

臺灣鋼筋混凝土結構耐震評估 非線性動力分析手冊(TEASDA)介紹

Taiwan

Earthquake

Assessment for

Structures by

Dynamic

Analysis

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大綱

- 前言
- 地震力輸入選擇
- 輔助程式
- 構件遲滯行為模擬
- 性能目標
- 案例說明

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前言

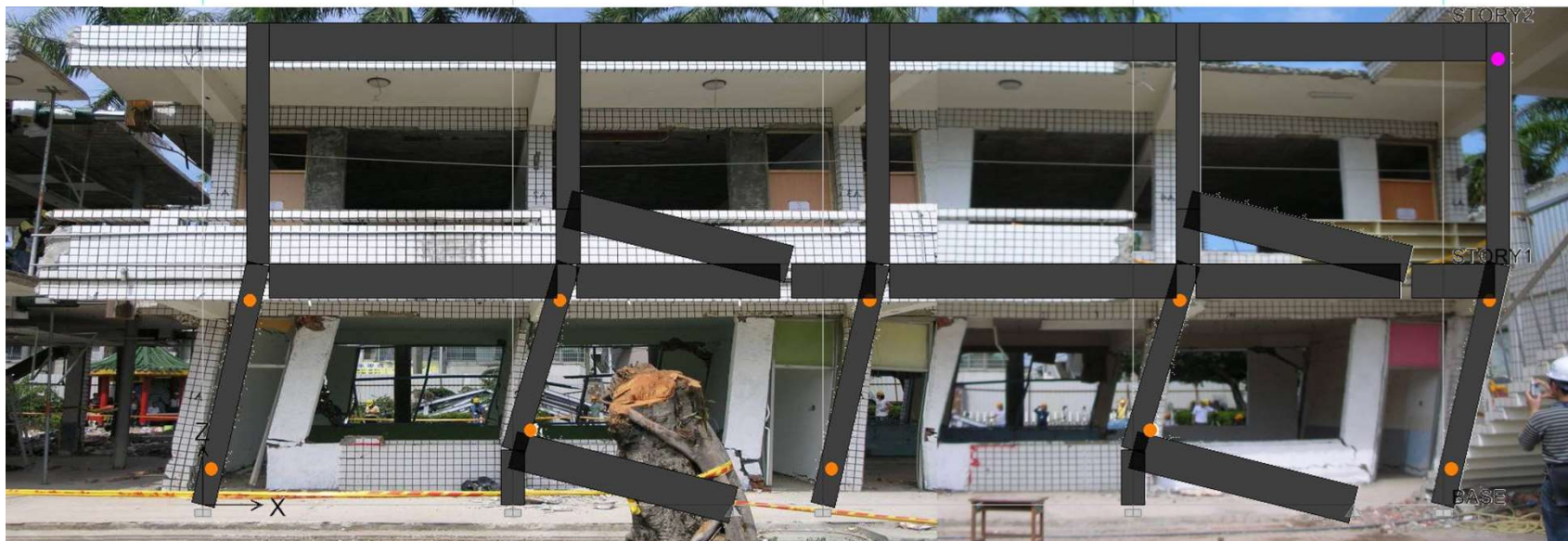


20160206美濃地震



20180206花蓮地震

臺灣結構耐震評估側推分析法(TEASPA)

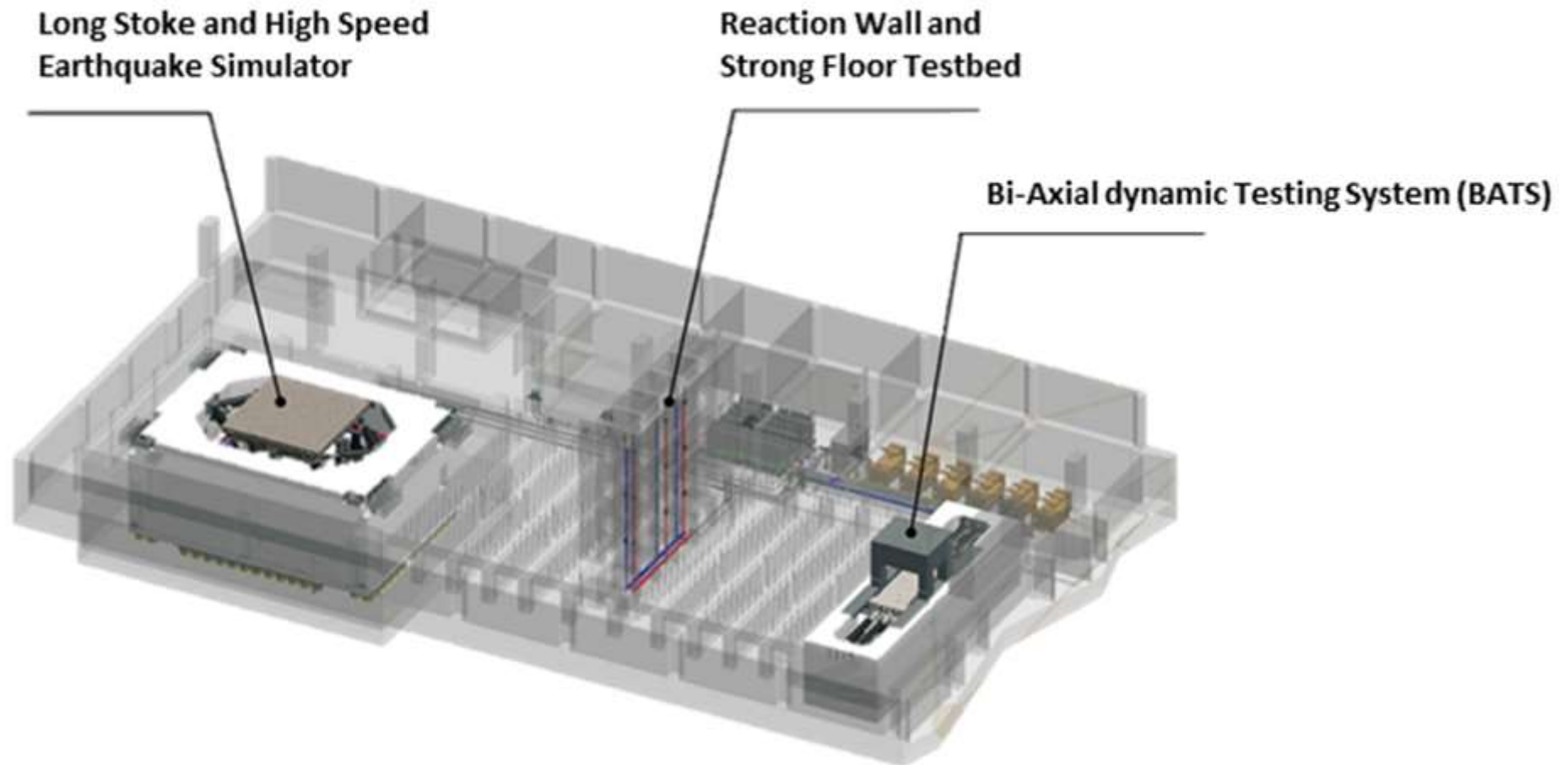


Missions of NCREE Tainan Laboratory

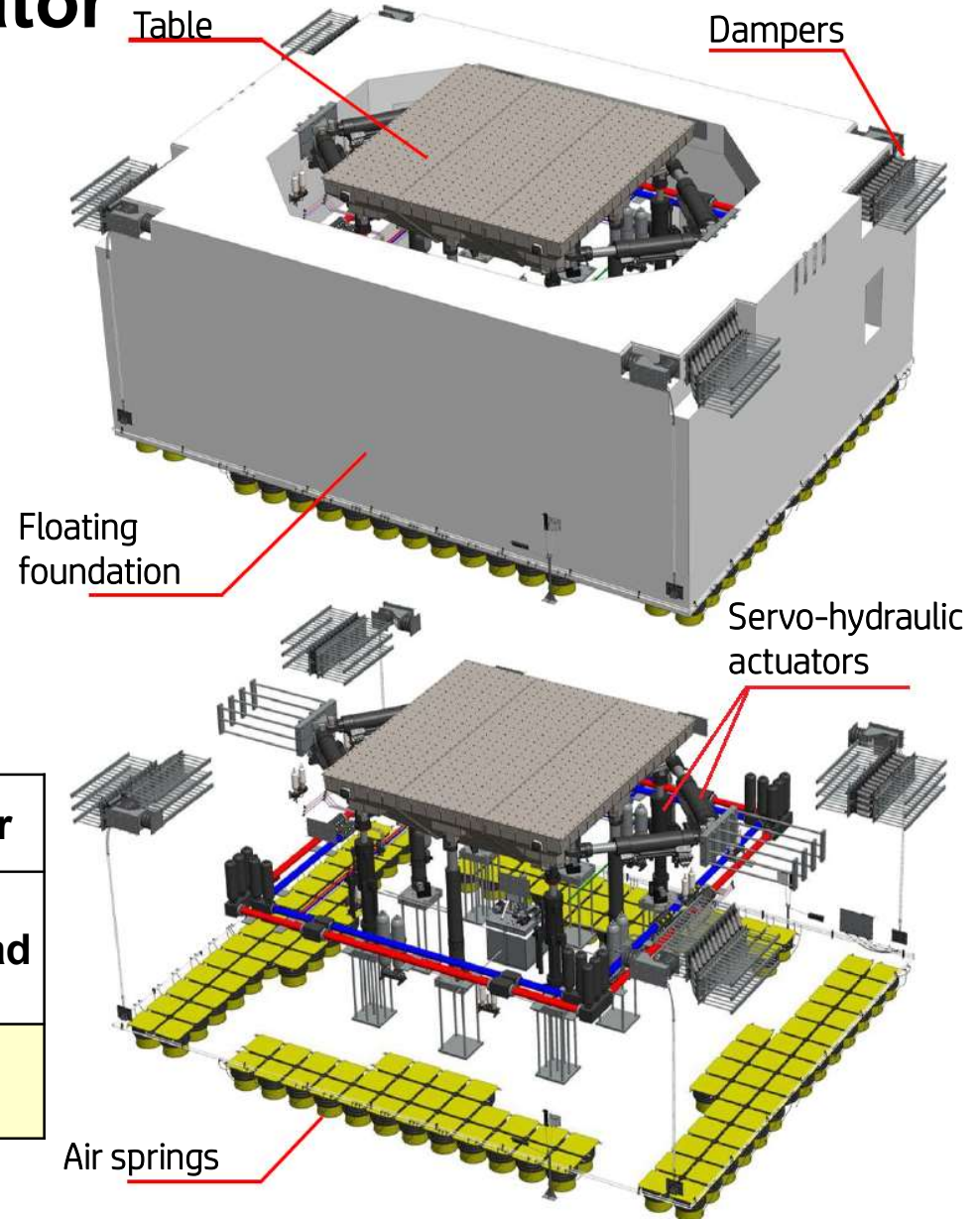
- Advanced earthquake engineering testing and simulation for near-fault ground motions.
- Research and design hub for supporting structures and critical parts of wind turbines.
- Developing anti-seismic technology for high-tech or petrochemical industries.



Layout of Major Facilities



Long-Stroke and High-Speed Earthquake Simulator



Specifications of the earthquake simulator				
Table Size (m ²)	Max Stroke (m)	Max Velocity (m/s)	Max Acc. (g)	Max payload (ton)
8 x 8	H±1 V±0.4	H±2 V±1	H±2.5 V±3.0	250

Mixed-use Residential and Commercial Buildings



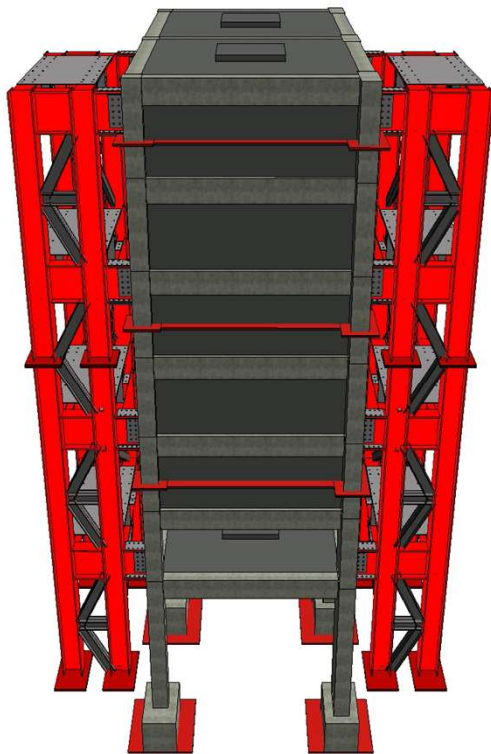
Photos of mixed-use residential and commercial building in Meinong EQ



Photos of soft story building in Kumamoto EQ

Study on Seismic Behavior with Mixed-use Residential and Commercial Building

- 1/2 scale RC structure with non-ductile detailing.
- Modulus design : 9-story, 7-story, 5-story and 3-story structures...
- High ceiling at 1st floor and soft story behavior.



3-story



7-story



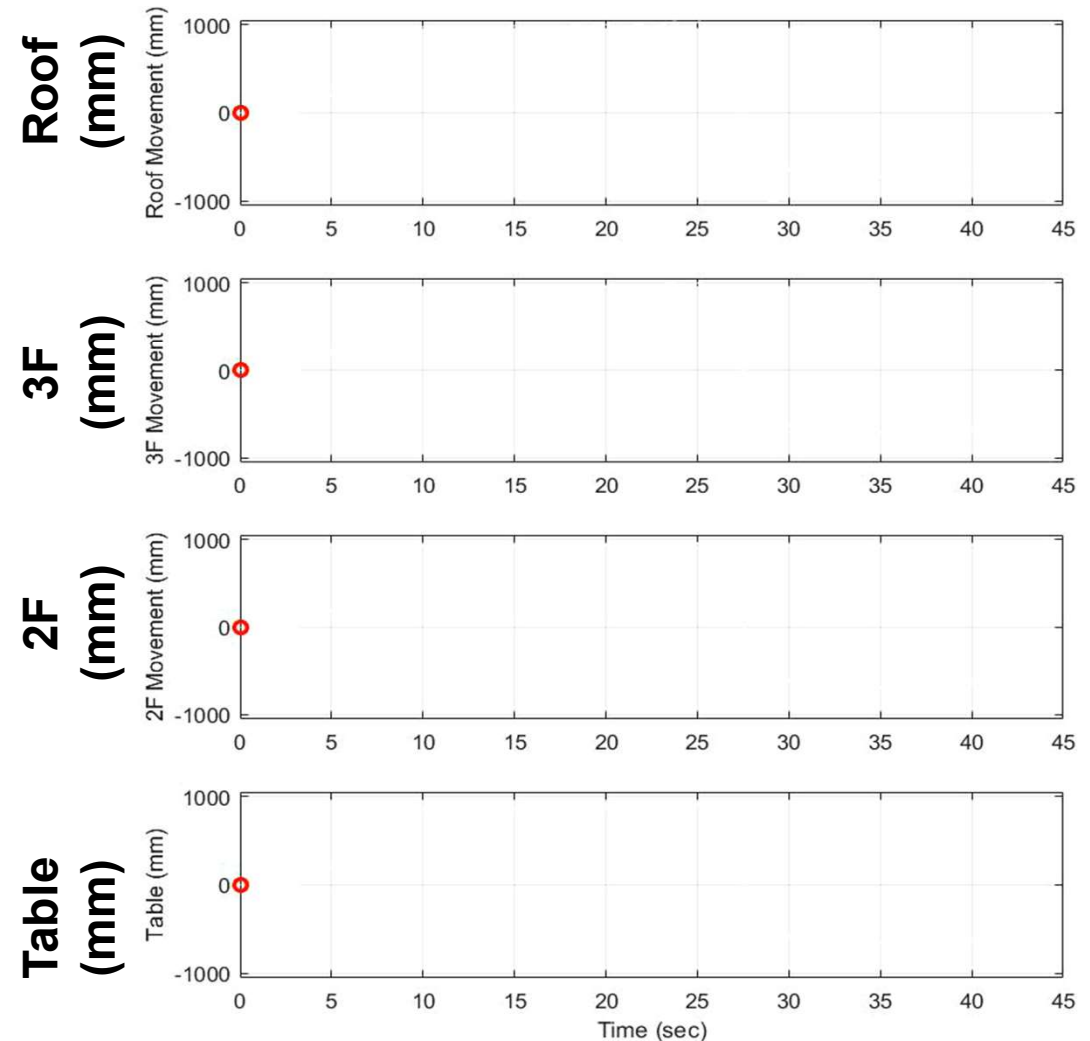
9-story

Grand Opening on Aug. 9, 2017

Left camera



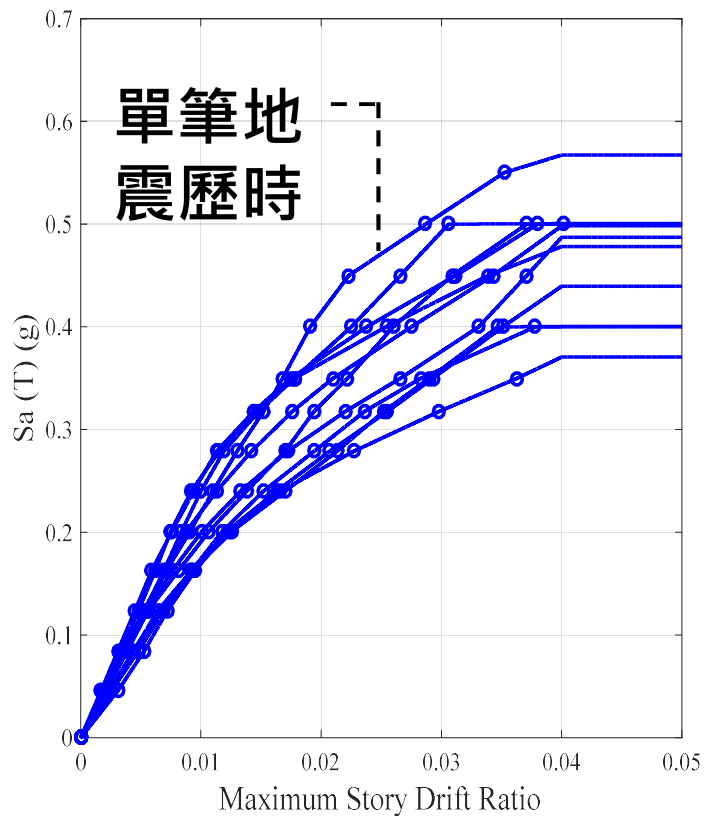
Right camera



Run 5_CHY063_200%



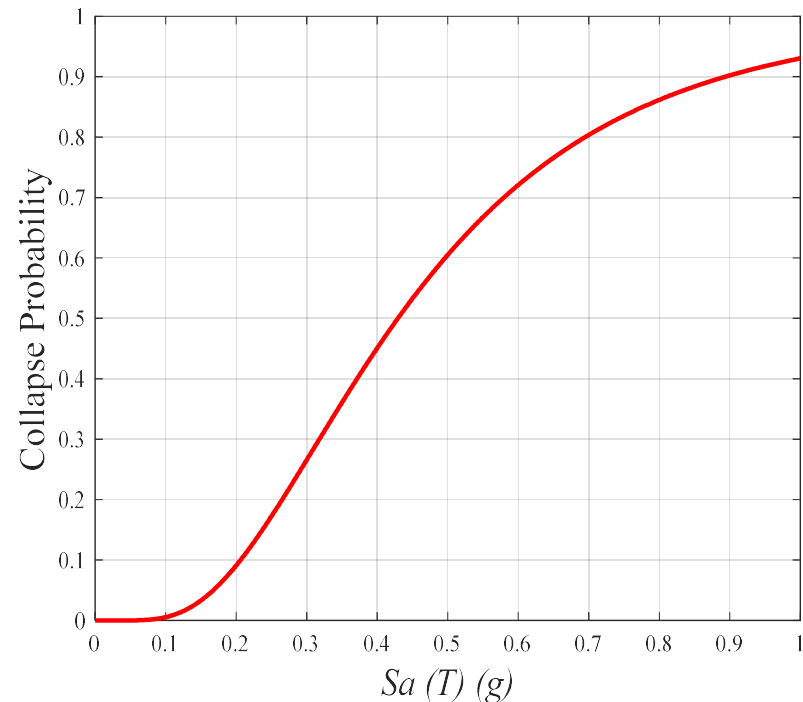
增量式動力分析 (Incremental Dynamic Analysis, IDA)



IDA曲線



倒塌判定準則



倒塌易損曲線

謝瑋桓、盧煉元、蕭輔沛、湯宇仕、黃尹男 (2018) 「中高樓結構機率式倒塌風險評估法之應用研究」，結構工程，33(2)，89-120頁。

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泛域工址設計用實測地震歷時資料庫

- 劉勛仁、簡文郁、張毓文，(2020)。台灣泛域工址設計用實測地震歷時篩選研究。中華民國第十五屆結構工程研討會暨第五屆地震工程研討會，編號：11143，台南。

Rank	Database	Eqk Time	Eqk Lon	Eqk Lat	Mw	Depth (km)	R_eqi (km)	R_hypo (km)	Station Code	Stn Lon	Stn Lat	Vs30 (m/sec)	Z1.0 (m)	TAP zone	Comp.	MSE	Scale Factor	PGA_A (gal)	PGV_V (cm/sec)	PGD_D (cm)	CAV (g-sec)	V/A (sec)	AD/V ²	Td_5-75 (sec)	Td_5-95 (sec)	Ti (sec)	RTRmin	RTRmin_T (sec)	RTRmax	RTRmax_T (sec)	RTRmax/RTRmin
1	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	GM	0.0228	1.19	461.4	54.5	59.0	1.351	0.118	9.181	150.0	149.996	150.0	0.900	2.154	1.605	0.132	1.783
1	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	NS	0.0633	1.53	405.8	53.3	65.1	1.432	0.131	9.298	5.7	11.484	150.0	0.900	0.600	2.601	0.266	2.890
1	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	EW	0.0446	1.28	524.7	55.7	53.3	1.274	0.106	9.025	4.6	10.628	150.0	0.900	0.400	1.955	0.087	2.172
1	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	VRT	0.1414	2.04	329.6	55.2	57.7	0.936	0.167	6.240	4.0	10.264	150.0	0.900	1.233	3.551	0.087	3.946
2	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	14.8	16.8	TCU076	120.8850	23.9070	573.2	26.0	0	GM	0.0345	1.35	379.2	59.0	41.1	2.428	0.156	4.476	90.0	89.995	89.995	0.900	0.115	2.011	0.500	2.235
2	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	14.8	16.8	TCU076	120.8850	23.9070	573.2	26.0	0	NS	0.0976	1.51	419.4	59.1	41.1	2.427	0.141	4.938	16.6	28.135	90.0	0.900	0.115	2.475	1.233	2.748
2	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	14.8	16.8	TCU076	120.8850	23.9070	573.2	26.0	0	EW	0.0757	1.57	342.8	58.9	41.0	2.429	0.172	4.057	17.5	28.665	90.0	0.900	0.550	2.392	4.329	2.657
2	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	14.8	16.8	TCU076	120.8850	23.9070	573.2	26.0	0	VRT	0.1266	2.48	272.2	31.7	17.7	1.642	0.117	4.796	16.5	28.765	90.0	0.900	0.550	3.524	3.275	3.916
3	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	6.7	9.8	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	3.09	181.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
3	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	6.7	9.8	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	5.39	167.1	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
3	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	6.7	9.8	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	2.96	196.5	30.1	17.2	0.474	0.153	3.735	3.3	8.970	83.0	0.900	0.400	3.557	2.848	3.952
3	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	6.7	9.8	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	0.14	296.2	24.1	17.5	0.383	0.250	2.897	9.7	13.825	83.0	0.900	0.450	13.308	4.329	14.786
4	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.72	2.77	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	1.72	277.7	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
4	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	2.05	2.22	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	5.39	167.1	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
4	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.93	3.46	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	2.96	196.5	30.1	17.2	0.474	0.153	3.735	3.3	8.970	83.0	0.900	0.400	3.557	2.848	3.952
4	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	3.67	1.87	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	0.14	296.2	24.1	17.5	0.383	0.250	2.897	9.7	13.825	83.0	0.900	0.450	13.308	4.329	14.786
5	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.71	3.42	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	1.71	342.8	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
5	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	2.52	4.04	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	5.39	167.1	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
5	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.81	2.96	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.0757	1.81	296.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
5	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	3.34	2.58	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	3.34	258.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
6	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.79	2.54	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	1.79	254.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
6	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	2.00	2.35	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	2.00	235.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
6	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.70	2.77	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	1.70	277.7	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
6	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	3.48	1.77	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	3.48	177.7	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
7	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	3.49	1.86	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	3.49	186.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
7	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	4.41	1.86	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	4.41	186.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
7	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	2.88	1.74	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	2.88	174.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
7	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	3.39	2.11	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	3.39	211.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
8	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.15	3.77	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	1.15	377.7	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
8	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.05	6.30	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	1.05	630.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
8	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.40	5.20	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	1.40	520.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
8	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	2.72	4.11	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	2.72	411.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
9	TSMIP	19990920174715	120.8160	23.8520	7.69	8.0	1.97	2.30	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	1.97	230.2	23.0	9.0	0.430	0.127	3.105	83.0	82.995	82.995	0.900	7.565	2.555	0.266	2.838
9	TSMIP	19990920180341	120.8610	23.7970	6.7	9.8	2.02	2.95	TCU122	120.8610	23.7970	623.6	23.0	0	NS	0.1562	2.02	295.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
9	TSMIP	19990920180341	120.8610	23.7970	6.7	9.8	2.06	2.08	TCU122	120.8610	23.7970	623.6	23.0	0	EW	0.1192	2.06	208.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
9	TSMIP	19990920180341	120.8610	23.7970	6.7	9.8	4.87	2.34	TCU122	120.8610	23.7970	623.6	23.0	0	VRT	0.0327	4.87	234.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
10	TSMIP	19990920180341	120.8610	23.7970	6.7	9.8	2.27	2.68	TCU122	120.8610	23.7970	623.6	23.0	0	GM	0.0428	2.27	268.2	17.5	4.7	0.390	0.105	2.582	2.4	9.005	83.0	0.900	7.565	5.118	0.266	5.686
10	TSMIP	19990920180341	120.8610	23.7970	6.7	9.8	2.04	2.52	TCU122	120.8610	23.7970	623.6	23.0	0	NS																

泛域工址設計用實測地震歷時資料庫

- 包含一般震區及臺北盆地(不含近斷層區域)初步建置完成資料庫群組

一般震區：

- 基本振動週期不超過 3 秒之結構物
- 轉角週期 $T_0 = 0.4 \sim 1.0$ 秒之正規化反應譜 ($S_s = 1.0$) 之分組，共有 7 個資料夾，各資料夾包含以下資訊
 - 地震紀錄歷時 (Raw Recorded Data)：垂直向、南北向及東西向地表歷時加速度，共 30 筆
 - 加速度歷時與反應譜 (Response Spectra Plots)：兩水平向基線修正後加速度歷時圖，以及原紀錄反應譜、調整後紀錄反應譜與標的反應譜比較圖，共 30 筆
 - 地震紀錄資訊總表 (Excel 檔)：資料目錄、欄位說明、使用說明等 3 個分頁

地震歷時強度縮放原則

- 依據工址計算設計反應譜轉角週期選取歷時紀錄資料夾
- 依據資料庫內Rank排序選取7筆地震歷時紀錄
- 針對任一地震歷時紀錄，計算阻尼比 = 5% 之反應譜
- 調整東西向及南北向之地震紀錄反應譜GeoMean值，於 $0.2T_1$ 至 $1.5T_1$ 週期範圍內之譜加速度值平均值不得低於設計譜加速度值之平均值，求得縮放係數(SF)
- 調整地震反應譜GeoMean值，於 $0.2T_1$ 至 $1.5T_1$ 週期範圍內任一點之譜加速度值不得低於設計譜加速度值之 90%，求得縮放係數(SF_m)
- 選用較大之縮放係數 $\text{Max}(SF, SF_m)$ 進行地震力歷時調整，惟縮放係數在475年與2500年地震迴歸期分別不得超過4.0 與6.0

