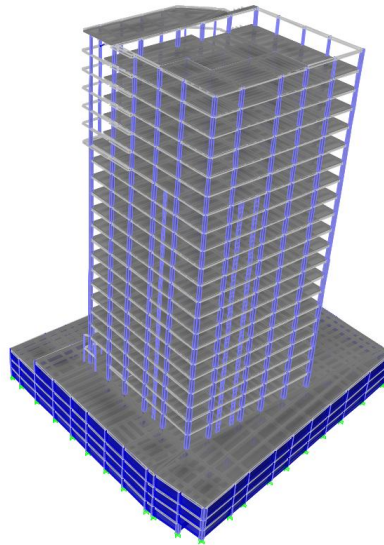


台中市辦公大樓耐震間柱設計



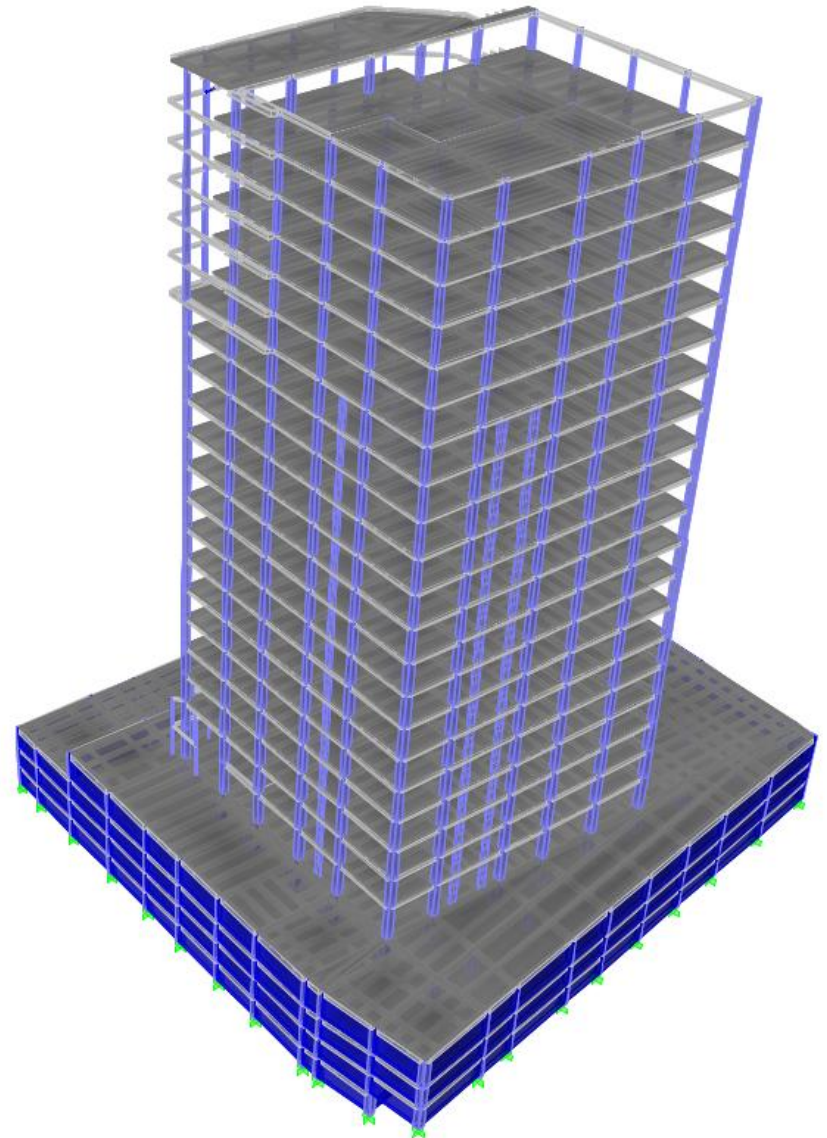
群策工程顧問

栗正暉 結構技師

2016/11/03

台中市辦公大樓耐震間柱設計

- 基地位置及建築概述
- 法規地震力
- 耐震間柱配置原則
- ETABS結構分析模型
- 結構體Drift Ratio
- 非線性靜力側推分析
- 耐震間柱施工大樣詳圖
- 施工照片



