Plastic Analysis and Design

Final Term Project 2017

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Group 3

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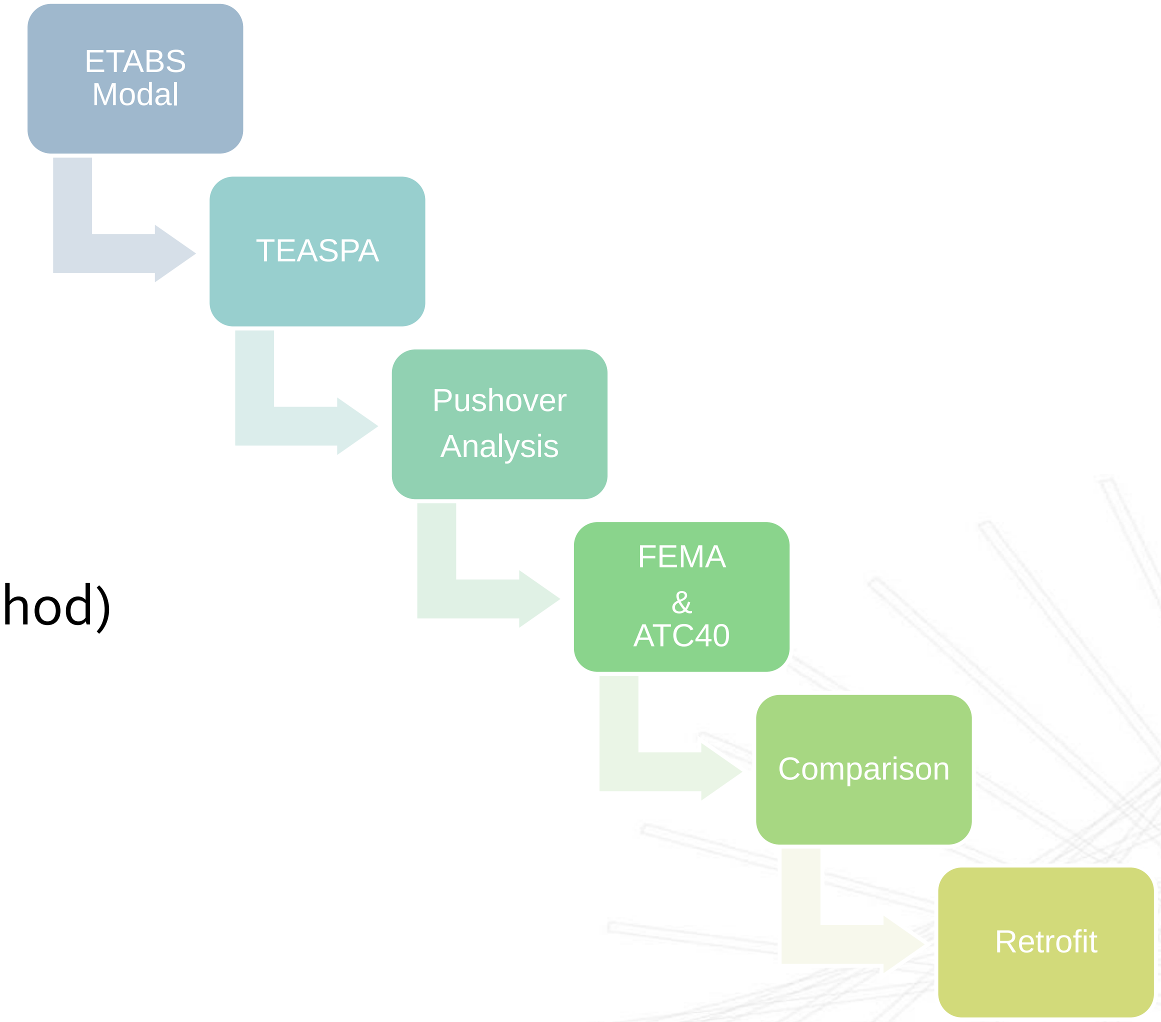
Outline

1. Introduction
2. Analytical Model
3. Seismic Evaluation
4. ATC-40
5. FEMA273
6. Mechanism Method (Upper Bound Method)
7. Retrofit
8. Summary and Remarks
9. Reference



Job Assignment

人員	工作項目
黃聖雯	XTRACT分析、TEASPA分析、ATC40檢核
蔡詠安	XTRACT分析、TEASPA分析、FEMA273檢核
張世昇	ETABS建模、TEASPA分析、結構物補強、Upper bound method

1. Introduction

- 1.1 Purposes
- 1.2 Basic Information
- 1.3 Seismic Records

1.1 Purposes

- 因921倒塌許多校舍之後，發現過去耐震設計規範的不足，並開始以現今規範進行校舍的耐震評估與補強

- 針對1022嘉義地震時倒塌的嘉義民雄農工實習工廠，探討結構物設計上的缺陷、破壞坍塌情形及原因。

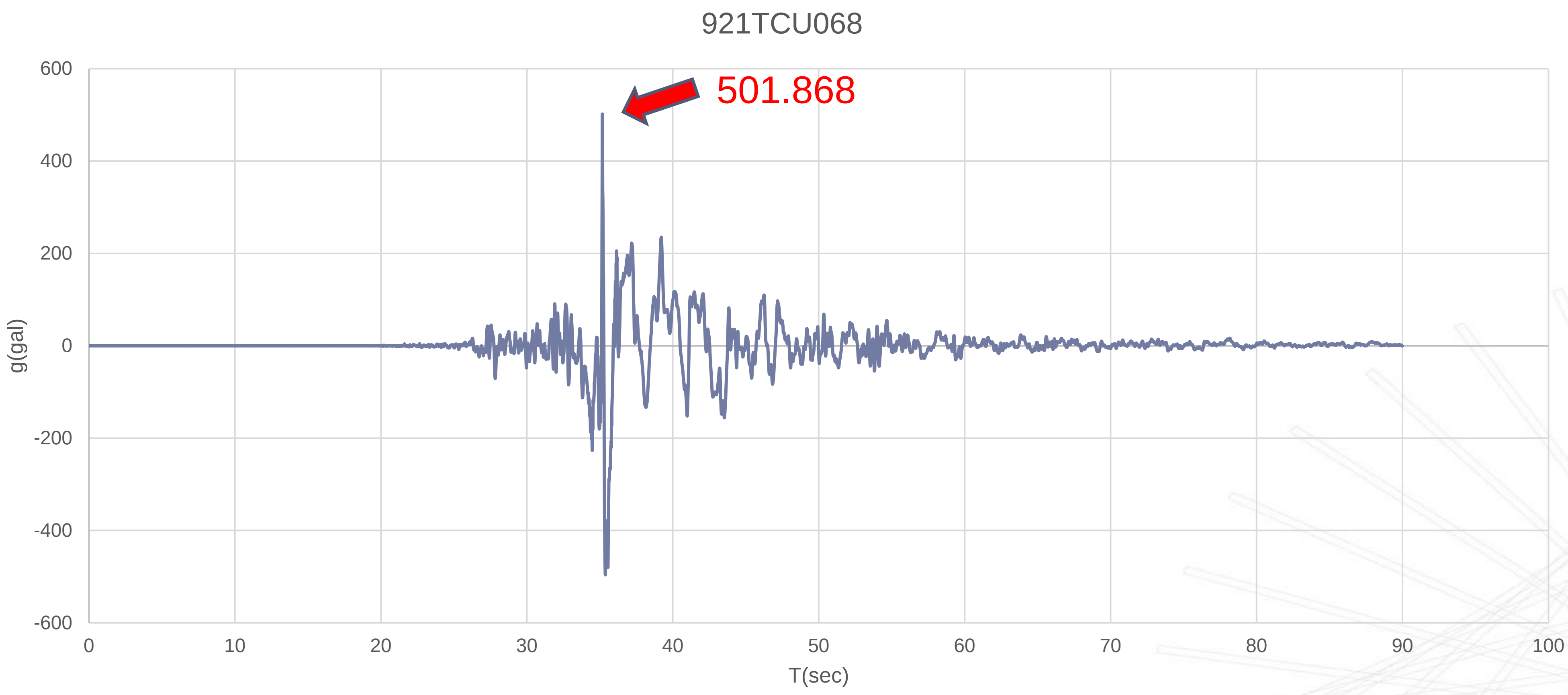
- 利用ETABS及TEASPA等工具進行分析，並配合ATC-40及FEMA273兩種耐震評估方法，來瞭解破壞情形、缺陷。

1.2 Basic Information

- Building Name ： 嘉義民雄農工實習工廠
- Soil Type ： Type 2
- Building Function ： Schoolhouse
- Structure System ： RC MRF
- Structure Size ： 2 floors without basement
- Plan Dimensions ： Long Dir. 48.4 m Short Dir. 12.5 m
- Materials ： Concrete $f_c'=$ 280 kgf/cm²
  Rebar $f_y =$ 2800 kgf/cm²
- Loadings ： Dead load 850 kg/m² Including all members
  Live load 250 kg/m²