註： T_1 為建築物於考慮方向之基本振動週期

歷時紀錄之挑選

475y_Ts=0.5s_Ss=1.0_Vs30_360_9999_T_0.03_1.5_Rank_1_30



475y_Ts=0.4s_Ss=1.0_Vs30_360_999
9_T_0.03_1.2_Rank_1_30

475y_Ts=0.5s_Ss=1.0_Vs30_360_999
9_T_0.03_1.5_Rank_1_30

475y_Ts=0.6s_Ss=1.0_Vs30_270_520
T_0.03_1.8_Rank_1_30

475y_Ts=0.7s_Ss=1.0_Vs30_270_520
T_0.03_2.1_Rank_1_30

475y_Ts=0.8s_Ss=1.0_Vs30_1_360_T
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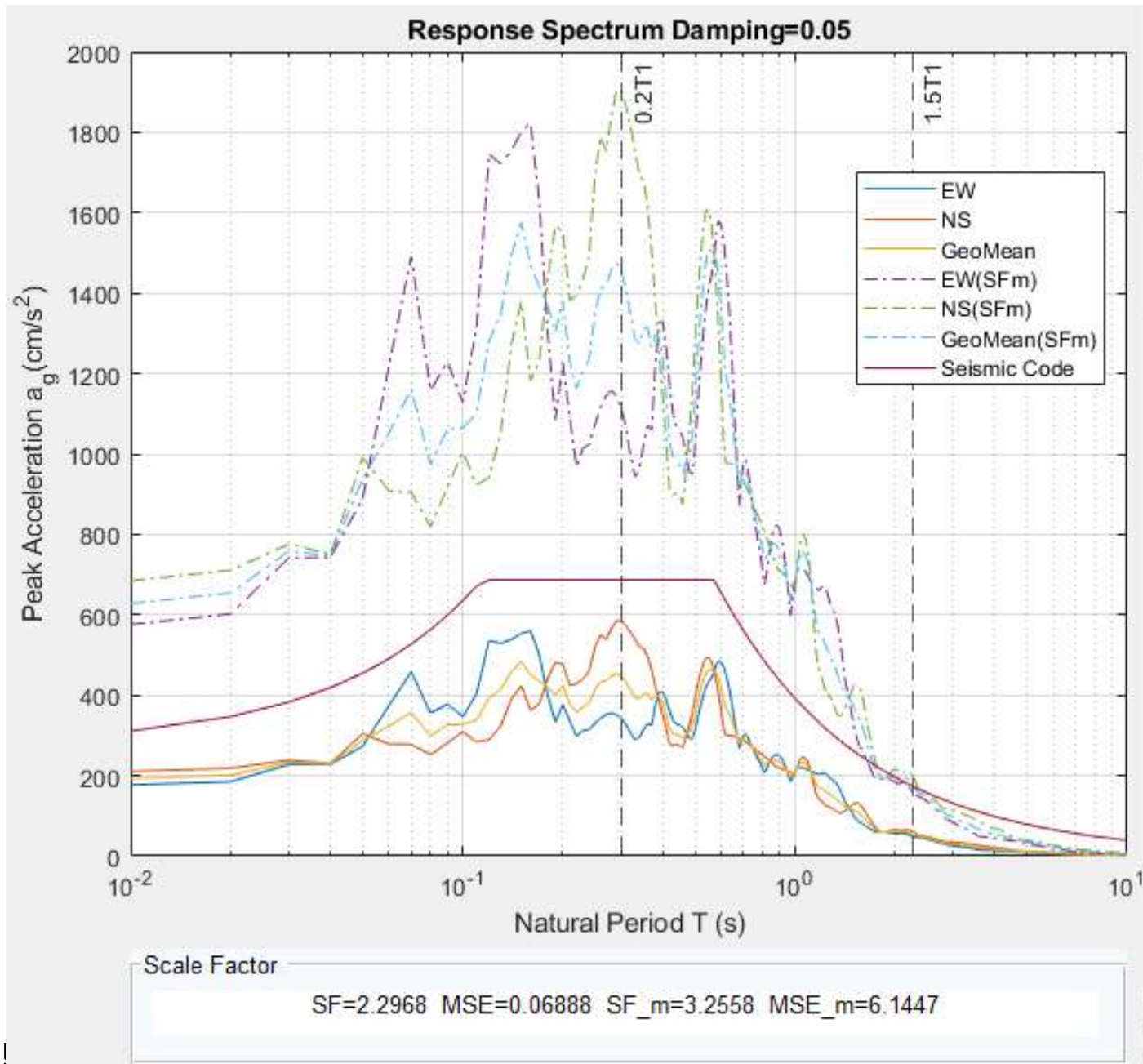
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0.03_2.7_Rank_1_30

475y_Ts=1.0s_Ss=1.0_Vs30_1_360_T
0.03_3.0_Rank_1_30

- Rank_001_19980717045114_CHY006_44319800.IDS.txt
- Rank_002_19990920174715_TCU137_26726300.IDS.txt
- Rank_003_19990925235249_TCU122_T078012.268.txt
- Rank_004_20000910085446_HWA049_26525400.IDS.txt
- Rank_005_20130602054303_TCU122_C9315300.SMT.txt
- Rank_006_20050305190800_ILA018_T475003.064.txt
- Rank_007_20131031120209_HWA006_13030400.CVA.txt
- Rank_008_19990920174715_TCU075_T173001.263.txt
- Rank_009_20160205195726_CHY096_33203600.MNS.txt
- Rank_010_19990920181617_TCU078_T020033.263.txt
- Rank_011_20091219130216_HWA052_12935300.CVA.txt
- Rank_012_20091219130216_HWA049_12635300.CVA.txt
- Rank_013_19990920174715_TCU047_T105001.263.txt
- Rank_014_20000910085446_HWA011_T255001.254.txt
- Rank_015_20091219130216_HWA030_T373001.353.txt
- Rank_016_19990920214638_CHY046_T182041.263.txt
- Rank_017_20020331065249_ILA066_45909000.IDS.txt
- Rank_018_20131031120209_HWA030_T373001.304.txt
- Rank_019_20131031120209_HWA043_F1630400.SMT.txt
- Rank_020_19990925235249_CHY029_T137005.268.txt
- Rank_021_20070809005547_TTN048_T534001.221.txt
- Rank_022_19991022021856_CHY034_41729500.IDS.txt
- Rank_023_19990920174715_TCU122_T078001.263.txt
- Rank_024_20131031120209_HWA005_T531001.304.txt
- Rank_025_20131031120209_HWA036_T443001.304.txt
- Rank_026_20020331065249_ILA052_T404001.090.txt
- Rank_027_19990920181617_TCU075_T173031.263.txt
- Rank_028_20100304001852_KAU018_T581001.063.txt
- Rank_029_19990920181617_TCU076_T091035.263.txt
- Rank_030_20040519070412_TTN006_T243001.140.txt

Rank	Eqk Time	Eqk Lon	Eqk Lat	Mw	Depth (km)	R_epi (km)	R_hypo (km)	Station Code	Stn Lon	Stn Lat	Vs30 (m/sec)	Z1.0 (m)	TAP Zone	CWB Filename	Comp.
1	19980717045114	120.6620	23.5030	6.2	2.8	13.4	13.7	CHY006	120.5600	23.5790	422.7	54.3	0	44319800.IDS	GM
1	19980717045114	120.6620	23.5030	6.2	2.8	13.4	13.7	CHY006	120.5600	23.5790	422.7	54.3	0	44319800.IDS	NS
1	19980717045114	120.6620	23.5030	6.2	2.8	13.4	13.7	CHY006	120.5600	23.5790	422.7	54.3	0	44319800.IDS	EW
1	19980717045114	120.6620	23.5030	6.2	2.8	13.4	13.7	CHY006	120.5600	23.5790	422.7	54.3	0	44319800.IDS	VRT
2	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	26726300.IDS	GM
2	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	26726300.IDS	NS
2	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	26726300.IDS	EW
2	19990920174715	120.8160	23.8520	7.69	8.0	38.6	39.5	TCU137	120.9300	24.1830	533.6	28.0	0	26726300.IDS	VRT
3	19990925235249	121.0020	23.8540	6.97	12.1	39.3	41.1	TCU122	120.6180	23.8120	623.6	23.0	0	T078012.268	GM
3	19990925235249	121.0020	23.8540	6.97	12.1	39.3	41.1	TCU122	120.6180	23.8120	623.6	23.0	0	T078012.268	NS
3	19990925235249	121.0020	23.8540	6.97	12.1	39.3	41.1	TCU122	120.6180	23.8120	623.6	23.0	0	T078012.268	EW
3	19990925235249	121.0020	23.8540	6.97	12.1	39.3	41.1	TCU122	120.6180	23.8120	623.6	23.0	0	T078012.268	VRT
4	20000910085446	121.5840	24.0850	6.2	17.7	10.4	20.6	HWA049	121.5640	23.9930	509.3	203.0	0	26525400.IDS	GM
4	20000910085446	121.5840	24.0850	6.2	17.7	10.4	20.6	HWA049	121.5640	23.9930	509.3	203.0	0	26525400.IDS	NS
4	20000910085446	121.5840	24.0850	6.2	17.7	10.4	20.6	HWA049	121.5640	23.9930	509.3	203.0	0	26525400.IDS	EW
4	20000910085446	121.5840	24.0850	6.2	17.7	10.4	20.6	HWA049	121.5640	23.9930	509.3	203.0	0	26525400.IDS	VRT
5	20130602054303	120.9740	23.8610	6.55	14.5	36.6	39.4	TCU122	120.6180	23.8120	623.6	23.0	0	C9315300.SMT	GM
5	20130602054303	120.9740	23.8610	6.55	14.5	36.6	39.4	TCU122	120.6180	23.8120	623.6	23.0	0	C9315300.SMT	NS
5	20130602054303	120.9740	23.8610	6.55	14.5	36.6	39.4	TCU122	120.6180	23.8120	623.6	23.0	0	C9315300.SMT	EW
5	20130602054303	120.9740	23.8610	6.55	14.5	36.6	39.4	TCU122	120.6180	23.8120	623.6	23.0	0	C9315300.SMT	VRT
6	20050305190800	121.7980	24.6530	5.85	7.0	11.5	13.4	ILA018	121.6880	24.6800	497.5	82.0	0	T475003.064	GM
6	20050305190800	121.7980	24.6530	5.85	7.0	11.5	13.4	ILA018	121.6880	24.6800	497.5	82.0	0	T475003.064	NS
6	20050305190800	121.7980	24.6530	5.85	7.0	11.5	13.4	ILA018	121.6880	24.6800	497.5	82.0	0	T475003.064	EW
6	20050305190800	121.7980	24.6530	5.85	7.0	11.5	13.4	ILA018	121.6880	24.6800	497.5	82.0	0	T475003.064	VRT
7	20131031120209	121.3480	23.5660	6.47	15.0	14.0	20.5	HWA006	121.4240	23.6710	557.1	78.3	0	13030400.CVA	GM
7	20131031120209	121.3480	23.5660	6.47	15.0	14.0	20.5	HWA006	121.4240	23.6710	557.1	78.3	0	13030400.CVA	NS
7	20131031120209	121.3480	23.5660	6.47	15.0	14.0	20.5	HWA006	121.4240	23.6710	557.1	78.3	0	13030400.CVA	EW
7	20131031120209	121.3480	23.5660	6.47	15.0	14.0	20.5	HWA006	121.4240	23.6710	557.1	78.3	0	13030400.CVA	VRT
8	19990920174715	120.8160	23.8520	7.69	8.0	19.4	21.0	TCU075	120.6880	23.9820	521.2	58.6	0	T173001.263	GM
8	19990920174715	120.8160	23.8520	7.69	8.0	19.4	21.0	TCU075	120.6880	23.9820	521.2	58.6	0	T173001.263	NS
8	19990920174715	120.8160	23.8520	7.69	8.0	19.4	21.0	TCU075	120.6880	23.9820	521.2	58.6	0	T173001.263	EW
8	19990920174715	120.8160	23.8520	7.69	8.0	19.4	21.0	TCU075	120.6880	23.9820	521.2	58.6	0	T173001.263	VRT
9	20160205195726	120.5440	22.9220	6.7	14.6	31.8	35.0	CHY096	120.2410	22.9810	423.0	279.0	0	33203600.MNS	GM
9	20160205195726	120.5440	22.9220	6.7	14.6	31.8	35.0	CHY096	120.2410	22.9810	423.0	279.0	0	33203600.MNS	NS
9	20160205195726	120.5440	22.9220	6.7	14.6	31.8	35.0	CHY096	120.2410	22.9810	423.0	279.0	0	33203600.MNS	EW
9	20160205195726	120.5440	22.9220	6.7	14.6	31.8	35.0	CHY096	120.2410	22.9810	423.0	279.0	0	33203600.MNS	VRT
10	19990920181617	121.0410	23.8610	6.78	12.5	19.9	23.5	TCU078	120.8540	23.8110	444.5	41.0	0	T020033.263	GM
10	19990920181617	121.0410	23.8610	6.78	12.5	19.9	23.5	TCU078	120.8540	23.8110	444.5	41.0	0	T020033.263	NS
10	19990920181617	121.0410	23.8610	6.78	12.5	19.9	23.5	TCU078	120.8540	23.8110	444.5	41.0	0	T020033.263	EW
10	19990920181617	121.0410	23.8610	6.78	12.5	19.9	23.5	TCU078	120.8540	23.8110	444.5	41.0	0	T020033.263	VRT
11	20091219130216	121.6630	23.7880	7.13	43.8	19.6	48.0	HWA052	121.4740	23.8190	576.5	90.1	0	12935300.CVA	GM
11	20091219130216	121.6630	23.7880	7.13	43.8	19.6	48.0	HWA052	121.4740	23.8190	576.5	90.1	0	12935300.CVA	NS
11	20091219130216	121.6630	23.7880	7.13	43.8	19.6	48.0	HWA052	121.4740	23.8190	576.5	90.1	0	12935300.CVA	EW
11	20091219130216	121.6630	23.7880	7.13	43.8	19.6	48.0	HWA052	121.4740	23.8190	576.5	90.1	0	12935300.CVA	VRT

歷時紀錄定比係數



大綱

- 前言
- 地震力輸入選擇
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- 性能目標
- 案例說明

TEASDA 輔助程式(version 1.0.5)

- UI操作介面
- 以MATLAB 2020b進行程式開發
- ETABS 2016以上版本



輔助程式操作說明

• 新增中英文輔助程式操作說明

程式架構說明

輔助程式是以 Matlab 2019a 程式所編譯成的執行檔，使用者必須先自行安裝 [MCRInstaller.exe](#)，建立可執行此輔助程式的操作環境，安裝流程和解說如下。

步驟 1. 從 MATLAB Runtime 中下載 R2019a 的 Runtime 安裝檔



執行電腦操作環境建置
R2019a 所製成的 Runtime 下載

步驟 2. 解壓縮下載的檔案並執行資料夾內 setup.exe 檔開始安裝 Runtime



1. 解壓縮下載的檔案
2. 用解壓縮後的資料夾
3. 執行 setup.exe 開始安裝

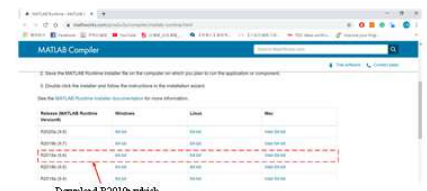
步驟 3. 依照安裝流程完成安裝 Runtime



Introduction


Auxiliary program is built based on MATLAB 2019a, therefore, users have to download and install [MCRInstaller.exe](#) in order to execute it. The illustration is shown below...

Step 1. Download installation file, R2019a, from MATLAB website.



Download R2019a, which version is corresponding to OS.

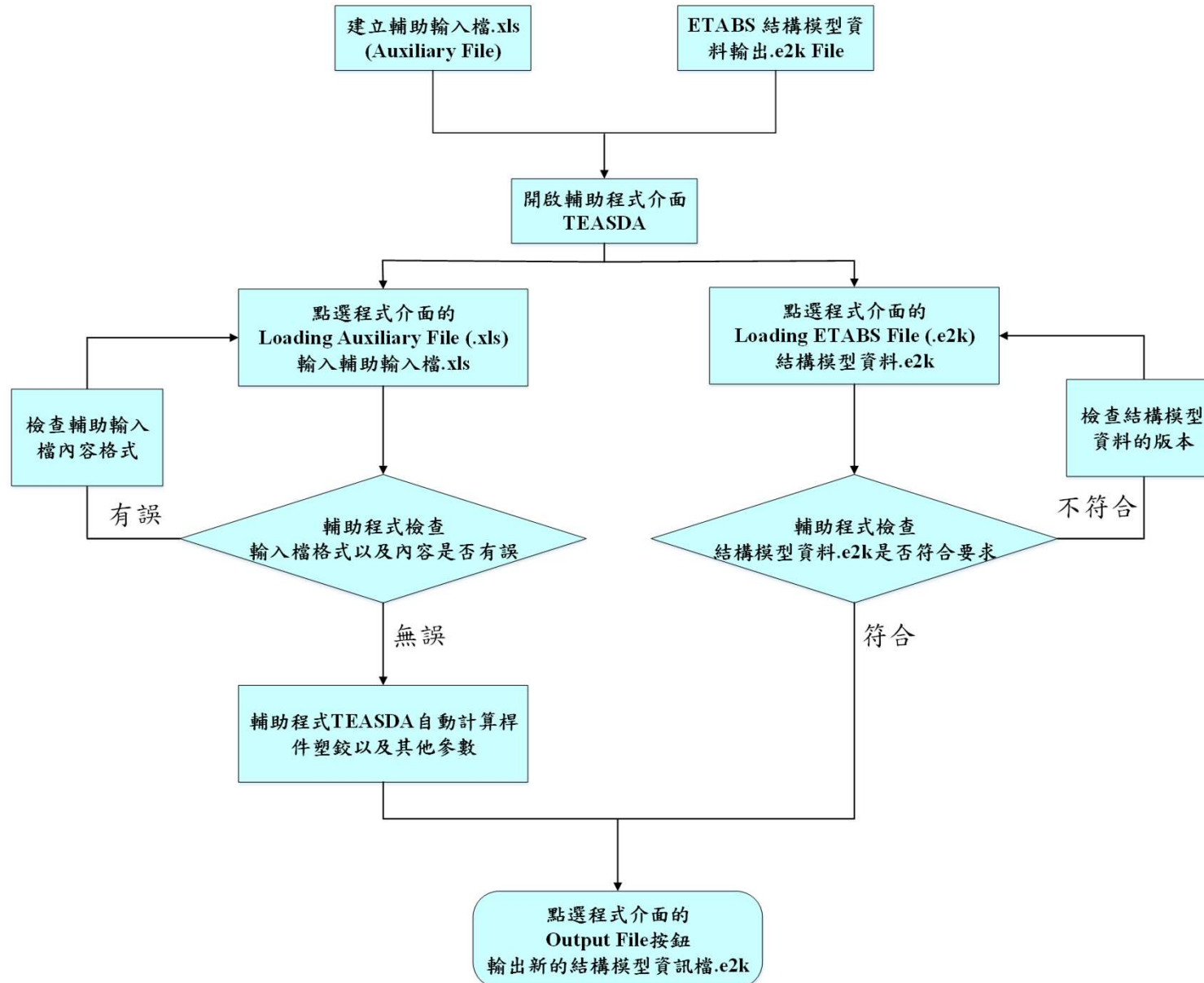
Step 2. Decompressing the file, then execute the setup.exe which is in the folder to start installation...

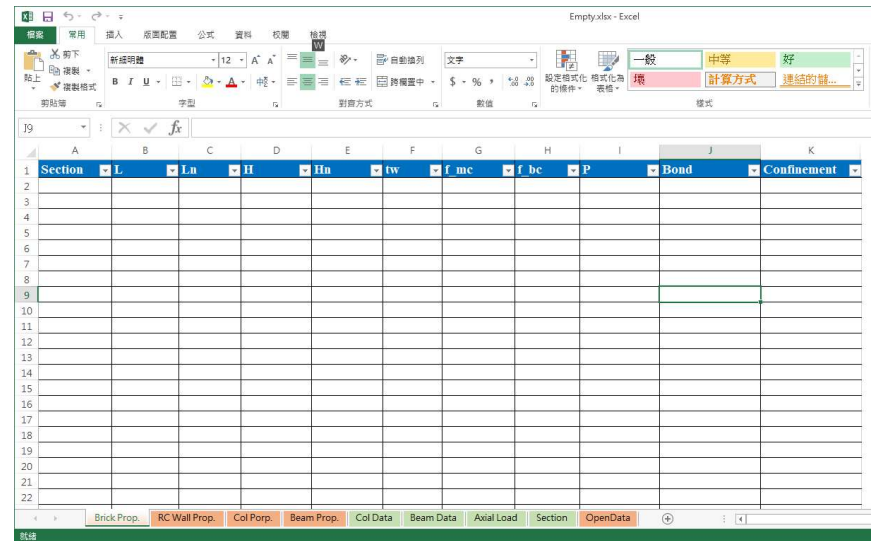


Take Matlab or C++ as an example
1. Extract the unzipped file
2. Open the file
3. Execute the file to start installation

Step 3. Following the indication of installation...

輔助程式操作流程

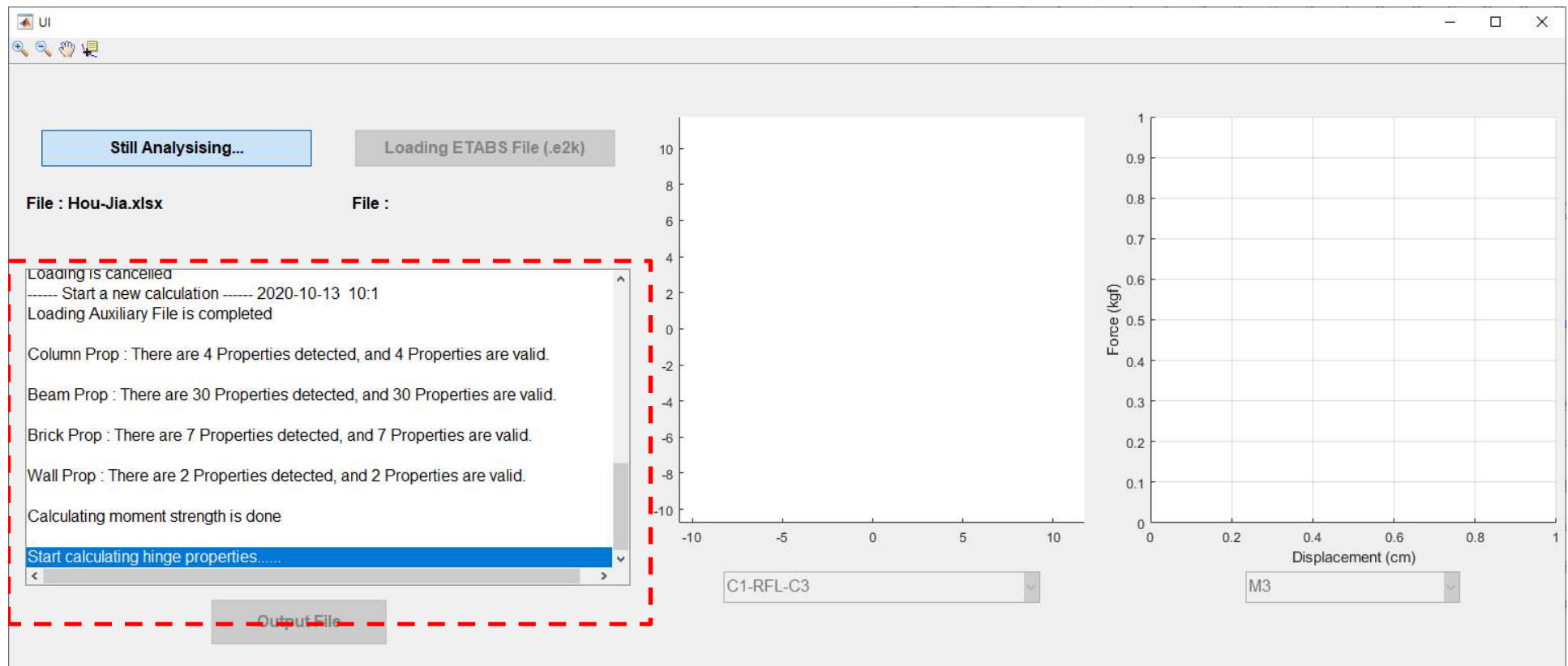




EXCEL共用輸入檔(*.xlsx)

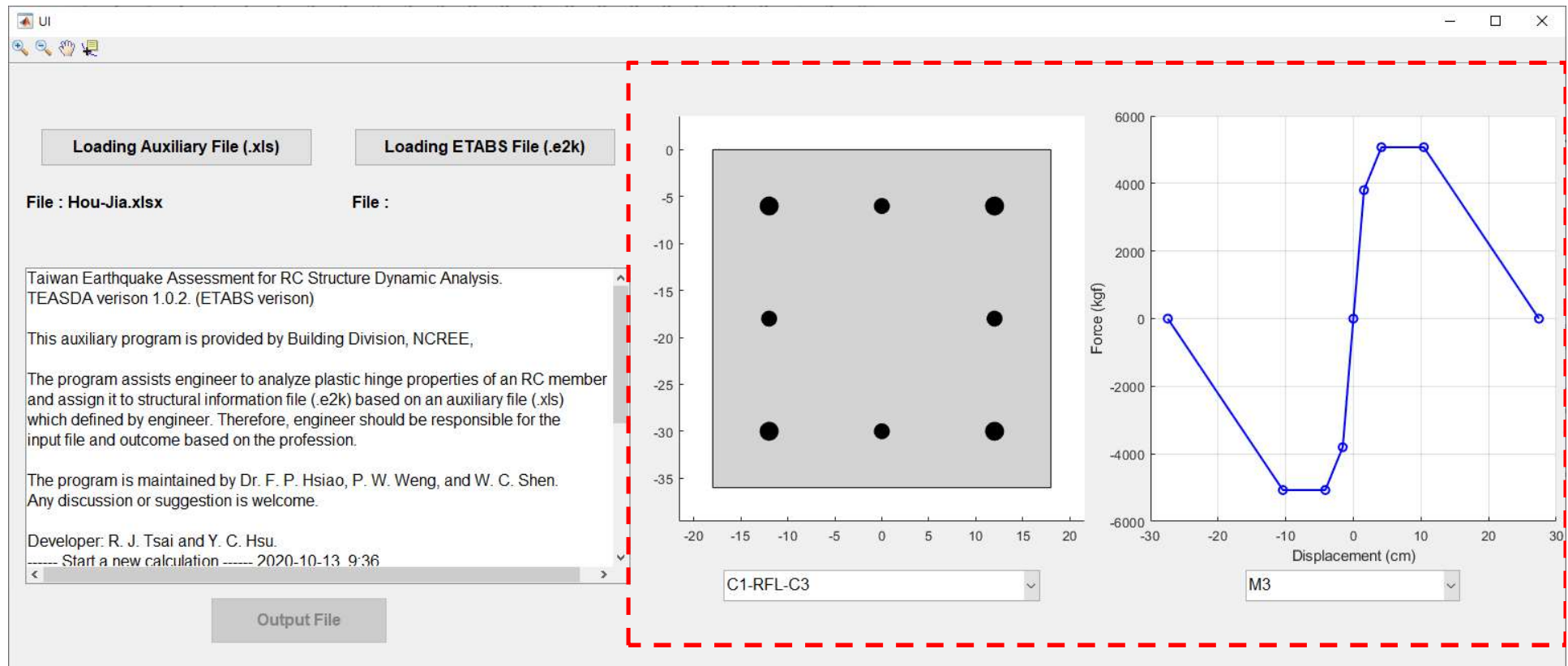
程式訊息回傳功能

- 各種構件斷面數量及讀取資訊
- 非線性鉸計算訊息
- 操作說明中提供常見之錯誤訊息說明



斷面分析結果資訊

- 圖形化介面
- 提供斷面之配筋、側力位移曲線



更新斷面強度分析核心程式

- BIAx (University of California, Berkeley)



The Earthquake Engineering Online Archive NISEE e-Library

BIAx-1 Software and Manuals



[Text-191062](#) Wallace, John W.; Moehle, Jack P.; BIAx: a computer program for the analysis of reinforced concrete sections



[Software-BIAx1ZIP](#) Wallace, John W.; Moehle, Jack P.; BIAx-1: Analysis of Reinforced Concrete Sections

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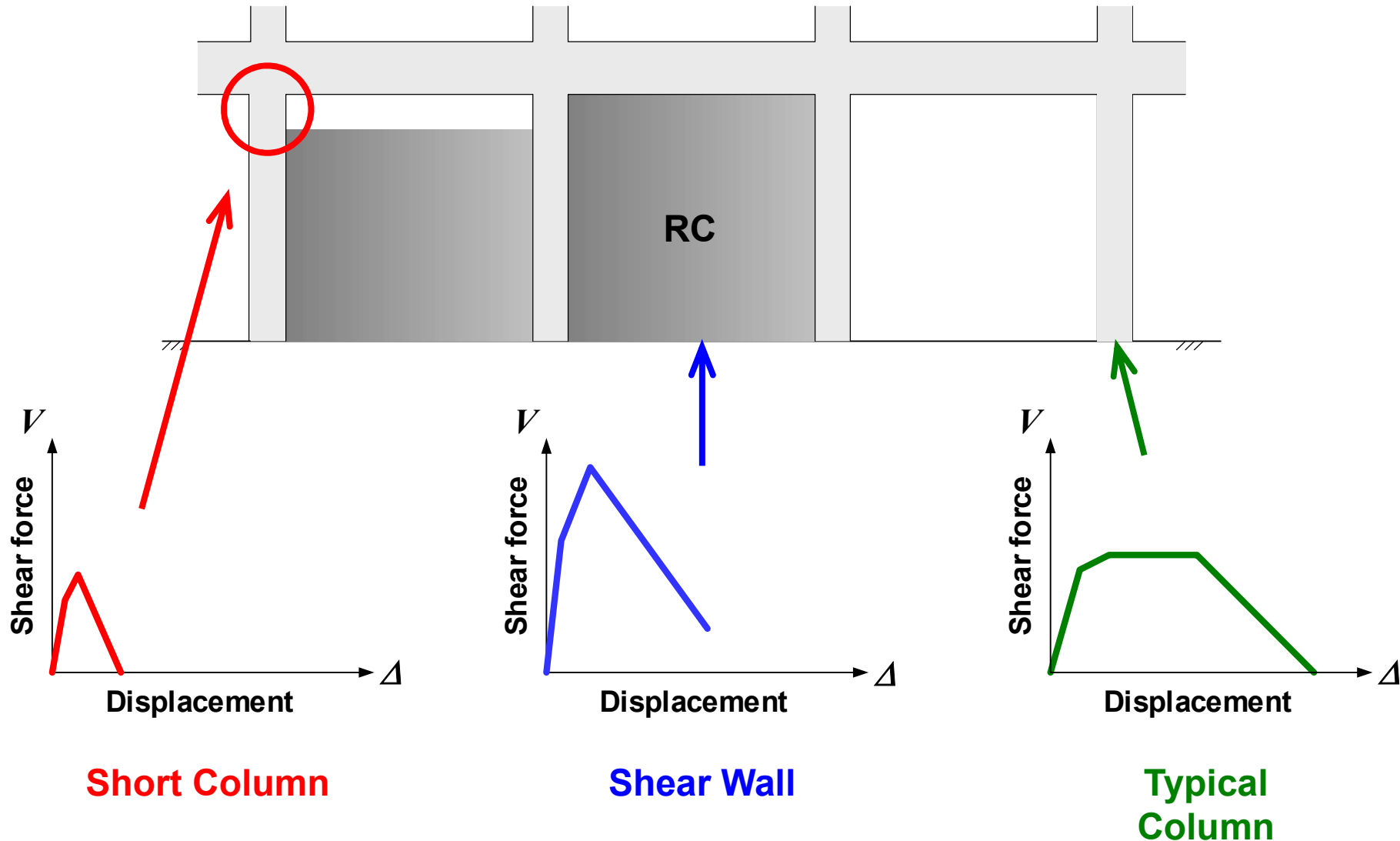
- 前言
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大綱

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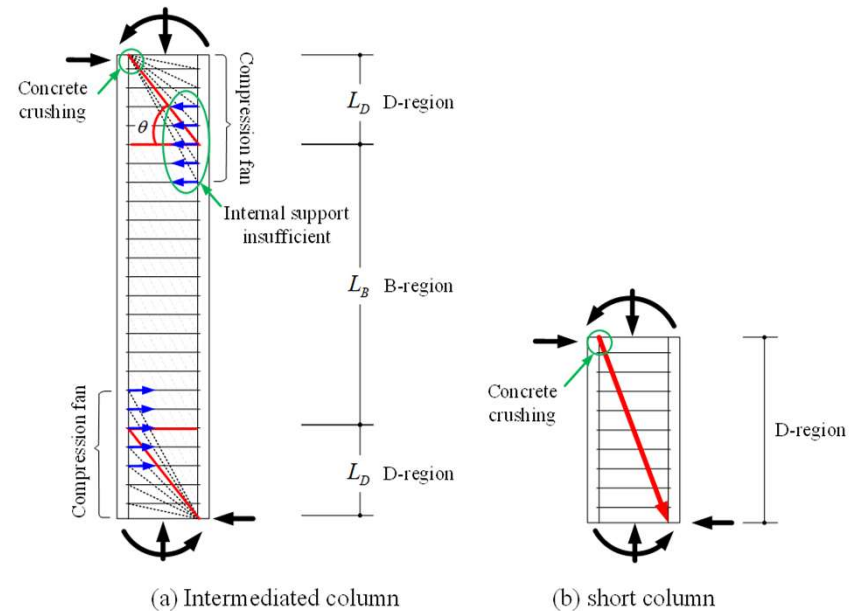
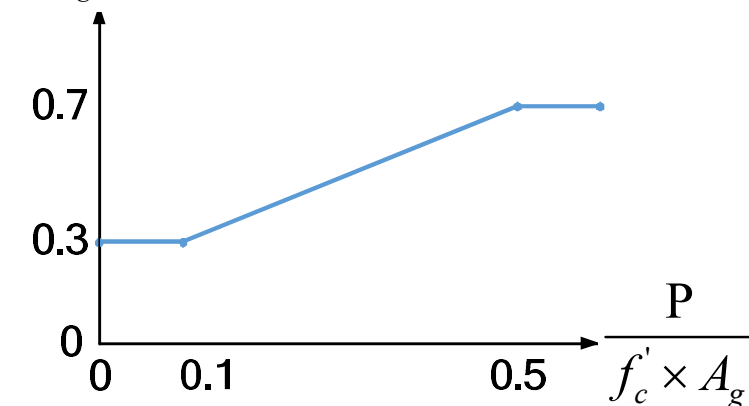
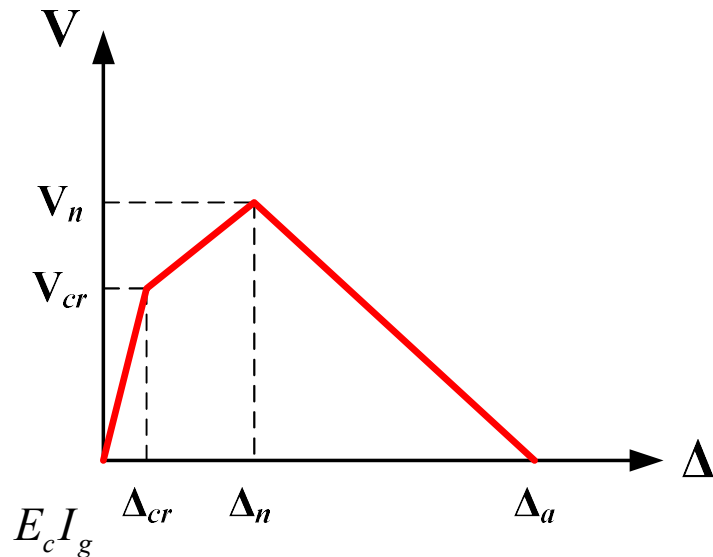
Nonlinear behaviors of RC structural members

Lateral force-displacement curves



Intermediate Short & Short Column

- Li, Y. A. and Hwang, S. J. (2017). "Prediction of Lateral Load Displacement Curves for Reinforced Concrete Short Columns Failed in Shear," Journal of Structural Engineering, ASCE, 143(2), DOI:10.1061/(ASCE)ST.1943-541X.0001656
- Li, Y. A., Weng, P. W., and Hwang, S. J., (2019) "Seismic Performance of RC Intermediate Short Columns Failed in Shear," ACI Structural Journal, Vol. 116, No. 3, May. 2019, pp. 195-206.