● 基地位置及建築概述



◆ 建築物概述

1. 地下4層RC構造/地上鋼構造

a. 裙樓 - 地上層8F

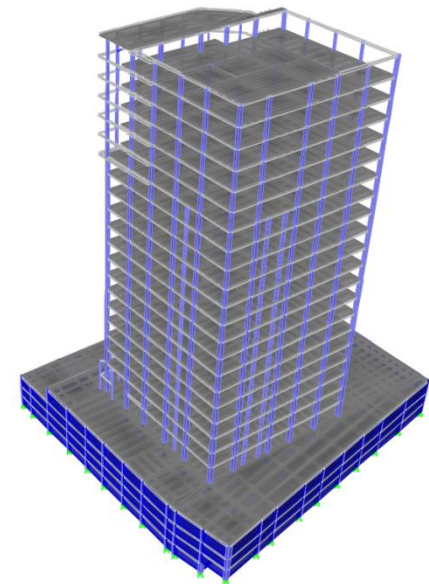
b. 塔樓 - 地上層20F

2. 地上層樓高 $H=4.5\text{m}$

a. 裙樓 - 總樓高36m

b. 塔樓 - 總樓高91m

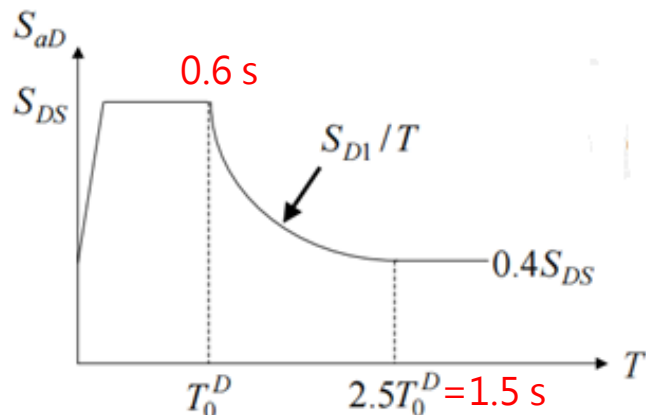
3. 地上層建築物外牆 - 玻璃帷幕



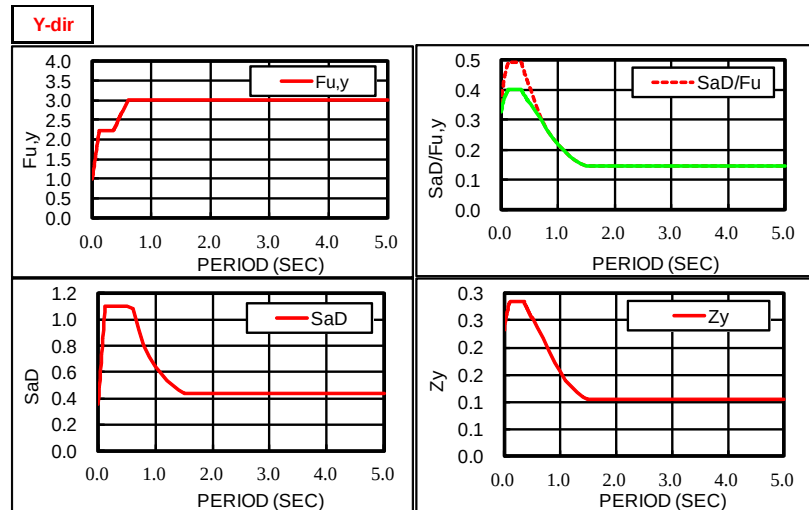
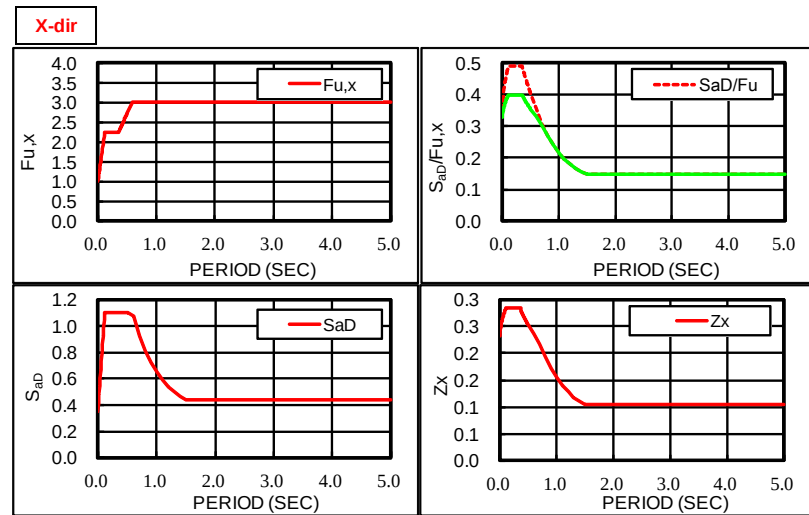
● 法規地震力 - 塔樓

1. 地盤分類:第一類地盤
2. 地震分區:台中市大雅區(近屯子腳斷層約6km)
 $S_S^D=0.8$ $S_1^D=0.45$ $S_S^M=1.0$ $S_1^M=0.55$
3. 韌性容量: $R_x=R_y=4.0$
4. 用途係數: $I=1.0$
5. 起始降伏地震力大倍數: $\alpha_y=1.0$
6. 法規週期($T_c=0.085H^{3/4}$): $T_c=2.494$ s
 (EBF, $T_c=0.07H^{3/4}$): $T_c=2.062$ s
7. 法規上限週期: $T_c=3.492$ s
8. 結構體動力週期 - $T_x=2.782$ s $T_y=2.857$ s
9. 基層剪力係數 - $V_x=0.0838$ $V_y=0.0838$