1.3 Seismic Records

921 TCU068 100%

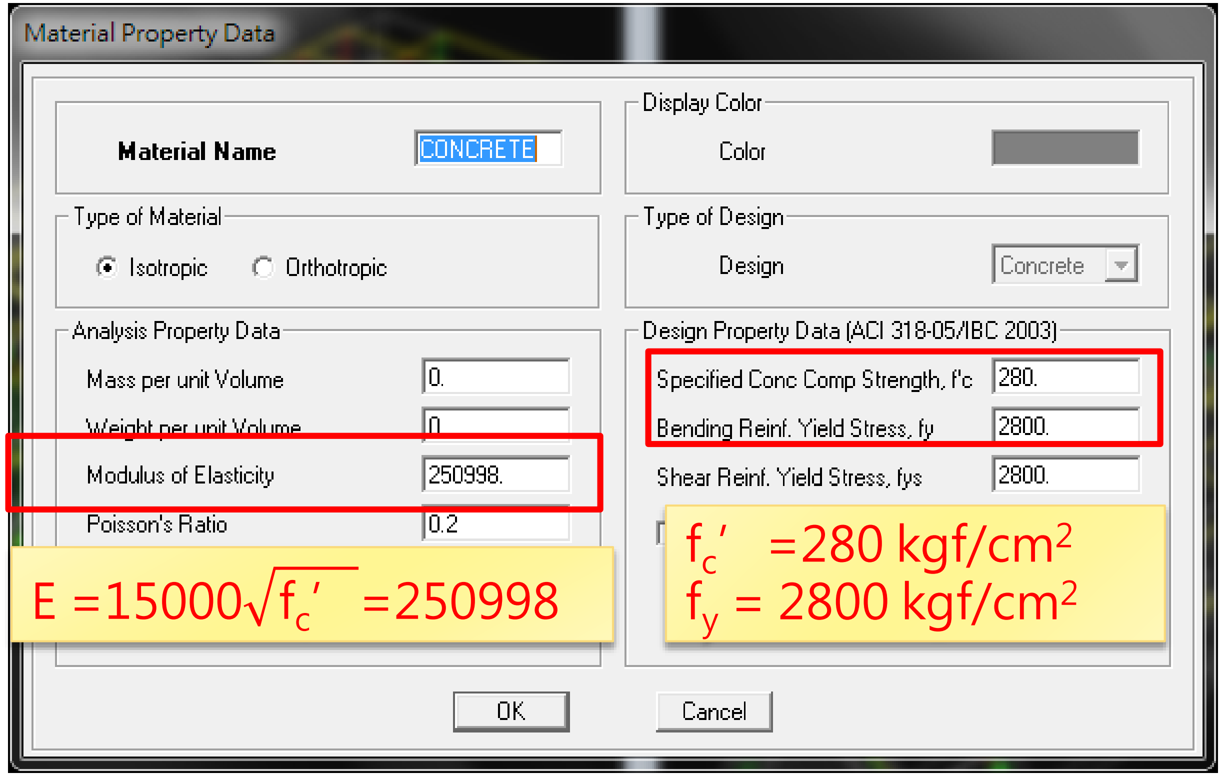


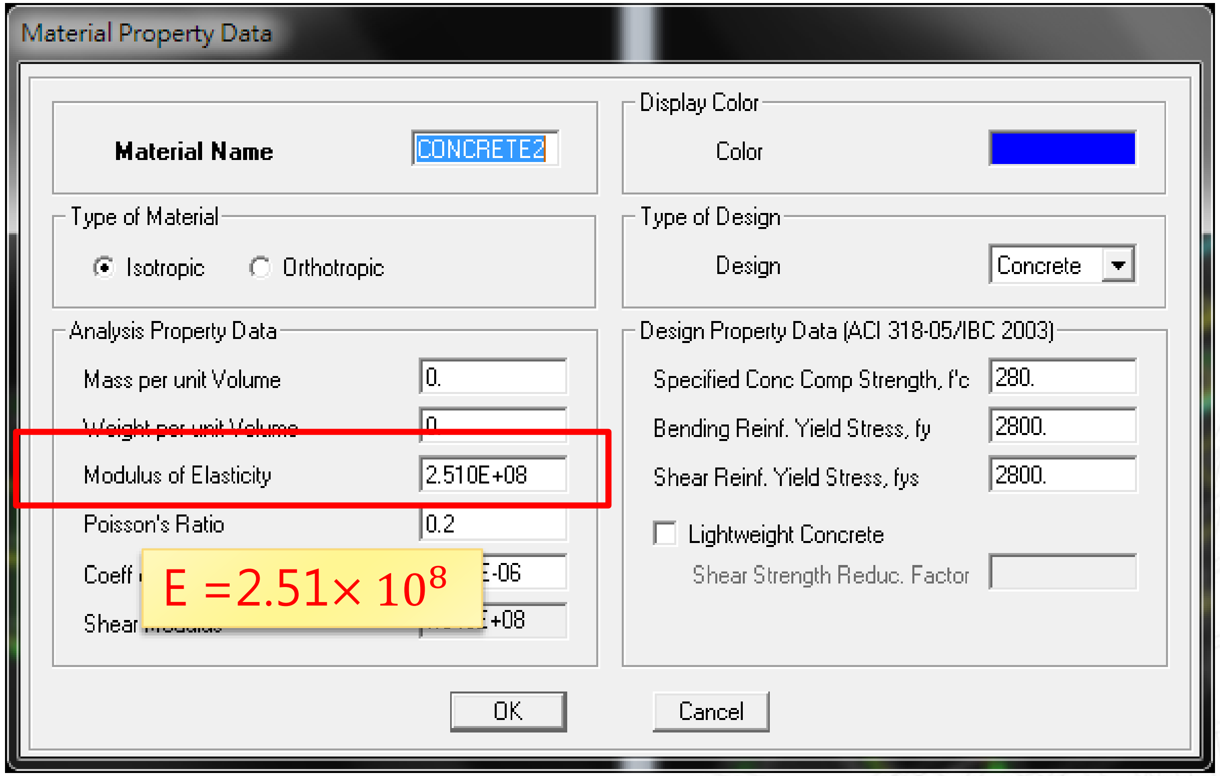
2. Analytical Model

- 2.1 ETABS

2.1 ETABS

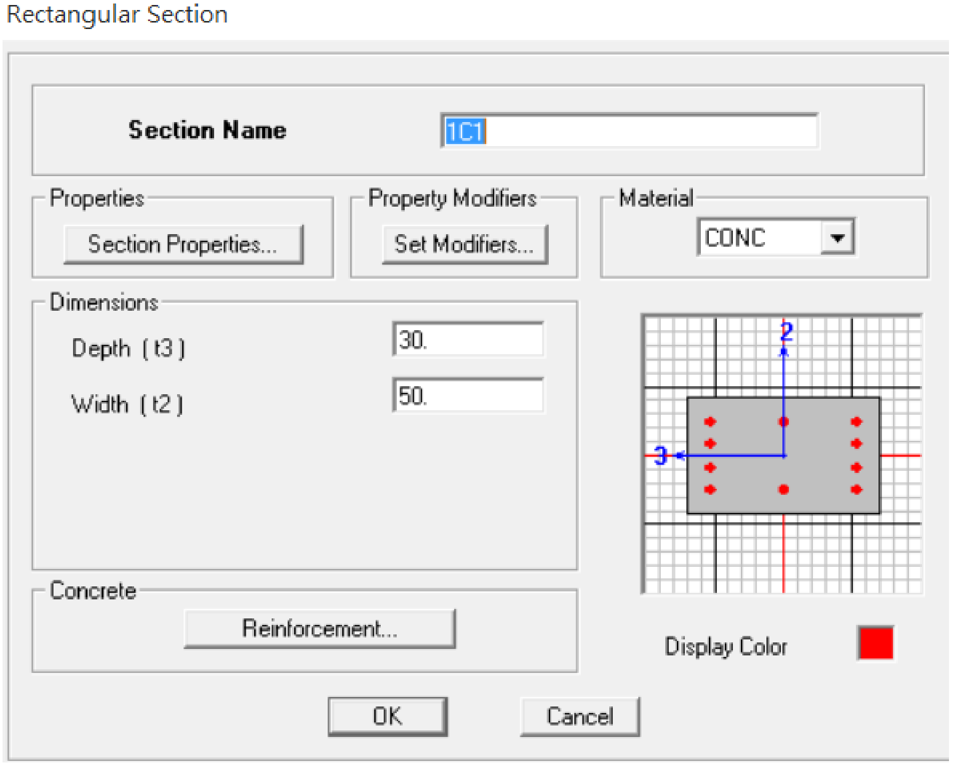
- Define Material Properties

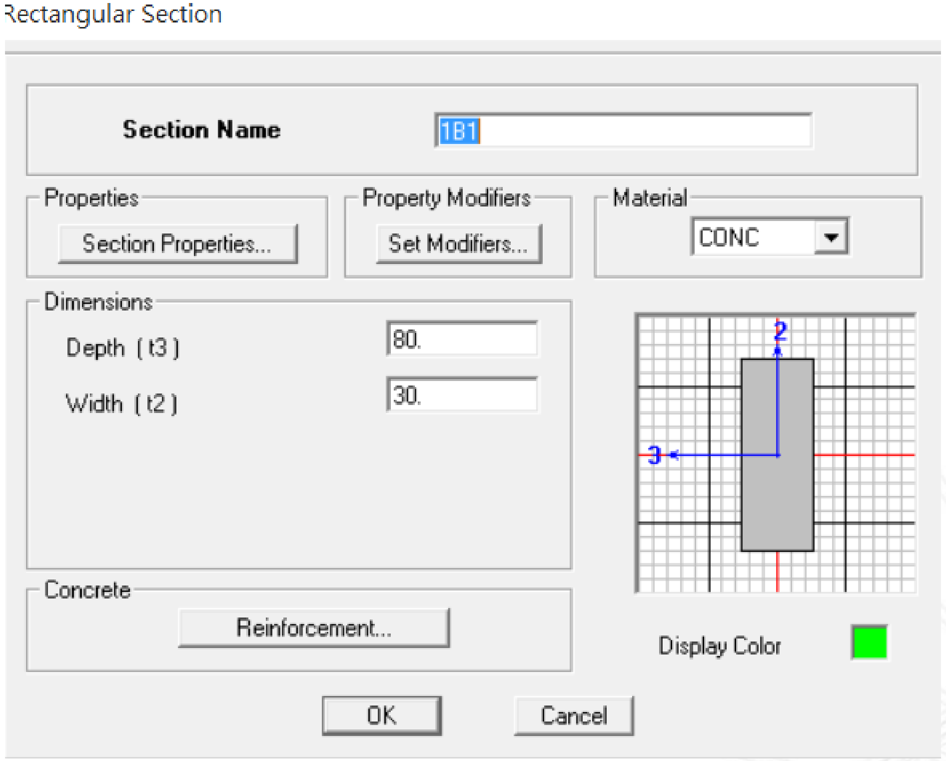




2.1 ETABS

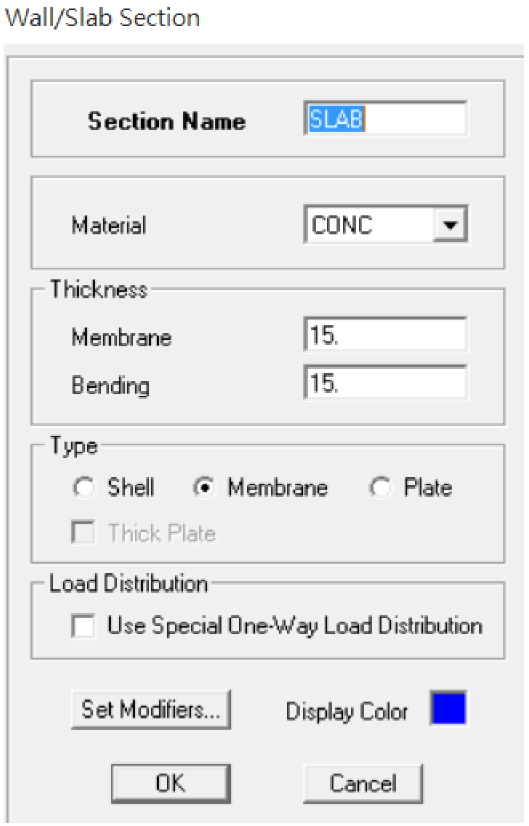
- Define Frame Section ：column 、beam

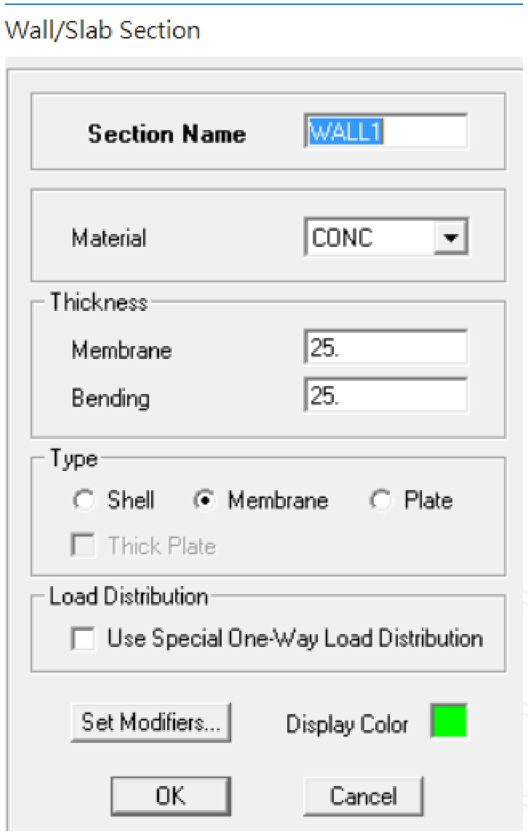




2.1 ETABS

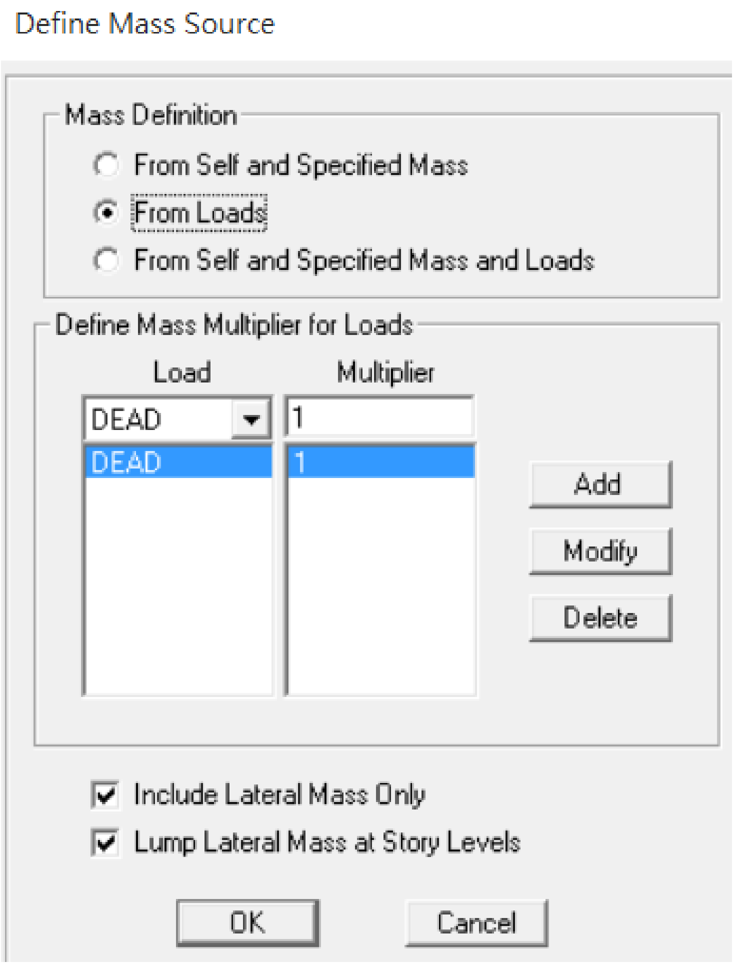
- Define： Slab 、Wall





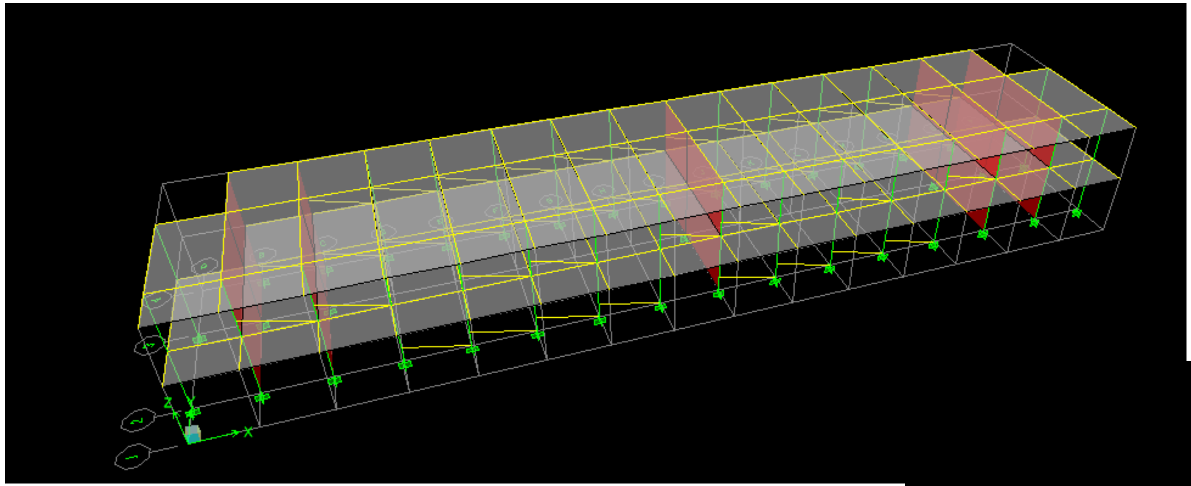
2.1 ETABS

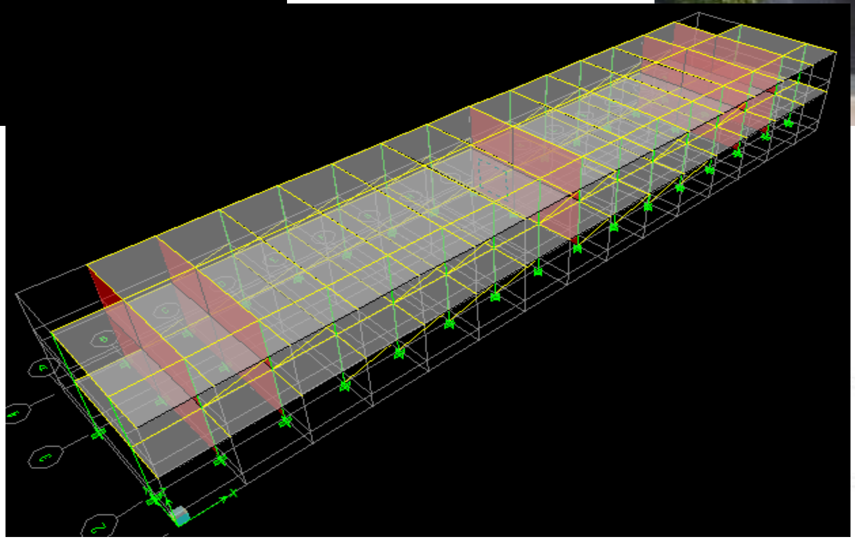
- Define ： Mass source



2.1 ETABS

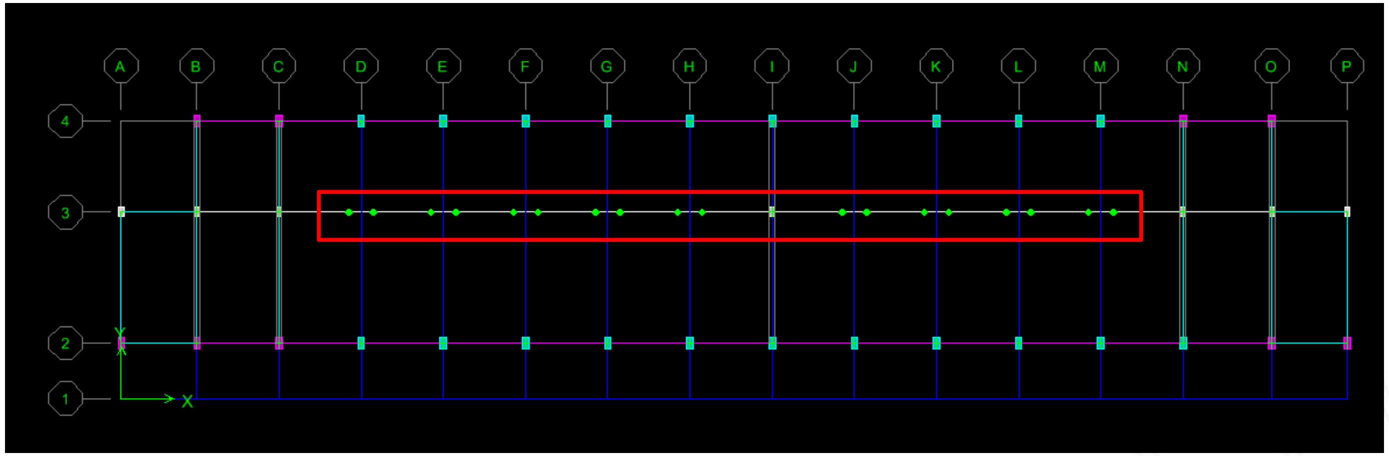
- Construct the model



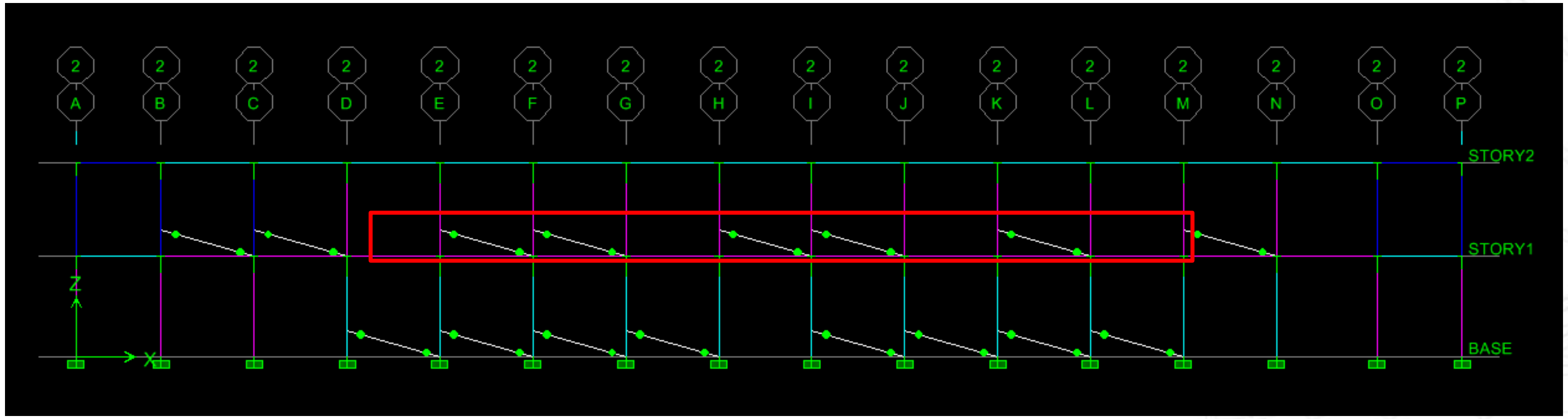


2.1 ETABS

- Construct the model
- **Secondary beams & Brace(brick wall)**

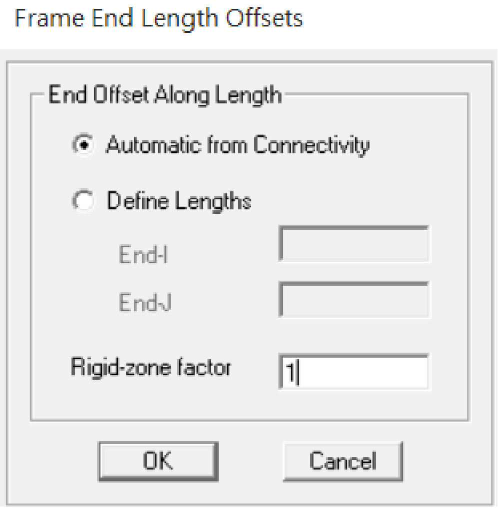


Set secondary beams and Braces as pin-connected

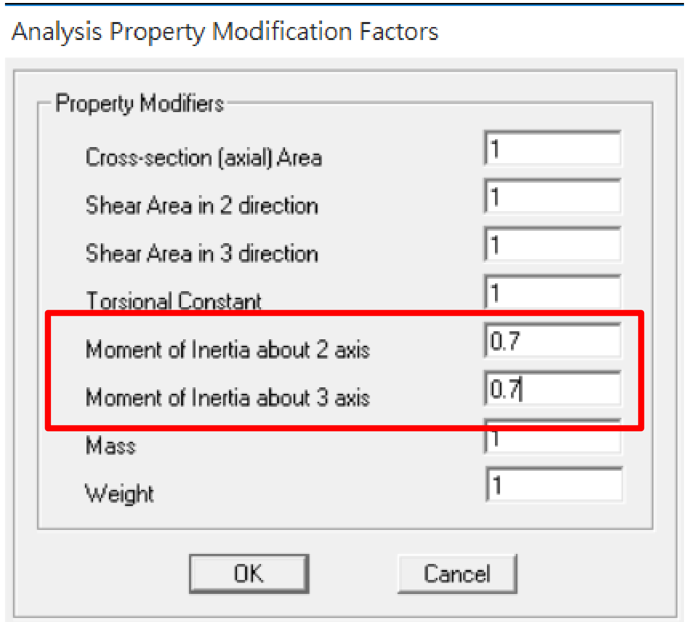


2.1 ETABS

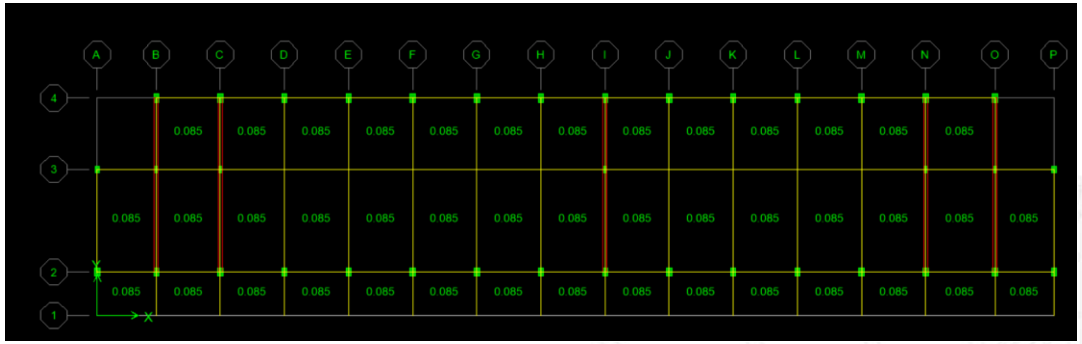
Assign



Rigid zone factor



Stiffness reduction in this step (Assign→Frame/Line→Frame property modifiers)

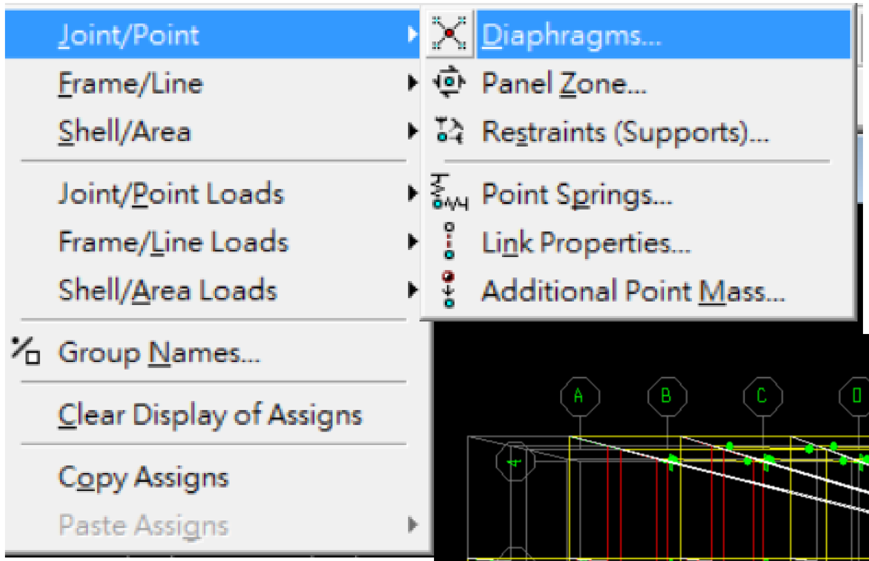


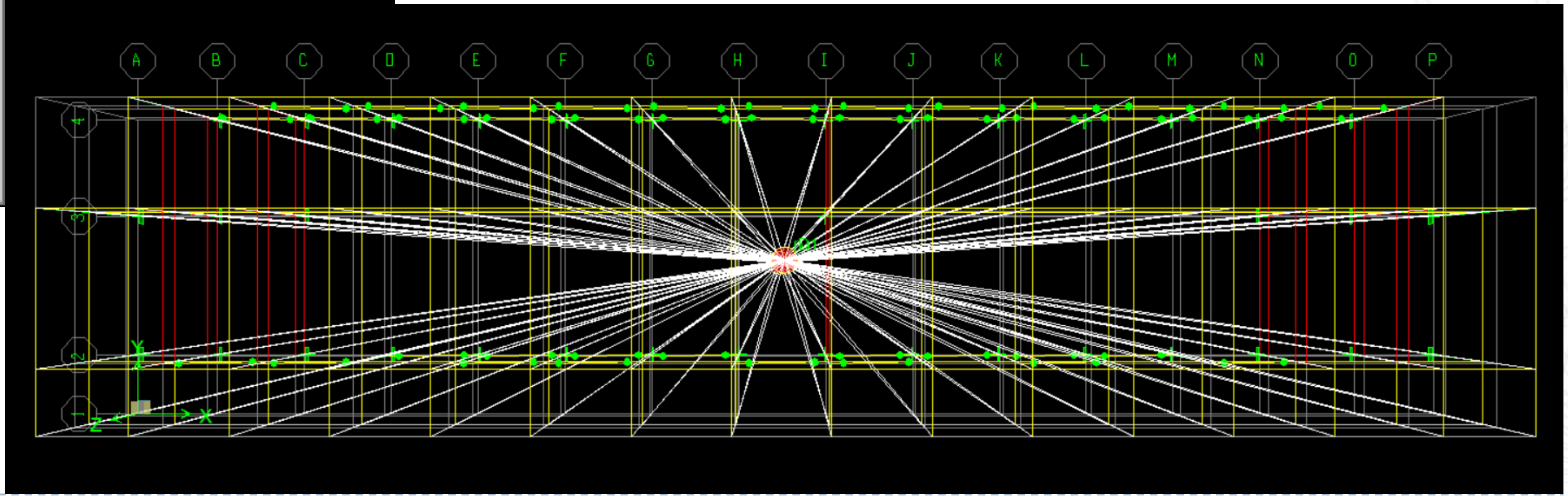
Assign load

2.1 ETABS

- Assign

剛性樓板設定





2.1 ETABS

- Model analysis

	+x	-x
週期	0.3982sec	0.3978sec
X向有效質量參與係數	96.647%	96.6449%
RFL振態係數	0.0344	0.0344
2FL振態係數	0.0236	0.0236

3. Seismic Evaluation

- 3.1 TEASPA & Pushover analysis setting
- 3.2 Analysis results

3.1 TEASPA & Pushover analysis setting

- Build the input file
- $ BUILDING PROPERTIES
- $ SITE SPECTRUM PARAMETER
- $ COLUMN PROPERTIES
- $ BEAM PROPERTIES
- $ COLUMN DATA
- $ BEAM DATA
- $ AXIAL LOAD
- $ COLUMN SECTION PROPERTIES

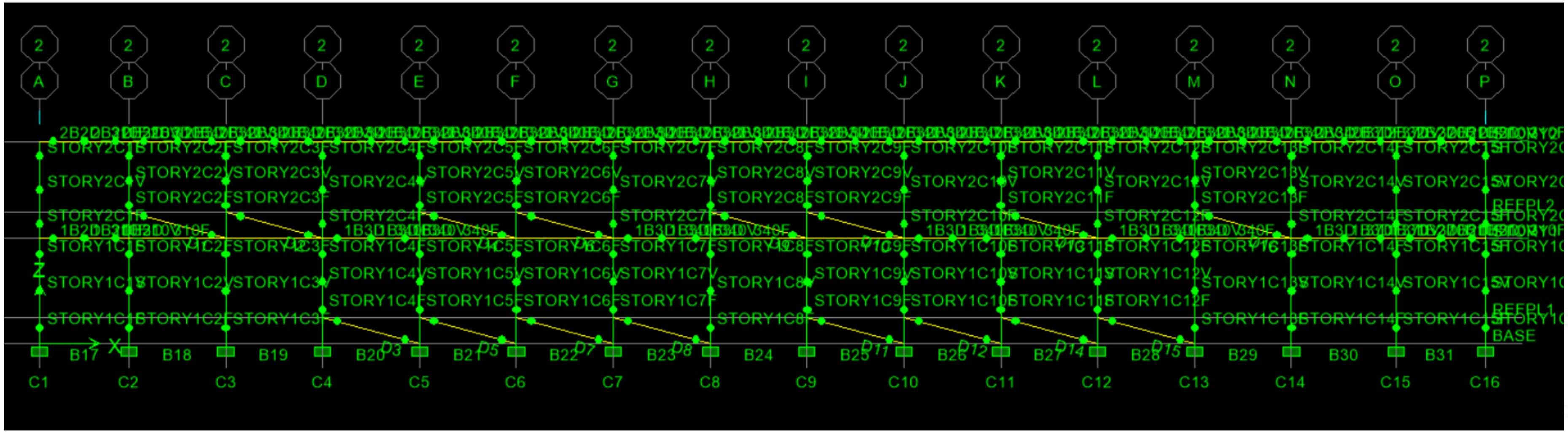
$$S_{DS} = N_A F_a S_S^D = 1.37 \times 1.0 \times 0.8 = 1.096$$

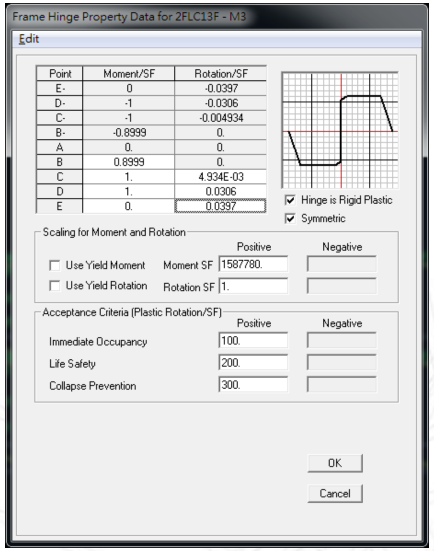
$$S_{D1} = N_v F_v S_1^D = 1.44 \times 1.1 \times 0.45 = 0.7128$$

3.1 TEASPA & Pushover analysis setting

- Run ColPH

we can get the new model (.e2k) with the plastic hinges





3.1 TEASPA & Pushover analysis setting

- Set pushover analysis in ETABS

Lateral force distribution

$$F_X = \frac{w_x h_x}{\sum w_x h_x} V$$

X向:

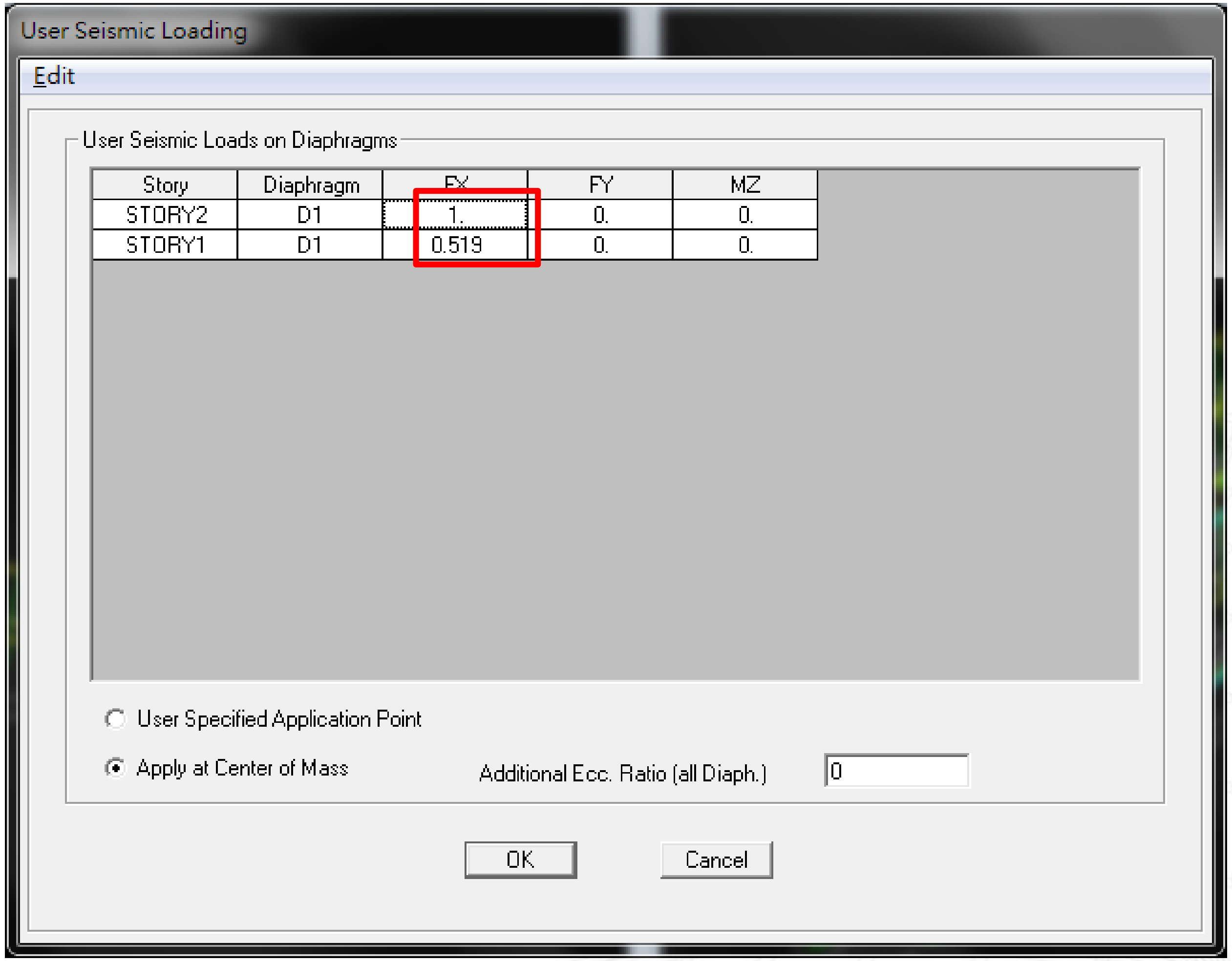
Story2 = 1

Story1 = 0.519

-X向:

Story2 = -1

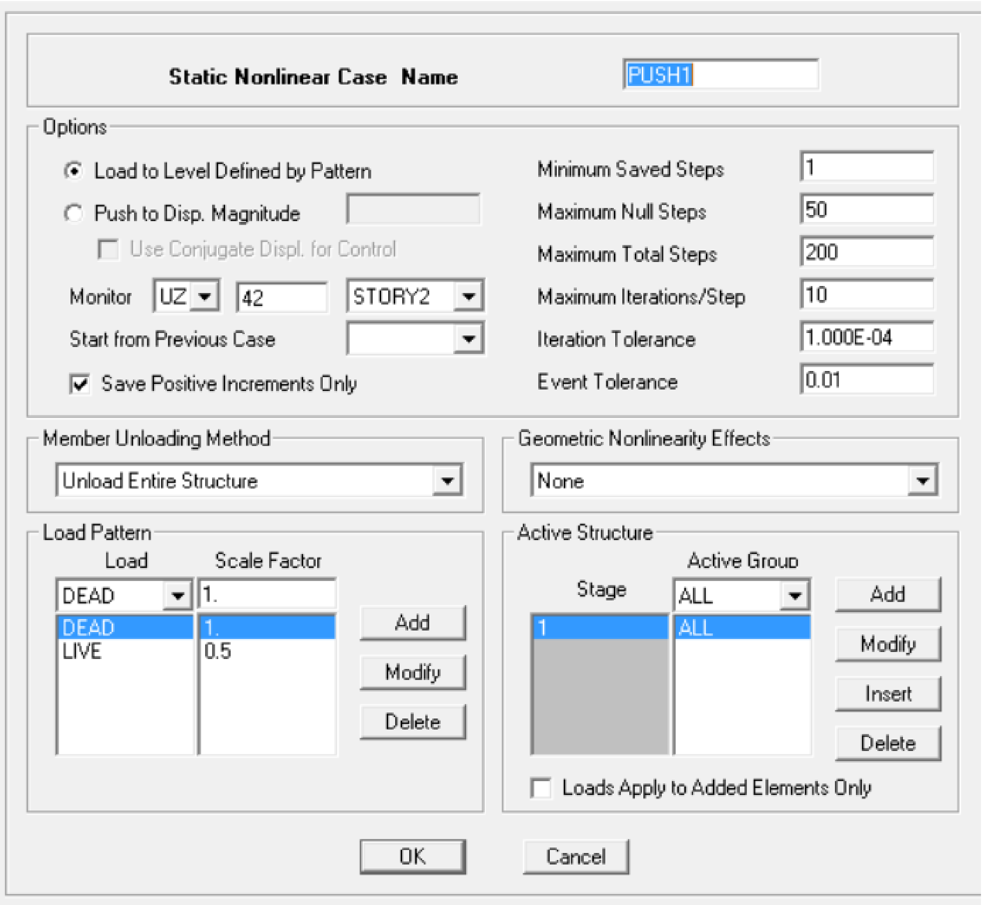
Story1 = -0.519



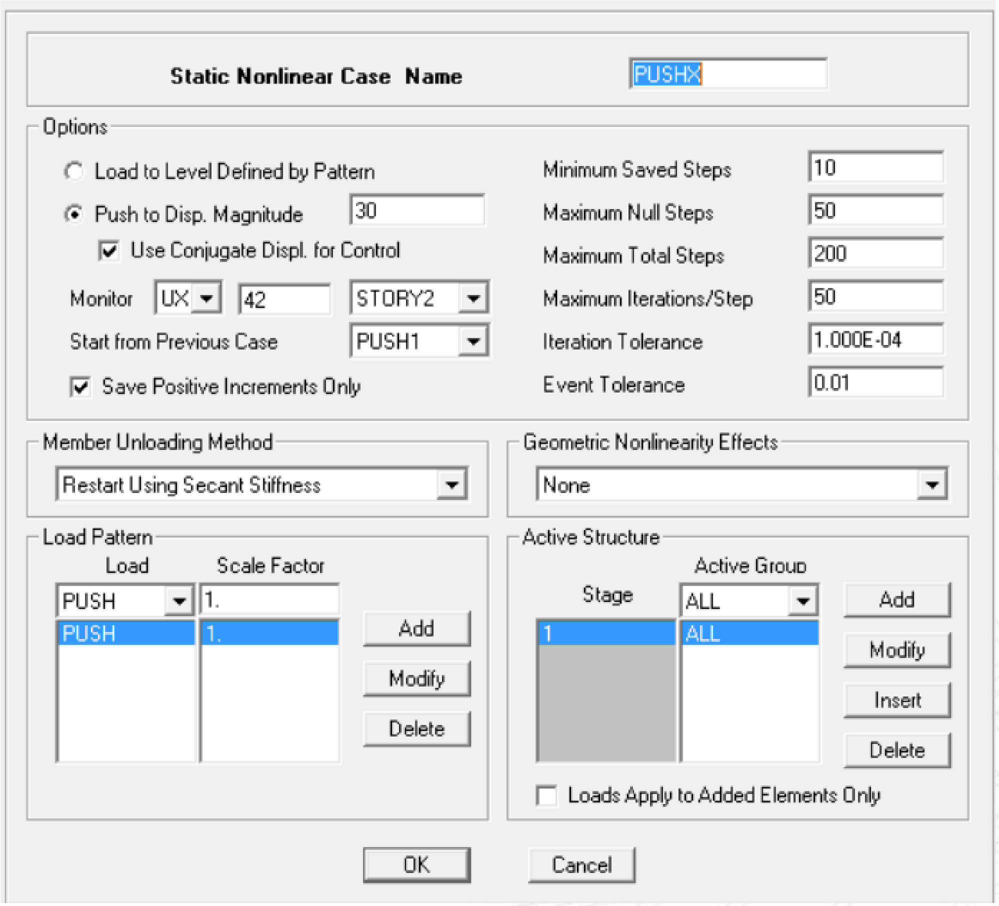
3.1 TEASPA & Pushover analysis setting

- Define static nonlinear analysis

Static Nonlinear Case Data

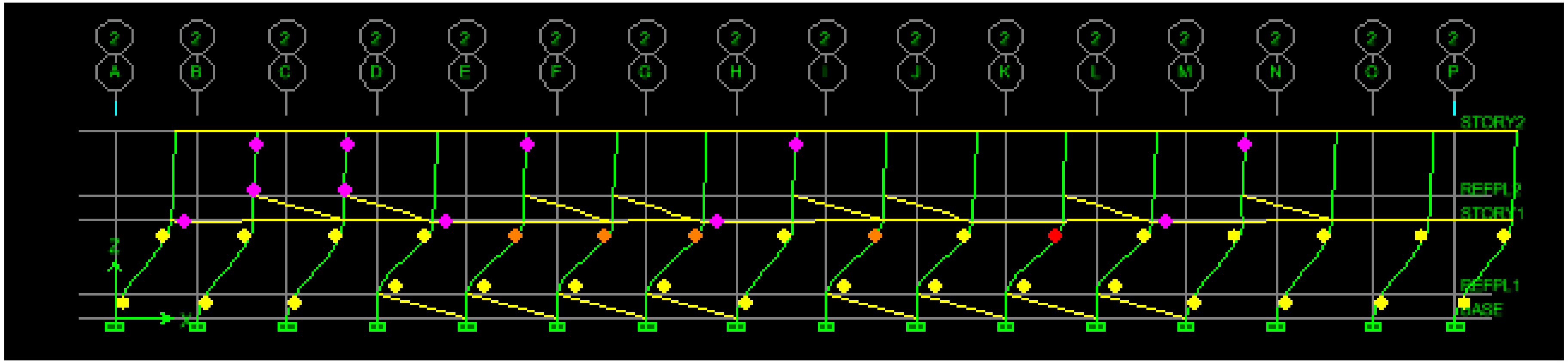


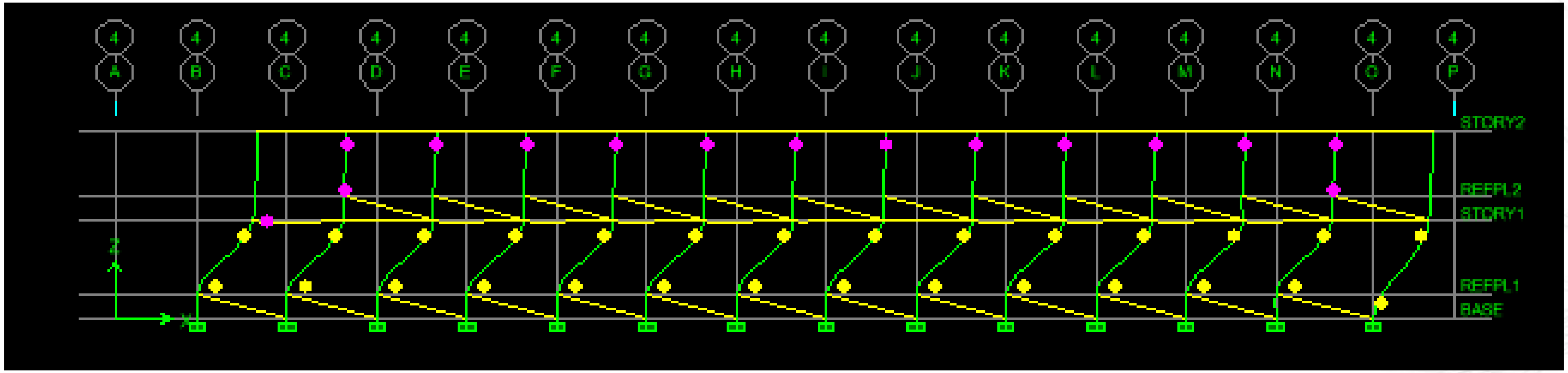
Static Nonlinear Case Data



3.2 Analysis results

- Analysis results:(+X direction)

