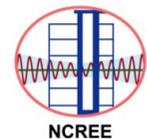


2016建築物耐震評估與補強技術講習會

耐震能力詳細評估之介紹(TEASPA)

主講人：周德光

May 13, 2016



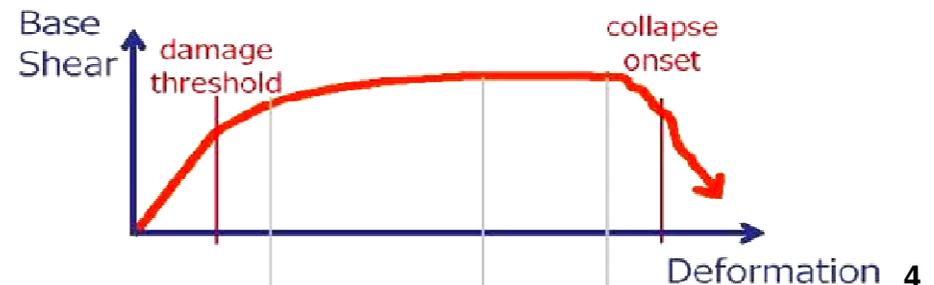
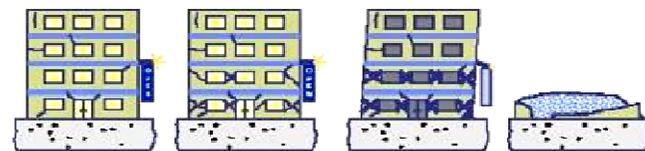
簡報大綱

- 前言
- 分析模型
- 模型建立
- 設定非線性鉸
- 輔助分析程式

前言

前言

- 建立建築物之數值模型
 - 柱、梁構件 → 彎矩與剪力非線性鉸
 - 磚牆 → 等值斜撐模擬
 - RC 牆 → 等值寬柱模擬
- 以 **ETABS** 軟體分析建築物之容量曲線
- 將建築物之容量曲線轉換為容量震譜求得性能目標地表加速度

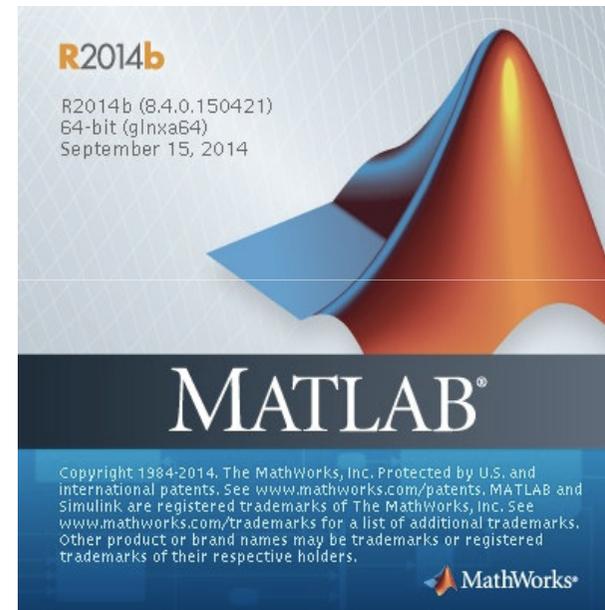


TEASPA 分析方法所需工具

- **CSI ETABS**
(8.0 以上版本)



- **MATLAB 或 MCR Installer**



TEASPA 耐震評估方法

<https://www.facebook.com/groups/1420428518211927/>

- 討論區
- 最新活動
- 檔案下載
 - 技術手冊
 - 示範例模型
 - 講習會簡報
 - MCR Installer
 - 32 位元
 - 64 位元
 - 輔助分析程式
 - 32 位元
 - 64 位元

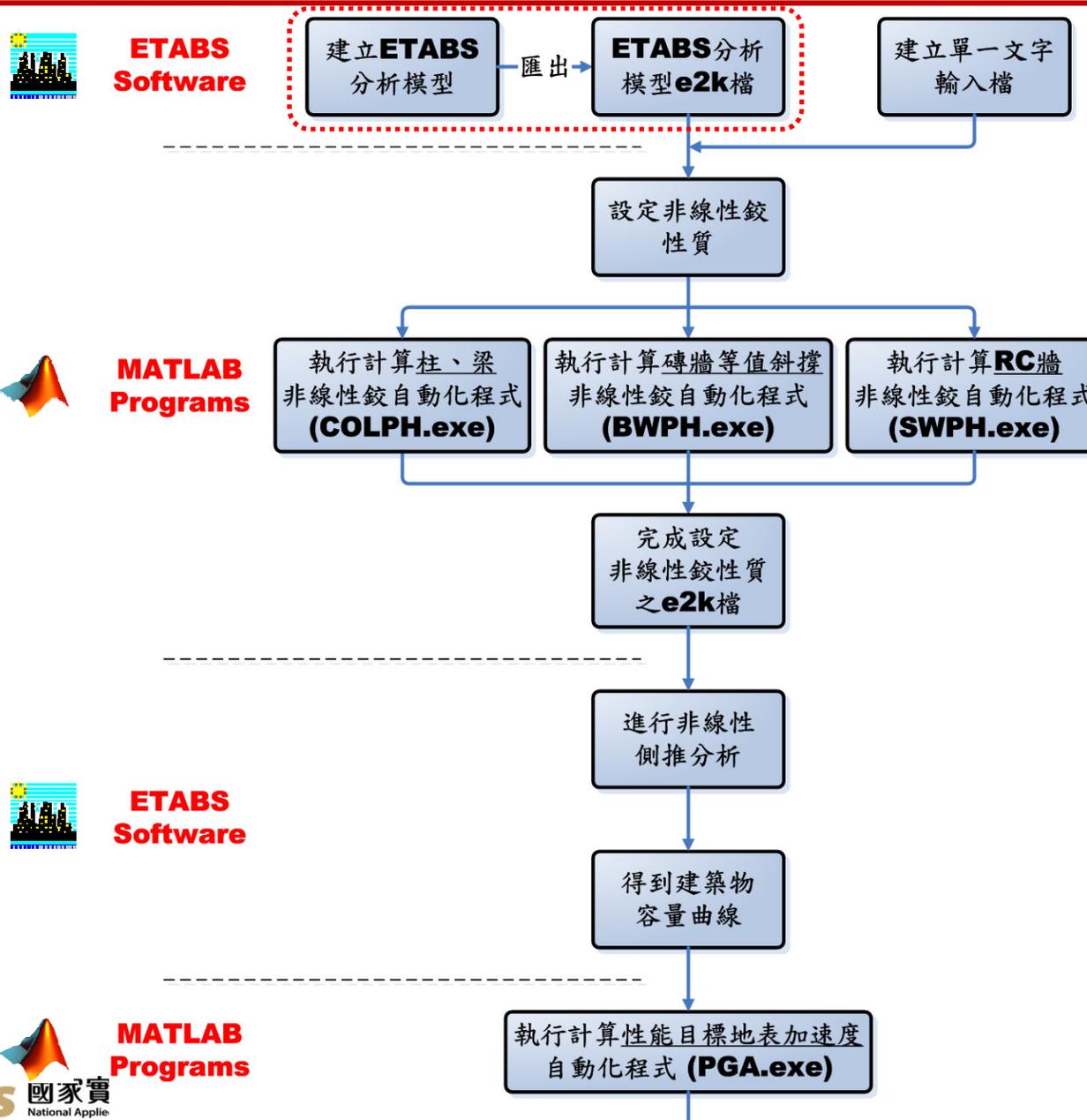


The screenshot shows the Facebook group page for 'TEASPA 耐震評估方法'. The page is a 'Closed Group' and has a search bar. The 'Files' tab is selected, showing a list of files available for download. The files include software packages, technical manuals, and seminar reports. Red text labels are overlaid on the right side of the file list to identify the content.

File Name	Download Link	Red Label
[程式] TEASPA 32位元(MIDAS版).zip	Download	
[程式] TEASPA 64位元(MIDAS版).zip	Download	
資料轉不出文字.rar	Download	
[報告]校舍結構耐震評估與補強技術手冊第三版(NCREE-13-023).pdf	Download	技術手冊
ETABS Examples (3rd).zip	Download	示範例模型
20140627 技術手冊講習會簡報.pdf	Download	講習會簡報
20140620 技術手冊講習會簡報.pdf	Download	講習會簡報
[程式] TEASPA 32位元(版本 2014.4.25).zip	Download	輔助分析程式
[程式] TEASPA 64位元(版本 2014.4.25).zip	Download	輔助分析程式
[程式] Windows 32位元電腦安裝 MCRInstaller 之下載連結	Download	MCR Installer
[報告]校舍結構耐震評估與補強技術手冊第二版(NCREE-09-023).pdf	Download	

分析模型

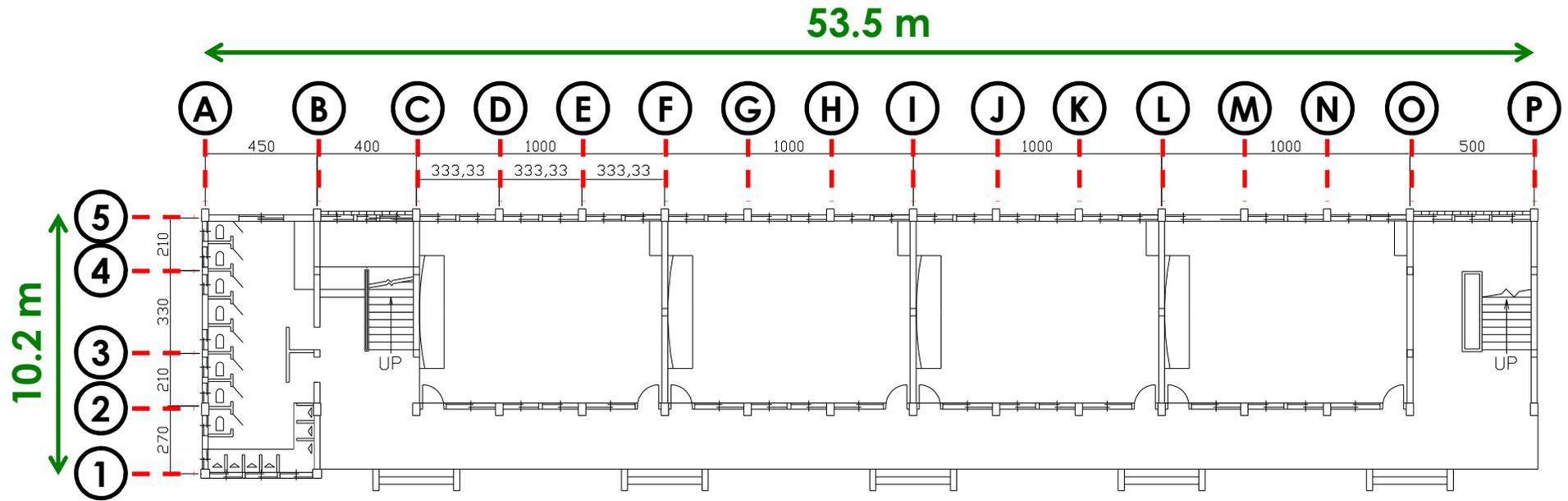
TEASPA 分析流程



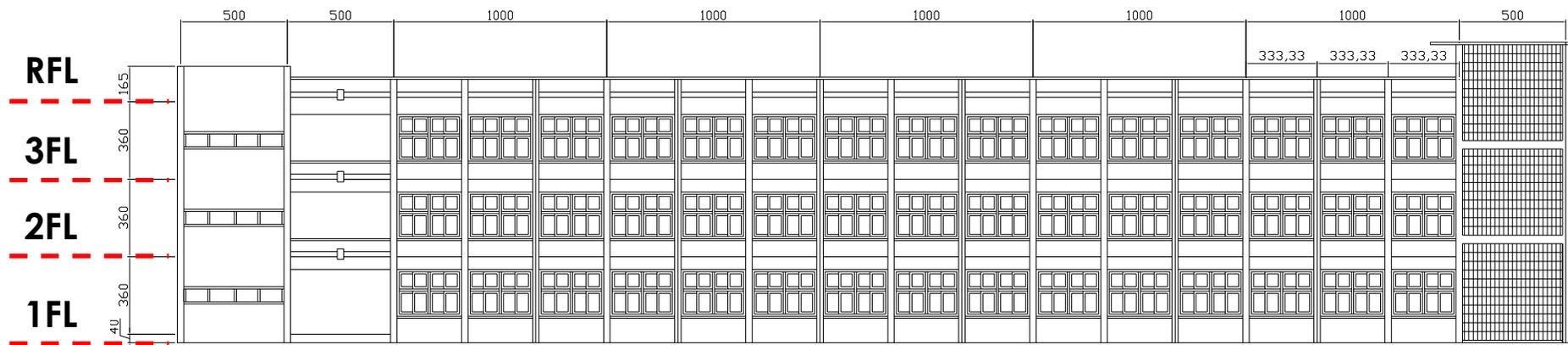
建立分析模型時所需資料

- 結構圖說：
 - 平面圖、立面圖、配筋圖、結構平面圖...
- 外觀照片：
 - 正面、背面、左右側面...
- 材料強度：
 - 鋼筋、混凝土、紅磚、水泥砂漿...
- 現場勘查：
 - 建築物現況、磚牆尺寸、窗台高度...

平、立面圖



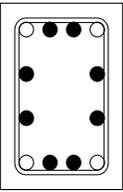
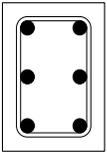
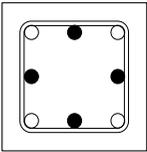
平面圖

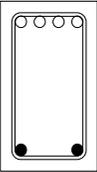
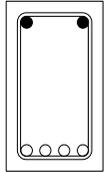
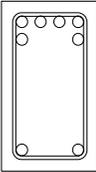
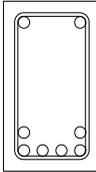
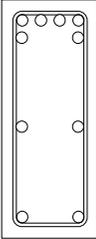
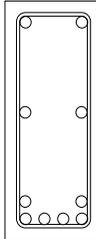


立面圖

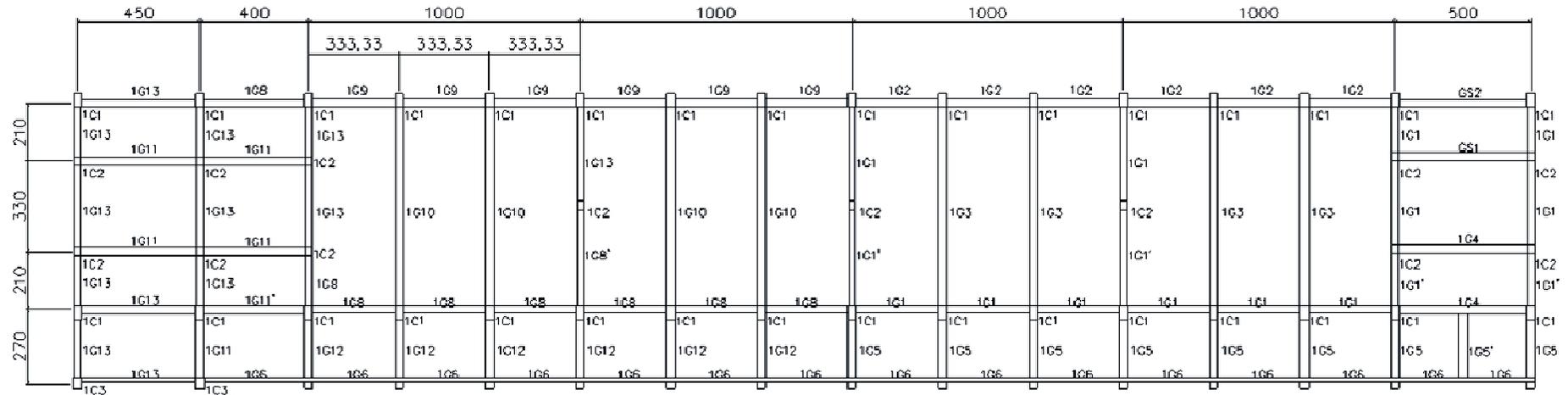
配筋圖

單位：cm

柱編號	C1	C2	C3
斷面			
主筋	○4-D22 ●8-D19	●6-D16	○4-D19 ●4-D16
箍筋	D10@25	D10@25	D10@25
尺寸	30×50	24×30	36×36

梁編號	G1		G2		G3	
	兩端	中央	兩端	中央	兩端	中央
斷面						
主筋	○4-D19 ●2-D16		○8-D22		○10-D22	
箍筋	D10@25		D10@25		D10@25	
尺寸	24×60		30×60		30×90	

結構平面圖

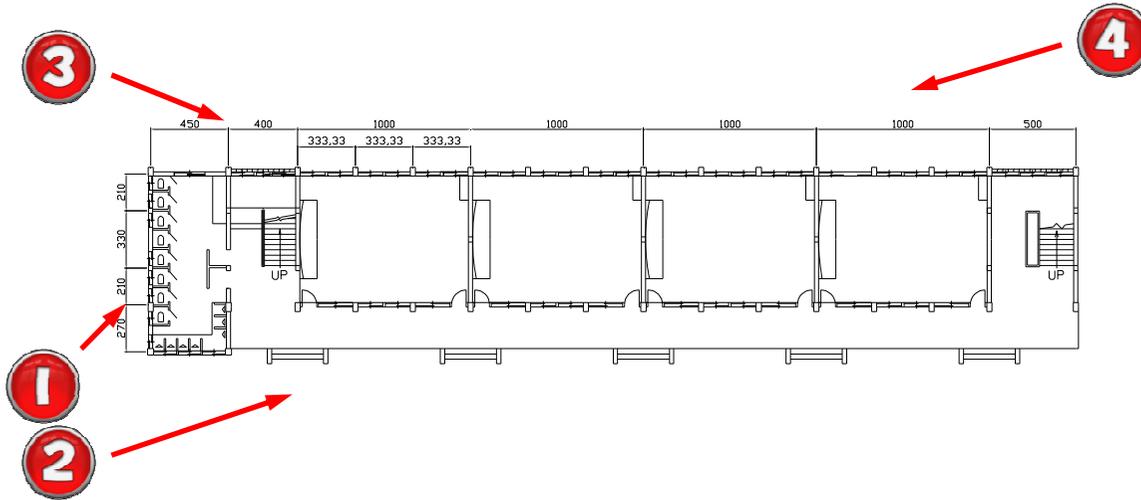


柱：1C1、1C2、1C3

梁：1G1、1G2、1G3、1G4、1G5、1G6、1G8、1G9、1G10、1G11、1G12、1G13

版：1S1、1S2

建築物外觀照片



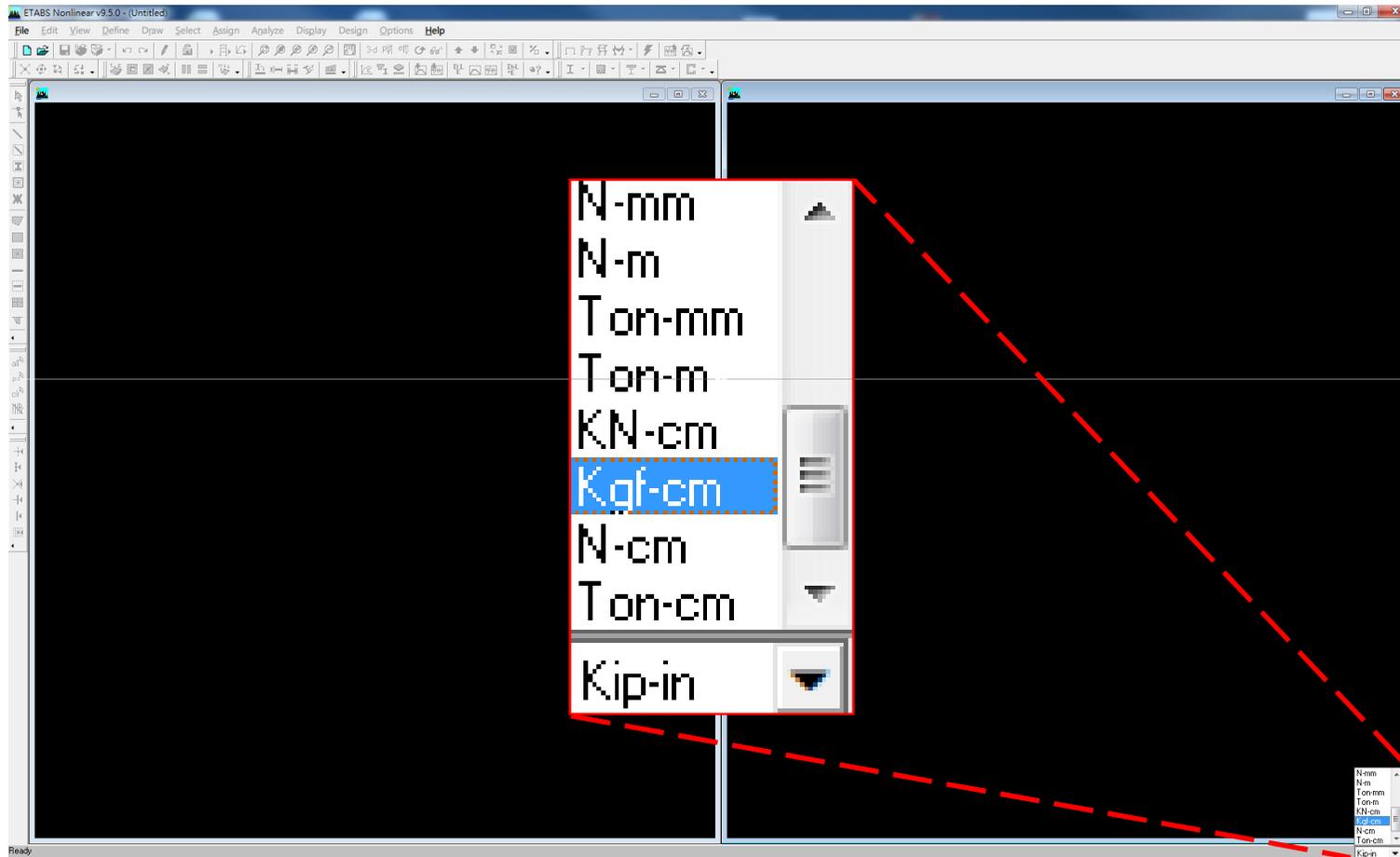
標的物基本資料

- 地上三層之鋼筋混凝土建築物，每層高度為 **3.6 公尺**
- 教室外單側有走廊，但走廊外無柱
- 長向長度為 **53.5 公尺**、短向為 **10.2 公尺**
- 長向有 **90 公分**高之窗台，教室間設置 **1B** 隔間磚牆
- 材料強度
 - 混凝土抗壓強度 $f'_c = 160 \text{ kgf/cm}^2$
 - 主筋與箍筋降伏強度均為 $f_y = 2800 \text{ kgf/cm}^2$
 - 紅磚抗壓強度 $f_{bc} = 150 \text{ kgf/cm}^2$
 - 水泥砂漿抗壓強度 $f_{mc} = 150 \text{ kgf/cm}^2$

模型建立

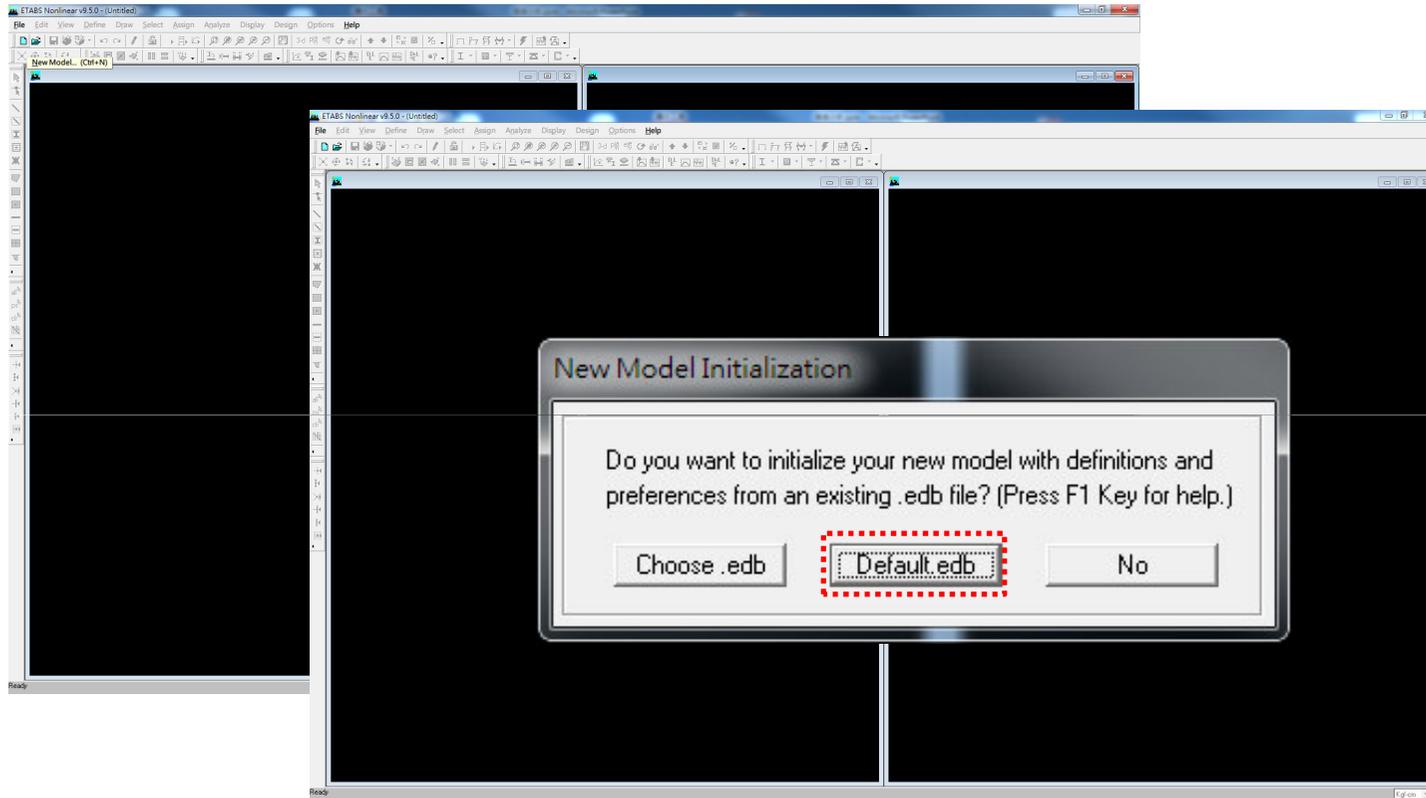
確認單位

- 調整單位為 *kgf-cm*

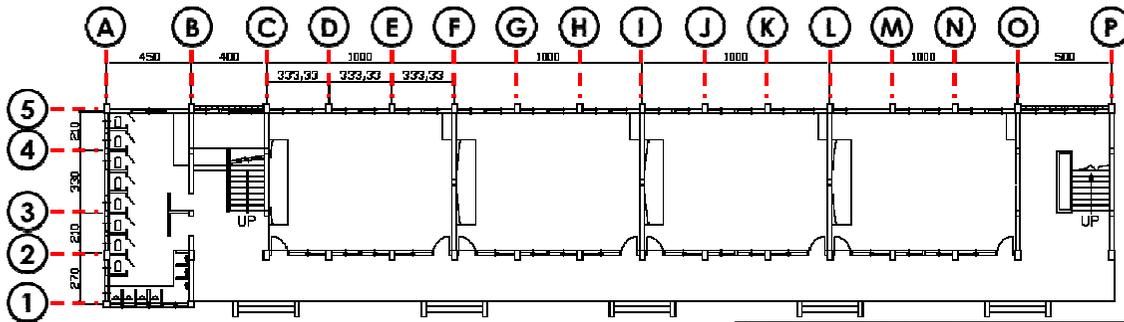


開始建立模型

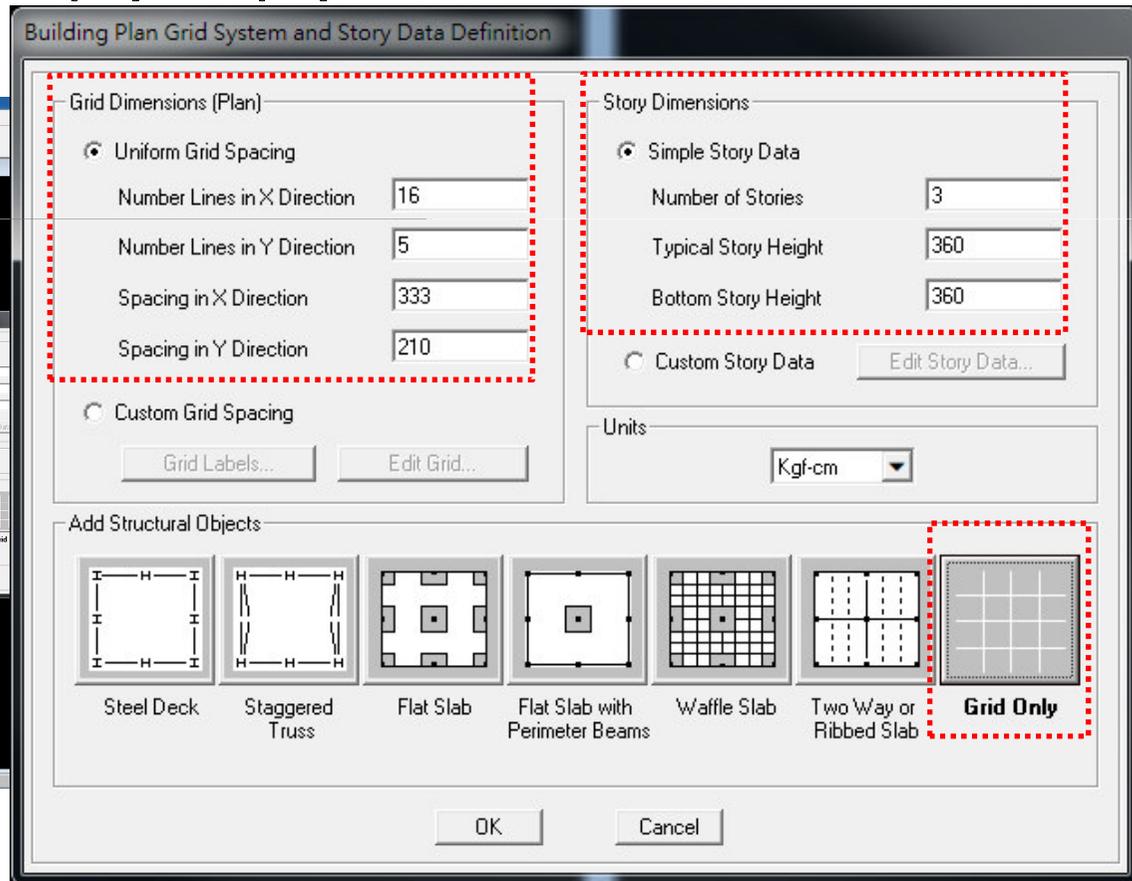
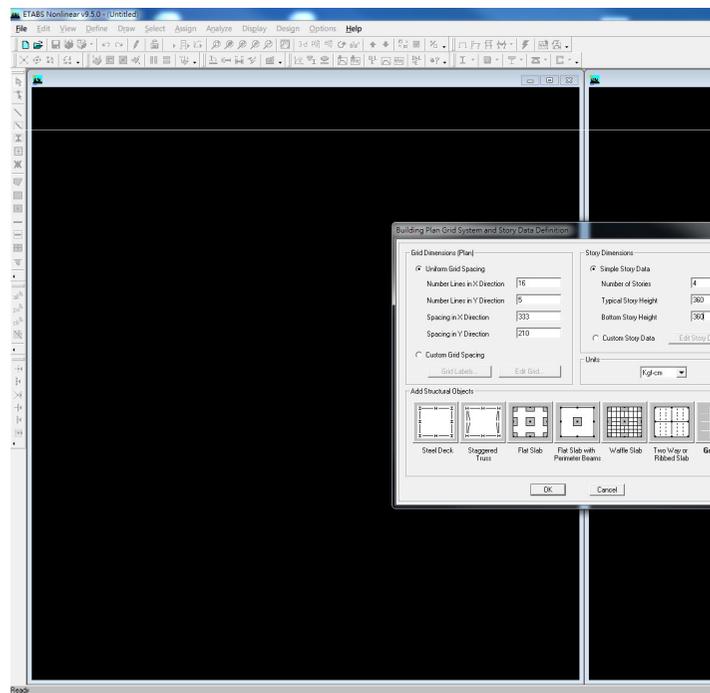
- File → New Model