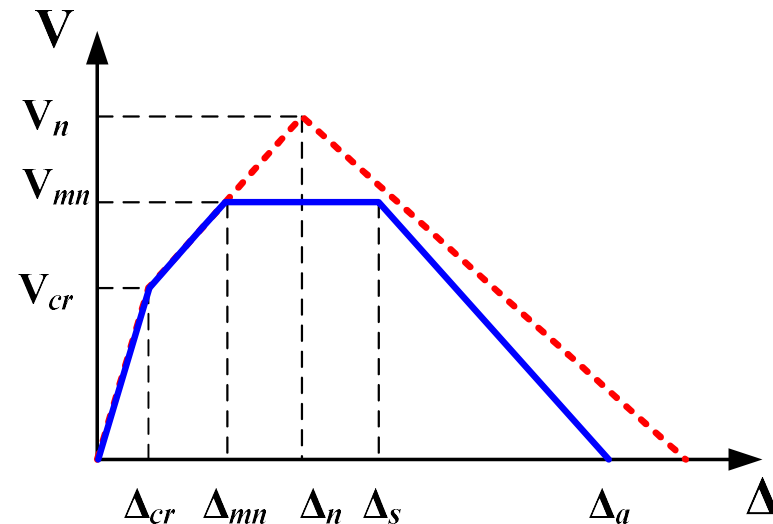
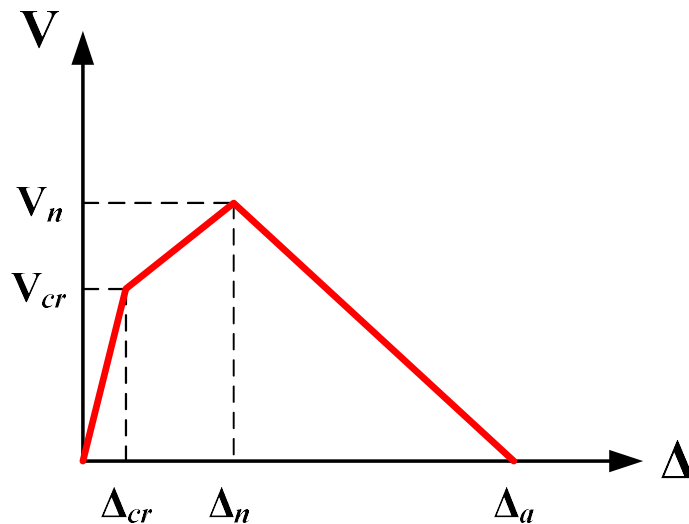
$$V_{n,t} = \frac{A_{st} f_{yt} d}{s} + \left(\frac{0.5 \sqrt{f'_c}}{M/Vd} \sqrt{1 + \frac{P}{0.5 \sqrt{f'_c} A_g}} \right) \times 0.8 A_g \quad (\text{ASCE/SEI 41-17})$$

$$V_{n,c} = K \zeta f'_c A_{str} \cos \theta \quad (\text{Hwang et al. 2017})$$

Typical Column

- Shen, W. C., Hwang, S. J., Li, Y. A., Weng, P. W. and Moehle, J. P., (2021) “Force-Displacement Model for Shear-Critical Reinforced Concrete Columns,” ACI Structural Journal, Vol. 118, No. 1, pp. 241- 249.

lateral stiffness effect by shear crack



Shear Strength of Beam

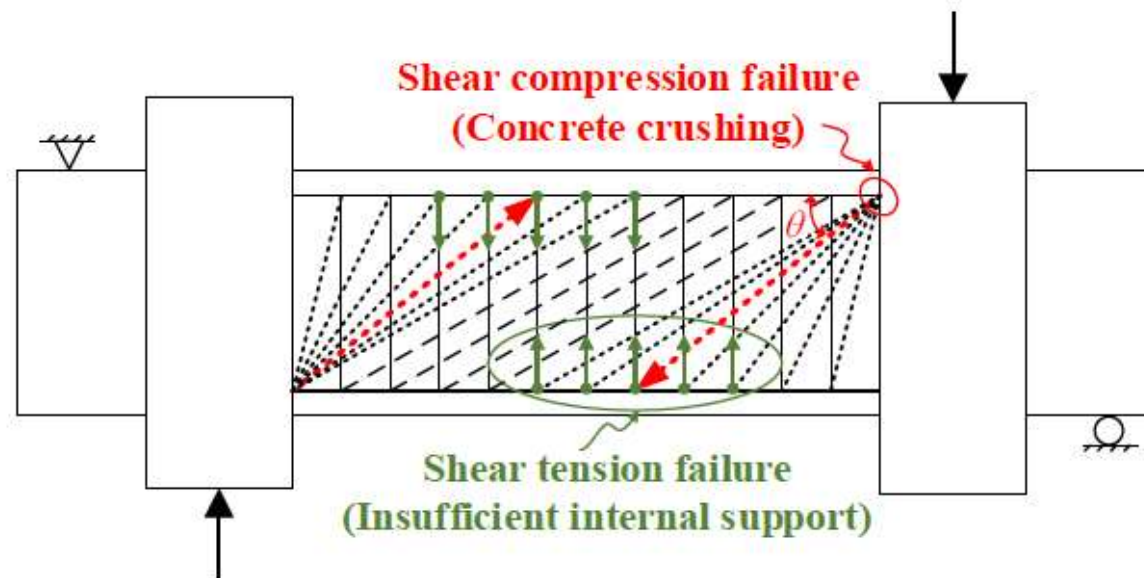
- ASCE/SEI 41-17
- Hwang, S. J., Yang, Y. H., and Li, Y. A., (2021) “Maximum Shear Strength of Reinforced Concrete Deep Beams,” ACI Structural Journal, V. 118, No. 6, pp. 155-164.

$$V_{n,c} = K \zeta f'_c A_{str} \sin \theta$$

(Hwang et al. 2017)

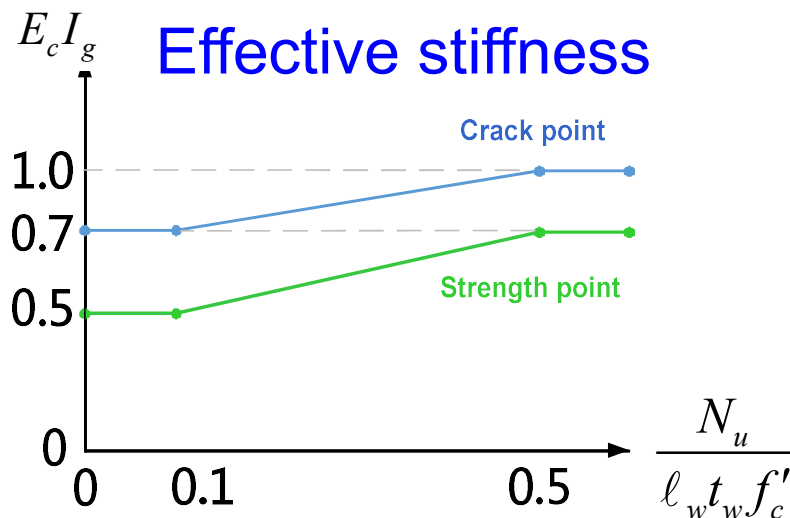
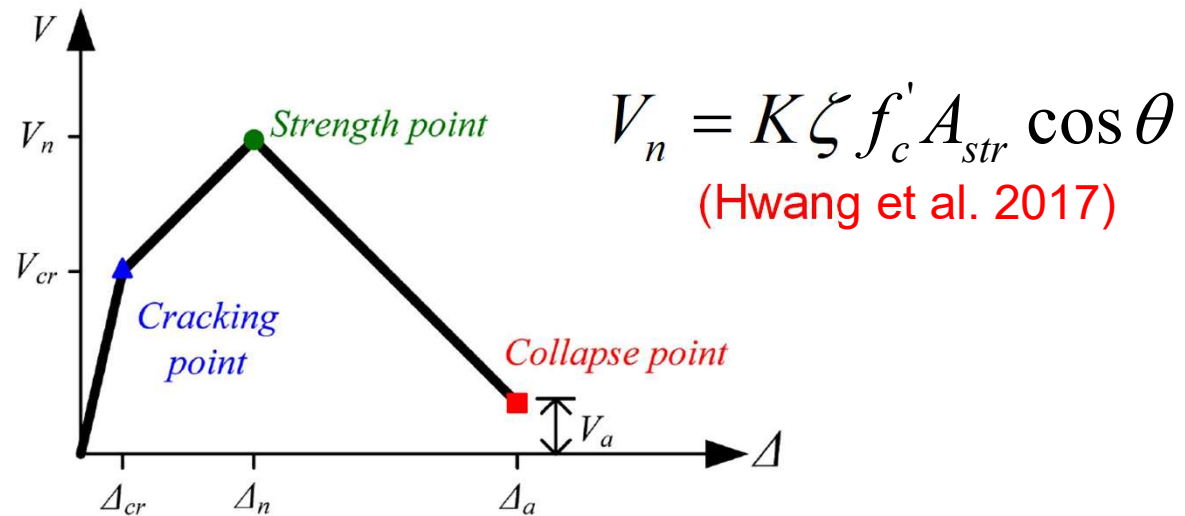
$$V_{n,t} = V_c + V_s = 2.12 \lambda_s \rho_w^{1/3} \sqrt{f'_c} b_w d + \frac{A_v f_y d}{s}$$

(ACI 318-19)



Shear Wall

- Weng, P. W., Li Y. A., Tu Y. S., and Hwang S. J., "Prediction of the Lateral Load-Displacement Curves for Reinforced Concrete Squat Walls Failing in Shear," Journal of Structural Engineering, ASCE, Vol. 143, No. 10, DOI: 10.1061/(ASCE)ST.1943-541X.0001872, 2017.



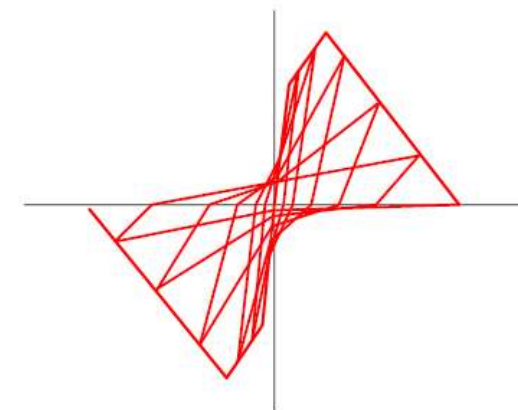
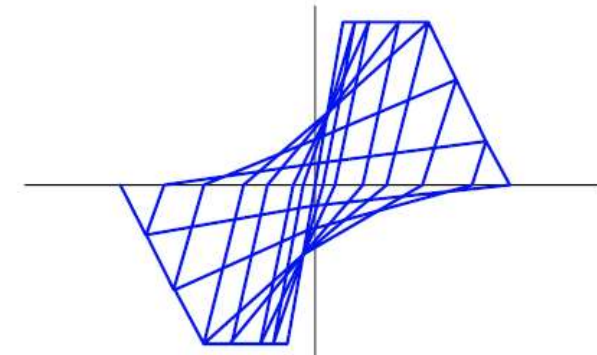
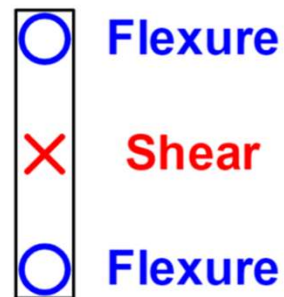
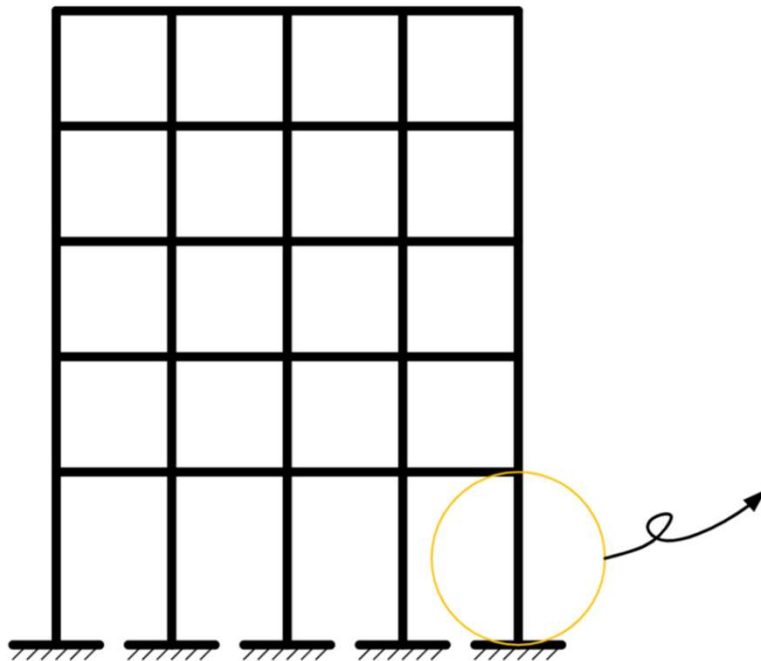
Collapse point

Axial condition	Strength V_a	Displ. Δ_a
$\frac{(A_s - A'_s) f_{yv} + Nu}{\ell_w t_w f'_c} \leq 0.05$	$0.2V_n$	$0.02h_w$
$\frac{(A_s - A'_s) f_{yv} + Nu}{\ell_w t_w f'_c} > 0.05$	0.0	$0.01h_w$

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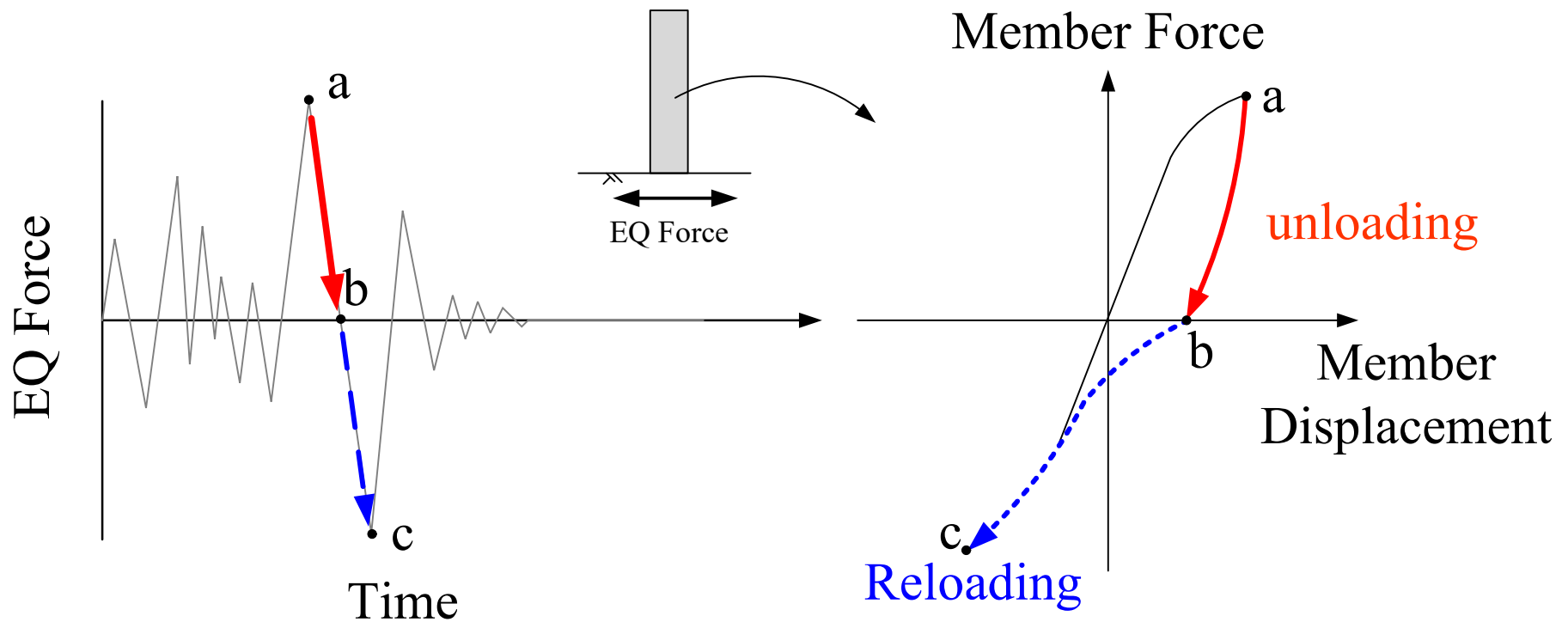
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Modeling of Flexure and Shear Characteristics



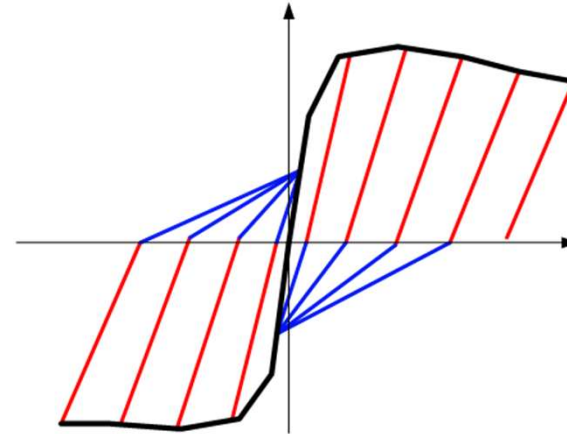
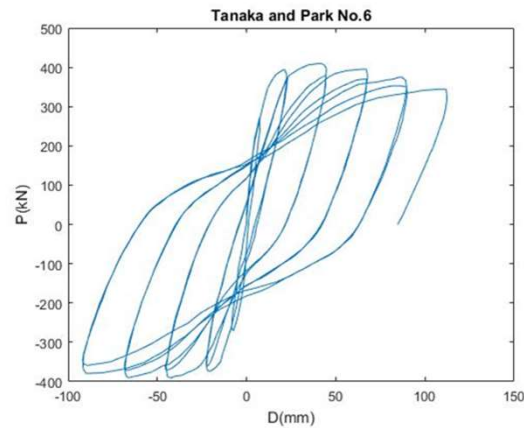
Shear
Hysteresis model

Hysteresis behavior

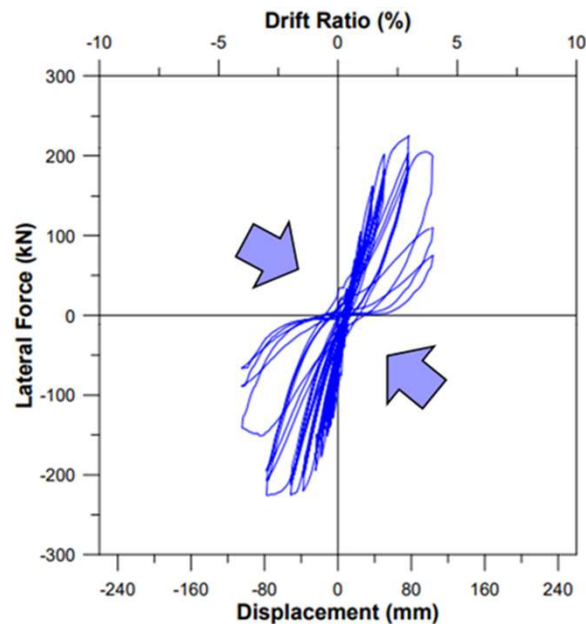


Hysteresis behavior

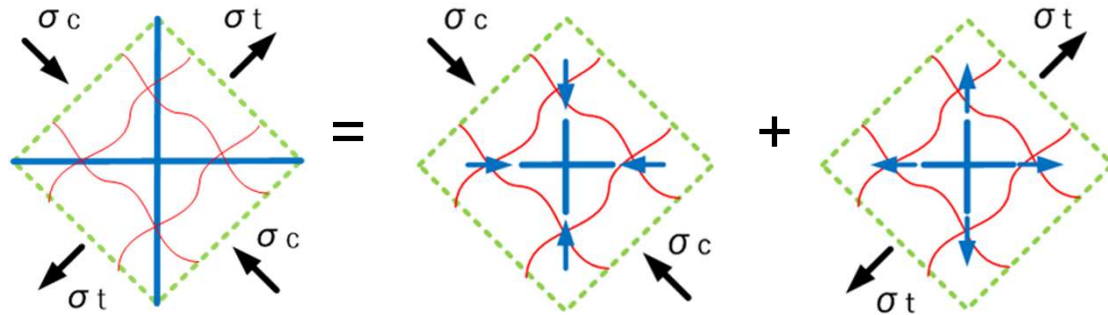
■ Stiffness degrading (red part):



■ Pinching (blue part):



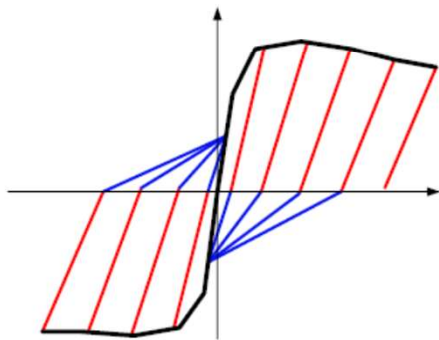
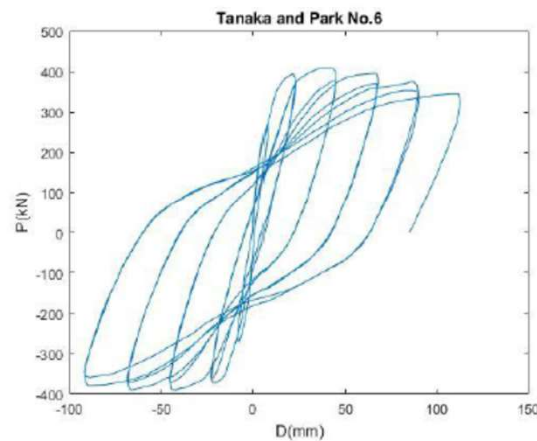
(Hsu and Mo 2010)



Hysteresis behavior

Different Failure Modes

Flexure



ductile

less

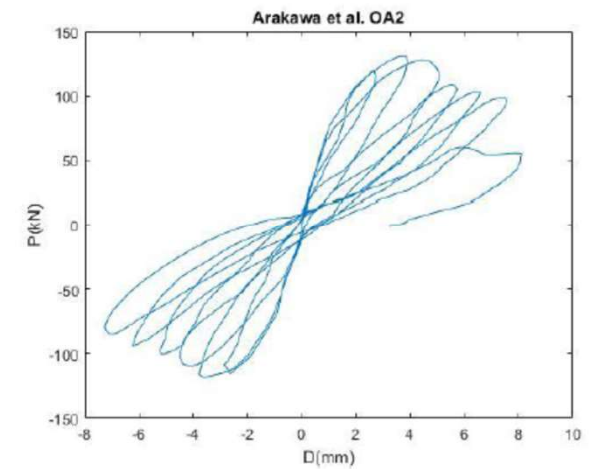
less

Member
behavior

Stiffness
degrading

pinching

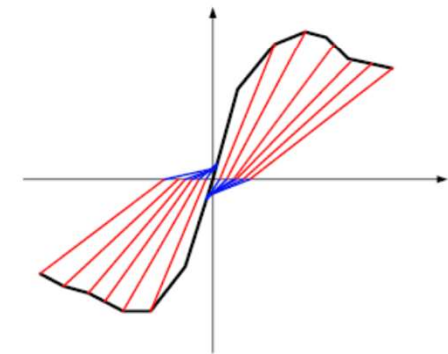
Shear



brittle

significant

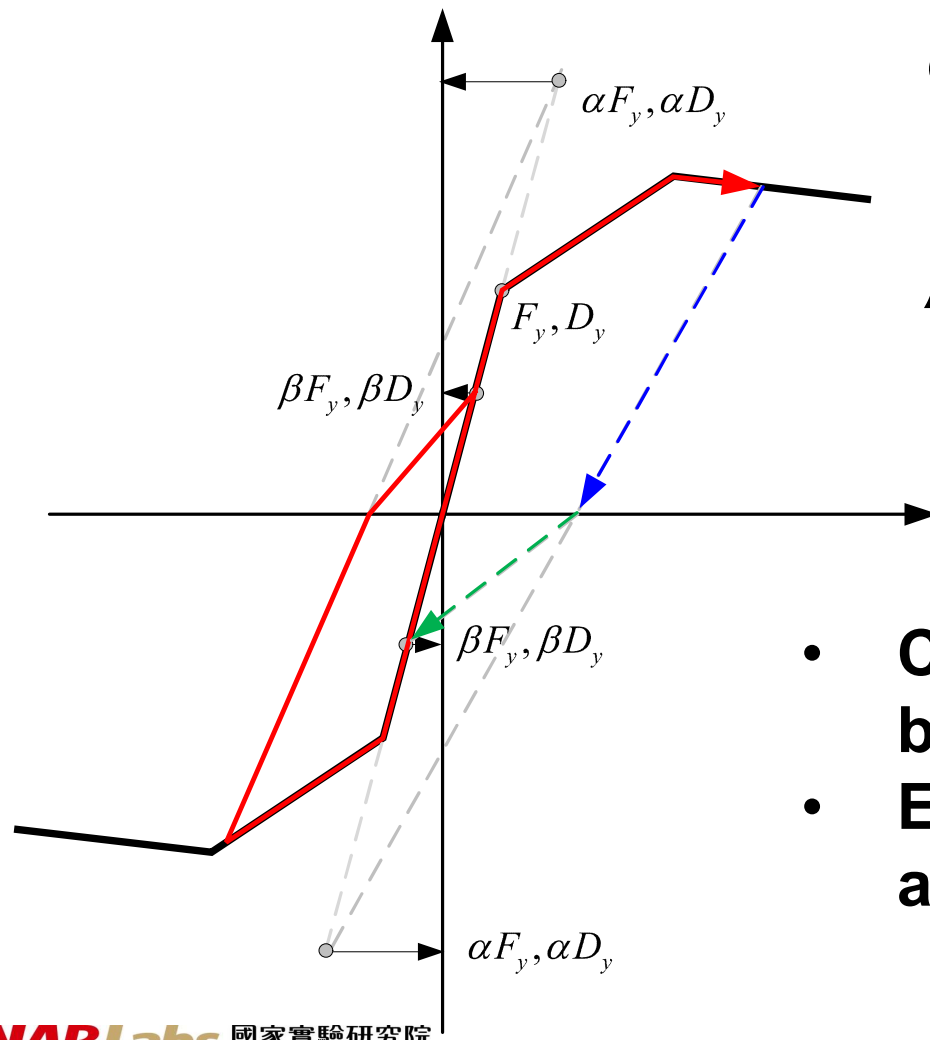
significant



Hysteresis model - Pivot model

- Two Parameters

(Dowell et. al, 1998)