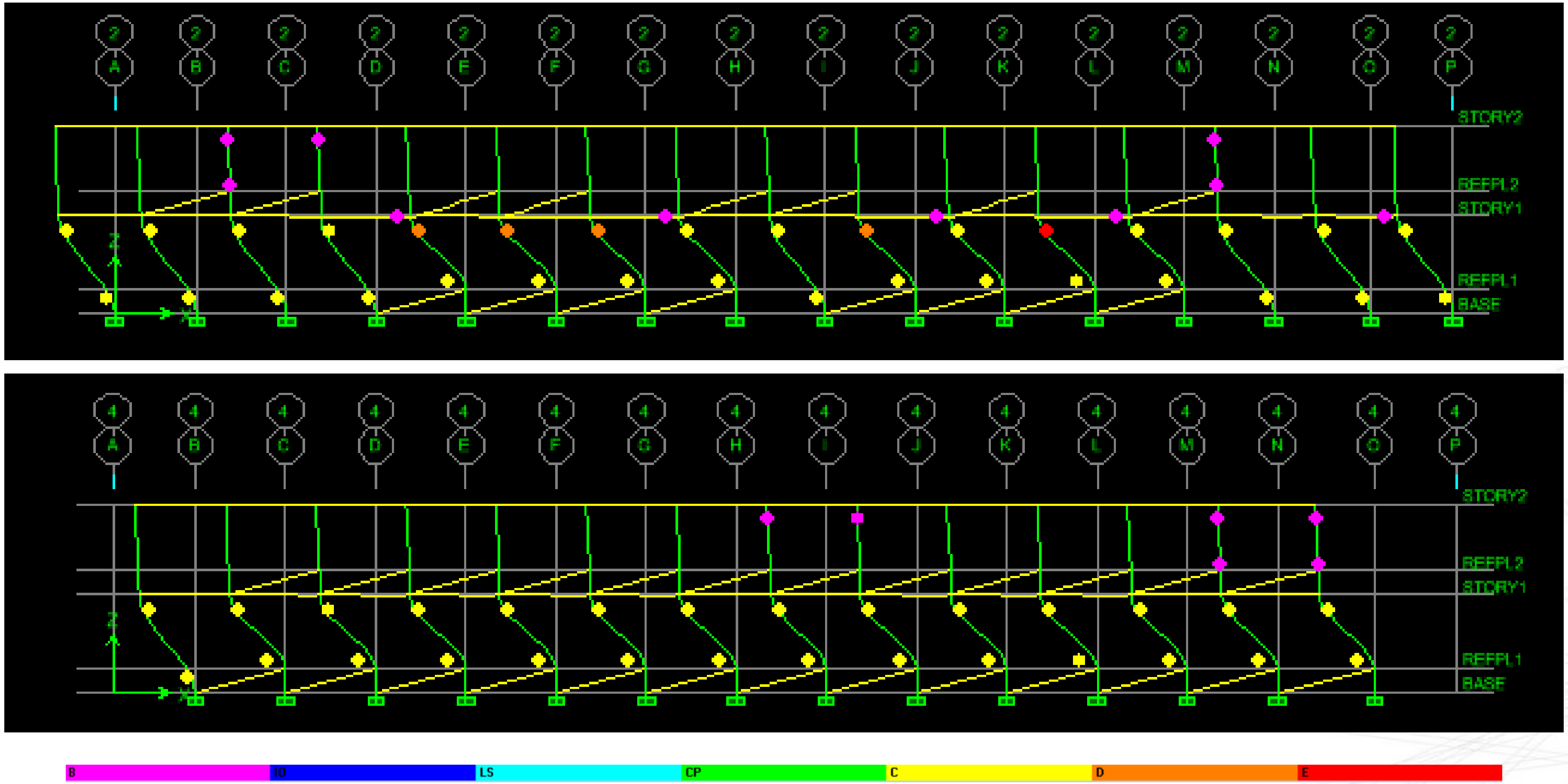




3.2 Analysis results

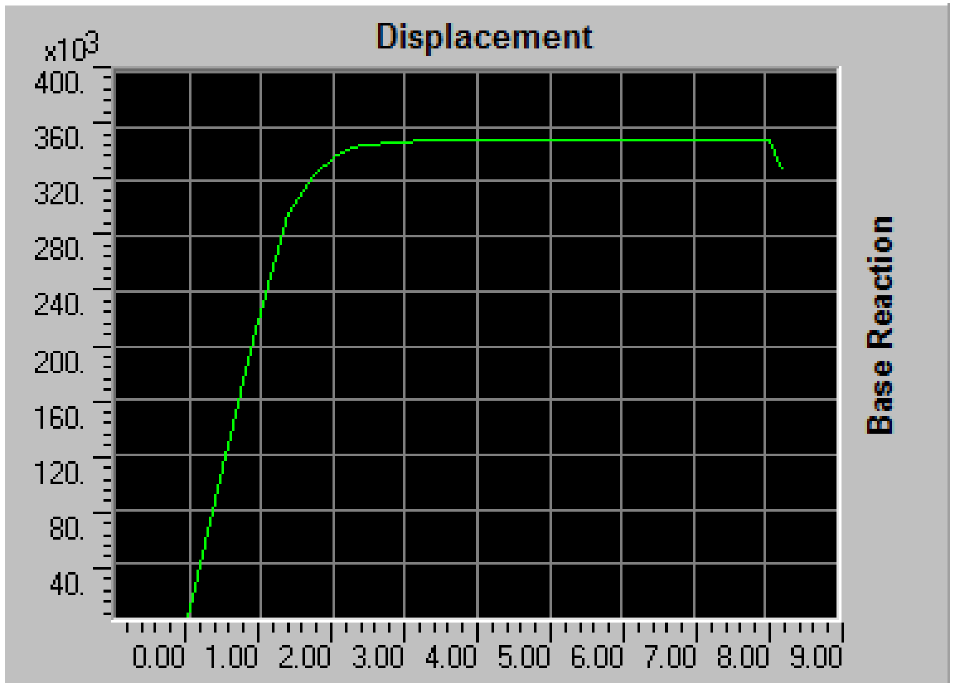
- Analysis results:(-X direction)

Strong Beam - Weak Column → Soft Story



3.2 Analysis results

- Pushover curve :(+X direction)



	Max.Displacement(cm)	Max.Base(kgf)
+X	8.0401	351295

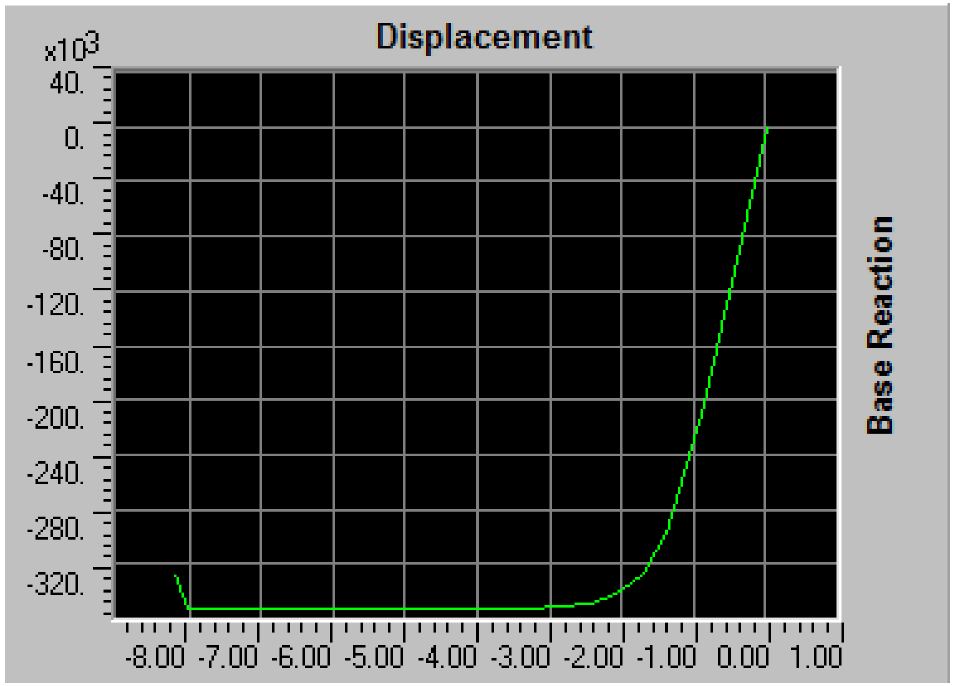
Check with TEASPA (filename*_colecho) (in kgf)：

$Name	story	Flexure(kgf)
C1	STORY1	6709.95
…	…	…
C37	STORY1	6163.79
	Σ	352484.9

Check ok!!

3.2 Analysis results

- Pushover curve :(-X direction)



	Max.Displacement(cm)	Max.Base(kgf)
-X	8.0058	353106

Check with TEASPA (filename*_colecho) (in kgf)：

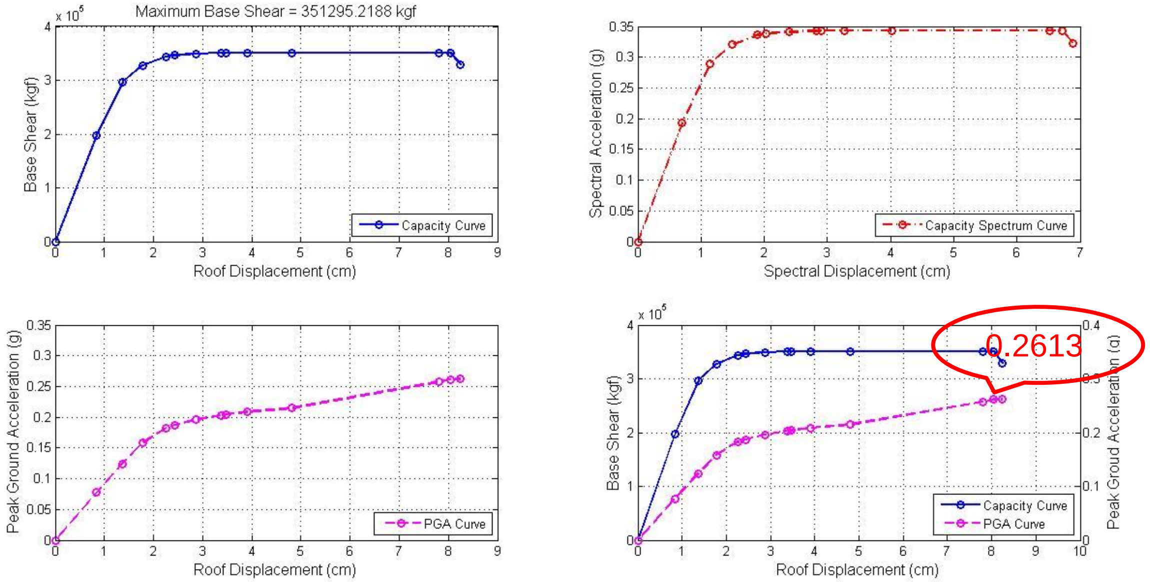
$Name	story	Flexure(kgf)
C1	STORY1	6707.53
…	…	…
C37	STORY1	8786.68
	Σ	354522.7

Check ok!!

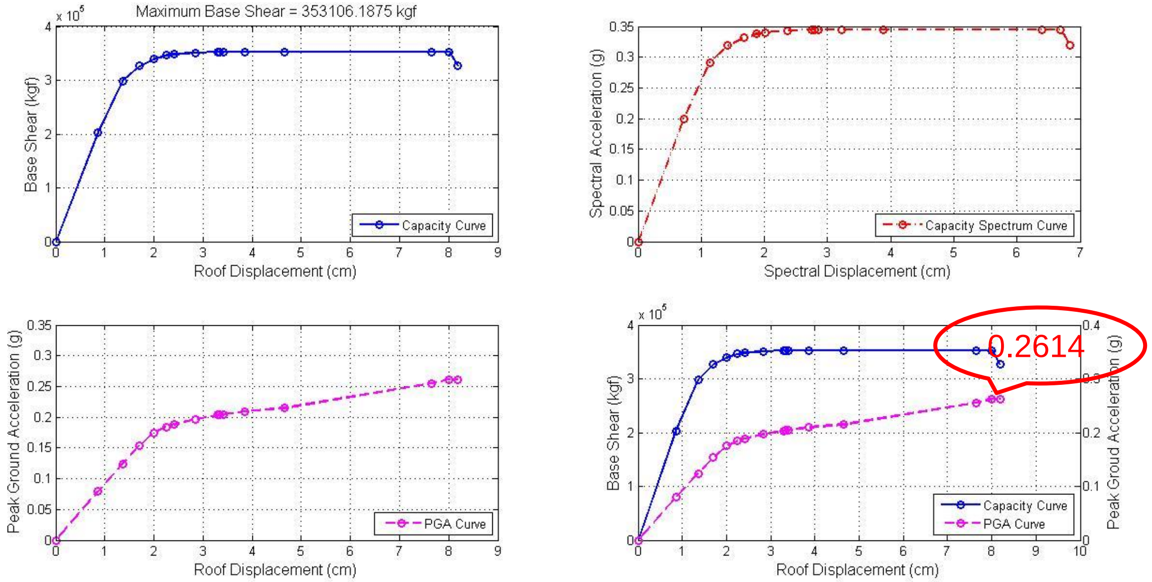
3.2 Analysis results

- Run PGA

(+X direction)



(-X direction)



3.2 Analysis results:(+X direction)

Max.Displacement(cm)	Max.Base Force(kgf)	Ap(g)	Drift ratio
8.0401	351295	0.261271	RFL：0.1516% 2FL：1.9287%

	位移準則	軸力破壞準則	評估標準
一般校舍用途結構	RFL：0.1516%<2% 2FL：1.9287%<2%	無	A_P=0.261271g A_T=0.4S_{DS}=0.4*1.096g=0.438g A_P<A_T

因為A_P<A_T（性能目標地表加速度值＜設計地震地表加速度值），所以需進行結構補強

3.2 Analysis results:(-X direction)

Max.Displacement(cm)	Max.Base Force(kgf)	Ap(g)	Drift ratio
8.0058	353106	0.261408	RFL：0.1444% 2FL：1.9232%

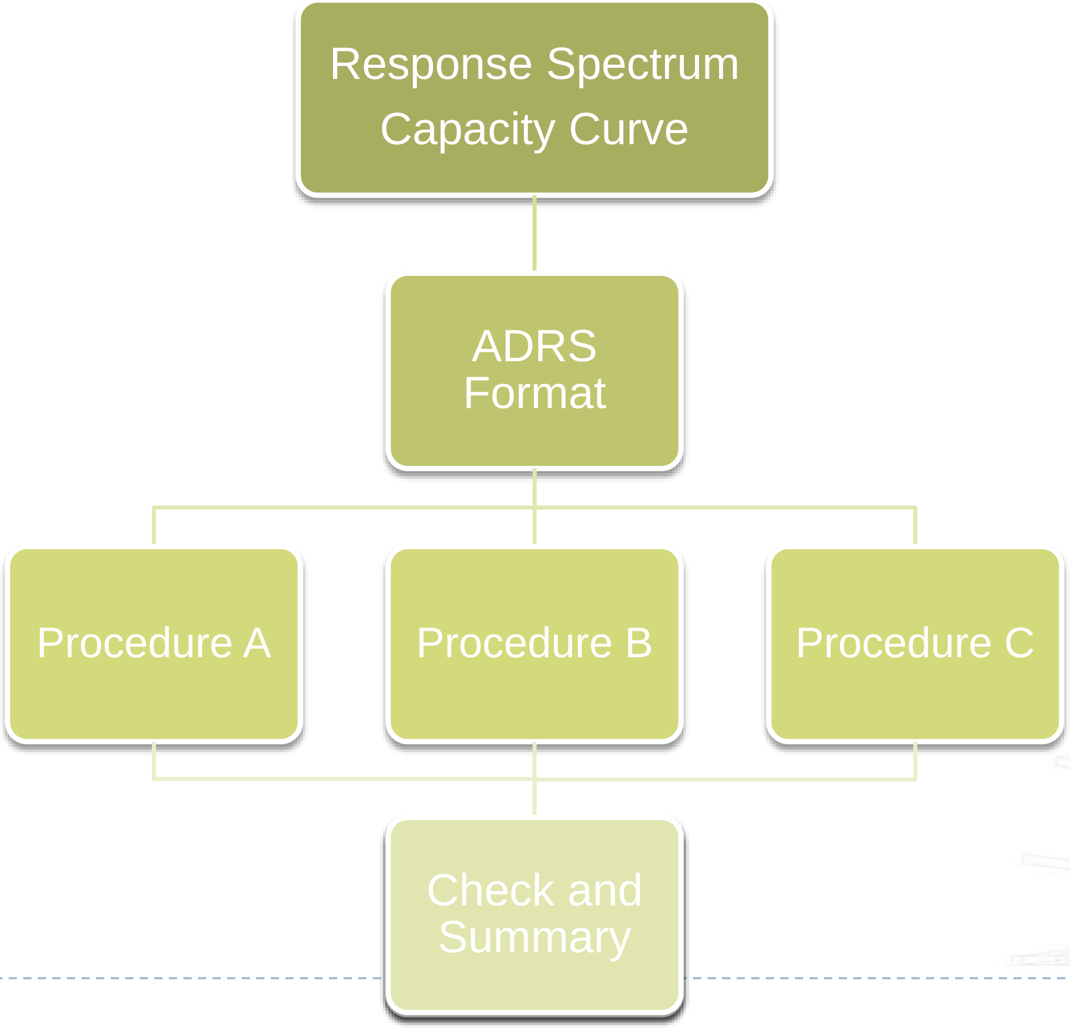
	位移準則	軸力破壞準則	評估標準
一般校舍用途結構	RFL：0.1444%<2% 2FL：1.9232%<2%	無	A_P=0.261408g A_T=0.4S_{DS}=0.4*1.096g=0.438g A_P<A_T

因為A_P<A_T（性能目標地表加速度值 < 設計地震地表加速度值），所以需進行結構補強

4. ATC40

- 4.1 ATC-40 flow chart and preparation
- 4.2 Procedure A
- 4.3 Procedure B
- 4.4 Procedure C
- 4.5 Check and Summary

4.1 ATC-40 flow chart and preparation



4.1 ATC-40 flow chart and preparation

	四湖鄉	0.7	0.4	0.9	0.5	
	口湖鄉	0.7	0.4	0.9	0.5	
	水林鄉	0.7	0.4	0.9	0.5	
	太保市	0.7	0.4	0.9	0.5	梅山斷層
	朴子市	0.7	0.4	0.9	0.5	
	布袋鎮	0.7	0.4	0.9	0.5	
	大林鎮	0.8	0.45	1.0	0.55	梅山、大尖山與觸口斷層
嘉義縣	民雄鄉	0.8	0.45	1.0	0.55	梅山斷層
	溪口鄉	0.8	0.45	1.0	0.55	梅山斷層
	新港鄉	0.7	0.4	0.9	0.5	梅山斷層
	六腳鄉	0.7	0.4	0.9	0.5	
	東石鄉	0.7	0.4	0.9	0.5	

表 2-4-4　近梅山斷層調整因子 N_A 與 N_V

(a) 設計地震之調整因子

N_A	r≦2 km	2km＜r≦5 km	5km＜r≦8 km	r＞8 km
	1.37	1.28	1.15	1.00
N_V	r≦2 km	2km＜r≦5 km	5km＜r≦8 km	r＞8 km
	1.44	1.36	1.20	1.00

表 2-2(a) 短週期結構之工址放大係數 F_a(線性內插求值)

地盤分類	震區短週期水平譜加速度係數 S_S (S_S^D 或 S_S^M)				
	$S_S \le 0.5$	$S_S=0.6$	$S_S=0.7$	$S_S=0.8$	$S_S \ge 0.9$
第一類地盤	1.0	1.0	1.0	1.0	1.0
第二類地盤	1.1	1.1	1.0	1.0	1.0
第三類地盤	1.2	1.2	1.1	1.0	1.0

表 2-2(b) 長週期結構之工址放大係數 F_v(線性內插求值)

地盤分類	震區一秒週期水平譜加速度係數 S_1 (S_1^D 或 S_1^M)				
	$S_1 \le 0.30$	$S_1=0.35$	$S_1=0.40$	$S_1=0.45$	$S_1 \ge 0.50$
第一類地盤	1.0	1.0	1.0	1.0	1.0
第二類地盤	1.5	1.4	1.3	1.2	1.1
第三類地盤	1.8	1.7	1.6	1.5	1.4

$S_S^D = 0.8$ $\quad S_1^D = 0.45$

$N_A = 1.37$ $\quad N_V = 1.44$

$S_S^D N_A = 1.096$ $\quad S_1^D N_V = 0.648$

$F_a = 1.0$ $\quad F_v = 1.1$

$S_{DS} = F_a S_S^D N_A = 1.096$

$S_{D1} = F_v S_1^D N_V = 0.7128$

4.1 ATC-40 flow chart and preparation

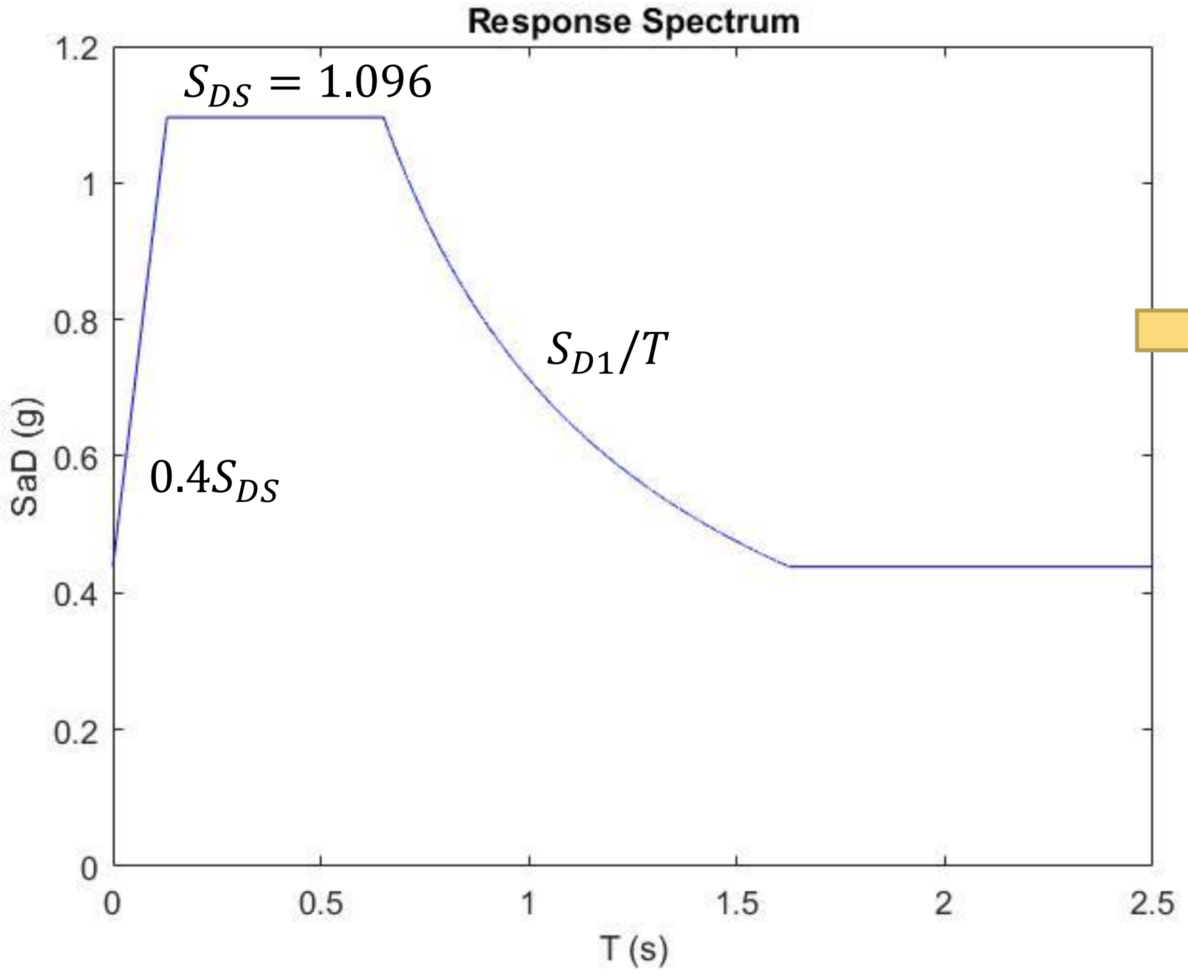
The structure is Type C

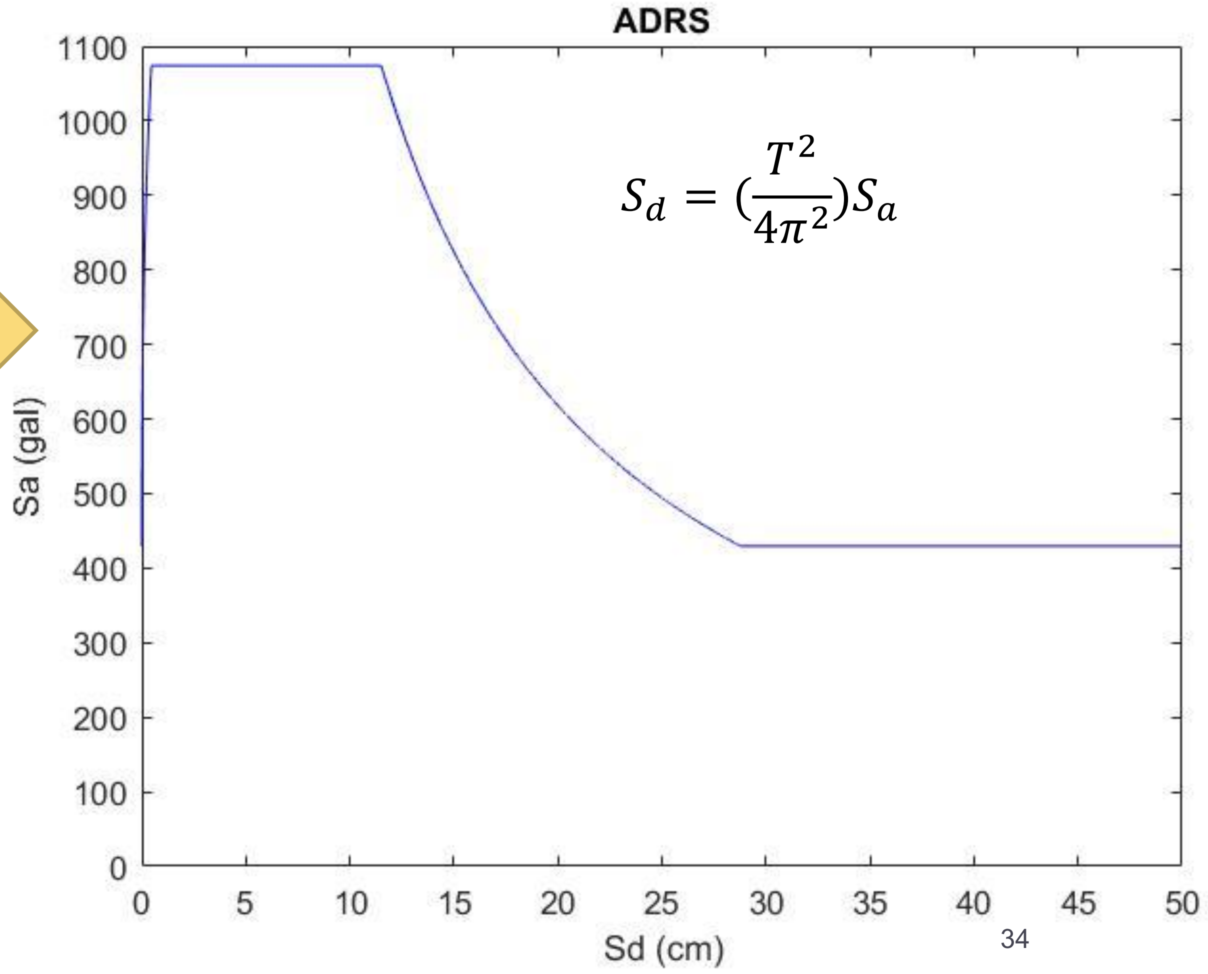
Shaking Duration	Essentially New Building	Average Existing Building	Poor Existing Building
Short	Type A	Type B	Type C
Long	Type B	Type C	Type C

Structural Behavior Type	β_0 (%)	κ
Type A	≤ 16.25	1.0
	> 16.25	$1.13 - \frac{0.51(a_y d_{pi} - d_y a_{pi})}{a_{pi} d_{pi}}$
Type B	≤ 25	0.67
	> 25	$0.845 - \frac{0.446(a_y d_{pi} - d_y a_{pi})}{a_{pi} d_{pi}}$
Type C	Any Value	0.33

