

建築物實施耐震能力評估及補強講習會

鋼筋混凝土建築物耐震能力詳細



評估系統SERC B之介紹

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報告內容

- 1 前言
- 2 鋼筋混凝土建築結構非線性行為
- 3 鋼筋混凝土建築結構耐震能力評估
- 4 結論

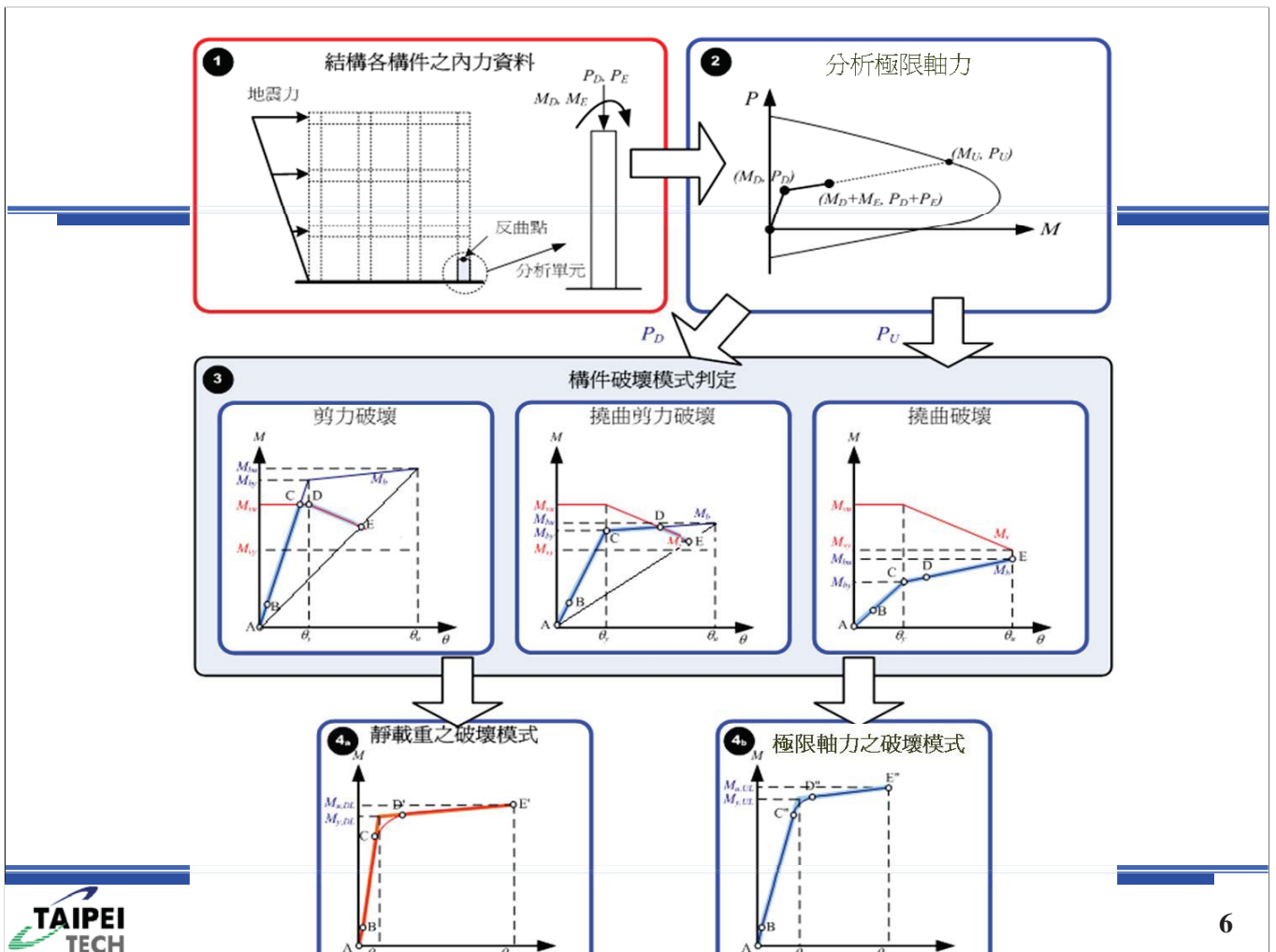
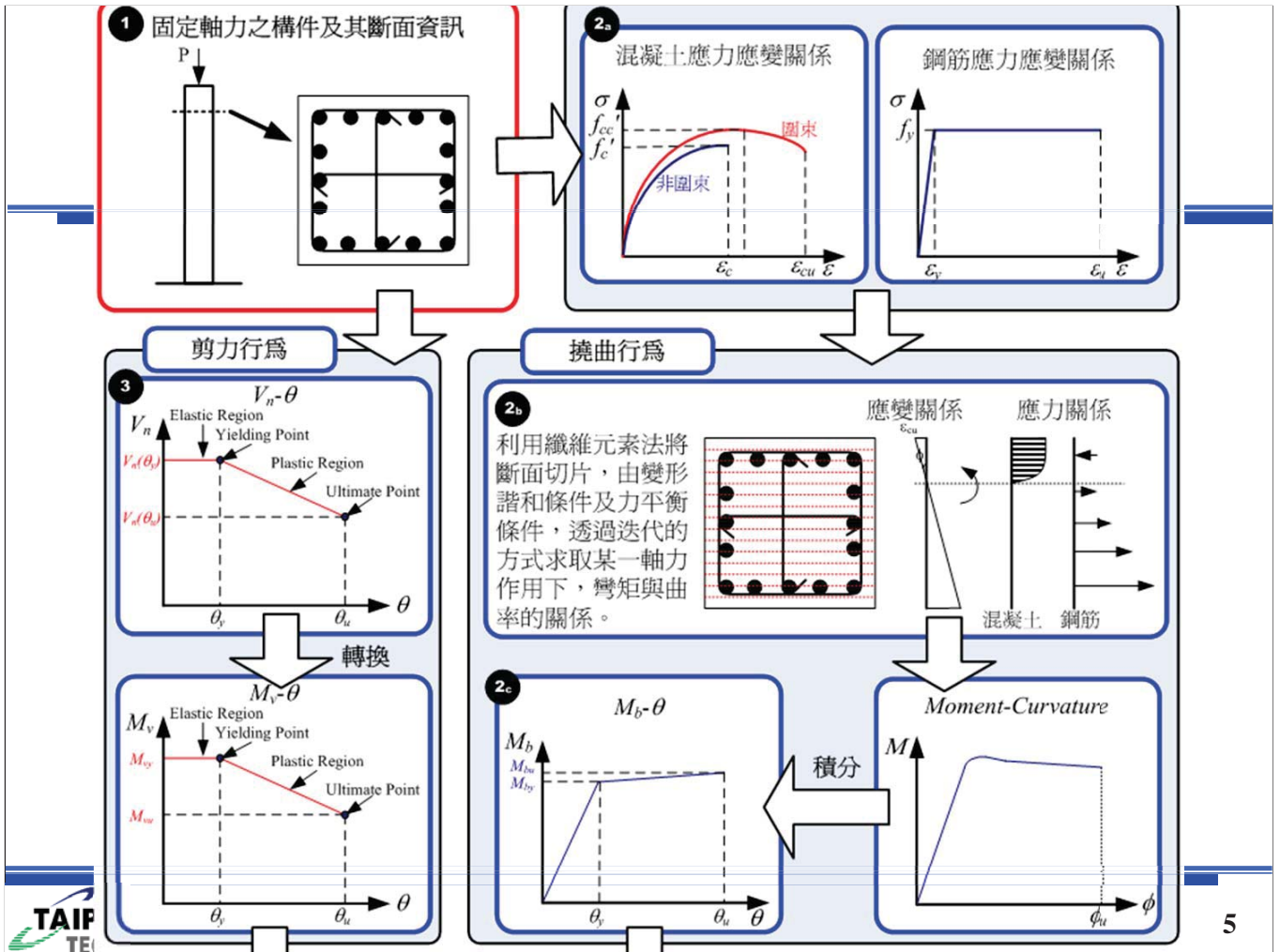


鋼筋混凝土建築結構非線性行為

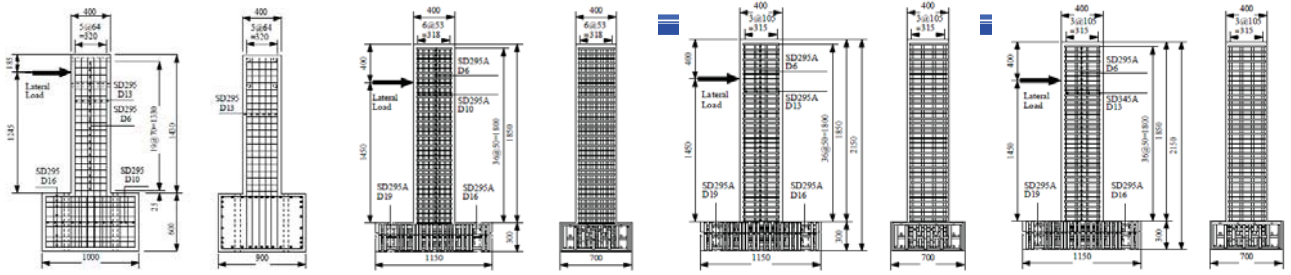
靜態側推分析 (Pushover Analysis)

- ① 藉由施加側向力於結構物上，隨著力量緩慢增加，記錄構材開裂、降伏、塑性變形和結構失敗等發展行為，並在一連串的迭代過程中，依各不同受力階段之結構行為，修正構材有效勁度與不平衡力，採用階段線性分析的方式，直到塑性鉸發展至崩塌機制或到達極限塑性變形為止。
- ② 能清楚地提供結構物在各性能階段的受力與變形行為。





東京工業大學 川島一彦研究室

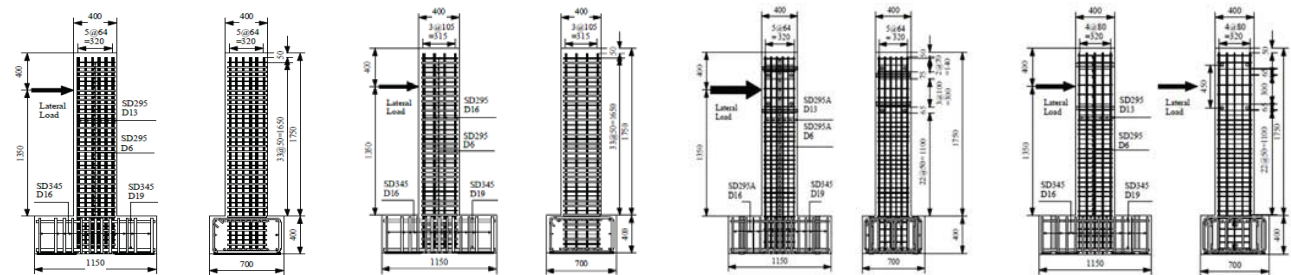


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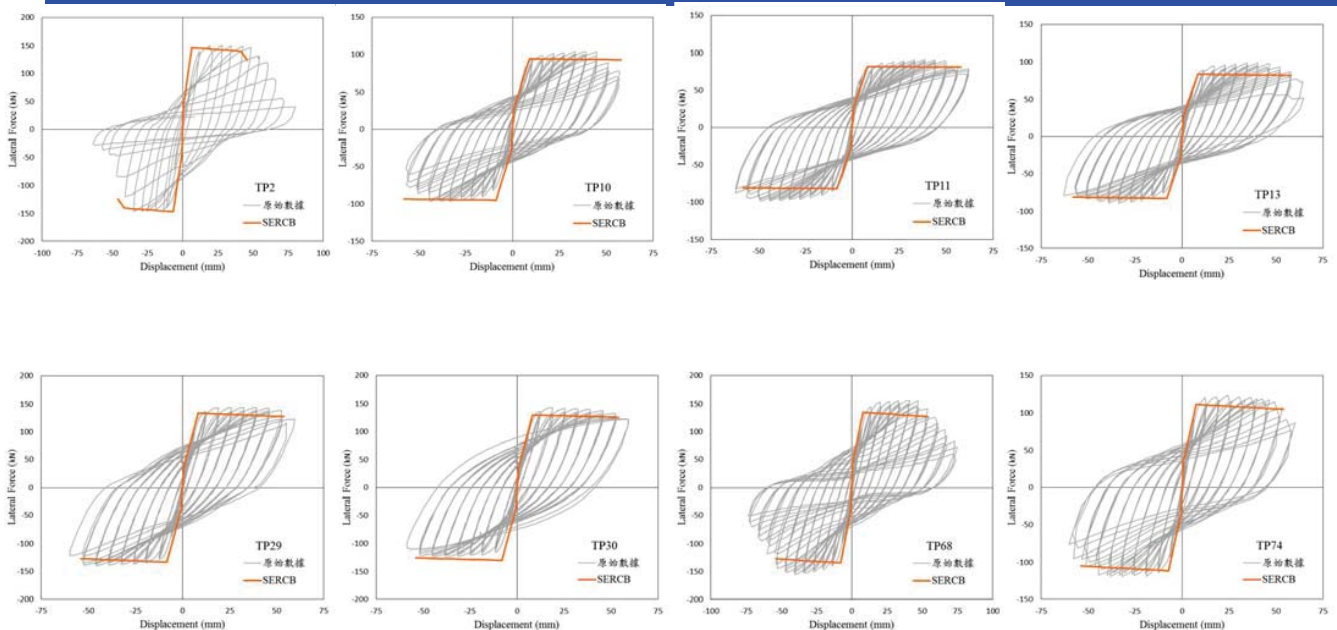
TP29

TP30

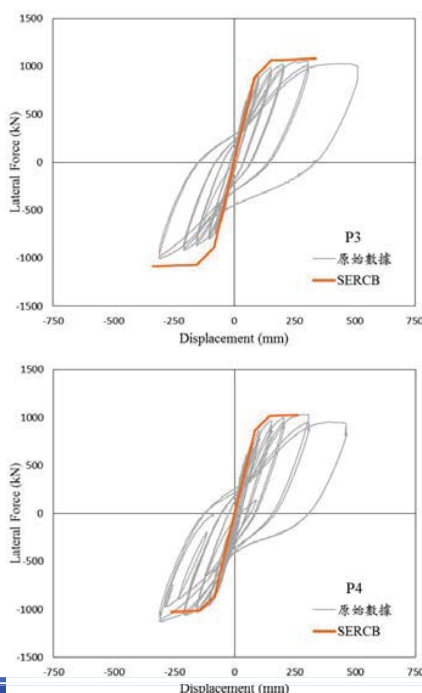
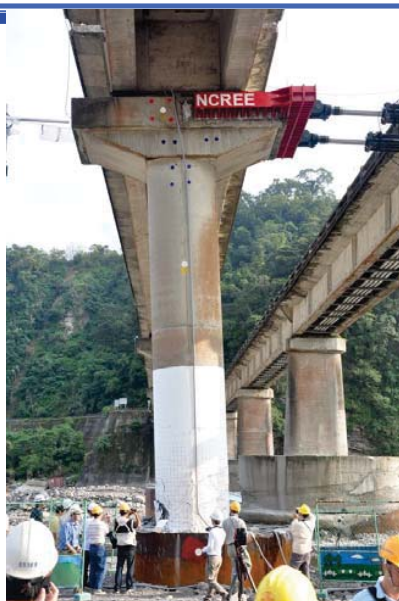
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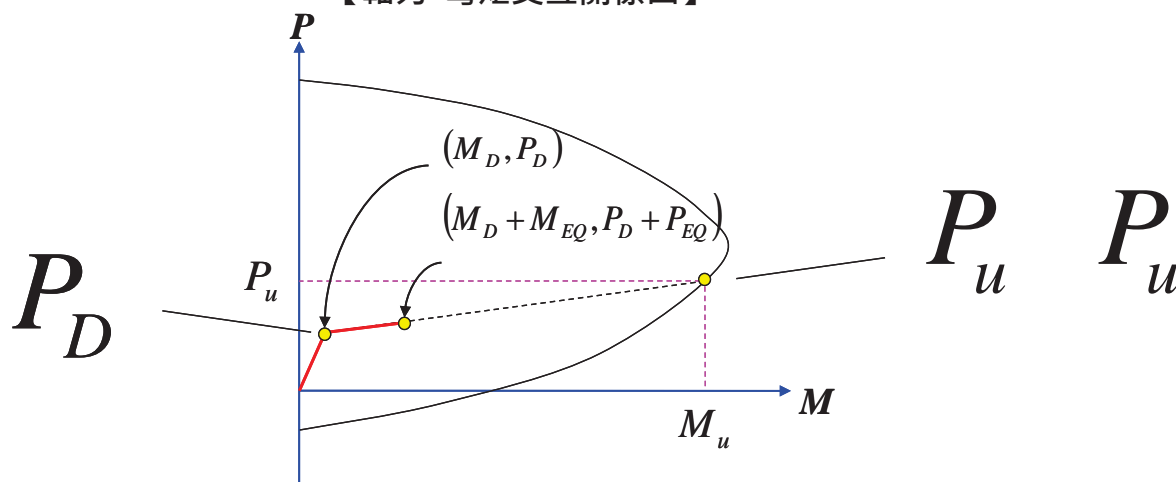


