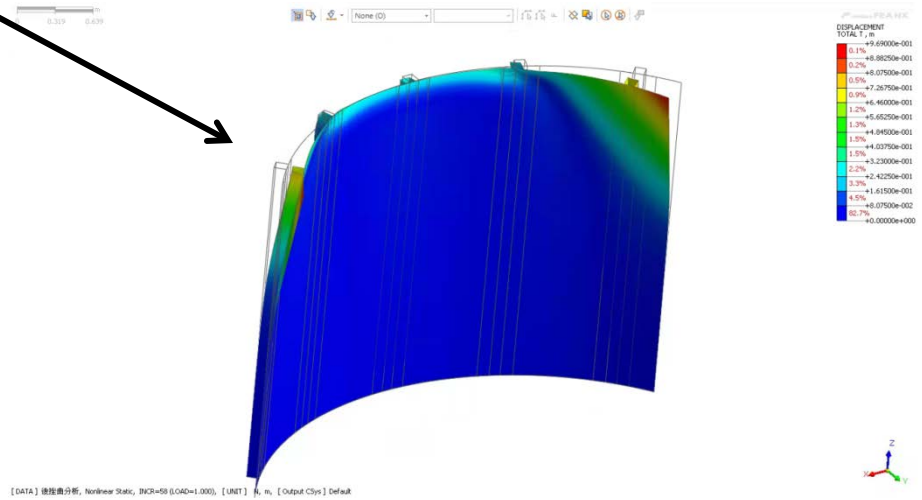


分析結果-3

28832900(N)=>近似線性挫曲結果







註:範例相關參數使用假設條件。