4.1 ATC-40 flow chart and preparation

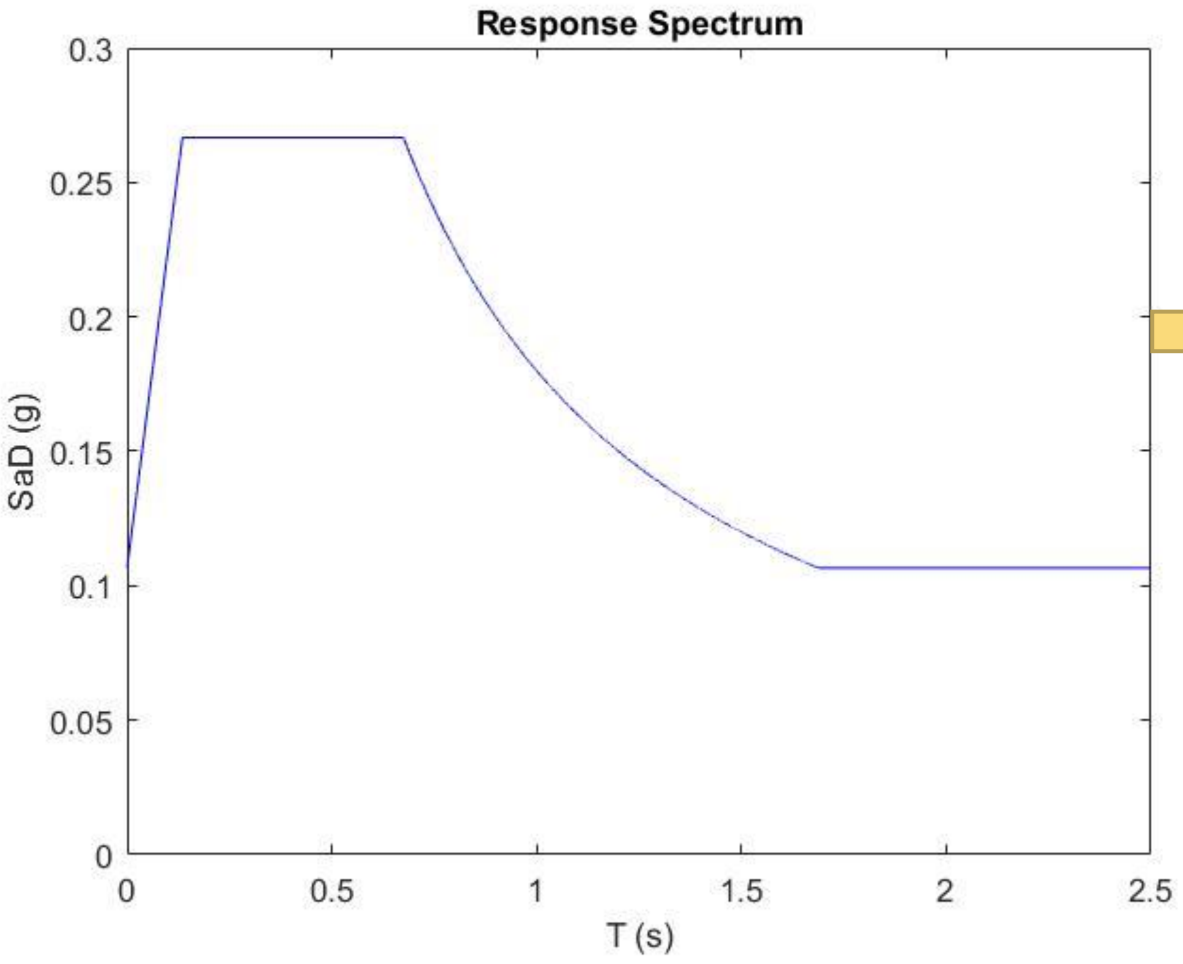
設計地震反應譜轉換成ADRS格式

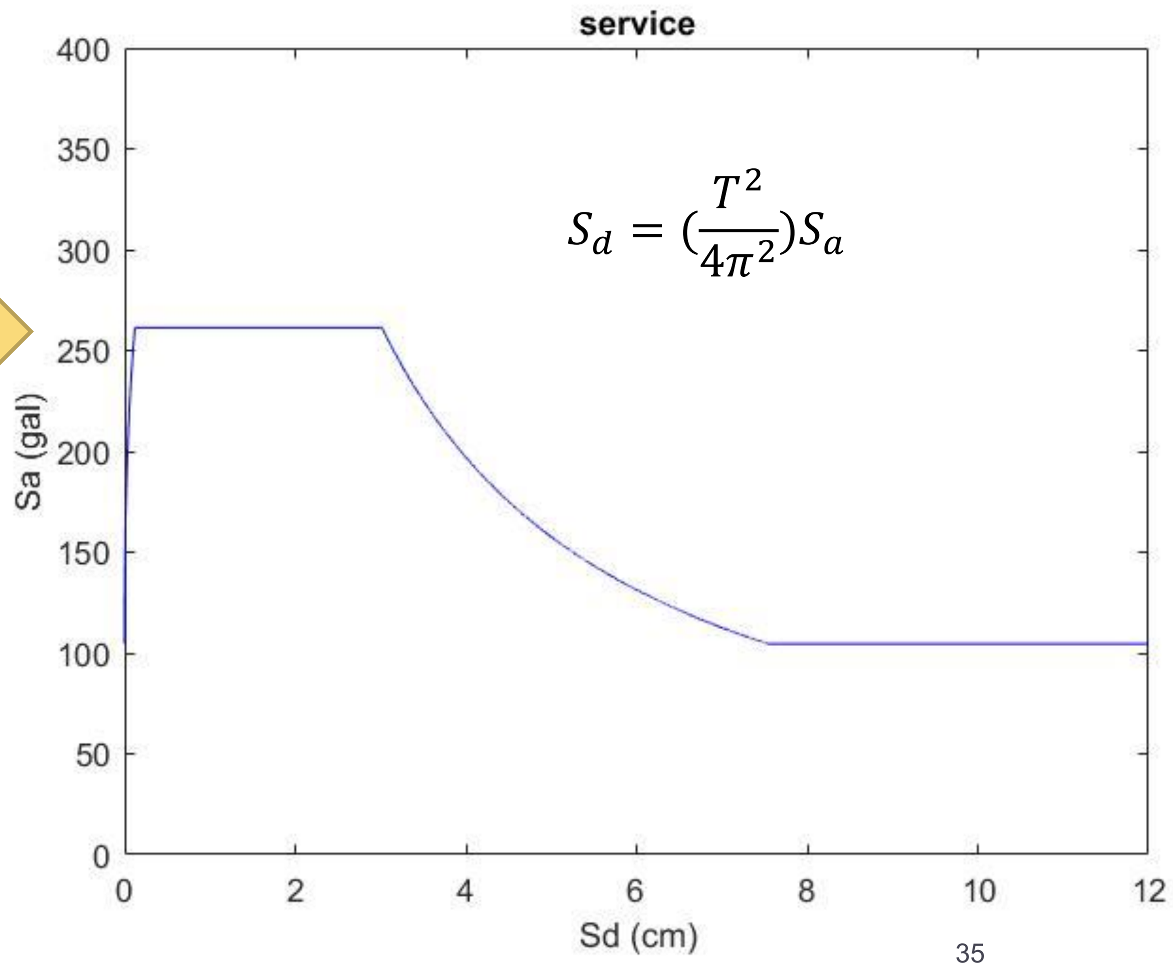




4.1 ATC-40 flow chart and preparation

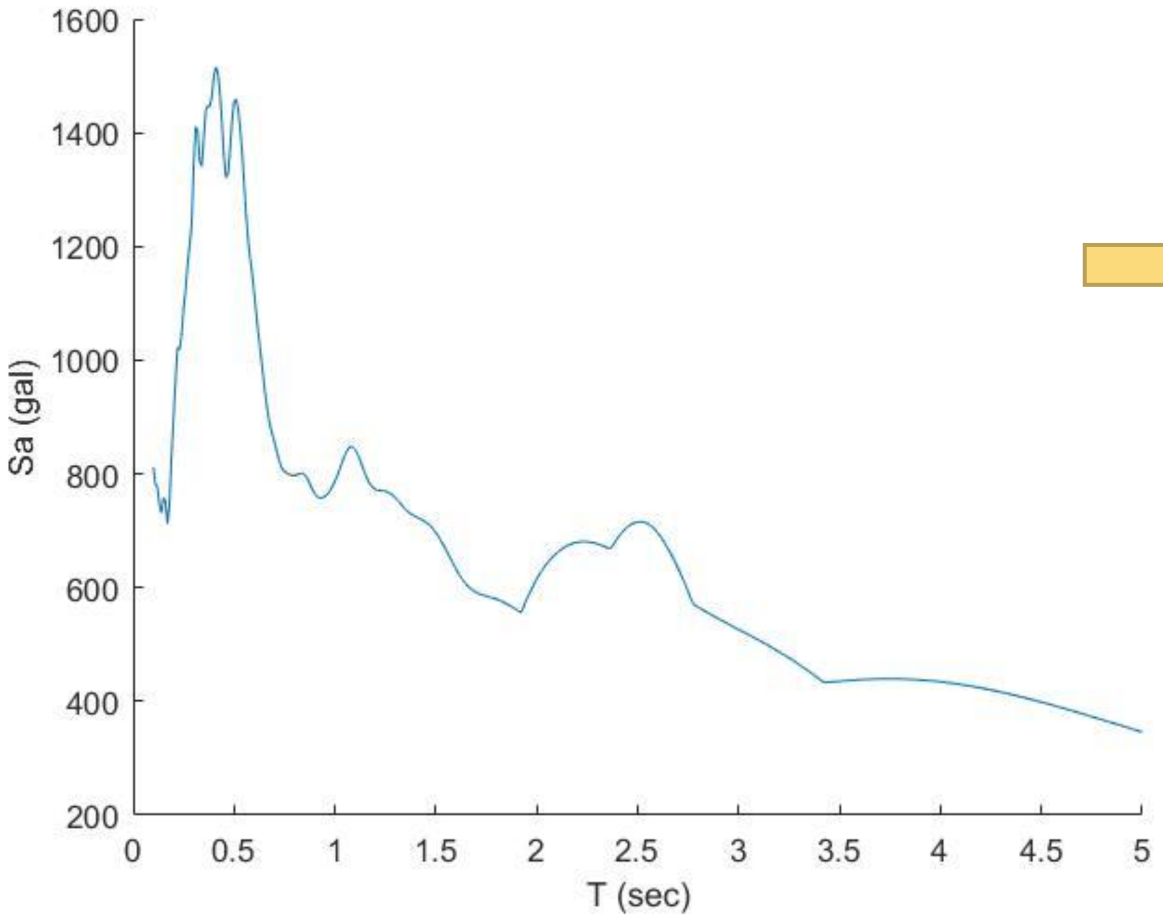
中小度地震設計反應譜轉換成ADRS格式

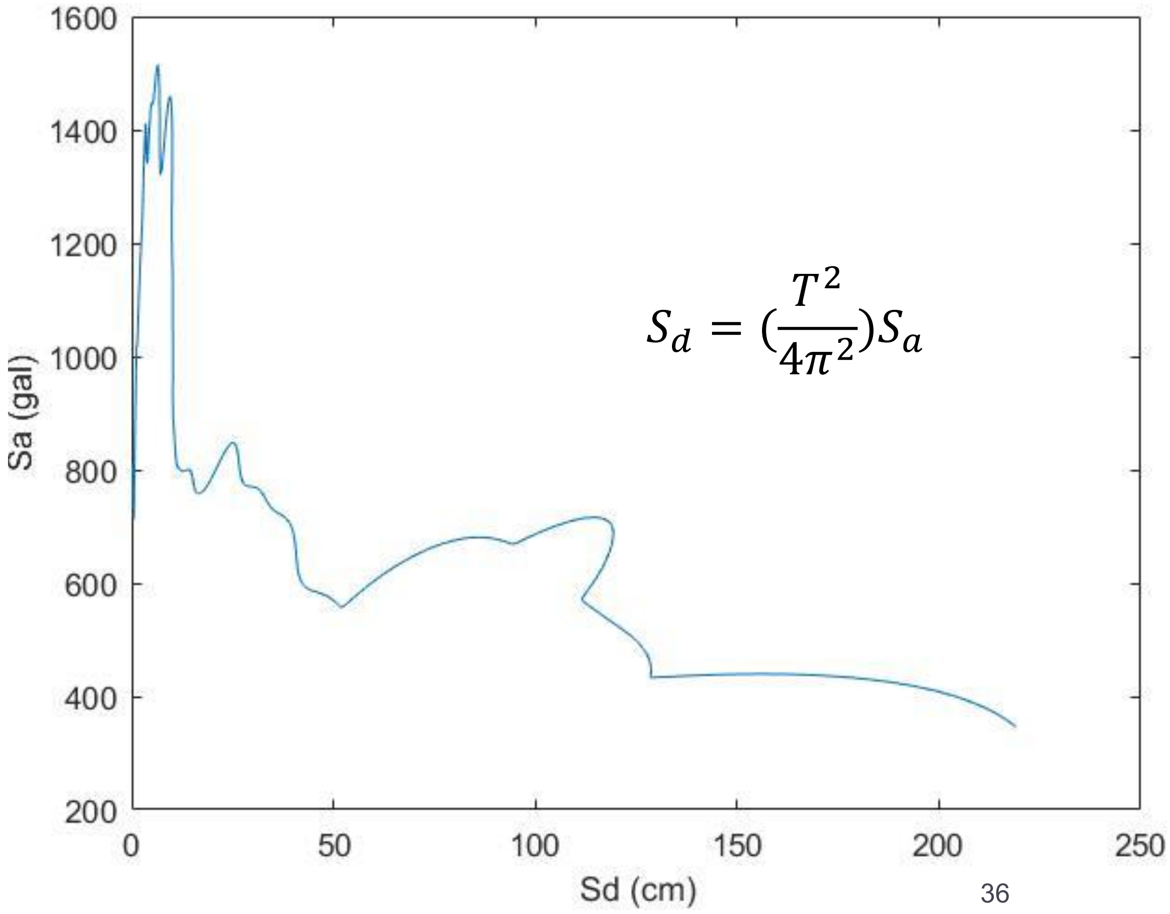




4.1 ATC-40 flow chart and preparation

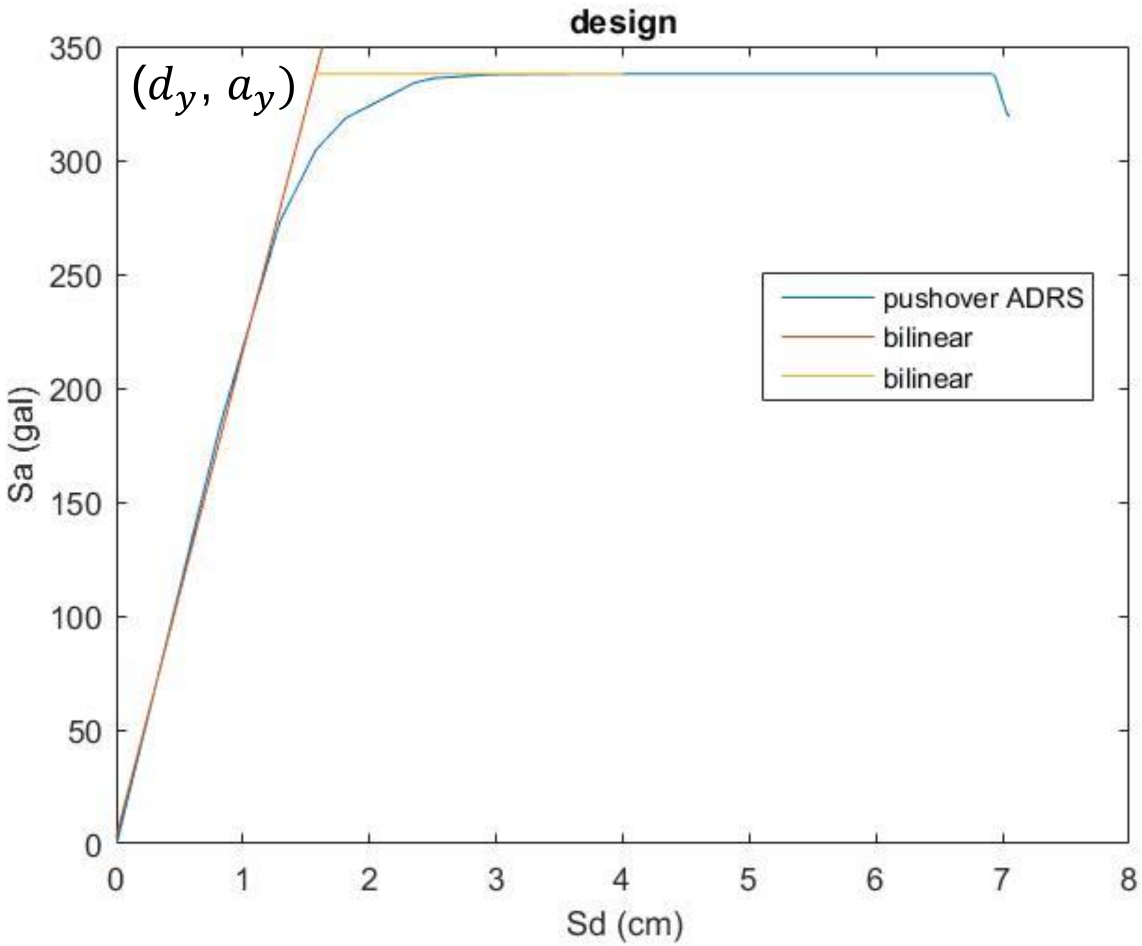
TCUo68反應譜轉換成ADRS格式





4.1 ATC-40 flow chart and preparation

Get the (d_y, a_y) from the bilinear curve



4.2 Procedure A

Procedure A:

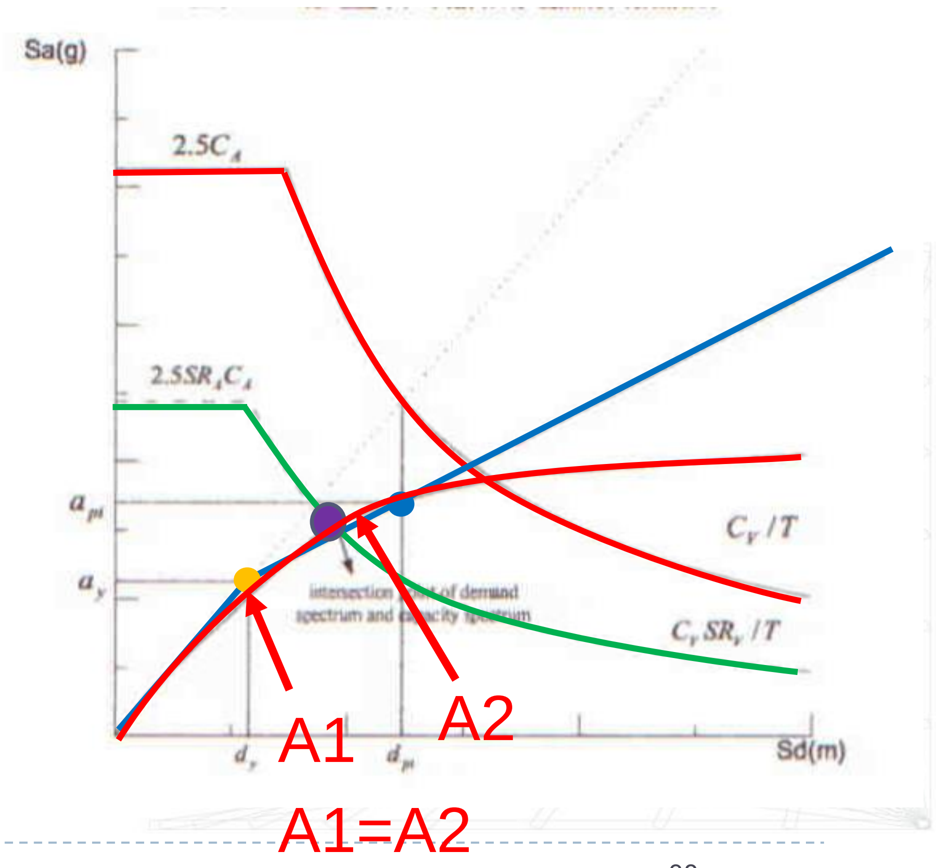
1.建立彈性反應譜及容量曲線並轉成ADRS格式

2.選擇一試誤點(d_{pi}, a_{pi})

3.容量譜雙線性面積相等，並得(d_y, a_y)

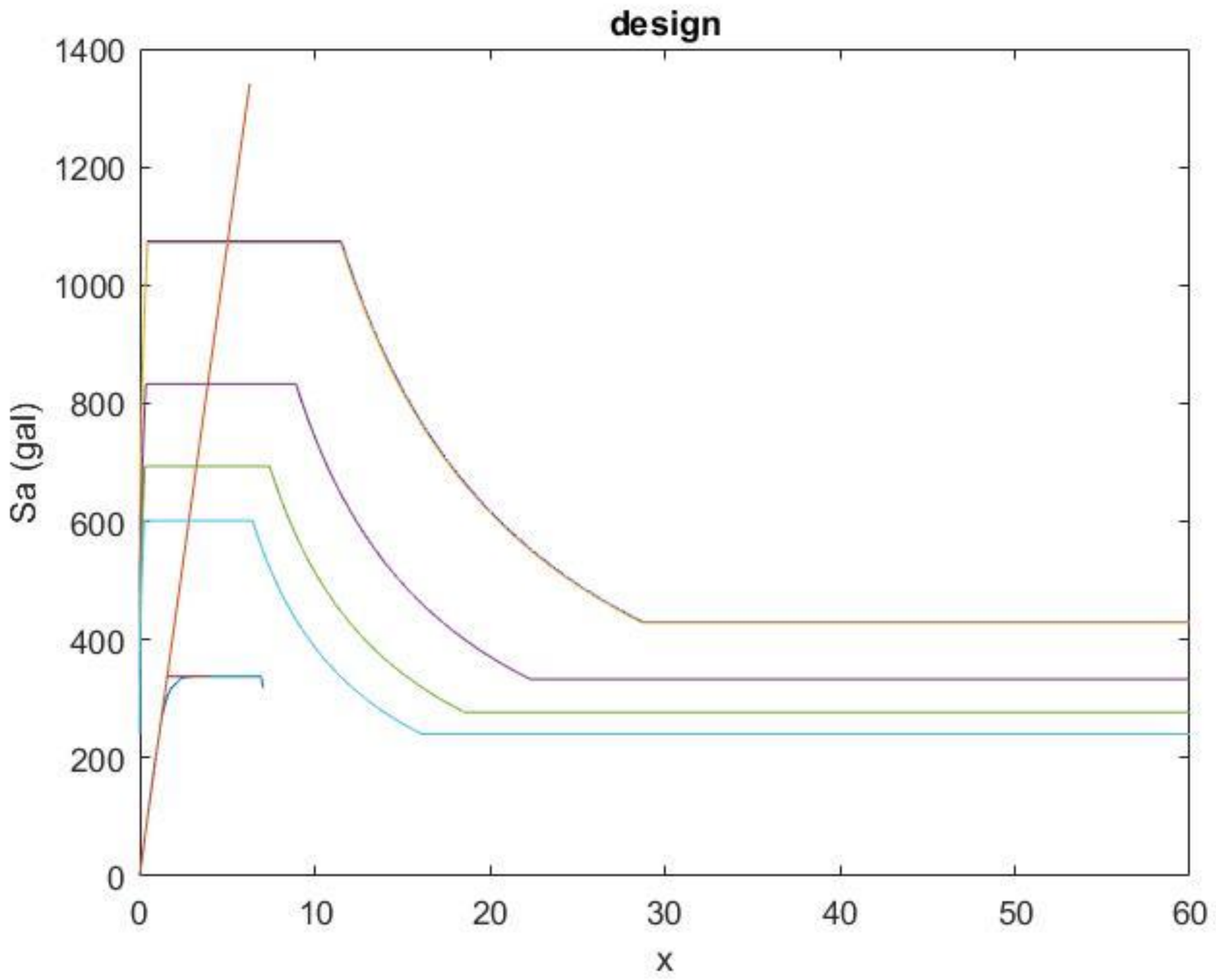
4.求出折減因子SR_A、SR_V，繪出折減後需求譜

5.折減需求譜與容量曲線交點須與試誤點誤差5%以內，則為功能績效點，否則須再次試誤



4.2 Procedure A

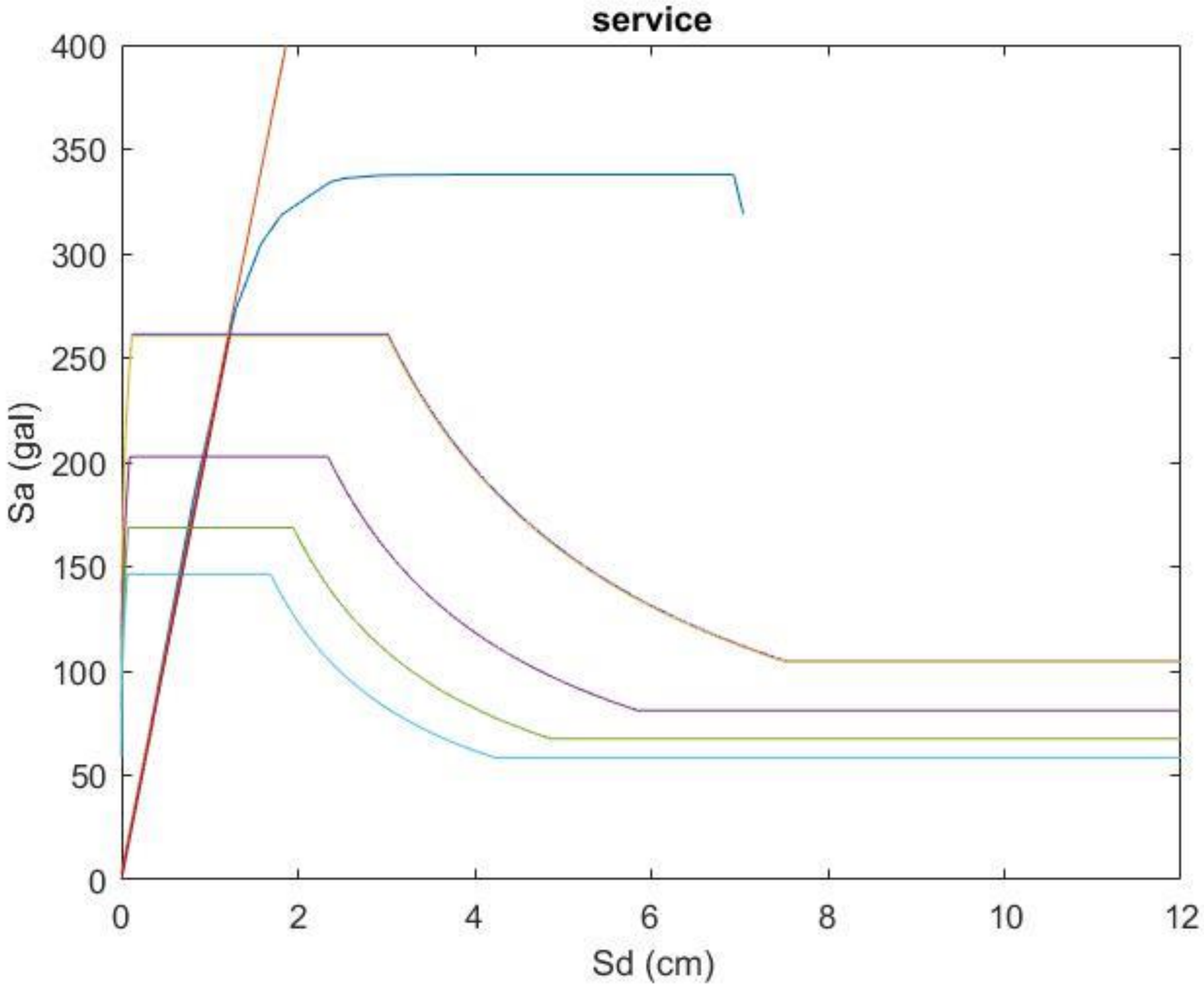
設計地震



Can’t find the performance point

4.2 Procedure A

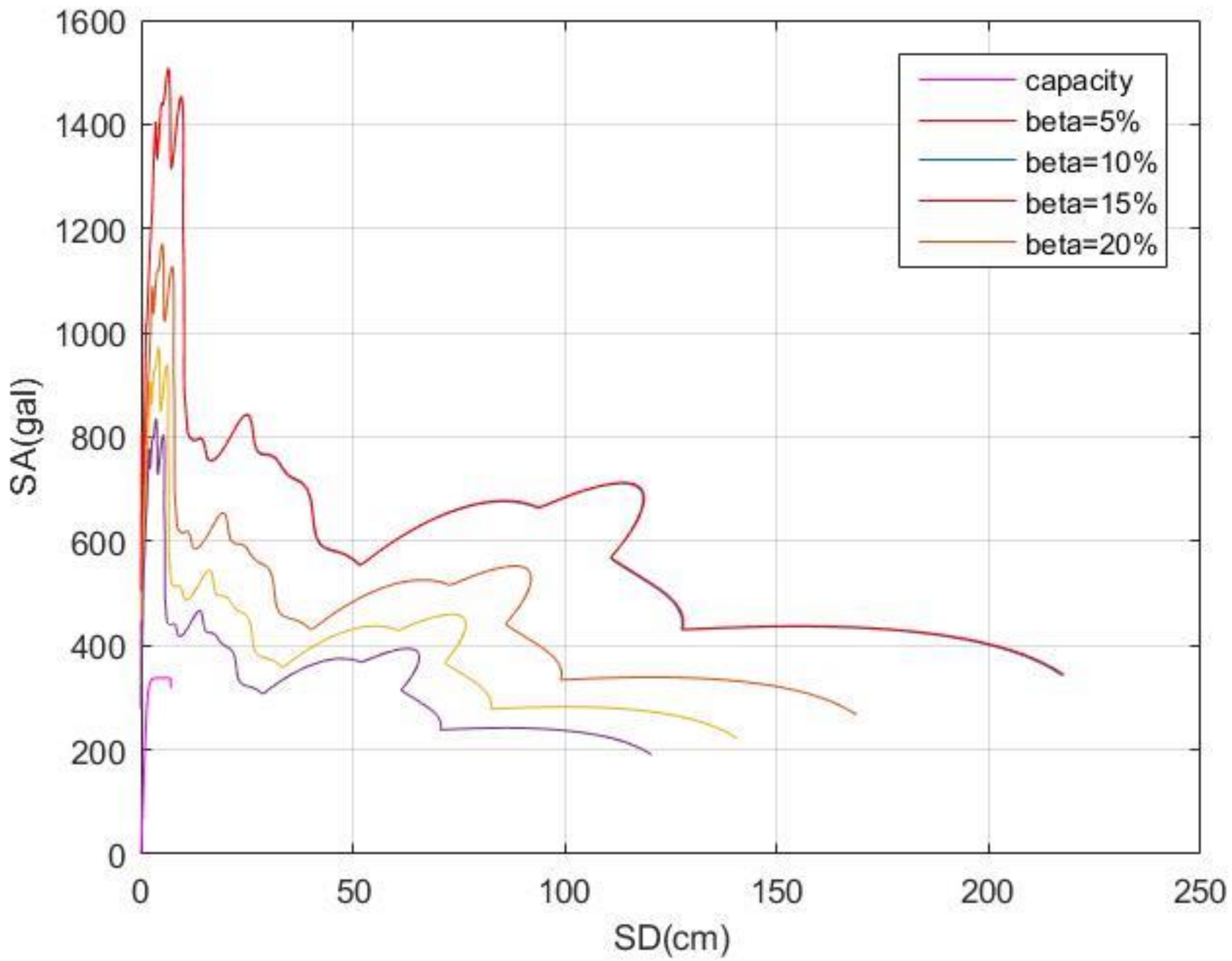
中小度地震



(1.158998 cm, 258.565696 gal)