牛鬥橋單柱試體



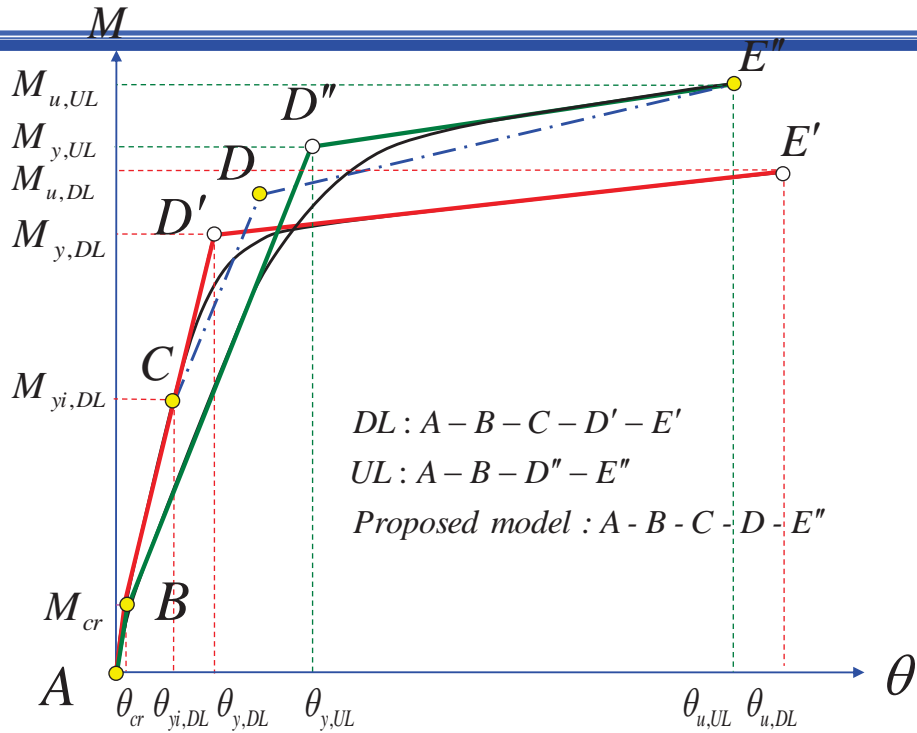
改良式構架鋼筋混凝土柱塑鉸之設定

【軸力-彎矩交互關係圖】



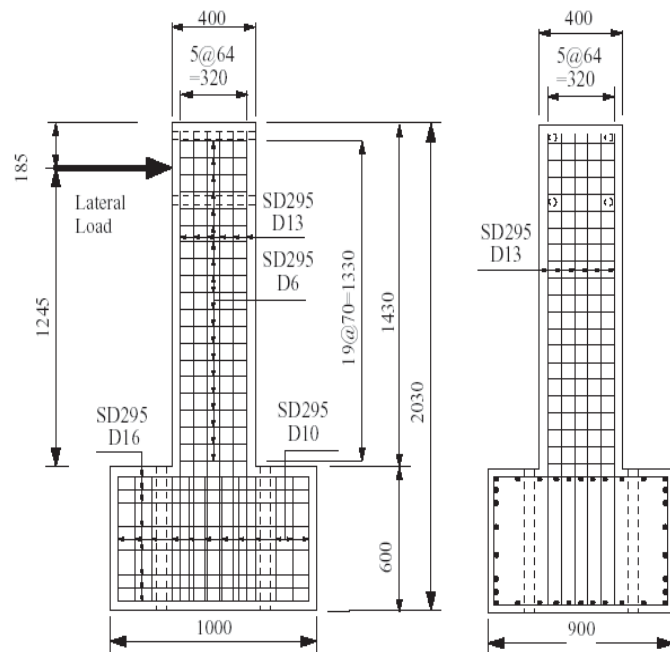
➔ 尋找柱斷面軸力

考慮軸力變化之塑鉸定義方式

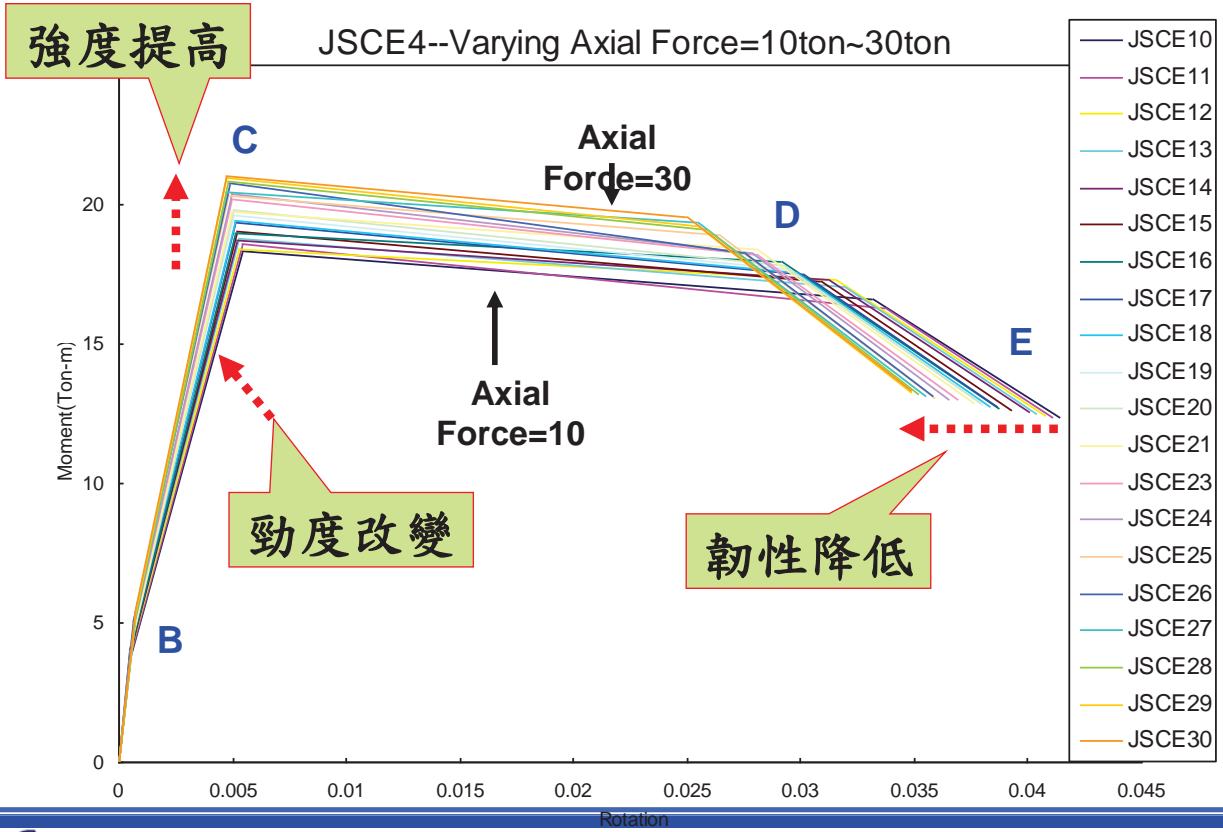


Case1. 混凝土固定 ($f_c' = 350$) - 軸力變化 (10ton ~ 30ton)

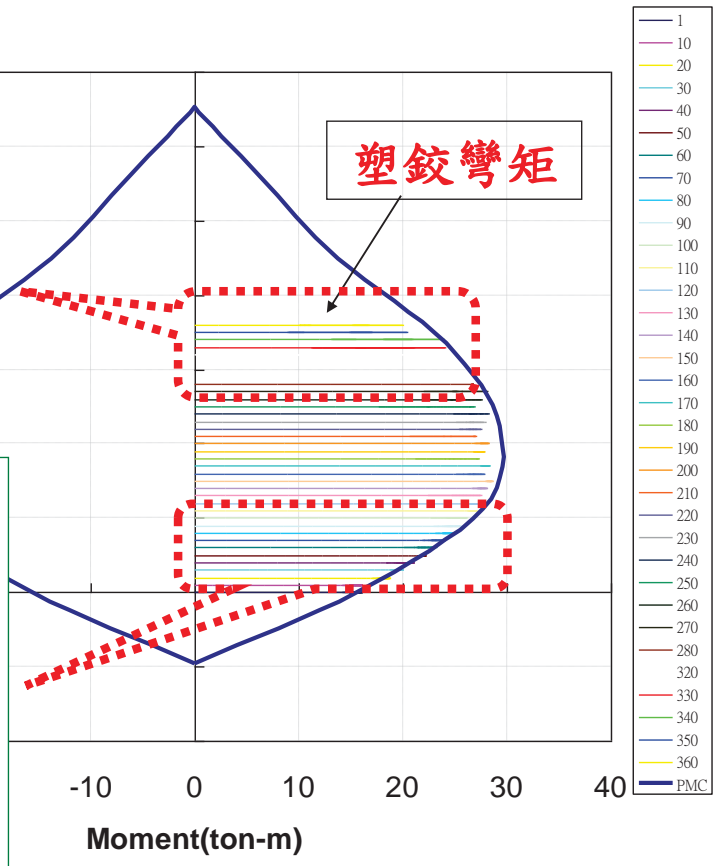
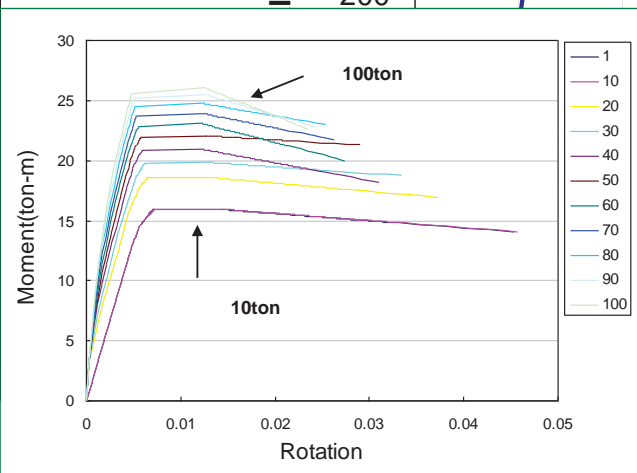
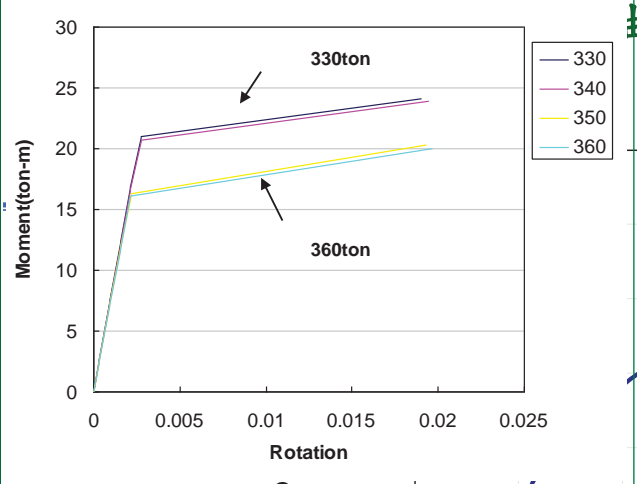
JSCE4



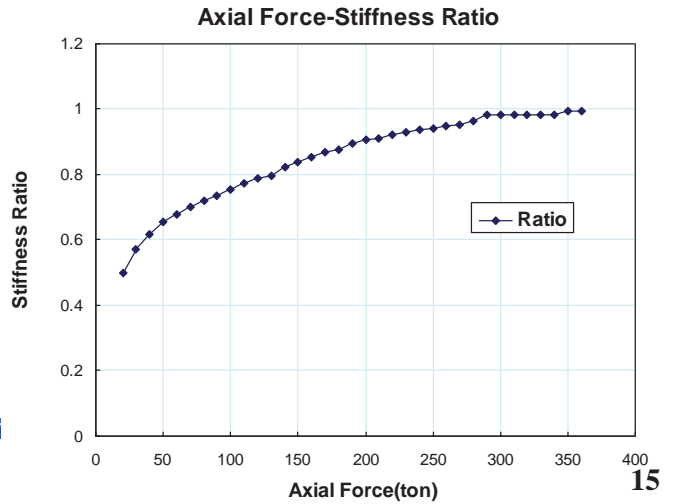
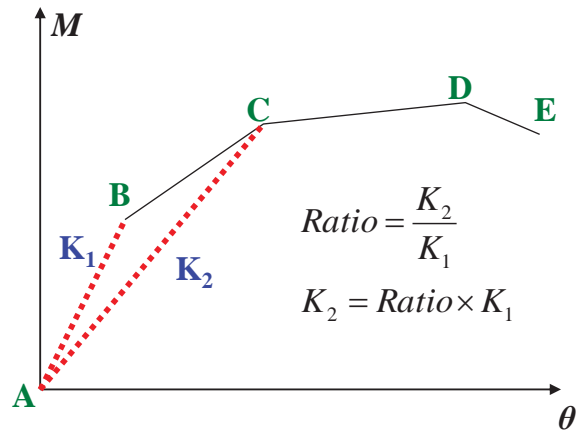
Case1. 混凝土固定 ($f_c' = 350$) - 軸力變化 (10ton~30ton)



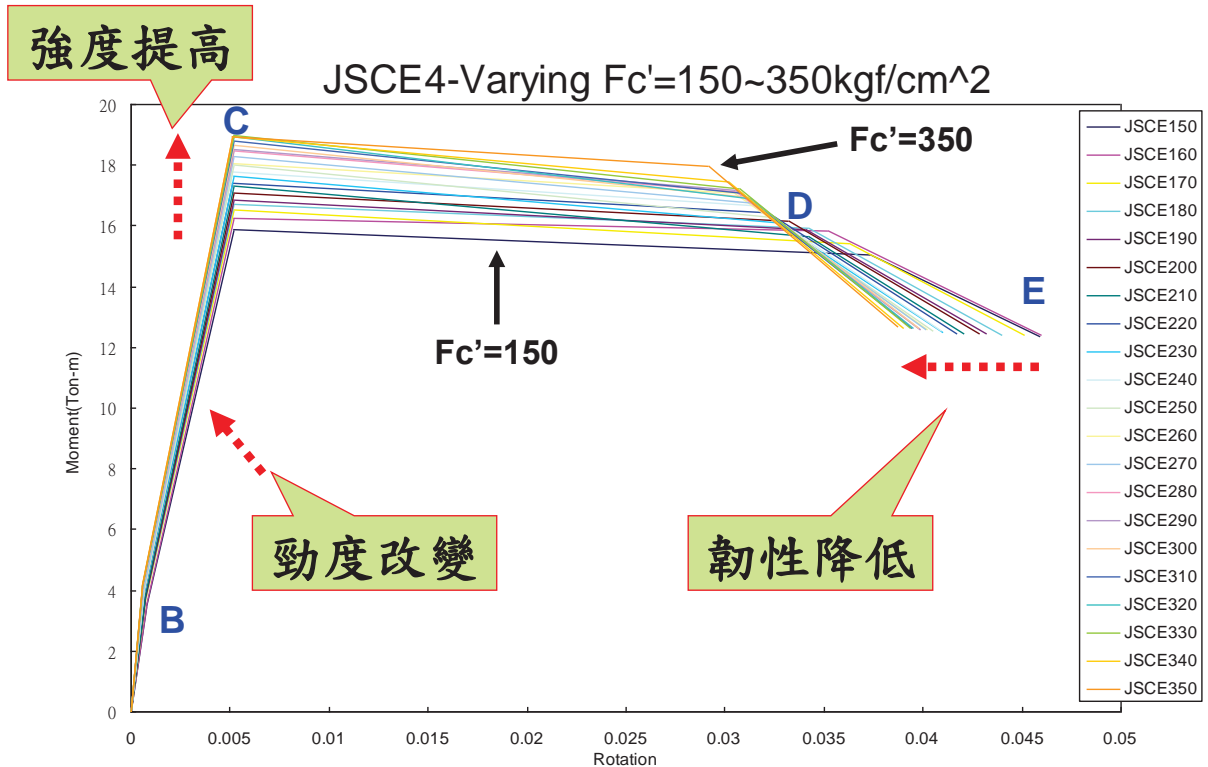
軸力變化 (1ton~360ton)