α Control unloading behavior
(stiffness degrading)

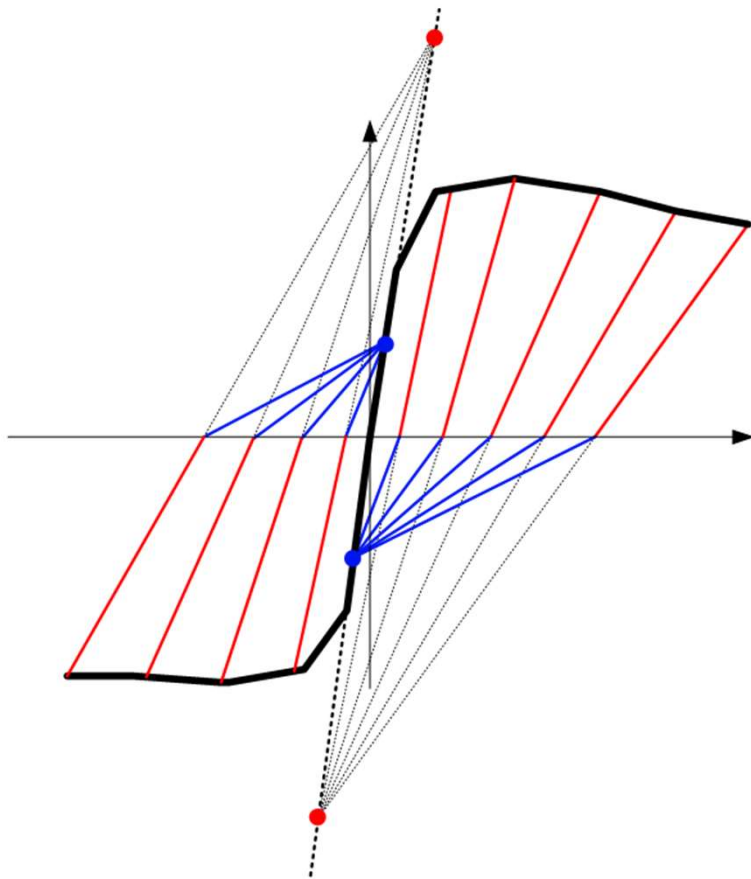
β Control reloading behavior
(inching effect)

- Can capture major hysteresis behavior
- Easily adopted in structural analysis software

Hysteresis model - Pivot model

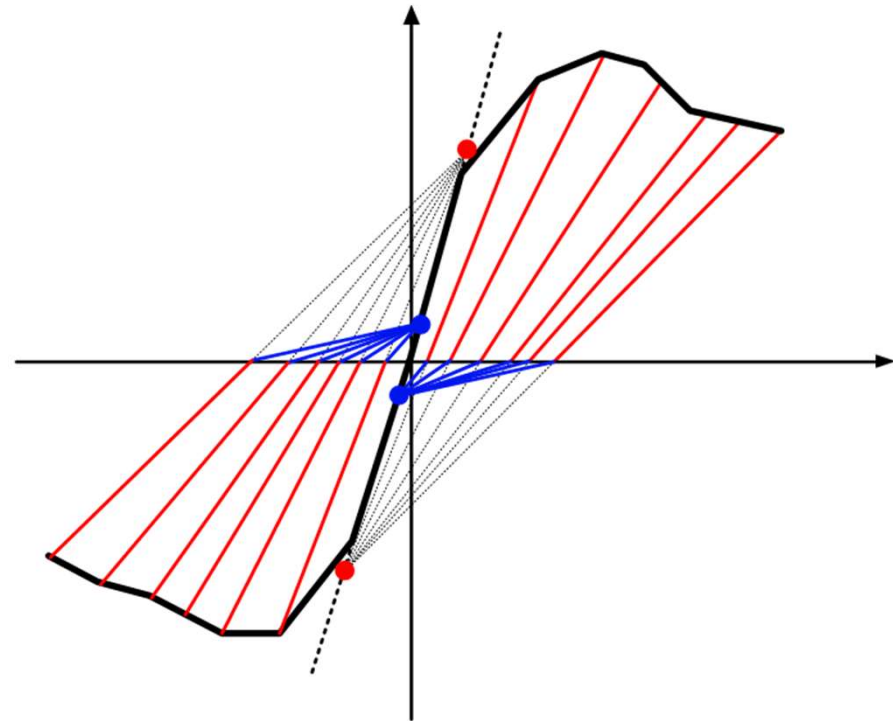
Flexure

large α , large β



Shear

small α , small β



Parameters of Pivot model for column

Ling, Y. C., Mogili, S., Hwang, S. J., (2022)“Parameter Optimization for Pivot Hysteresis Model for Reinforced Concrete Columns with Different Failure Modes.” Earthquake Engng Struct Dyn., Vol. 51, pp. 2167- 2187. (<https://doi.org/10.1002/eqe.3658>)

Flexure Hinge Axial load ratio Longi. reinforcement index Trans. reinforcement index

$$\alpha_F = 0.30 \times \left(\frac{N}{A_g f'_c} \right)^{-2.8} \times \left(\frac{\rho_l f_{yl}}{f'_c} \right)^{1.0} \times \left(\frac{\rho_t f_{yt}}{f'_c} \right)^{0.65} + 2.20 \leq 10$$
$$\beta_F = 0.62 \times \left(\frac{N}{A_g f'_c} \right)^{0.10} \times \left(\frac{\rho_l f_{yl}}{f'_c} \right)^{0.10} \times \left(\frac{\rho_t f_{yt}}{f'_c} \right)^{-0.15} \leq 1$$

Shear Hinge

$$\alpha_S = 1.0 \times \left(\frac{N}{A_g f'_c} \right)^{-3.0} \times \left(\frac{\rho_l f_{yl}}{f'_c} \right)^{2.3} \times \left(\frac{\rho_t f_{yt}}{f'_c} \right)^{1.5} + 2.10 \leq 10$$
$$\beta_S = 0.13 \times \left(\frac{N}{A_g f'_c} \right)^{0.16} \times \left(\frac{\rho_l f_{yl}}{f'_c} \right)^{-0.37} \times \left(\frac{\rho_t f_{yt}}{f'_c} \right)^{-0.35} \leq 1$$

Solution Procedure

Column database
(ACI+NCREE+JAPAN)
63F, 18 FS, 32 S



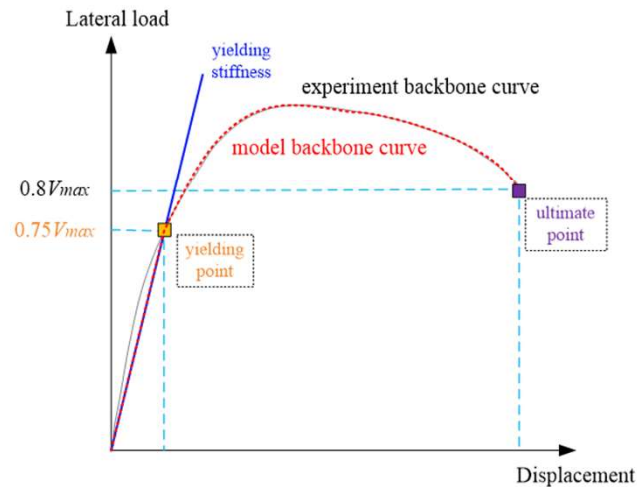
Idealized yielding point
F-type: $0.75 M_n$
S-type: $0.6 M_n$



Parametric equations
optimization
(based on energy dissipation)

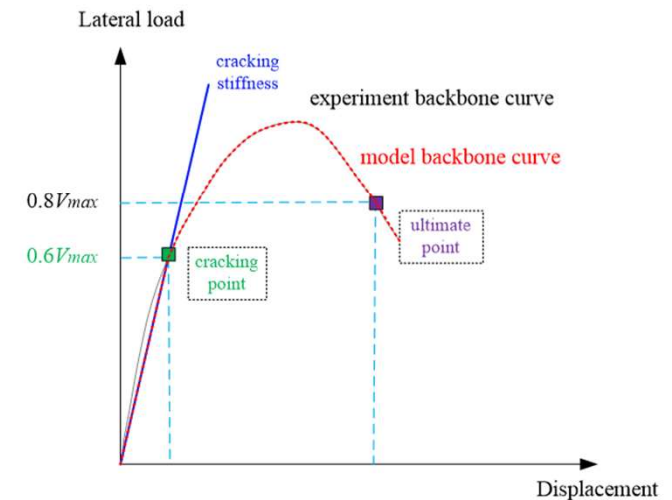
F-type
Priestley and Park (1987)

$0.75V_{max}$



S-type
ASCE41-13

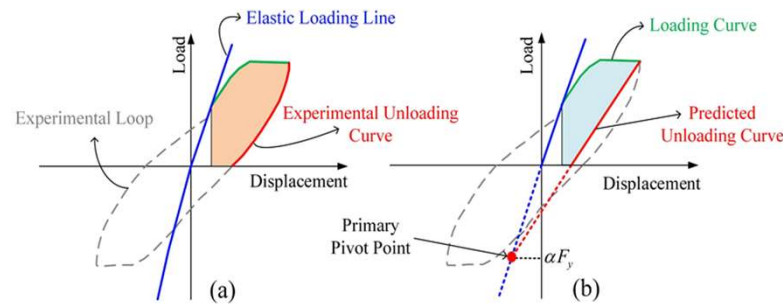
$0.6V_{max}$



Parameter Optimization Process

- Optimization criteria : dissipated energy
- Loop energy indicator
- Average energy indicator

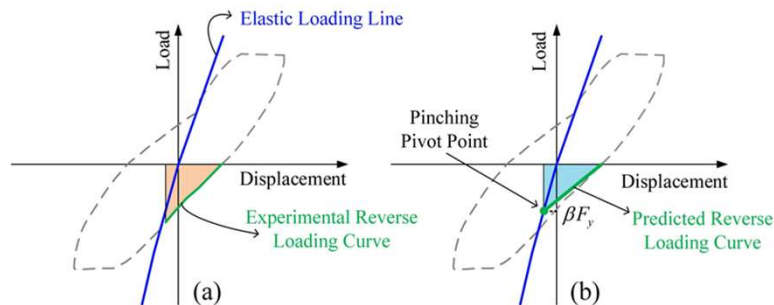
$$I_{\alpha}^{j+} = (A_{\alpha}^{j+})_{model} / (A_{\alpha}^{j+})_{test} ; I_{\alpha}^{j-} = (A_{\alpha}^{j-})_{model} / (A_{\alpha}^{j-})_{test}$$



$$I_{\alpha}^{avg} = \frac{\sum_{j=1}^{n_{loop}} (V_{max}^{j+} \times I_{\alpha}^{j+} + V_{max}^{j-} \times I_{\alpha}^{j-})}{\sum_{j=1}^{n_{loop}} (V_{max}^{j+} + V_{max}^{j-})}$$

$$I_{\beta}^{avg} = \frac{\sum_{j=1}^{n_{loop}} (V_{max}^{j+} \times I_{\beta}^{j+} + V_{max}^{j-} \times I_{\beta}^{j-})}{\sum_{j=1}^{n_{loop}} (V_{max}^{j+} + V_{max}^{j-})}$$

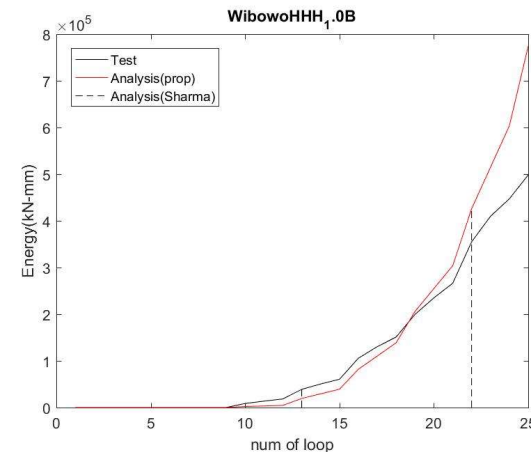
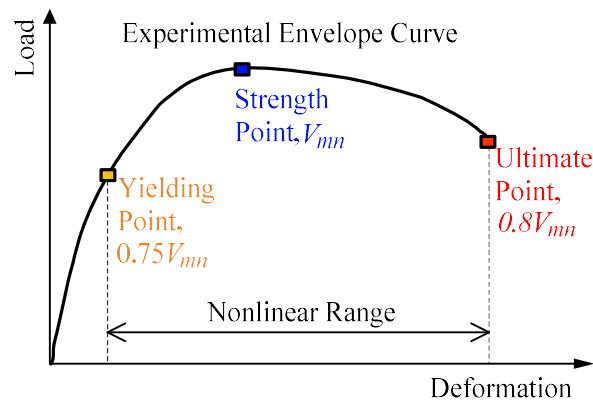
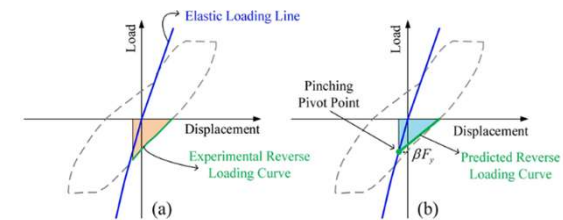
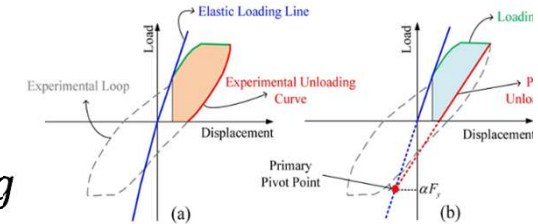
$$I_{\beta}^{j+} = (A_{\beta}^{j+})_{model} / (A_{\beta}^{j+})_{test} ; I_{\beta}^{j-} = (A_{\beta}^{j-})_{model} / (A_{\beta}^{j-})_{test}$$



Comparison of Results - Energy Indicator

Three performance indicators:

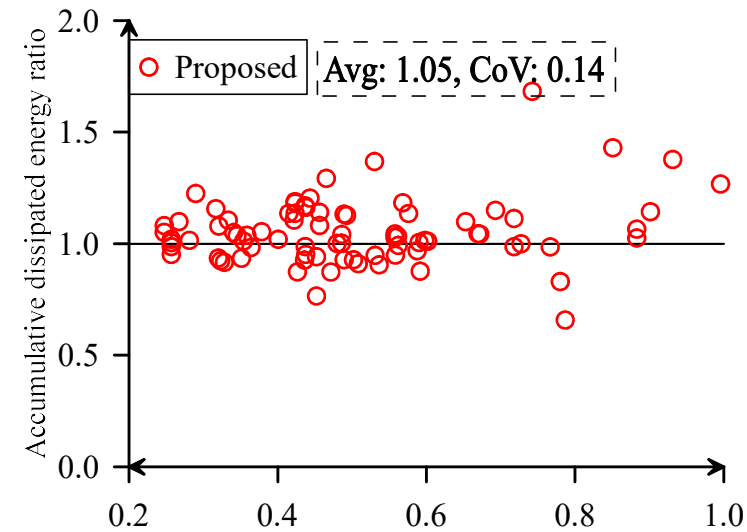
1. Average energy index for stiffness degrading, I_{α}^{avg}
2. Average energy index for pinching, I_{β}^{avg}
3. Model-to-test accumulative energy dissipation ratio, R_d
(Overall performance)



Comparison of Results - Energy Indicator

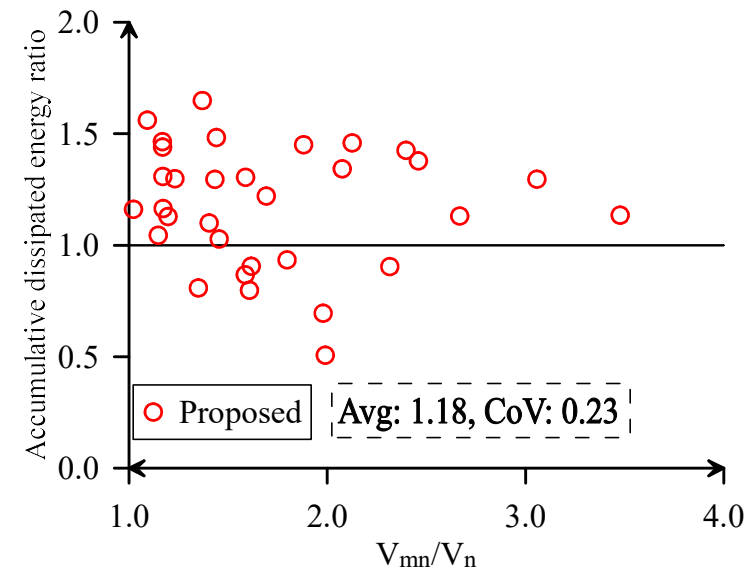
Flexure type

(suitable for Flexure hinge)

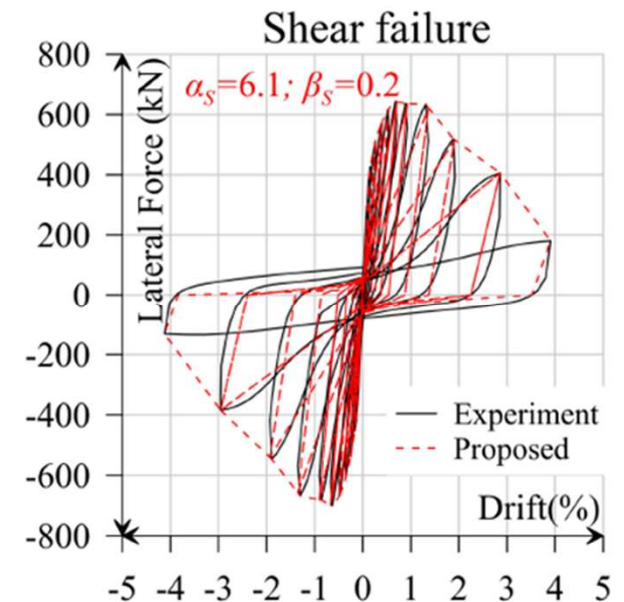
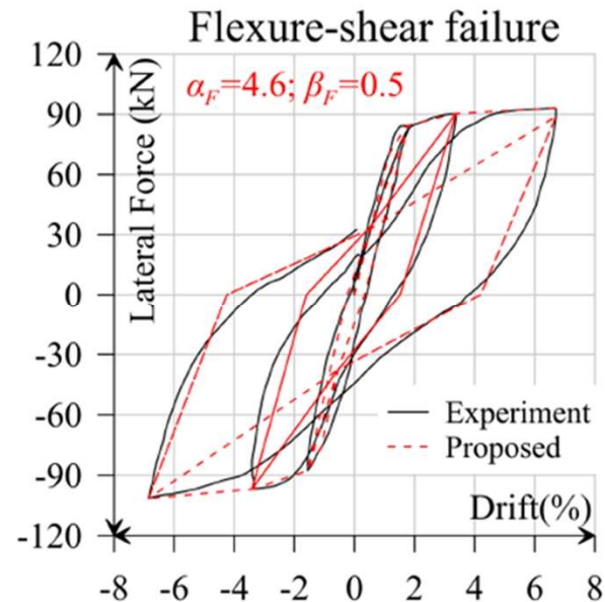
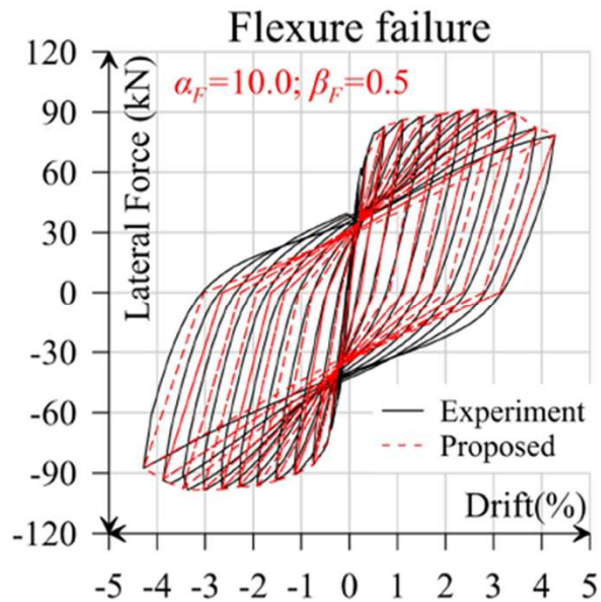


Shear type

(suitable for Shear hinge)



Comparison of Results

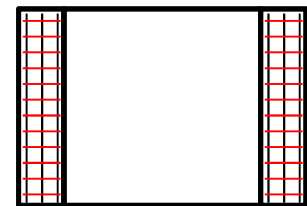
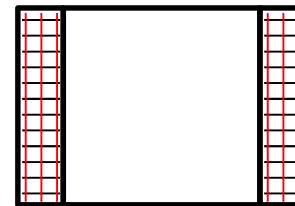
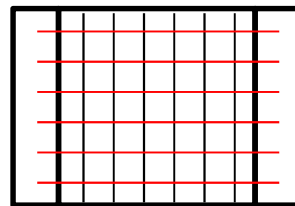
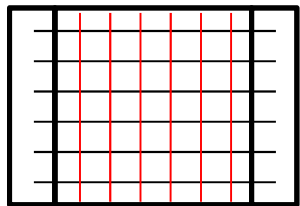


Parameters of Pivot model for wall

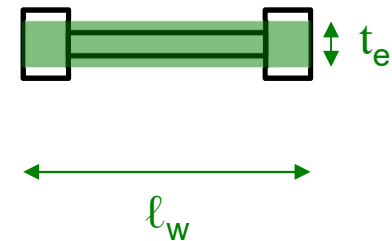
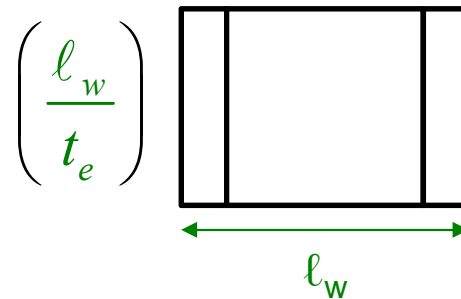
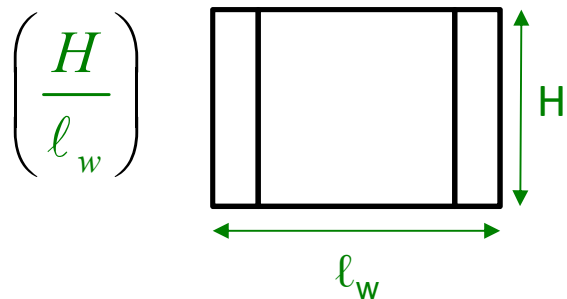
Ling, Y. C., Mogili, S., Hwang S. J., Rojas-León M. and Wallace J. W., "Parameter Optimization for a Pivot Hysteresis Model for Reinforced Concrete Walls with Different Failure Modes," Earthquake Engng Struct Dyn. (under review)

Axial load ratio

$$\left(\frac{P}{A_g f_c'} \right) \left(\frac{\rho_{wv} f_{y,wv}}{f_c'} \right) \left(\frac{\rho_{wh} f_{y,wh}}{f_c'} \right) \left(\frac{\rho_c f_{y,c}}{f_c'} \right) \left(\frac{\rho_{ct} f_{y,ct}}{f_c'} \right)$$



Geometric condition



Parameters of Pivot model for wall

Ling, Y. C., Mogili, S., Hwang S. J., Rojas-León M. and Wallace J. W., “Parameter Optimization for a Pivot Hysteresis Model for Reinforced Concrete Walls with Different Failure Modes,” Earthquake Engng Struct Dyn. (under review)

Flexure Hinge

$$\alpha_F = 0.26 \times \left(\frac{P}{A_g f'_c} \right)^{-0.95} \times \left(\frac{\rho_{wv} f_{y,wv}}{f'_c} \right)^{-0.84} \times \left(\frac{\rho_c f_{y,c}}{f'_c} \right)^{1.7} \times \left(\frac{\rho_{ct} f_{y,ct}}{f'_c} \right)^{-0.31} \times \left(\frac{H}{\ell_w} \right)^{-0.83} + 0.35 \leq 10$$

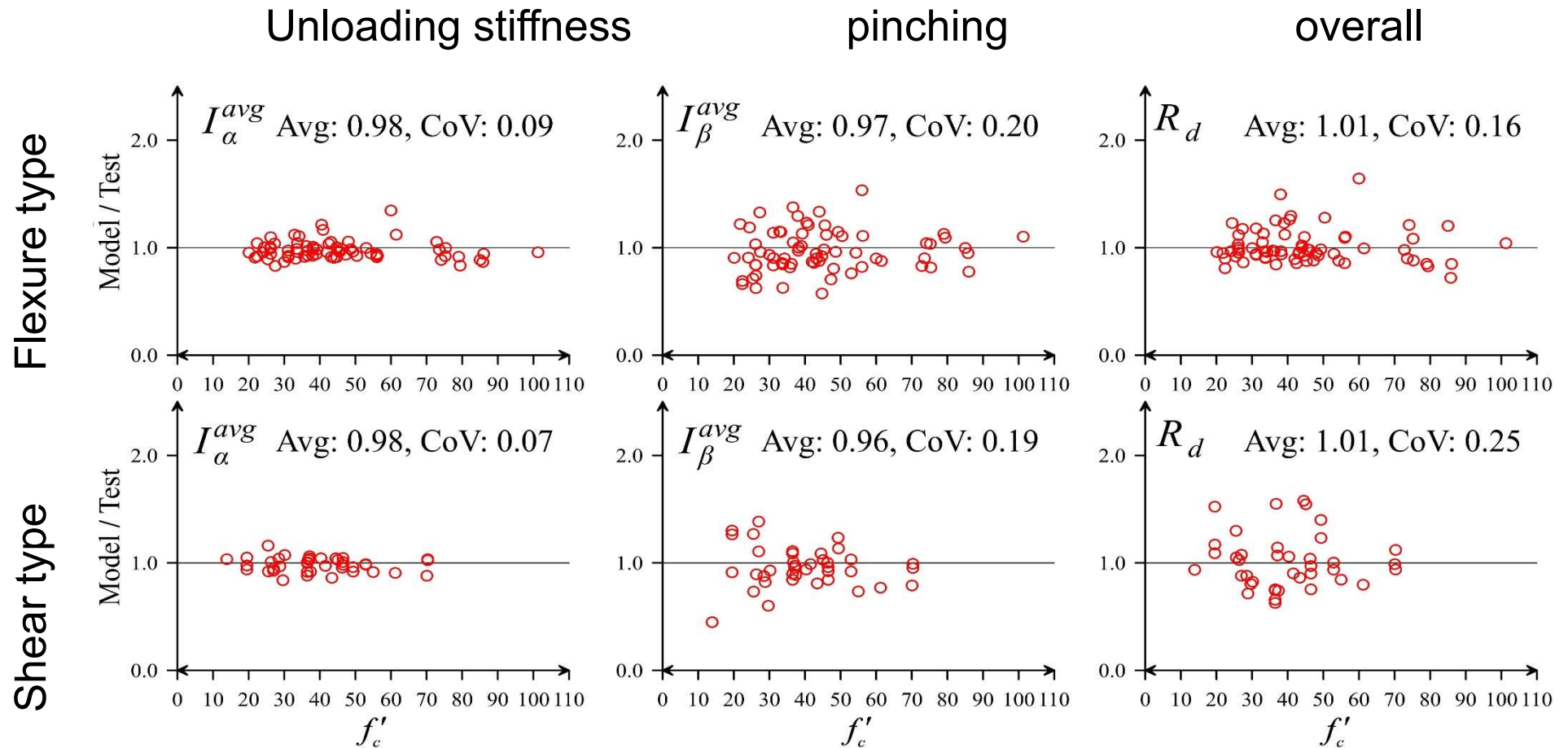
$$\beta_F = 1.3 \times \left(\frac{P}{A_g f'_c} \right)^{0.11} \times \left(\frac{\rho_{wv} f_{y,wv}}{f'_c} \right)^{0.25} \times \left(\frac{H}{\ell_w} \right)^{0.62} \leq 1$$

Shear Hinge

$$\alpha_S = 0.21 \times \left(\frac{P}{A_g f'_c} \right)^{-2.0} \times \left(\frac{\rho_c f_{y,c}}{f'_c} \right)^{1.2} \times \left(\frac{H}{\ell_w} \right)^{-3.0} + 0.68 \leq 10$$

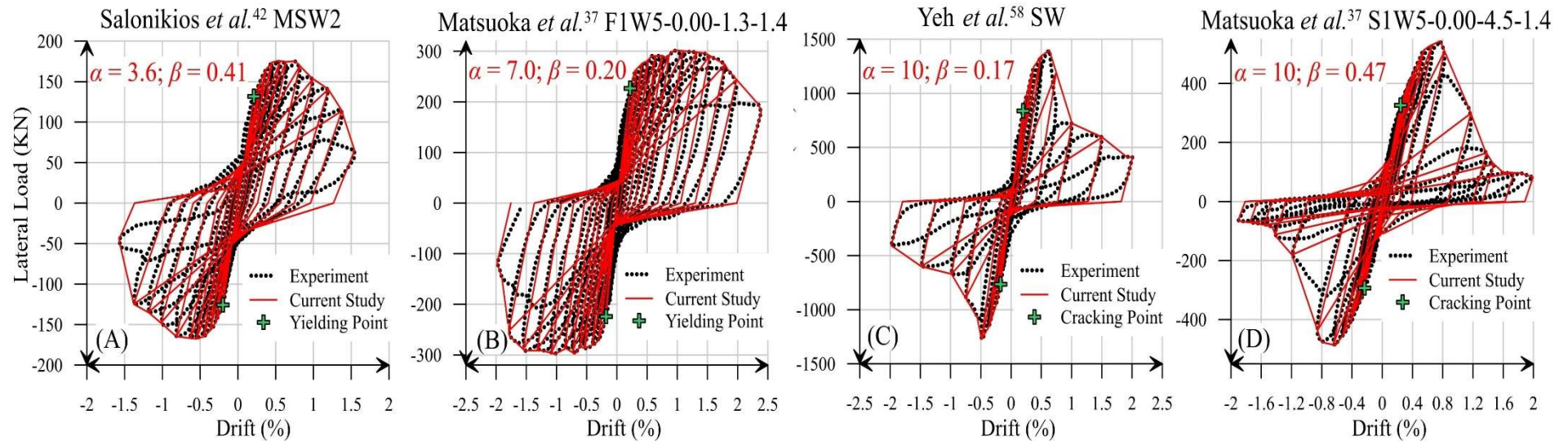
$$\beta_S = 0.10 \times \left(\frac{P}{A_g f'_c} \right)^{0.19} \times \left(\frac{\rho_{wv} f_{y,wv}}{f'_c} \right)^{-0.1} \times \left(\frac{\rho_{wh} f_{y,wh}}{f'_c} \right)^{-0.1} \times \left(\frac{\rho_c f_{y,c}}{f'_c} \right)^{-0.28} \times \left(\frac{\ell_w}{t_e} \right)^{0.51} \times \left(\frac{H}{\ell_w} \right)^{0.53} + 0.01 \leq 1$$

Comparison of Results - Energy Indicator



- All indicators are close to 1 with low CoV.