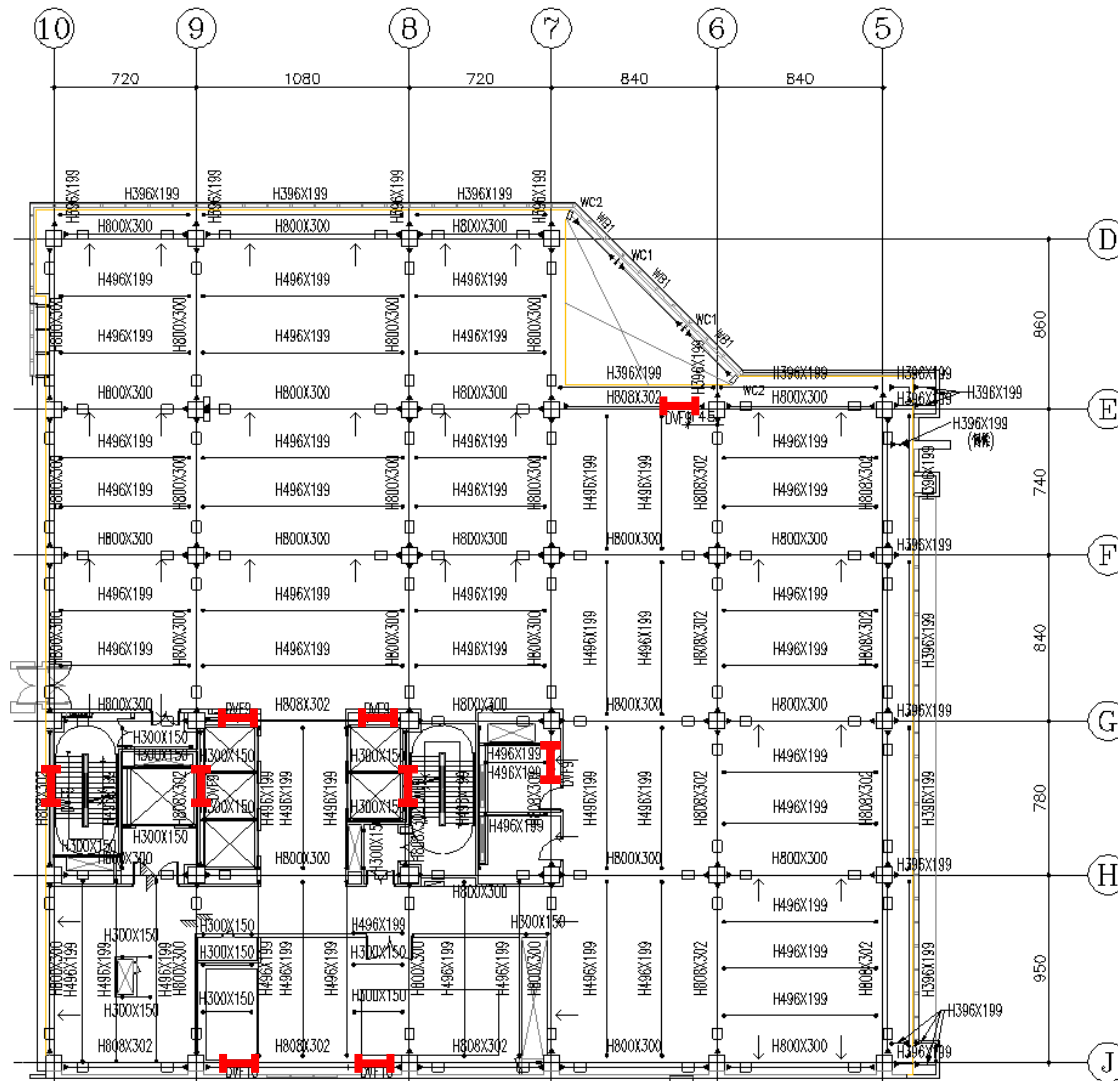
S_{aD} : 工址設計水平譜加速度係數



◆ S_{aD} 計算結果



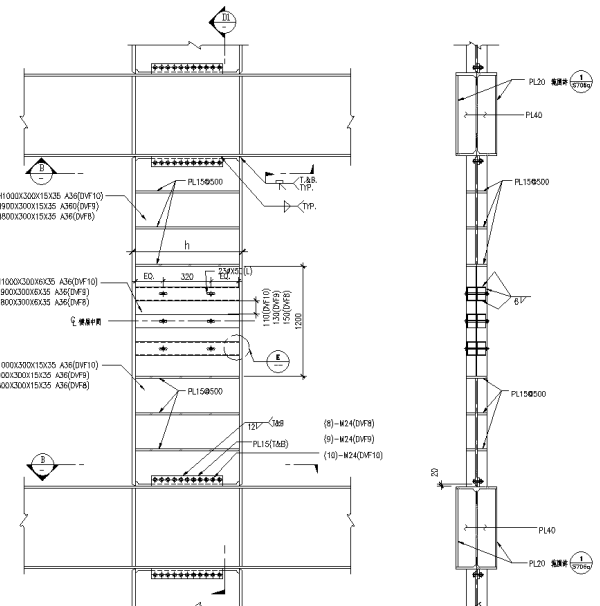
● 耐震間柱配置原則



塔樓標準層結構平面

◆ 配置原則(H:耐震間柱位置)

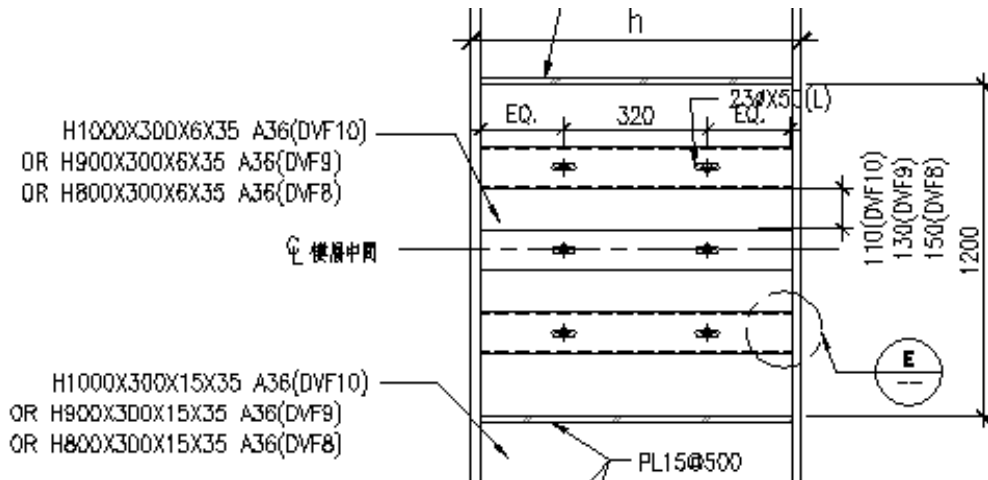
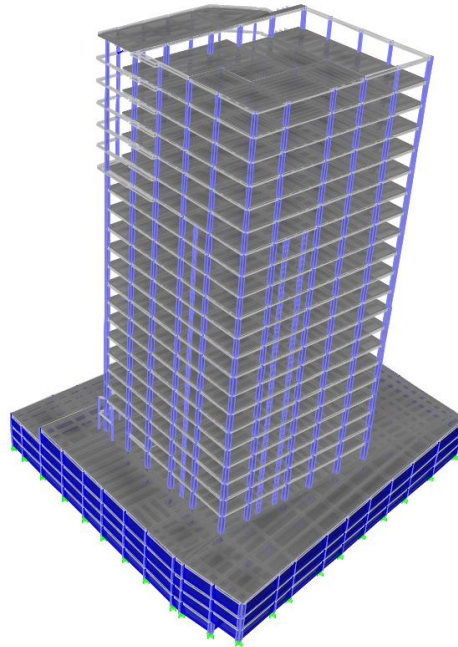
1. 採對稱原則配置
2. 樓電梯間
3. 外牆位置



耐震間柱詳圖

● ETABS結構分析模型

◆ 塔樓模型



◆ 耐震間柱断面設定

1. 間柱中間段 $L=1200\text{mm}$ (腹板厚度 $=6\text{mm}$)

I/Wide Flange Section

Section Name

Properties

Material

Dimensions

Outside height (t3)	1000.
Top flange width (t2)	300.
Top flange thickness (tf)	35.
Web thickness (tw)	6.
Bottom flange width (t2b)	300.
Bottom flange thickness (tfb)	35.

Display Color ☒ ■

2. 間柱上、下段(腹板厚度=15mm)

I/Wide Flange Section

Section Name

Properties

Property Modifiers

Material

Dimensions

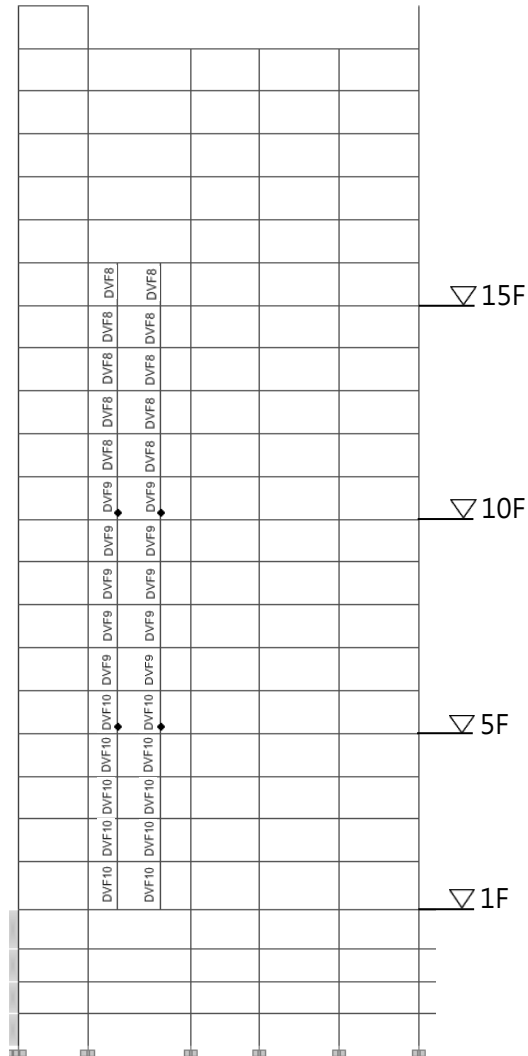
Outside height (t3)	1000.
Top flange width (t2)	300.
Top flange thickness (tf)	35.
Web thickness (tw)	15.
Bottom flange width (t2b)	300.
Bottom flange thickness (tfb)	35.