1. 繪製格線



平面圖



1-1 調整格線間距

Building Plan Grid System and Story Data Definition

Grid Dimensions (Plan)

Uniform Grid Spacing

Number Lines in X Direction: 16

Number Lines in Y Direction: 5

Spacing in X Direction: 333

Spacing in Y Direction: 210

Custom Grid Spacing

Grid Labels... **Edit Grid...**

Story Dimensions

Simple Story Data

Number of Stories: 4

Typical Story Height: 360

Bottom Story Height: 360

Custom Story Data Edit Story Data...

Units: Kgf-cm

Add Structural Objects

Define Grid Data

Edit Format

X Grid Data

	Grid ID	Ordinate	Line Type	Visibility	Bubble Loc.	Grid Color
1	A	0.	Primary	Show	Top	
2	B	333.	Primary	Show	Top	
3	C	666.	Primary	Show	Top	
4	D	999.	Primary	Show	Top	
5	E	1332.	Primary	Show	Top	
6	F	1665.	Primary	Show	Top	
7	G	1998.	Primary	Show	Top	
8	H	2331.	Primary	Show	Top	
9	I	2664.	Primary	Show	Top	
10	J	2997.	Primary	Show	Top	

Units: Kgf-cm

Display Grids as

Ordinate Spacing

Hide All Grid Lines

Glue to Grid Lines

Bubble Size: 125

Reset to Default Color

Reorder Ordinates

Y Grid Data

	Grid ID	Ordinate	Line Type	Visibility	Bubble Loc.	Grid Color
1	1	0.	Primary	Show	Left	
2	2	210.	Primary	Show	Left	
3	3	420.	Primary	Show	Left	
4	4	630.	Primary	Show	Left	
5	5	840.	Primary	Show	Left	
6						
7						
8						
9						
10						

預設畫面

OK Cancel

Define Grid Data

Edit Format

X Grid Data

	Grid ID	Spacing	Line Type	Visibility	Bubble Loc.	Grid Color
1	A	333	Primary	Show	Top	
2	B	333	Primary	Show	Top	
3	C	333	Primary	Show	Top	
4	D	333	Primary	Show	Top	
5	E	333	Primary	Show	Top	
6	F	333	Primary	Show	Top	
7	G	333	Primary	Show	Top	
8	H	333	Primary	Show	Top	
9	I	333	Primary	Show	Top	
10	J	333	Primary	Show	Top	

Units: Kgf-cm

Display Grids as

Ordinate Spacing

Hide All Grid Lines

Glue to Grid Lines

Bubble Size: 125

Reset to Default Color

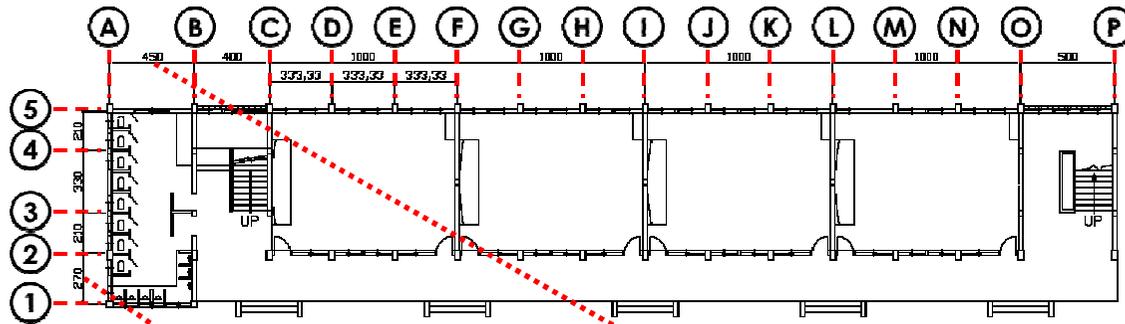
Reorder Ordinates

Y Grid Data

	Grid ID	Spacing	Line Type	Visibility	Bubble Loc.	Grid Color
1	1	210	Primary	Show	Left	
2	2	210	Primary	Show	Left	
3	3	210	Primary	Show	Left	
4	4	210	Primary	Show	Left	
5	5	0	Primary	Show	Left	
6						
7						
8						
9						
10						

OK Cancel

1-1 調整格線間距



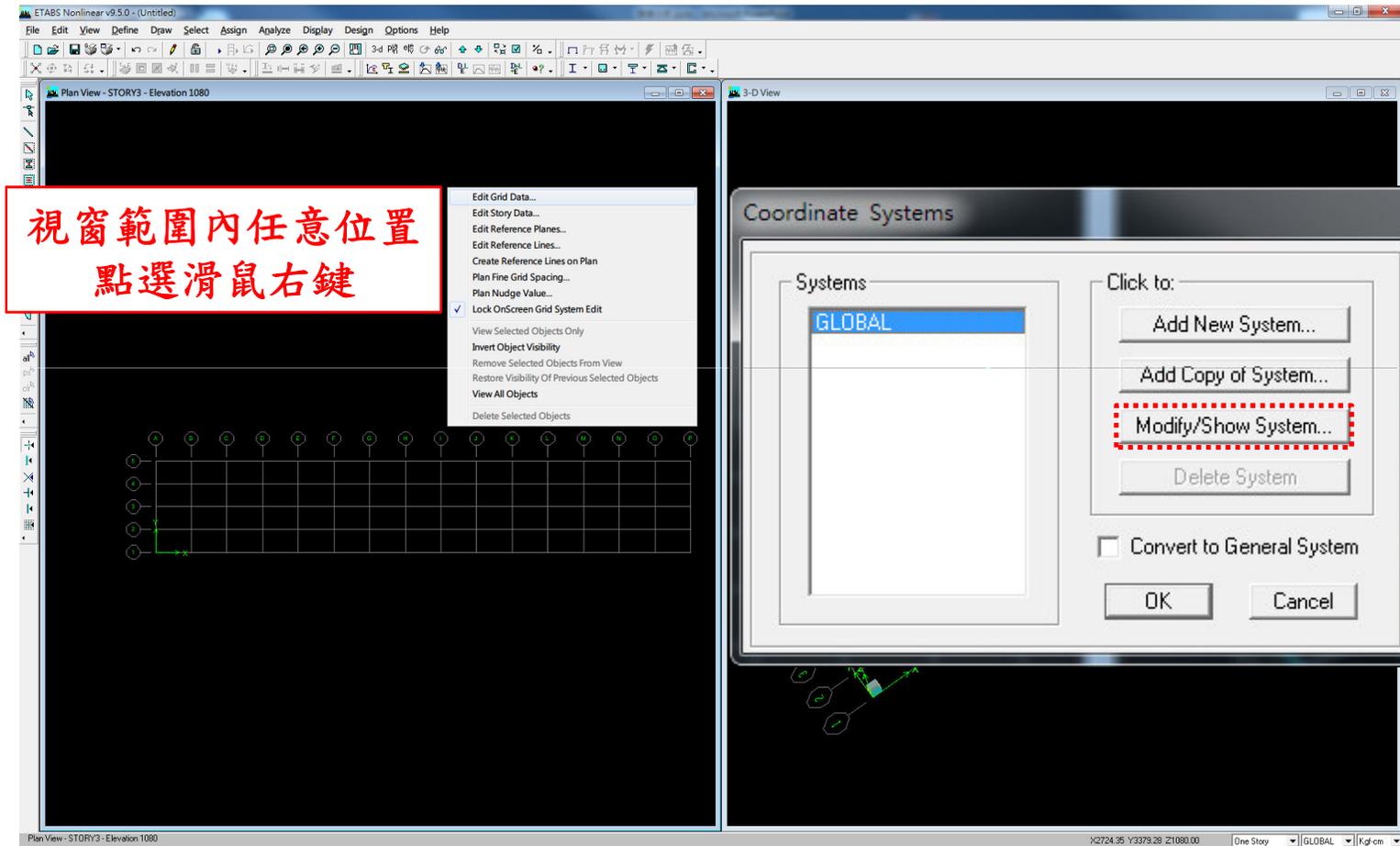
平面圖

Grid ID	Spacing	Line Type	Visibility	Bubble Loc.	Grid Color	
1	A	450	Primary	Show	Top	
2	B	400	Primary	Show	Top	
3	C	333	Primary	Show	Top	
4	D	333	Primary	Show	Top	
5	E	333	Primary	Show	Top	
6	F	333	Primary	Show	Top	
7	G	333	Primary	Show	Top	
8	H	333	Primary	Show	Top	
9	I	333	Primary	Show	Top	
10	J	333	Primary	Show	Top	

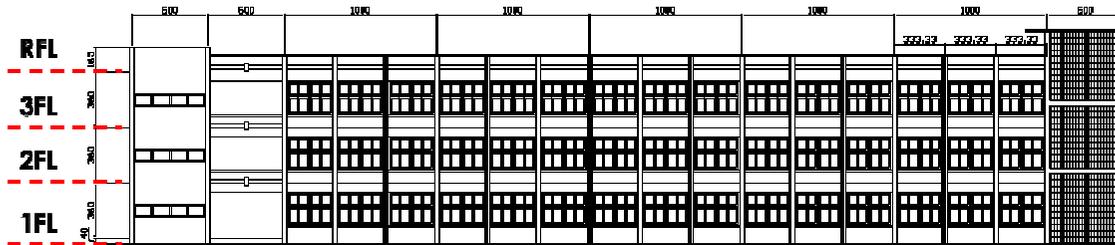
Grid ID	Spacing	Line Type	Visibility	Bubble Loc.	Grid Color	
1	1	270	Primary	Show	Left	
2	2	210	Primary	Show	Left	
3	3	330	Primary	Show	Left	
4	4	210	Primary	Show	Left	
5	5	0	Primary	Show	Left	
6						
7						
8						
9						
10						

1-1 調整格線間距

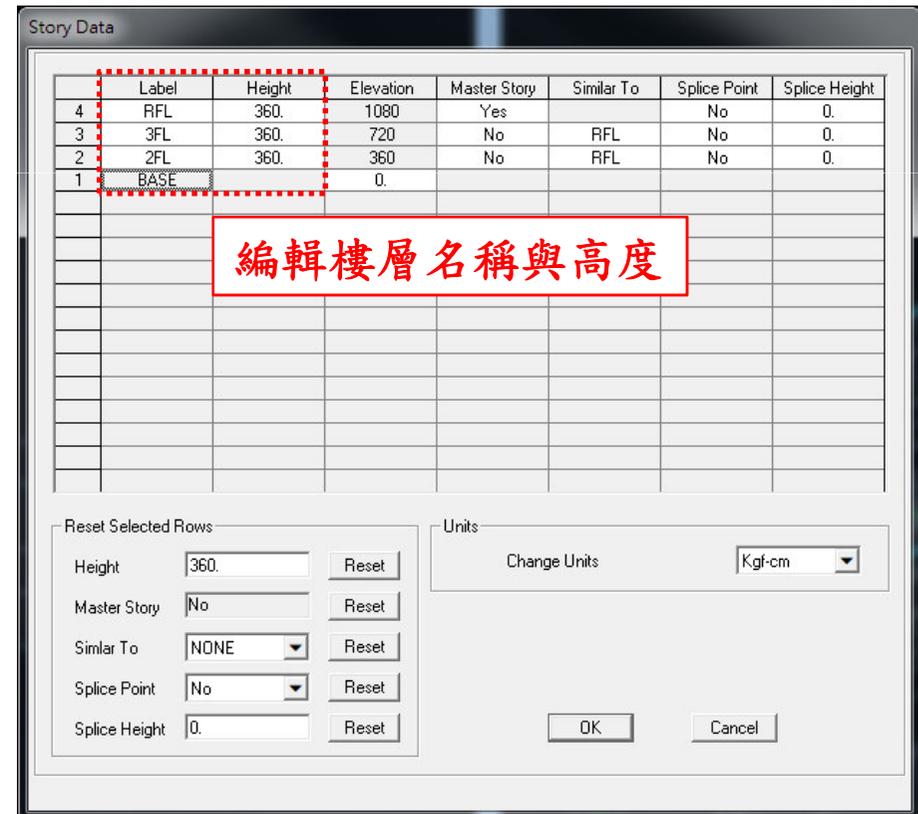
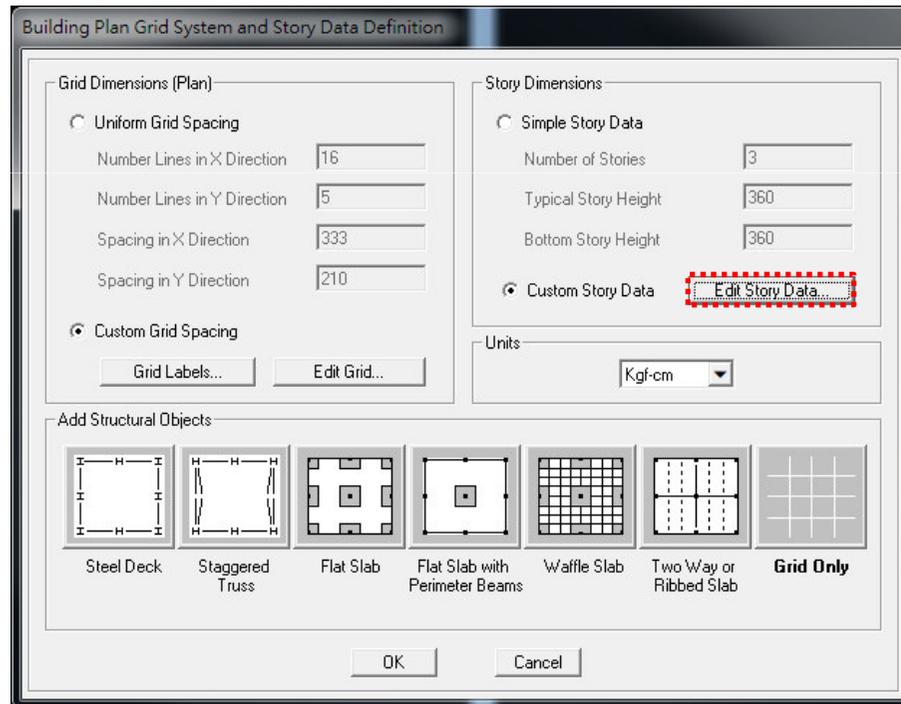
- Edit → Edit Grid Data



1-2 調整樓層高度



立面圖



1-2 調整樓層高度

- Edit → Edit Story Data

視窗範圍內任意位置
點選滑鼠右鍵

	Label	Height	Elevation	Master Story	Similar To	Splice Point	Splice Height
4	STORY3	360.	1080.	Yes		No	0.
3	STORY2	360.	720.	No	STORY3	No	0.
2	STORY1	360.	360.	No	STORY3	No	0.
1	BASE		0.				

編輯樓層名稱與高度

預設畫面

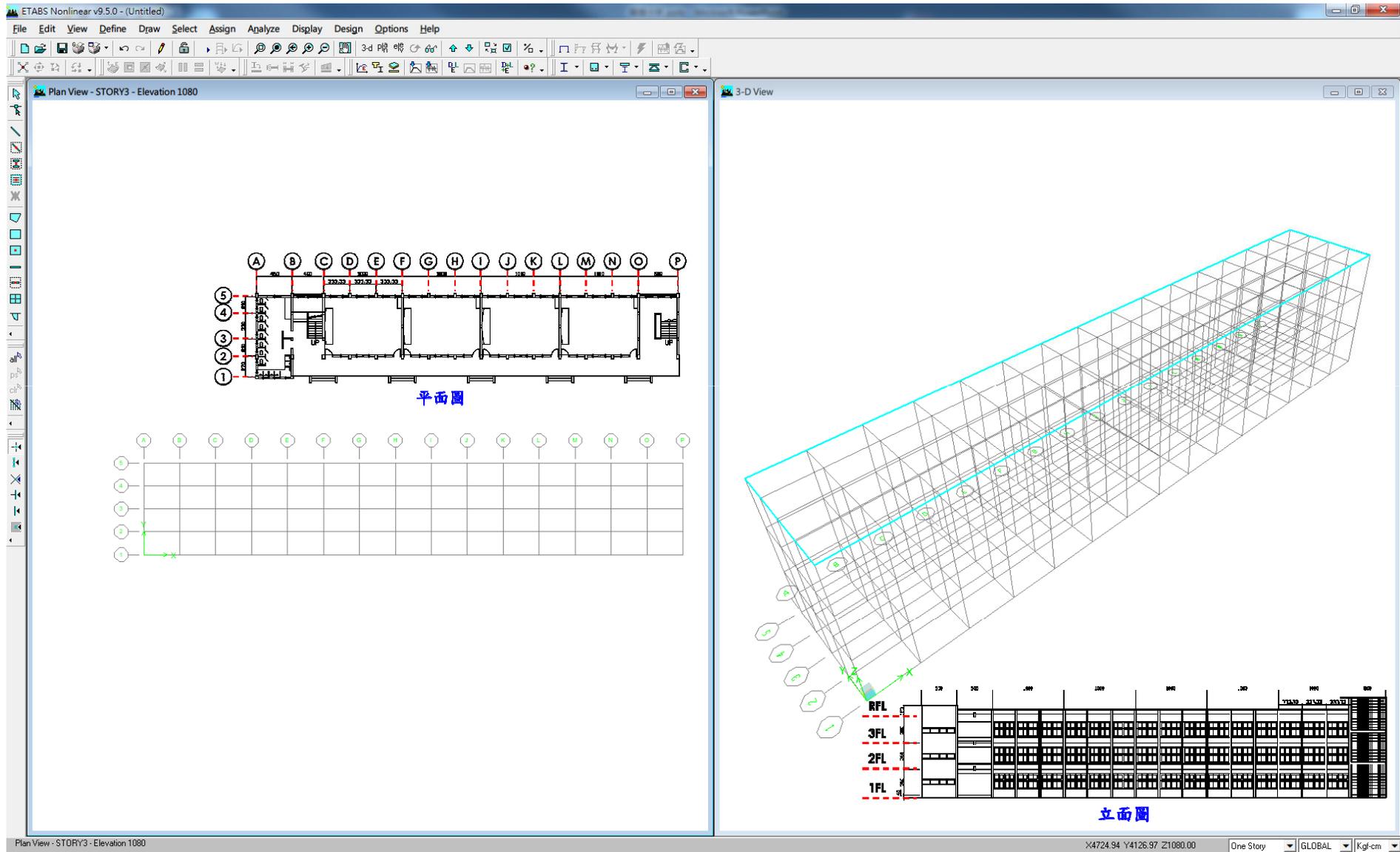
Reset Selected Rows

Height: 360. [Reset]
Master Story: No [Reset]
Similar To: NONE [Reset]
Splice Point: No [Reset]
Splice Height: 0 [Reset]

Units: Change Units: Kgf-cm

OK Cancel

完成格線繪製



2. 新增材料性質

- Define → Material Properties

快捷列

Define Materials

Materials

- CONC
- OTHER
- STEEL

Click to:

- Add New Material..
- Modify/Show Material..
- Delete

Material Property Data

Material Name: TFLCONC

Display Color: Color

Type of Material: Isotropic Orthotropic

Type of Design: Design: Concrete

Analysis Property Data

Mass per unit Volume	2.448E-06
Weight per unit Volume	2.403E-03
Modulus of Elasticity	189736.66
Poisson's Ratio	0.2
Coeff of Thermal Expansion	9.900E-06
Shear Modulus	79056.942

Design Property Data (ACI 318-05/IBC 2003)

Specified Conc Comp Strength, f'c	160.
Bending Reinf. Yield Stress, fy	2800.
Shear Reinf. Yield Stress, fys	2800.

Lightweight Concrete

Shear Strength Reduc. Factor

OK Cancel

混凝土強度：160 kgf/cm²
主筋強度：2800 kgf/cm²
箍筋強度：2800 kgf/cm²

2. 新增柱、梁斷面

• Define → Frame Sections

快捷列

Define Frame Properties

Properties

Type in property to find:

- A-CompBm
- A-CompBm
- A-GravBm
- A-GravCol
- A-LatBm
- A-LatCol
- A-TrChdw10
- A-TrChdw12
- A-TrChdw14
- A-TrWeb8
- A-TrWeb10
- A-TrWeb12

Click to:

- Import I/Wide Flange
- Add I/Wide Flange
- Add I/Wide Flange
- Add Channel
- Add Tee
- Add Angle
- Add Double Angle
- Add Box/Tube
- Add Pipe
- Add Rectangular

Cancel

Reinforcement Data

Design Type

- Column
- Beam

Configuration of Reinforcement

- Rectangular
- Circular

Lateral Reinforcement

- Ties
- Spiral

Rectangular Reinforcement

Cover to Rebar Center: 6.1

Number of Bars in 3-dir: 4

Number of Bars in 2-dir: 4

Bar Size: #6

Corner Bar Size: #7

Check/Design

- Reinforcement to be Checked
- Reinforcement to be Designed

OK Cancel

Rectangular Section

Section Name: 1FLC1

Properties: Section Properties... Property Modifiers: Set Modifiers... Material: 1FLCONC

Dimensions

Depth (t3): 30

Width (t2): 50

Concrete: Reinforcement...