Comparison of Results



Flexure-Rectangular

Flexure-Barbell

Shear-Rectangular

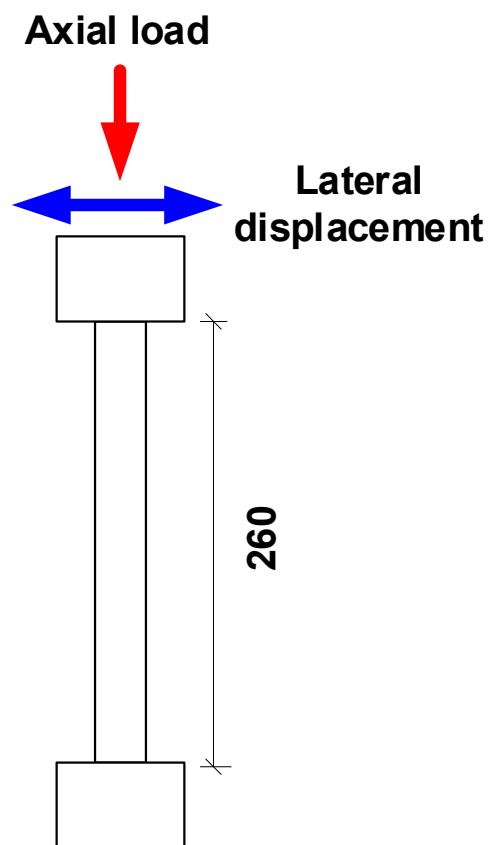
Shear-Barbell

大綱

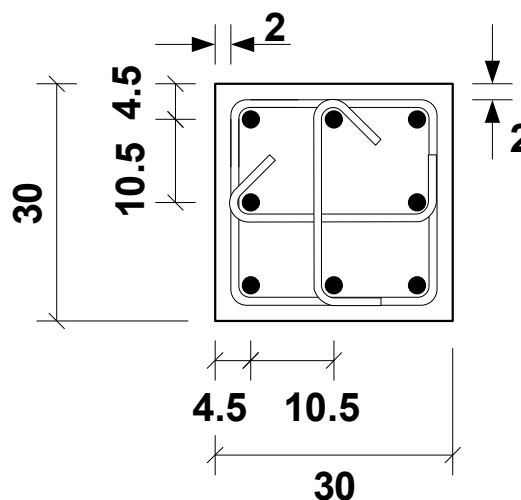
- 前言
- 地震力輸入選擇
- 輔助程式
- **構件遲滯行為模擬**
 - 非線性行為
 - 遲滯模型
 - **實驗比對**
- 性能目標
- 案例說明

Column-cyclic test

- Static cyclic loading test



cyclic loading test



Longi. bar : 8-D19
Hoops : D10@12
Tie : D10@24

column section

$$f'_c = 220 \text{ kgf/cm}^2$$

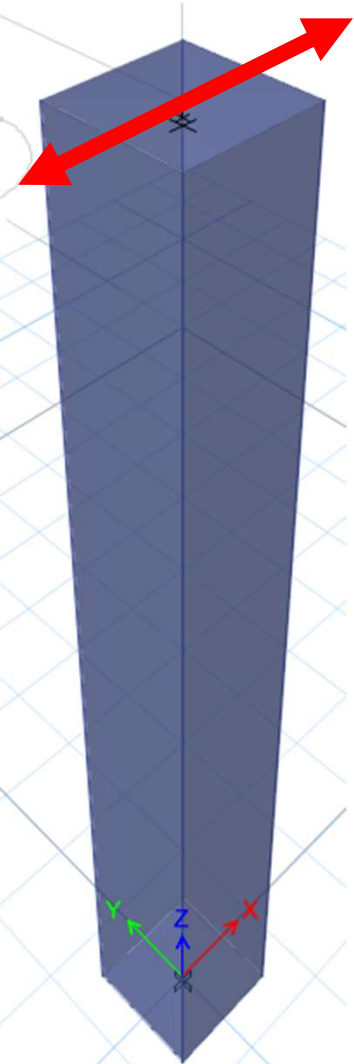
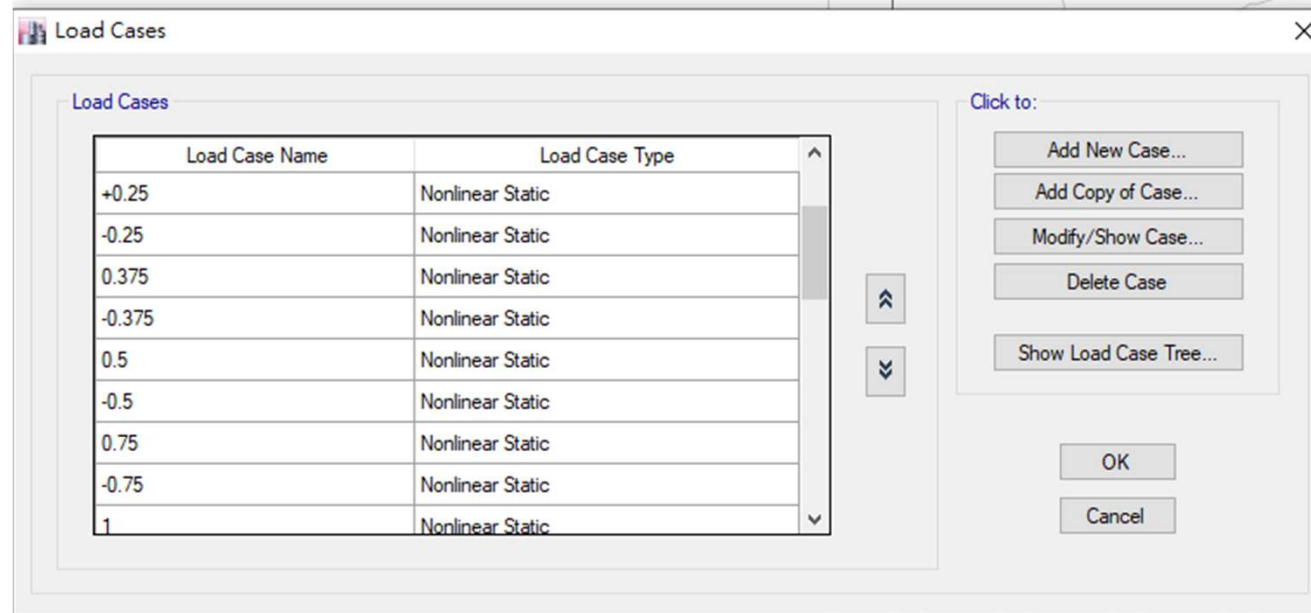
$$f_{y\ell} = 4630 \text{ kgf/cm}^2$$

$$f_{yt} = 3569 \text{ kgf/cm}^2$$

$$P \approx 0.12 f'_c A_g$$

ETABS-column model

- Load cases.



Default hinge parameter

Hinge Property Data for Story1C1-M3 - Moment M3

Displacement Control Parameters

Point	Moment/SF	Rotation/SF
E-	0	-0.0702
D-	-1	-0.0337
C-	-1	-0.0078
B-	-0.75	0
A	0	0
B	0.75	0
C	1	0.0078
D	1	0.0337
E	0	0.0702

☐ Symmetric

Type

☒ Moment - Rotation

☐ Moment - Curvature

Hinge Length

☒ Relative Length

Hysteresis Type and Parameters

Hysteresis Isotropic

No Parameters Are Required For This Hysteresis Type

Load Carrying Capacity Beyond Point E

☒ Drops To Zero

☐ Is Extrapolated

Scaling for Moment and Rotation

☐ Use Yield Moment

Moment SF

Positive	Negative
127446.12	127446.12

kN-mm

☐ Use Yield Rotation (Steel Objects Only)

Rotation SF

Positive	Negative
1	1

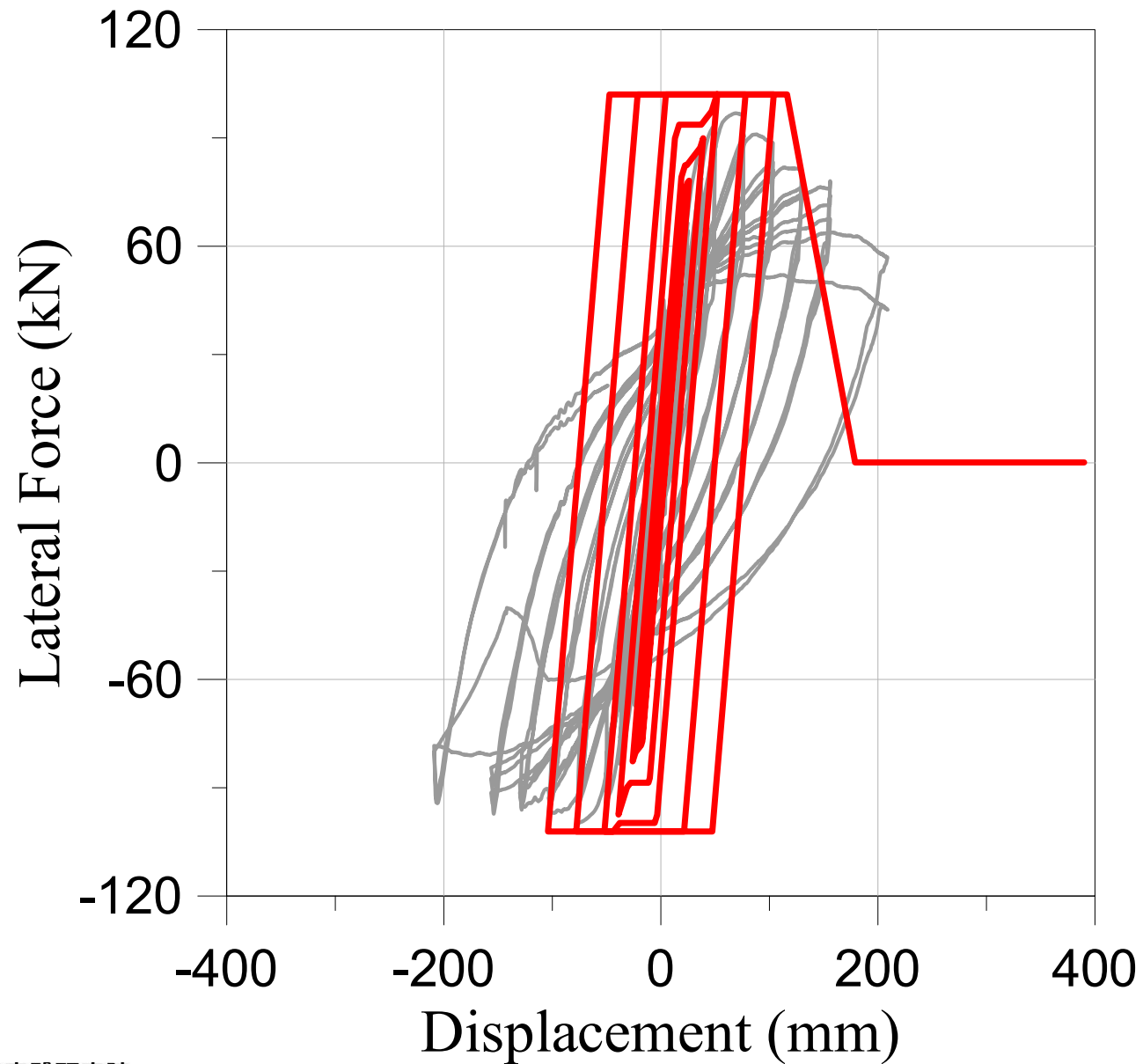
Acceptance Criteria (Plastic Rotation/SF)

	Positive	Negative
Immediate Occupancy	100	-100
Life Safety	200	-200
Collapse Prevention	300	-300

☐ Show Acceptance Criteria on Plot

OK Cancel

Simulation result



Pivot parameter

Hinge Property Data for Story1C1-M3 - Moment M3

Displacement Control Parameters

Point	Moment/SF	Rotation/SF
E-	0	-0.0702
D-	-1	-0.0337
C-	-1	-0.0078
B-	-0.75	0
A	0	0
B	0.75	0
C	1	0.0078
D	1	0.0337
E	0	0.0702

☐ Symmetric

Type

☒ Moment - Rotation

☐ Moment - Curvature

Hinge Length

☒ Relative Length

Hysteresis Type and Parameters

Hysteresis	Pivot
α_1	10
α_2	10
β_1	0.6857
β_2	0.6857
η	0

Load Carrying Capacity Beyond Point E

☒ Drops To Zero

☐ Is Extrapolated

Scaling for Moment and Rotation

☐ Use Yield Moment

Moment SF

Positive	Negative
127446.12	127446.12

kN-mm

☐ Use Yield Rotation (Steel Objects Only)

Rotation SF

Positive	Negative
1	1

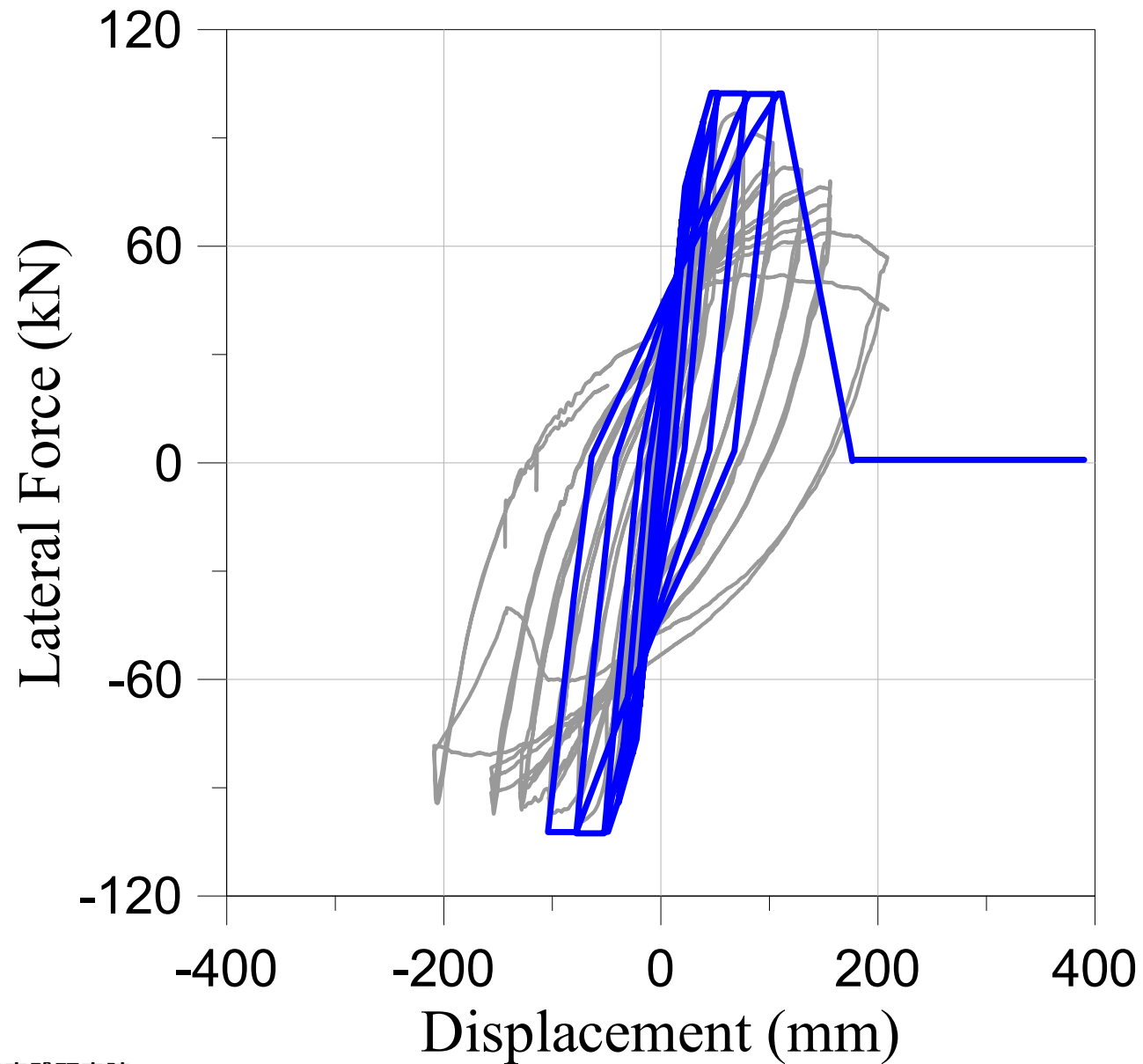
Acceptance Criteria (Plastic Rotation/SF)

	Positive	Negative
Immediate Occupancy	100	-100
Life Safety	200	-200
Collapse Prevention	300	-300

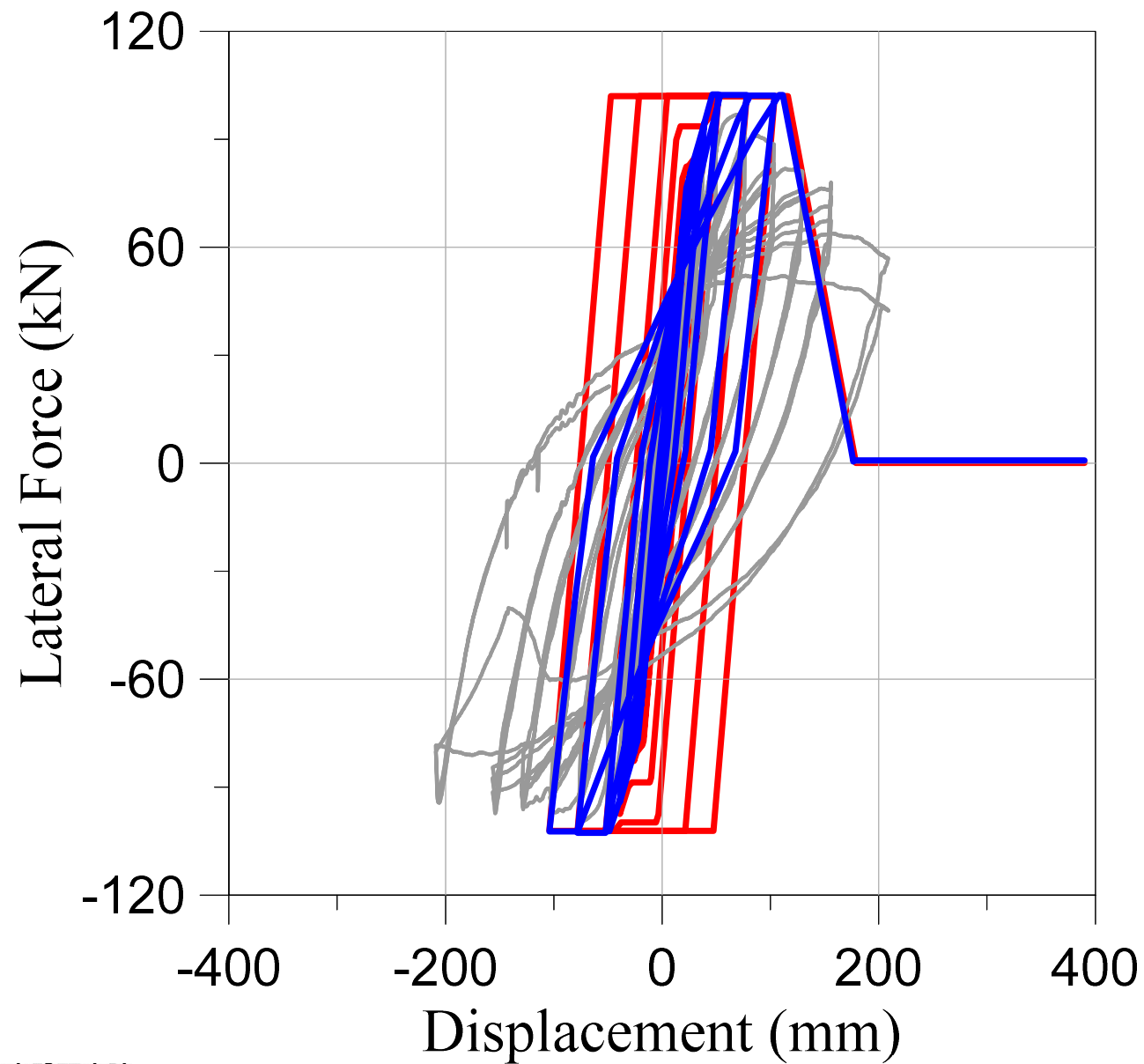
☐ Show Acceptance Criteria on Plot

OK Cancel

Simulation result



Comparison



Shaking Table Test



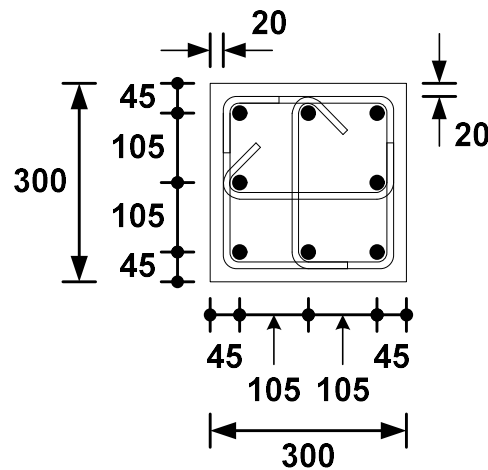
**Three-story
specimen**

**Seven-story
specimen**

Specimen Design

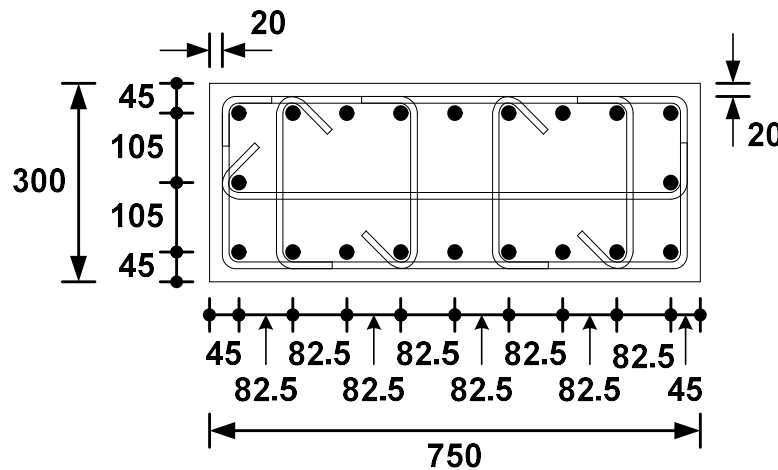
1. Detailing (90° hoop, 90-135° tie)
2. Not compatible strong-column weak-beam design.

Column A



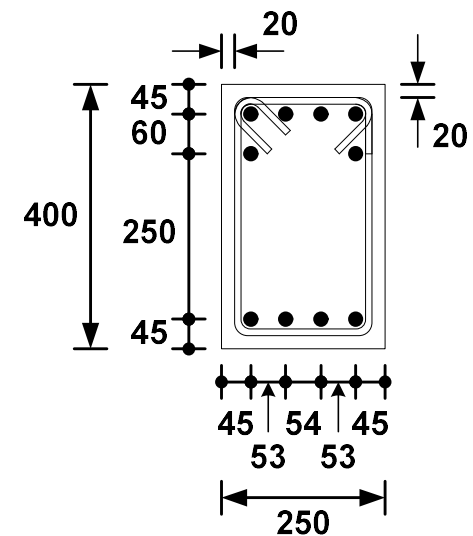
Longitudinal Rebar: 8-D19
Stirrups: D10@120
Crossties: D10@240

Column B

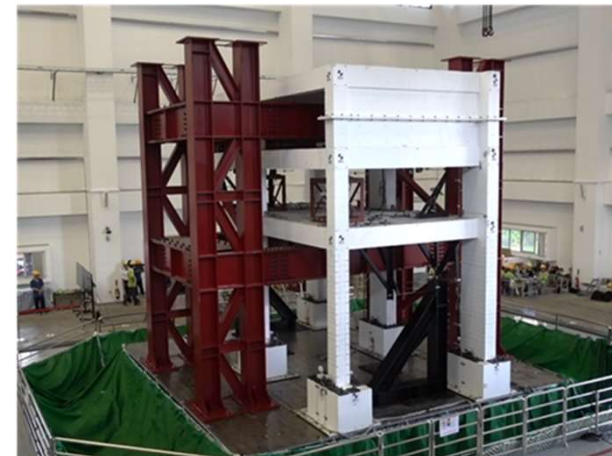



Longitudinal Rebar: 20-D19
Stirrups: D10@120
Crossties: D10@240

Beam



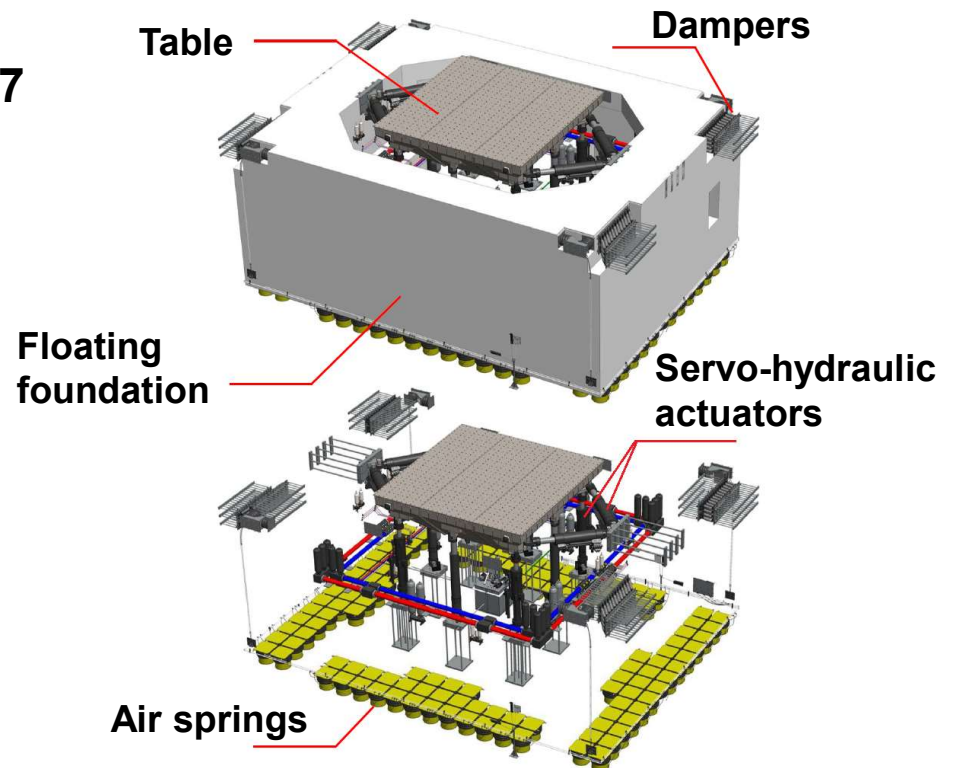
Longitudinal Rebar: 10-D19
Stirrups: D10@150



NAR Labs 國家實驗研究院
National Applied Research Laboratories

Long Stroke / High Velocity Earthquake Simulator

NCREE Tainan laboratory opened in 2017

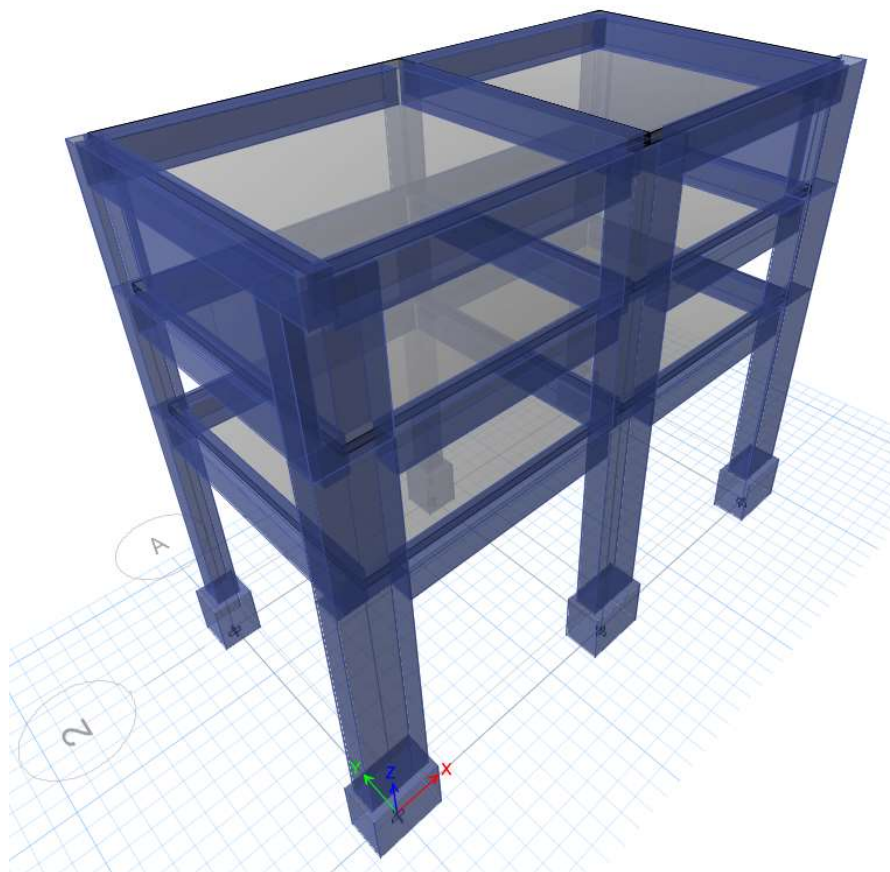


Site	Specifications of the earthquake simulator				
	Size (m)	Max Stroke (m)	Max Velocity (m/s)	Max Acceleration (g)	Max payload (ton)
Tainan Lab	8 x 8	H±1 V±0.4	H±2 V±1	H±2.5 V±3.0	250
Taipei Lab	5 x 5	H±0.25 V±0.1	H±1 V±0.5	H±1.5 V±1.0	50