4.2 Procedure A

TCUo68



Can’t find the performance point

4.3 Procedure B

Procedure:

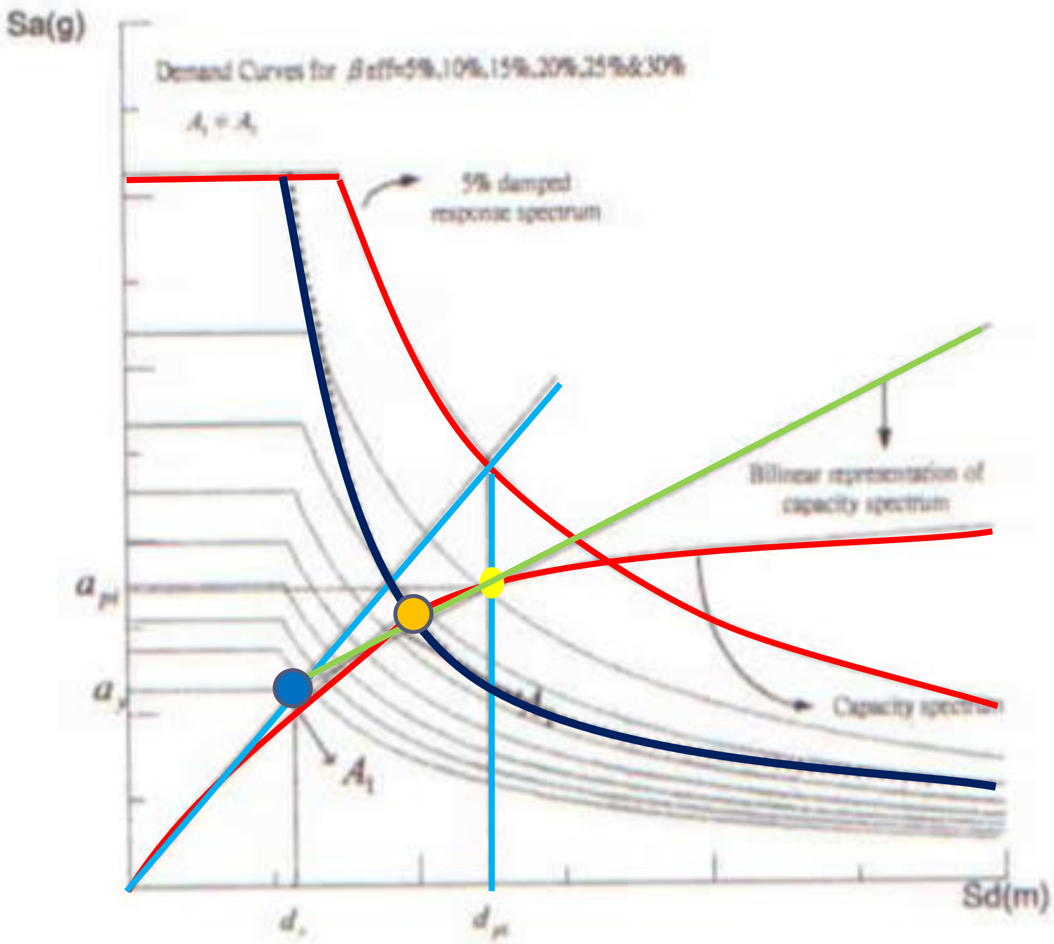
1.建立彈性反應譜及容量曲線並轉成ADRS格式

2.以初始勁度交需求譜點為d*，而得a*並雙線性化容量譜得dy及ay

3.求出 $a'_{pi} = \frac{(a^* - a_y)(d_{pi} - d_y)}{d^* - d_y} + a_y$ $\beta_{eff} = \frac{63.7\kappa(a_y d_{pi} - d_y a'_{pi})}{a'_{pi} d_{pi}} + 5$

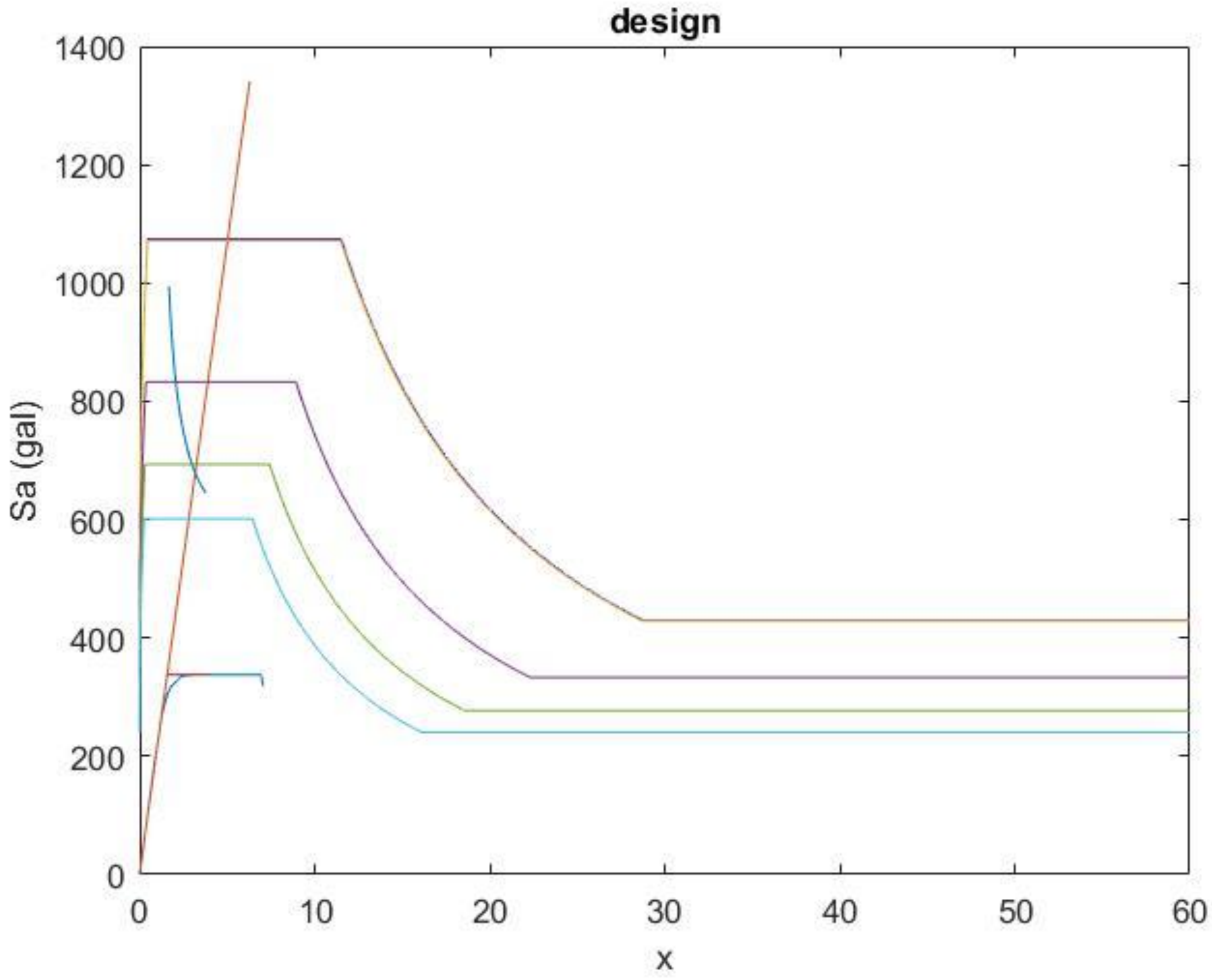
可得d_{pi}與β_{eff}關係式

4. d_{pi}變化則可求得線段(代表不同β_{eff}功能績效點)，與雙線化容量譜交點即為所求功能績效點



4.3 Procedure B

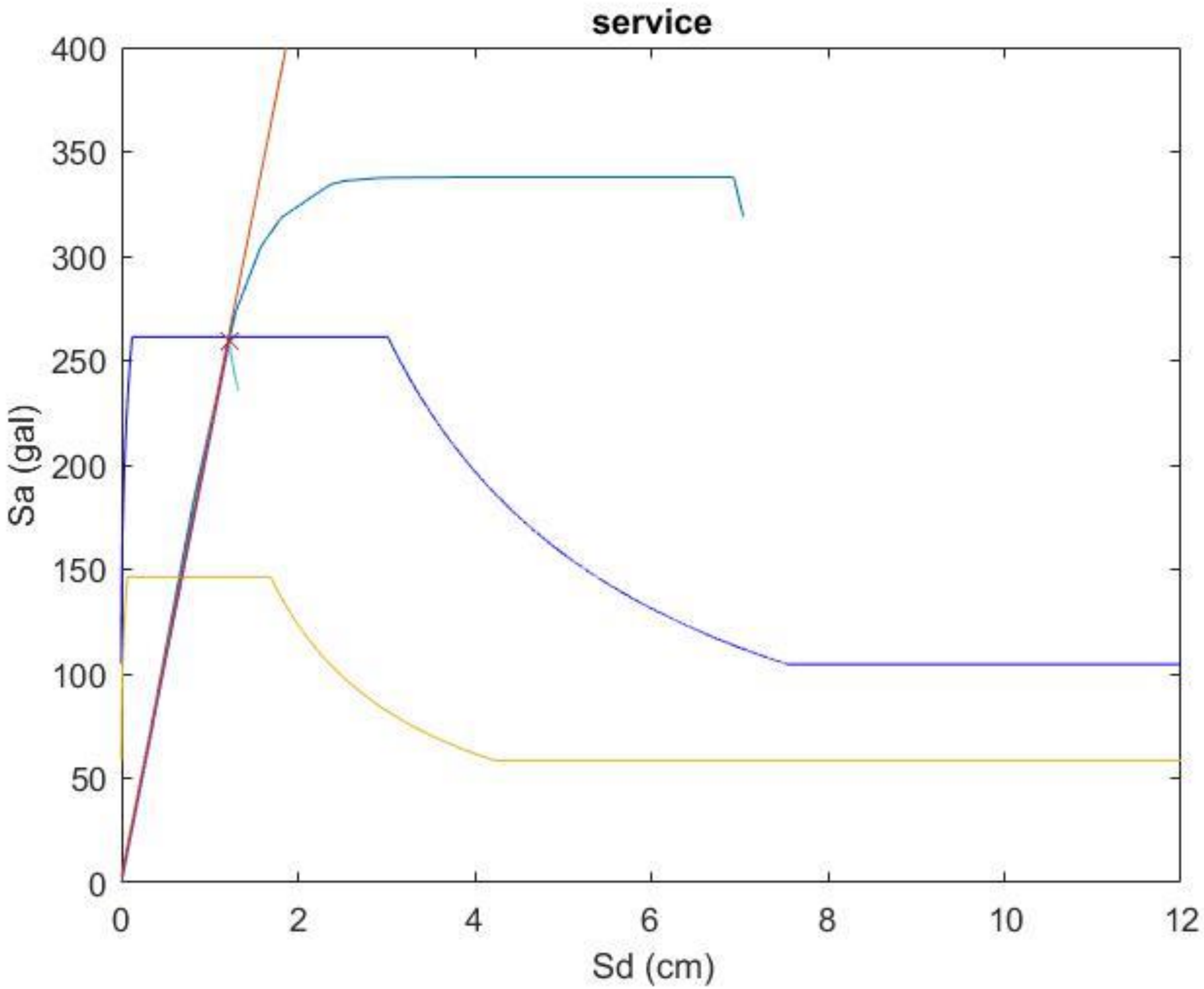
設計地震



Can't find the performance point

4.3 Procedure B

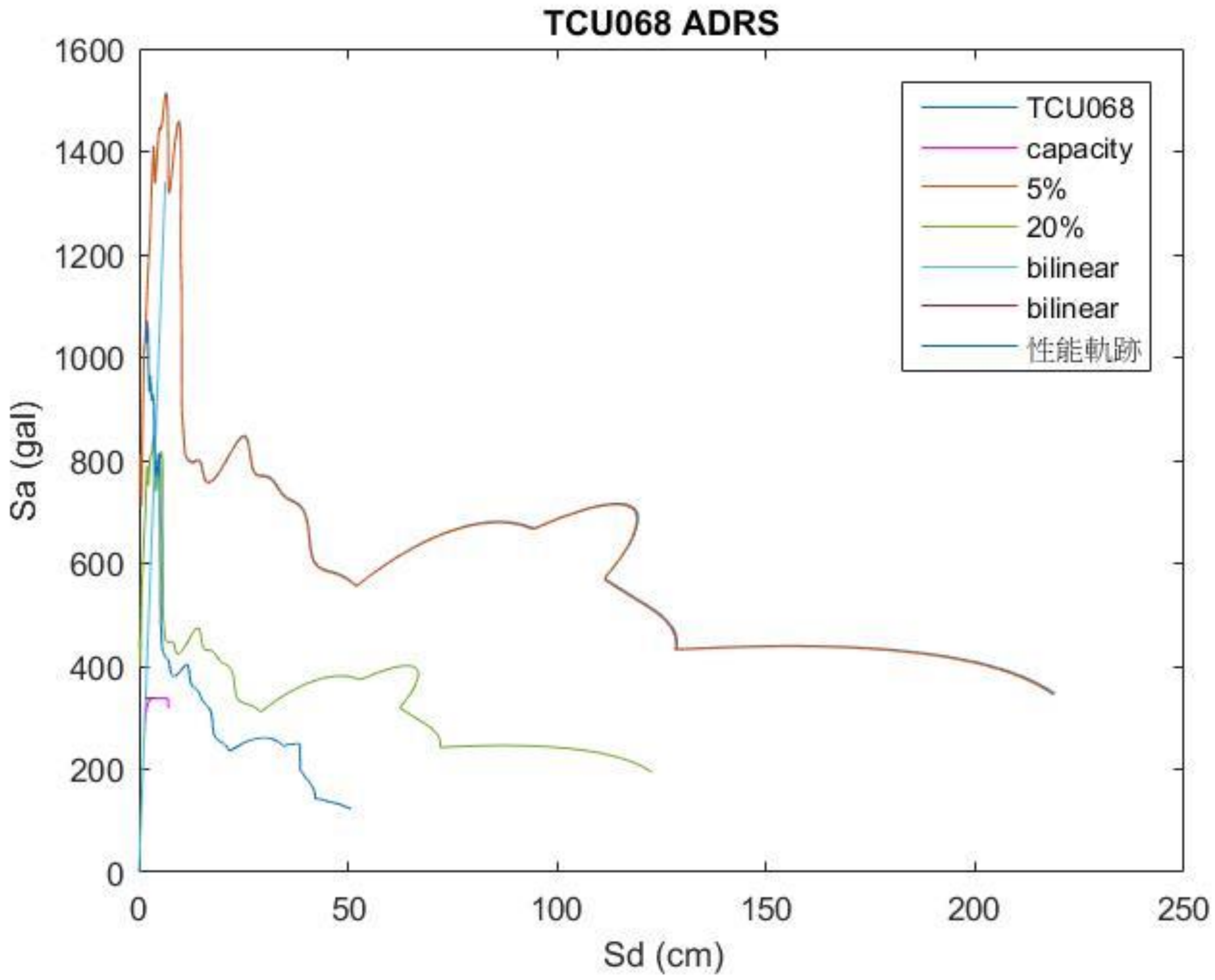
中小度地震



(1.218313 cm, 259.050000 gal)

4.3 Procedure B

TCUo68



Can’t find the performance point

4.4 Procedure C

Procedure:

1.建立彈性反應譜及容量曲線並轉成ADRS格式

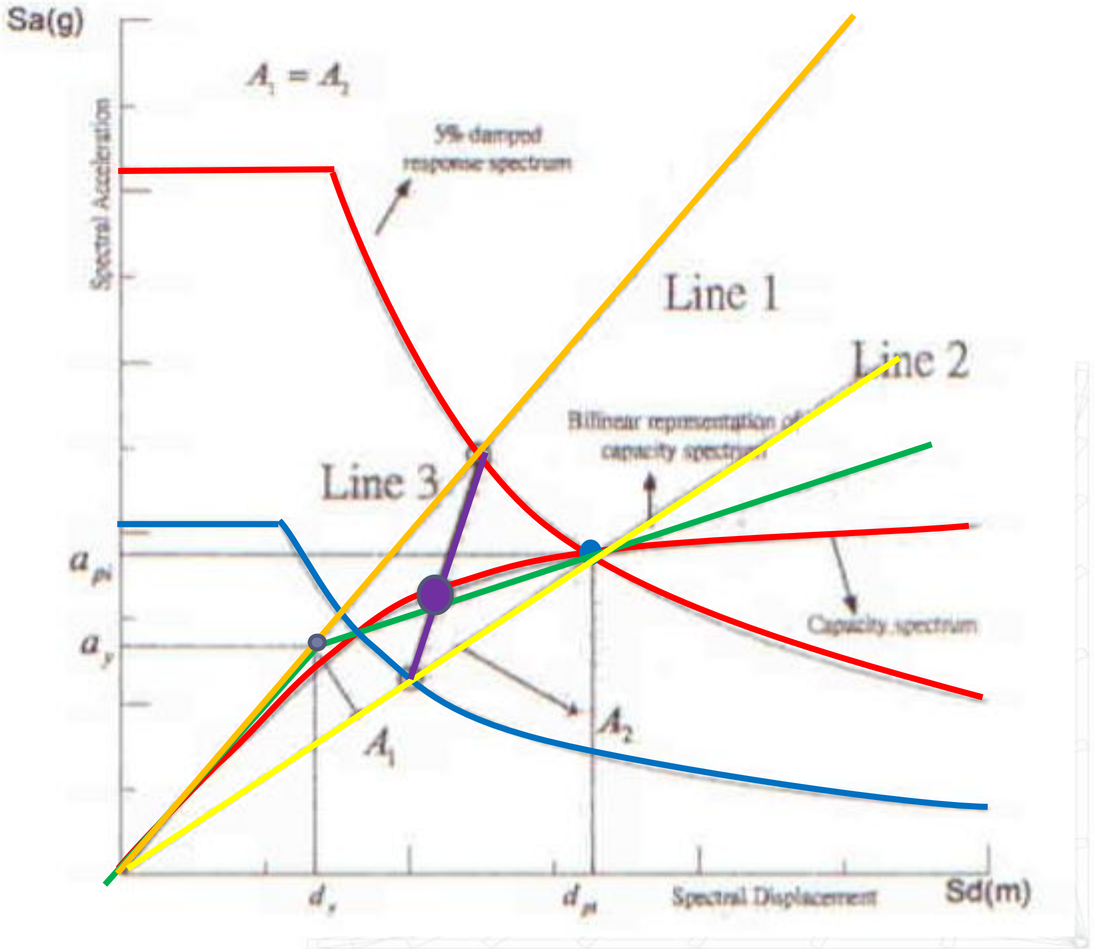
2.選擇一試誤點(d_{pi}, a_{pi})，一般選擇容量譜與需求譜交點，並雙線性

3.決定d_{pi}/d_y，求出$\alpha = \frac{\frac{a_{pi}}{a_y}-1}{\frac{d_{pi}}{d_y}-1}$，之後查表求出$\beta_{eff}$，繪出折減需求譜

4.繪製Line1 (初始勁度與需求譜連線)，Line2 ((d_{pi}, a_{pi})與原點連線)，

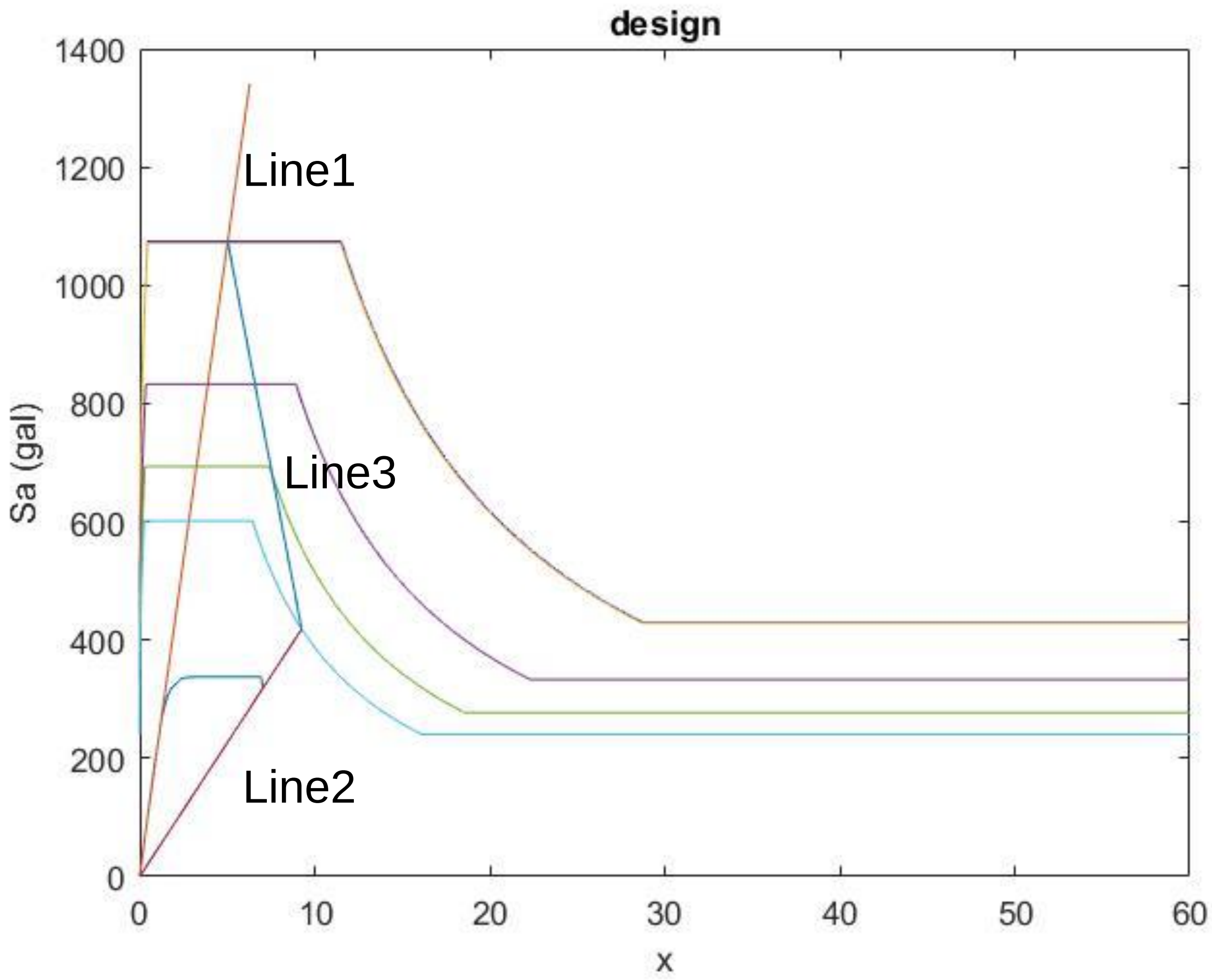
5.繪製Line3 (Line1與容量譜交點及Line2與折減需求譜交點連線)

6.Line3與容量譜交點即為功能績效點(與試誤點誤差5%以內)