Diagram

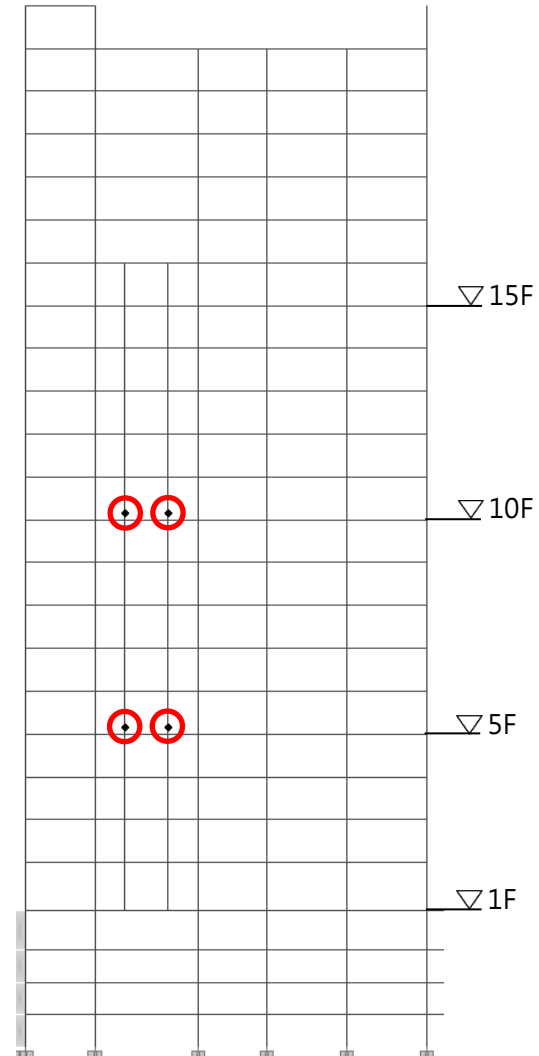
Display Color

● ETABS結構分析模型

◆ 耐震間柱斷面深度 - 1000、900及800mm



◆ 耐震間柱 - 釋放軸力(○)



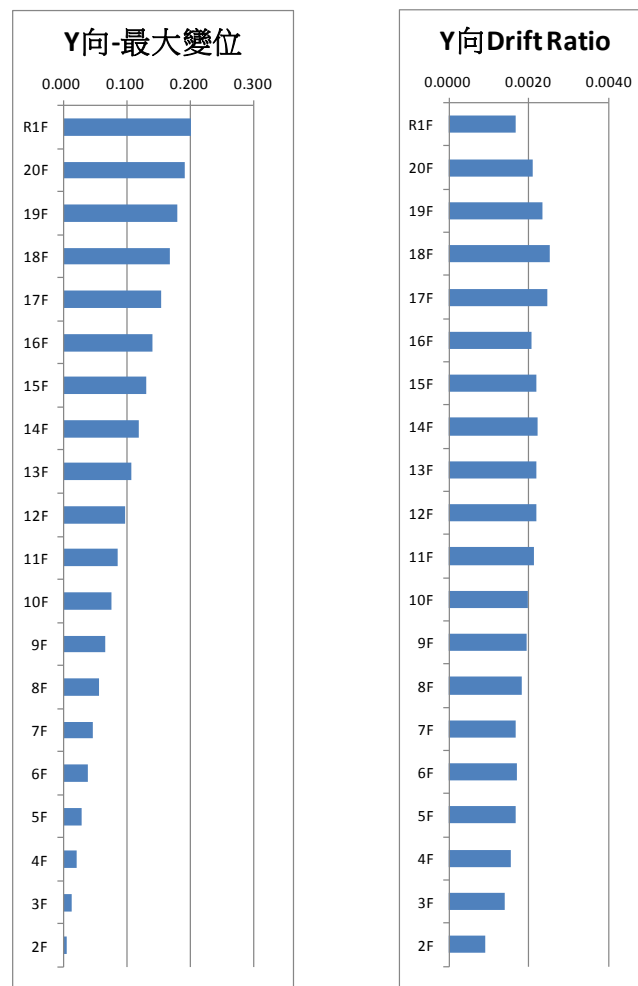
● 結構體Drift Ratio

◆ X向地震力



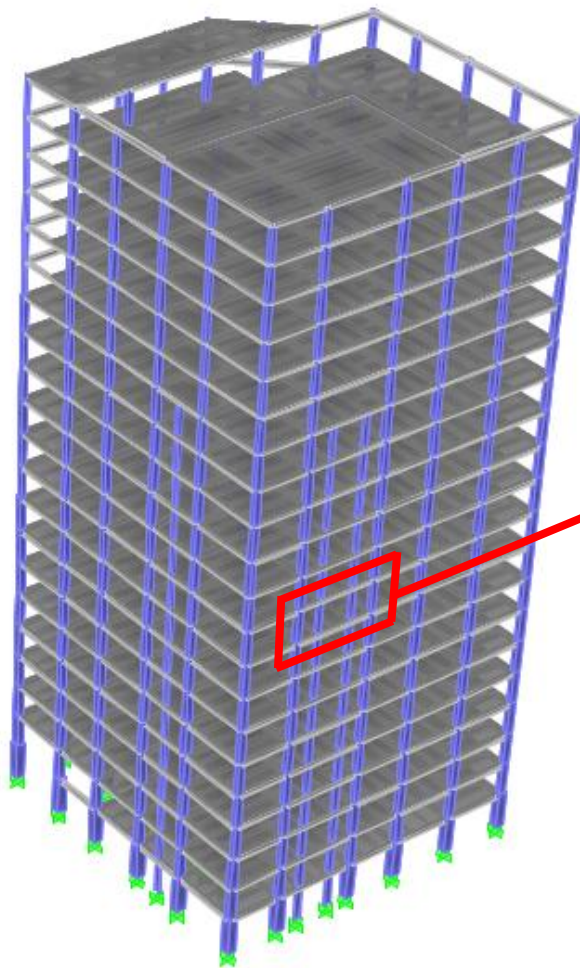
	最大變形	最大轉角
X向	0.211	0.0034
Y向	0.202	0.0025