Display Color: [Green]

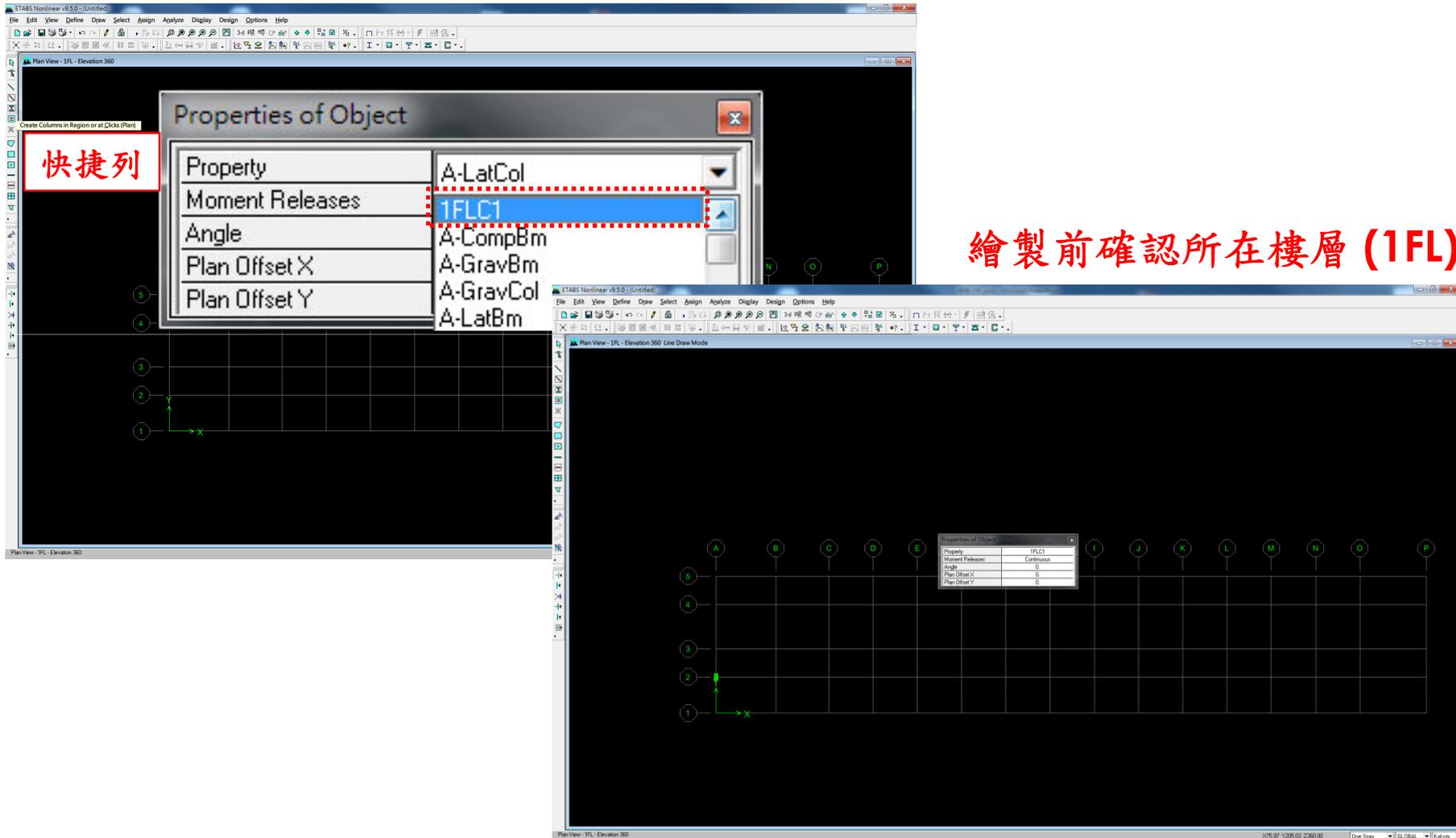
OK Cancel

EQ

1FLC1

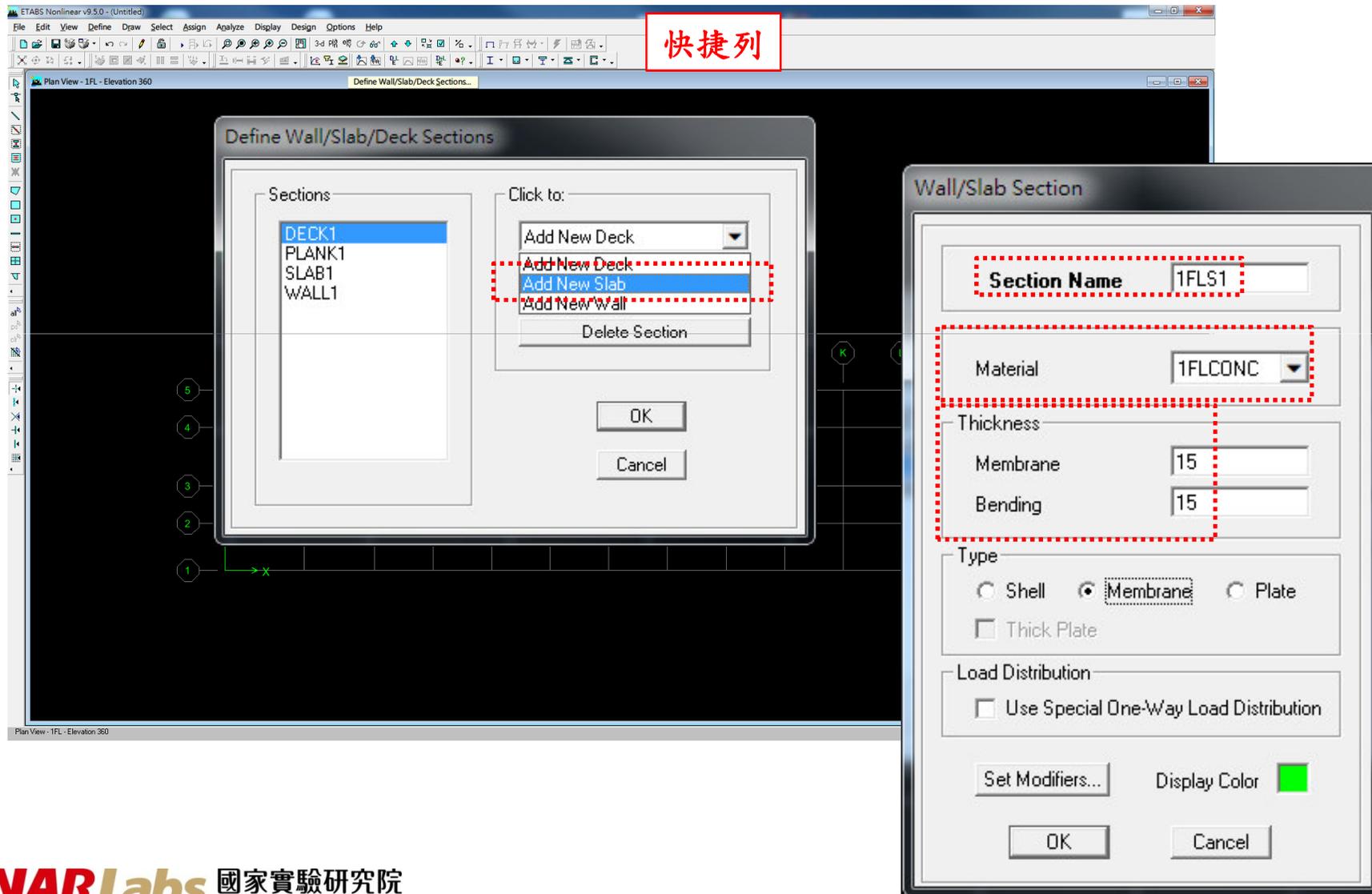
3. 繪製柱、梁

- 選擇柱斷面 (以1FLC1為例)



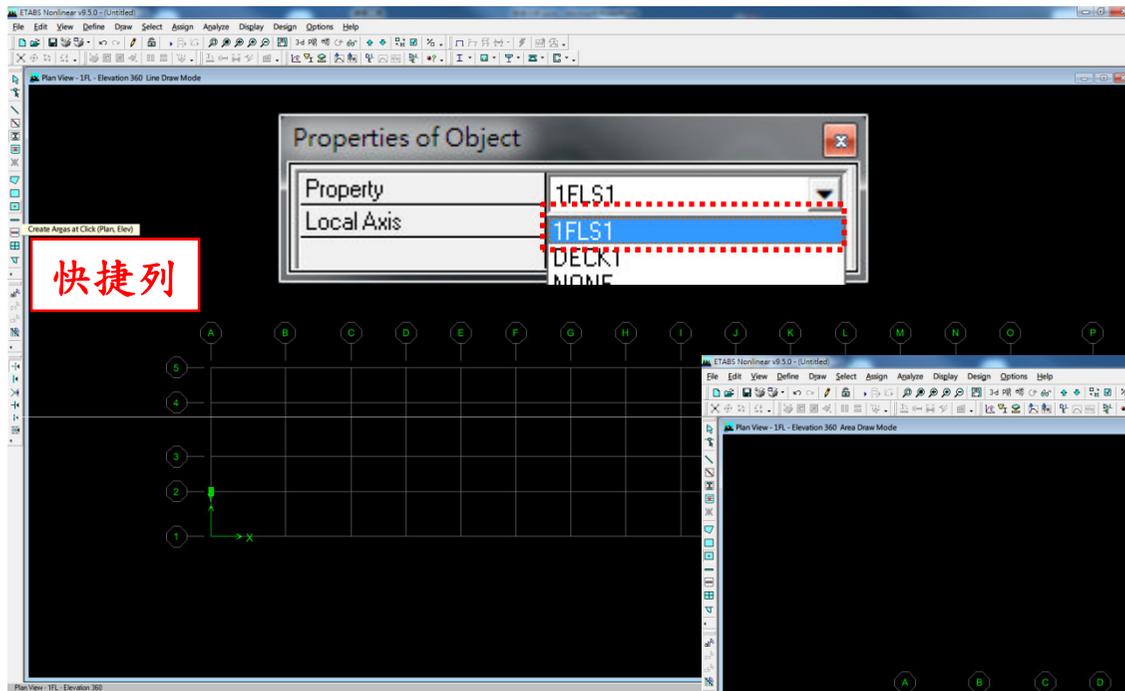
4. 新增樓版

- Define → Wall/Slab/Deck Sections

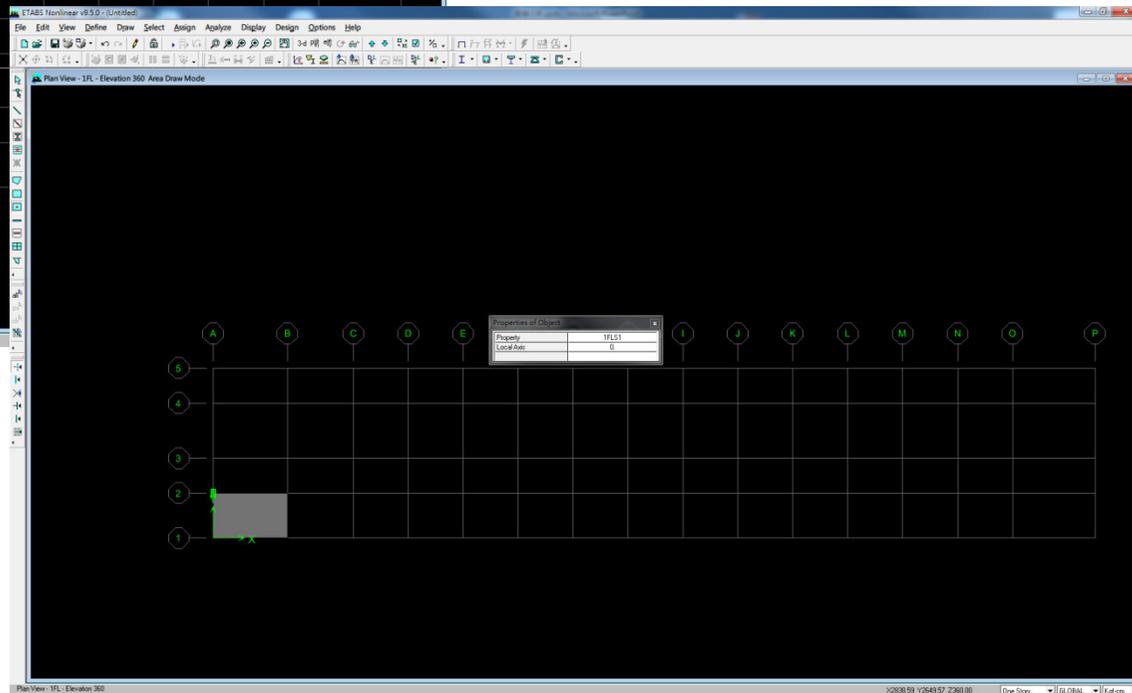


5. 繪製樓版

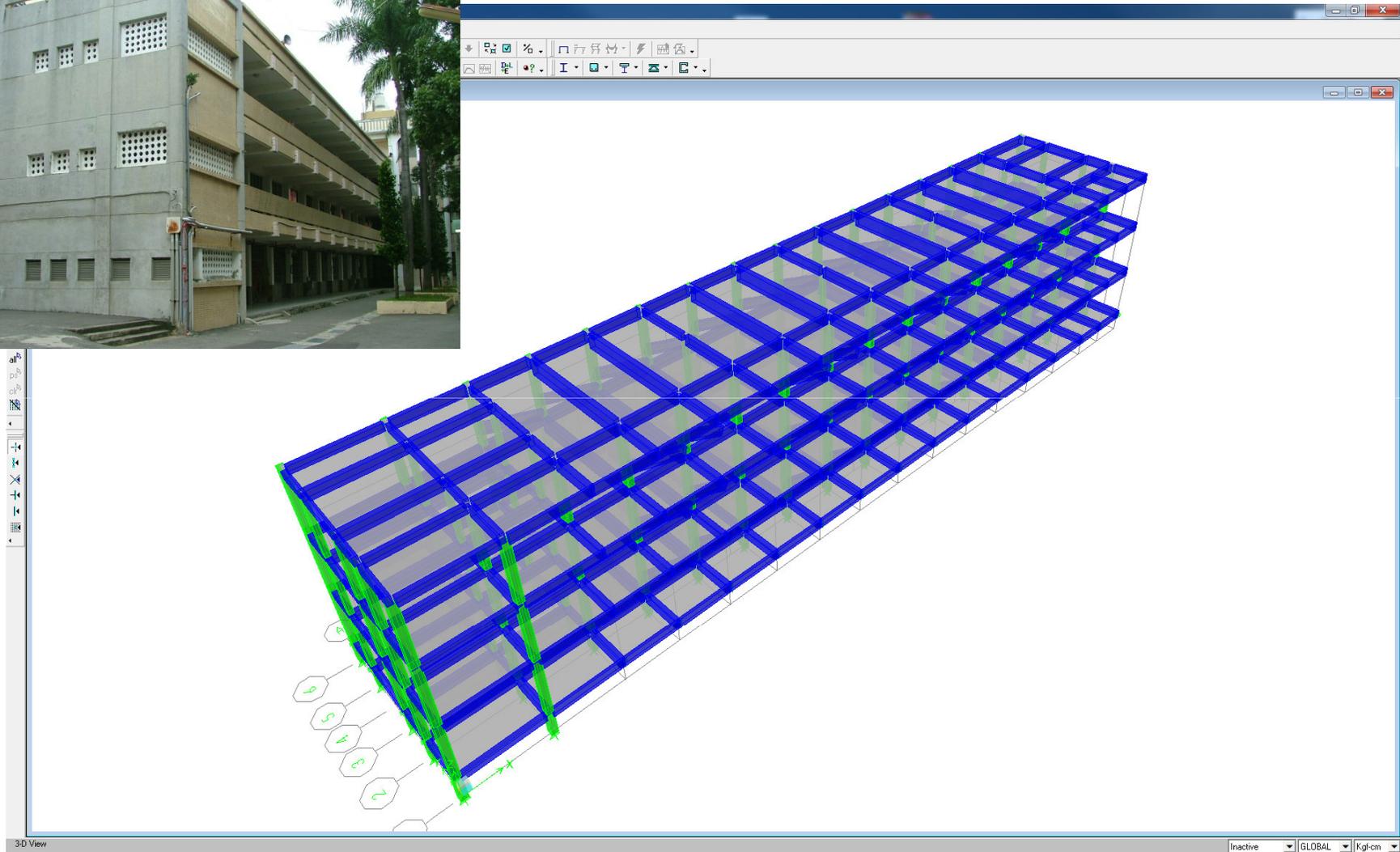
- 選擇樓版斷面 (以1FLS1為例)



繪製前確認所在樓層 (1FL)



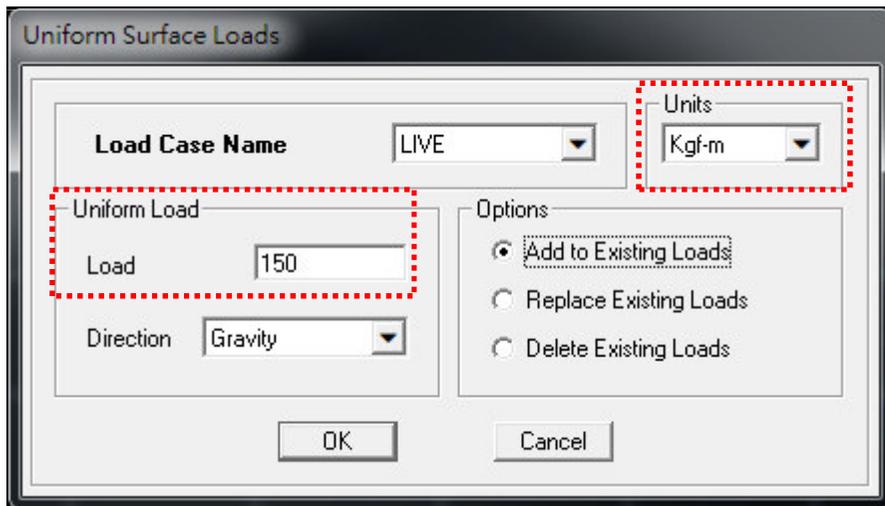
3D模型樣貌



6. 設定垂直載重

- 進行側推分析時，建議考慮之垂直載重應包含設計靜載重加上 $1/2$ 設計活載重
- 本案例校舍設定 $1/2$ 設計活載重為 150 kgf/m^2

確認單位為 kgf-m



建築技術規則建築構造編第十七條：

建築物構造之活載重，因樓地板之用途而不同，不得小於以下所列：

教室： 250 kgf/m^2

圖書館： 600 kgf/m^2

7. 設定基礎邊界條件

- Assign → Restraints (Supports)

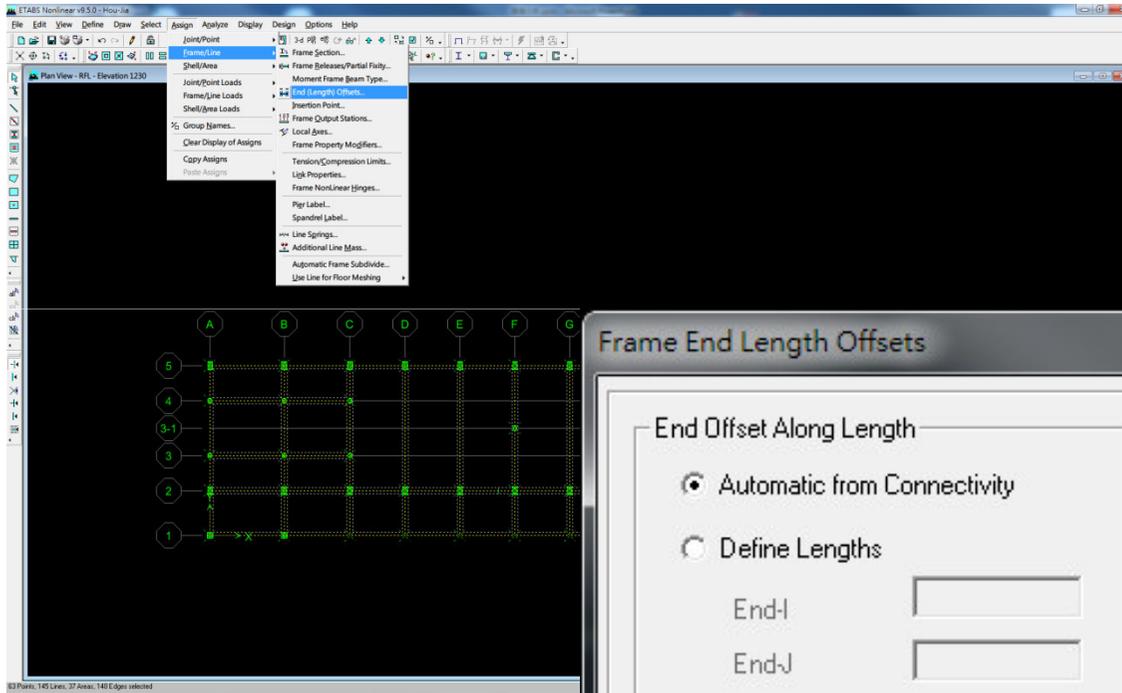
The image displays the ETABS software interface. The main window shows a structural model with a grid of columns and beams. A red dashed box highlights the base of the structure, labeled 'BASE'. A red box with the text '快捷列' (Shortcut Column) is positioned above the model. Two 'Assign Restraints' dialog boxes are overlaid on the screen. The top-right dialog box is titled 'Assign Restraints' and contains the following options:

- Restraints in Global Directions:
 - Translation X
 - Translation Y
 - Translation Z
 - Rotation about X
 - Rotation about Y
 - Rotation about Z
- Fast Restraints:
 - [Icon: Fixed Support]
 - [Icon: Roller Support]
 - [Icon: Pin Support]
 - [Icon: Point Support]

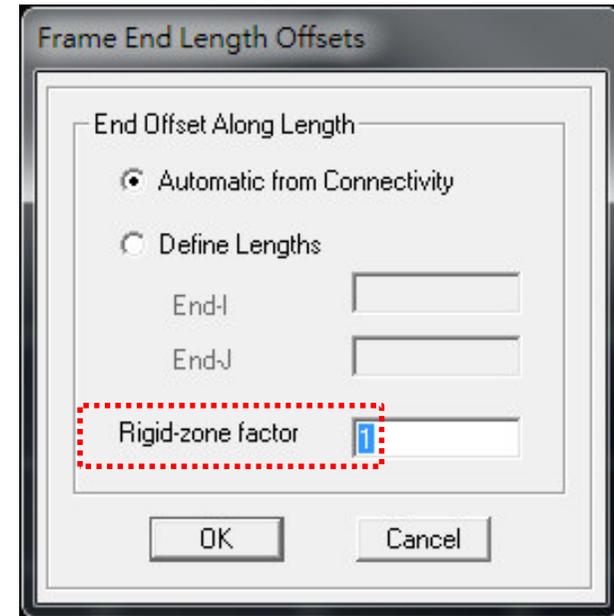
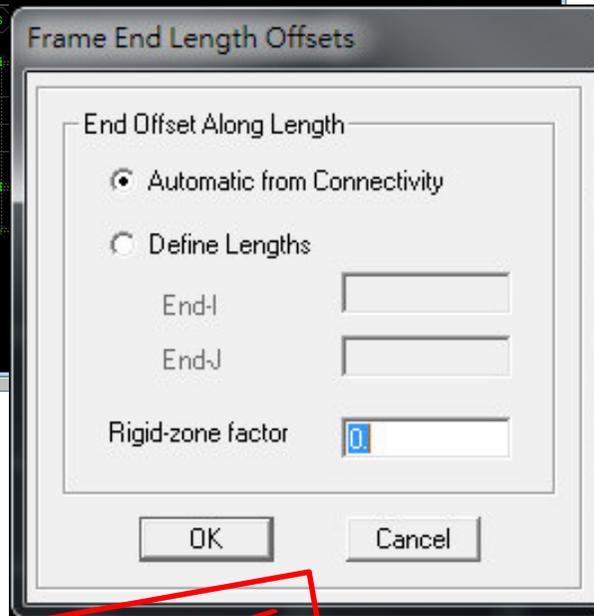
The bottom-left dialog box is a smaller version of the same 'Assign Restraints' dialog, with a red box containing the text '預設畫面' (Default Screen) overlaid on it.

8. 設定為剛性接頭

- Assign → Frame/Line → End (Length) Offsets



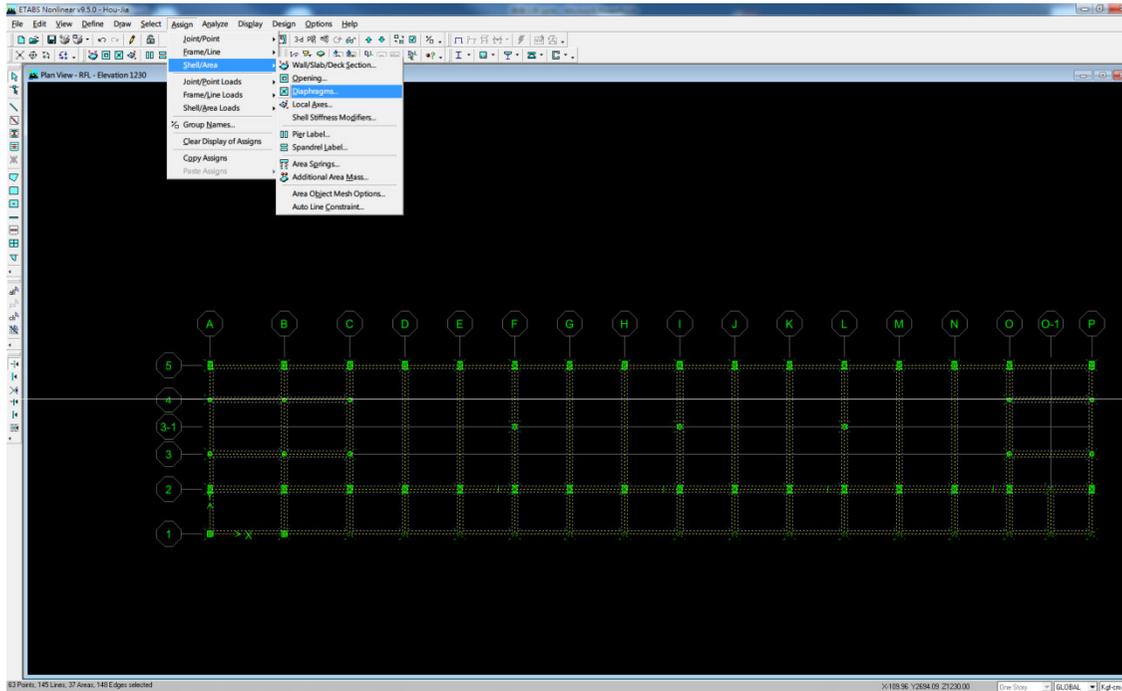
將梁柱接頭部分視為剛體：
Rigid zone factor=1，
預設值為 0