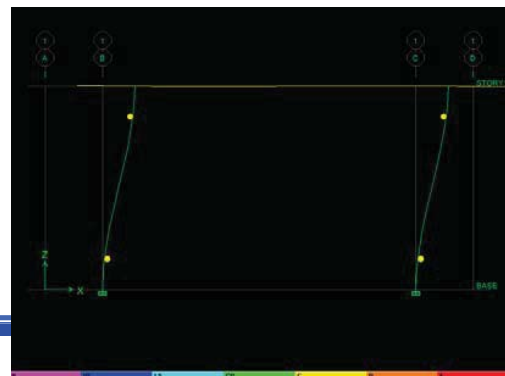
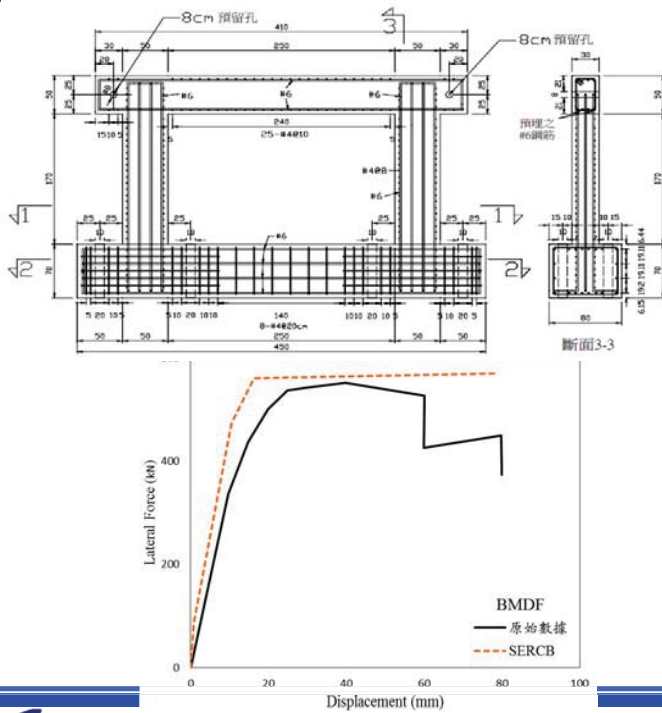
Axial Force	Ratio	Axial Force	Ratio
20(ton)	0.500126	200(ton)	0.905517
30	0.572653	210	0.910601
40	0.617576	220	0.923186
50	0.654692	230	0.93012
60	0.677131	240	0.936486
70	0.701033	250	0.940281
80	0.721649	260	0.94852
90	0.737022	270	0.953338
100	0.752531	280	0.962182
110	0.773794	290	0.983667
120	0.788129	300	0.983783
130	0.797386	310	0.983838
140	0.821175	320	0.984352
150	0.838802	330	0.984071
160	0.851769	340	0.98372
170	0.869229	350	0.994867
180	0.875656	360	0.993796
190	0.895279		



Case2. 混凝土變化($f_c' = 150 \sim 350$)-軸力固定(16ton)



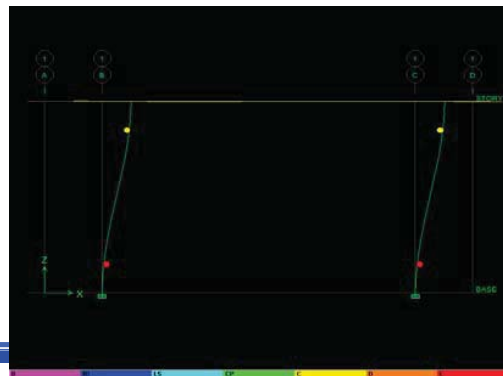
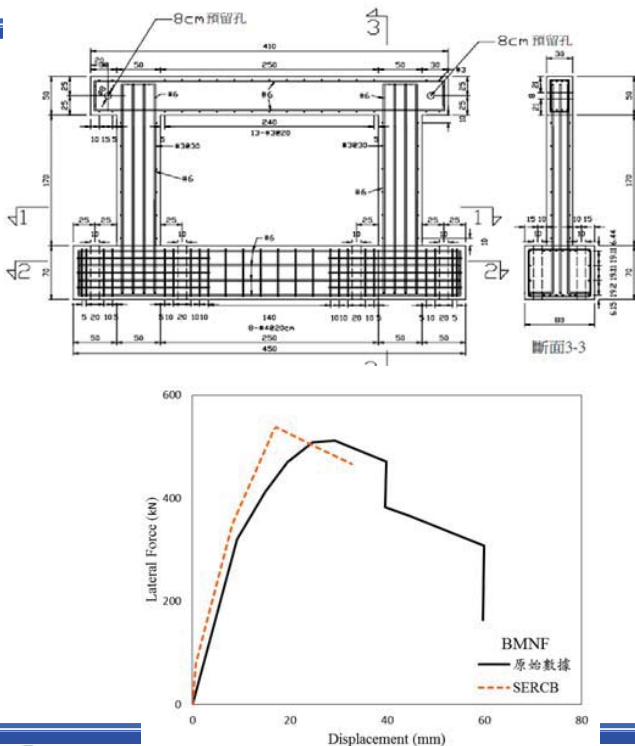
構架BMDF試體



(含開口RC牆非韌性構架之耐震行為研究·黃世建、陳力平、陳俊宏·2003)

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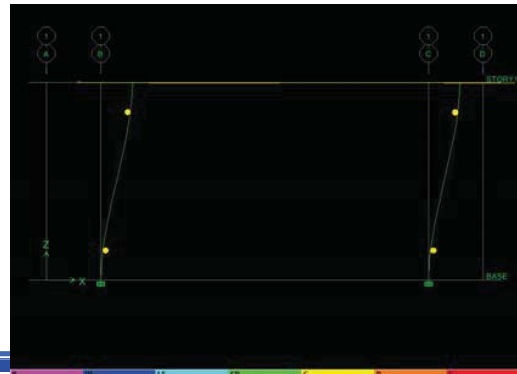
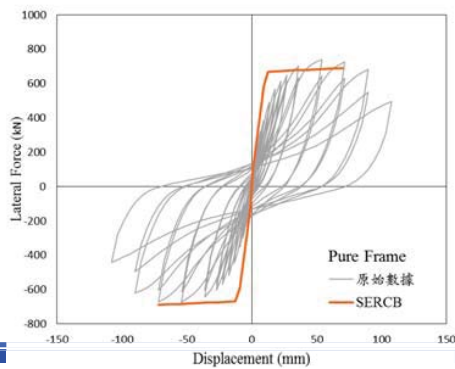
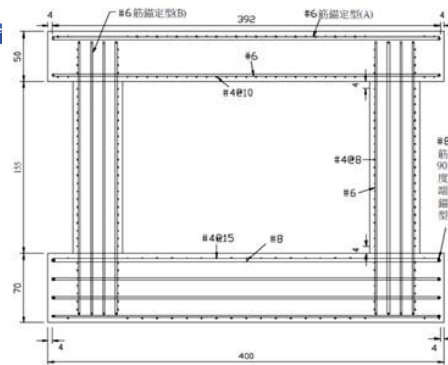
構架BMNF試體



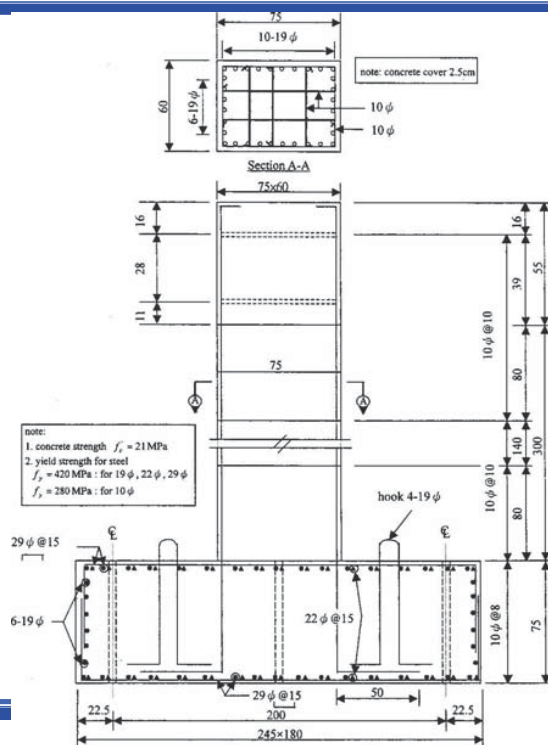
(含開口RC牆非韌性構架之耐震行為研究·黃世建、陳力平、陳俊宏·2003)

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構架Pure Frame試體

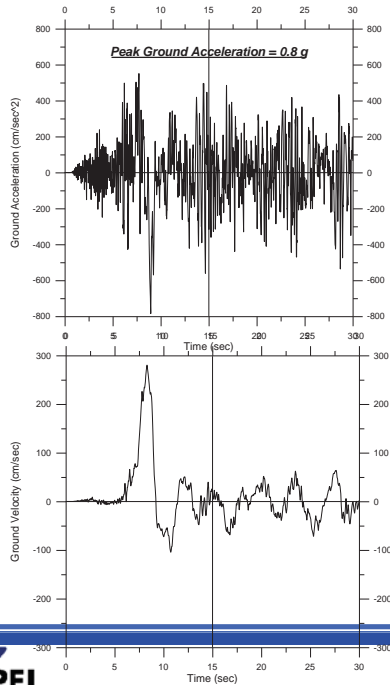


Pseudodynamic test of reinforced concrete columns

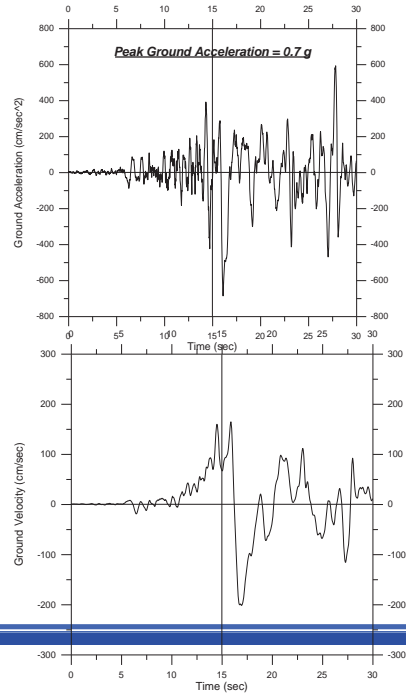


Ground acceleration and velocity for TCU075、TCU102

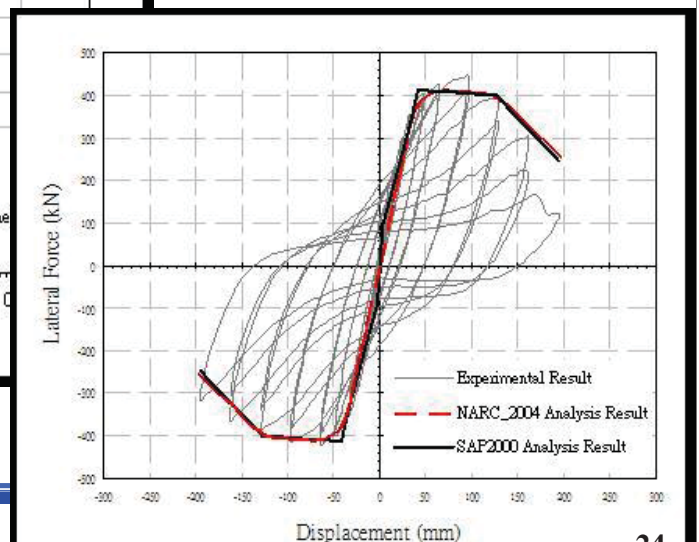
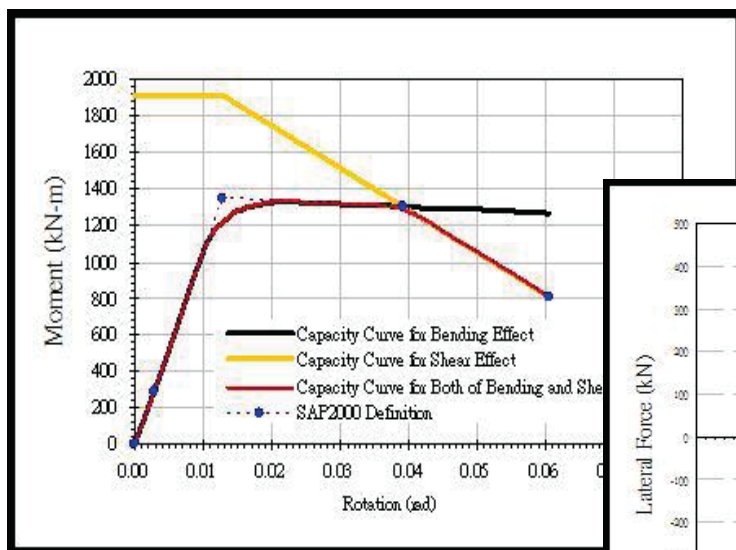
Ground acceleration and velocity for TCU075



Ground acceleration and velocity for TCU102

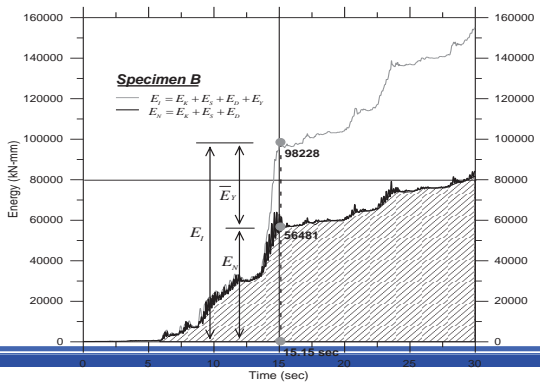
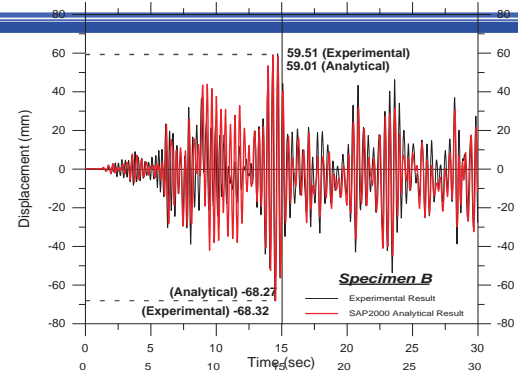
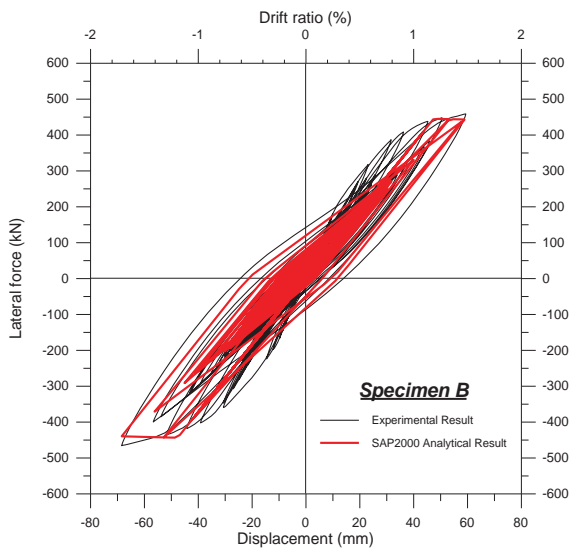