◆ Y向地震力



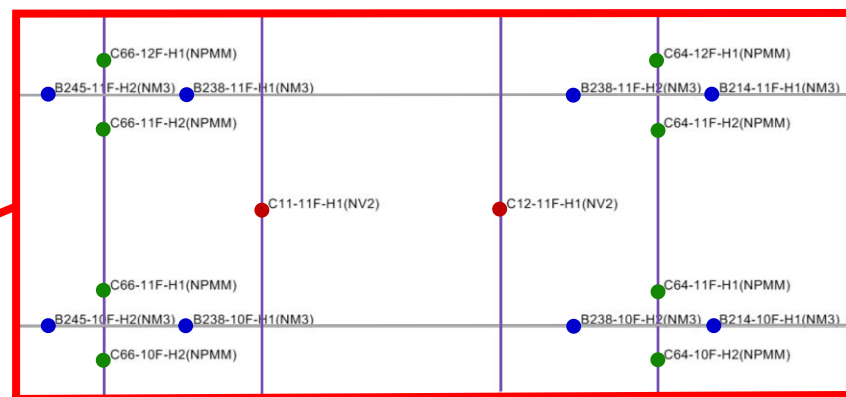
● 非線性靜力側推分析

◆ ETABS 結構模型



◆ Pushover分析載重→1.0DL+0.5LL

◆ 構架塑鉸設定

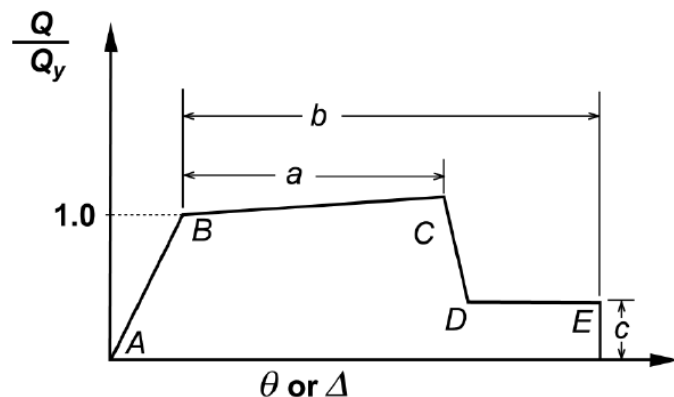


- 耐震間柱剪力塑鉸V2
- 柱軸力&彎矩塑鉸PMM3
- 梁彎矩塑鉸M3

● 非線性靜力側推分析

◆ 塑鉸參數設定

FEMA 273 Acceptance Criteria



Definition of the A,B,C,D,E

steel	Plastic Rotation Angles, Radians		Residual strength ratio	Plastic Rotation Angles, Radians		
	a	b		IO	LS	CP
PMM	9 θ_y	11 θ_y	0.6	1 θ_y	6 θ_y	8 θ_y
M3	9 θ_y	11 θ_y	0.6	1 θ_y	6 θ_y	8 θ_y
V2	14 θ_y	16 θ_y	0.7	0.5 θ_y	10 θ_y	13 θ_y

鋼構塑角設定

Frame Hinge Property Data for NPM3 - PMM

Edit

Point	Moment/SF	Rotation/SF
E-	-0.6	-11
D-	-0.6	-9
C-	-1.27	-9
B-	-1	0
A	0	0
B	1	0
C	1.27	9
D	0.6	9
E	0.6	11

☒ Hinge is Rigid Plastic
☒ Symmetric

Scaling for Moment and Rotation

☐ Use Yield Moment Moment SF Positive Negative

☒ Use Yield Rotation Rotation SF Positive Negative

Acceptance Criteria (Plastic Rotation/SF)

Immediate Occupancy Positive Negative 1.

Life Safety Positive Negative 6.

Collapse Prevention Positive Negative 8.

Axial Load - Displacement Relationship

☒ Proportional to Moment - Rotation
☐ Elastic - Perfectly Plastic

Define/Show Interaction...

OK Cancel

PMM(鋼柱)

Frame Hinge Property Data for NM3 - M3

Edit

Point	Moment/SF	Rotation/SF
E-	-0.6	-11
D-	-0.6	-9
C-	-1.27	-9
B-	-1	0
A	0	0
B	1	0
C	1.27	9
D	0.6	9
E	0.6	11

☒ Hinge is Rigid Plastic
☒ Symmetric

Scaling for Moment and Rotation

☒ Use Yield Moment Moment SF Positive Negative

☒ Use Yield Rotation Rotation SF Positive Negative

Acceptance Criteria (Plastic Rotation/SF)

Immediate Occupancy Positive Negative 1.

Life Safety Positive Negative 6.

Collapse Prevention Positive Negative 8.

OK Cancel

M3(梁)

Frame Hinge Property Data for NV2 - V2

Edit

Point	Force/SF	Disp/SF
E-	-0.7	-16
D-	-0.7	-14
C-	-1.42	-14
B-	-1	0
A	0	0
B	1	0
C	1.42	14
D	0.7	14
E	0.7	16

☒ Hinge is Rigid Plastic
☒ Symmetric

Scaling for Force and Disp

☒ Use Yield Force Force SF Positive Negative

☒ Use Yield Disp Disp SF Positive Negative

Acceptance Criteria (Plastic Disp/SF)

Immediate Occupancy Positive Negative 0.5

Life Safety Positive Negative 10.

Collapse Prevention Positive Negative 13.

Type

☒ Force - Displacement
☐ Stress - Strain

Hinge Length OK Cancel

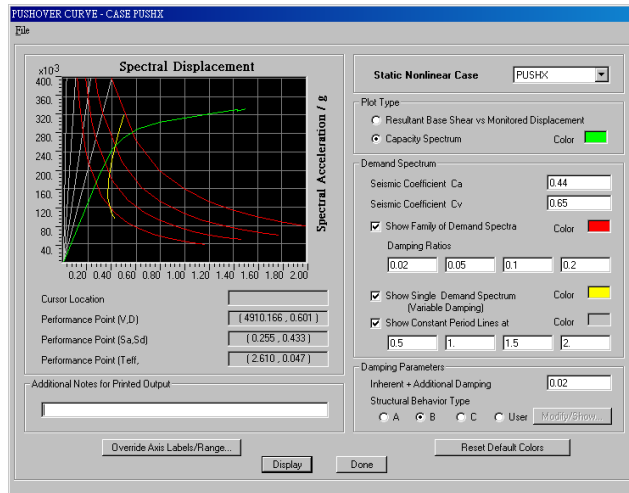
☐ Relative Length

V2(耐震間柱)