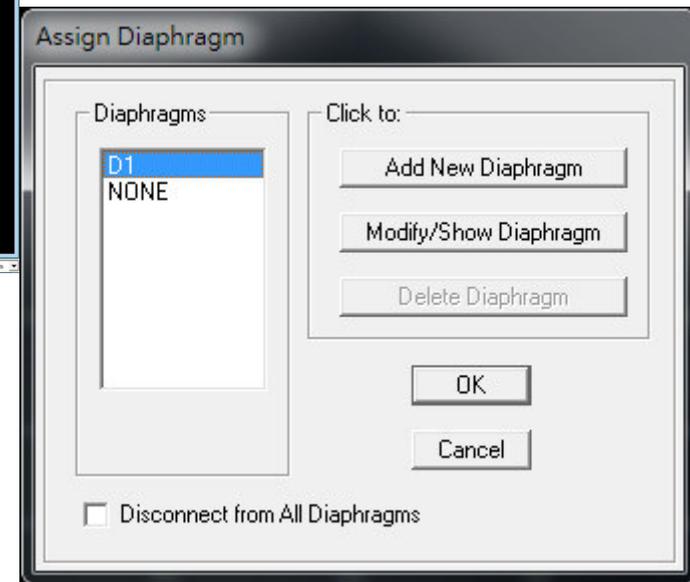
預設畫面

9. 設定剛性樓板

- Assign → Shell/Area → Diaphragms

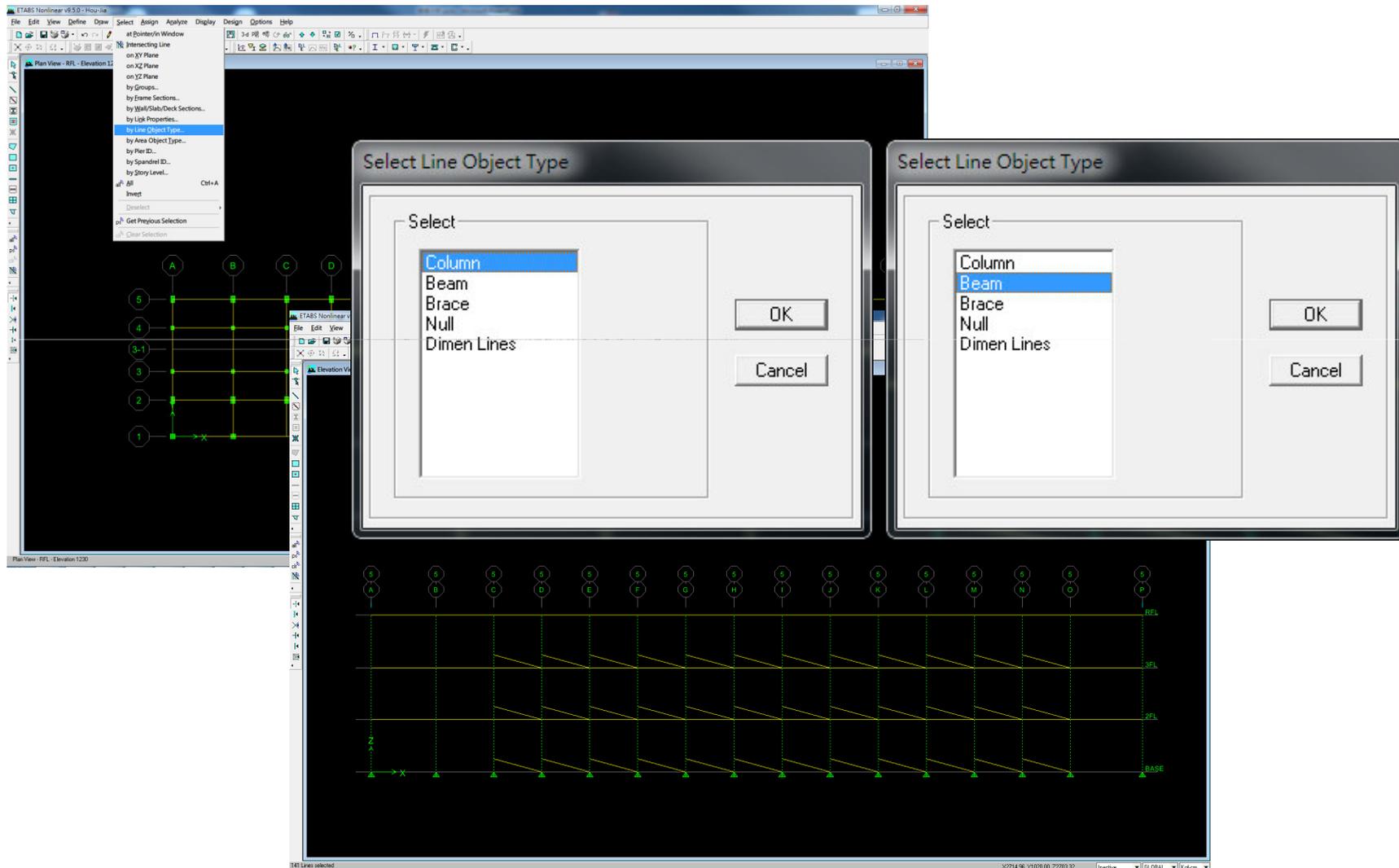


為簡化低矮型校舍結構物之側推分析，將樓版假設為剛性樓版



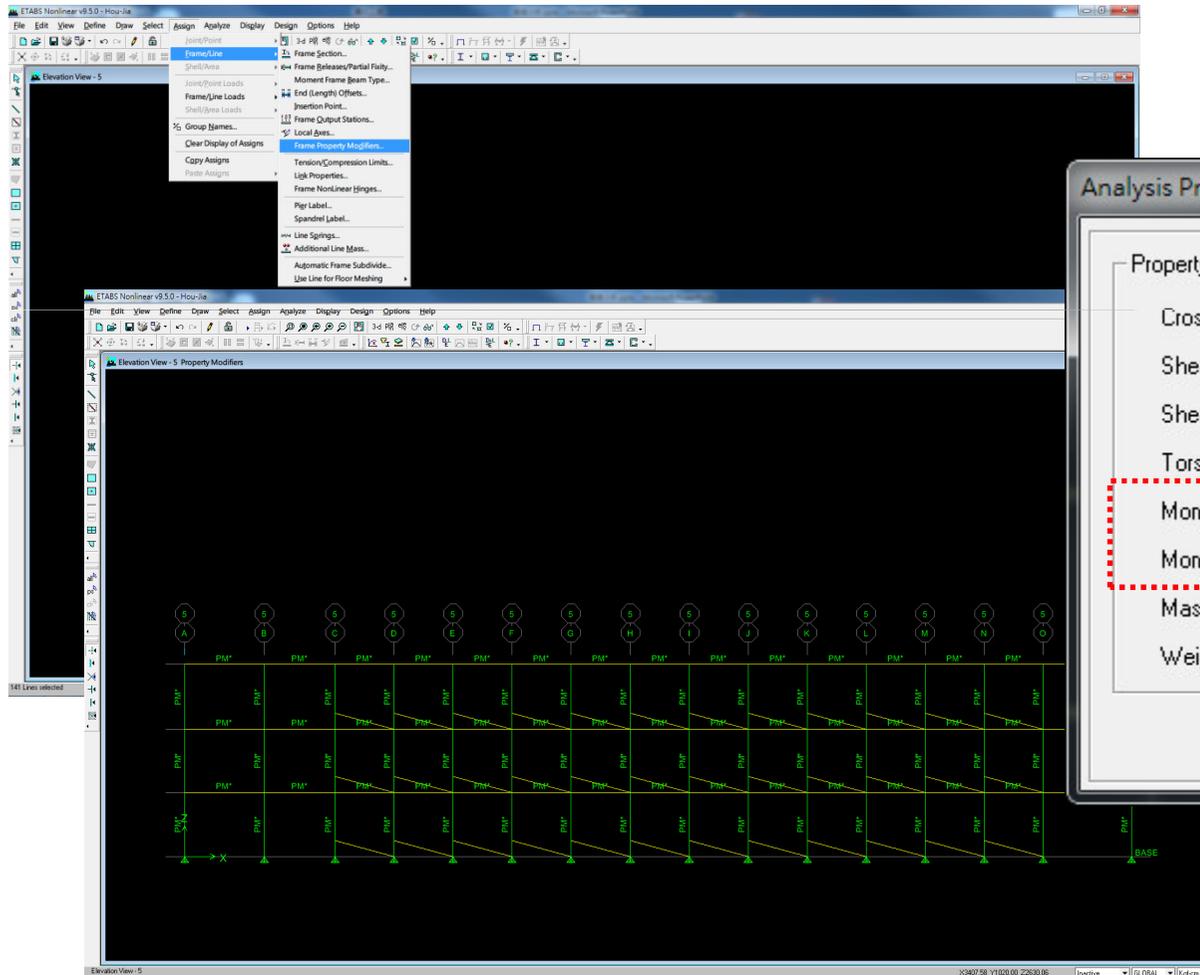
10. 撓曲勁度折減

- Select → by Line Object Type

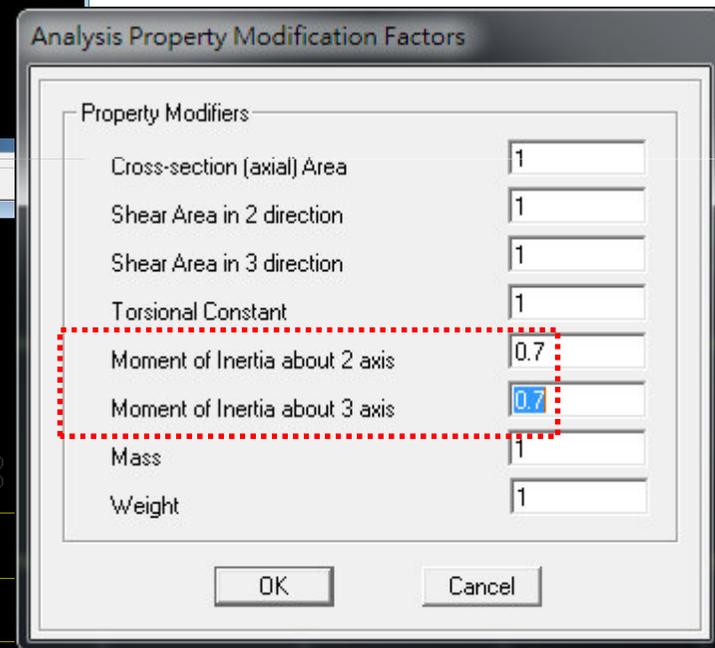


10. 撓曲勁度折減

- Assign → Frame/Line → Frame Property Modifiers

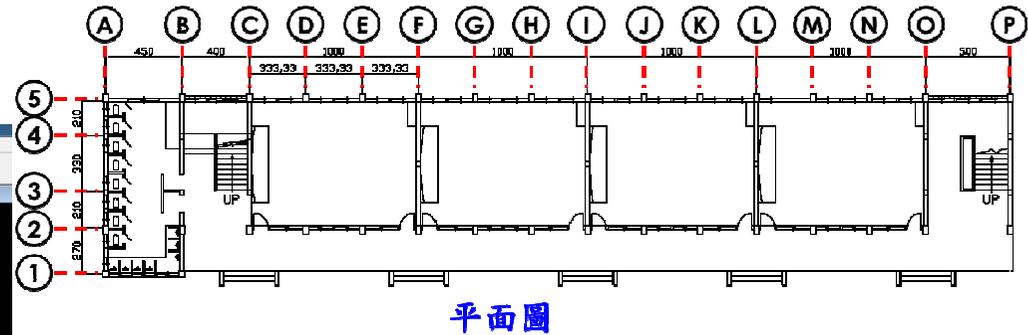


柱構件折減 0.7
梁構件折減 0.7



快速建立模型之技巧

- Edit → Replicate



ETABS Nonlinear v9.5.0 - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Help

Undo Assign Property Modifiers Ctrl+Z
Redo Ctrl+Y

Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Delete
Add to Model from Template

Replicate
Edit Grid Data
Edit Story Data
Edit Reference Planes...
Edit Reference Lines...
Merge Points...
Align Points/Lines/Edges...
Move Points/Lines/Areas...
Expand/Shrink Areas...
Merge Areas
Mesh Walls for Openings
Mesh Areas...
Split Area Edge
Join Lines
Divide Lines...
Extrude Points to Lines...
Extrude Lines to Areas...
Auto Relabel All...

Replicate

Linear Radial Mirror Story

Increment Data

dx 333
dy 0
Number 12

Options...
OK
Cancel

Delete Original

ETABS Nonlinear v9.5.0 - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Help

ETABS Nonlinear v9.5.0 - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Help

3305.74 Y102.00 22728.32

設定非線性鉸

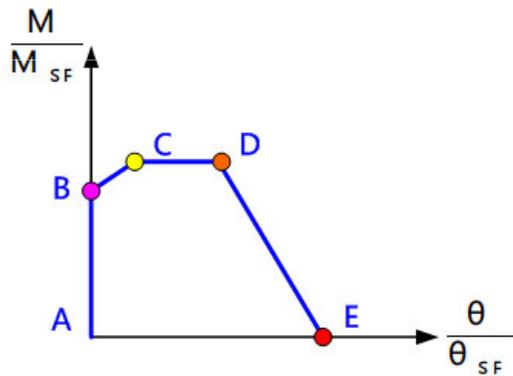
- **ETABS** 內建
- 自行定義

ETABS 內建之非線性鉸

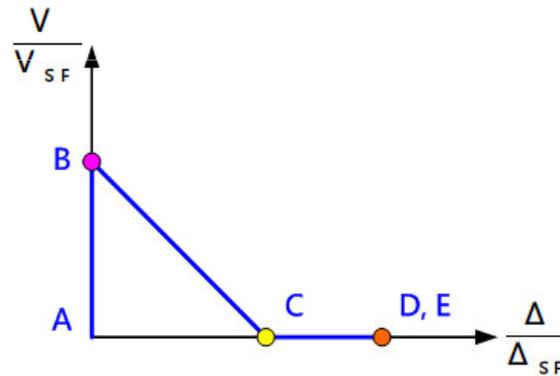
- 依據 **FEMA 273** 及 **ATC-40** 之建議，內建四種非線性鉸：
 1. 軸力非線性鉸 (axial hinge) : P
 2. 與軸力互制之彎矩非線性鉸 (P-M-M hinge) : PMM
 3. 彎矩非線性鉸 (moment hinge) : M3 (X向)、M2 (Y向)
 4. 剪力非線性鉸 (shear hinge) : V2 (X向)、V3 (Y向)

自行定義非線性鉸

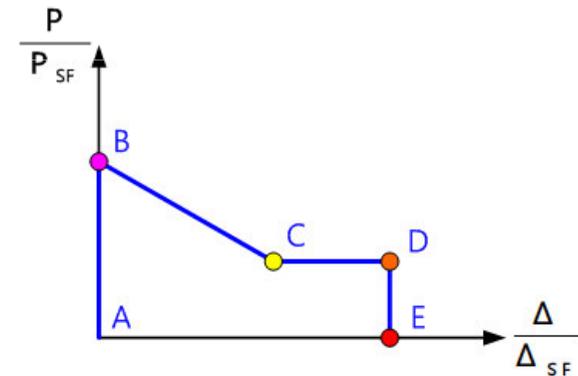
- **ETABS .e2k** 模型檔
- **TEASPA** 輔助分析程式
- 輔助程式共用輸入檔



彎矩非線性鉸參數



剪力非線性鉸參數



軸力非線性鉸參數

TEASPA 輔助分析程式

□ Win 32 位元

- [\[程式\] TEASPA 32 位元 \(版本 2014.4.25\)](#)
 - BWPH、COLPH、SWPH、PGA
- [\[程式\] Windows 32 位元 MCR Installer](#)

□ Win 64 位元

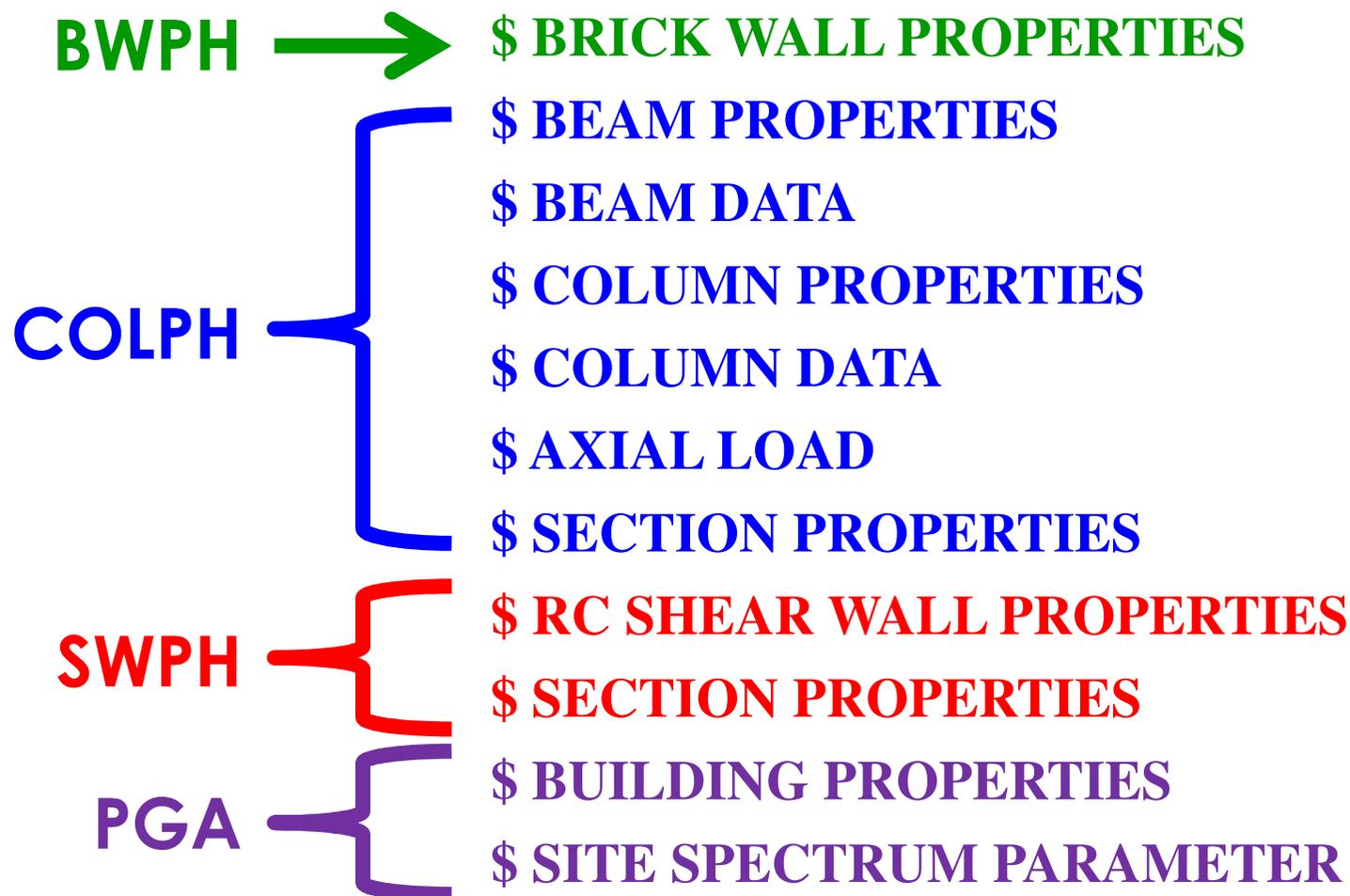
- [\[程式\] TEASPA 64 位元 \(版本 2014.4.25\)](#)
 - BWPH、COLPH、SWPH、PGA
- [\[程式\] Windows 64 位元 MCR Installer](#)

TEASPA 輔助分析程式

- 自動計算磚牆構件非線性鉸程式
 - **BWPH.exe**
- 自動計算梁柱構件非線性鉸程式
 - **COLPH.exe**
- 自動計算 **RC** 牆構件非線性鉸程式
 - **SWPH.exe**
- 自動計算性能目標地表加速度程式
 - **PGA.exe**

輔助程式共用輸入檔 (*.txt)

- 技術手冊 (NCREE 13-023) 附錄 B：
耐震詳細評估輔助分析程式使用說明



柱、梁桿件之模擬與設定

COLPH.exe

柱之破壞模式

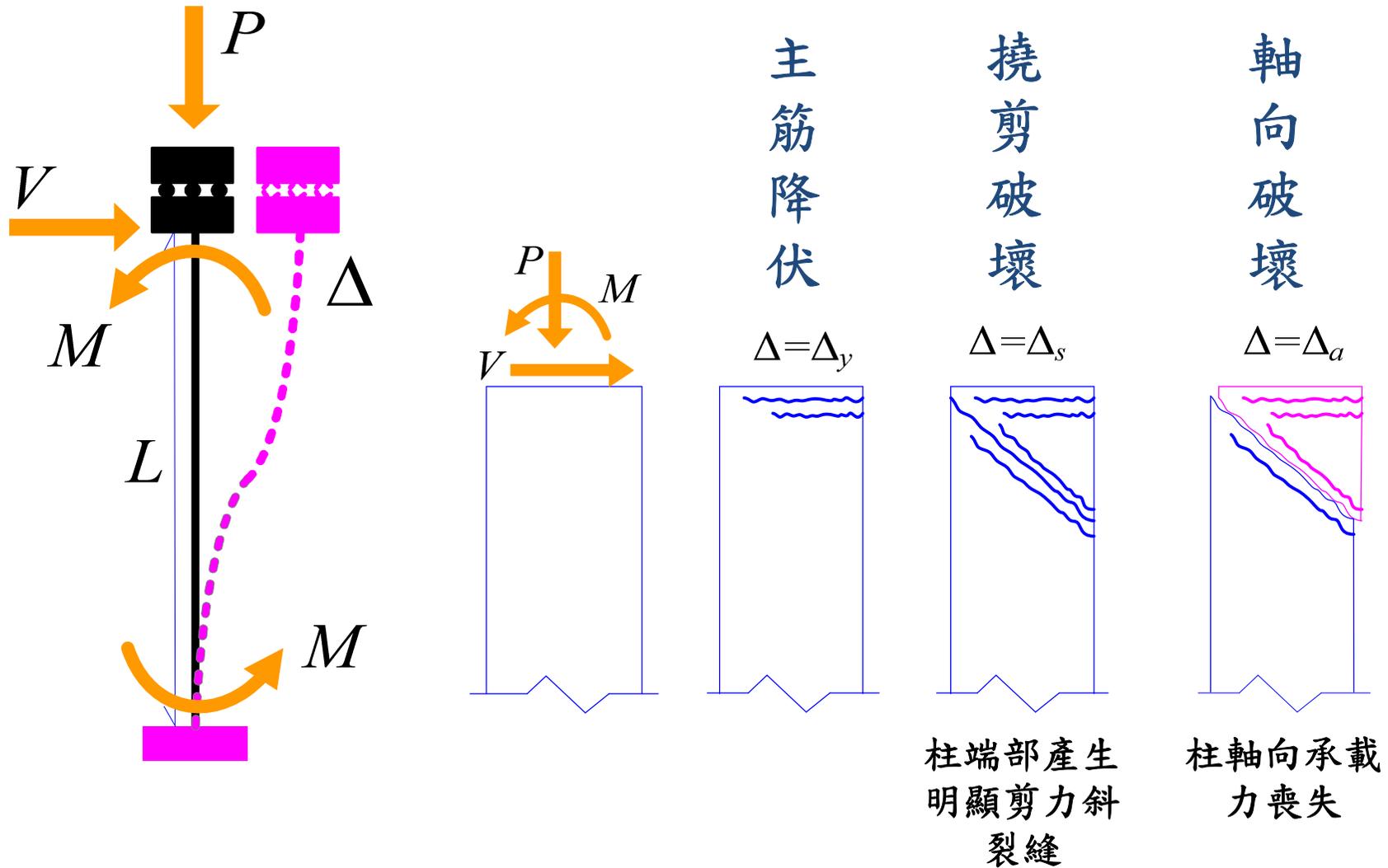
撓曲、撓剪



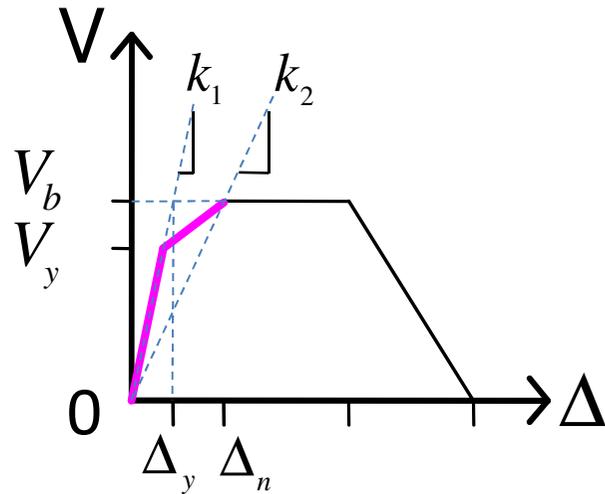
剪力



雙曲率柱側變位之發展歷程

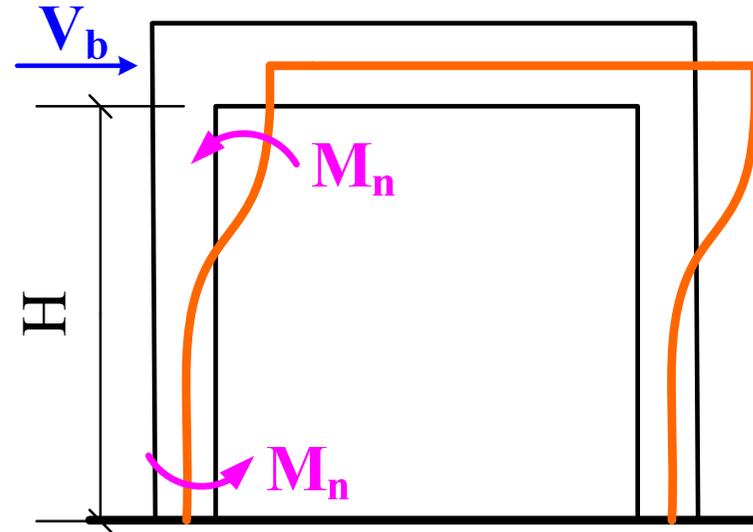


Load Deflection Curve due to Flexure



$$V_y = \frac{2M_y}{H}$$

$$k_1 = \frac{12 \times 0.7 E_c I_g}{H}$$

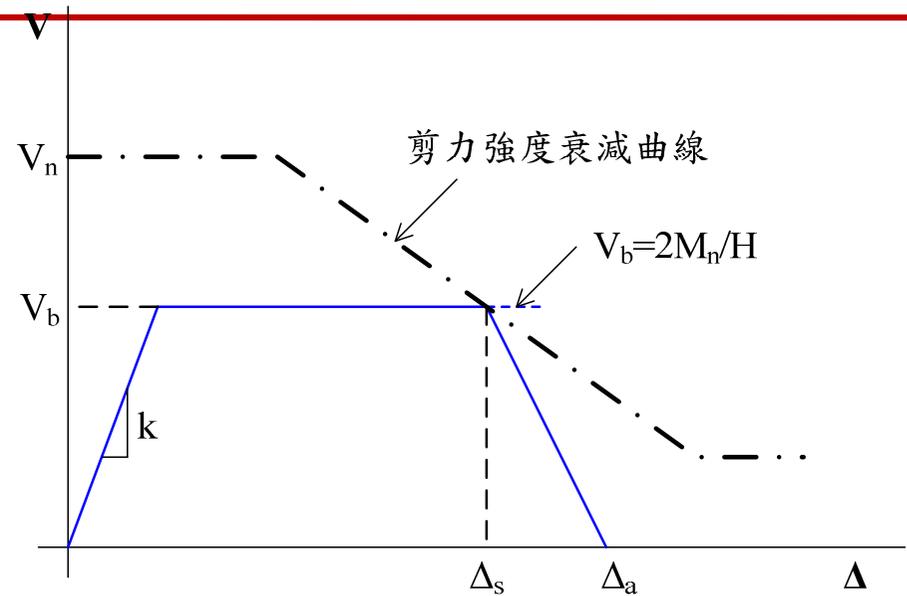
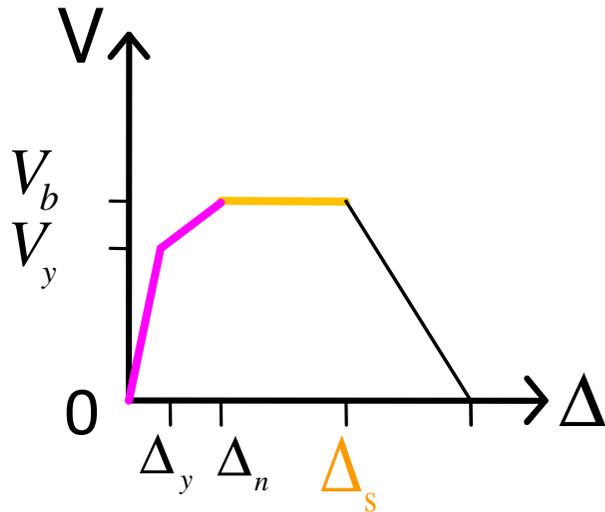


$$V_b = \frac{2M_n}{H}$$

$$k_2 = \frac{12 \times 0.35 E_c I_g}{H}$$

$$\Delta_y = \frac{V_b}{k_1} \quad \Delta_n = \frac{V_b}{k_2}$$

Load Deflection Curve due to Flexure



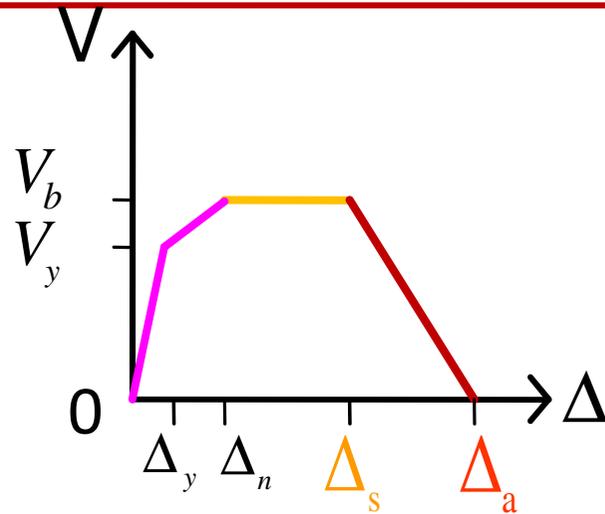
$$\Delta_s = \left(\frac{3}{100} + 4\rho'' - \frac{v_m}{133\sqrt{f'_c}} - \frac{P}{40A_g f'_c} \right) H$$

Where $\rho'' = \frac{A_{st}}{bs}$ 為剪力箍筋體積比

$v_m = \frac{V_b}{bd}$ 為剪應力

Elwood & Moehle (2005)

Load Deflection Curve due to Flexure

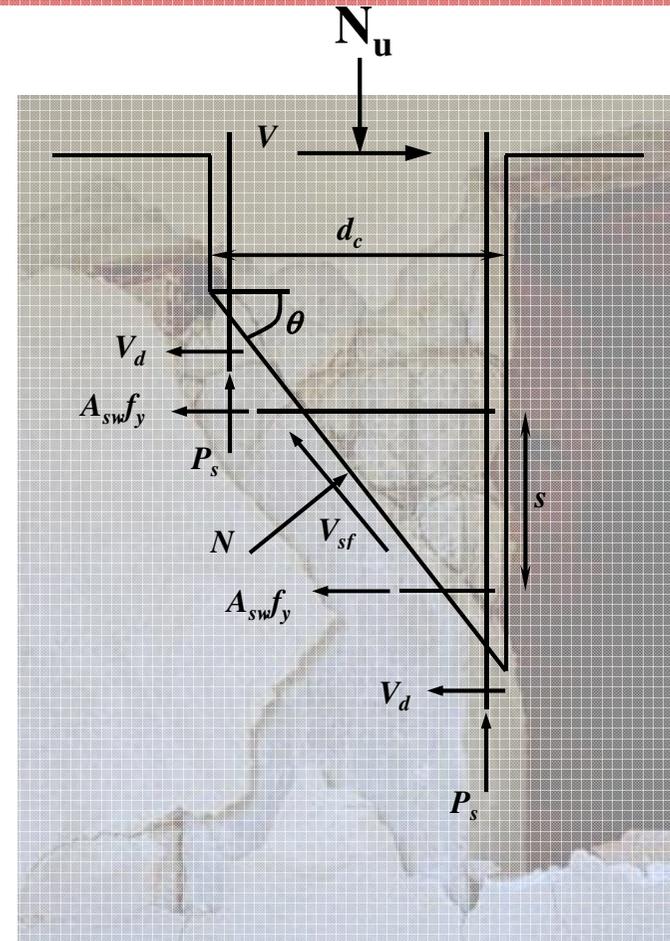


$$\Delta_a = \left(\frac{4}{100} \frac{1 + \tan^2 \theta}{\tan \theta + P \frac{s}{\kappa' A_{st} f_{yt} d_c \tan \theta}} \right) H$$

$\kappa' = 1.0$, for $\Delta_s / \Delta_y \leq 2$;

$\kappa' = 0.7$, for $\Delta_s / \Delta_y \geq 6$;

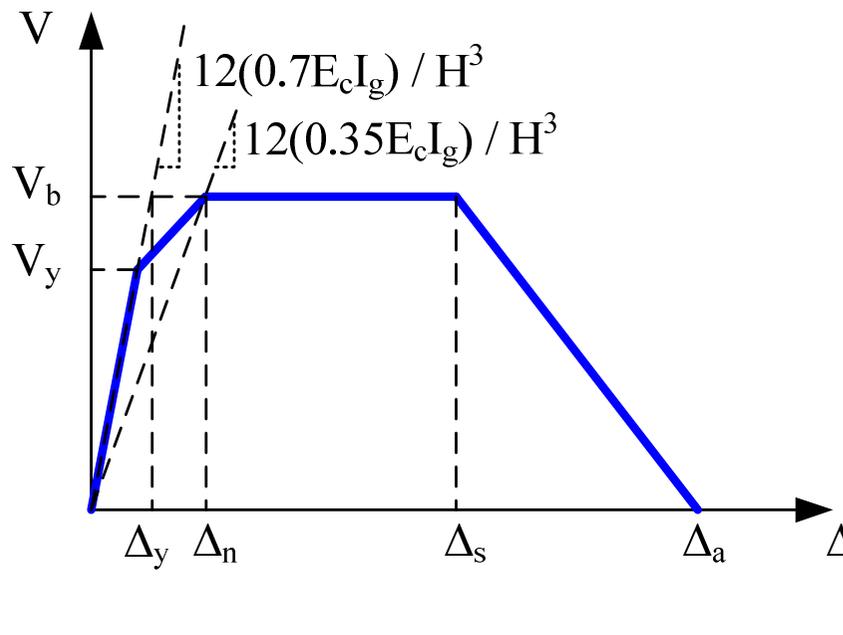
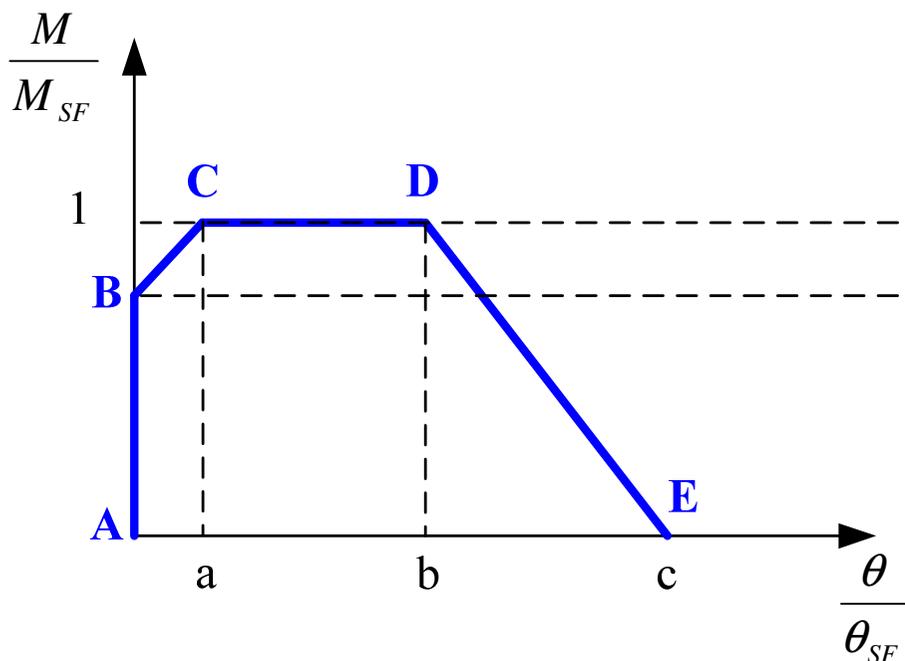
interpolation for Δ_s / Δ_y between 2 to 6.