Specimen A — cyclic loading test and analysis result



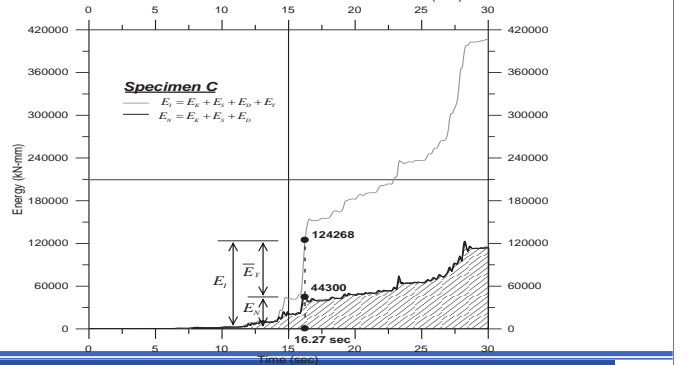
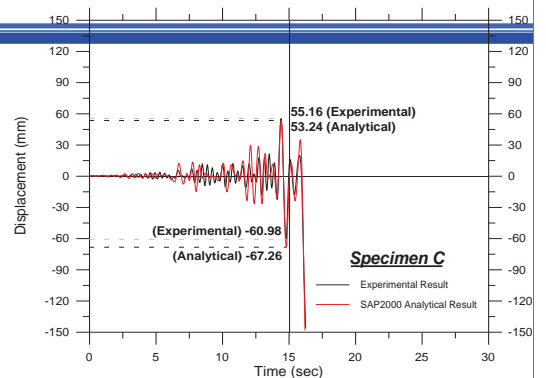
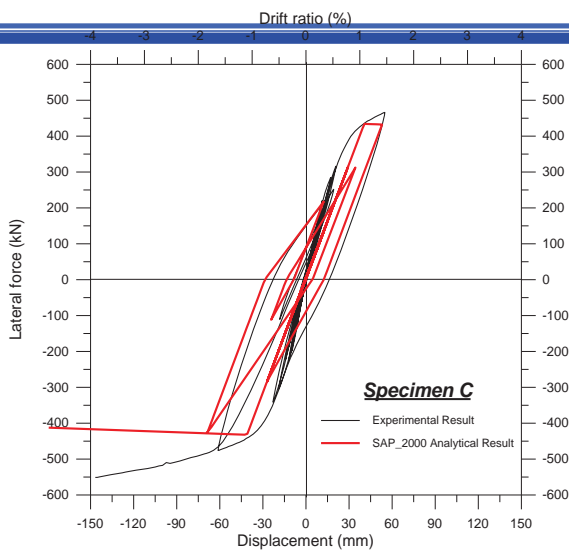
Specimen B –

Pseudodynamic and analysis results for as-built Specimen subject to TCU075₂₅



Specimen C –

Pseudodynamic and analysis results for as-built Specimen subject to TCU102



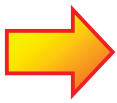
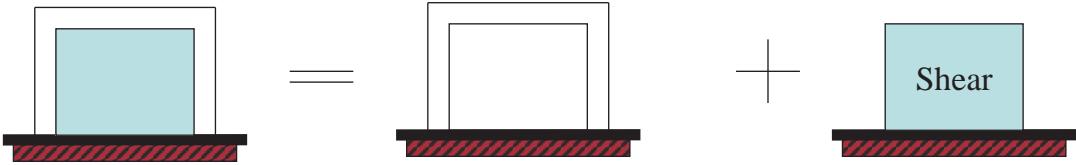
Yu-Chi Sung, Shuenn-Yih Chang and Chin-Kuo Su,
“Analytical and Experimental Responses of
Reinforced Concrete Bridge Columns under Strong
Near-Fault Ground Motion” submitted to Journal of
Earthquake Engineering.

RC牆模擬分析

Frame structure
infilled with RC wall

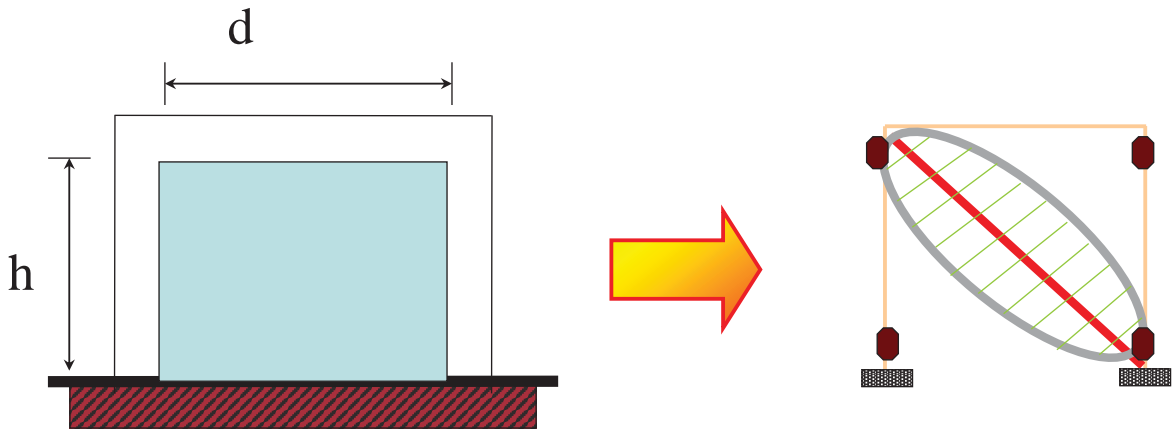
Frame structure
[Bending]

RC wall
[Shear]



Pushover analysis is highly sensitive to the structural nonlinearity of frame and RC wall

RC Structural Wall



SOFTEN STRUT-TIE MODEL

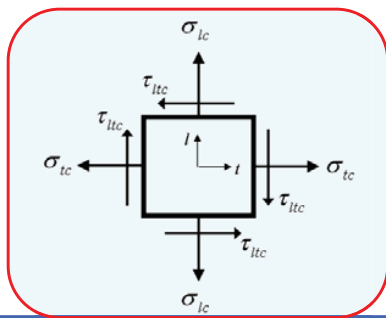
Equivalent diagonal structural strut of an RC wall

Equilibrium (1/2)

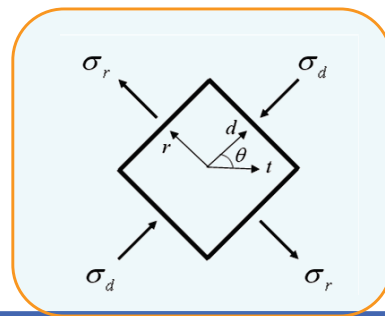
Based on the theory of fixed angle softened truss model, the angle of cracks in the postcracking concrete coincides with the angle

$$\theta = \tan^{-1}\left(\frac{h}{d}\right)$$

$$(\sigma_{lc}, \sigma_{tc}, \tau_{ltc})$$

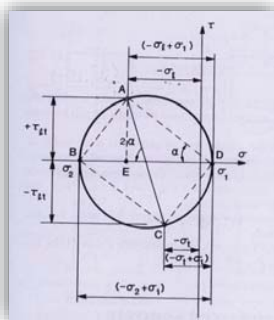


$$(\sigma_d - \sigma_r)$$



Equilibrium (2/2)

The equilibrium can be expressed as following Eqs., according to the Mohr circle of stress.



$$\sigma_{lc} = \sigma_d \cos^2 \theta + \sigma_r \sin^2 \theta$$

$$\sigma_{tc} = \sigma_d \sin^2 \theta + \sigma_r \cos^2 \theta$$

$$\tau_{ltc} = (-\sigma_d + \sigma_r) \sin \theta \cos \theta$$

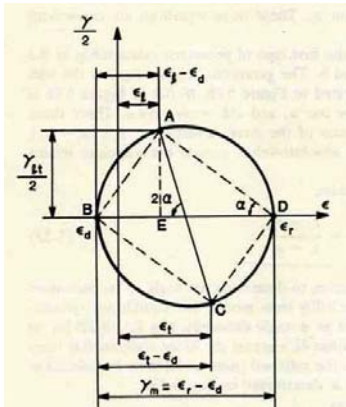
$$V_c = \tau_{ltc} \times b_w \times d$$

The total shear force applied on the RC wall

$$V = V_c + V_s = \tau_{ltc} \times b_w \times d + A_{st} \times f_t \times \frac{d}{s} \tan \theta$$

Compatibility

Based on the theory of fixed angle softened truss model, the compatibility can be expressed as following Eqs., according to the Mohr circle of strain.



$$\epsilon_l = \epsilon_d \cos^2 \theta + \epsilon_r \sin^2 \theta$$

$$\epsilon_t = \epsilon_d \sin^2 \theta + \epsilon_r \cos^2 \theta$$

$$\gamma_{lt} / 2 = (-\epsilon_d + \epsilon_r) \sin \theta \cos \theta$$

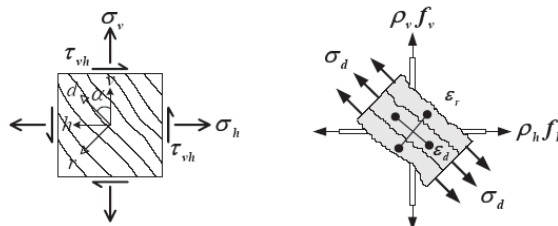
Constitutive Laws of Concrete(1/3)

Both the strength and stiffness of cracked reinforced concrete in compression are lower than those of uniaxial compressed concrete.

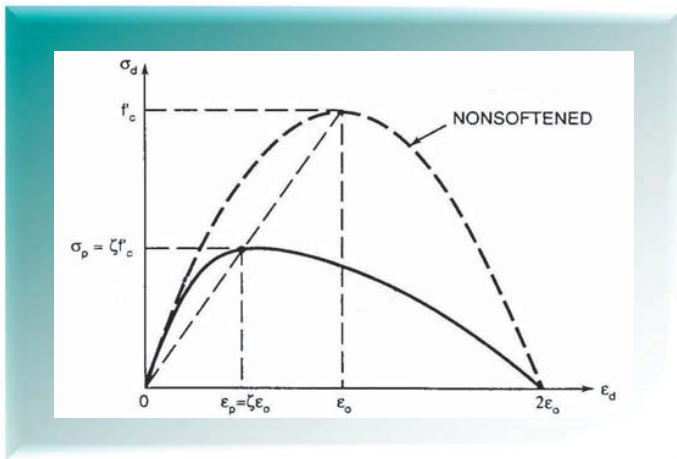


Softening effect on the biaxial constitute laws of concrete

$$\zeta = \frac{0.9}{\sqrt{1 + 600\epsilon_r}}$$



Constitutive Laws of Concrete(2/3)



$$\epsilon_d / \zeta \epsilon_0 \leq 1$$

$$\sigma_d = \zeta f'_c \left[2 \left(\frac{\epsilon_d}{\zeta \epsilon_0} \right) - \left(\frac{\epsilon_d}{\zeta \epsilon_0} \right)^2 \right]$$

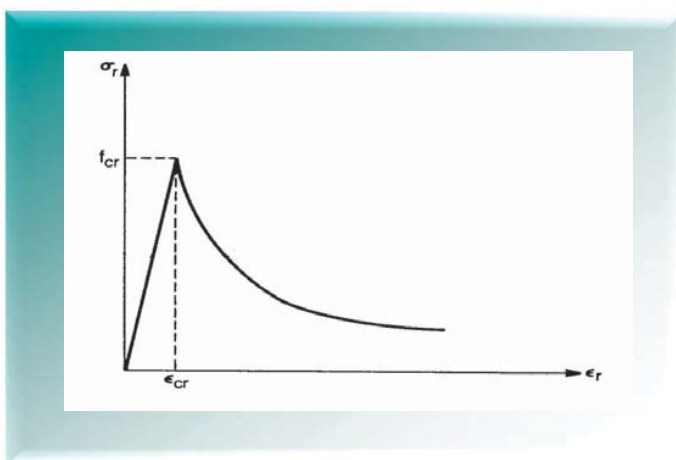
$$\epsilon_d / \zeta \epsilon_0 > 1$$

$$\sigma_d = \zeta f'_c \left[1 - \left(\frac{\epsilon_d / \zeta \epsilon_0 - 1}{2 / \zeta - 1} \right)^2 \right]$$

Belarbi and Hsu

$$\zeta = \frac{0.9}{\sqrt{1 + 600 \epsilon_r}}$$

Constitutive Laws of Concrete(3/3)