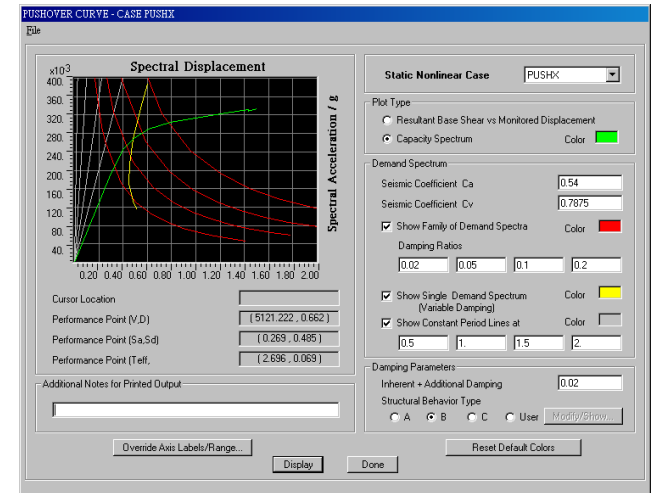
● 非線性靜力側推分析

◆ Pushover 側推分析結果

X方向：

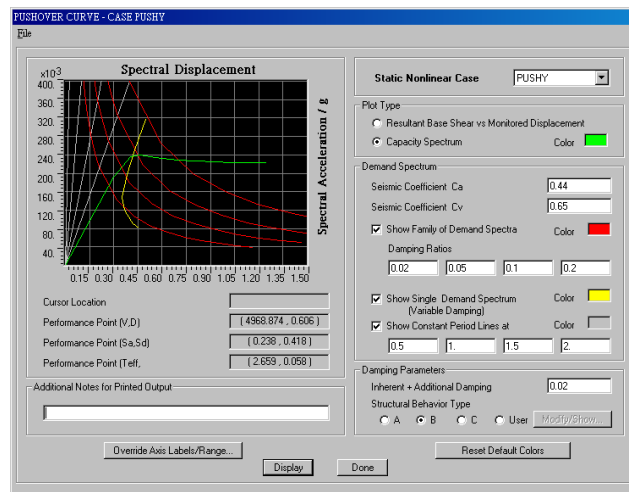


475年回歸期

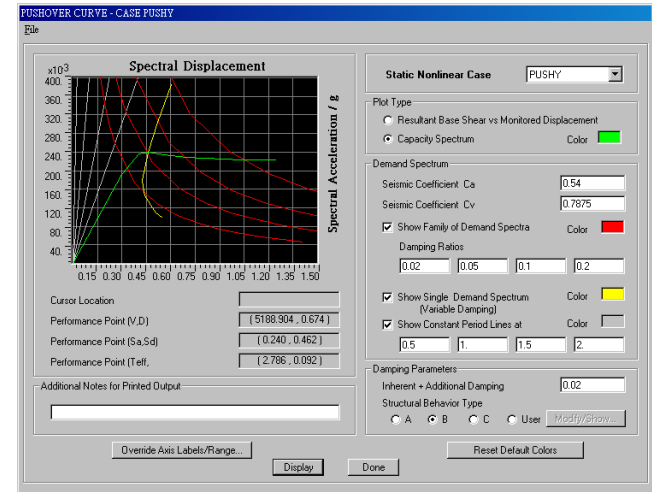


2500年回歸期

Y方向：



475年回歸期

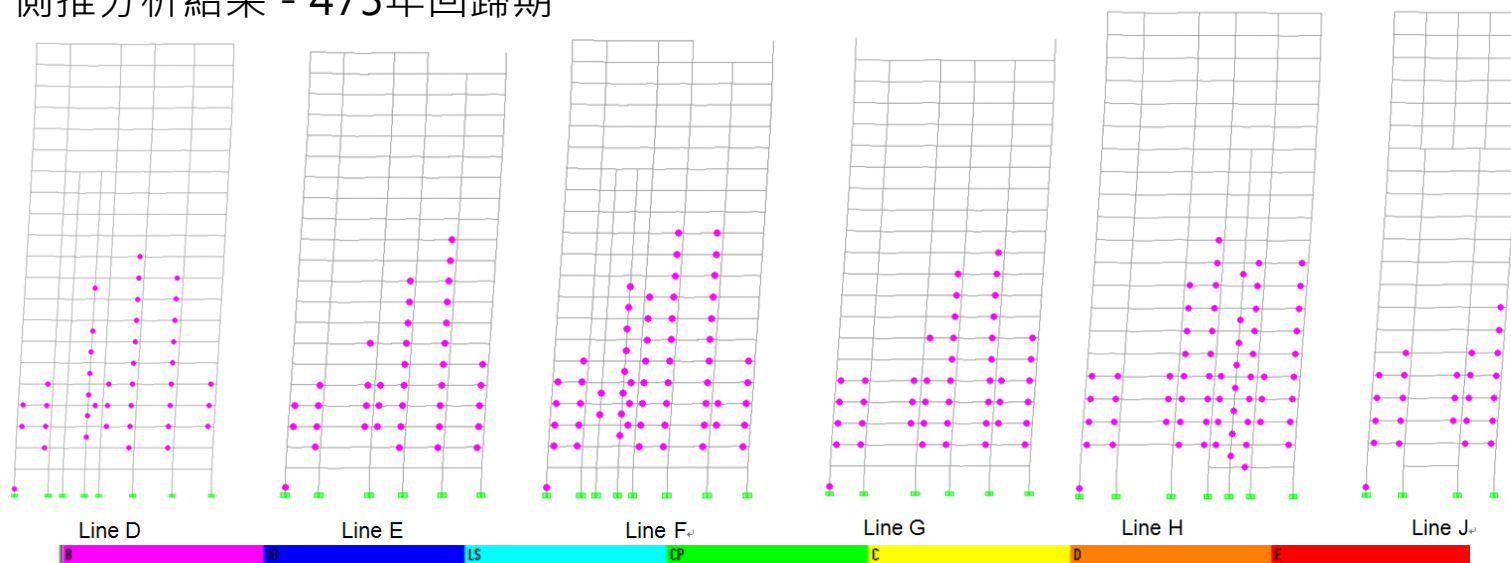


2500年回歸期

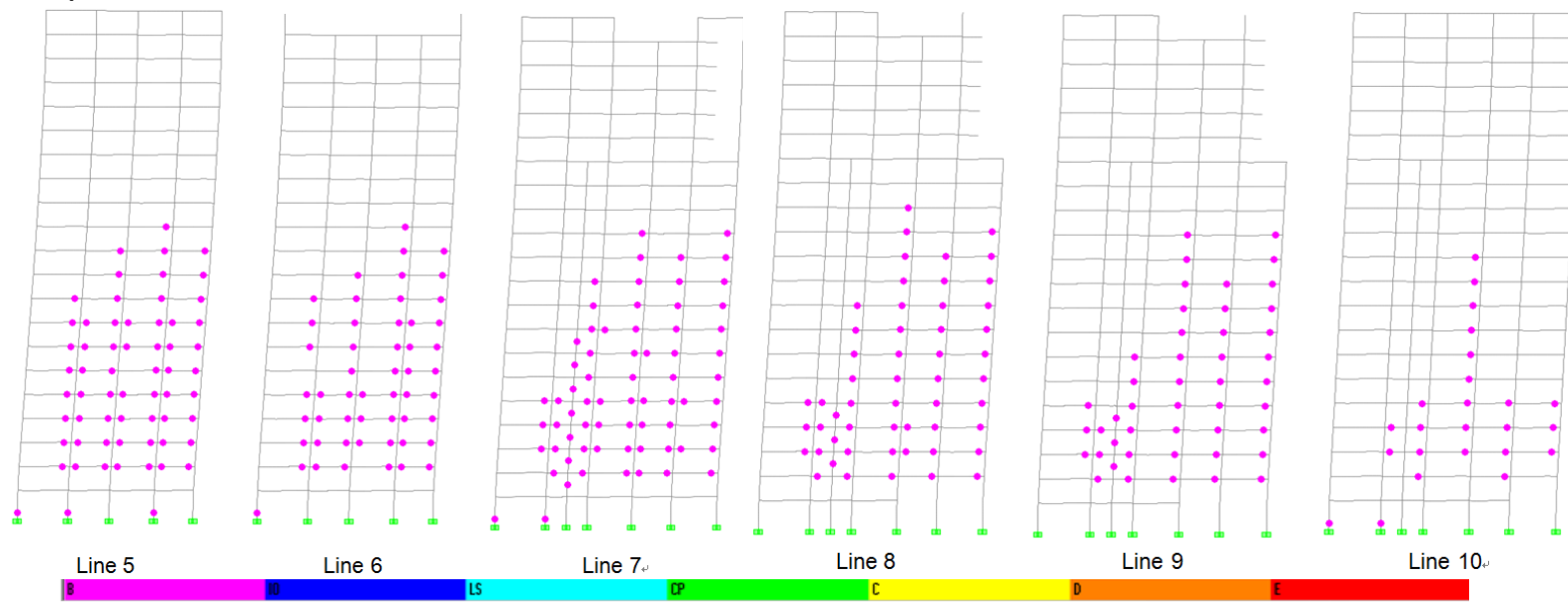
● 非線性靜力側推分析

◆ Pushover 側推分析結果 - 475年回歸期

X方向：



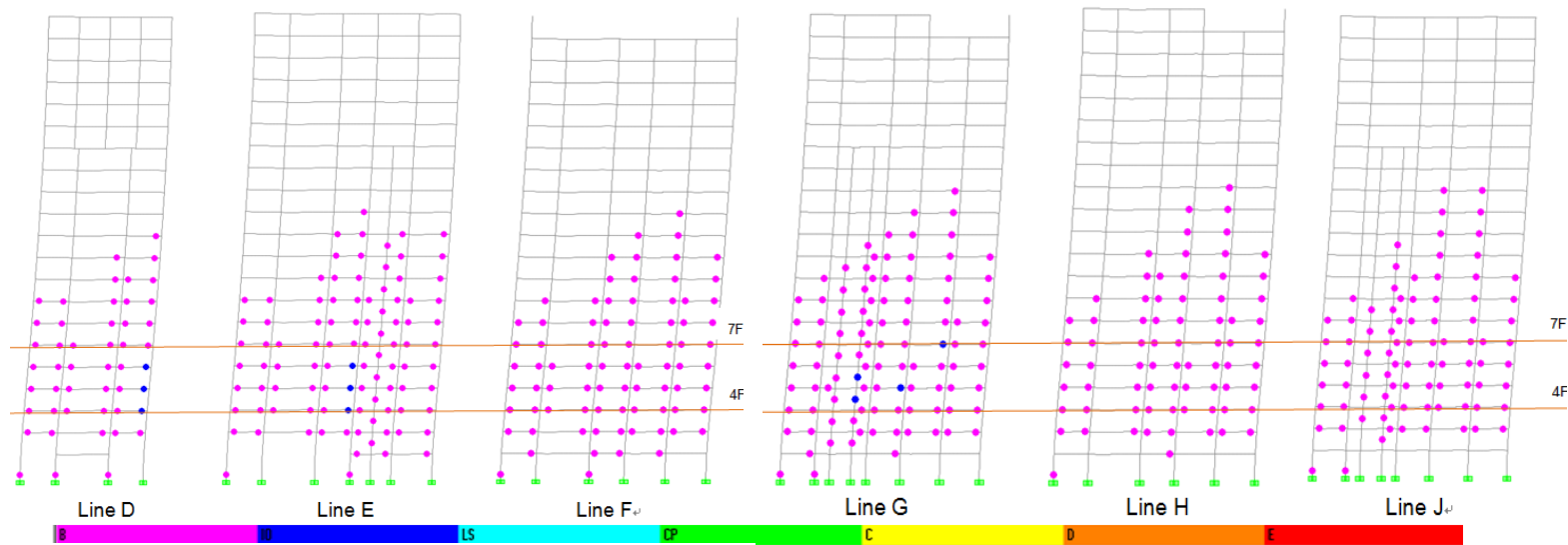
Y方向：



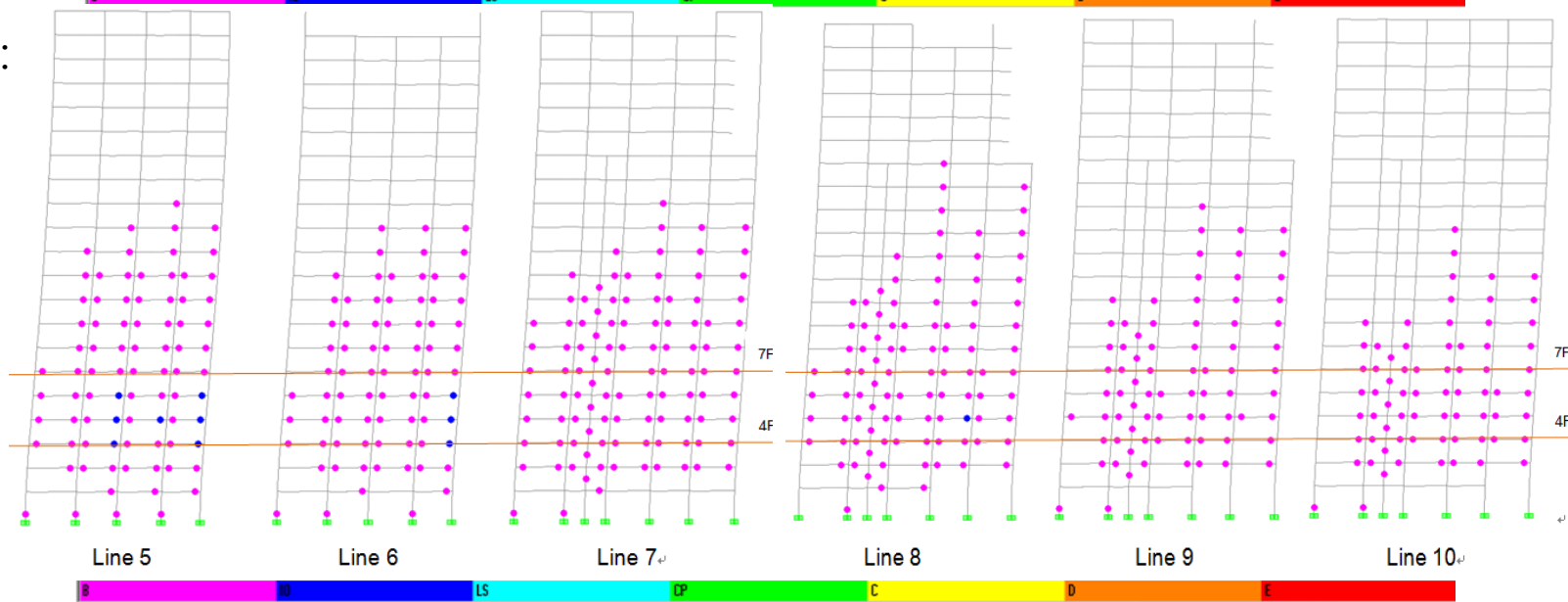
● 非線性靜力側推分析

◆ Pushover 側推分析結果 - 2500年回歸期

X方向：



Y方向：



● 非線性靜力側推分析

◆ Pushover 側推分析結論

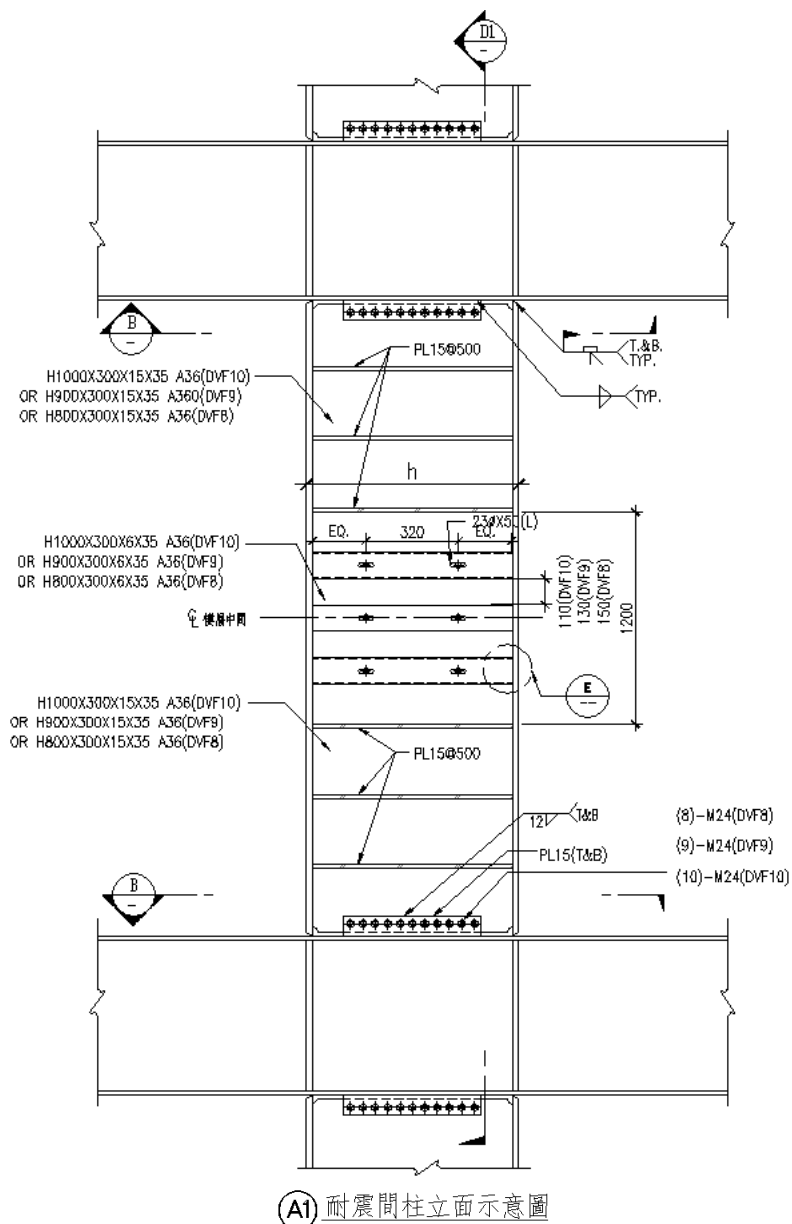