Elwood & Moehle (2005)

d_c : 核心混凝土深度
(箍筋中心到中心距離)

撓剪破壞非線性鉸參數



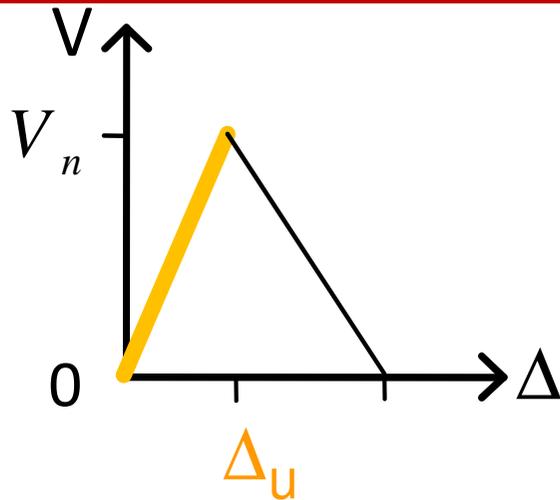
Point	Moment / SF	Rotation / SF
A	0	0
B	$\min(M_y/M_n, 0.95)$	0
C	1	a
D	1	b
E	0	c

$$a = \frac{\Delta_n}{H} - \frac{\Delta_y}{H} \quad b = \frac{\Delta_s}{H} - \frac{\Delta_y}{H}$$

$$c = \max\left(\frac{\Delta_a}{H}, \frac{\Delta_s}{H}\right) \quad \Delta_y = \frac{V_b}{k} = \frac{V_b H^3}{12(0.7E_c I_g)}$$

Moment SF	M_n
Rotation SF	1

Load Deflection Curve due to Shear



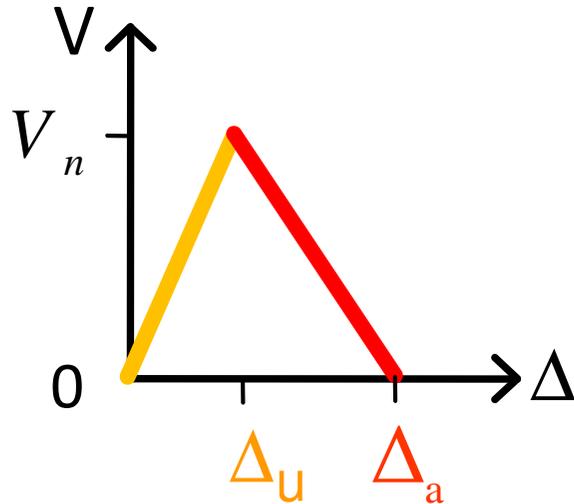
- Lateral strength of double curvature column
- Lateral stiffness of double curvature column
- Lateral displacement of yielding point

$$V_n = V_c + V_s$$

$$k_1 = \frac{12 \times 0.7 E_c I_g}{H}$$

$$\Delta_u = \frac{V_n}{k}$$

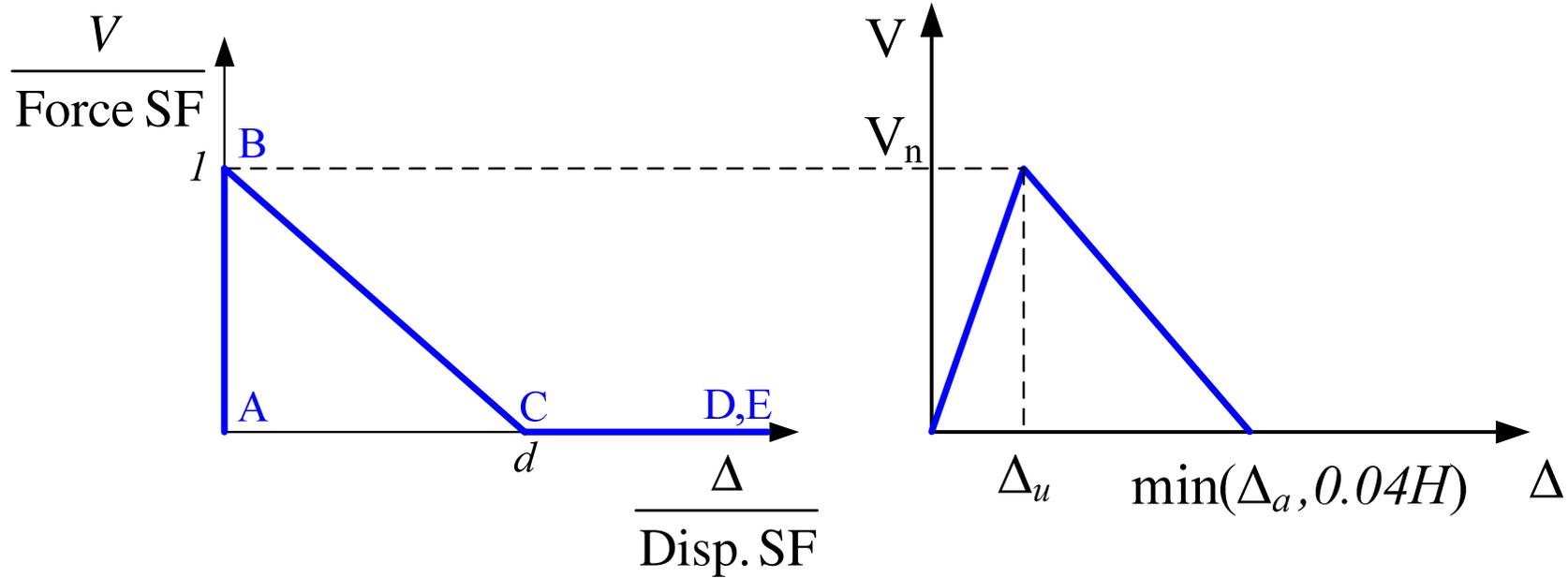
Load Deflection Curve due to Shear



$$\Delta_a = \left(\frac{4}{100} \frac{1 + \tan^2 \theta}{\tan \theta + P \frac{s}{\kappa' A_{st} f_{yt} d_c \tan \theta}} \right) H$$

$\kappa' = 1.0$, for shear failure

剪力破壞非線性鉸參數

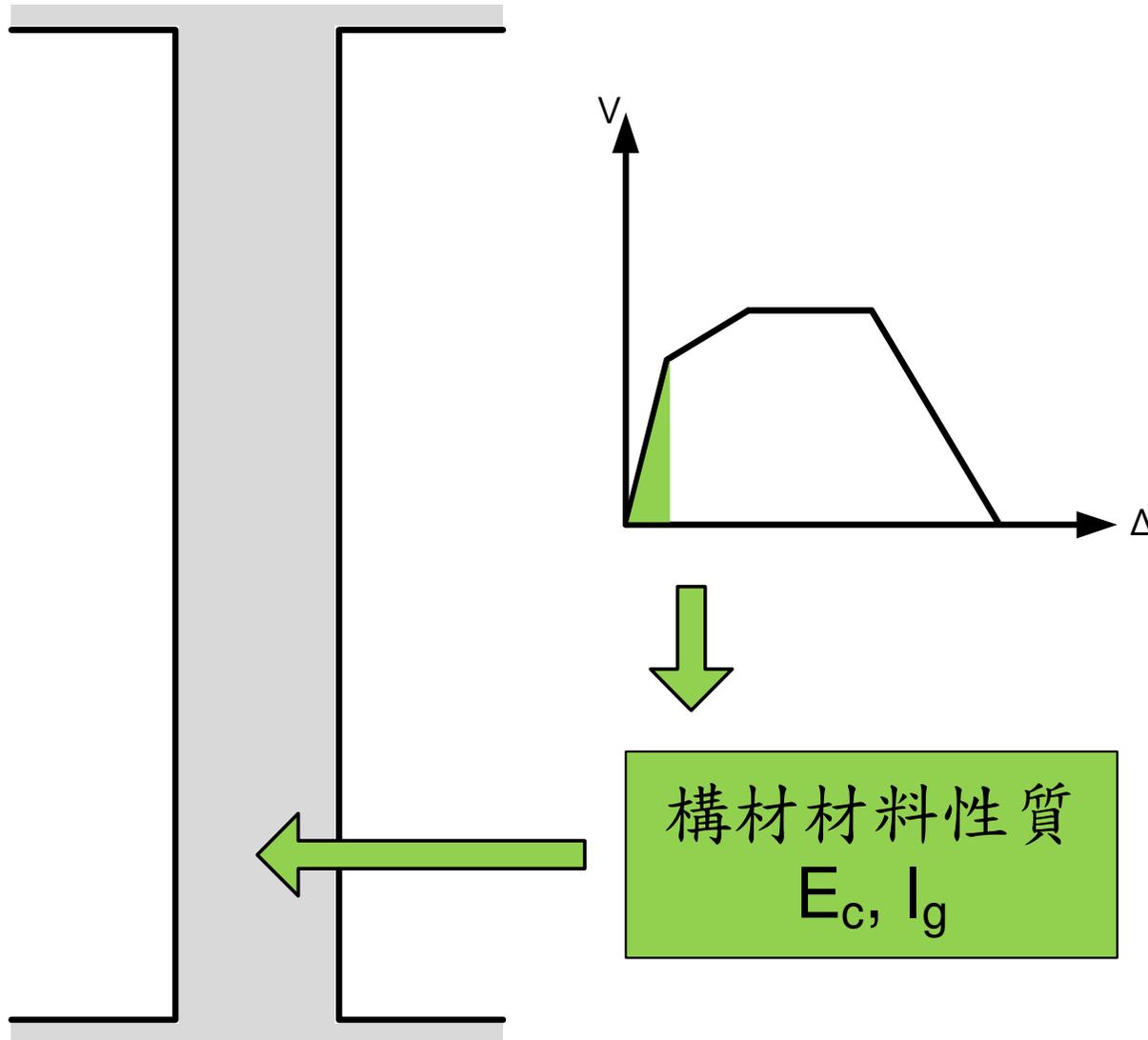


Point	Force / SF	Disp / SF
A	0	0
B	1	0
C	0	d
D	0	10d
E	0	10d

$$d = \min\left(\frac{\Delta_a}{H}, 0.04\right)$$

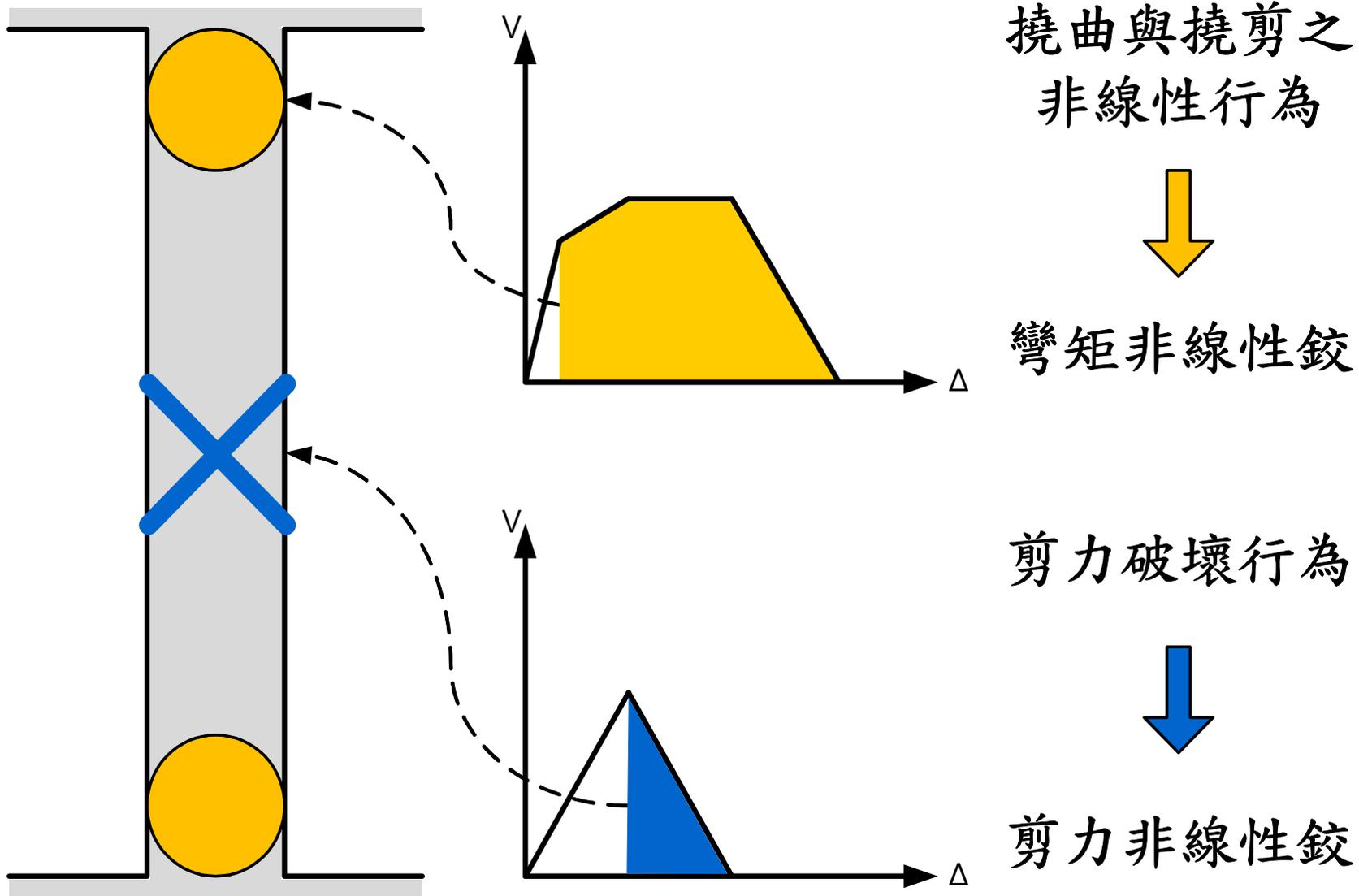
Force SF	V_n
Disp SF	H

柱彈性行為模擬



彈性勁度
折減
 $0.7E_c I_g$

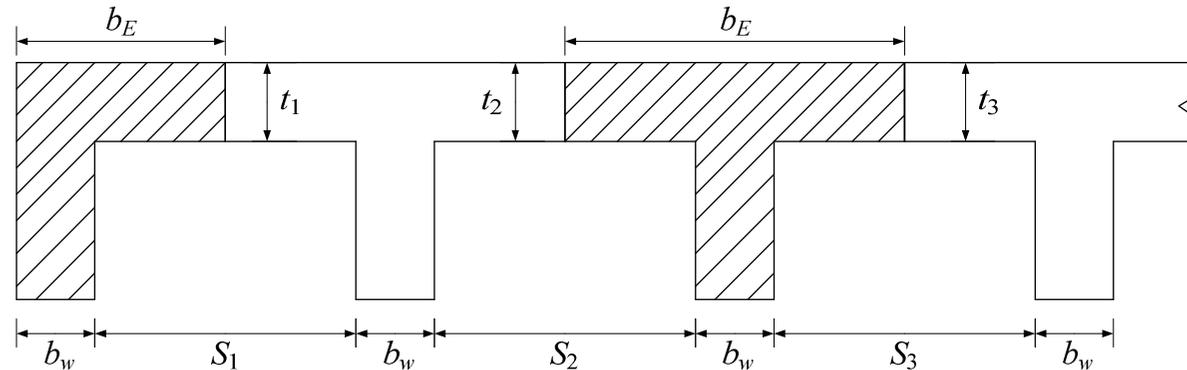
柱非線性行為模擬



梁之非線性鉸設定

- 校舍結構之梁常與樓板連接形成 **T型梁**，因此梁的模擬應考慮 **T型梁** 之行為
- 技術手冊第三版依據 **ASCE 41-06** 所建議之 **梁非線性鉸參數** 進行設定
- 設定 **T型梁非線性鉸** 時，因斷面呈 **T型** 不對稱之緣故，必須注意其非線性鉸因正負彎矩的差異性，因其斷面呈 **T型** 不對稱之緣故

T 型梁有效翼緣寬度



1. T 型梁翼緣之有效版寬不得超過該梁跨度之 **1/4**；梁腹每側懸出之有效翼緣寬度不得超過翼緣厚(版厚)之 **8** 倍或該梁與鄰梁間淨距之 **1/2**。

$$b_E = \min(L/4, b_w + \min(8t_2, \frac{S_2}{2}) + \min(8t_3, \frac{S_3}{2}))$$

2. 梁僅一側有翼緣者，其有效懸出翼緣寬度不得超過該梁跨度之 **1/12**、翼緣厚(版厚)之 **6** 倍或該梁與鄰梁間淨距之 **1/2**。

$$b_E = \min(b_w + \frac{L}{12}, b_w + 6t_1, b_w + \frac{S_1}{2})$$

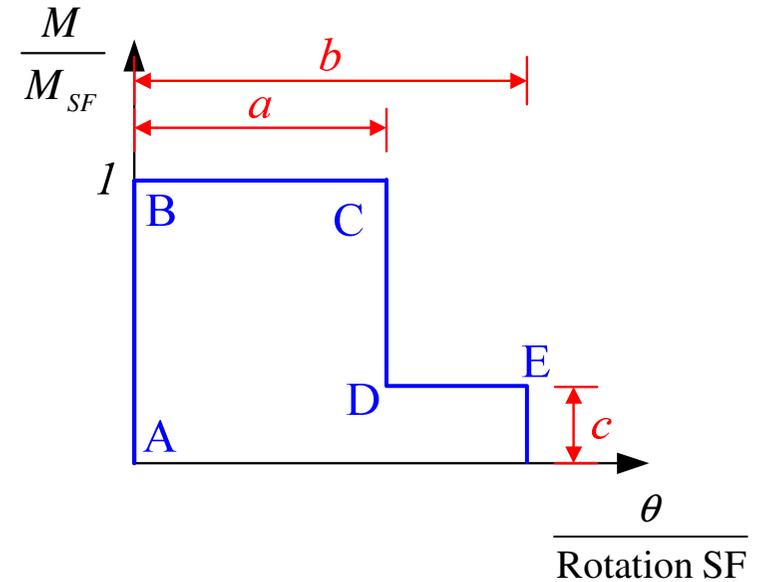
梁彎矩非線性鉸參數

$\frac{\rho - \rho'}{\rho_{bal}}$	箍筋	$\frac{V}{0.27b_w d \sqrt{f'_c}}$	a	b	c
≤ 0.0	有圍束	≤ 3	0.025	0.05	0.2
≤ 0.0	有圍束	≥ 6	0.02	0.04	0.2
≥ 0.5	有圍束	≤ 3	0.02	0.03	0.2
≥ 0.5	有圍束	≥ 6	0.015	0.02	0.2
≤ 0.0	無圍束	≤ 3	0.02	0.03	0.2
≤ 0.0	無圍束	≥ 6	0.01	0.015	0.2
≥ 0.5	無圍束	≤ 3	0.01	0.015	0.2
≥ 0.5	無圍束	≥ 6	0.005	0.01	0.2

ρ : 梁斷面受拉鋼筋比

ρ' : 梁斷面受壓鋼筋比

ρ_{bal} : 梁斷面產生平衡應變狀態之鋼筋比

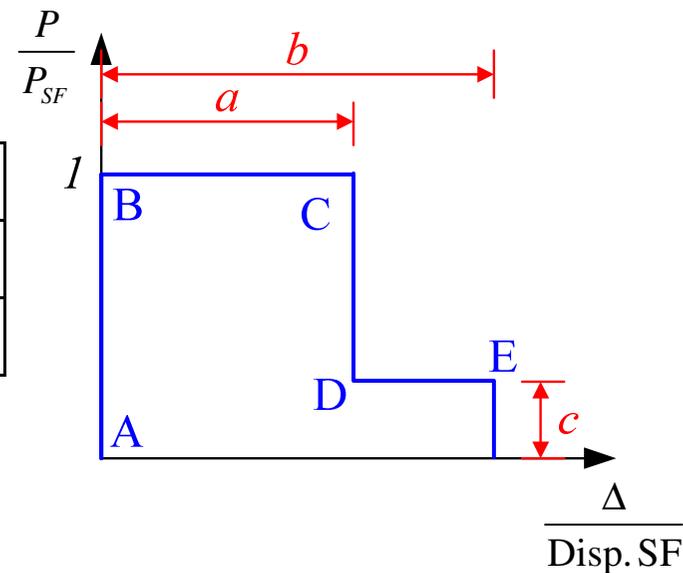


彎矩非線性鉸

Point	Moment / SF	Rotation / SF
A	0	0
B	1	0
C	1	a
D	c	a
E	c	b

梁剪力非線性鉸參數

箍筋間距	a	b	c
箍筋間距 $\leq (d/2)$	0.003	0.02	0.2
箍筋間距 $> (d/2)$	0.003	0.01	0.2



d ：有效深度
(構材最外受壓纖維至受拉鋼筋斷面重心之距離)

剪力非線性鉸

Point	Force / SF	Disp / SF
A	0	0
B	1	0
C	1	a
D	c	a
E	c	b

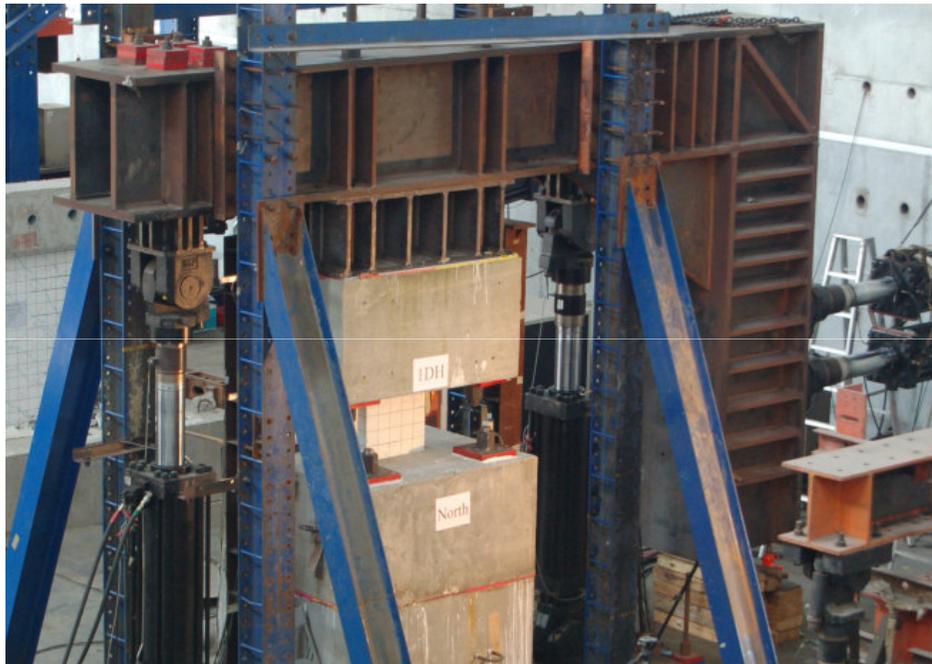
極短柱之模擬與設定

COLPH.exe

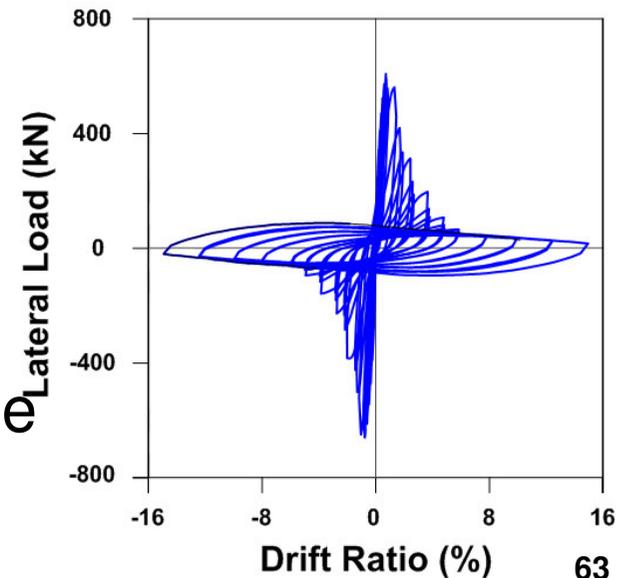
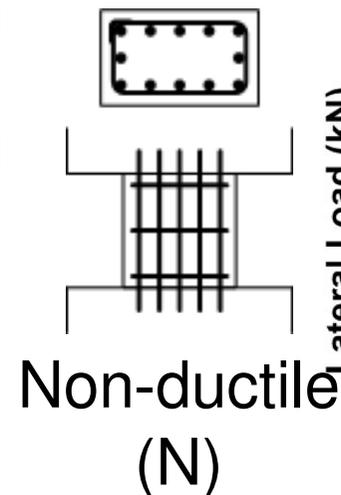
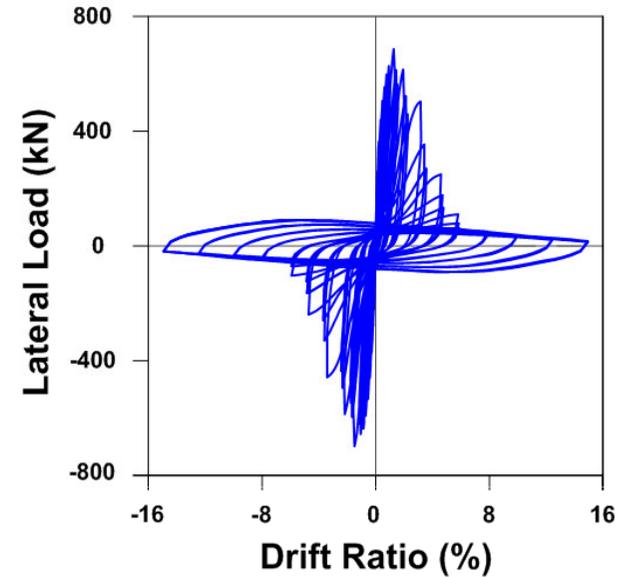
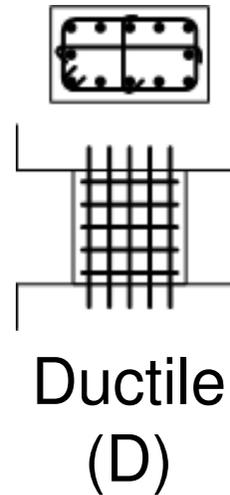
極短柱之剪力強度