$$\epsilon_r \leq \epsilon_{cr}$$

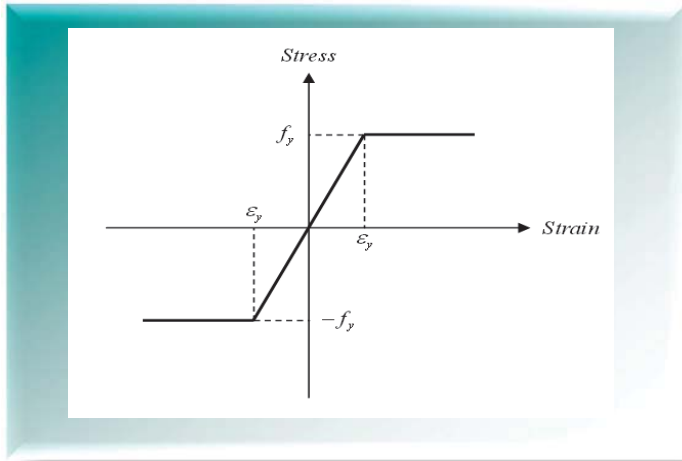
$$\sigma_r = E_c \epsilon_r$$

$$\epsilon_r > \epsilon_{cr}$$

$$\sigma_r = f_{cr} \left(\frac{\epsilon_{cr}}{\epsilon_r} \right)^{0.4}$$

Vecchio and Collins

Constitutive Laws of Reinforcement



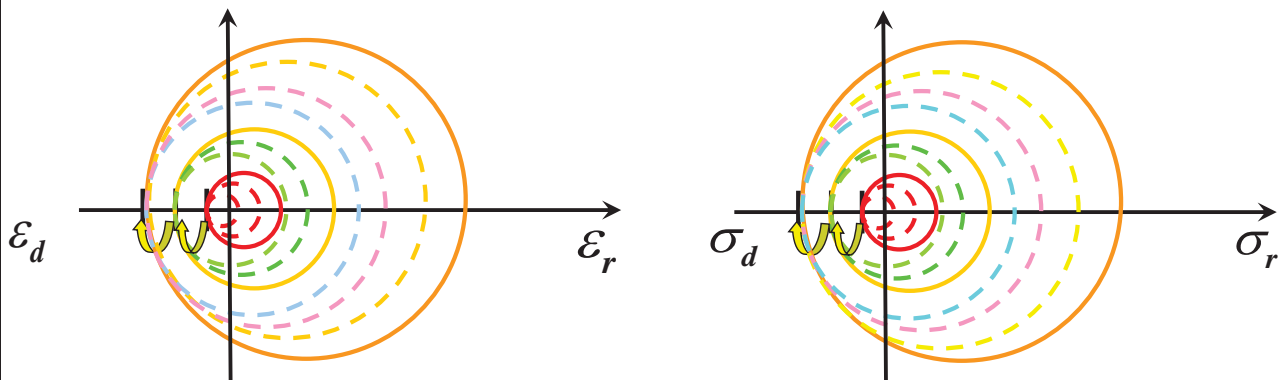
$$\epsilon_s \leq \epsilon_y$$

$$f_s = E_s \epsilon_s$$

$$\epsilon_s > \epsilon_y$$

$$f_s = f_y$$

$$V_s = A_{st} \times f_t \times \frac{d}{s} \tan \theta$$



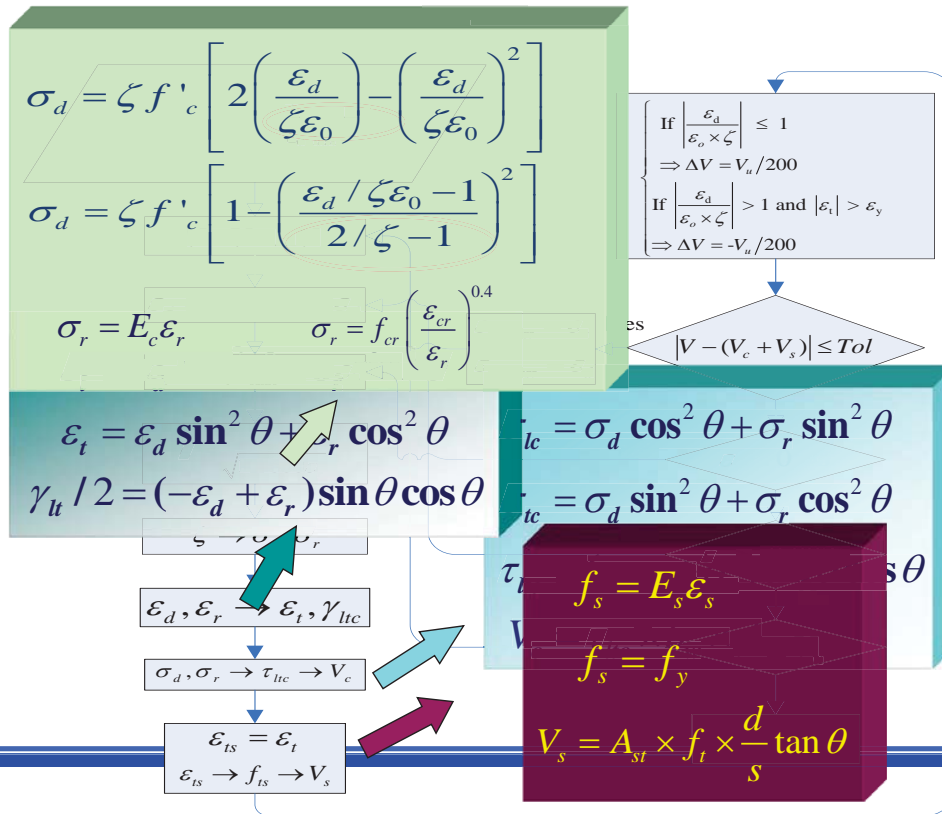
$$V = V_c + V_s$$

?

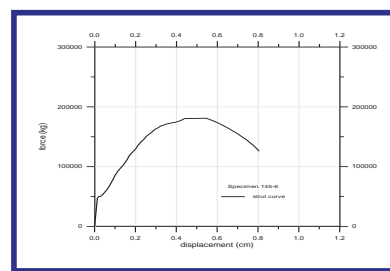
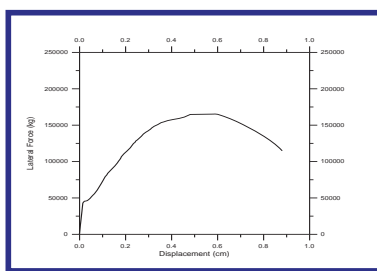
$$V_c = \tau_{ltc} \times b_w \times d$$

$$V_s = A_{st} \times f_t \times \frac{d}{s} \tan \theta$$

RC牆剪力分析流程



Aeff of equivalent diagonal structural strut

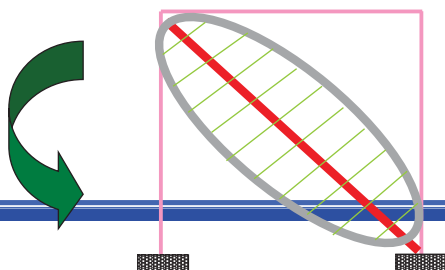


$$V = V_c + V_s$$

$$\delta = \gamma_{lt} \times h$$

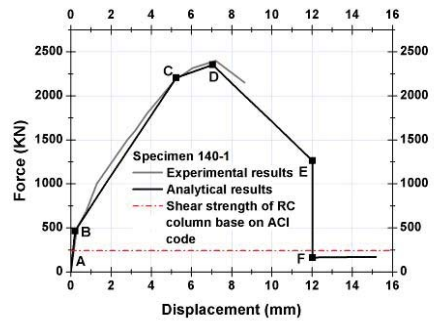
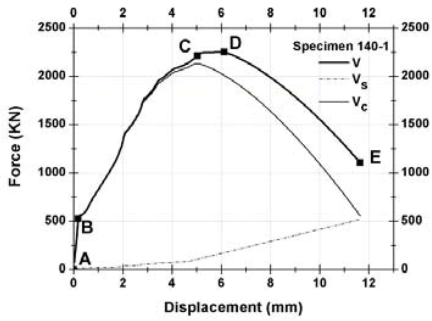
$$V_{strut} = \frac{V}{\cos \theta}$$

$$\delta_{strut} = \delta \times \cos \theta$$



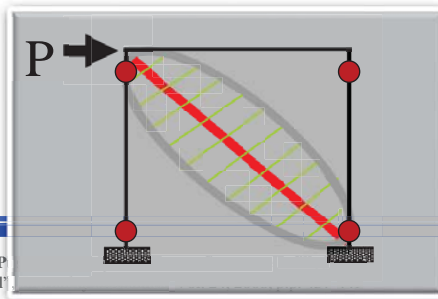
$$\Rightarrow A_{eff} = \frac{P}{\delta} \times \frac{L}{E_c}$$

Pushover Analysis Results (specimen 140-1)



Shear strength of RC wall

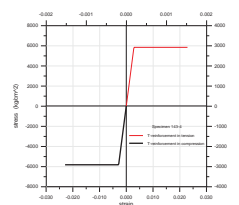
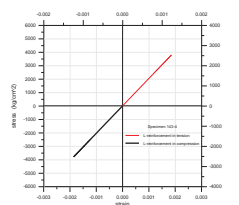
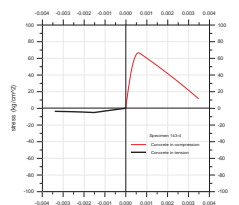
Pushover Analysis Results



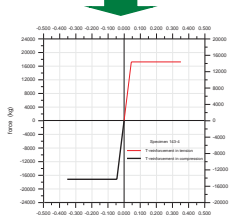
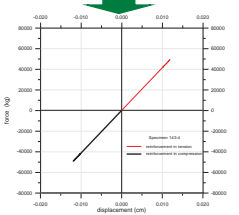
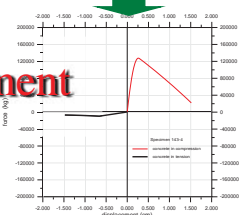
Lai, M.C., Sung, Y.C., "A Study on P...
Low-rise Reinforced Concrete Wall"

分析方式

Stress-Strain



Force-Displacement

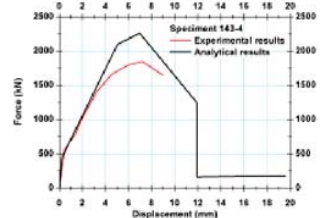
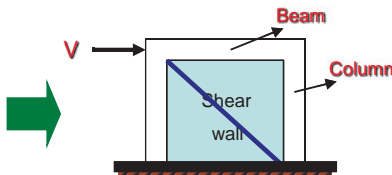
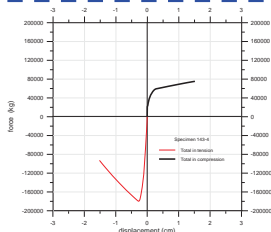


Σ

Concrete

Longitudinal reinforcements

Transverse reinforcements



RC牆模擬-等值柱

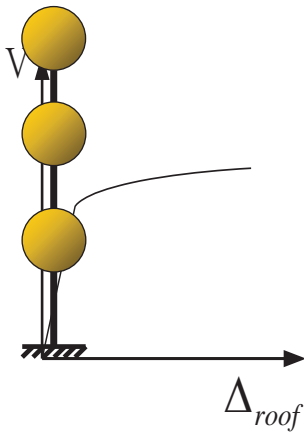


鋼筋混凝土建築結構耐震能力評估

容量震譜法

Transform Capacity Curve to Capacity Spectrum

(Capacity Curve)

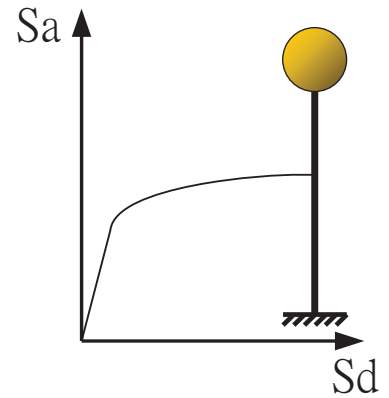


$$S_a = \frac{V}{\alpha_1 W}$$

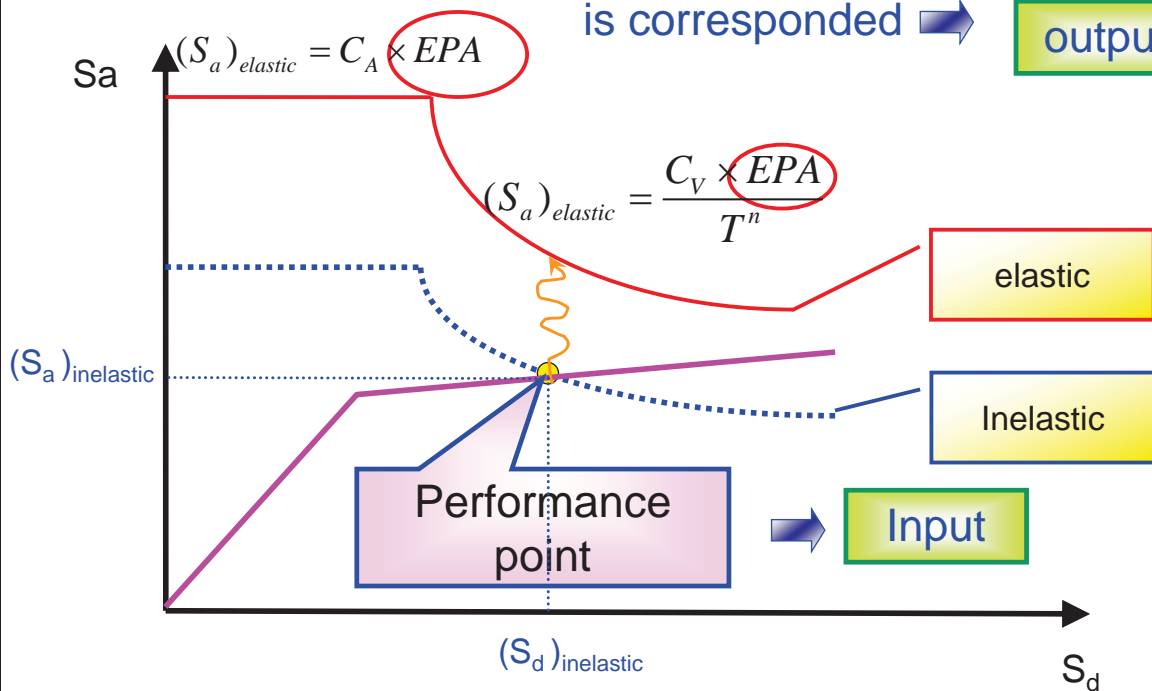


$$S_d = \frac{\Delta_{roof}}{PF_1 \phi_{roof,1}}$$

(Capacity Spectrum)



Find EPA which every performance is corresponded → **output**

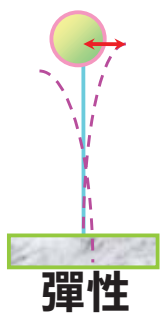


耐震設計規範中各種地震力之定義

(475年回歸期地震)

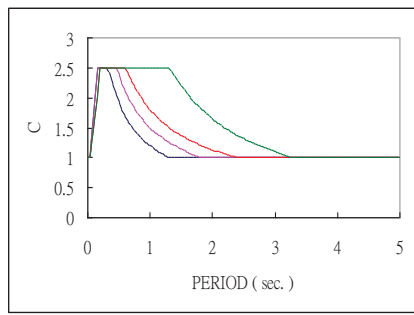
$$S_a = EPA \times C = S_{DS}$$

$$S_{ai} = EPA \times C / F_U = S_{DS} / F_U$$

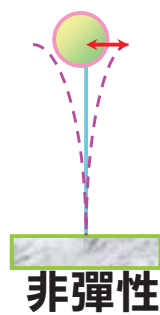


EPA

短週期彈性結構



C



EPA

短週期非彈性結構

$$S_a = S_{DS} = EPA \times 2.5$$

$$EPA = S_{DS} / 2.5 = 0.4 S_{DS}$$

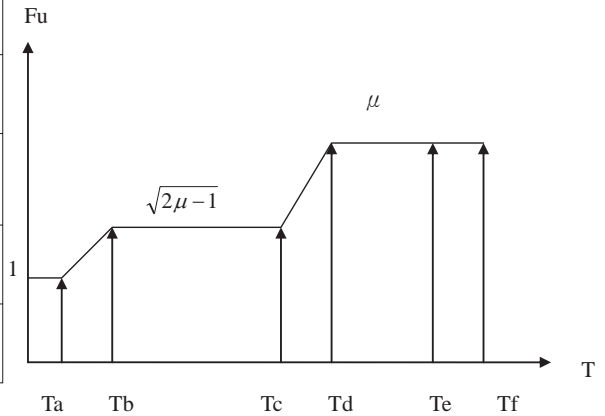
$$S_{ai} = S_{DS} / F_U = EPA \times 2.5 / F_U$$

$$EPA = S_{DS} / 2.5 = 0.4 S_{DS}$$



F_u-μ-T 結構系統地震力折減係數法

彈性週期	F _u
$T \leq 0.2T_0^D$	$F_{u,1} = F_{u,2} + [F_{u,2} - 1] \frac{T - 0.2T_0^D}{0.2T_0^D}$
$0.2T_0^D < T \leq 0.6T_0^D$	$F_{u,2} = \sqrt{[1 + \alpha(R^* - 1)] [2R^* - 1 - \alpha(R^* - 1)]}$
$0.6T_0^D < T < T_0^D$	$F_{u,3} = F_{u,2} + [F_{u,4} - F_{u,2}] \frac{T - 0.6T_0^D}{0.4T_0^D}$
$T_0^D \leq T$	$F_{u,4} = \frac{u_u}{u_y} = R^*$

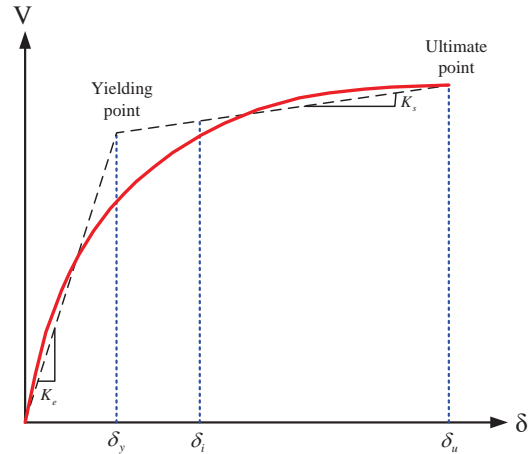


$F_u-\mu-T$ 結構系統地震力折減係數法

$$F_u(R) = \begin{cases} R_i & ; T \geq T_0^D \\ A + (R_i - A) \times \frac{T - 0.6T_0^D}{0.4T_0^D} & ; 0.6T_0^D \leq T < T_0^D \\ A & ; 0.2T_0^D \leq T < 0.6T_0^D \\ A + (A - 1) \times \frac{T - 0.2T_0^D}{0.2T_0^D} & ; T \leq 0.2T_0^D \end{cases}$$