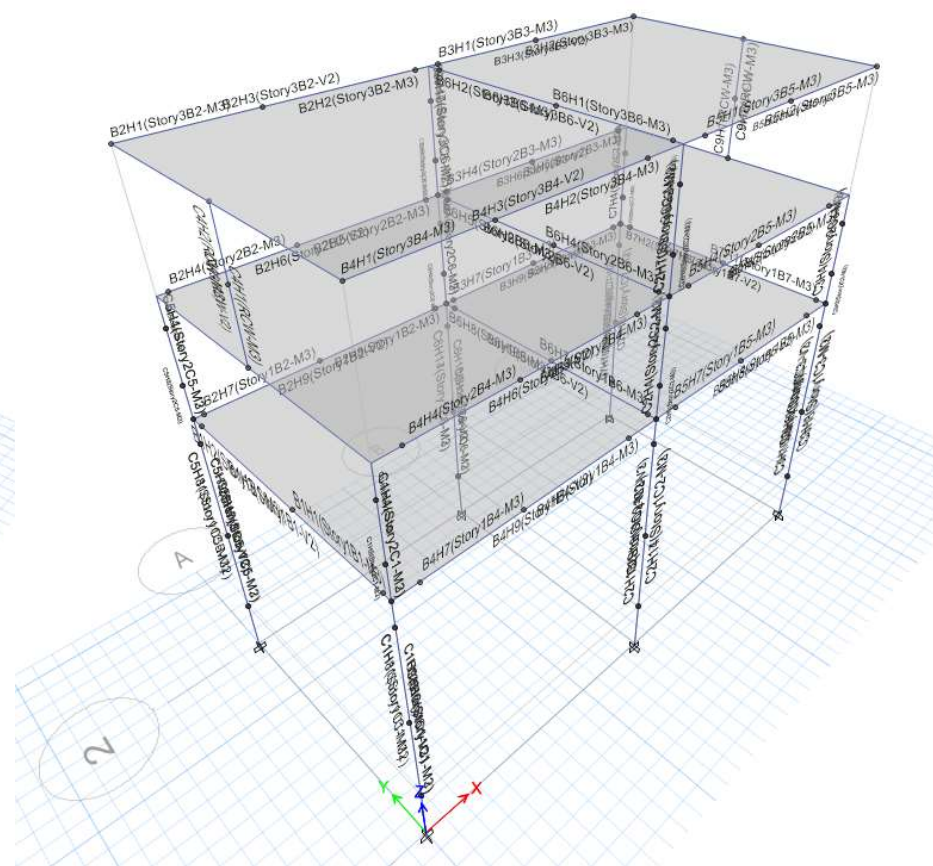
Input Ground Motion

Run	EQ／Target PGA	Measured PGA	Measured PGV
1	(Near-fault) TCU 052／350 gal	331 gal	65 cm/sec
2	(Far-fault) CHY 047／420 gal	413 gal	33.5 cm/sec
3	(Near-fault) TCU 052／800 gal	944 gal	142.6 cm/sec
4	(Near-fault) TCU 052／1000 gal	1191 gal	180.7 cm/sec

Numerical Model

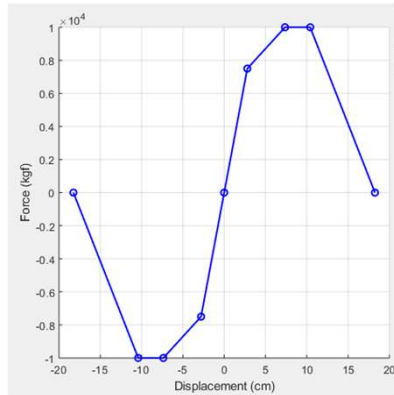
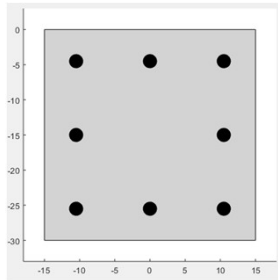


3D View of model

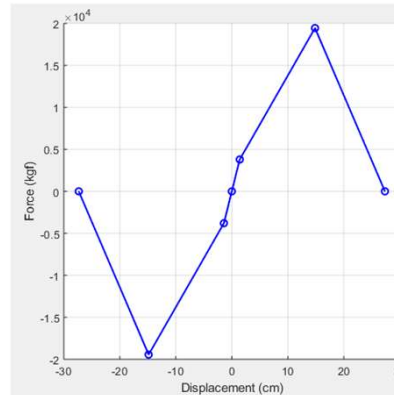


Nonlinear hinge assignment

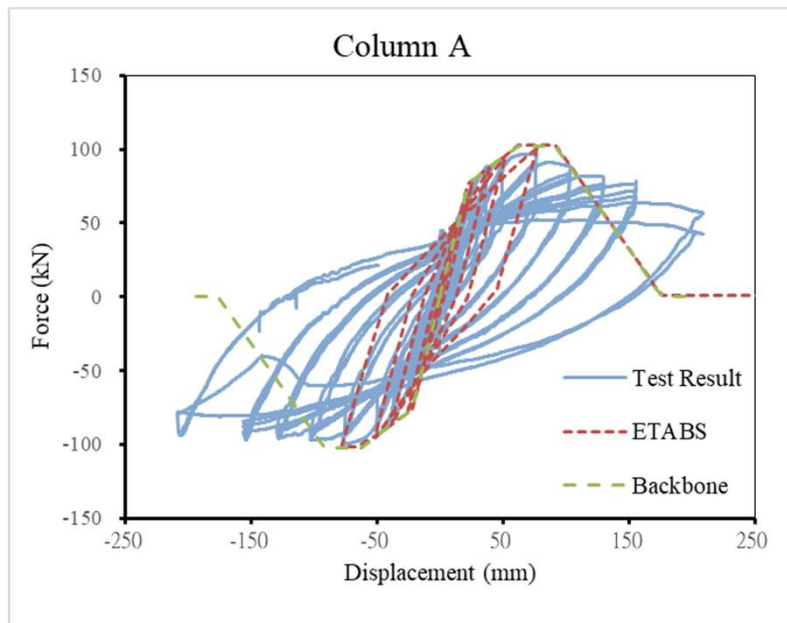
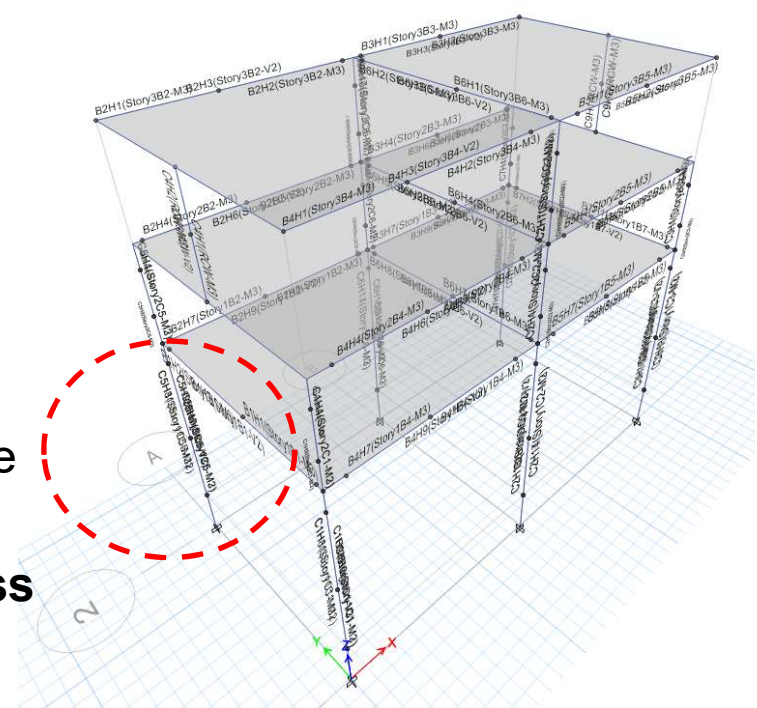
Column A (Flexure)



M2 Nonlinear Hinge



V3 Nonlinear Hinge



Elastic stiffness

$$I_{eff} = 0.3I_g$$

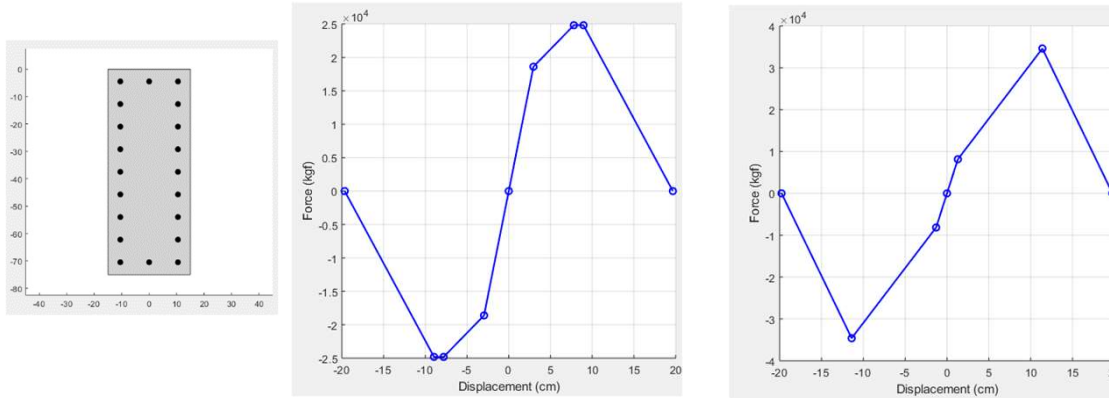
Secant stiffness

$$I_{scan} = 0.5 I_{eff}$$

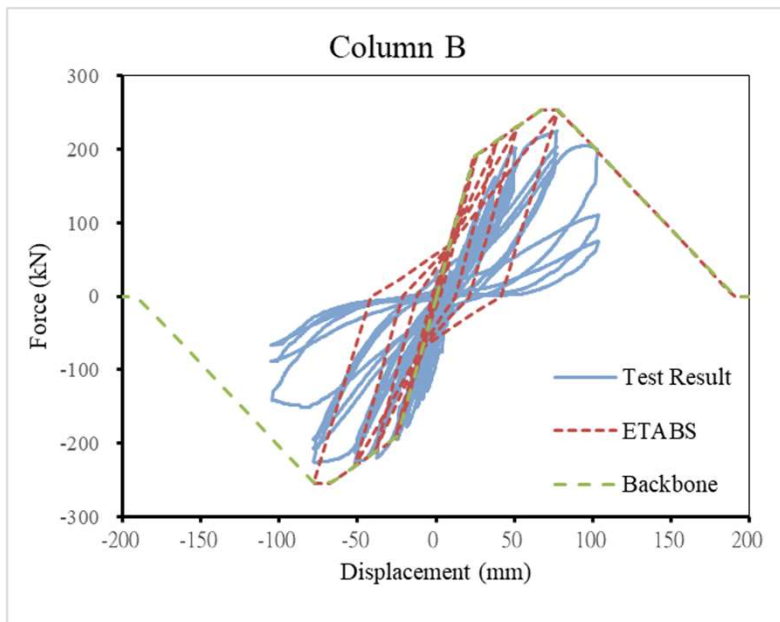
Pivot parameters

α	β	η
10	0.566	0

Column B (Flexure-Shear)



M2 Nonlinear Hinge V3 Nonlinear Hinge



Elastic stiffness

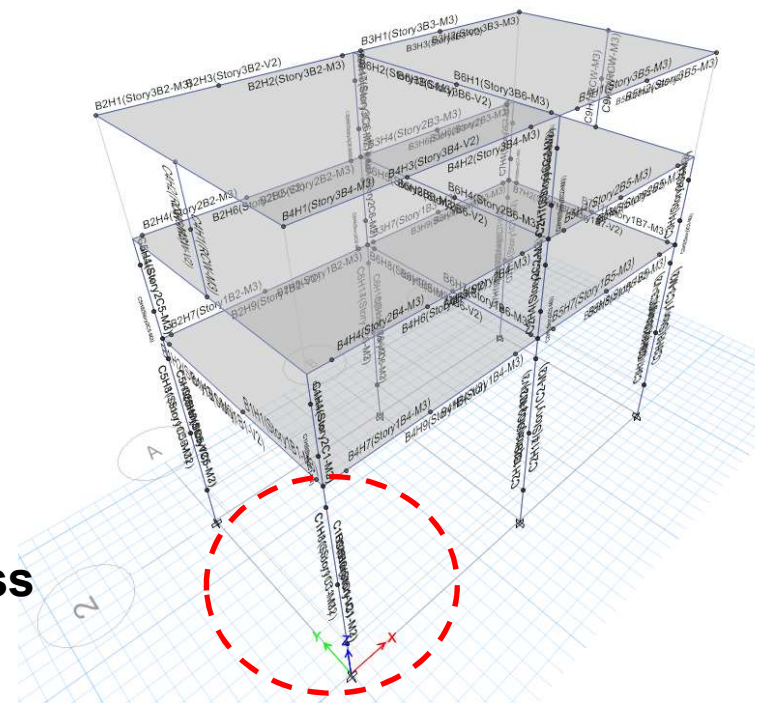
$$I_{eff} = 0.3I_g$$

Secant stiffness

$$I_{scan} = 0.5 I_{eff}$$

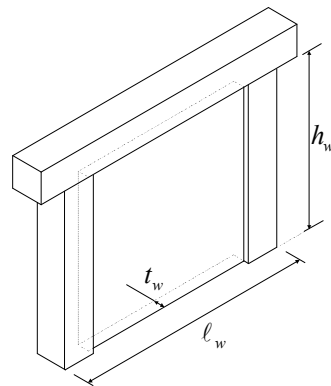
Pivot parameters

α	β	η
10	0.534	0

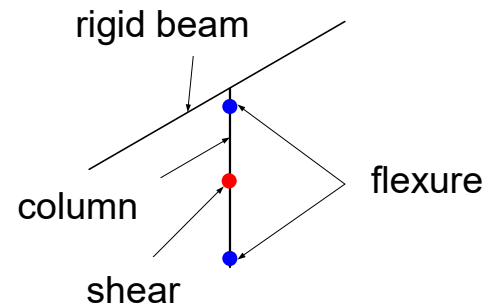


Shear Wall

Equivalent Area Column Model



(a) Shear wall



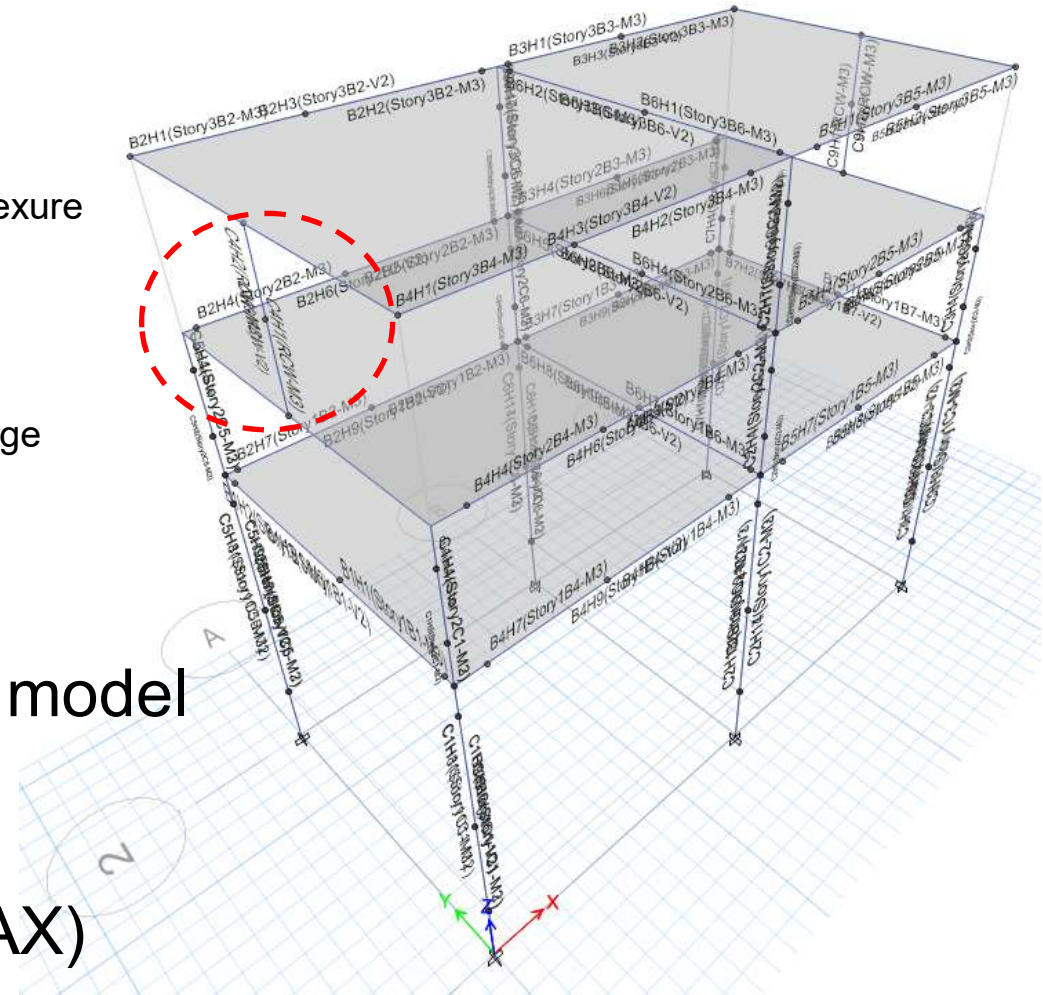
(b) Nonlinear hinge

Shear strength:

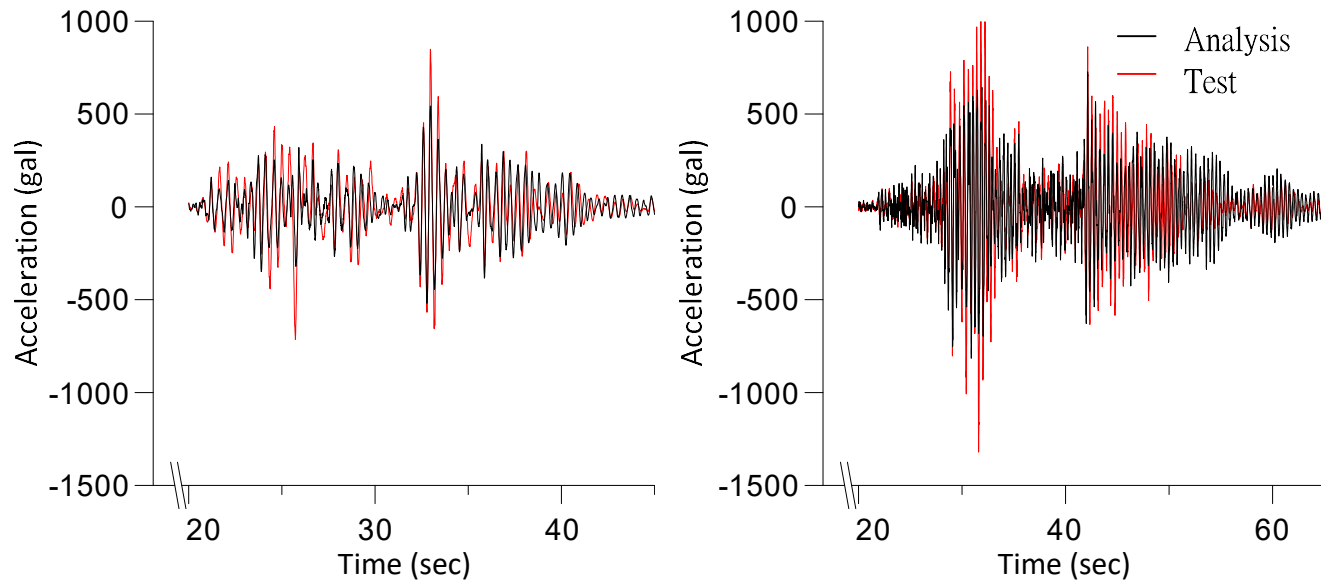
Softened Strut-and-tie model

Flexural strength:

Sectional Analysis (BIAX)