4.4 Procedure C

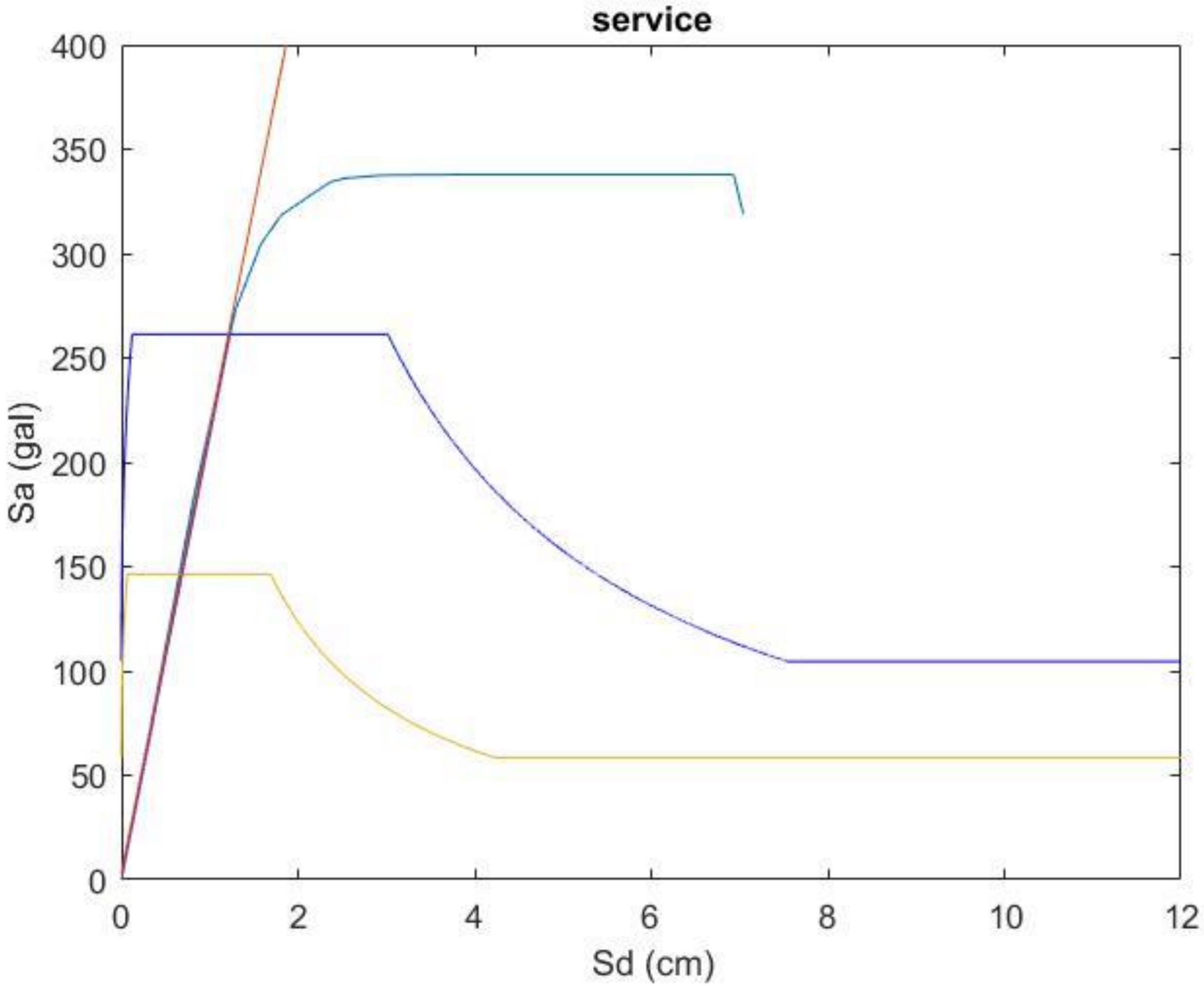
設計地震



Can’t find the performance point

4.4 Procedure C

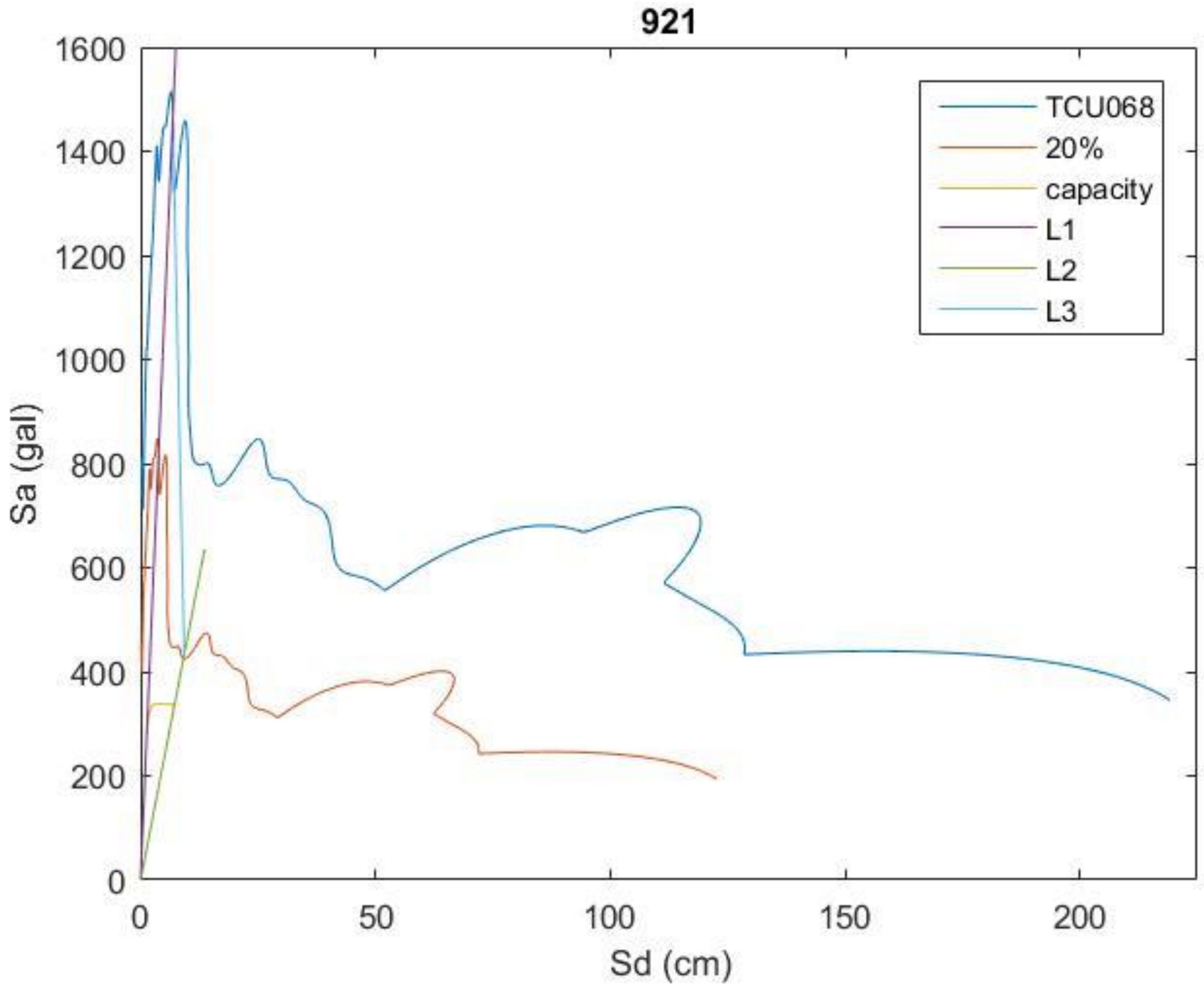
中小度地震



(1.230129 cm, 261.333333 gal)

4.4 Procedure C

TCUo68



Can’t find the performance point

4.5 Check and Summary

	設計地震力	中小地震	TCU068
Procedure A	N/A	Sd = 1.158998 (cm) Sa = 258.565696 (gal)	N/A
Procedure B	N/A	Sd = 1.218313 (cm) Sa = 259.050000 (gal)	N/A
Procedure C	N/A	Sd = 1.230129 (cm) Sa = 261.333333 (gal)	N/A

4.5 Check and Summary

設計地震	Sd (cm)	Damage Level
Procedure A	N/A	Collapse
Procedure B	N/A	Collapse
Procedure C	N/A	Collapse

TCU068	Sd (cm)	Damage Level
Procedure A	N/A	Collapse
Procedure B	N/A	Collapse
Procedure C	N/A	Collapse

中小型地震	Sd (cm)	Δ_{roof}	Drift ratio	Damage Level
Procedure A	1.158998	2.240317	0.290950305	Operational
Procedure B	1.218313	2.354972	0.305840524	Operational
Procedure C	1.230129	2.377812	0.308806766	Operational

4.5 Check and Summary

Check by the ATC-40 performance level

設計地震	Sd (cm)	Δ_{roof}	Max. total drift	Max. inelastic drift	Performance Level
Procedure A	N/A	N/A	N/A	N/A	Collapse
Procedure B	N/A	N/A	N/A	N/A	Collapse
Procedure C	N/A	N/A	N/A	N/A	Collapse

ATC Performance Level				
Interstory drift limit	Immediate occupancy	Damage control	Life Safety	Structural Stability
Max. total drift	0.01	0.01-0.02	0.02	0.33V/P
Max. inelastic drift	0.005	0.005-0.015	No limit	No limit

4.5 Check and Summary

Check by the ATC-40 performance level

中小型地震		Sd (cm)	Δ_{roof}	Max. total drift	Max. inelastic drift	
Procedure A	Story 2	1.158998	2.240317	0.001441	0.000688	Immediate Occupancy
	Story 1			0.004268	0.001238	Immediate Occupancy
Procedure B	Story 2	1.218313	2.354972	0.001454	0.000997	Immediate Occupancy
	Story 1			0.004542	0.001512	Immediate Occupancy
Procedure C	Story 2	1.230129	2.377812	0.001457	0.001059	Immediate Occupancy
	Story 1			0.004597	0.001566	Immediate Occupancy

ATC Performance Level				
Interstory drift limit	Immediate occupancy	Damage control	Life Safety	Structural Stability
Max. total drift	0.01	0.01-0.02	0.02	0.33V/P
Max. inelastic drift	0.005	0.005-0.015	No limit	No limit

4.5 Check and Summary

Check by the ATC-40 performance level

TCU068	Sd (cm)	Δ_{roof}	Max. total drift	Max. inelastic drift	Performance Level
Procedure A	N/A	N/A	N/A	N/A	Collapse
Procedure B	N/A	N/A	N/A	N/A	Collapse
Procedure C	N/A	N/A	N/A	N/A	Collapse

ATC Performance Level				
Interstory drift limit	Immediate occupancy	Damage control	Life Safety	Structural Stability
Max. total drift	0.01	0.01-0.02	0.02	0.33V/P
Max. inelastic drift	0.005	0.005-0.015	No limit	No limit

4.5 Check and Summary

Check the base shear < the capacity shear

Transform Sa to base shear by using $S_a = \frac{V/M}{\alpha_1}$

<table>
<tr><th>設計地震</th><th>Sa</th><th>Base Shear(kgf)</th><th>PGA(capacity)
(gal)</th><th>V(capacity)
(kN)</th></tr>
<tr><td>Procedure A</td><td>N/A</td><td>N/A</td><td rowspan="3">256.662</td><td rowspan="3">3442.961</td></tr>
<tr><td>Procedure B</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Procedure C</td><td>N/A</td><td>N/A</td></tr>
</table>

4.5 Check and Summary

Check the base shear < the capacity shear

Transform the Sa to base shear by using $S_a = \frac{V/M}{\alpha_1}$

中小型地震	Sa	Base Shear(kgf)	PGA(capacity) (gal)	V(capacity) (kN)
Procedure A	258.565696	2910.425811	256.662	3442.961
Procedure B	259.050000	2915.877162		
Procedure C	261.333333	2941.57845		

4.5 Check and Summary

Check the base shear < the capacity shear

Transform the Sa to base shear by using $S_a = \frac{V/_{M}}{\alpha_1}$

TCU068	Sa	Base Shear(kgf)	PGA(capacity) (gal)	V(capacity) (kN)
Procedure A	N/A	N/A	256.662	3442.961
Procedure B	N/A	N/A		
Procedure C	N/A	N/A		

4.5 Check and Summary

Summary：

1) We get similar results from three procedures.

2) Performance level

	Δ_{roof}	**Performance Level**
設計地震	N/A	Collapse
中小地震	2.377812	Immediate Occupancy
TCU068	N/A	Collapse

5. FEMA273

- 5.1 Linear Static Procedure(LSP)
- 5.2 Linear Dynamic Procedure(LDP)
- 5.3 Nonlinear Static Procedure(NSP)
- 5.4 Check and Summary

5.1 Linear Static Procedure(LSP)

Pseudo lateral load

$$\boxed{V} = C_1 C_2\, C_3\, S_a W$$

$$F_x = C_{vx} V$$

5.1 Linear Static Procedure(LSP)

Period Determination

- Method 1: Dynamic Analysis from ETABS

- Method 2:Approximated formula (h in feet)

$$T = C_t h_n^{3/4}$$

C_t 0.03 for moment-resisting frame of reinforced concrete

	Approximated formula	ETABS Analysis
T	0.3446	0.3982

5.1 Linear Static Procedure(LSP)

- Coefficients Determination C_1 、 C_2

$$C_1 = 1.5 \text{ for } T < 0.10 \text{ second}$$

$$C_1 = 1.0 \text{ for } T \geq T_0 \text{ second}$$

Table 3-1 Values for Modification Factor C_2

	$T = 0.1$ second		$T \geq T_0$ second	
Performance Level	**Framing Type 1**[1]	**Framing Type 2**[2]	**Framing Type 1**[1]	**Framing Type 2**[2]
Immediate Occupancy	1.0	1.0	1.0	1.0
Life Safety	1.3	1.0	1.1	1.0
Collapse Prevention	1.5	1.0	1.2	1.0

1. Structures in which more than 30% of the story shear at any level is resisted by components or elements whose strength and stiffness may deteriorate during the design earthquake. Such elements and components include: ordinary moment-resisting frames, concentrically-braced frames, frames with partially-restrained connections, tension-only braced frames, unreinforced masonry walls, shear-critical walls and piers, or any combination of the above.
2. All frames not assigned to Framing Type 1.

5.1 Linear Static Procedure(LSP)

- Coefficients Determination C_3

$$\theta_i = \frac{P_i \delta_i}{V_i h_i}$$

P_i = vertical load on ith story

δ_i = lateral drift on ith story

h_i = height od ith story

V_i = shear force on ith story

$$C_3 = 1.0 \ \ for\ \theta < 0.1$$

$$C_3 = 1 + \frac{5(\theta - 0.1)}{T} \ \ for\ \theta \geq 0.1$$

5.1 Linear Static Procedure(LSP)

- Pseudo lateral load Determination

$$V = C_1 C_2 C_3 S_a W$$

	設計地震力	中小地震	TCU068
C_1	1.29934	1.29934	1.29934
C_2	1.219736	1.219736	1.219736
C_3	1	1	1
S_a(g)	1.096	0.266	1.337
W(kgf)	1125604	1125604	1125604
V(kgf)	1955172	474521.6	2385095

5.1 Linear Static Procedure(LSP)

- Lateral force distribution

$$C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$$

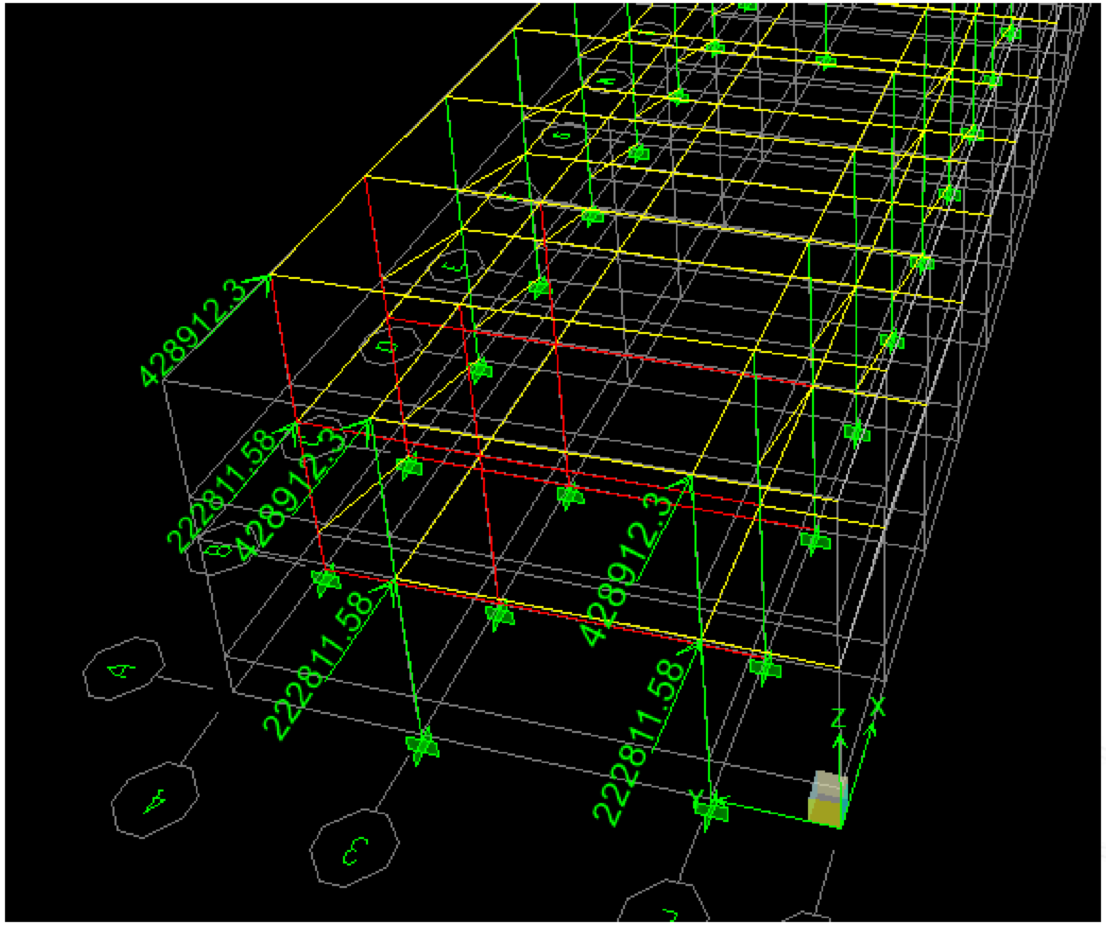
W_X:Dead weight of the ith story
h_x : Height from base to ith story
k : 1.0 for T<0.5(sec)

$$F_x = C_{vx} V$$

	設計地震力	中小地震	TCU068
V(kgf)	1955172	474521.6	2385095
C_{v1}	0.34188	0.34188	0.34188
C_{v2}	0.65812	0.65812	0.65812
F_1(kgf)	668434.7	162229.6	815417.2
F_2(kgf)	1286737	312292	1569678

5.1 Linear Static Procedure(LSP)

- Apply lateral force



5.1 Linear Static Procedure(LSP)

- Data output

Beam Forces

Edit View

Beam Forces

Story	Beam	Load	Loc	P	V2	V3	T	M2	M3
STORY2	B1	COMB1	25.000	0.00	-2803.13	0.00	0.000	0.000	-447382.813
STORY2	B1	COMB1	70.000	0.00	-2594.72	0.00	0.000	0.000	-325190.938
STORY2	B1	COMB1	115.000	0.00	-2188.88	0.00	0.000	0.000	-216819.688
STORY2	B1	COMB1	160.000	0.00	-1705.03	0.00	0.000	0.000	-129760.313
STORY2	B1	COMB1	205.000	0.00	-1408.88	0.00	0.000	0.000	-60437.813
STORY2	B1	COMB1	250.000	0.00	-1310.16	0.00	0.000	0.000	0.000
STORY1	B1	COMB1	25.000	0.00	-2803.13	0.00	-0.001	0.000	-447382.813
STORY1	B1	COMB1	70.000	0.00	-2594.72	0.00	-0.001	0.000	-325190.938
STORY1	B1	COMB1	115.000	0.00	-2188.88	0.00	-0.001	0.000	-216819.688
STORY1	B1	COMB1	160.000	0.00	-1705.03	0.00	-0.001	0.000	-129760.313
STORY1	B1	COMB1	205.000	0.00	-1408.88	0.00	-0.001	0.000	-60437.813
STORY1	B1	COMB1	250.000	0.00	-1310.16	0.00	-0.001	0.000	0.000
STORY2	B2	COMB1	25.000	0.00	-5789.06	0.00	-0.001	0.000	-935898.437
STORY2	B2	COMB1	70.000	0.00	-5372.25	0.00	-0.001	0.000	-683288.125
STORY2	B2	COMB1	115.000	0.00	-4560.56	0.00	-0.001	0.000	-458319.062
STORY2	B2	COMB1	160.000	0.00	-3592.87	0.00	-0.001	0.000	-275973.750
STORY2	B2	COMB1	205.000	0.00	-3000.56	0.00	-0.001	0.000	-129102.187
STORY2	B2	COMB1	250.000	0.00	-2803.12	0.00	-0.001	0.000	0.000
STORY1	B2	COMB1	25.000	0.00	-5789.06	0.00	-0.001	0.000	-935898.436
STORY1	B2	COMB1	70.000	0.00	-5372.25	0.00	-0.001	0.000	-683288.124
STORY1	B2	COMB1	115.000	0.00	-4560.56	0.00	-0.001	0.000	-458319.062
STORY1	B2	COMB1	160.000	0.00	-3592.87	0.00	-0.001	0.000	-275973.750
STORY1	B2	COMB1	205.000	0.00	-3000.56	0.00	-0.001	0.000	-129102.187
STORY1	B2	COMB1	250.000	0.00	-2803.12	0.00	-0.001	0.000	0.000
STORY2	B3	COMB1	25.000	0.00	-5971.87	0.00	-0.001	0.000	-977031.249
STORY2	B3	COMB1	70.000	0.00	-5555.06	0.00	-0.001	0.000	-716194.374
STORY2	B3	COMB1	115.000	0.00	-4743.37	0.00	-0.001	0.000	-482998.750
STORY2	B3	COMB1	160.000	0.00	-3775.69	0.00	-0.001	0.000	-292426.875
STORY2	B3	COMB1	205.000	0.00	-3183.37	0.00	-0.001	0.000	-137328.750
STORY2	B3	COMB1	250.000	0.00	-2985.94	0.00	-0.001	0.000	0.000
STORY1	B3	COMB1	25.000	0.00	-5971.88	0.00	0.000	0.000	-977031.250
STORY1	B3	COMB1	70.000	0.00	-5555.06	0.00	0.000	0.000	-716194.375

5.1 Linear Static Procedure(LSP)

- Acceptance Criteria

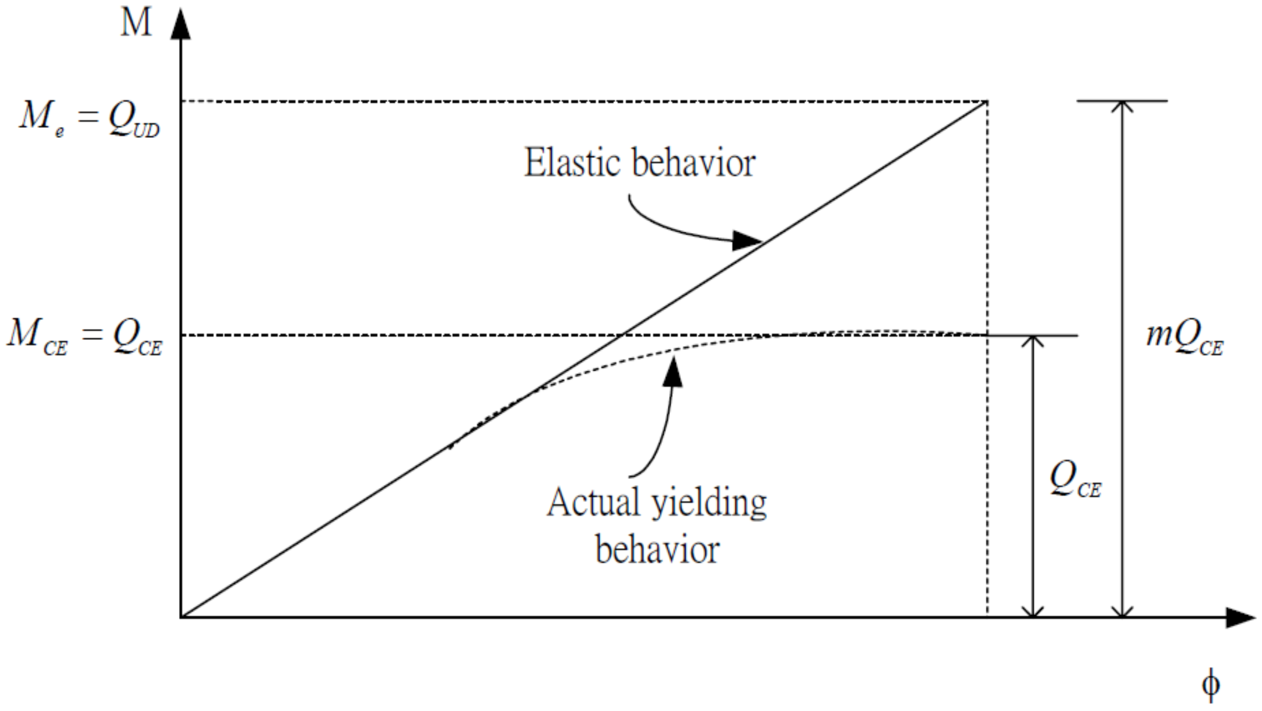
$$m\,\kappa Q_{CE} \geq Q_{UD}$$

m : Capacity modifier

k : Knowledge factor = 1.0

Q_{CE}: Capacity

Q_{UD}: Demand



5.1 Linear Static Procedure(LSP)

- Q_{UD} (Demand)

Beam Forces

Edit View

Beam Forces

Story	Beam	Load	Loc	P	V2	V3	T	M2	M3
STORY2	B1	COMB1	25.000	0.00	-2803.13	0.00	0.000	0.000	-447382.813
STORY2	B1	COMB1	70.000	0.00	-2594.72	0.00	0.000	0.000	-325190.938
STORY2	B1	COMB1	115.000	0.00	-2188.88	0.00	0.000	0.000	-216819.688
STORY2	B1	COMB1	160.000	0.00	-1705.03	0.00	0.000	0.000	-129760.313
STORY2	B1	COMB1	205.000	0.00	-1408.88	0.00	0.000	0.000	-60437.813
STORY2	B1	COMB1	250.000	0.00	-1310.16	0.00	0.000	0.000	0.000
STORY1	B1	COMB1	25.000	0.00	-2803.13	0.00	-0.001	0.000	-447382.813
STORY1	B1	COMB1	70.000	0.00	-2594.72	0.00	-0.001	0.000	-325190.938
STORY1	B1	COMB1	115.000	0.00	-2188.88	0.00	-0.001	0.000	-216819.688
STORY1	B1	COMB1	160.000	0.00	-1705.03	0.00	-0.001	0.000	-129760.313
STORY1	B1	COMB1	205.000	0.00	-1408.88	0.00	-0.001	0.000	-60437.813
STORY1	B1	COMB1	250.000	0.00	-1310.16	0.00	-0.001	0.000	0.000
STORY2	B2	COMB1	25.000	0.00	-5789.06	0.00	-0.001	0.000	-935898.437
STORY2	B2	COMB1	70.000	0.00	-5372.25	0.00	-0.001	0.000	-683288.125
STORY2	B2	COMB1	115.000	0.00	-4560.56	0.00	-0.001	0.000	-458319.062
STORY2	B2	COMB1	160.000	0.00	-3592.87	0.00	-0.001	0.000	-275973.750
STORY2	B2	COMB1	205.000	0.00	-3000.56	0.00	-0.001	0.000	-129102.187
STORY2	B2	COMB1	250.000	0.00	-2803.12	0.00	-0.001	0.000	0.000
STORY1	B2	COMB1	25.000	0.00	-5789.06	0.00	-0.001	0.000	-935898.436
STORY1	B2	COMB1	70.000	0.00	-5372.25	0.00	-0.001	0.000	-683288.124
STORY1	B2	COMB1	115.000	0.00	-4560.56	0.00	-0.001	0.000	-458319.062
STORY1	B2	COMB1	160.000	0.00	-3592.87	0.00	-0.001	0.000	-275973.750
STORY1	B2	COMB1	205.000	0.00	-3000.56	0.00	-0.001	0.000	-129102.187
STORY1	B2	COMB1	250.000	0.00	-2803.12	0.00	-0.001	0.000	0.000
STORY2	B3	COMB1	25.000	0.00	-5971.87	0.00	-0.001	0.000	-977031.249
STORY2	B3	COMB1	70.000	0.00	-5555.06	0.00	-0.001	0.000	-716194.374
STORY2	B3	COMB1	115.000	0.00	-4743.37	0.00	-0.001	0.000	-482998.750
STORY2	B3	COMB1	160.000	0.00	-3775.69	0.00	-0.001	0.000	-292426.875
STORY2	B3	COMB1	205.000	0.00	-3183.37	0.00	-0.001	0.000	-137328.750
STORY2	B3	COMB1	250.000	0.00	-2985.94	0.00	-0.001	0.000	0.000
STORY1	B3	COMB1	25.000	0.00	-5971.88	0.00	0.000	0.000	-977031.250
STORY1	B3	COMB1	70.000	0.00	-5555.06	0.00	0.000	0.000	-716194.375

5.1 Linear Static Procedure(LSP)

- Q_{CE} (Capacity)

number	My(kN-m)
1C1	106.9
1C2	80.67
1C3	40.8
2C1	83.04
2C2	55.15
2C3	40.32

number	Mu(kN-m)上拉下壓	My(kN-m)上壓下拉
1B1	647.3	322.1
1B2 2B2	153.3	70.51
1B3 2B3	179.3	107.4
2B1	480.5	309.7
2B4	55.17	55.17
1B4	77.13	77.13
CB	227.9	101.6

5.1 Linear Static Procedure(LSP)

- Beam data

	1B1	1B2,2B2	1B3,2B3	2B1	2B4	1B4	CB
ρ	0.015797	0.010778	0.007193	0.008782	0.00573	0.008595	0.014143
ρ′	0.006452	0.004584	0.003666	0.005533	0.00573	0.008595	0.005161
ρbal	0.04335	0.04335	0.04335	0.04335	0.04335	0.04335	0.04335
V	11741.14	14228.13	14283.16	7840.8	8329.93	12868.87	14233.12
bw	11.811	9.8425	9.8425	14.9606	9.8425	9.8425	11.811
d	31.496	19.685	25.5905	31.496	15.748	15.748	19.685
f'c	3982.607	3982.607	3982.607	3982.607	3982.6066	3982.607	3982.607
ρ-ρ'/ρbal	0.215571	0.142875	0.081342	0.074949	2.644E-07	3.97E-07	0.207182
V/bdf'c^2	0.500132	1.163652	0.898579	0.263677	0.8515827	1.315606	0.97005
m	6	6	6	6	3	3	3

5.1 Linear Static Procedure(LSP)

- Result

		設計地震	中小地震	TCU068
Beam (NG)	Story1	20	0	32
	Story2	12	0	28
	Total	32	0	60
Column (NG)	Story1	37	18	37
	Story2	37	0	37
	Total	74	18	74

5. FEMA273

- 5.1 Linear Static Procedure(LSP)
- 5.2 Linear Dynamic Procedure(LDP)
- 5.3 Nonlinear Static Procedure(NSP)
- 5.4 Check and Summary