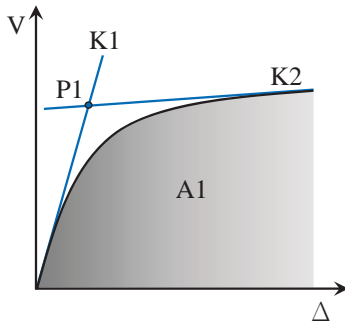
$$A = \sqrt{[1 + \alpha(R_i - 1)][2R_i - 1 - \alpha(R_i - 1)]}$$

$$R_i = \frac{\delta_i}{\delta_y}$$

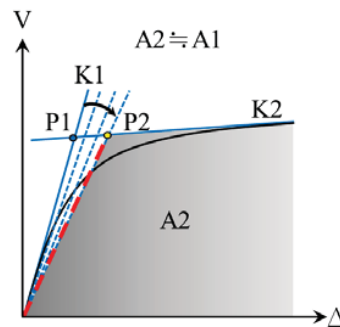


容量曲線降伏點選取辦法(1/2)

Step 1

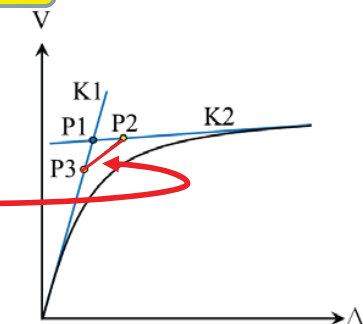


Step 2

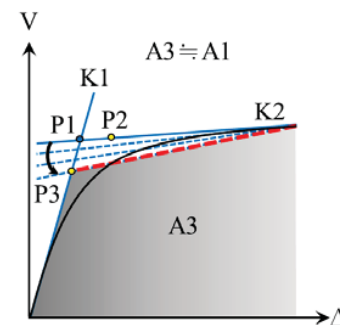


Step 4

滿足等極限能量



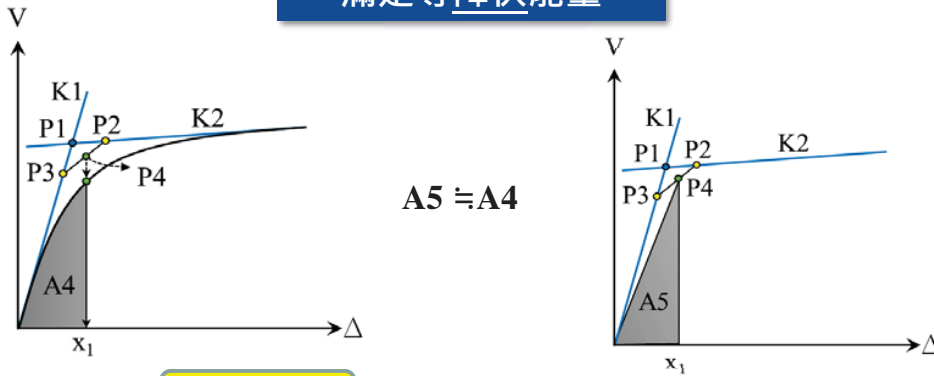
Step 3



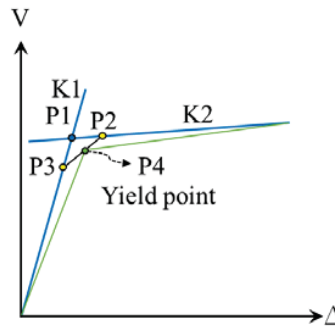
容量曲線降伏點選取辦法(2/2)

Step 5

滿足等降伏能量



Step 6



$F_u-\mu-T$ 結構系統地震力折減係數法

一般工址 有效最大加速度(EPA)

較短週期	短週期	中週期	長週期
$T \leq 0.2T_0^D$	$0.2T_0^D \leq T < T_0^D$	$T_0^D \leq T < 2.5T_0^D$	$T \geq 2.5T_0^D$
$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{\left[1 + \frac{3T}{0.4T_0^D} \right]}$	$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{2.5}$	$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{\frac{S_{D1}}{0.4S_{DS}T}}$	

F_u - μ - T 結構系統地震力折減係數法

台北盆地 有效最大加速度(EPA)

較短週期	短週期	中週期	長週期
$T \leq 0.2T_0^D$	$0.2T_0^D \leq T < T_0^D$	$T_0^D \leq T < 2.5T_0^D$	$T \geq 2.5T_0^D$
$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{\left[1 + \frac{3T}{0.4T_0^D} \right]}$	$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{2.5}$	$\frac{a_{pi} \times F_u(R)}{\left[\frac{S_{aD}(T)}{0.4S_{DS}} \right]} = \frac{a_{pi} \times F_u(R)}{\frac{T_0^D}{0.4T}}$	

等值遲滯阻尼法

有效最大加速度(EPA)

非彈性譜加速度與彈性譜加速度之比

$$B_1 \text{ or } B_s = \frac{(S_a)_{elastic}}{(S_a)_{inelastic}}$$

$$(S_a)_{inelastic} = a_{pi}$$

$$(S_d)_{inelastic} = d_{pi}$$

側推分析所得容量震譜中任何一處譜加速度 a_{pi}

對應的有效最大速度(EPA)與所在工址之地震需求特性(如

S_{aD} & S_{DS} 等), 橋梁結構物等效振動週期 T 、等值黏滯性阻尼 (β_{eff}) 與阻尼比異於5%加速度修正係數 B_1 或 B_s

等有關, 可表示如下:

等值遲滯阻尼法

一般工址 有效最大加速度(EPA)

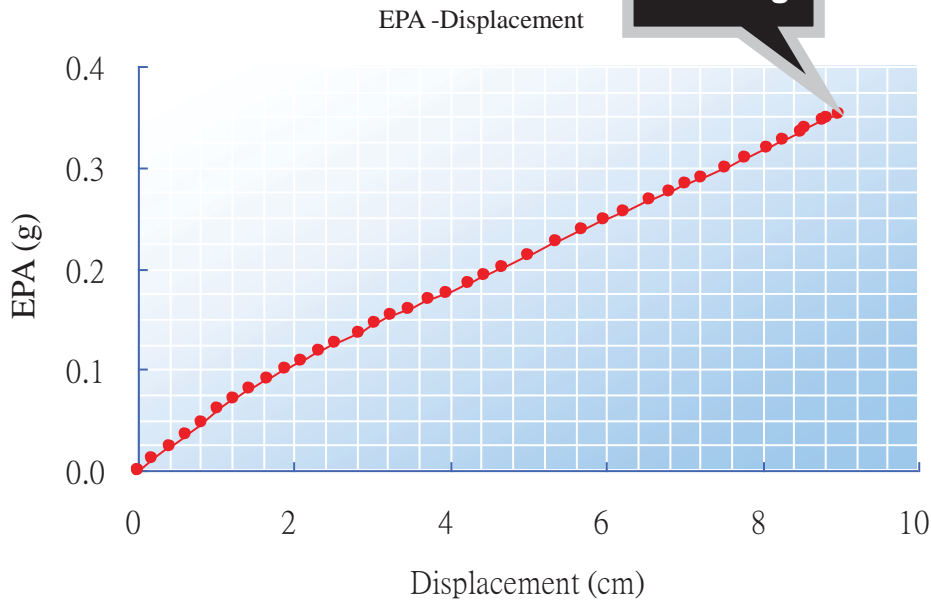
較短及短週期	中週期	長週期
$T \leq T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})}$	$T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})} < T \leq 2.5T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})}$	$2.5T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})} < T$
$EPA = \frac{a_{pi} \times B_s(\beta_{eff})}{\left(\frac{2.5S_{aD}(T)}{S_{DS}}\right)} = \frac{a_{pi} \times B_s(\beta_{eff})}{2.5}$	$EPA = \frac{a_{pi} \times B_1(\beta_{eff})}{\left(\frac{2.5S_{aD}(T)}{S_{DS}}\right)}$	$EPA = \frac{a_{pi} \times B_1(\beta_{eff})}{\left(\frac{2.5S_{D1}(T)}{S_{DS}T}\right)}$

等值遲滯阻尼法

台北盆地 有效最大加速度(EPA)

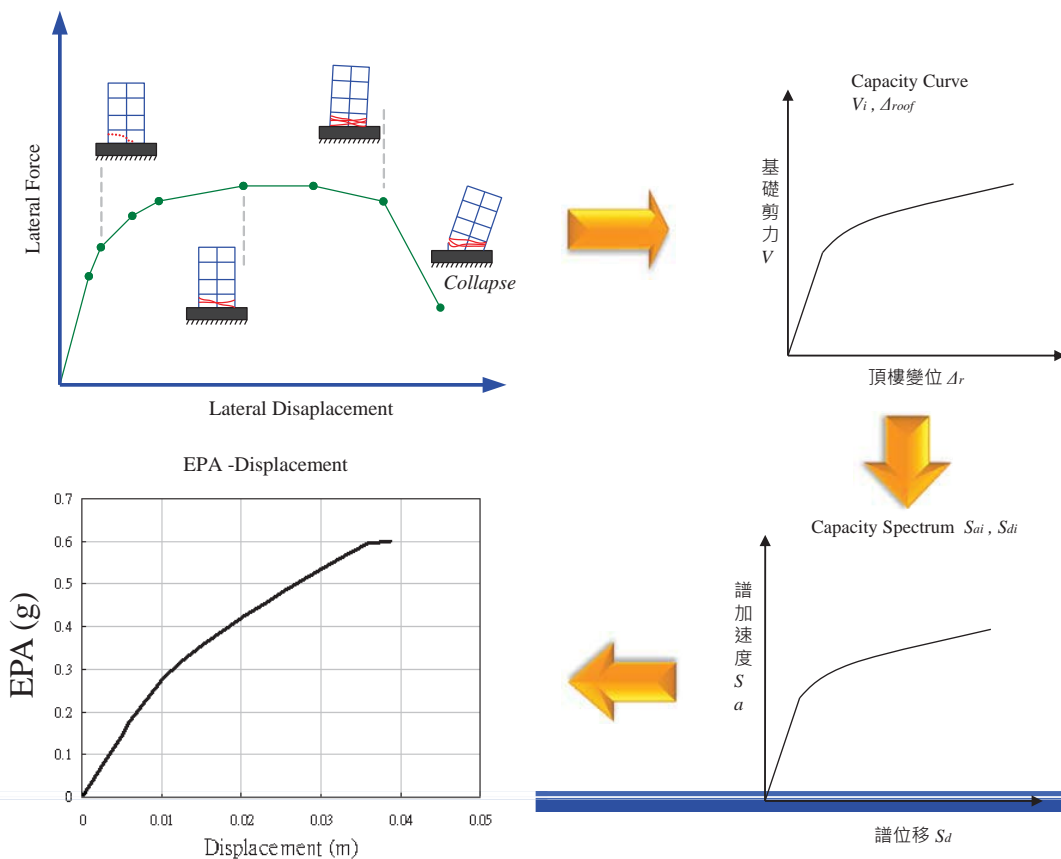
較短及短週期	中週期	長週期
$T \leq T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})}$	$T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})} < T \leq 2.5T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})}$	$2.5T_0^D \frac{B_s(\beta_{eff})}{B_1(\beta_{eff})} < T$
$EPA = \frac{a_{pi} \times B_s(\beta_{eff})}{\left(\frac{2.5S_{aD}(T)}{S_{DS}}\right)} = \frac{a_{pi} \times B_s(\beta_{eff})}{2.5}$	$EPA = \frac{a_{pi} \times B_1(\beta_{eff})}{\left(\frac{2.5S_{aD}(T)}{S_{DS}}\right)}$	$EPA = \frac{a_{pi} \times B_1(\beta_{eff})}{\left(\frac{2.5T_0^D}{T}\right)}$

EPA對位移關係圖



Yu-Chi Sung, Chin-Kuo Su, Chuan-Wei Wu, and I-Chau Tsai, "Performance-Based Damage Assessment of Low-Rise Reinforced Concrete Buildings", submitted to the Journal of China Institute of Engineer. 【SCI · EI】

結構性能耐震評估



8.2 耐震能力評估與耐震補強

1. 建築物進行耐震能力評估前，應對主要結構部分(如梁、柱、剪力牆與斜撐系統等)作實地調查。並應充分了解建築物之現況、震害經驗與修復補強情形等影響耐震能力之各項因素。
2. 耐震能力評估與補強的基準應為主管建築機關所認可者，耐震能力評估的方法應為公認之學理。
3. 耐震補強應依據耐震能力評估之結果，作通盤檢討後確認建築物之耐震安全性。如有必要作補強以提昇其耐震能力時，應依主管建築機關規定之程序辦理。
4. 耐震補強應依其補強的目標，採用改善結構系統、增加結構體韌性與強度等方式進行，惟應注意各項抗震構材之均衡配置，以使建築物整體結構系統耐震能力之均衡提昇。
5. 耐震補強或改修不得產生有害基礎安全之情形(如沈陷、變形等)。

解說：

行政院已於民國 89 年 6 月 16 日核定「建築物實施耐震能力評估及補強方案」，期以公有建築物先行執行，作為民間表率，供爾後全面實施之參考，對於私有建築物擬以宣導方式推動。為確實有效進行建築物耐震評估及補強，該方案於 97 年 11 月 27 日修正部分條文，其對於耐震能力評估及補強基準如下，可供參考：

- 一、建築物之耐震能力評估分初步評估與詳細評估，初步評估供快速篩選優先評估順序對象之用。經初步評估判定為無疑慮者，得不必進行詳細評估；判定為有疑慮及確有疑慮者，除拆除重建外，應進行詳細評估或耐震設計補強。
- 二、實施耐震能力詳細評估之建築物，其不需補強或補強後之耐震能力應達下列基準：
 - (一) 建築物之耐震能力以其能抵抗之最大地表加速度表示，其耐震能力應達本規範所規定工址回歸期475年之設計地震地表加速度乘以用途係數 I。
 - (二) 建築物亦得以性能目標作為耐震能力之檢核標準，確保該建築物在工址回歸期475年之設計地震力下所需達到之性能水準。
 - (三) 進行結構耐震能力評估與補強設計時，應考慮非結構牆之效應，並檢討軟弱層存在之情況。
- 三、用途係數 $I=1.5$ 之建築物，應檢討其供水、供電及消防設備系統固定之耐震能力；並應考慮墜落物對建築使用機能之影響。設備系統固定處之耐震能力以其所在樓層加速度檢核之，其耐震能力應達本規範之加速度規定。

建築物耐震設計規範及解說

8.2 耐震能力評估與耐震補強

1. 建築物進行耐震能力評估前，應對主要結構部分(如梁、柱、剪力牆與斜撐系統等)作實地調查。並應充分了解建築物之現況、震害經驗與修復補強情形等影響耐震能力之各項因素。
2. 耐震能力評估與補強的基準應為主管建築機關所認可者，耐震能力評估的方法應為公認之學理。
3. 耐震補強應依據耐震能力評估之結果，作通盤檢討後確認建築物之耐震安全性。如有必要作補強以提昇其耐震能力時，應依主管建築機關規定之程序辦理。
4. 耐震補強應依其補強的目標，採用改善結構系統、增加結構體韌性與強度等方式進行，惟應注意各項抗震構材之均衡配置，以使建築物整體結構系統耐震能力之均衡提昇。
5. 耐震補強或改修不得產生有害基礎安全之情形(如沈陷、變形等)。