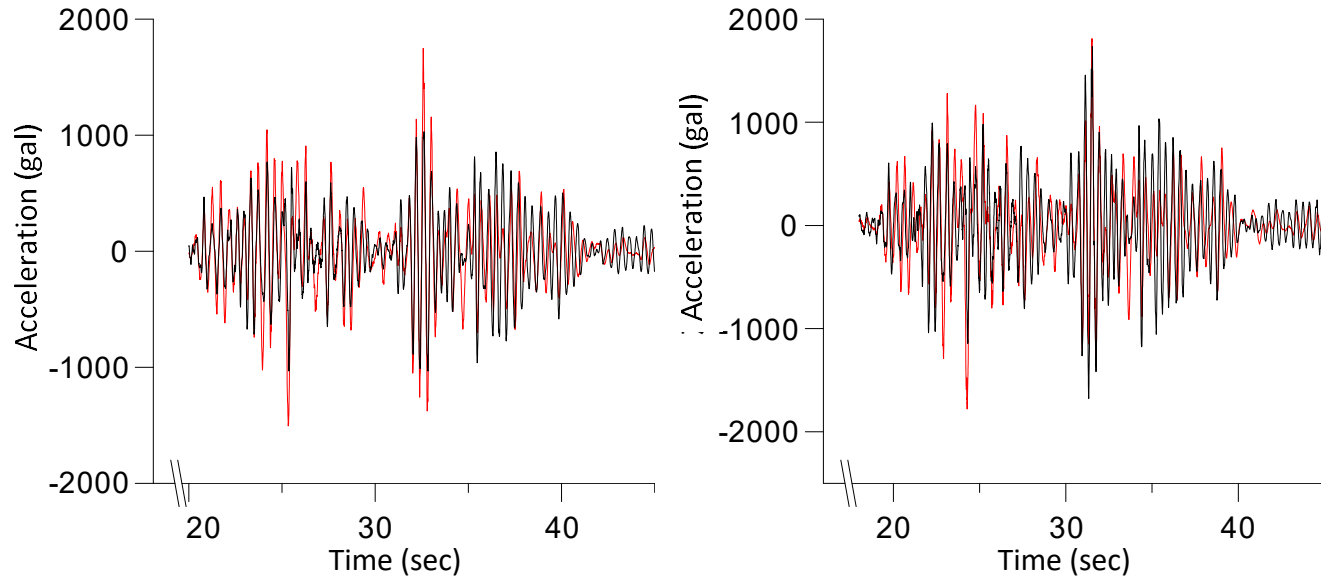


Analysis Result-Roof Acceleration



(a)TCU 052/350 gal

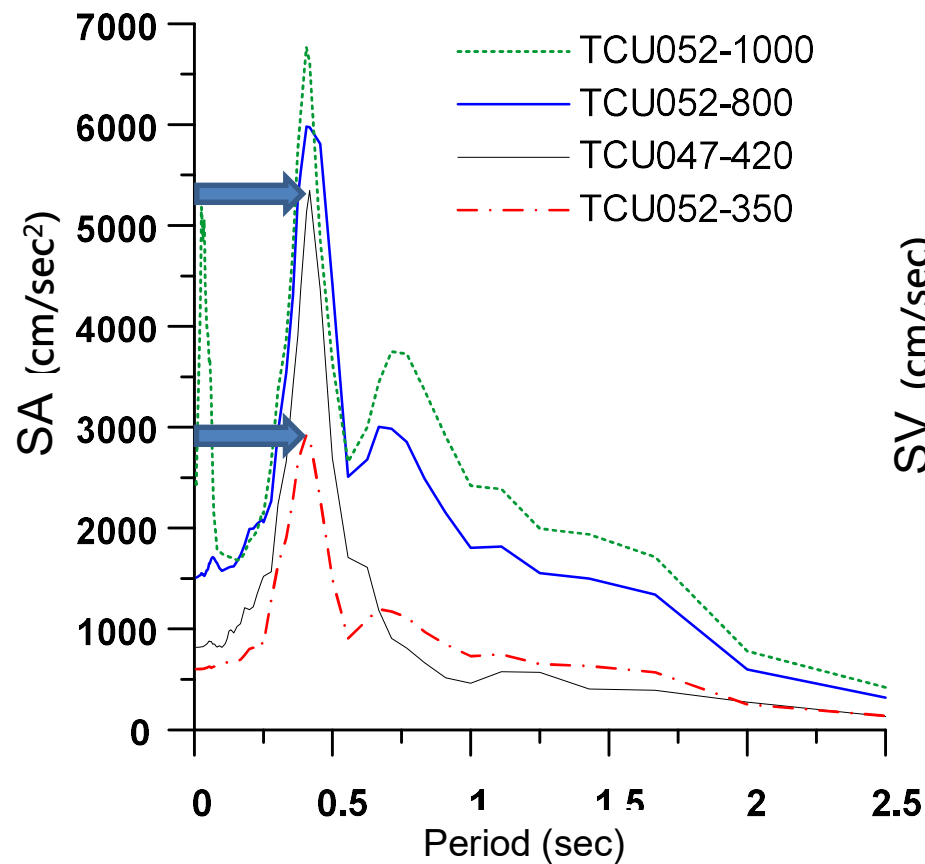
(b)CHY 047/420 gal



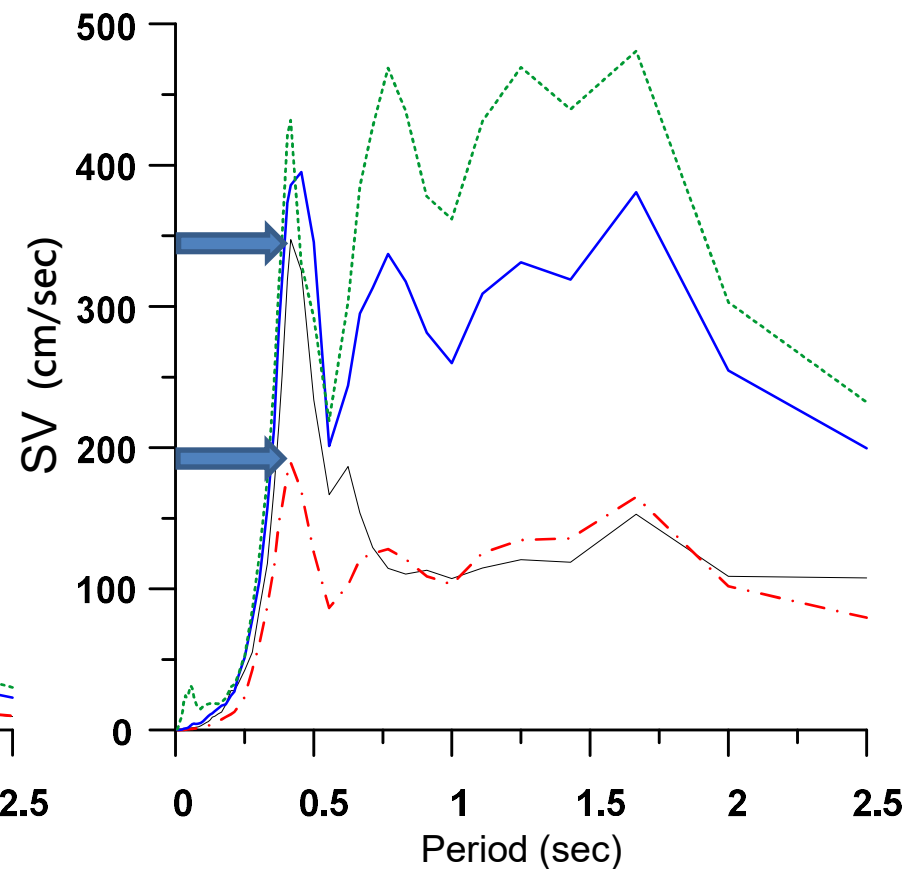
(c)TCU 052/800 gal

(d)TCU 052/1000 gal

Analysis Result-Roof Spectrum



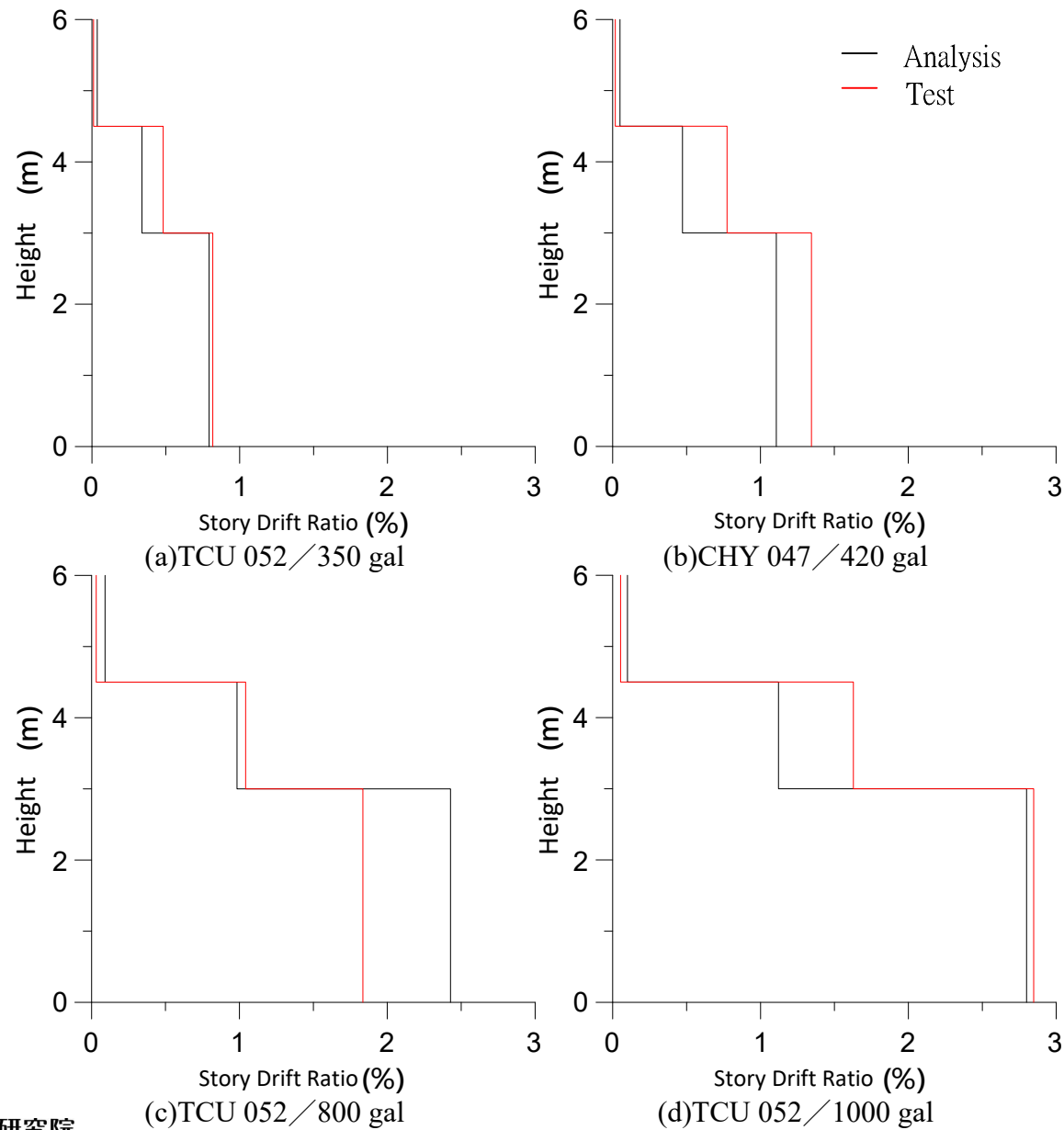
(b) acceleration spectrum



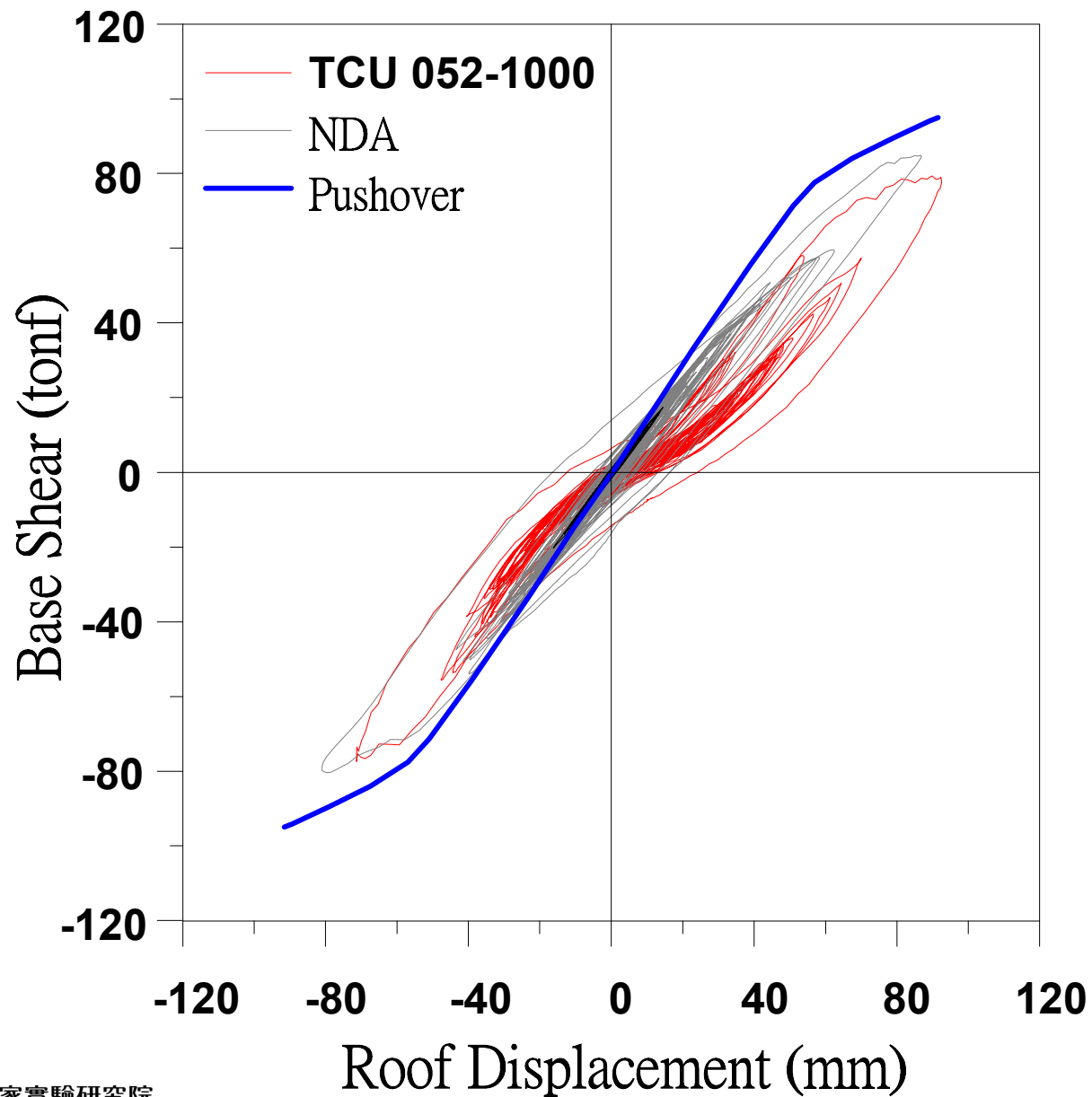
(b) velocity spectrum

	Measured Period	Analysis period
1 st mode(X)	0.397 sec	0.405 sec
2 nd mode(Y)	0.055 sec	0.054 sec

Analysis Results-Story Drift Ratio



Analysis Results

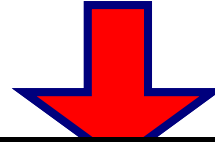


大綱

- 前言
- 地震力輸入選擇
- 輔助程式
- 構件遲滯行為模擬
- **性能目標**
- 案例說明

校舍結構之性能目標

	性能目標地表加速度 A_p		A_T
$I=1.25$ (一般校舍)	V_{\max}	$D_R^T = 2.0\%$	$0.4S_{DS}$
$I=1.5$ (緊急避難用)	$0.80V_{\max}$	$D_R^T = 1.0\%$	$0.4S_{DS}$



	性能目標地表加速度 A_p			A_T
$I=1.25$ (一般校舍)	V_{\max}	$D_R^T = 2.0\%$	任一構件發生 軸力破壞	$0.4S_{DS}$
$I=1.5$ (緊急避難用)	$0.80V_{\max}$	$D_R^T = 1.0\%$	任一構件發生 軸力破壞	$0.4S_{DS}$

性能目標

- 構件準則

- 為避免垂直承載構件若發生嚴重破壞，恐導致結構物發生連鎖性倒塌，故對於構件所採用之性能準則，規定以垂直承載構件不得發生軸向破壞或完全喪失側向強度。

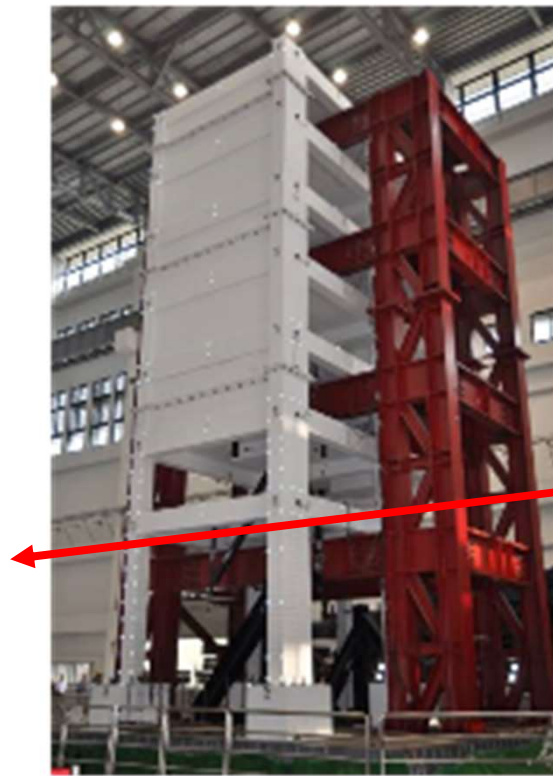
- 整體準則

用途係數	性能目標
第一類及第二類建築($I=1.5$)	$D_r^T = 1\%$
第三類建築($I=1.25$)	$D_r^T = 2\%$
第四類建築($I=1.0$)	$D_r^T = 2.5\%$

大綱

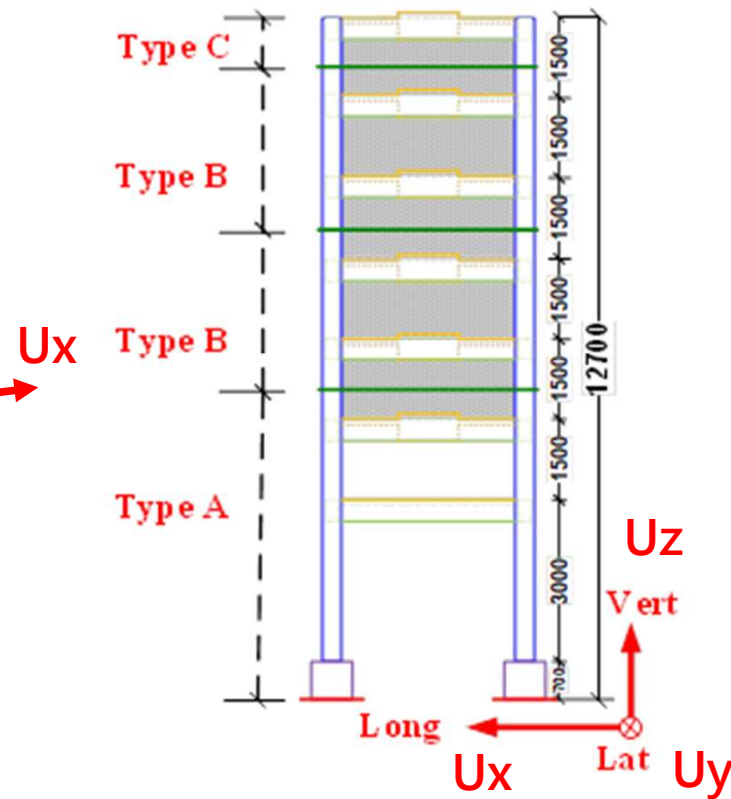
- 前言
- 地震力輸入選擇
- 輔助程式
- 構件遲滯行為模擬
- 性能目標
- 案例說明

案例說明- 1/2 縮尺 7 層樓 RC 構架試體

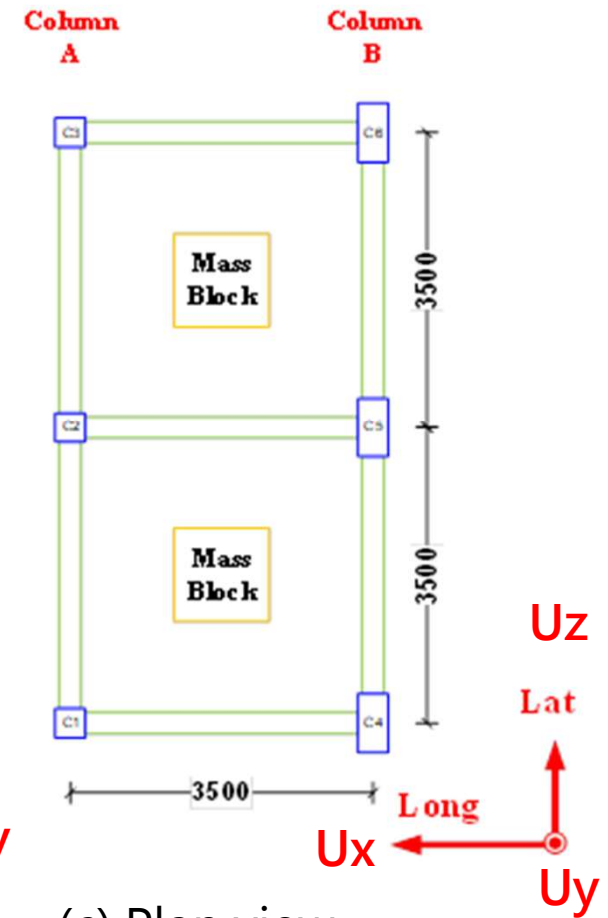


(a) Specimen

Unit: mm



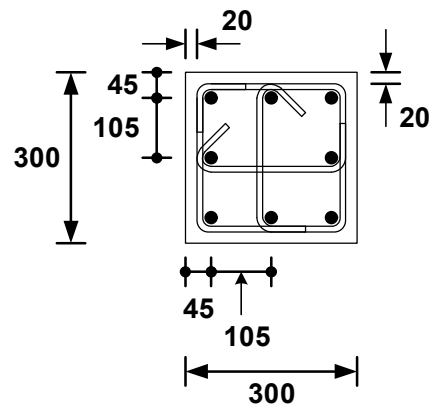
(b) elevation



(c) Plan view

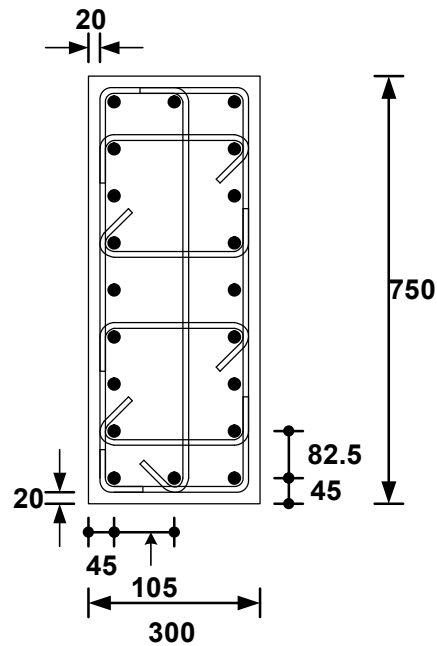
梁柱構件

Column A



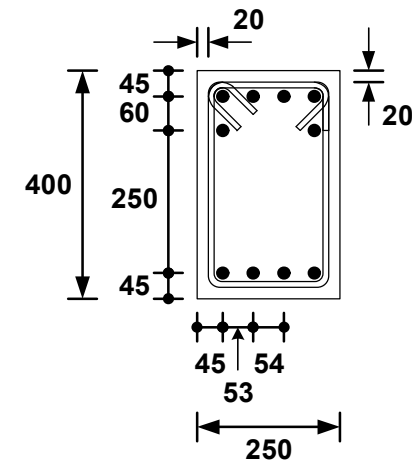
Longitudinal Rebar: 8-D19
Stirrups: D10@120
Crossties: D10@240

Column B



Longitudinal Rebar: 20-D19
Stirrups: D10@120
Crossties: D10@240

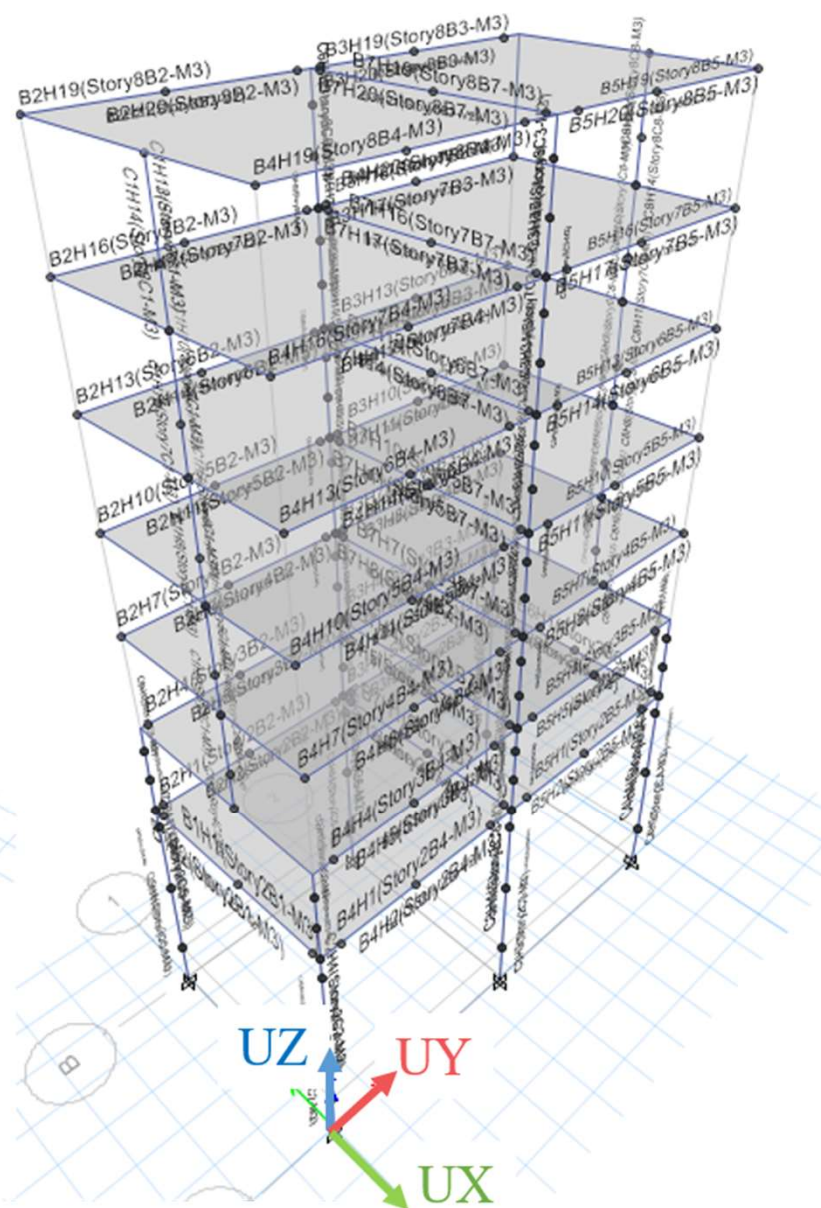
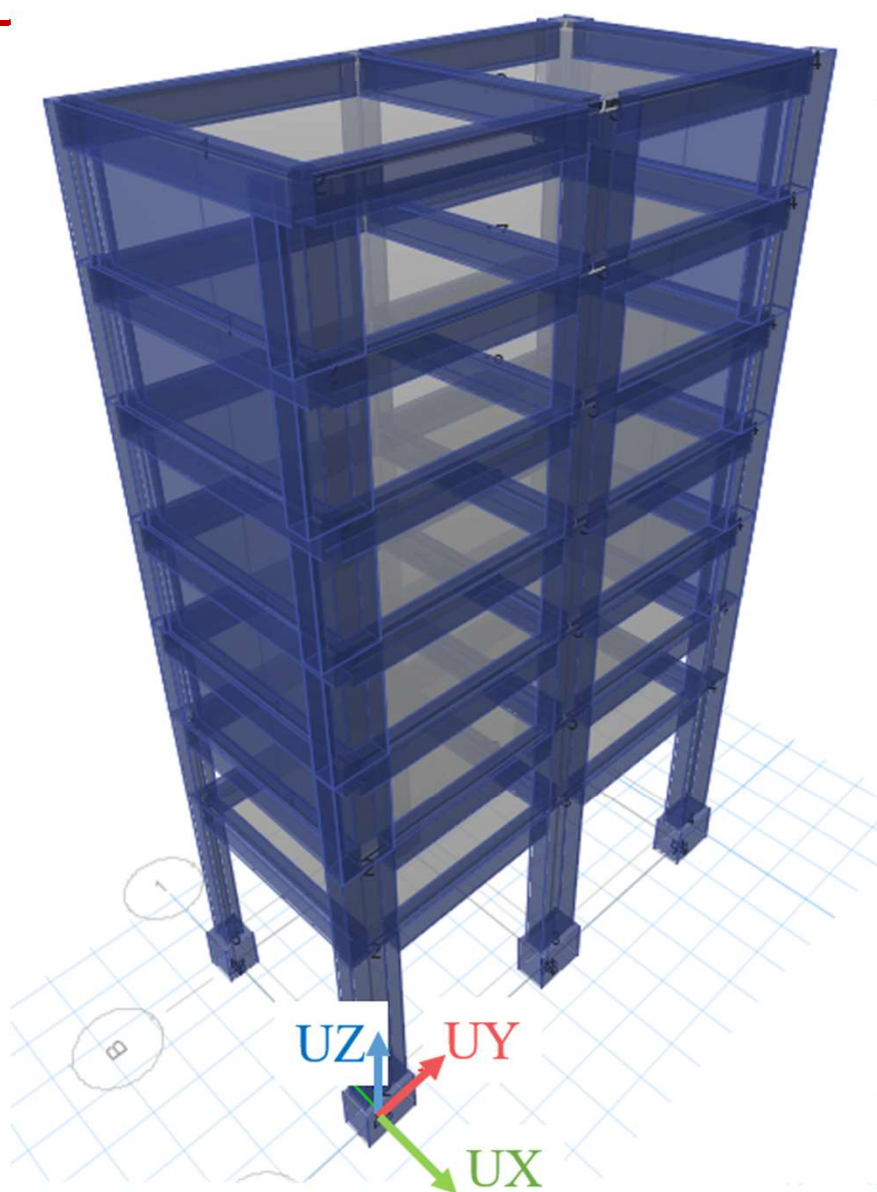
Beam



Longitudinal Rebar: 10-D19
Stirrups: D10@150

Section types (Unit: mm)

TEASDA 分析模型



各樓層載重

- 3F – Roof
 - 額外質量塊 $1100 \times 1100 \times 400 \approx 1160 \text{ kgf}$ (每層兩塊)
- 自重
- 結構週期

模態	週期	模態參與質量比		
	(sec)	Sum UX	Sum UY	Sum RZ
1	0.66	0.72	0.00	0.17
2	0.628	0.72	0.96	0.17
3	0.472	0.83	0.96	0.94

樓層	質量 (kg)
Roof	18128.19
Story7	21681.28
Story6	21501
Story5	21501
Story4	21501
Story3	19374.55
Story2	19347.52
Story1	5181.87
Base	1775.95

TEASDA Input 檔 - RC 柱

• 柱斷面-1

Col Prop.

Section	fc	fyl	fyt	cover	hoop3	spacing3	num hoop3	hoop2	spacing2	num hoop2
1C30	238	4630	3569	2	3	14.4	3	3	14.4	3
1C75	238	4630	3569	2	3	18	6	3	14.4	3

Section

1C30				
30	30			
		4.5	15	25.5
4.5	4630	6	6	6
15	4630	6		6
25.5	4630	6	6	6

1C75				
75	30			
		4.5	15	25.5
4.5	4630	6	6	6
12.75	4630	6		6
21	4630	6		6
29.25	4630	6		6
37.5	4630	6		6
45.75	4630	6		6
54	4630	6		6
62.25	4630	6		6
70.5	4630	6	6	6

TEASDA Input 檔 - RC 柱

• 柱斷面-2

Col Data

Label	Story	Section	H	Hn3	FromBottom3	Hn2	FromBottom2
C3	Story8	1C75	150	110	0	110	0
C6	Story8	1C30	150	110	0	110	0
C1	Story8	WRF	150	110	0	110	0
C8	Story8	WRF	150	110	0	110	0
C3	Story7	1C75	150	110	0	110	0
C6	Story7	1C30	150	110	0	110	0
C1	Story7	W6F	150	110	0	110	0
C8	Story7	W6F	150	110	0	110	0
C3	Story6	1C75	150	110	0	110	0
C6	Story6	1C30	150	110	0	110	0
C1	Story6	W5F	150	110	0	110	0
C8	Story6	W5F	150	110	0	110	0
C3	Story5	1C75	150	110	0	110	0
C6	Story5	1C30	150	110	0	110	0
C1	Story5	W4F	150	110	0	110	0
C8	Story5	W4F	150	110	0	110	0
C3	Story4	1C75	150	110	0	110	0
C6	Story4	1C30	150	110	0	110	0
C1	Story4	W3F	150	110	0	110	0
C8	Story4	W3F	150	110	0	110	0
C2	Story3	1C75	150	110	0	110	0
C3	Story3	1C75	150	110	0	110	0
C4	Story3	1C75	150	110	0	110	0
C5	Story3	1C30	150	110	0	110	0
C6	Story3	1C30	150	110	0	110	0
C7	Story3	1C30	150	110	0	110	0
C2	Story2	1C75	300	260	0	260	0
C3	Story2	1C75	300	260	0	260	0
C4	Story2	1C75	300	260	0	260	0
C5	Story2	1C30	300	260	0	260	0
C6	Story2	1C30	300	260	0	260	0
C7	Story2	1C30	300	260	0	260	0

Axial Load

Story	Label	Loc	P
Story8	C3	0	-3801.26
Story8	C6	0	-2924.16
Story8	C7	0	-1545.12
Story8	C1	0	-5754.3
Story8	C8	0	-4530.7
Story7	C3	0	-7591.97
Story7	C6	0	-5927.16
Story7	C1	0	-11491.65
Story7	C8	0	-11859.88
Story6	C3	0	-11383.31
Story6	C6	0	-9089.13
Story6	C1	0	-17197.59
Story6	C8	0	-17515.74
Story5	C3	0	-15172.22
Story5	C6	0	-12270.11
Story5	C1	0	-22886.53
Story5	C8	0	-23172.02
Story4	C3	0	-18958.61
Story4	C6	0	-15477.34
Story4	C1	0	-28558.06
Story4	C8	0	-28821.98
Story3	C2	0	-17559.87
Story3	C3	0	-22261.45
Story3	C4	0	-17191.32
Story3	C5	0	-15106.28
Story3	C6	0	-18432.32
Story3	C7	0	-15723.43
Story2	C2	0	-20658.76
Story2	C3	0	-26414.3
Story2	C4	0	-20292.56
Story2	C5	0	-17197.97
Story2	C6	0	-21767.6
Story2	C7	0	-17808.07
Story1	C2	0	-21404.22
Story1	C3	0	-27159.76
Story1	C4	0	-21038.01
Story1	C5	0	-17636.48
Story1	C6	0	-22206.11
Story1	C7	0	-18246.57

TEASDA Input 檔 - RC 梁

• 梁斷面

Beam Prop.

Section ▾	L ▾	fc ▾	fyl ▾	fyt ▾	cover ▾	hoop ▾	spacing ▾	num hoop ▾	TR ▾
B1F	350	238	4630	3569	2	3	15	2	0

Section

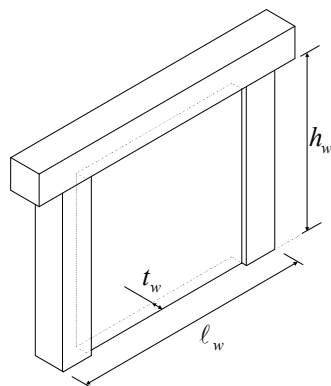
B1F					
40	25				
		4.5	9.8	15.2	20.5
4.5	4630	6	6	6	6
10.5	4630	6			6
35.5	4630	6	6	6	6

Beam Data

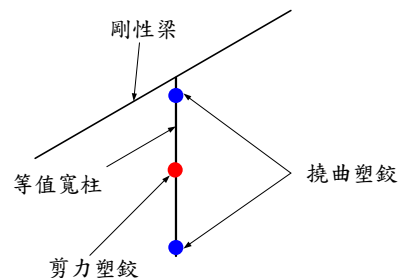
Label ▾	Story ▾	Section ▾
B2	Story8	B1F
B3	Story8	B1F
B4	Story8	B1F
B5	Story8	B1F
B7	Story8	B1F
B2	Story7	B1F
B3	Story7	B1F
B4	Story7	B1F
B5	Story7	B1F
B7	Story7	B1F
B2	Story6	B1F
B3	Story6	B1F
B4	Story6	B1F
B5	Story6	B1F
B7	Story6	B1F
B2	Story5	B1F
B3	Story5	B1F
B4	Story5	B1F
B5	Story5	B1F
B7	Story5	B1F
B2	Story4	B1F
B3	Story4	B1F
B4	Story4	B1F
B5	Story4	B1F
B7	Story4	B1F
B2	Story3	B1F
B3	Story3	B1F
B4	Story3	B1F
B5	Story3	B1F
B7	Story3	B1F
B1	Story2	B1F
B2	Story2	B1F
B3	Story2	B1F
B4	Story2	B1F
B5	Story2	B1F
B6	Story2	B1F
B7	Story2	B1F

TEASDA Input 檔 - RC 牆

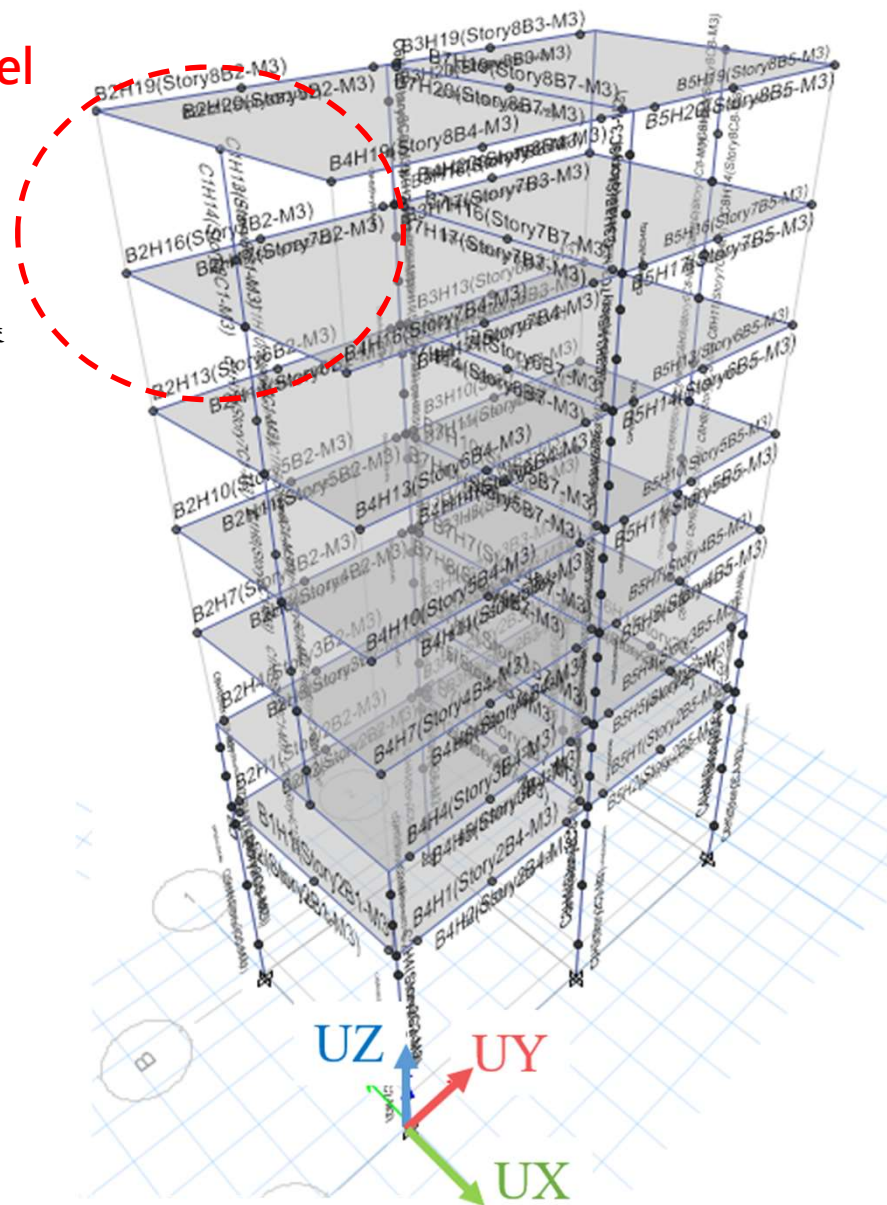
Equivalent Area Column Model



(a) 剪力牆



(b) 等值寬柱



TEASDA Input 檔 - RC 牆

- 牆斷面-1

RC Wall Prop.