- 對於鋼筋混凝土構件之剪力強度，第二版係參酌 **ACI 318** 規範公式以提出建議，但若為極短柱 (**高寬比 ≤ 2 者**)，剪力強度之估算並不準確，恐 高估鋼筋貢獻之剪力強度。
- 第三版採用 軟化拉壓桿模式 (Softened Strut-and-Tie Model, SST)，做為前述剪力強度之計算，使得極短柱剪力強度之估算，更趨合理。

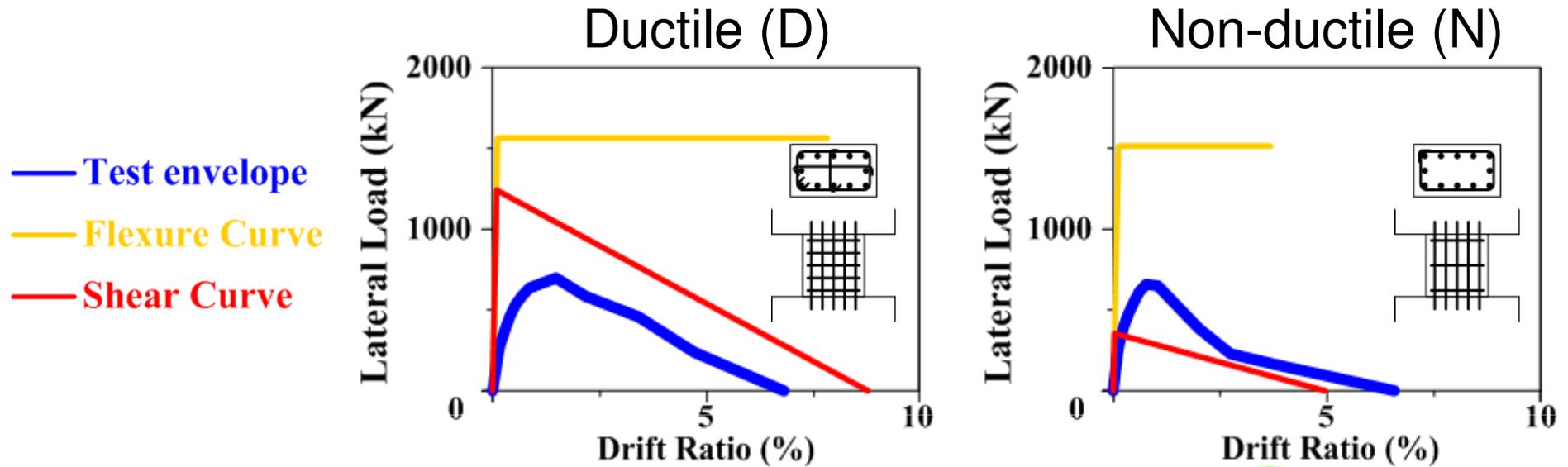
RC短柱受剪破壞之耐震評估研究



黃益堂、黃世建，「鋼筋混凝土短柱受剪破壞之耐震行為曲線研究」，國家地震工程研究中心研究報告，NCREE 08-027，2008。

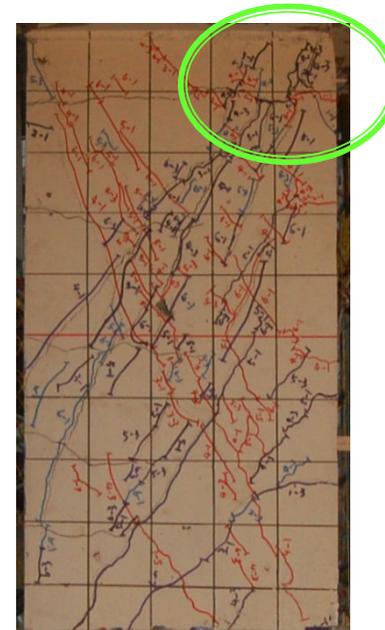


技術手冊第二版評估結果

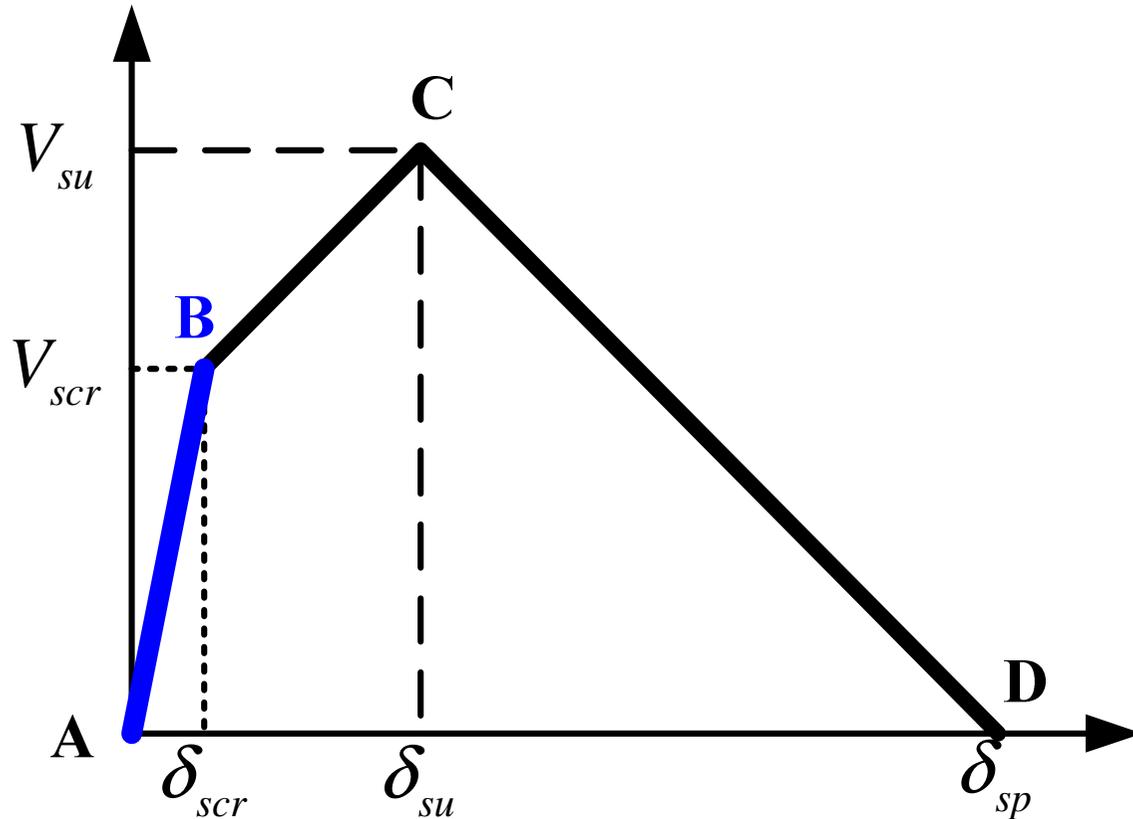


混凝土擠碎破壞

$$V_n = \frac{A_{st} f_{yt} d}{s} \cot \alpha + 0.17 \left(1 + \frac{N}{14A_g} \right) \sqrt{f'_c} bd$$



極短柱之剪力非線性行為



B：剪力開裂點

V_{scr} 以 ACI 牆開裂
公式計算

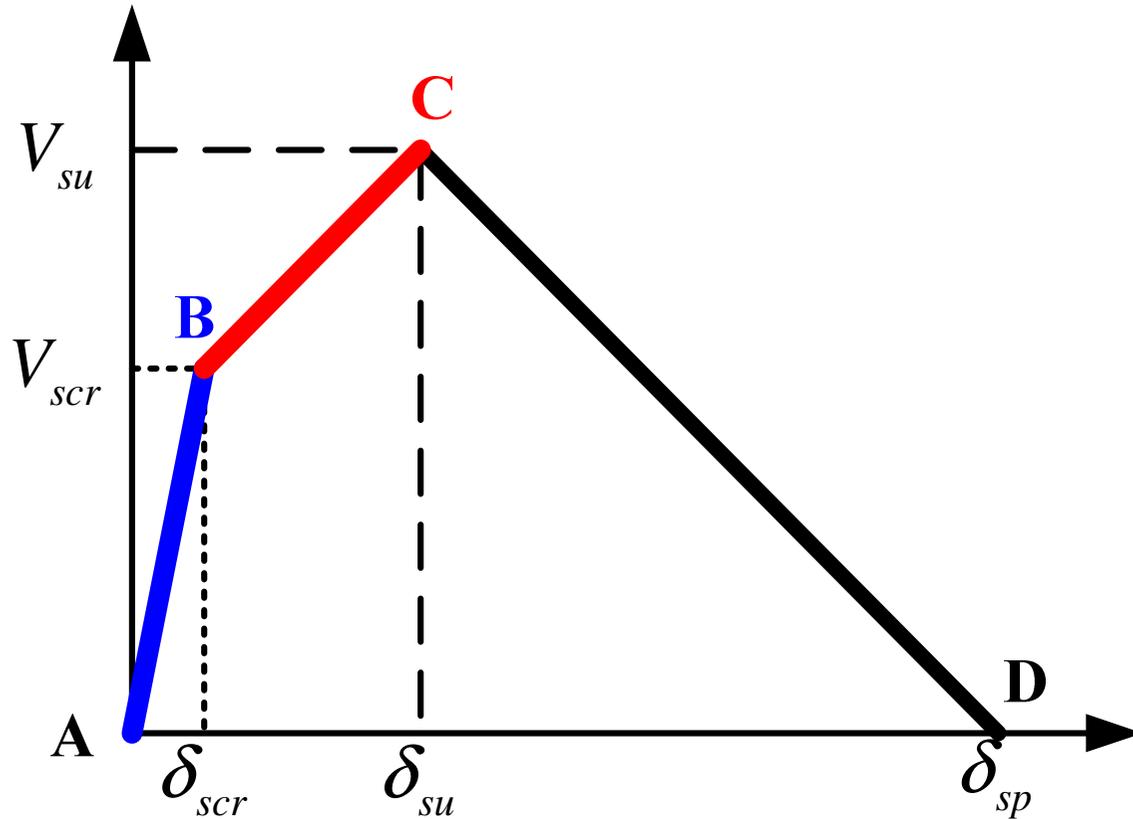
$$\delta_{scr} = \delta_{s,cr} + \delta_{f,cr}$$

$$\delta_{s,cr} = \gamma_{vh} H = \frac{2(1+\nu)}{E_c} \frac{1.2}{bh} V_{scr} H$$

$$\delta_{f,cr} = \frac{V_{scr} H^3}{12E_c I}$$

$$I = 0.7I_g$$

極短柱之剪力非線性行為



C：剪力極限點

V_{su} 以 SST 計算

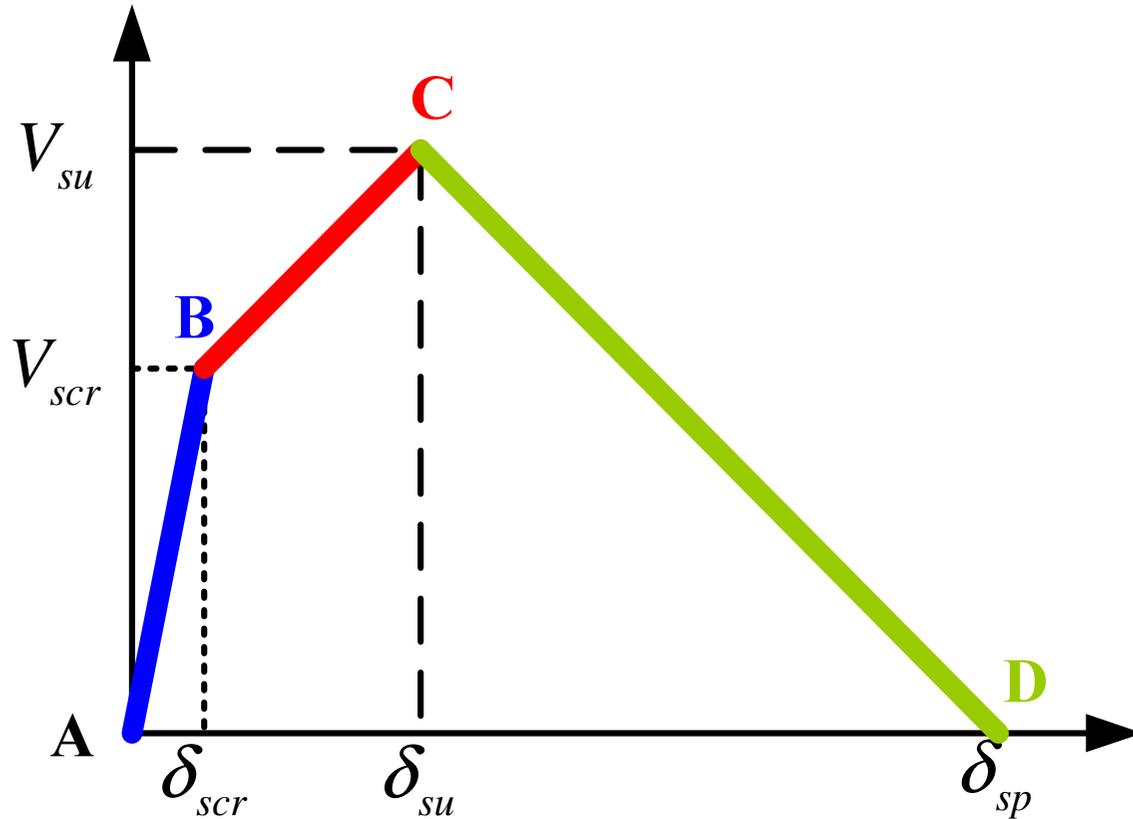
$$\delta_{su} = \delta_{s,su} + \delta_{f,su}$$

$$\delta_{s,su} = \gamma_{vh,su} H$$

$$\delta_{f,su} = \frac{V_{su} H^3}{12E_c I}$$

$$I = 0.35I_g$$

極短柱之剪力非線性行為



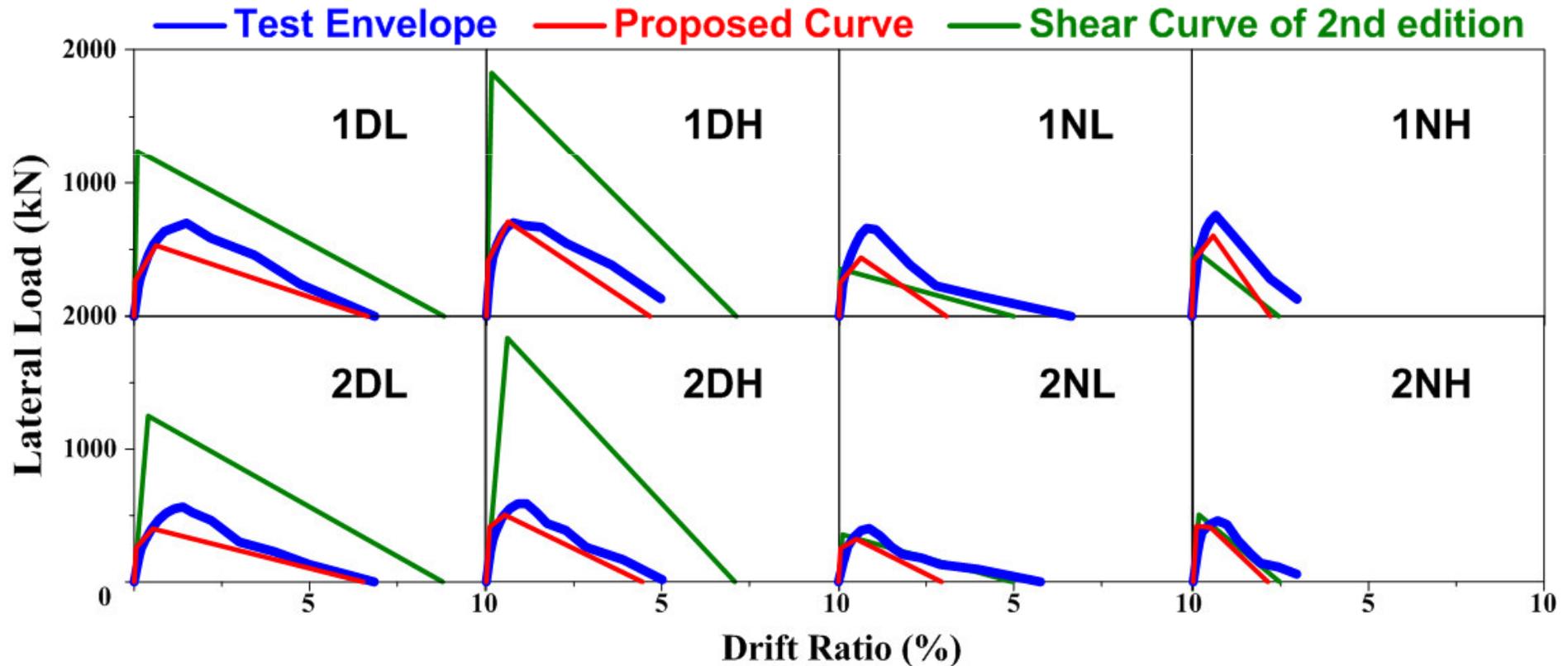
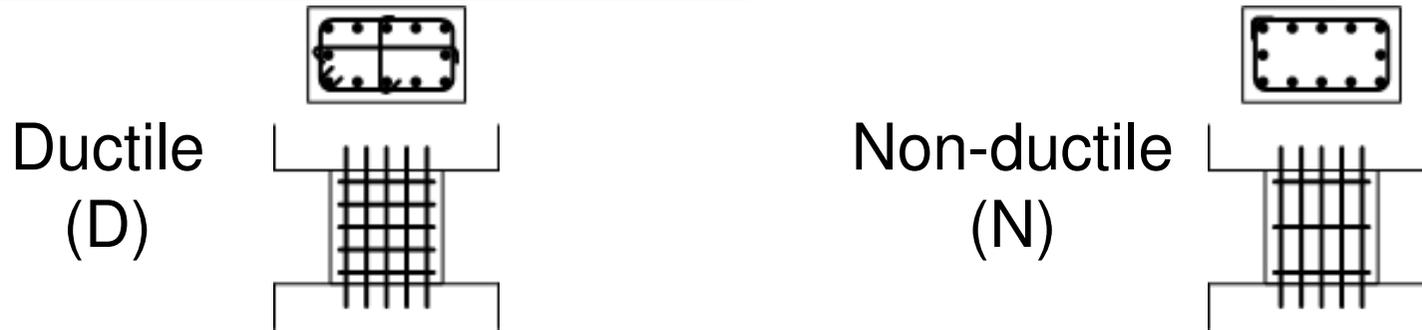
D : 剪力殘餘強度點

$$V_{sp} = 0$$

$$\delta_{sp} = \delta_{su} + rH$$

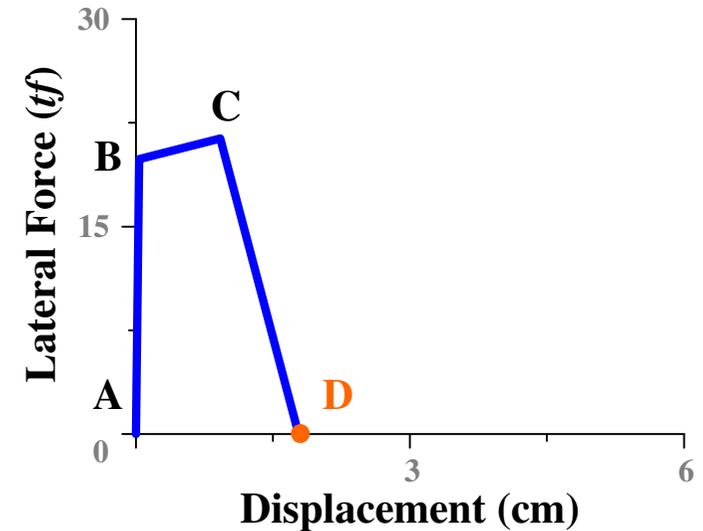
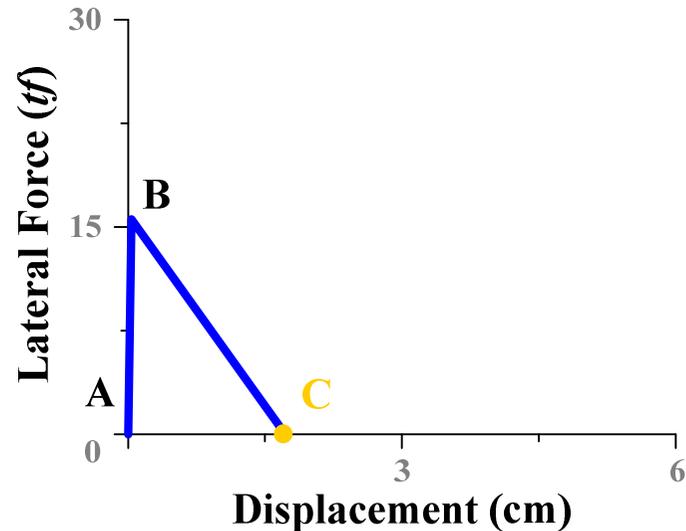
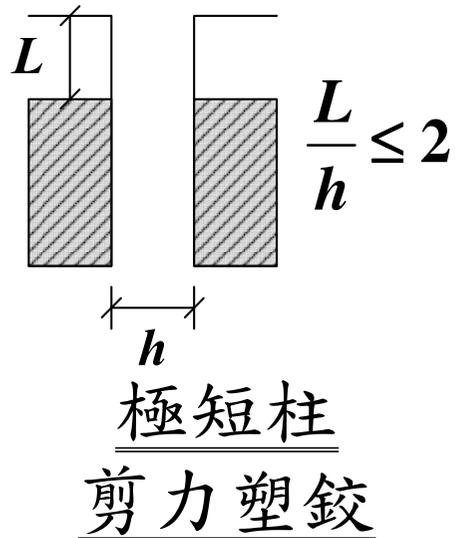
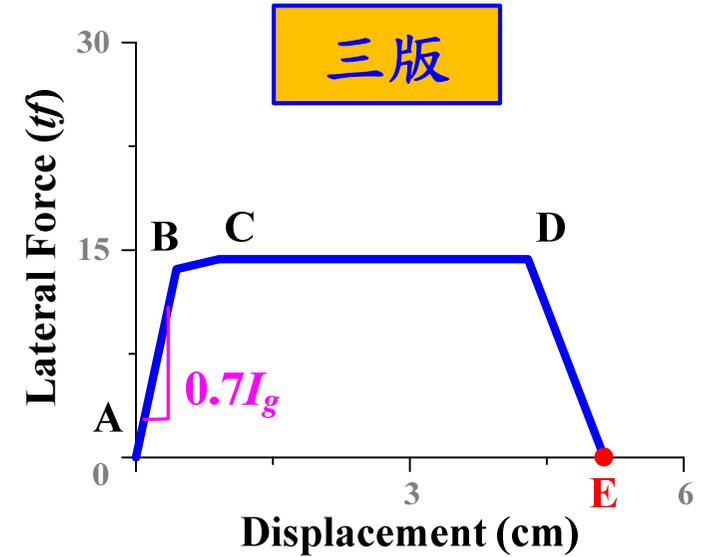
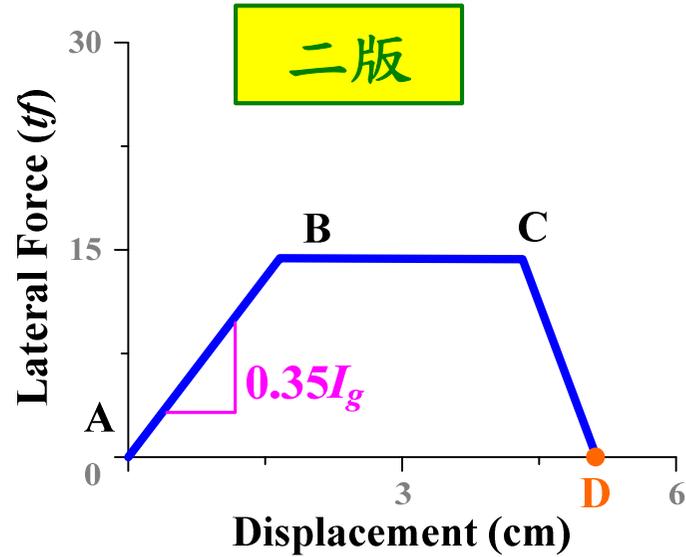
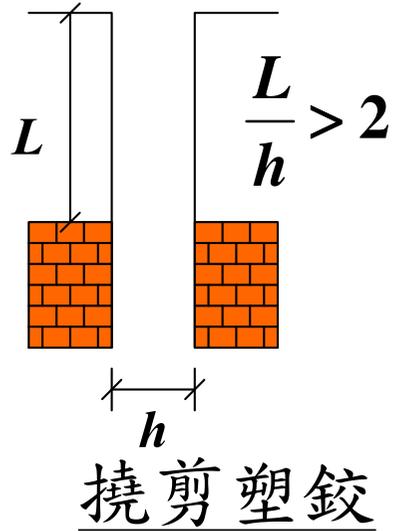
位移係數 r 可參考 ASCE 41-06 建議之
非線性轉角係數

SST 模型計算 D 區剪力行為



李翼安、邱聰智、蕭輔沛、黃世建，「鋼筋混凝土短柱受剪破壞之耐震評估研究」，
 結構工程期刊，第29卷第1期，2014年3月。

側力-位移曲線差異比較



- ✓ 極短柱強度點延後發生
- ✓ 一般柱有機會發展強度

磚牆桿件之模擬與設定

BWPH.exe

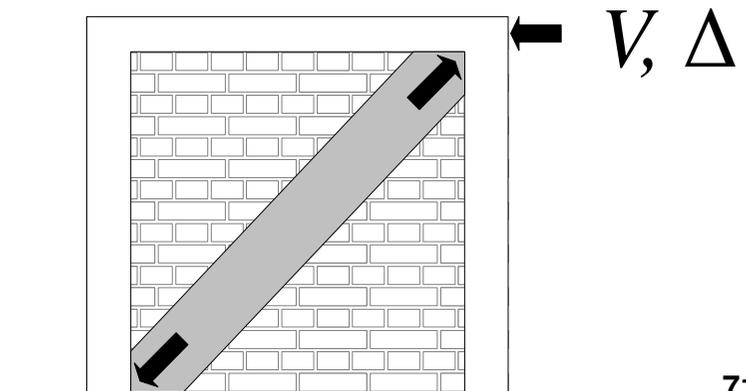
磚牆構件之非線性鉸計算

1. 磚牆行為之模擬

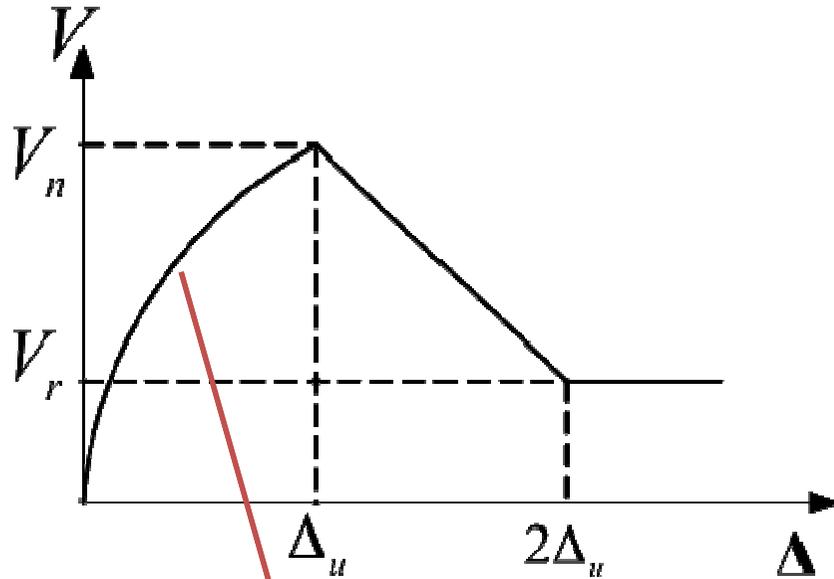
- 成大許茂雄教授進行一系列磚牆研究，建議磚牆可以一**等值受壓斜撐**進行模擬，該斜撐必須與磚牆具有相等之**勁度與強度**，其端點與構架**鉸接**。
- 以斜撐上之**軸力非線性鉸**表現磚牆之破壞行為。

2. 磚牆壓力非線性鉸計算依據

- 建築物磚構造設計及施工規範 (2008)