解說：

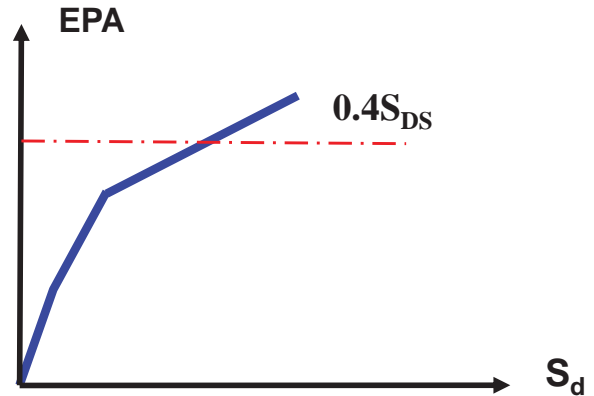
行政院已於民國 89 年 6 月 16 日核定「建築物實地耐震能力評估及補強方案」，期以公有建築物先行執行，作為民間表率，供爾後全面實施之參考，對於私有建築物擬以宣導方式推動。為確實有效進行建築物耐震評估及補強，該方案於 97 年 11 月 27 日修正部分條文，其對於耐震能力評估及補強基準如下，可供參考：

- 一、建築物之耐震能力評估分初步評估與詳細評估，初步評估供快速篩選優先評估順序對象之用。經初步評估判定為無疑慮者，得不必進行詳細評估；判定為有疑慮及確有疑慮者，除拆除重建外，應進行詳細評估或耐震設計補強。
- 二、實地耐震能力詳細評估之建築物，其不需補強或補強後之耐震能力應達下列基準：
 - (一) 建築物之耐震能力以其能抵抗之最大地表加速度表示，其耐震能力應達本規範所規定工址回歸期475年之設計地震地表加速度乘以用途係數I。
 - (二) 建築物亦得以性能目標作為耐震能力之檢核標準，確保該建築物在工址回歸期475年之設計地震力下所需達到之性能水準。
 - (三) 進行結構耐震能力評估與補強設計時，應考慮非結構牆之效應，並檢討軟弱層存在之情況。

三、用途係數I=1.5之建築物，應檢討其供水、供電及消防設備系統固定之耐震能力；並應考慮墜落物對建築使用機能之影響。設備系統固定處之耐震能力以其所在樓層加速度檢核之，其耐震能力應達本規範之加速度規定。

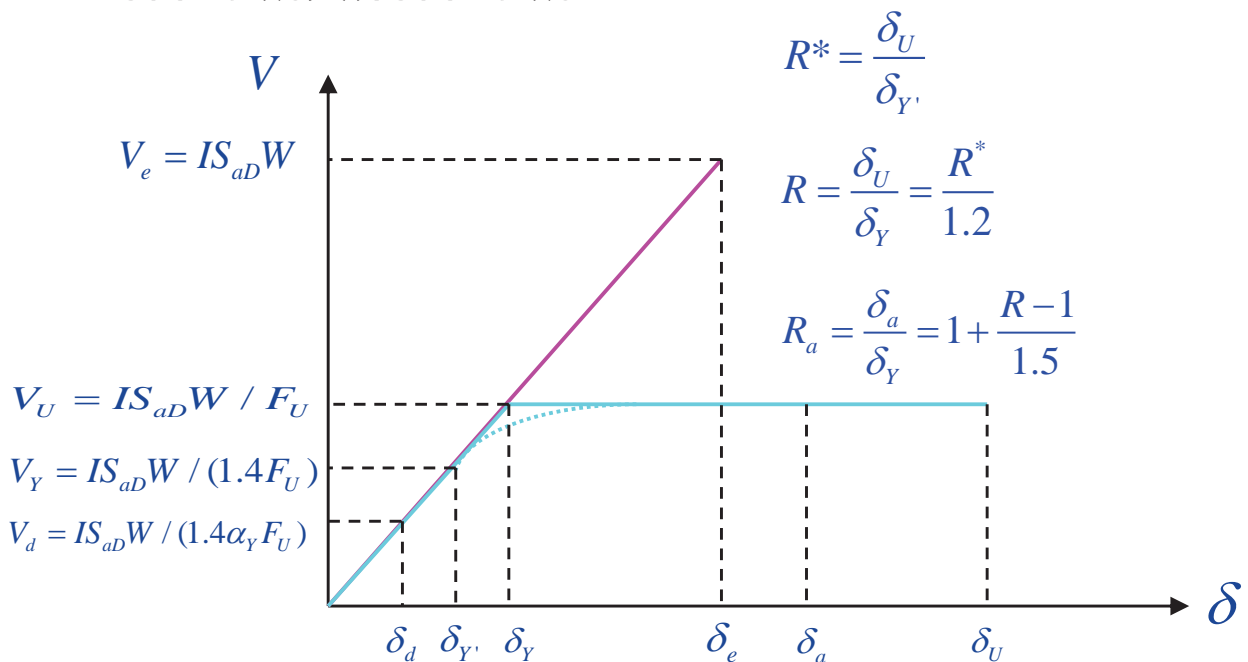
設計地震：0.4S_{DS}

檢核



耐震設計規範中各種地震力之定義

彈性系統與非彈性系統



建築物之耐震性能 (適用於一般工址或台北盆地)

性能狀態	安全性	使用性	修復性	
			短期	長期
PL_A PL_A^* PL_A^{**}	結構保持彈性	與地震前機能相同	臨時維修	無
PL_B PL_B^* PL_B^{**}	結構產生可修復之塑性變形防止倒塌	短期搶修可恢復震前機能	緊急修復或更換受損構件	局部整修或結構補強

建築物之性能目標 (適用於一般工址或台北盆地)

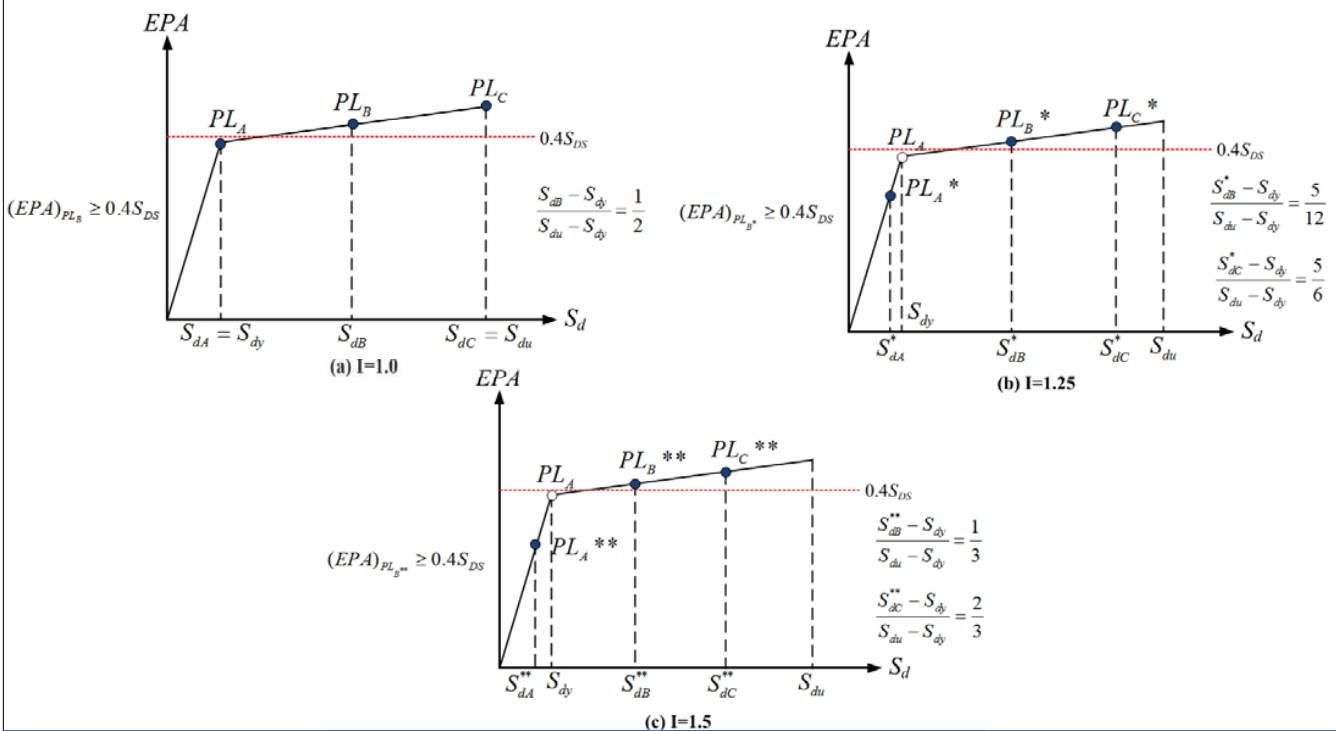
地震等級	用途係數		
	I=1.0	I=1.25	I=1.5
設計地震	PL_B	PL_B^*	PL_B^{**}

建築物非彈性位移 與非彈性位移容量之比值r

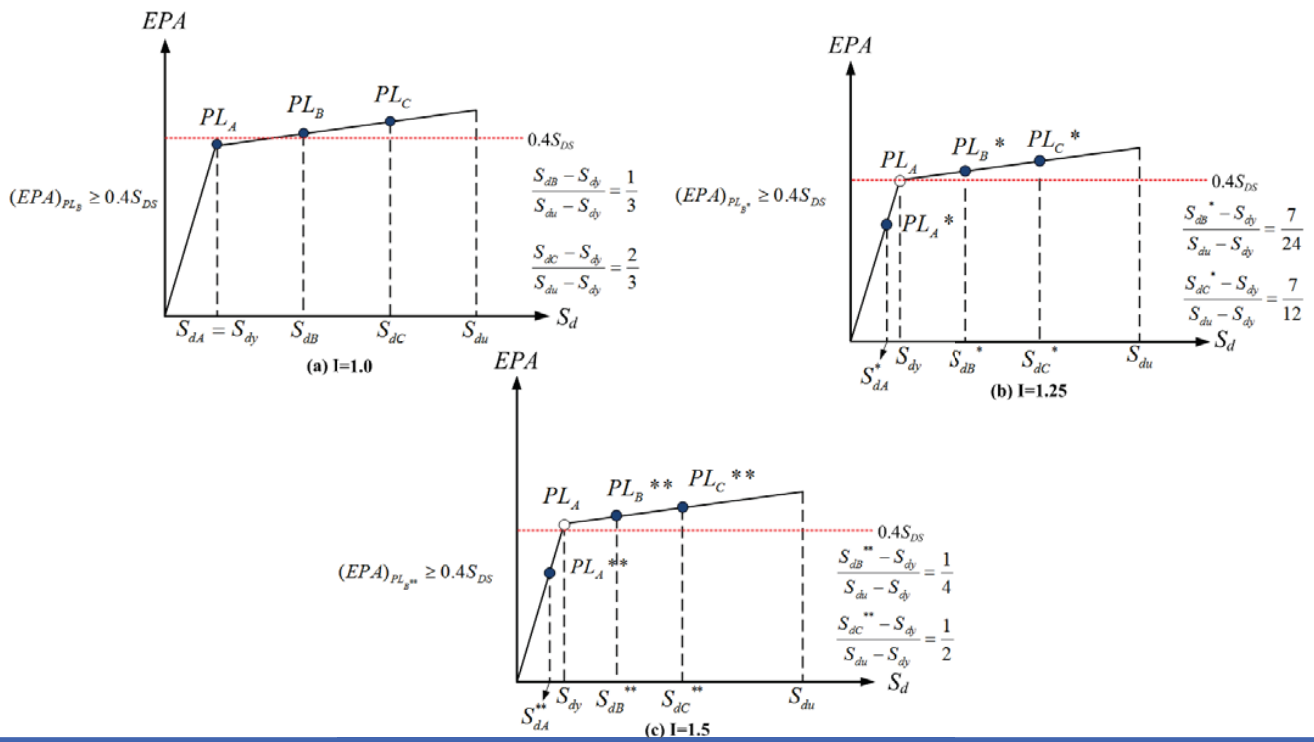
性能狀態	一般工址			台北盆地		
	I=1.0	I=1.25	I=1.5	I=1.0	I=1.25	I=1.5
PL _B	1/2	—	—	1/3	—	—
PL _B *	—	5/12	—	—	7/24	—
PL _B **	—	—	1/3	—	—	1/4

註： $r = \frac{S_d - S_{dy}}{S_{du} - S_{dy}}$ S_d : 非彈性譜位移 S_{dy} : 降伏譜位移 S_{du} : 極限譜位移

一般地址之建築物耐震性能目標



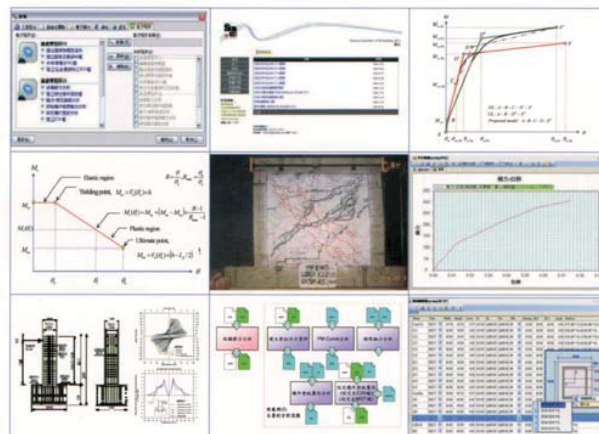
臺北盆地之建築物耐震性能目標



鋼筋混凝土建築物耐震能力評估手冊 — 視窗化輔助分析系統 SERCB Win2012 —

內政部建築研究所

SERCB Win2012



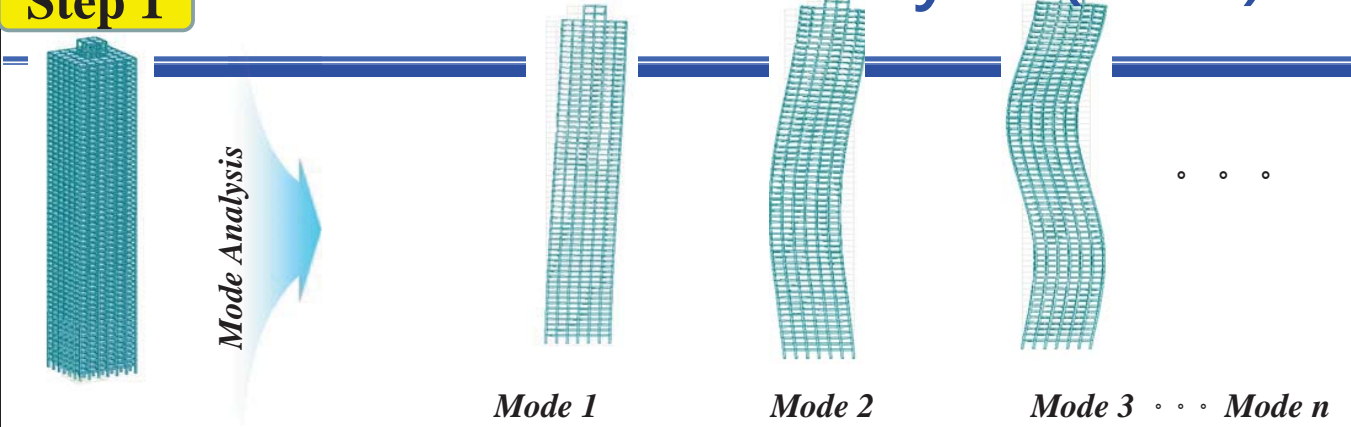
中華民國 101 年 4 月

高樓層建築物耐震能力分析

Chopra 2004

Modal Pushover Analysis (MPA)