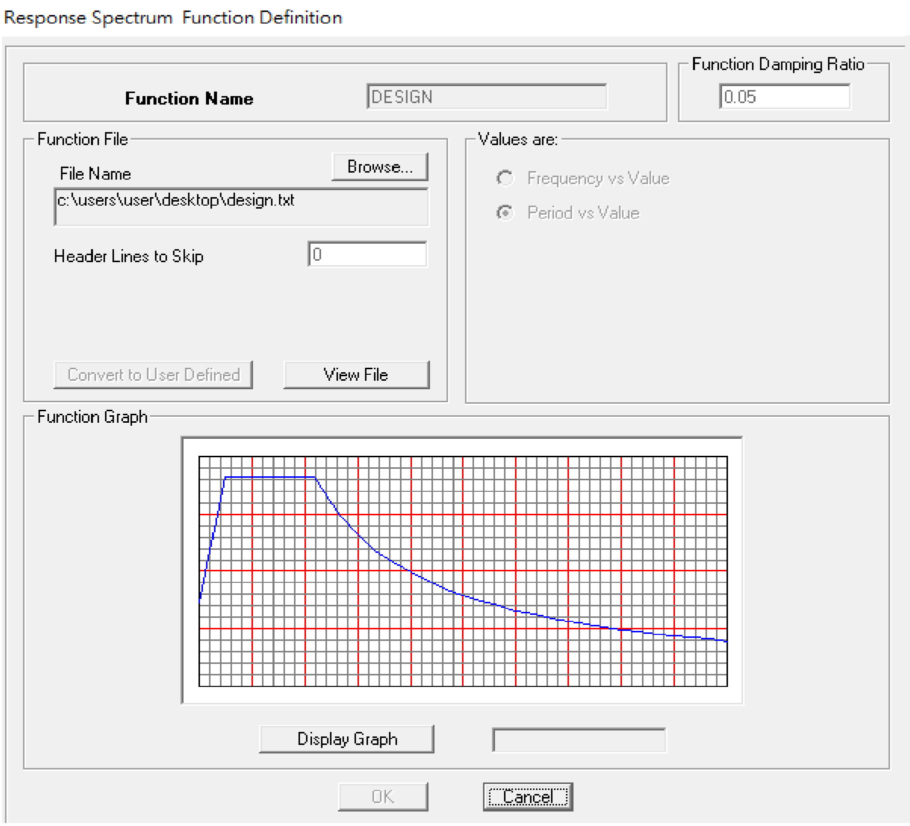
5.2 Linear Dynamic Procedure(LDP)

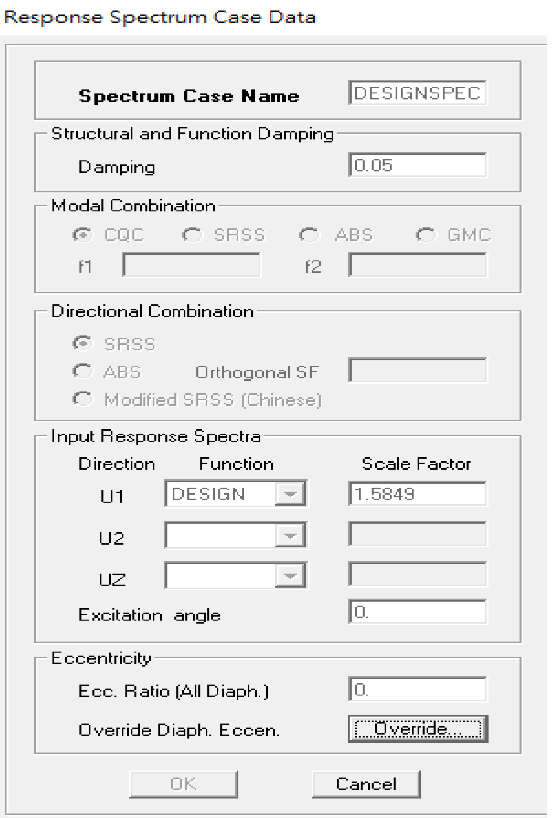
- Modification Factor Determination

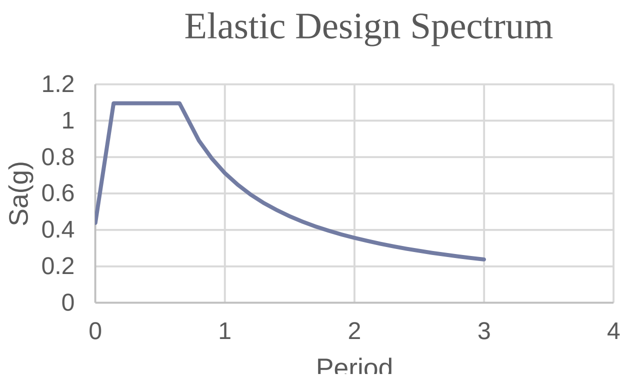
C_1	1.29934
C_2	1.219736
C_3	1
$C_1 \times C_2 \times C_3$	1.584852

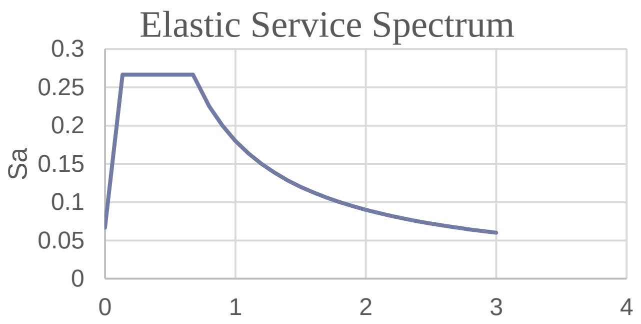
5.2 Linear Dynamic Procedure(LDP)

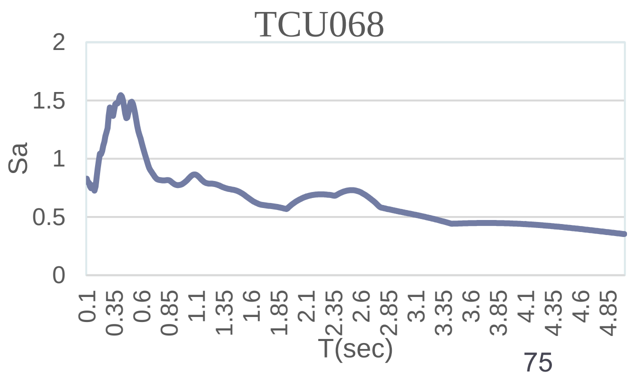
- Apply Response Spectrum











5.2 Linear Dynamic Procedure(LDP)

- Result

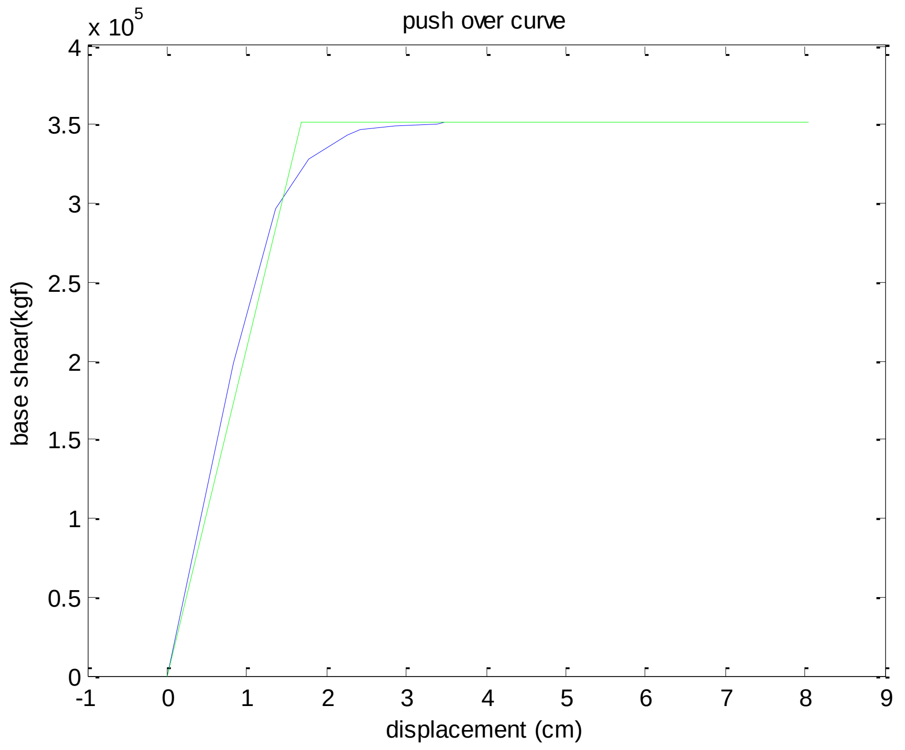
		設計地震	中小地震	TCU068
Beam (NG)	Story1	24	0	0
	Story2	2	0	0
	Total	26	0	0
Column (NG)	Story1	37	16	37
	Story2	28	0	37
	Total	65	16	74

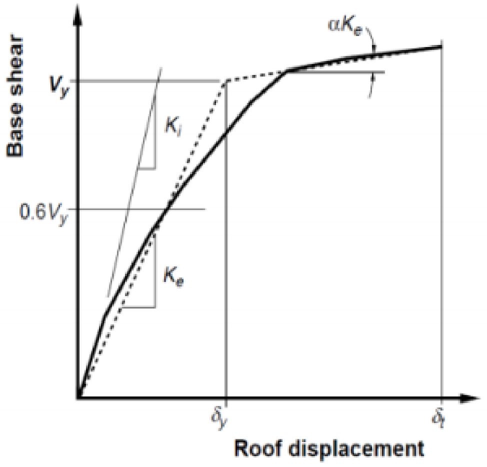
5. FEMA273

- 5.1 Linear Static Procedure(LSP)
- 5.2 Linear Dynamic Procedure(LDP)
- 5.3 Nonlinear Static Procedure(NSP)
- 5.4 Check and Summary

5.3 Nonlinear Static Procedure(NSP)

- Period Determination





$$T_e = T_i \sqrt{\frac{K_i}{K_e}}$$

	code	ETABS
T_i	0.3446	0.3982
K_i	233055.4	233055.4
K_e	209727.1	209727.1
T_e	0.36326	0.41976

5.3 Nonlinear Static Procedure(NSP)

- Coefficients Determination

Table 3-2 *Values for Modification Factor C_0*

Number of Stories	Modification Factor[1]
1	1.0
2	1.2
3	1.3
5	1.4
10+	1.5

1. Linear interpolation should be used to calculate intermediate values.

$$C_1 = 1.0 \quad for \quad T_e \geq T_0$$

$$C_1 = \frac{1 + \frac{(R-1)T_0}{T_e}}{R} \quad for\ T_e < T_0$$

Values for C_1 need not exceed those values given in Section 3.3.1.3.
In no case may C_1 be taken as less than 1.0.

$$C_3 = 1.0 \quad for \quad \alpha \geq 0$$

$$C_3 = 1.0 + \frac{|\alpha|(R-1)^{3/2}}{T_e} \quad for \quad \alpha < 0$$

$$R = \frac{S_a}{V_y / W} \cdot \frac{1}{C_0}$$

Table 3-1 *Values for Modification Factor C_2*

Performance Level	$T = 0.1$ second: Framing Type 1[1]	$T = 0.1$ second: Framing Type 2[2]	$T \geq T_0$ second: Framing Type 1[1]	$T \geq T_0$ second: Framing Type 2[2]
Immediate Occupancy	1.0	1.0	1.0	1.0
Life Safety	1.3	1.0	1.1	1.0
Collapse Prevention	1.5	1.0	1.2	1.0

5.3 Nonlinear Static Procedure(NSP)

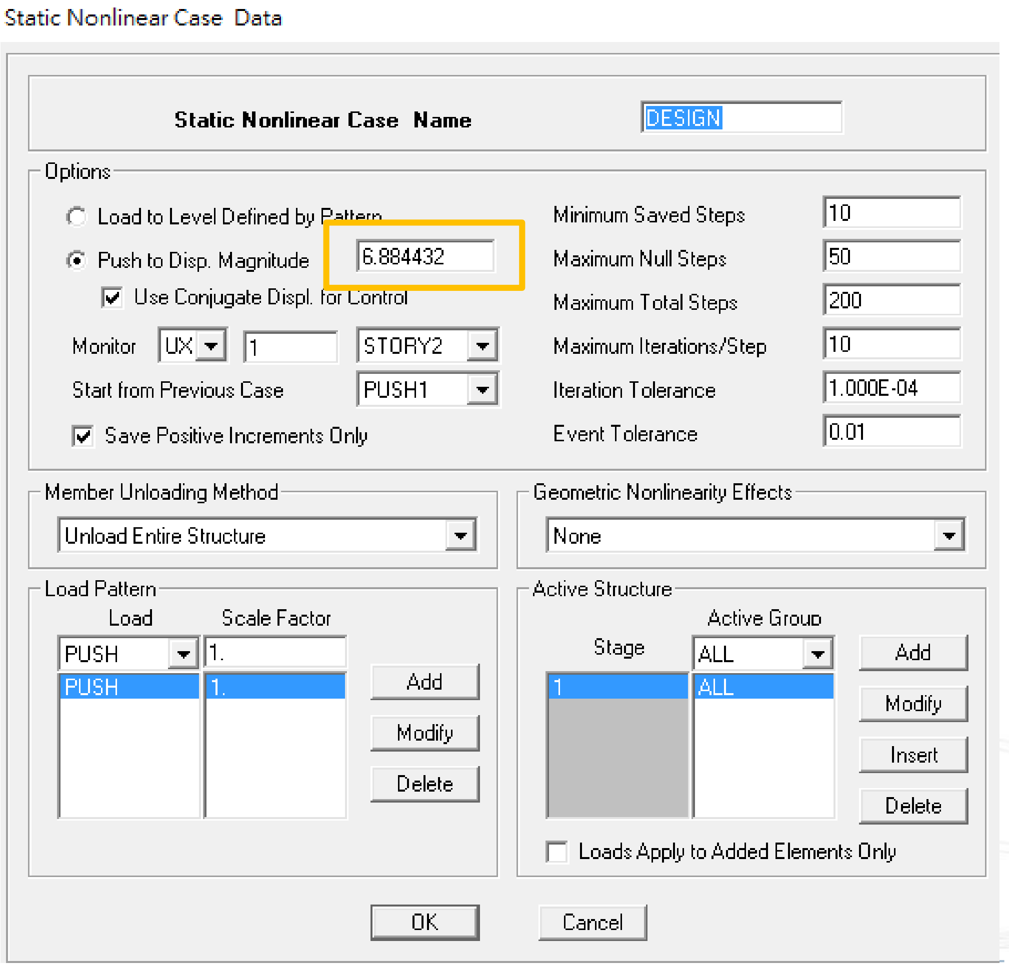
- Target Displacement

$$\delta_t = C_0 C_1 C_2 C_3 S_a \frac{T_e^2}{4\pi^2} g$$

	設計地震力	中小地震力	TCU068
R	2.92648	0.710259	3.569985
C_0	1.2	1.2	1.2
C_1	1.520349	0.649919	1.569037
C_2	1.219736	1.219736	1.222
C_3	1	1	1
S_a	1.096	0.266	1.337
W	1125604	1125604	1125604
T_e	0.36326	0.36326	0.36326
δ_t	6.884433	0.7143	8.683797

5.3 Nonlinear Static Procedure(NSP)

- Nonlinear static analysis



5.3 Nonlinear Static Procedure(NSP)

- Data output

Column Hinge States

Edit View

Column Hinge States

	Column	Load	Hinge	Loc	P	V2	V3	T	M2	M3	U1Plastic	U2Plastic	U3Plastic	R1Plastic	R2Plastic	R3Plastic
	C5	PUSHX-15	STORY2C5V	235.000	0.00	9985.90	0.00	0.000	0.000	0.000	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-16	STORY2C5V	235.000	0.00	9985.91	0.00	0.000	0.000	0.000	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-17	STORY2C5V	235.000	0.00	9985.91	0.00	0.000	0.000	0.000	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-0	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	15067.310	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-1	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	756963.776	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-2	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1291317.864	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-3	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1456641.333	0.0000	0.0000	0.0000	0.00000	0.00000	0.00081
	C5	PUSHX-4	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1546078.064	0.0000	0.0000	0.0000	0.00000	0.00000	0.00247
	C5	PUSHX-5	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582978.898	0.0000	0.0000	0.0000	0.00000	0.00000	0.00316
	C5	PUSHX-6	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.023	0.0000	0.0000	0.0000	0.00000	0.00000	0.00455
	C5	PUSHX-7	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.237	0.0000	0.0000	0.0000	0.00000	0.00000	0.00693
	C5	PUSHX-8	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.262	0.0000	0.0000	0.0000	0.00000	0.00000	0.00722
	C5	PUSHX-9	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.271	0.0000	0.0000	0.0000	0.00000	0.00000	0.00731
	C5	PUSHX-10	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.458	0.0000	0.0000	0.0000	0.00000	0.00000	0.00939
	C5	PUSHX-11	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.776	0.0000	0.0000	0.0000	0.00000	0.00000	0.01294
	C5	PUSHX-12	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582979.803	0.0000	0.0000	0.0000	0.00000	0.00000	0.01324
	C5	PUSHX-13	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582980.123	0.0000	0.0000	0.0000	0.00000	0.00000	0.01680
	C5	PUSHX-14	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582980.442	0.0000	0.0000	0.0000	0.00000	0.00000	0.02035
	C5	PUSHX-15	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582980.761	0.0000	0.0000	0.0000	0.00000	0.00000	0.02390
	C5	PUSHX-16	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582981.081	0.0000	0.0000	0.0000	0.00000	0.00000	0.02746
	C5	PUSHX-17	STORY1C5F	100.000	0.00	0.00	0.00	0.000	0.000	1582981.119	0.0000	0.0000	0.0000	0.00000	0.00000	0.02789
	C5	PUSHX-0	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-10198.790	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-1	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-899605.745	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
	C5	PUSHX-2	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1451633.241	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00053
	C5	PUSHX-3	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1532894.344	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00202
	C5	PUSHX-4	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.147	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00398
	C5	PUSHX-5	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.231	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00492
	C5	PUSHX-6	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.357	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00631
	C5	PUSHX-7	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.571	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00870
	C5	PUSHX-8	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.596	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00898
	C5	PUSHX-9	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.605	0.0000	0.0000	0.0000	0.00000	0.00000	-0.00908
	C5	PUSHX-10	STORY1C5F	400.000	0.00	0.00	0.00	0.000	0.000	-1593113.792	0.0000	0.0000	0.0000	0.00000	0.00000	[illegible]

5.3 Nonlinear Static Procedure(NSP)

Acceptance Criteria

Table 6-6 Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Reinforced Concrete Beams

Conditions			Modeling Parameters[3]			Acceptance Criteria[3]				
			Plastic Rotation Angle, radians		Residual Strength Ratio	Plastic Rotation Angle, radians — Component Type — Performance Level				
						Primary			Secondary	
			a	b	c	IO	LS	CP	LS	CP
i. Beams controlled by flexure[1]										
$\frac{\rho-\rho'}{\rho_{bal}}$	Trans. Reinf.[2]	$\frac{V}{b_w d \sqrt{f'_c}}$								
≤ 0.0	C	≤ 3	0.025	0.05	0.2	0.005	0.02	0.025	0.02	0.05
≤ 0.0	C	≥ 6	0.02	0.04	0.2	0.005	0.01	0.02	0.02	0.04
≥ 0.5	C	≤ 3	0.02	0.03	0.2	0.005	0.01	0.02	0.02	0.03
≥ 0.5	C	≥ 6	0.015	0.02	0.2	0.005	0.005	0.015	0.015	0.02
≤ 0.0	NC	≤ 3	0.02	0.03	0.2	0.005	0.01	0.02	0.02	0.03
≤ 0.0	NC	≥ 6	0.01	0.015	0.2	0.0	0.005	0.01	0.01	0.015
≥ 0.5	NC	≤ 3	0.01	0.015	0.2	0.005	0.01	0.01	0.01	0.015
≥ 0.5	NC	≥ 6	0.005	0.01	0.2	0.0	0.005	0.005	0.005	0.01

Table 6-7 Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Reinforced Concrete Columns

Conditions			Modeling Parameters[4]			Acceptance Criteria[4]				
			Plastic Rotation Angle, radians		Residual Strength Ratio	Plastic Rotation Angle, radians — Component Type — Performance Level				
						Primary			Secondary	
			a	b	c	IO	LS	CP	LS	CP
i. Columns controlled by flexure[1]										
$\frac{P}{A_g f'_c}$	Trans. Reinf.[2]	$\frac{V}{b_w d \sqrt{f'_c}}$								
≤ 0.1	C	≤ 3	0.02	0.03	0.2	0.005	0.01	0.02	0.015	0.03
≤ 0.1	C	≥ 6	0.015	0.025	0.2	0.005	0.01	0.015	0.01	0.025
≥ 0.4	C	≤ 3	0.015	0.025	0.2	0.0	0.005	0.015	0.010	0.025
≥ 0.4	C	≥ 6	0.01	0.015	0.2	0.0	0.005	0.01	0.01	0.015
≤ 0.1	NC	≤ 3	0.01	0.015	0.2	0.005	0.005	0.01	0.005	0.015
≤ 0.1	NC	≥ 6	0.005	0.005	–	0.005	0.005	0.005	0.005	0.005
≥ 0.4	NC	≤ 3	0.005	0.005	–	0.0	0.0	0.005	0.0	0.005
≥ 0.4	NC	≥ 6	0.0	0.0	–	0.0	0.0	0.0	0.0	0.0

5.3 Nonlinear Static Procedure(NSP)

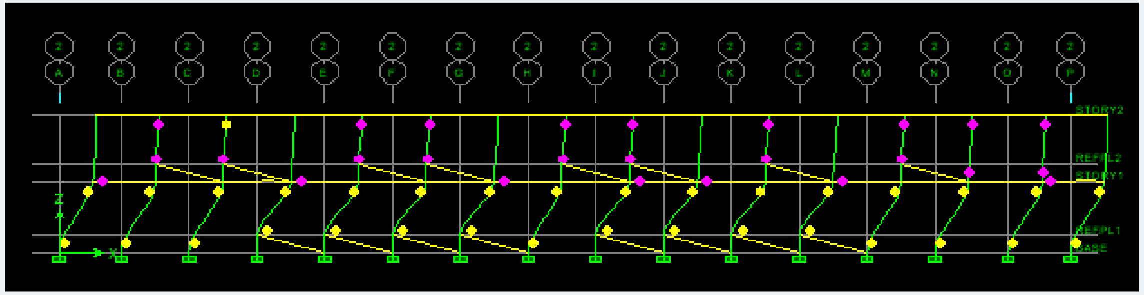
- Result

		設計地震	中小地震	TCU068
Beam (NG)	Story1	0	0	0
	Story2	0	0	0
	Total	0	0	0
Column (NG)	Story1	37	0	37
	Story2	0	0	0
	Total	37	0	37

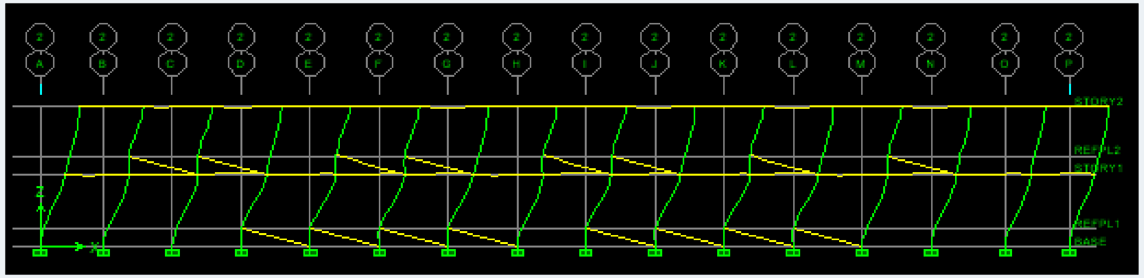
5.3 Nonlinear Static Procedure(NSP)

- Column Plastic Hinges

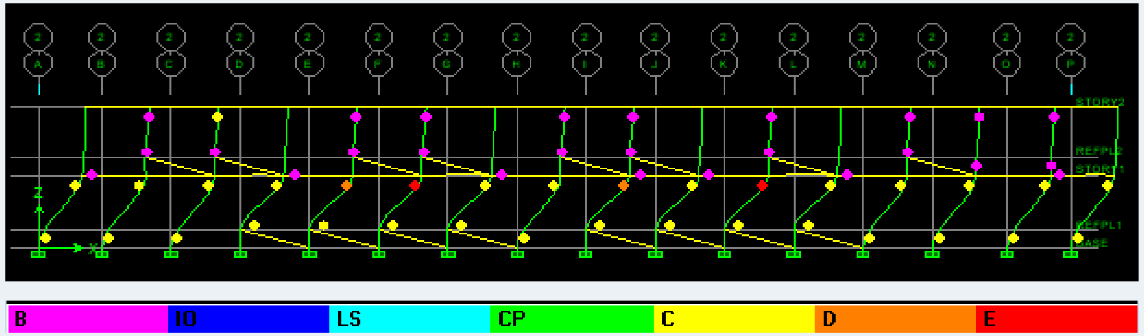
Design



Service



TCU068



5.4 Check and Summary

		設計地震			中小地震			TCU068		
		LSP	LDP	NSP	LSP	LDP	NSP	LSP	LDP	NSP
Beam	Story1	20	24	0	0	0	0	32	39	0
	Story2	12	2	0	0	0	0	28	0	0
	total	32	26	0	0	0	0	60	39	0
Column	Story1	37	37	37	18	16	0	37	37	37
	Story2	37	28	0	0	0	0	37	37	0
	total	74	65	37	18	16	0	74	74	37

5.4 Check and Summary

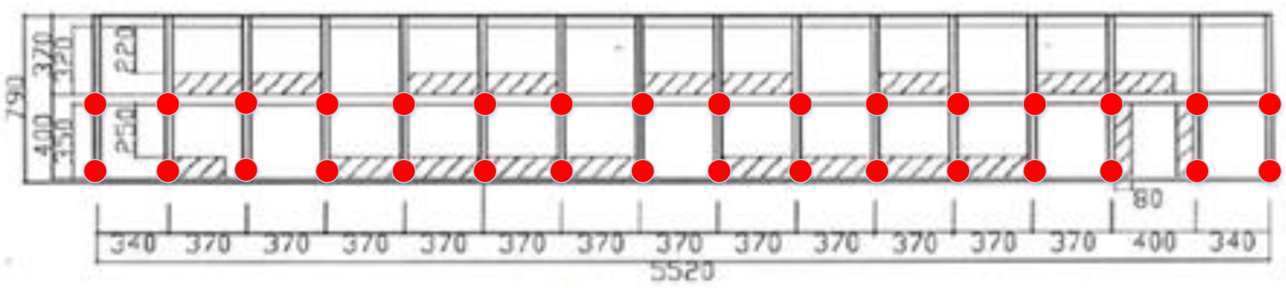
- 1. 三筆地震:

  TCU068 > 設計地震 > 中小地震

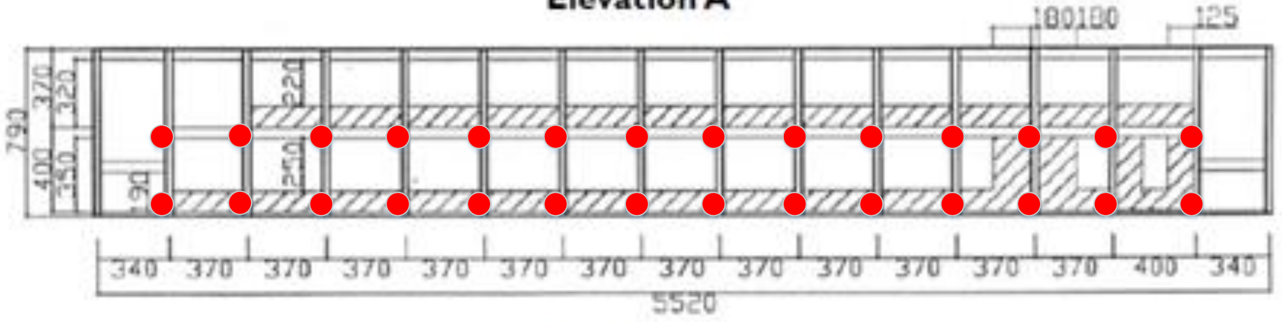
- 2. 強梁弱柱
- 3. 線性靜力(LSP)最為保守
- 4. 非線性分析較接近真實破壞情況

6.Upper bound method

- Assumption
- 1.一樓panel mechanism
- 2.忽略梁跟二樓柱的塑鉸貢獻
- 3.二樓無層間變位
- 4.利用TEASPA定義之塑鉸Mp



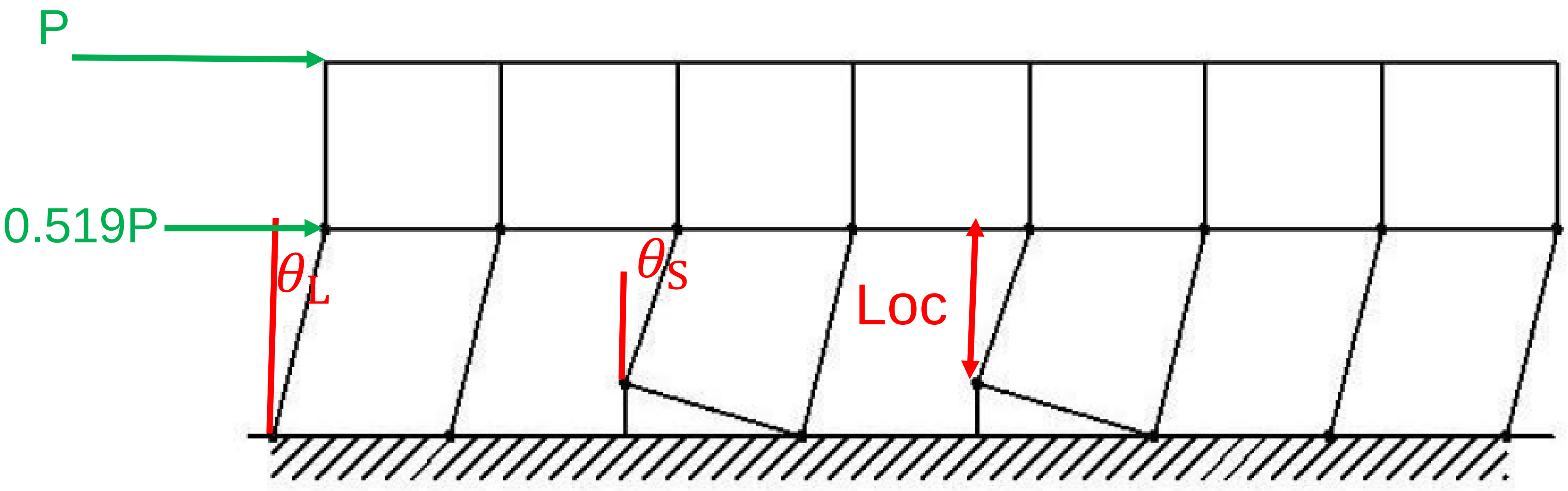
Elevation A



Elevation C

6.Upper bound method

- $\theta_S \times Loc = \theta_L \times (Loc + 100)$
- Loc為扣除窗台之柱淨高
- 假設P分布與樓高成正比