1. 475年回歸期地震危害水準下(BSE-1)達到Immediate Occupancy Performance Level(1-B)
2500年回歸期地震危害水準下(BSE-2)達到Life Safety Performance Level(3-C)
2. 極限層剪力採475年及2500年回歸期($I=1.25$)Pushover結果與設計地震力比值(V_n/V_e)值
 P_u/P_y (2.2~2.4)。

1F柱採鋼柱模擬	Performance Point		Drift Ratio	P_u/P_y	$\Delta u/\Delta y$
	P_u (ton)	Δu (cm)	Δu /總樓高		
X向-475年回歸期	4880	60.5	0.0067	2.20	1.94
X向-2500年回歸期	5087	66.7	0.0074	2.29	2.14
Y向-475年回歸期	4929	61.2	0.0068	2.22	1.94
Y向-2500年回歸期	5150	68.0	0.0075	2.32	2.16

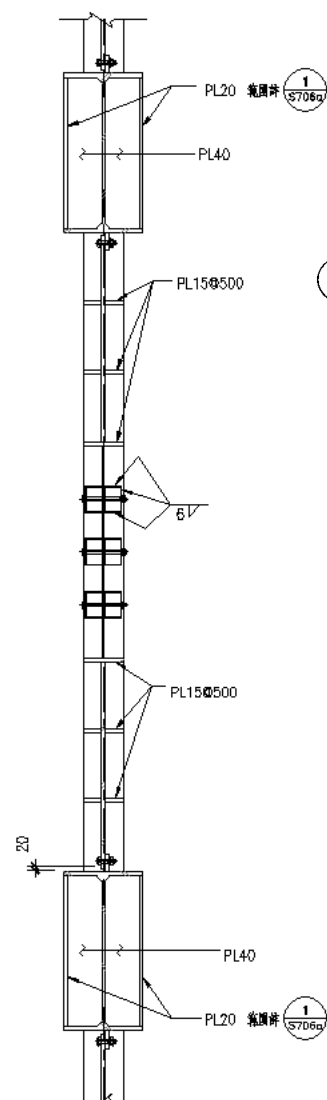