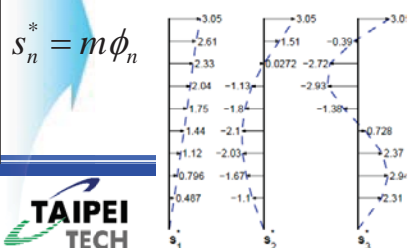
Step 1



Mode shape Φ_n Frequency W_n

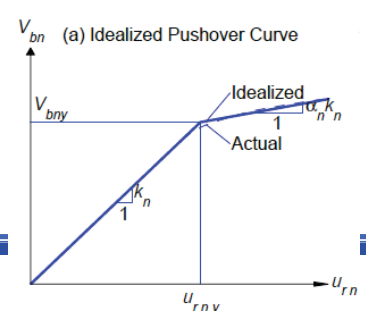
Step 2

Force distributions

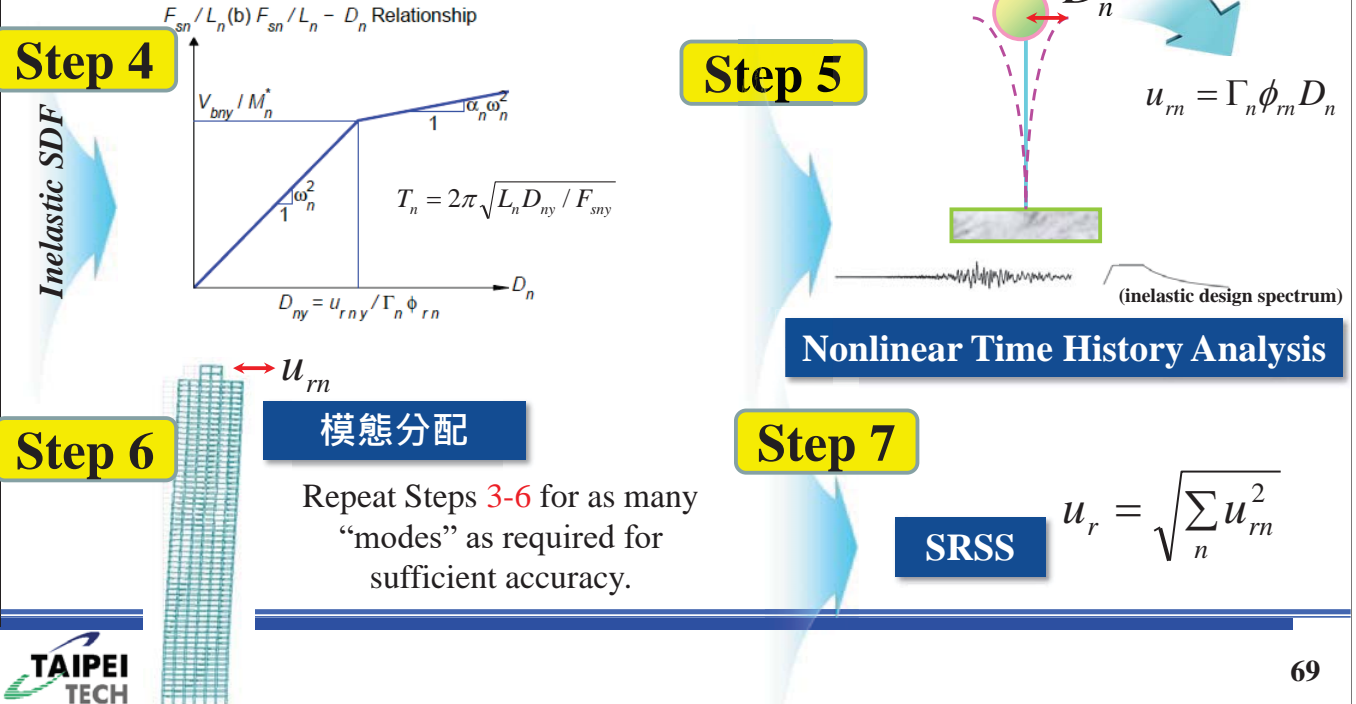


Step 3

Pushover Analysis



Modal Pushover Analysis (MPA)



Complete Quadratic Combination Method (CQC)

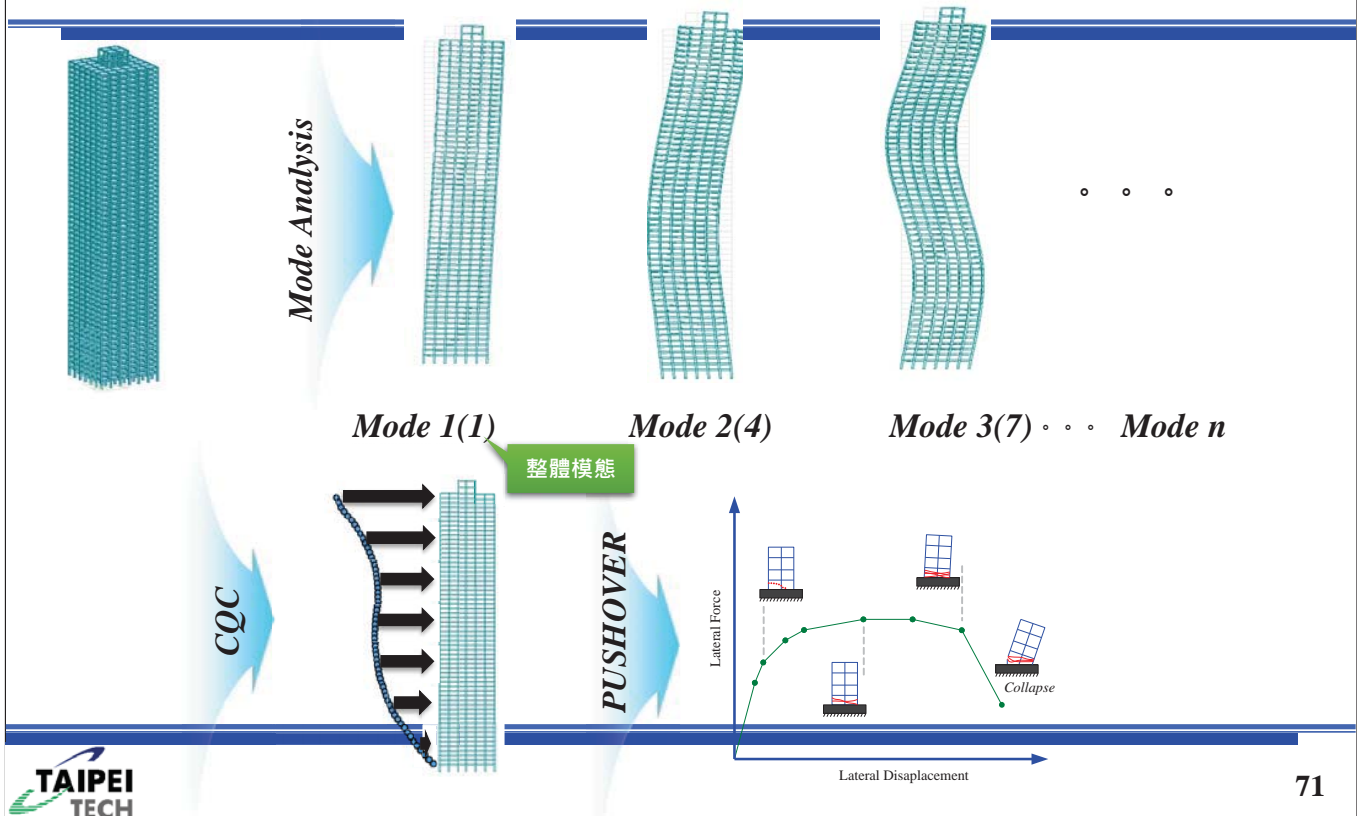
$$r_a = \left(\sum_{j=1}^N \sum_{k=1}^N S_{jk} r_j r_k \right)^{1/2}$$

$$S_{jk} = \frac{8\sqrt{\xi_j \xi_k} (\xi_j + r \xi_k) r^{3/2}}{(1-r^2)^2 + 4\xi_j \xi_k r (1+r^2) + 4(\xi_j^2 + \xi_k^2) r^2}$$

$$r = \frac{w_k}{w_j}$$

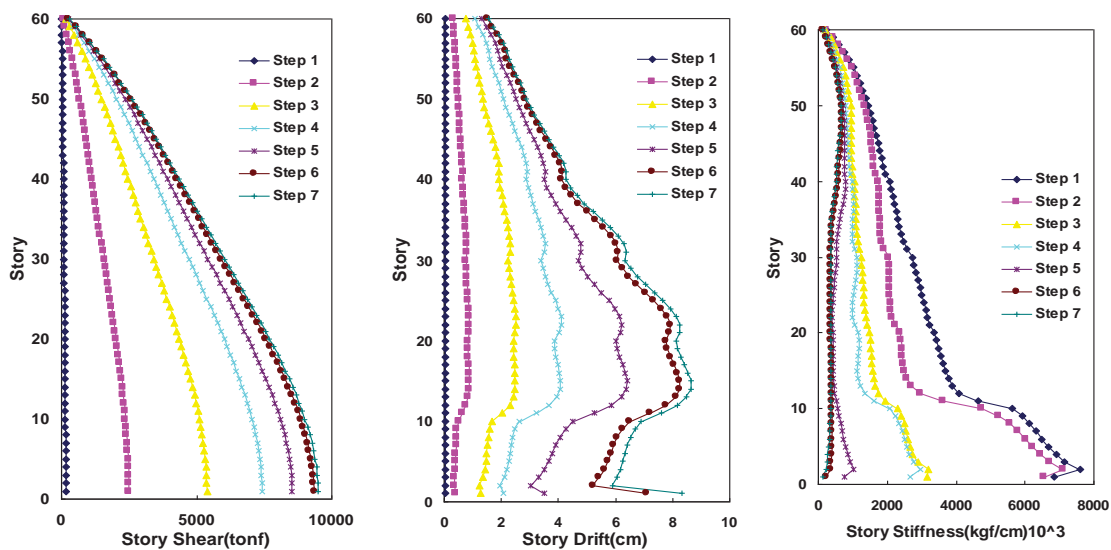
其中， r_j 、 r_k 分別為第 j 振態及第 k 振態最大反應值， S_{jk} 為第 j 振態與第 k 振態之關係係數。 ξ_j 、 ξ_k 分別為第 j 、 k 振態的阻尼比， w_j 、 w_k 分別為第 j 、 k 振態的圓周頻率。

Complete Quadratic Combination Method (CQC)



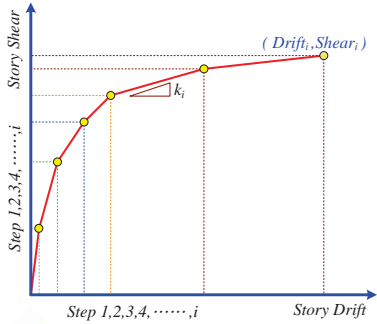
Time History Analysis

PUSHOVER可得各樓層之層間位移、層間剪力與層間勁度

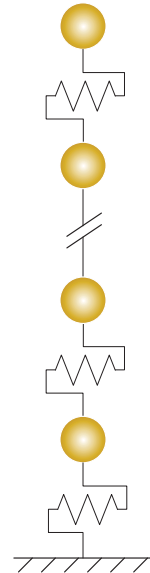


Time History Analysis

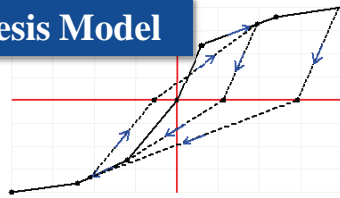
建立層間位移與層間剪力關係



Stick Model

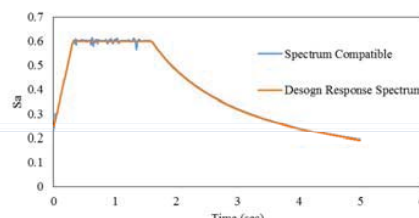
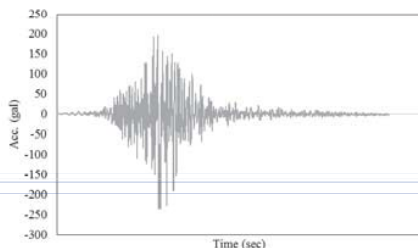
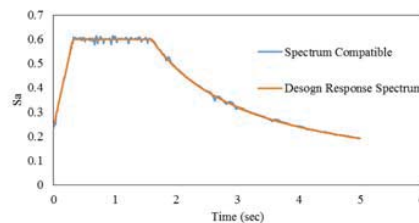
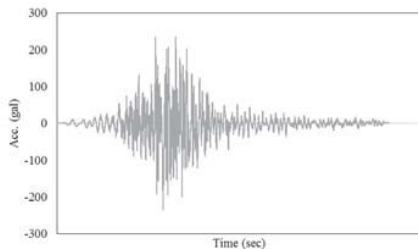
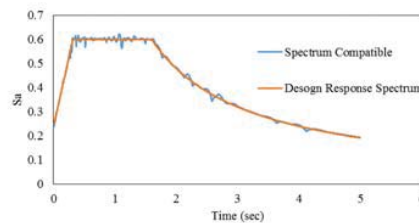
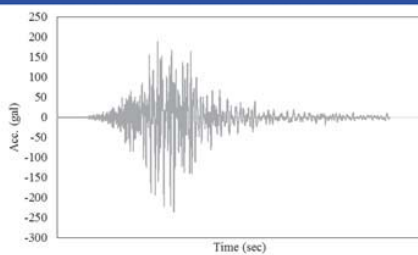


Hysteresis Model



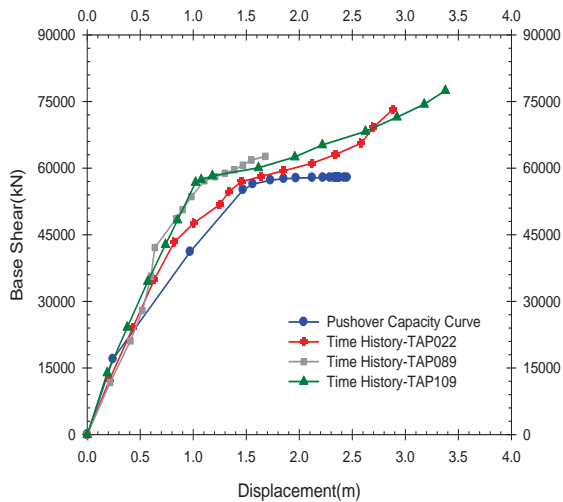
Time History Analysis

Spectrum Compatible

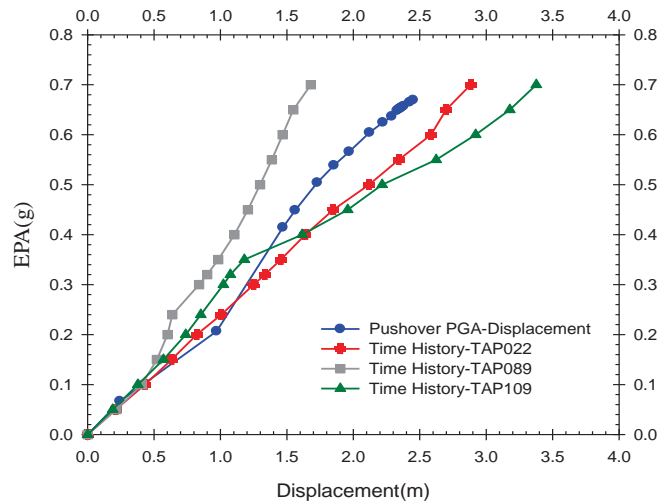


Comparison of capacity curves obtained by time history analysis and pushover analysis

Base shear vs roof displacement



EPA vs roof displacement



SERCB特色

結論

- 內政部營建署97年3月審核通過。
- 修正ATC-40所提出之容量震譜法(或稱PushOver Method)觀念，提出改良式建築物耐震能力評估方法。
- 考量材料非線性組成率，由考量彎矩-剪力互制行為建立塑鉸，理論背景完整，並已與實驗比對驗證。
- 可提供ETABS(V8.4.8與V9.0以上之版本)與MIDAS GEN(V761與V820)執行PUSHOVER分析。(持續銜接最新版)
- 考量地震力作用下，軸力變化對構件性能之影響。
- 應用上無樓層數限制。
- 操作全視窗化，易操作，易檢核分析後結果。
- 開闢專屬網頁供使用者免費下載軟體，並設立Q & A專欄作為各界意見溝通之平台。定期(每年元旦)與不定期通知使用者最新資訊。專屬網站：

<http://sercb.dyndns.org/SERCBWeb/Default.aspx>

Thank You !