6.Upper bound method

- Caculation

$$\sum P_i h_i \delta\theta_i = \mathrm{P}\left(400\times\theta_L\right)+0.519P\left(400\theta_L\right)=607.6\mathrm{P}\theta_L$$

$$\sum(M_{p,i}\delta\theta_{S,i})+\sum(M_{p,i}\delta\theta_{L,i})=123369715.8\theta_L$$

$$\mathrm{V}_{\mathrm{upperbound}}=\left(1+0.519\right)\mathrm{P}=308424.3\mathrm{kgf}$$

$$\mathrm{V}_{\mathrm{pushover}}=351295kgf$$

$\mathrm{V}_{\mathrm{upperbound}}$	$\mathrm{V}_{\mathrm{pushover}}$	error
308424.3kgf	351295kgf	13%

7.Retrofit

- $V_{pushover} = 351295 kgf$

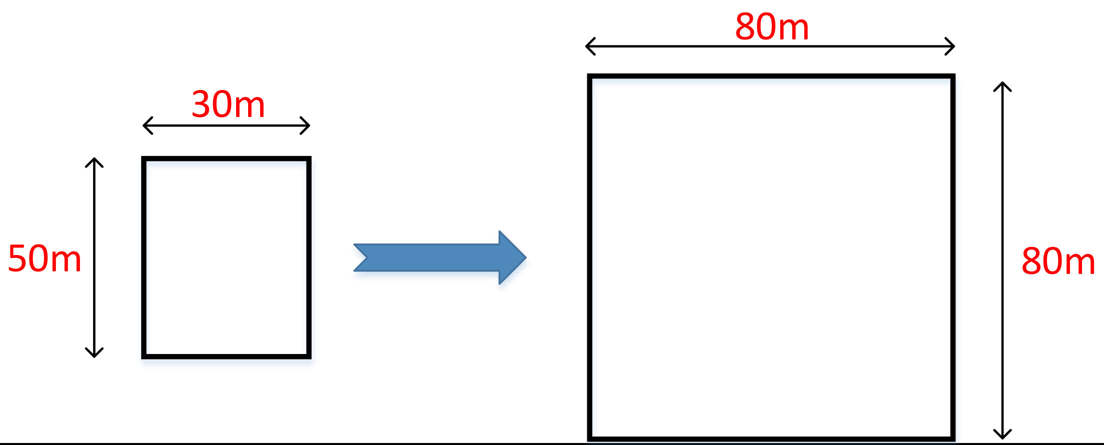
- $A_p = 0.261271g$, $A_T = 0.438g$

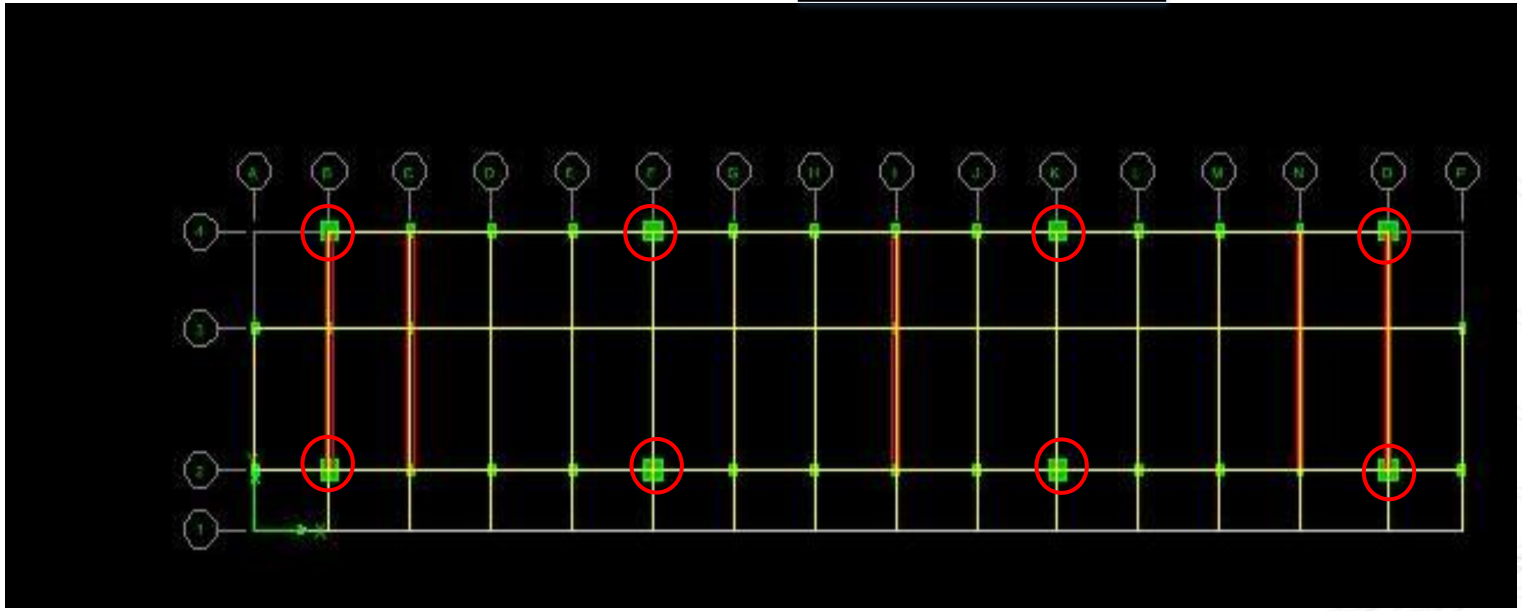
$$V^* = \frac{A_T}{A_p} V_{pushover} = \frac{0.438g}{0.261g} \times 351295 = 589530 kgf$$

- $\Delta V = 238235\text{kgf}$

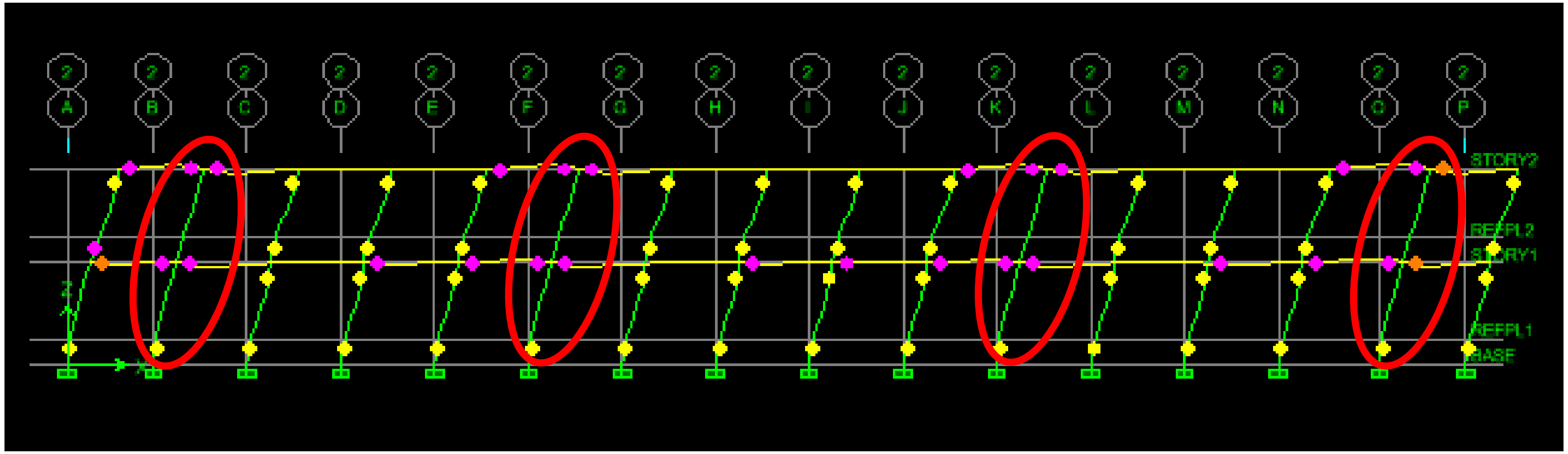
7.Retrofit

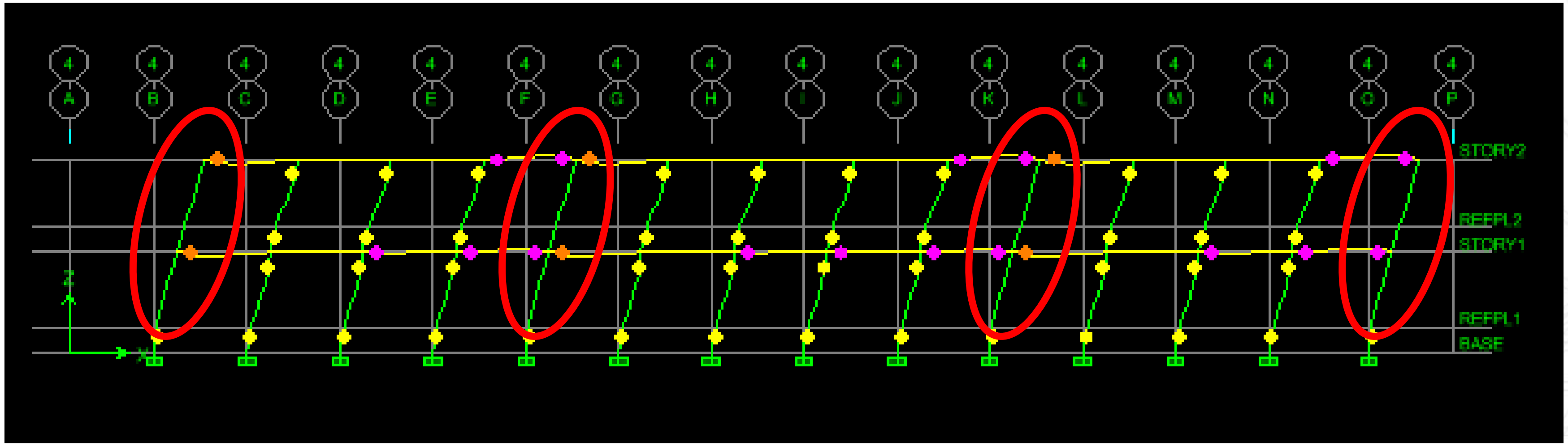
- column



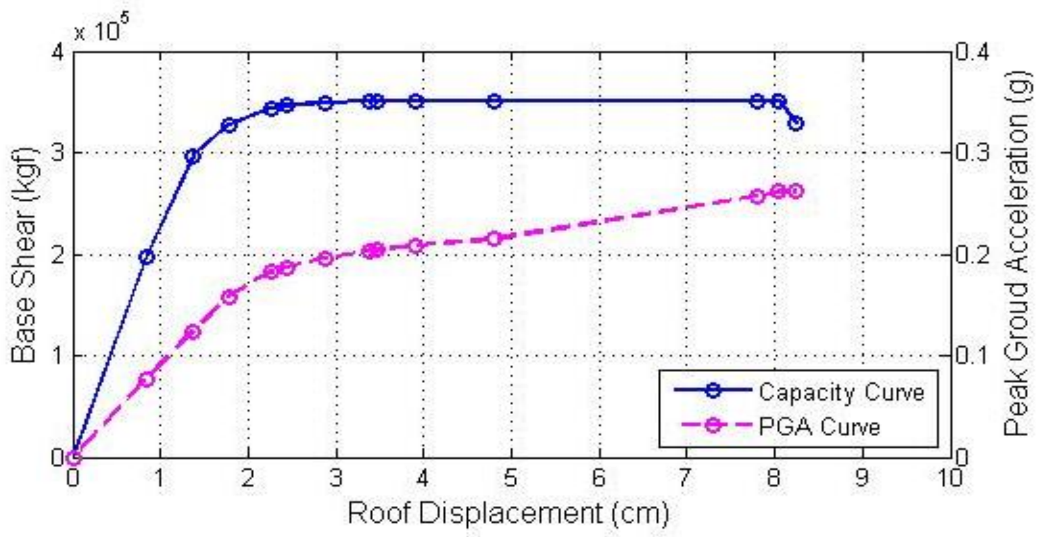


7.Retrofit

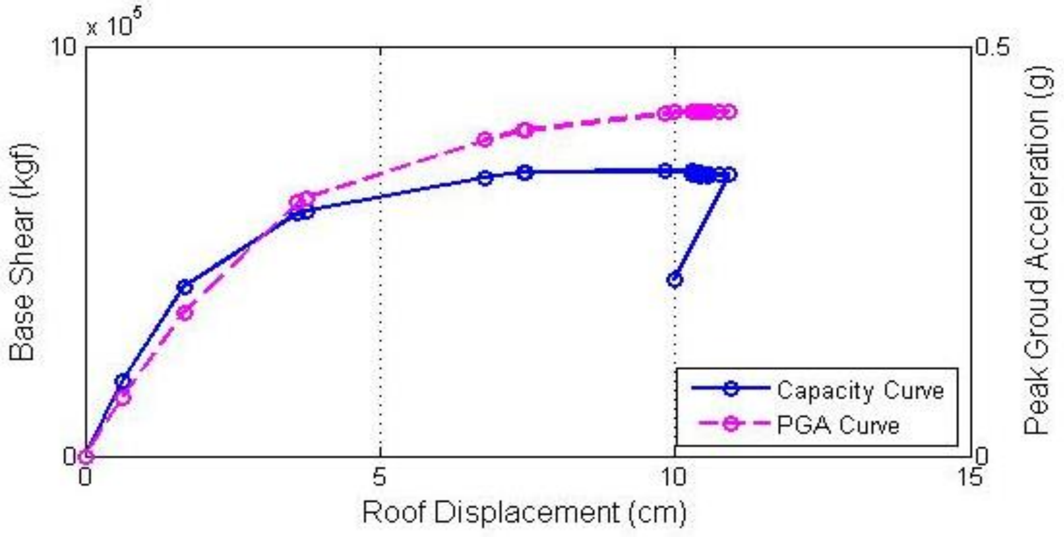

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
STORY2
REFPL2
STORY1
REFPL1
BASE


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
STORY2
REFPL2
STORY1
REFPL1
BASE

7.Retrofit



補強前



補強後

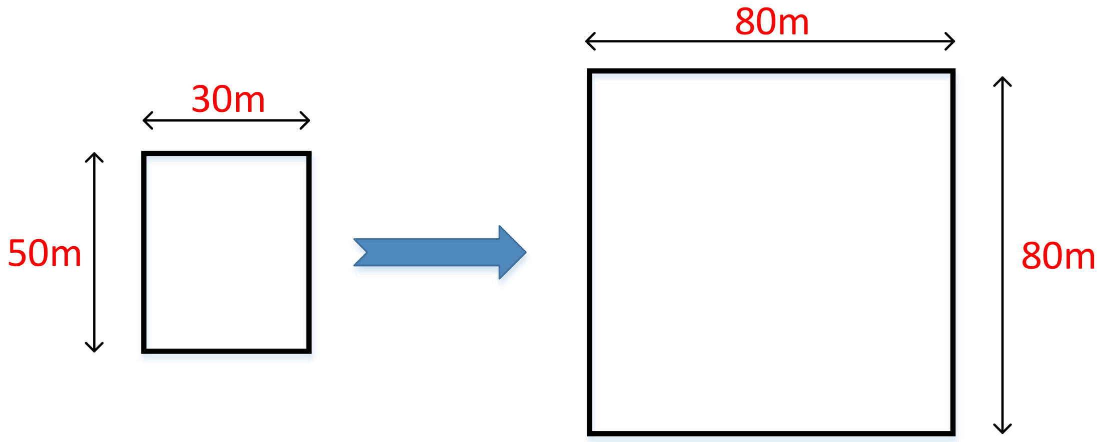
階段	Max.Displacement(cm)	Max.Base(kN)	Drift ratio	Ap(g)
補強前	8.0401	351295	RFL：0.1516% 2FL：1.9287%	0.261271
補強後	10.8977	685999	RFL：1.6042% 2FL：1.241%	0.420725

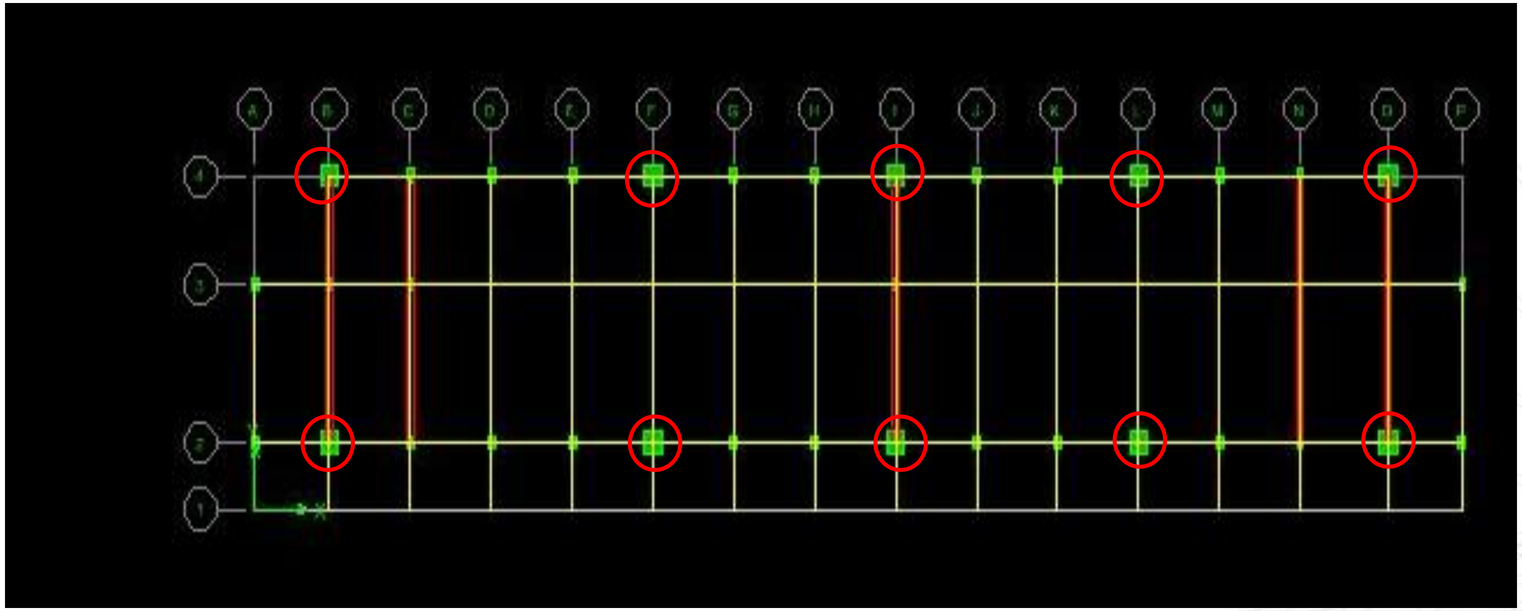
<0.438g(NG)

<2%(OK)

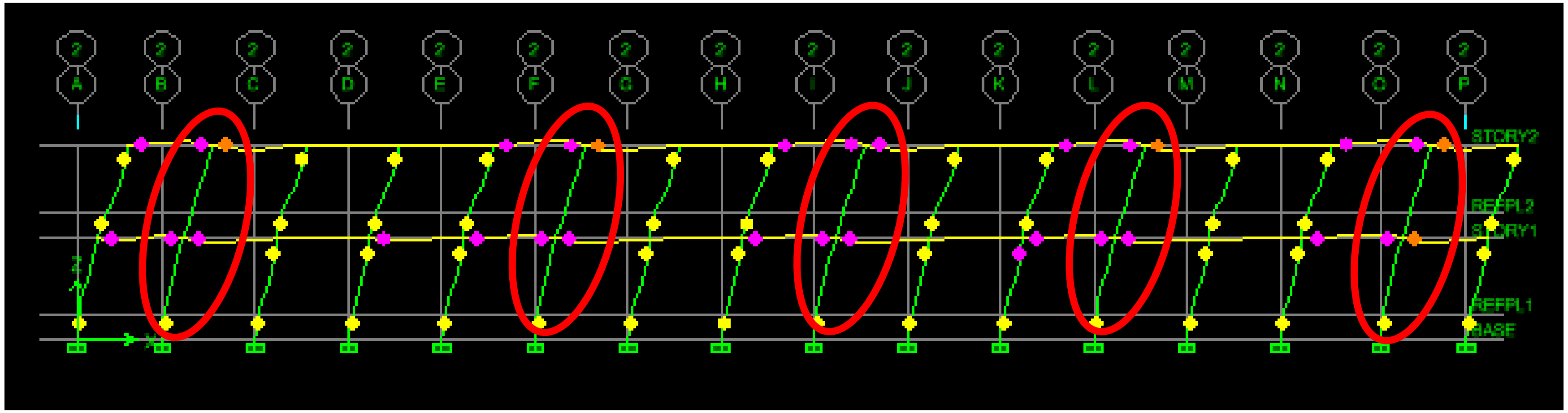
7.Retrofit

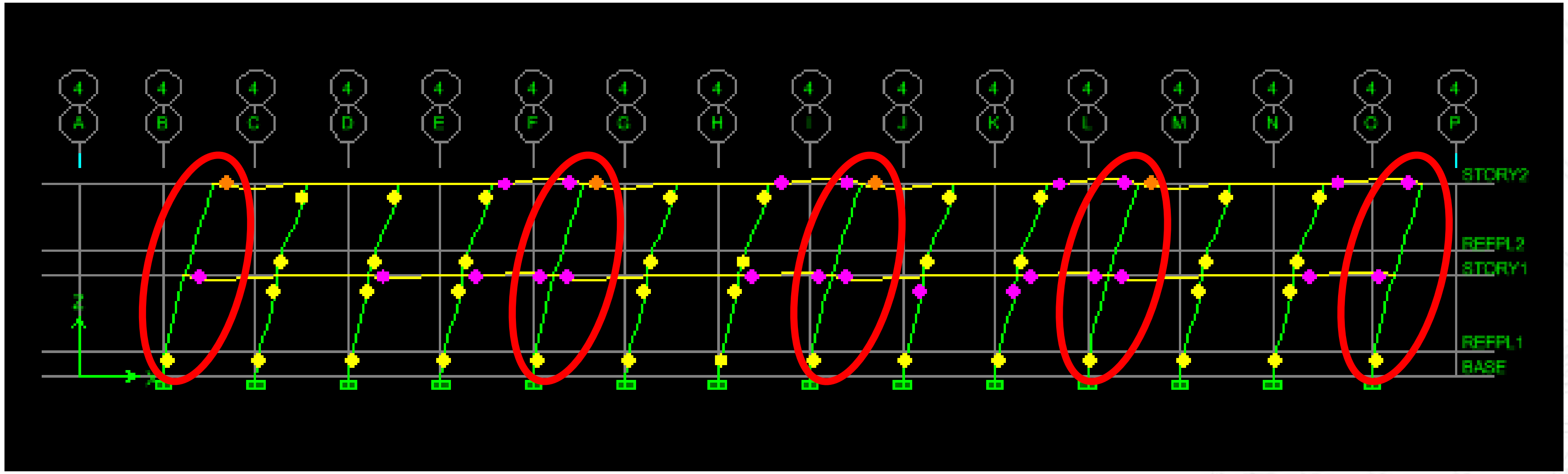
- Column



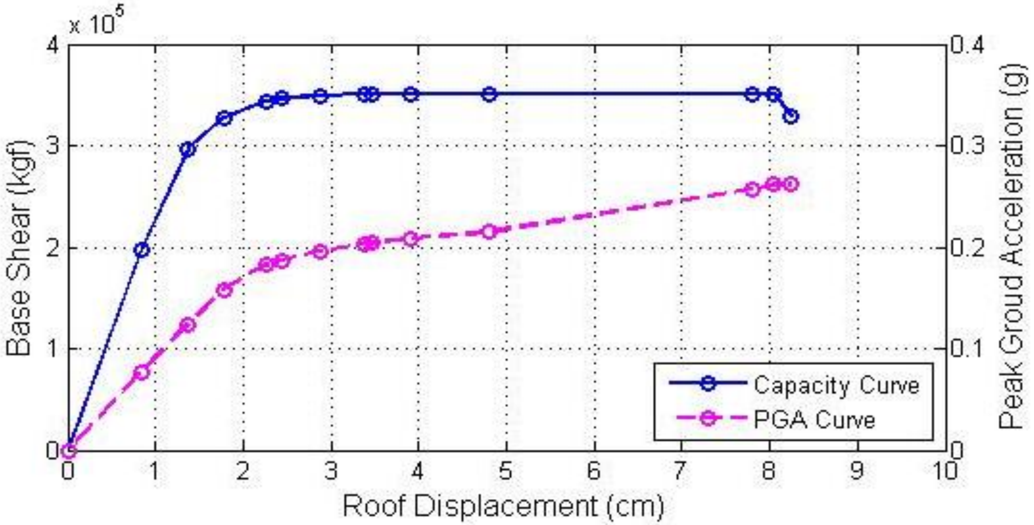


7.Retrofit

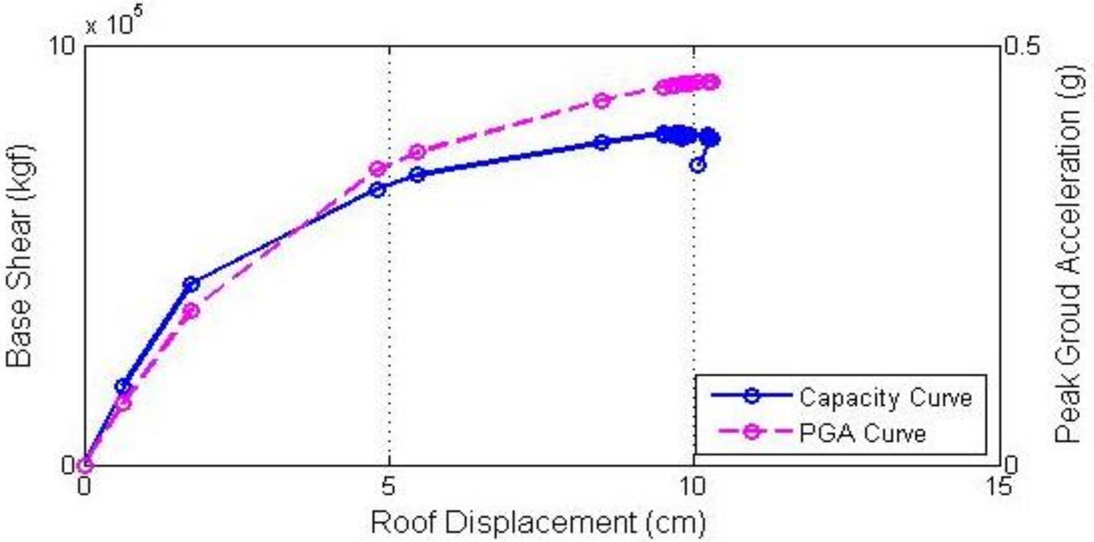

STORY2
REFPL2
REFPL1
BASE


STORY2
REFPL2
STORY1
REFPL1
BASE

7.Retrofit



補強前



補強後

階段	Max.Displacement(cm)	Max.Base(kN)	Drift ratio	Ap(g)
補強前	8.0401	351295	RFL：0.1516% 2FL：1.9287%	0.261271
補強後	10.2814	790039	RFL：1.6182% 2FL：1.074%	0.455733

>0.438g(OK)

<2%(OK)

8.Conclusion

- 1.ETABS側推結果可知破壞模式為1樓Panel Mechanism (強梁弱柱)
- 2.根據Pushover結果$A_P < A_T$，所以此建築物需要進行耐震補強
- 3.ATC-40結果為在設計地震與TCU068下是Collapse，中小度地震為Operational (Immediate Occupancy)
- 4.從FEMA273檢核，可以發現非線性分析較接近真實破壞情況
- 5.利用Upper Bound Method求得的結果與Pushover結果相差約13%
- 6.因為破壞模式為1樓Panel Mechanism(強梁弱柱)，希望將其變成強柱弱梁，故需要增強柱之強度，將10根柱進行擴柱後，其A_P可以達到設計最大地表加速度A_T

9. Reference

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Thank you for listening