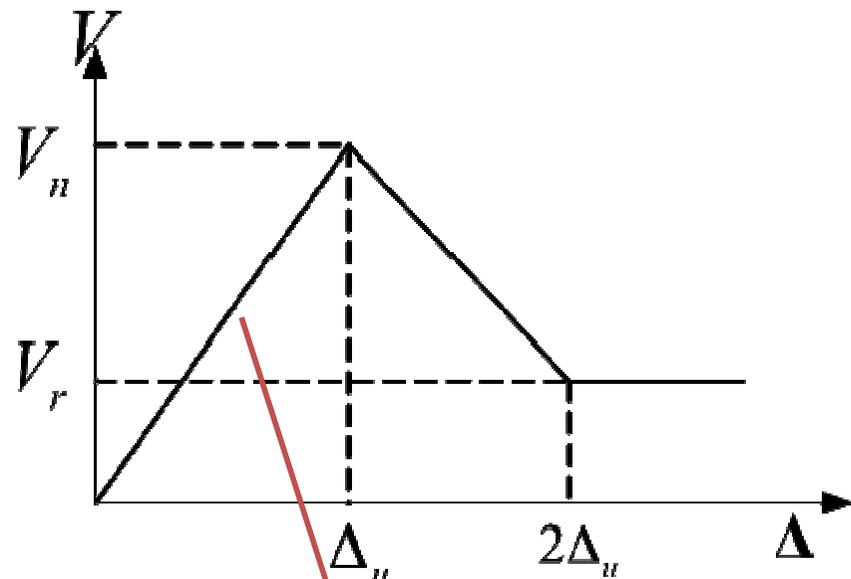
磚牆等值斜撐模型



(a)

建築物磚構造設計及施工規範
側向載重位移曲線

$$\frac{V}{V_u} = a_1 \left(\frac{\Delta}{\Delta_u} \right) + a_2 \left(\frac{\Delta}{\Delta_u} \right)^2 + a_3 \left(\frac{\Delta}{\Delta_u} \right)^3$$



(b)

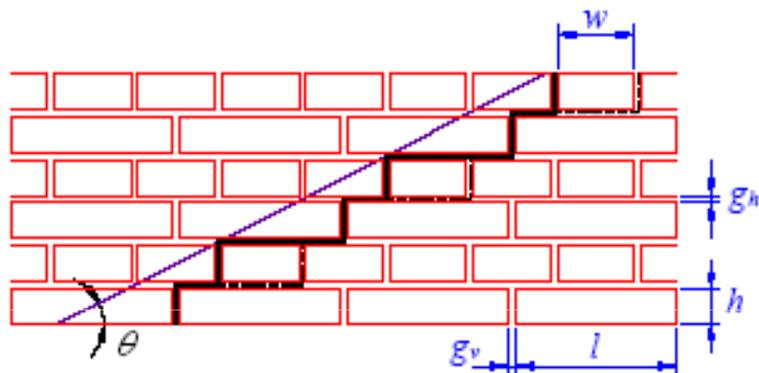
NCEE 建議曲線

$$E_u = 61.29 \eta_1 \eta_2 f_{bc}^{0.7} f_{mc}^{0.3}$$

磚牆臨界破裂角

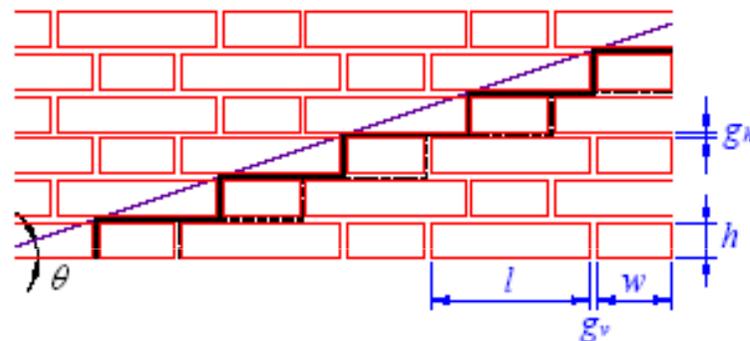
1. 英國式
砌法

$$\tan\theta = \frac{h + g_h}{w + g_v}$$



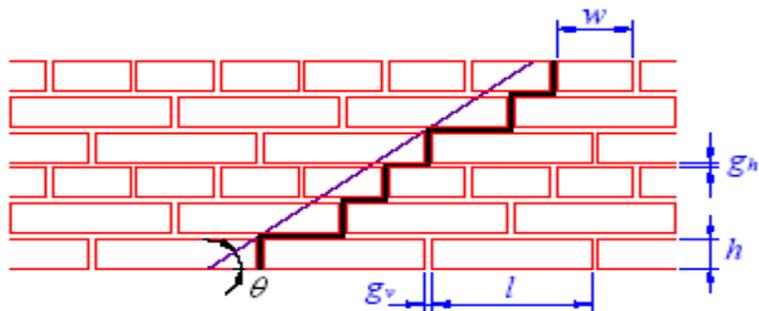
2. 法國式
砌法

$$\tan\theta = \frac{2(h + g_h)}{w + l + 2g_v}$$



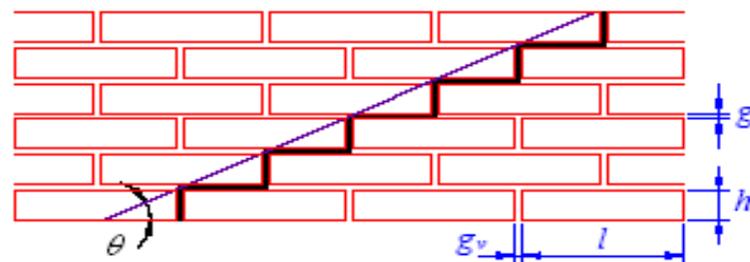
3. 二順一丁
砌法

$$\tan\theta = \frac{3(h + g_h)}{2(w + g_v)}$$

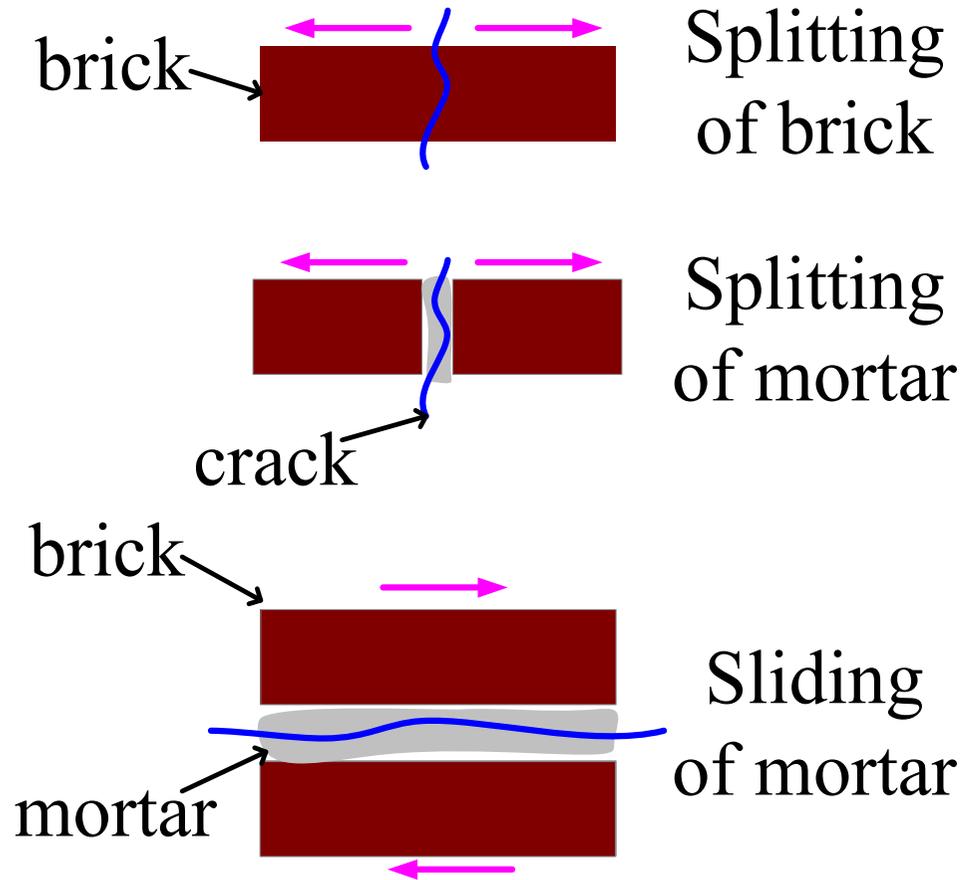


4. 順砌法

$$\tan\theta = \frac{2(h + g_h)}{l + g_v}$$



Cracks of brick masonry



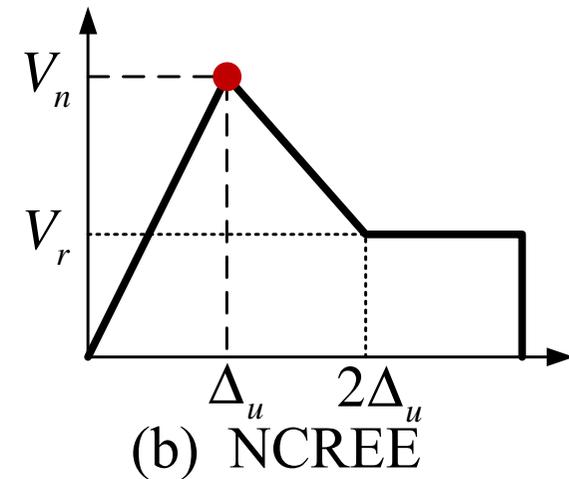
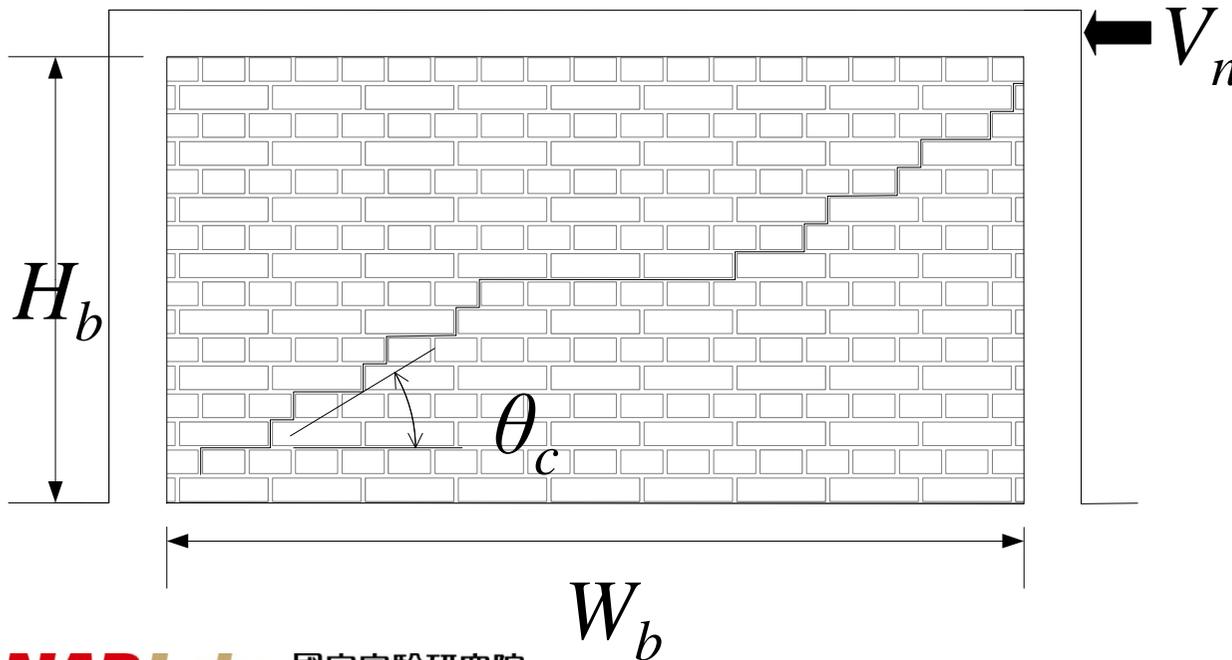
(Taiwan masonry building code, 2007)

1. 豎向灰縫的劈裂裂縫
2. 豎向劈磚的劈裂裂縫
3. 水平灰縫的滑移裂縫

四面圍束牆：Ultimate strength

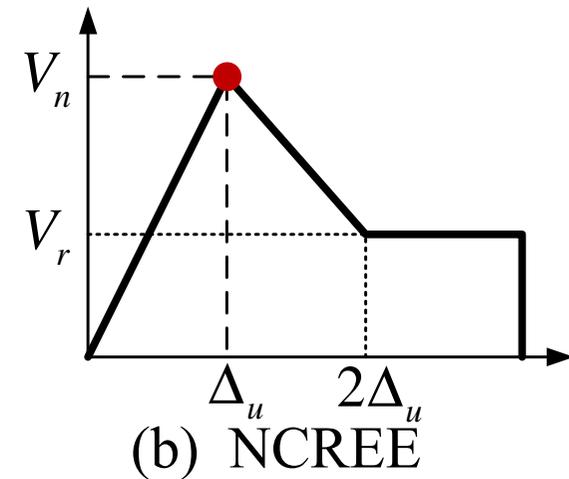
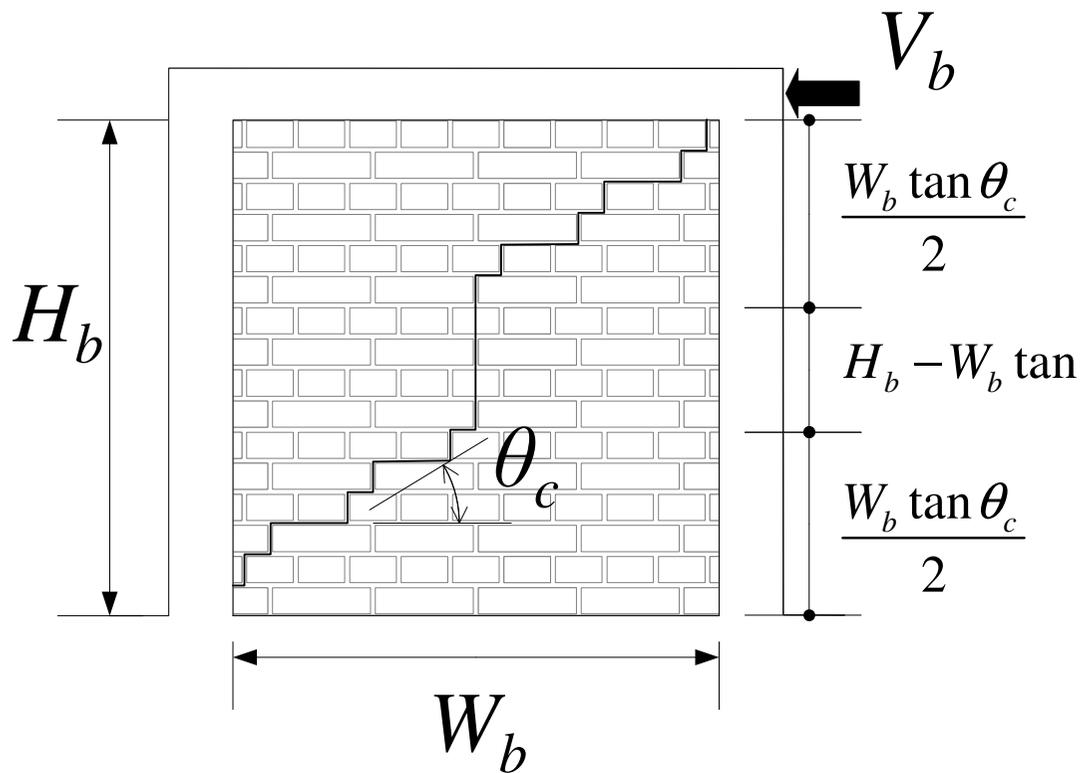
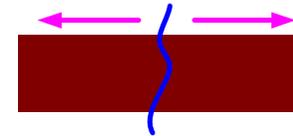
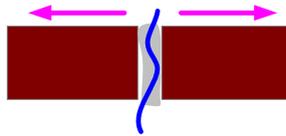
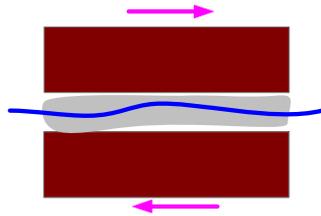
$$(H_b/W_b) \leq \tan \theta_c$$

$$V_n = \tau_f (W_b \times T_b) + 0.45 f_{mbt} (H_b \times T_b)$$



四面圍束牆： $(H_b/W_b) > \tan \theta_c$

$$V_n = \tau_f (W_b \times T_b) + 0.45 f_{mbt} (W_b \tan \theta_c \times T_b) + \frac{0.45 f_{mbt} + 0.45 f_{bt}}{2} [(H_b - W_b \tan \theta_c) \times T_b]$$

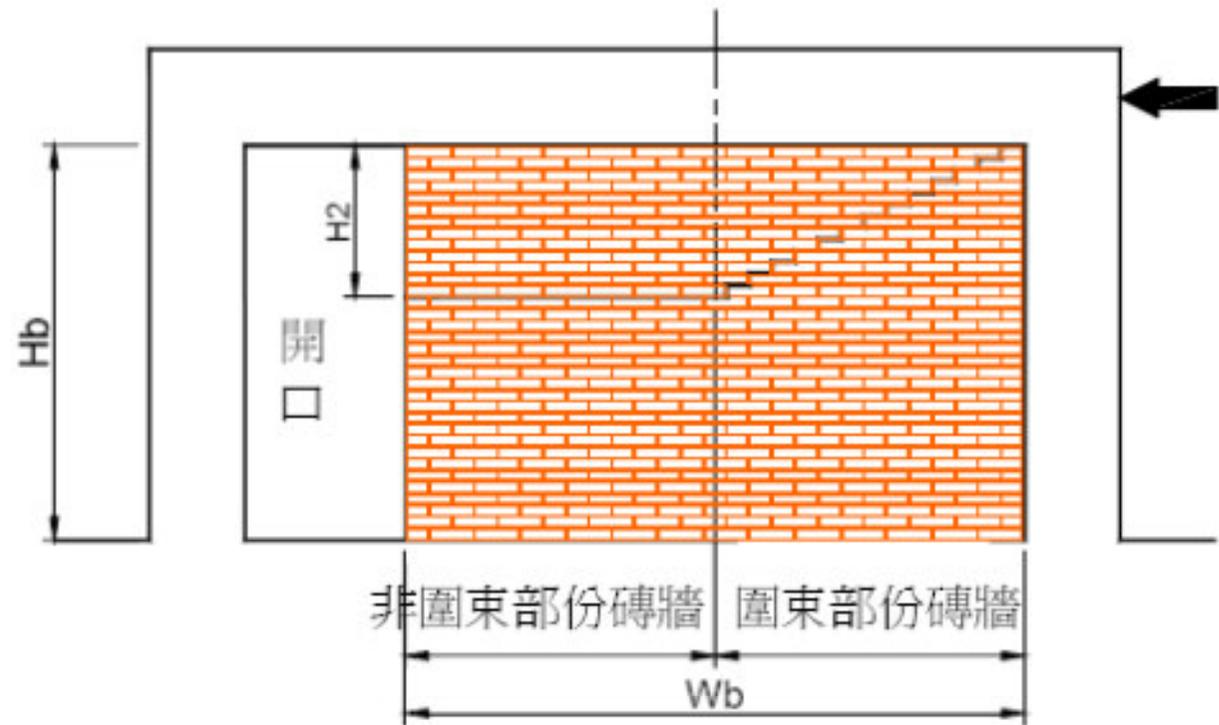
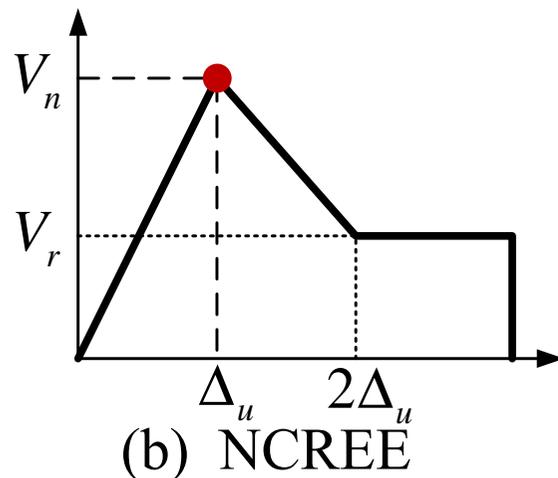


三邊圍束磚牆：

$$V_n = T_b \times (W_b \times \tau_f + H_2 \times 0.45 f_{mbt})$$

$$H_2 = 0.5W_b \tan \theta \leq H_b$$

非圍束部份磚牆
無法形成階梯狀
對角斜撐機制



(a) 三邊圍束破壞路徑例

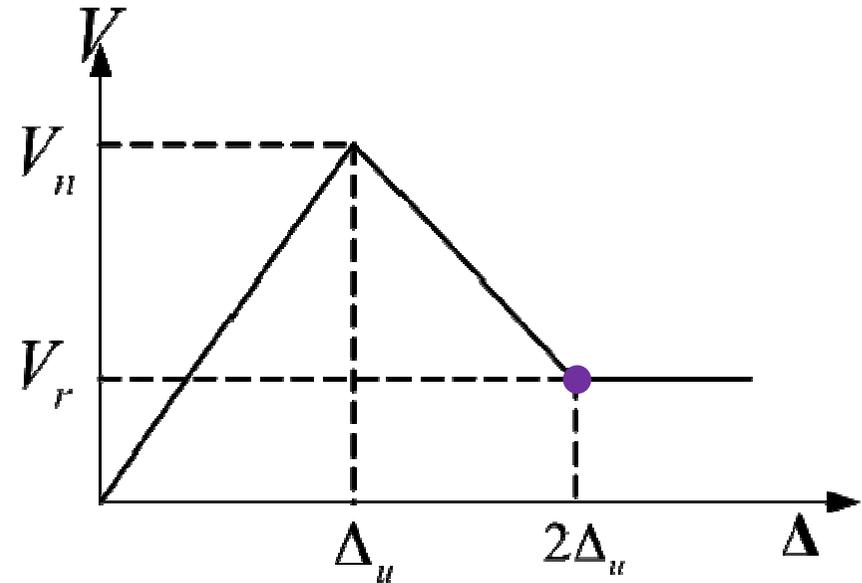
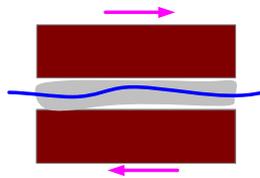
磚牆殘餘強度點之強度與位移

(A) 非窗台磚牆之殘餘強度為：

$$V_r = \tau_f \times T_b \times W_b \leq 0.6 V_n$$

(B) 窗台磚牆之殘餘強度為：

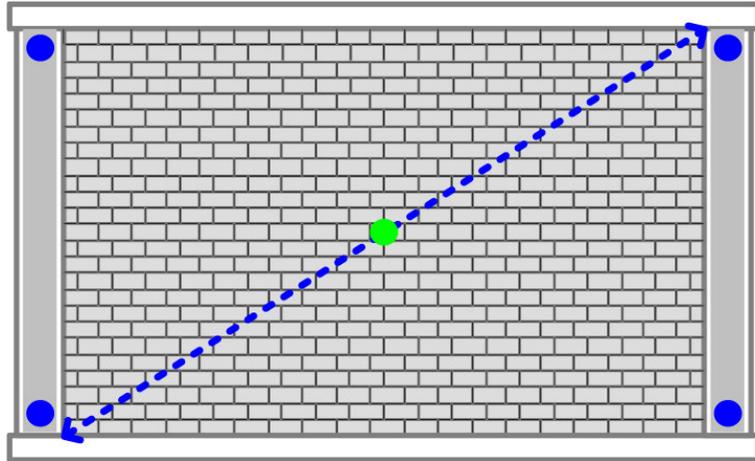
$$V_r = 0.7 \times \tau_f \times T_b \times W_b \leq 0.6 V_n$$



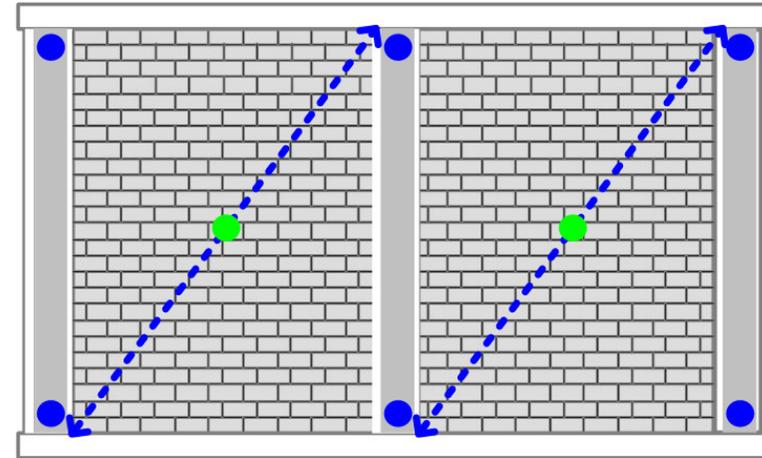
根據試驗之觀察，磚牆約在達到約兩倍水平極限位移時，磚牆強度會衰減至水平殘餘強度

磚牆之最大水平位移可參考試驗結果並保守考慮取牆高之**2.0%**為限制

四面圍束磚牆實驗驗證



● 軸力非線性鉸

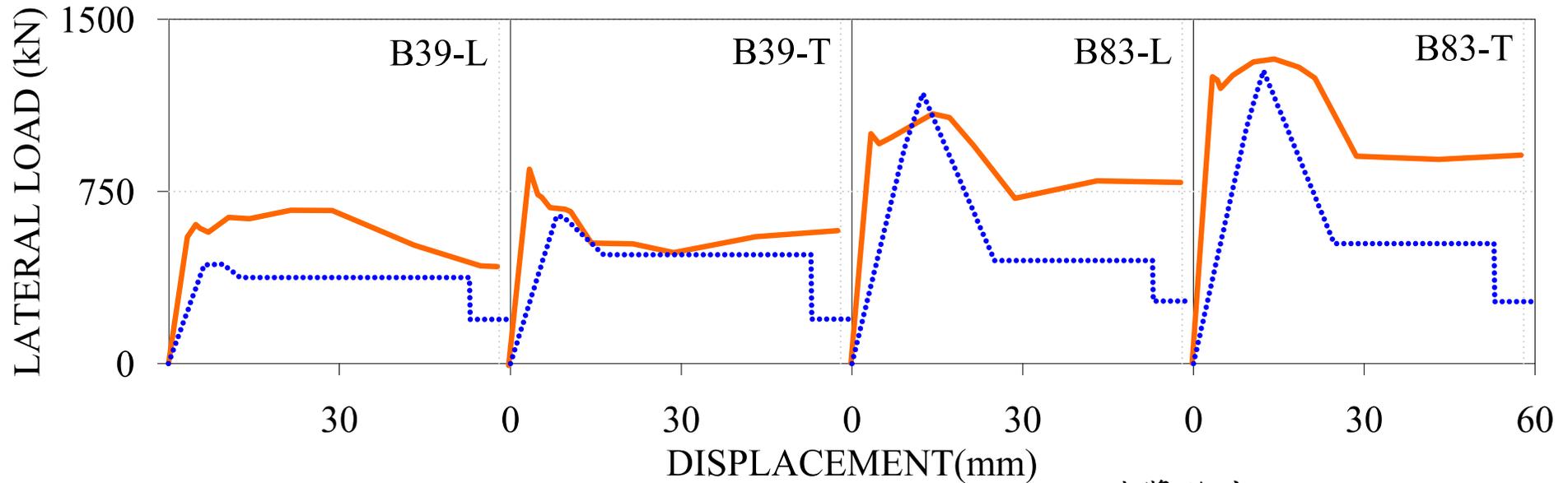
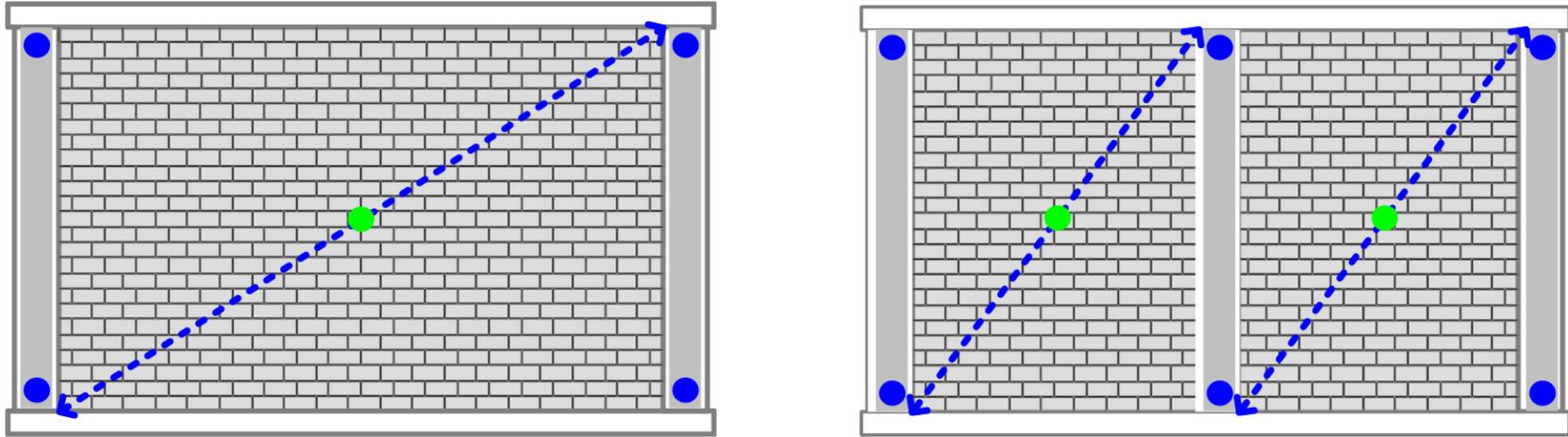