3. 2500年回歸期地震力作用下，4F~7F部分梁塑性轉角達 $1.0\theta_y \sim 2.0\theta_y$ (Life Safety)，於4F~7F大梁梁翼切削。
4. 建物達Collapse Prevention Performance Level (CP)時， $\Delta u/\Delta y$ 值約為4.6。

	Δu (cm)	$\Delta u/\Delta y$	R
X向-達CP性能階段	144	4.6	4
Y向-達CP性能階段	145	4.6	4

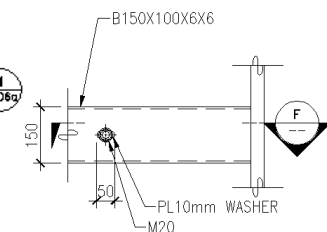
● 耐震間柱施工大樣詳圖



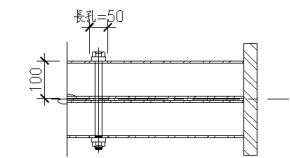
Ⓐ 耐震間柱立面示意圖



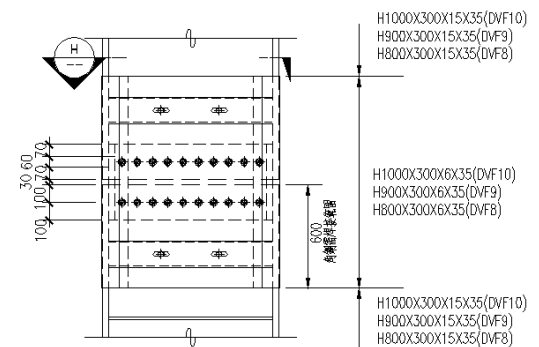
Ⓓ 耐震間柱剖面示意圖



Ⓔ 耐震間柱大樣詳圖

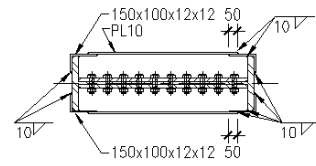


Ⓕ 耐震間柱大樣詳圖



Ⓖ 耐震間柱大樣詳圖

5F, 10F, 耐震間柱大樣詳圖



Ⓗ 耐震間柱大樣詳圖

● 施工照片

◆ 安裝位置 - 1F



◆ 安裝位置 - 5F(釋放軸力)



感 謝 聆 聽