● 彎矩非線性鉸



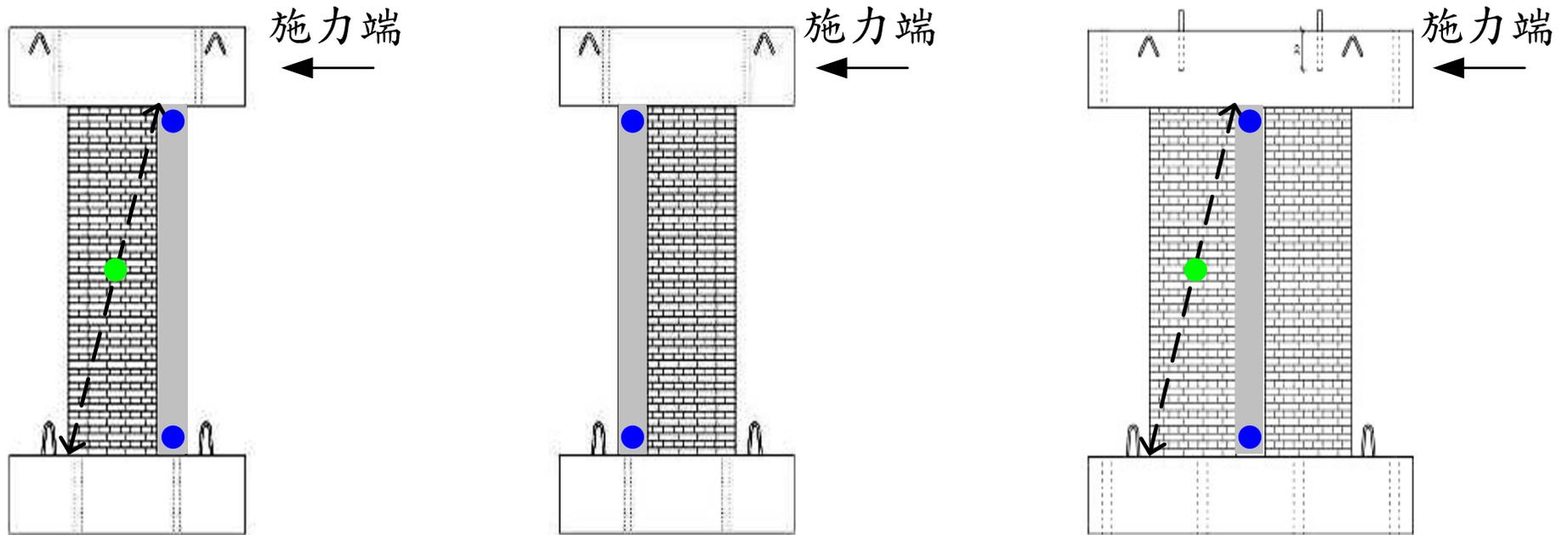
邱聰智、黃世建等，中華民國第十一屆結構工程研討會，2012年9月，Paper No. 13020

四面圍束磚牆實驗驗證



砂漿強度：
L為7 MPa； T為10 MPa

三面圍束磚牆實驗驗證



試體A、
試體AC、

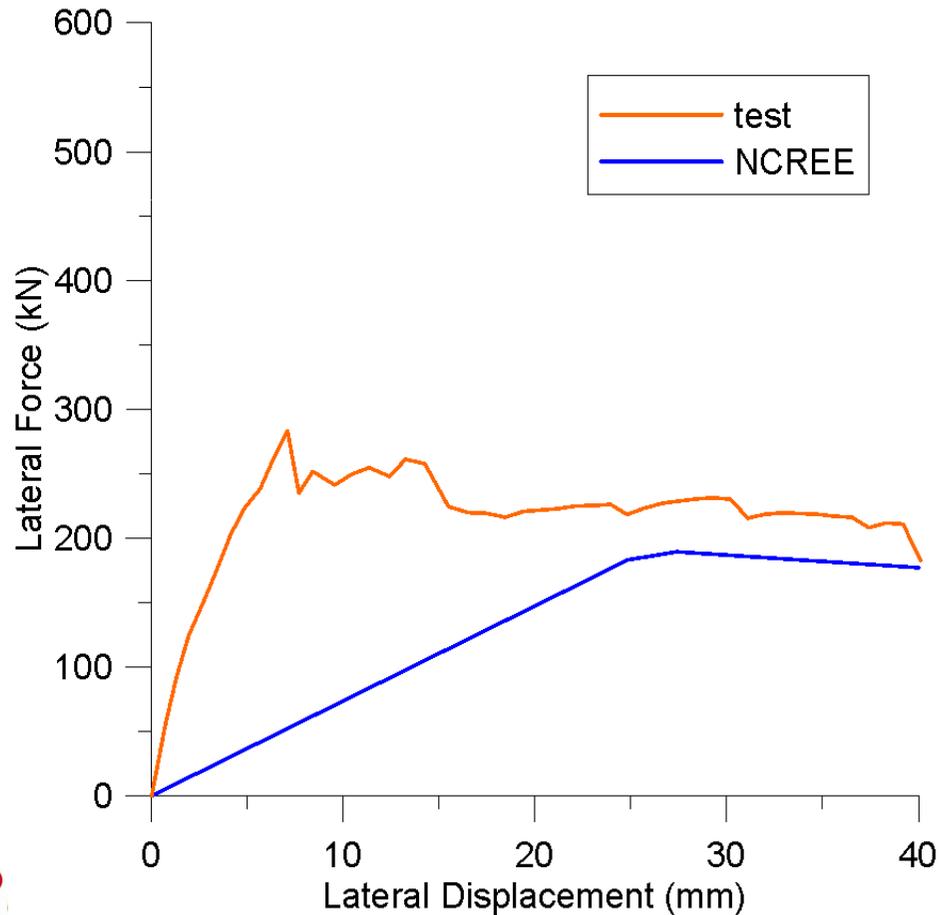
試體C

試體B、
試體BC、

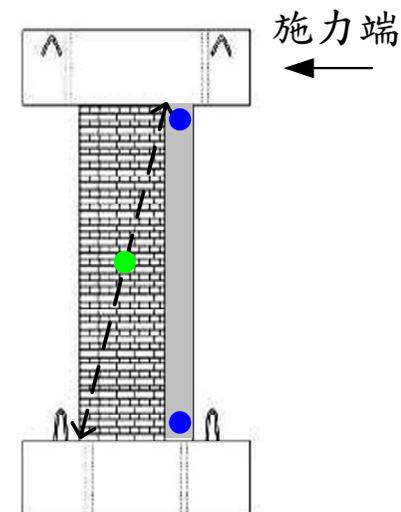
- 軸力非線性鉸
- 彎矩非線性鉸

試體A：單向側推

$$\frac{V_{test}}{V_{cal.}} = 1.5$$

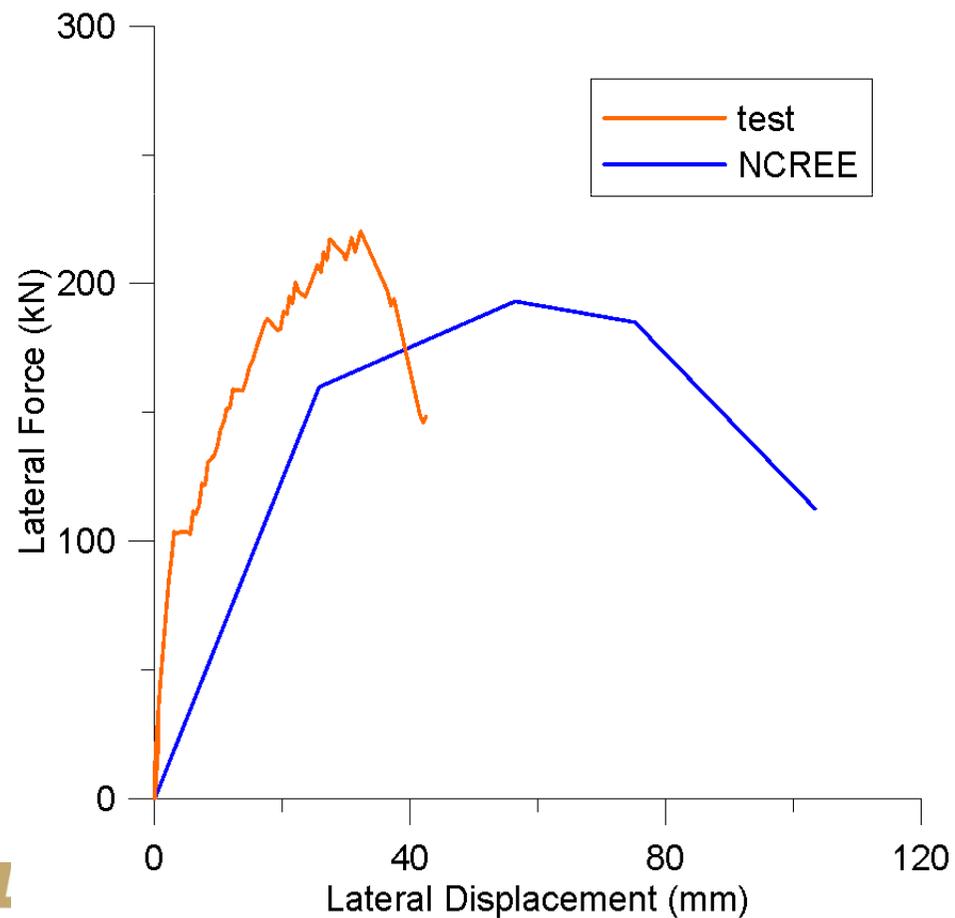


Yi-Hsuan TU (2011)

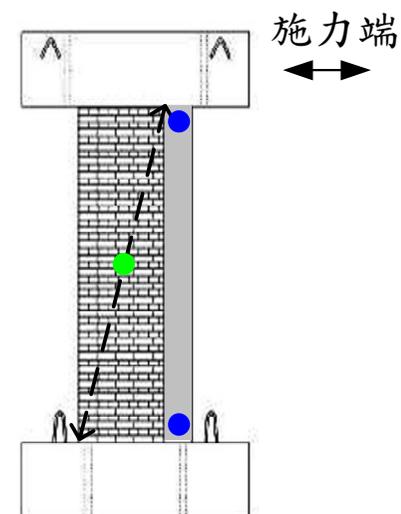


試體AC：雙向側推

$$\frac{V_{test}}{V_{cal.}} = 1.14$$

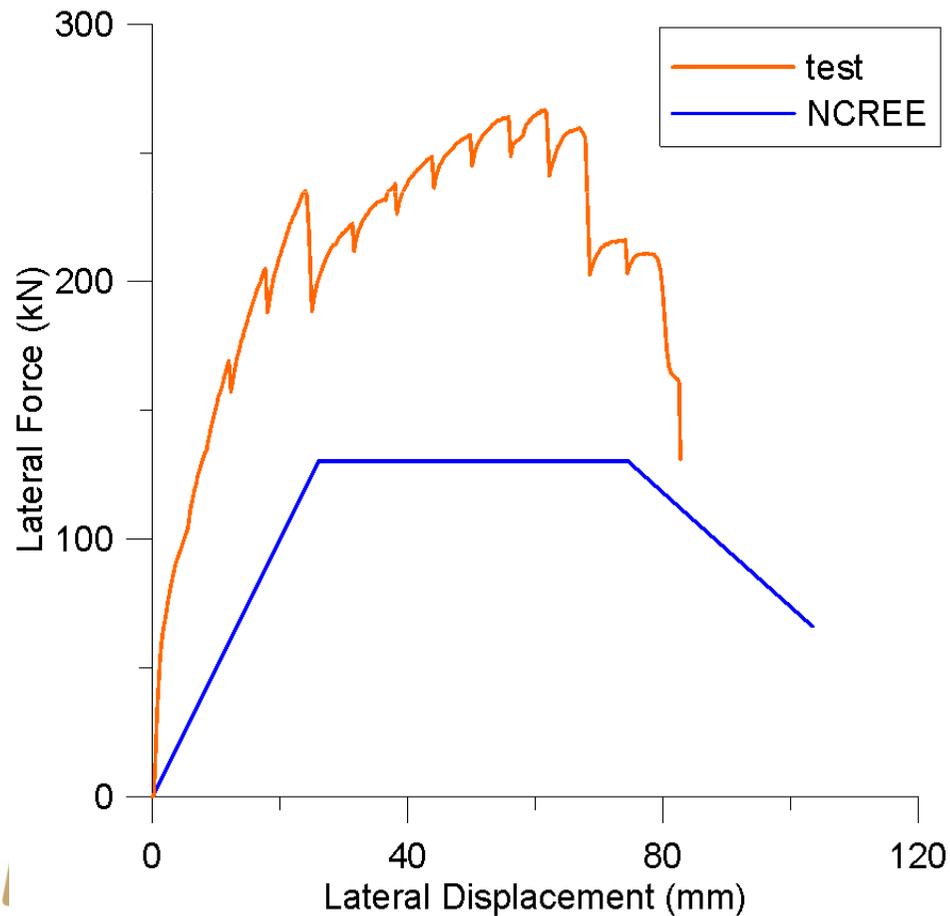


Yi-Hsuan TU (2011)

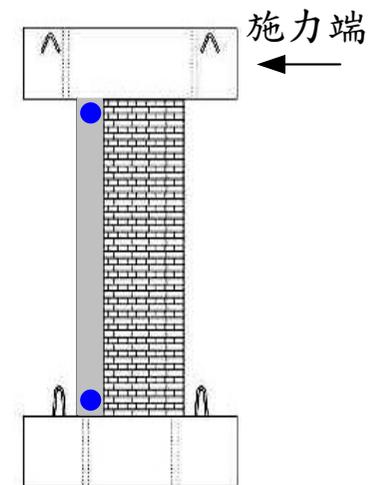


試體C：單向側推

$$\frac{V_{test}}{V_{cal.}} = 2.05$$

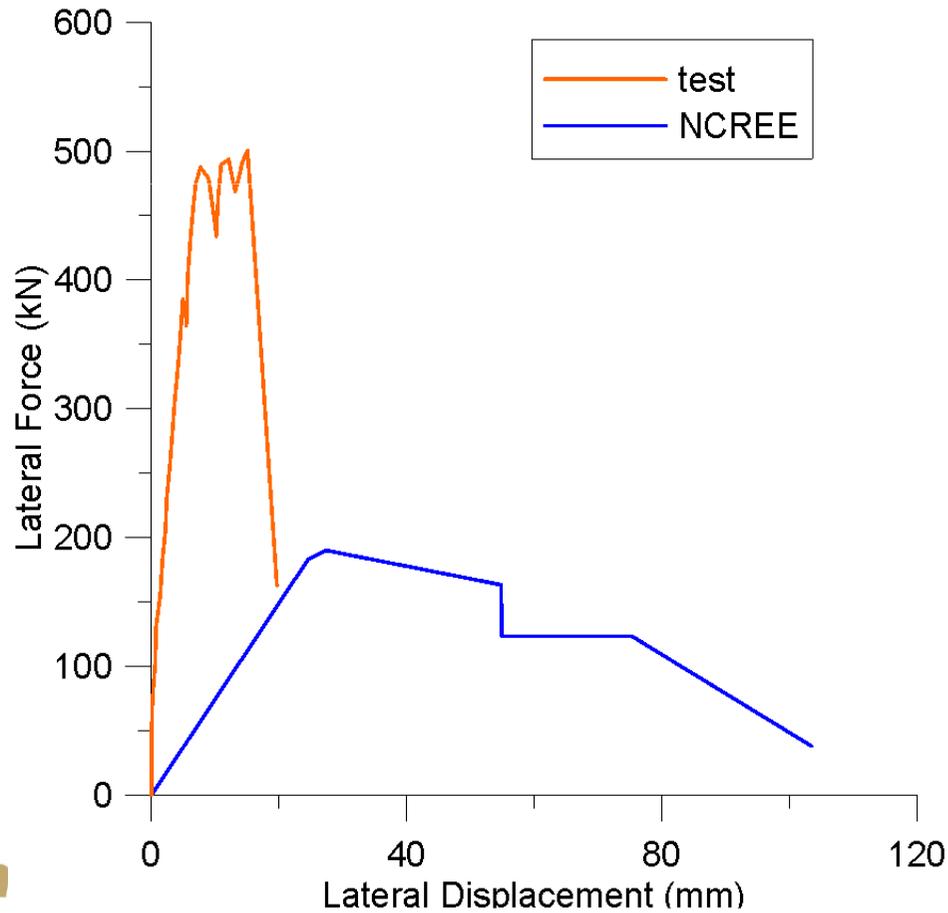


Yi-Hsuan TU (2011)

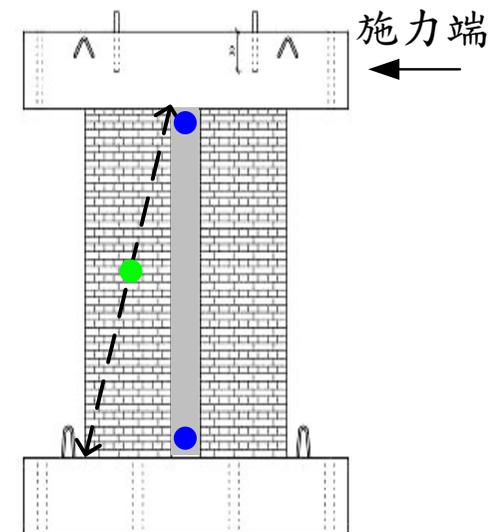


試體B：單向側推

$$\frac{V_{test}}{V_{cal.}} = 2.64$$

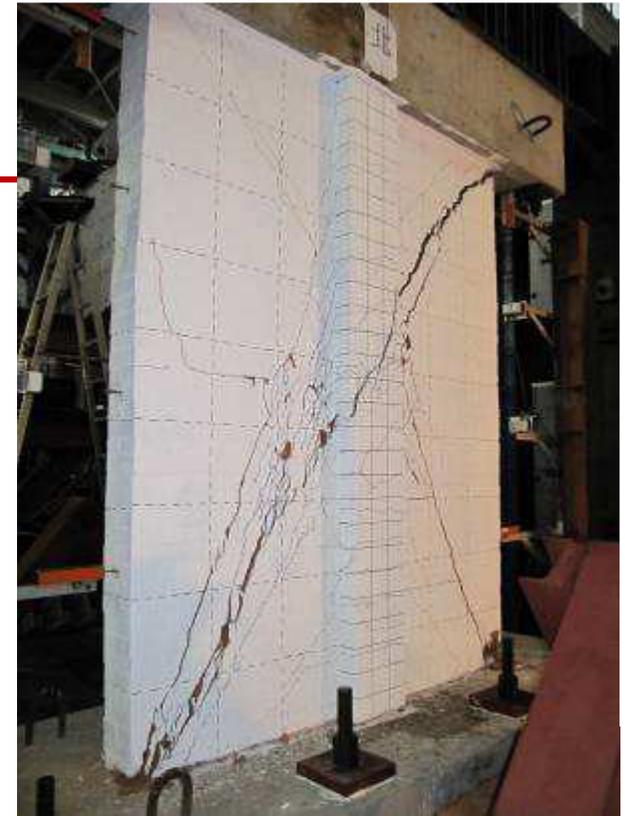
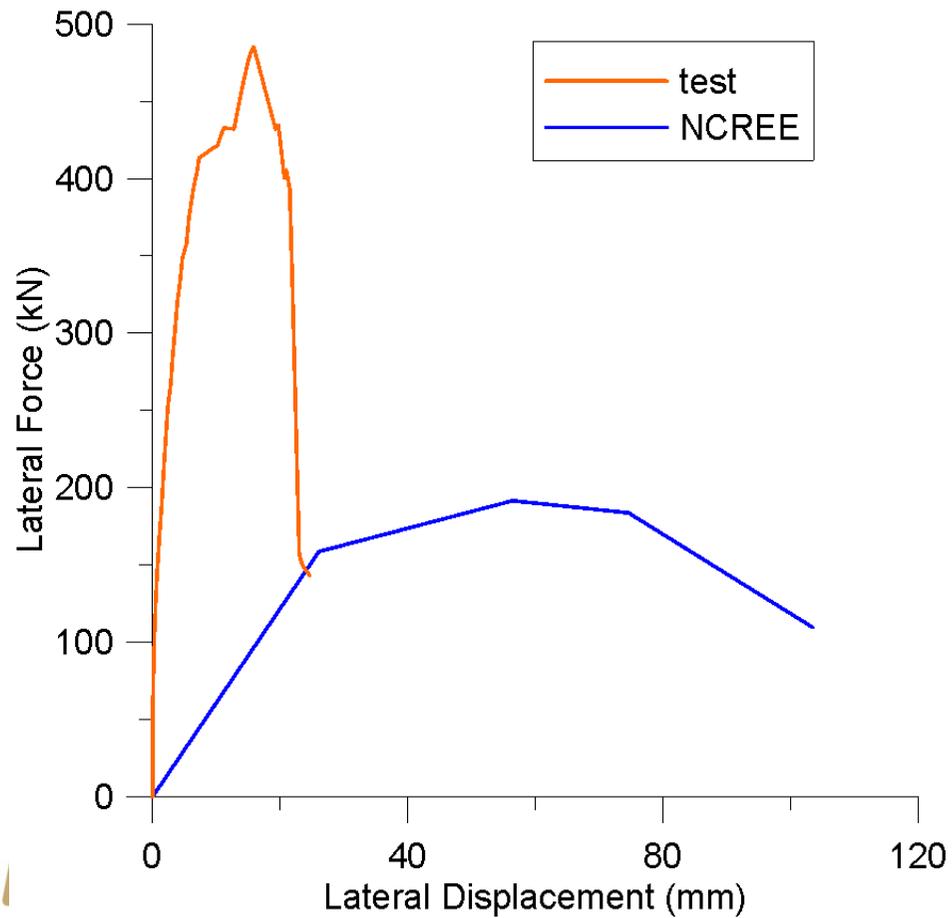


Yi-Hsuan TU (2011)

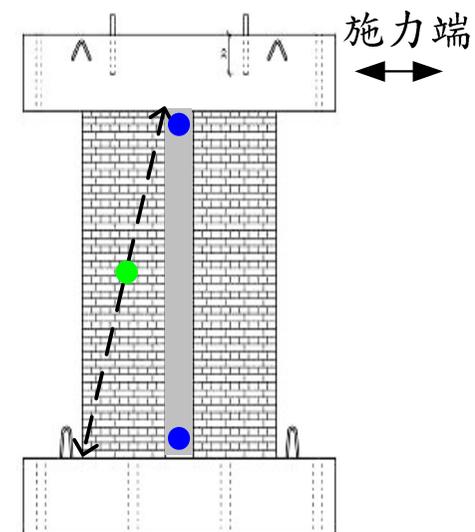


試體BC：雙向側推

$$\frac{V_{test}}{V_{cal.}} = 2.54$$



Yi-Hsuan TU (2011)



側推分析法之檢核要項

為瞭解「現況」或「補強後」之詳細評估結果與分析模型設定一致，可透過下列檢核要項加以確認：

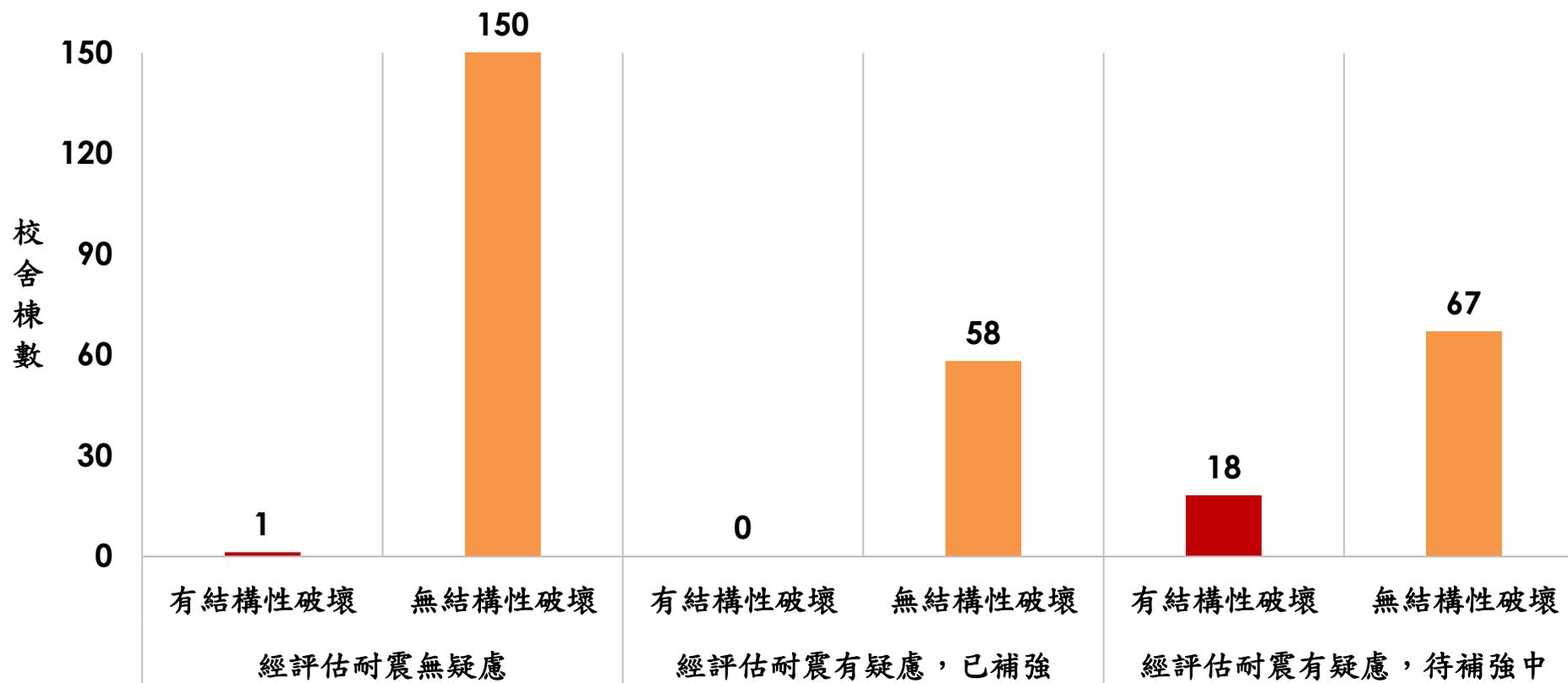
1. 結構系統模擬及設定
2. 柱軸力檢核
3. 非線性鉸參數檢核
4. 非線性鉸位置檢核
5. 最大基底剪力檢核
6. 破壞模式檢核
7. 性能目標地表加速度檢核

結論

- 非線性鉸參數可依技術手冊內容自行計算後逐一輸入，輔助分析程式係**簡化**非線性鉸設定之處理程序，惟使用者應瞭解文字輸入檔**各欄位之定義**
- 結構分析模型之設定應與現況接近，可利用**檢核要項**加以確認分析結果是否有異
- **非線性鉸參數**影響側推分析結果甚鉅，應確實檢視非線性鉸設定是否正確無誤

臺南市0206地震震損校舍之統計

- 經評估耐震**無疑慮**151棟校舍中，有結構性破壞計有1棟，占0.7%
- 經評估耐震**有疑慮**且**已補強**58棟校舍中，**無結構性破壞**
- 經評估耐震**有疑慮****待補強**85棟校舍中，有結構性破壞計有18棟，占21%



- 經評估耐震無疑慮：經初步評估、詳細評估或補強設計解除列管
- 經評估耐震有疑慮且已補強：完成補強或拆除程序
- 經評估耐震有疑慮待補強中：尚待執行補強或拆除作業
- 本圖僅統計歸仁區、永康區、北門區、玉井區、佳里區、山上區、善化區、麻豆區、左鎮區之校舍

簡報結束，敬請指教