Section	fc	H	Hn	lv	tw	P	db	fy	dbh	fyh	nh	dbv	fyv	nv	Num Opening
W3F	238	150	110	380	15	-28558.1	6	4630	3	2855	3	44	2855	44	0
W4F	238	150	110	380	15	-22886.5	6	4630	3	2855	3	44	2855	44	0
W5F	238	150	110	380	15	-17197.6	6	4630	3	2855	3	44	2855	44	0
W6F	238	150	110	380	15	-11491.7	6	4630	3	2855	3	44	2855	44	0
WRF	238	150	110	380	15	-5754.3	6	4630	3	2855	3	44	2855	44	0

TEASDA Input 檔 - RC 牆

• 牆斷面-2

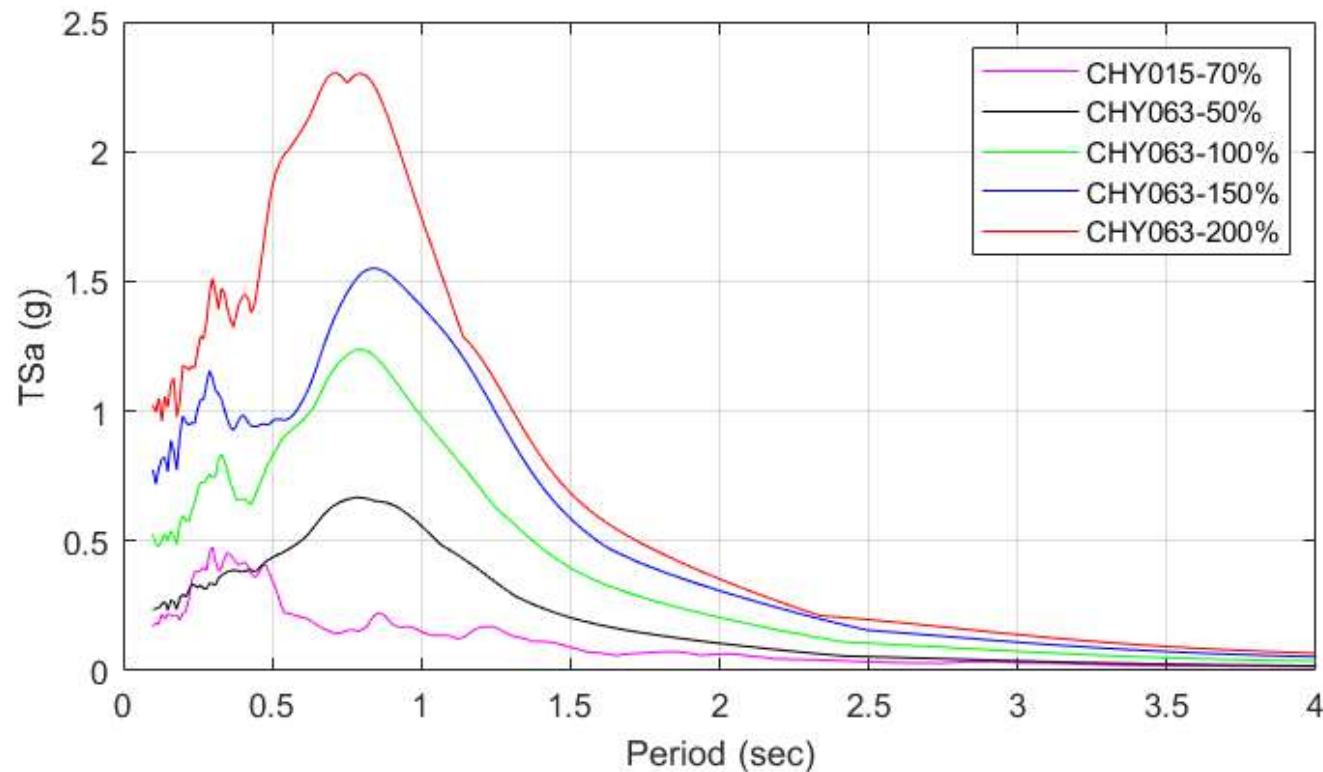
Section

W3F														
30	30	350	15	380	75									
		4.5	12.75	21	27	29.25	32	37.5	43	45.75	48	54	62.25	70.5
4.5	4630				6			6			6			
15	4630				6						6			
25.5	4630				6			6			6			
32.5	2855						3		3					
47.5	2855						3		3					
62.5	2855						3		3					
77.5	2855						3		3					
92.5	2855						3		3					
107.5	2855						3		3					
122.5	2855						3		3					
137.5	2855						3		3					
152.5	2855						3		3					
167.5	2855						3		3					
182.5	2855						3		3					
197.5	2855						3		3					
212.5	2855						3		3					
227.5	2855						3		3					
242.5	2855						3		3					
257.5	2855						3		3					
272.5	2855						3		3					
287.5	2855						3		3					
302.5	2855						3		3					
317.5	2855						3		3					
332.5	2855						3		3					
347.5	2855						3		3					
354.5	4630	6	6	6		6		6		6		6	6	6
365	4630	6												6
375.5	4630	6	6	6		6		6		6		6	6	6

TEASDA 分析模型 七層樓構架振動台試驗驗證

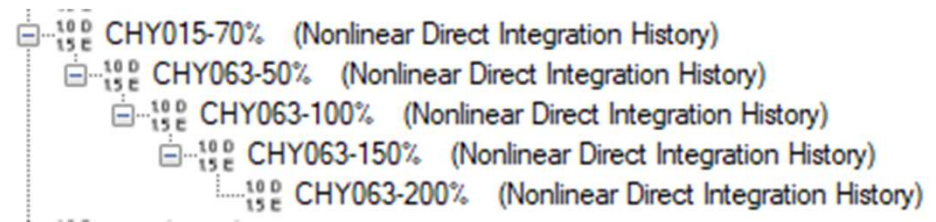
X-方向 輸入歷時反應譜

類型	測站	輸入歷時方向	最大地表加速度 (g)	Rate
遠域	CHY015	UX / UY / UZ	0.10 / 0.11 / 0.02	70%
近斷層	CHY063		0.21 / 0.12 / 0.08	50%
			0.42 / 0.24 / 0.16	100%
			0.63 / 0.36 / 0.24	150%
			0.84 / 0.48 / 0.32	200%



Load Case 設定

- 3向
- Continuous Cases



Load Case Data

General

Load Case Name: CHY015-70%

Load Case Type/Subtype: Time History / Nonlinear Direct Integration

Exclude Objects in this Group: Not Applicable

Mass Source: Previous

Initial Conditions

☒ Zero Initial Conditions - Start from Unstressed State

☐ Continue from State at End of Nonlinear Case (Loads at End of Case ARE Included)

Nonlinear Case

Loads Applied

Load Type	Load Name	Function	Scale Factor
Acceleration	U1	Y_70%	9810
Acceleration	U2	X_70%	9810
Acceleration	U3	Z_70%	9810

Other Parameters

Geometric Nonlinearity Option: P-Delta

Number of Output Time Steps: 102400

Output Time Step Size: 0.002 sec

Damping: Mass: 0.5575; Stiff: 0.0044; Modal: No

Time Integration: Newmark

Nonlinear Parameters: User Defined

OK Cancel

3 向加速度歷時輸入

Load Case Data

General

Load Case Name: CHY063-50%

Load Case Type/Subtype: Time History / Nonlinear Direct Integration

Exclude Objects in this Group: Not Applicable

Mass Source: Previous

Initial Conditions

☐ Zero Initial Conditions - Start from Unstressed State

☒ Continue from State at End of Nonlinear Case (Loads at End of Case ARE Included)

Nonlinear Case: CHY015-70%

Loads Applied

Load Type	Load Name	Function	Scale Factor
Acceleration	U1	Y_50%	9810
Acceleration	U2	X_50%	9810
Acceleration	U3	Z_50%	9810

Other Parameters

Geometric Nonlinearity Option: P-Delta

Number of Output Time Steps: 46080

Output Time Step Size: 0.002 sec

Damping: Mass: 0.5575; Stiff: 0.0044; Modal: No

Time Integration: Newmark

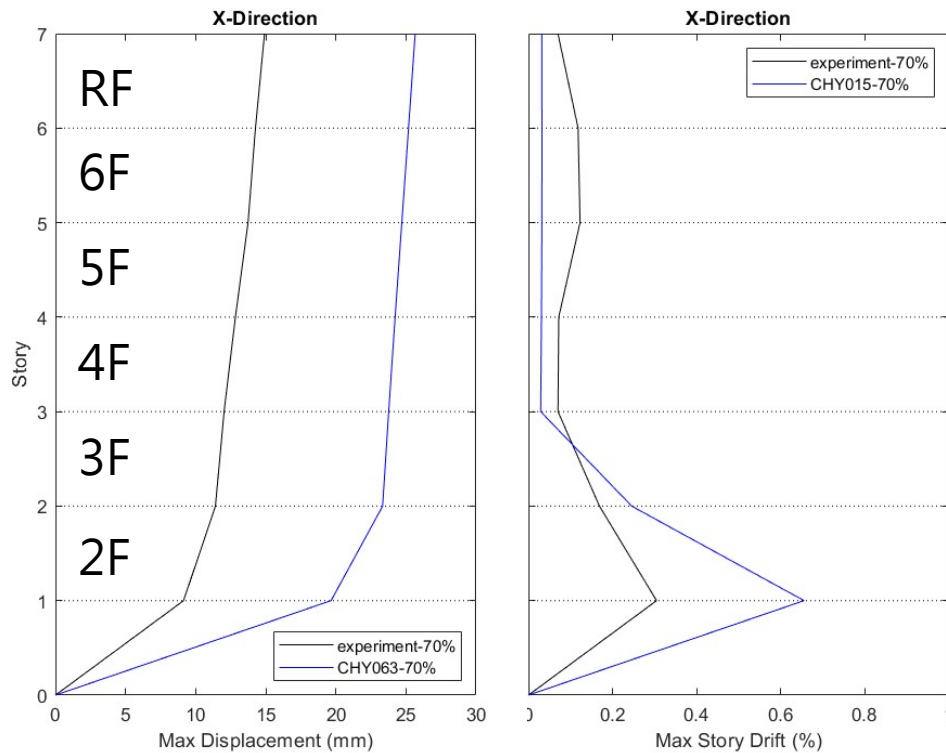
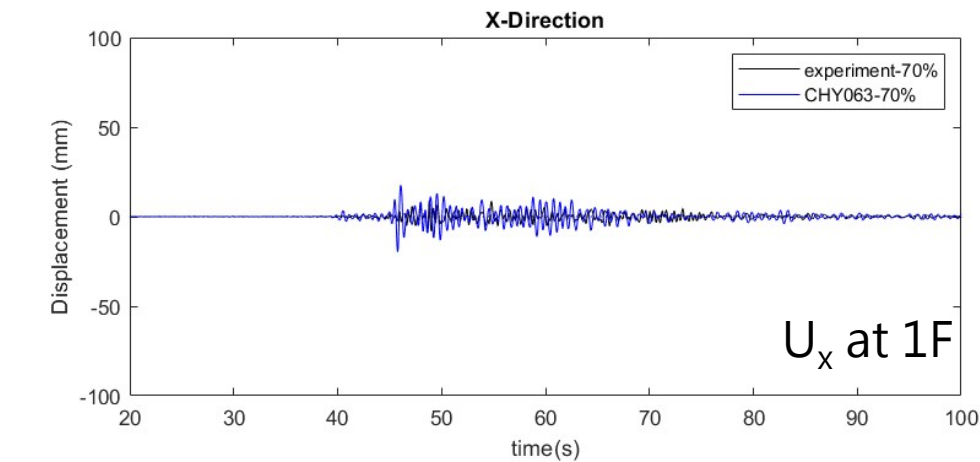
Nonlinear Parameters: User Defined

OK Cancel

CHY063-50% 接續 CHY015-70%

TEASDA 1.0 分析結果

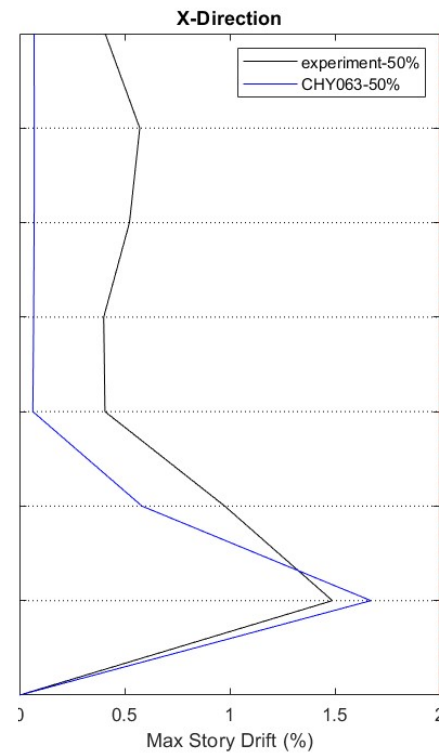
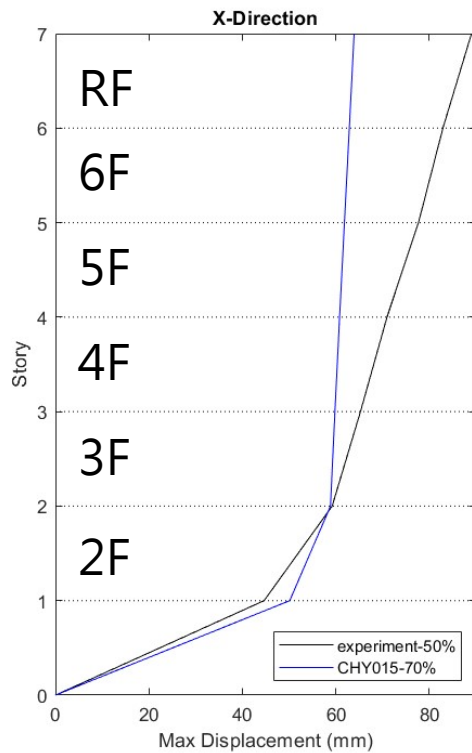
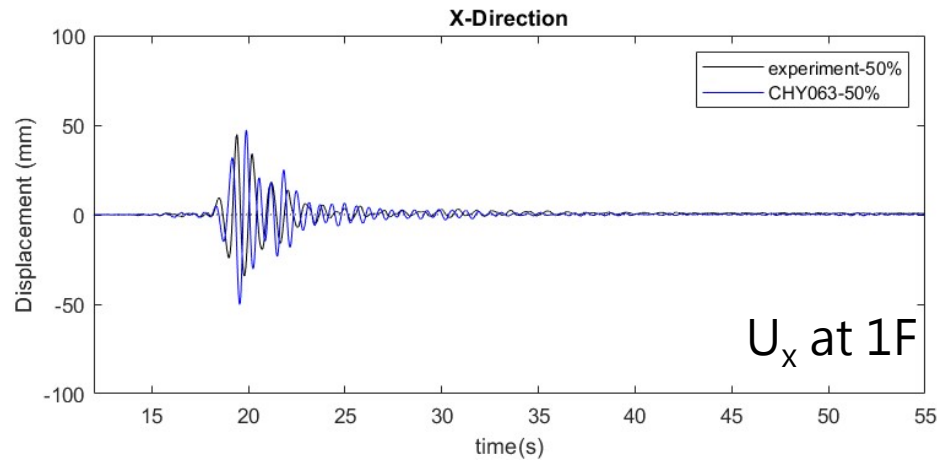
CHY015-70%



$\xi = 5\%$
- Continuous Cases
3DOF

TEASDA 1.0 分析結果

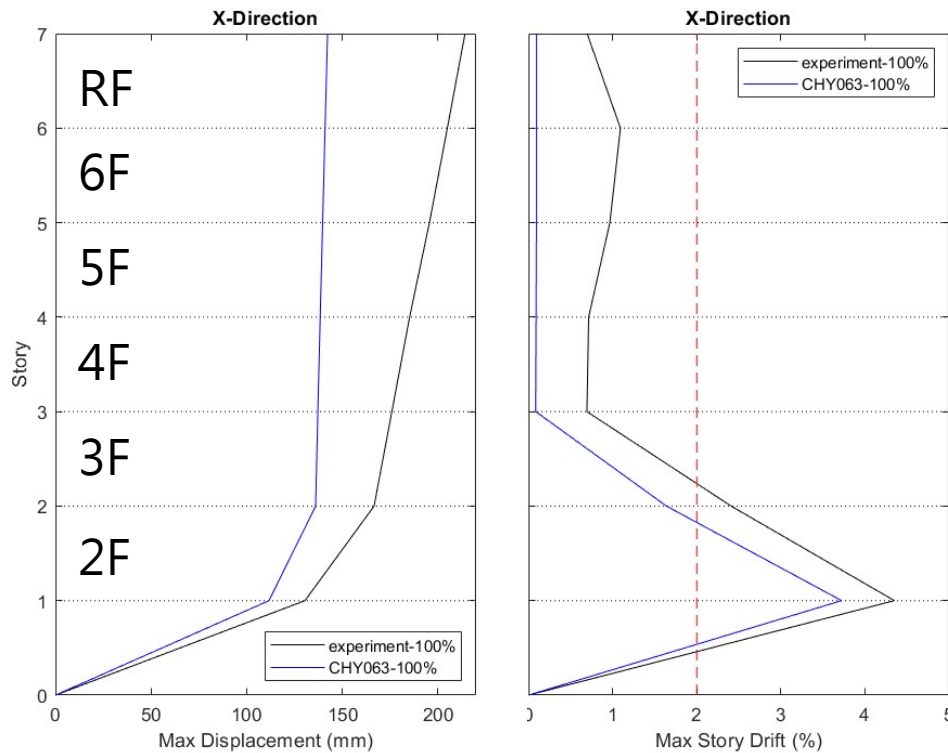
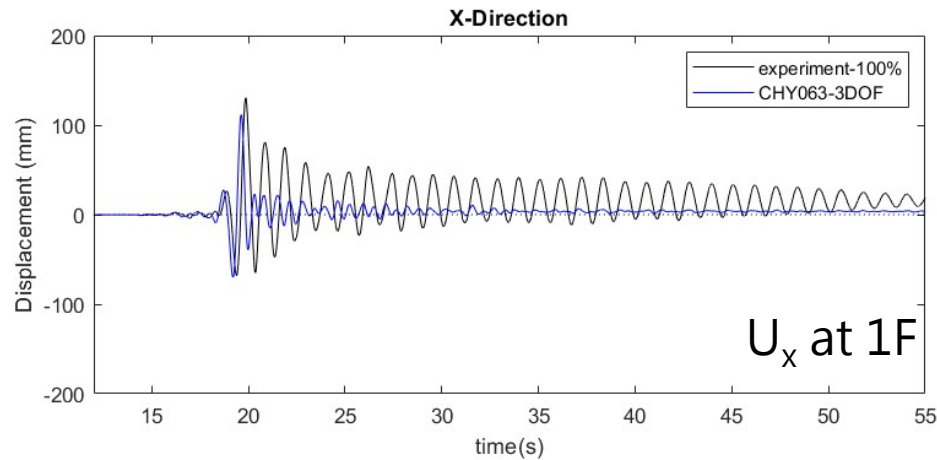
CHY063-50%



$\xi = 5\%$
- Continuous Cases
3DOF

TEASDA 1.0 分析結果

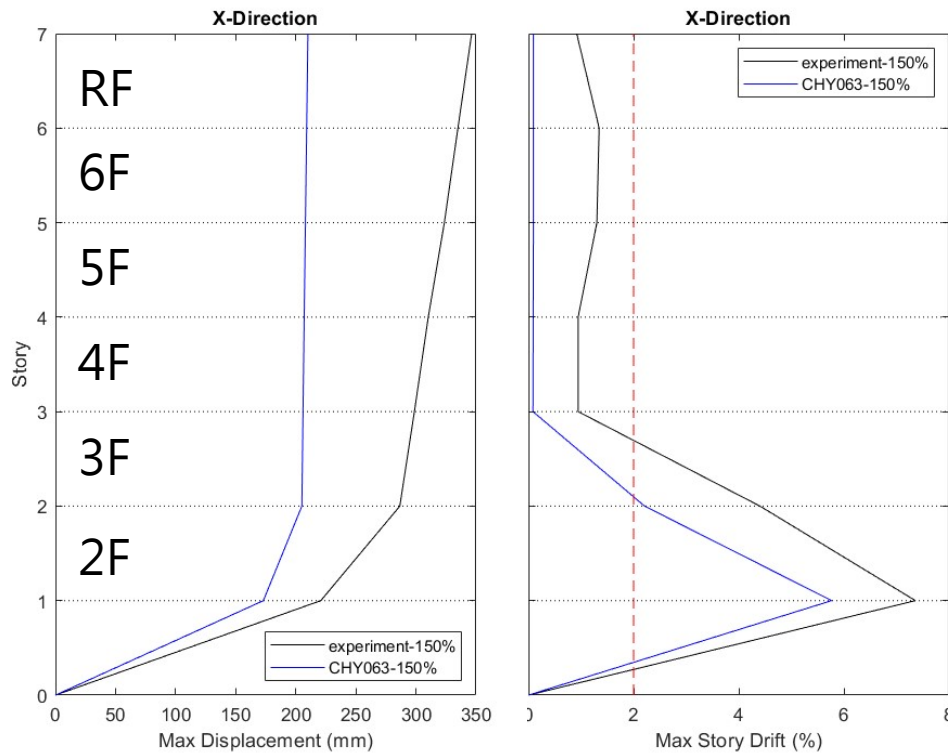
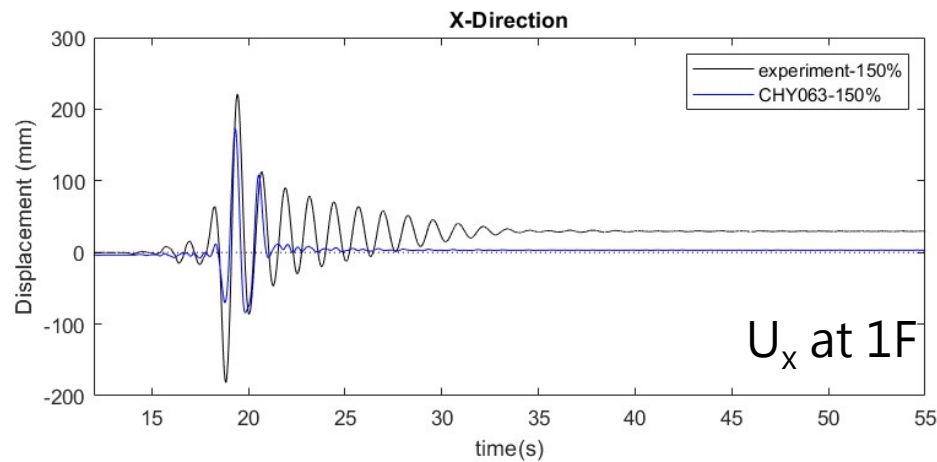
CHY063-100%



$\xi = 5\%$
- Continuous Cases
3DOF

TEASDA 1.0 分析結果

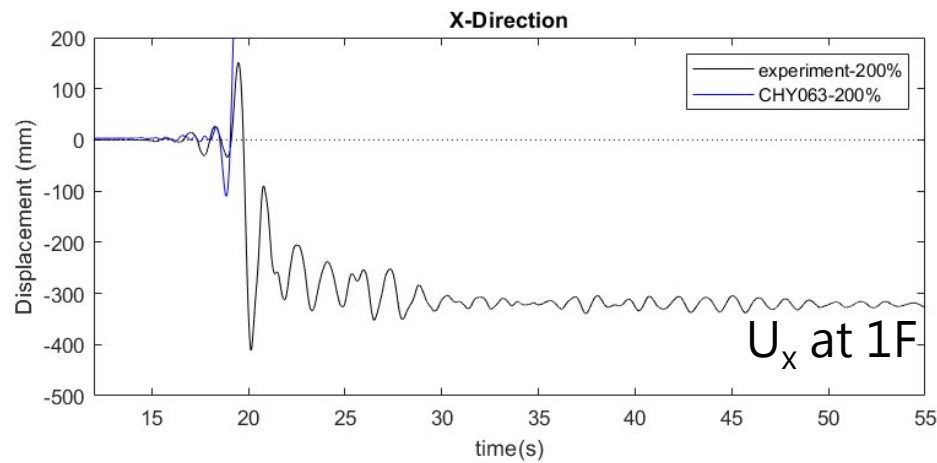
CHY063-150%



$\xi = 5\%$
- Continuous Cases
3DOF

TEASDA 1.0 分析結果

CHY063-200%

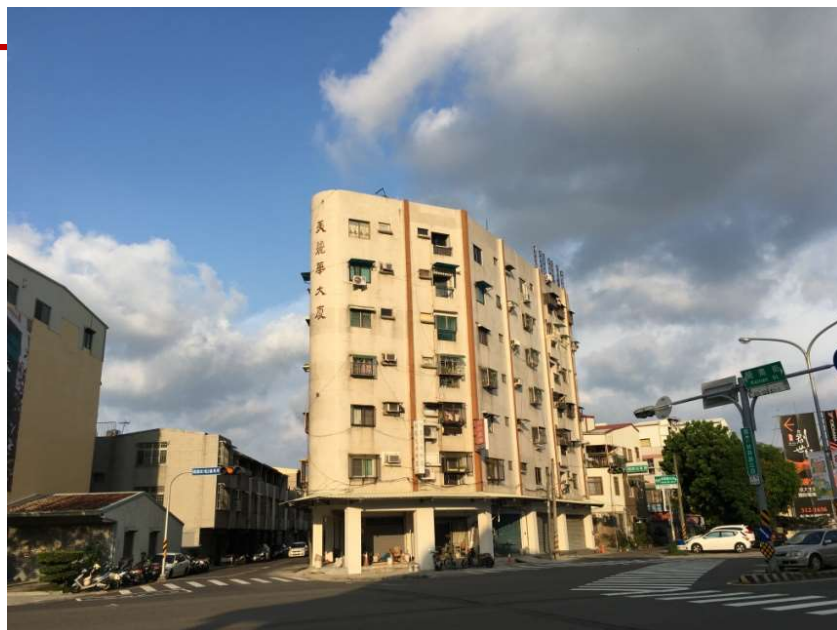


$\xi = 5\%$
- Continuous Cases
3DOF

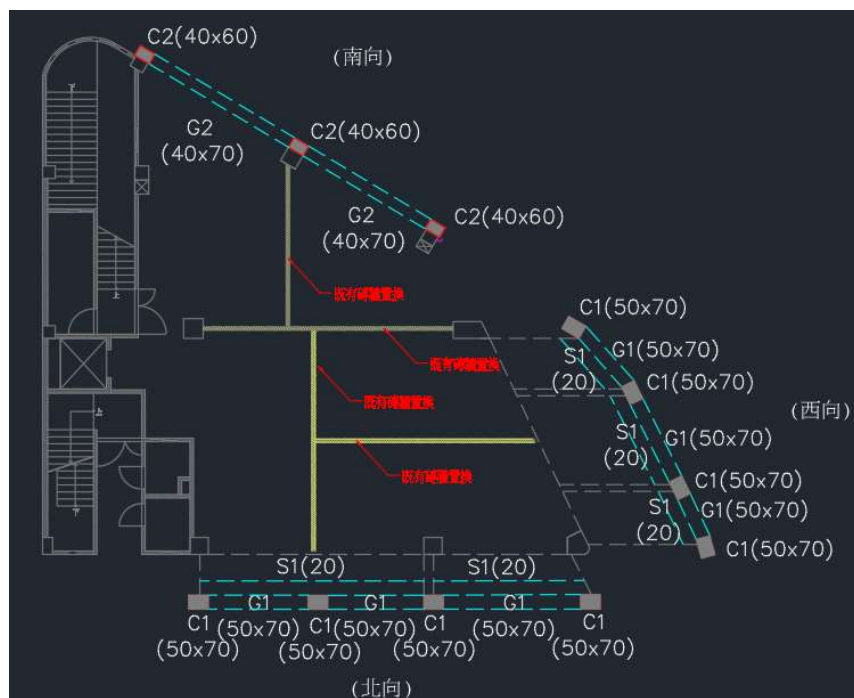
小結

- 整體來說，使用 TEASDA 塑鉸模型之設定，勁度和實驗試體相比較大、最大層間位移角和最大位移皆略小於實驗結果。
- 本模型之分析結果 (200%) 與試體倒塌時機一致。

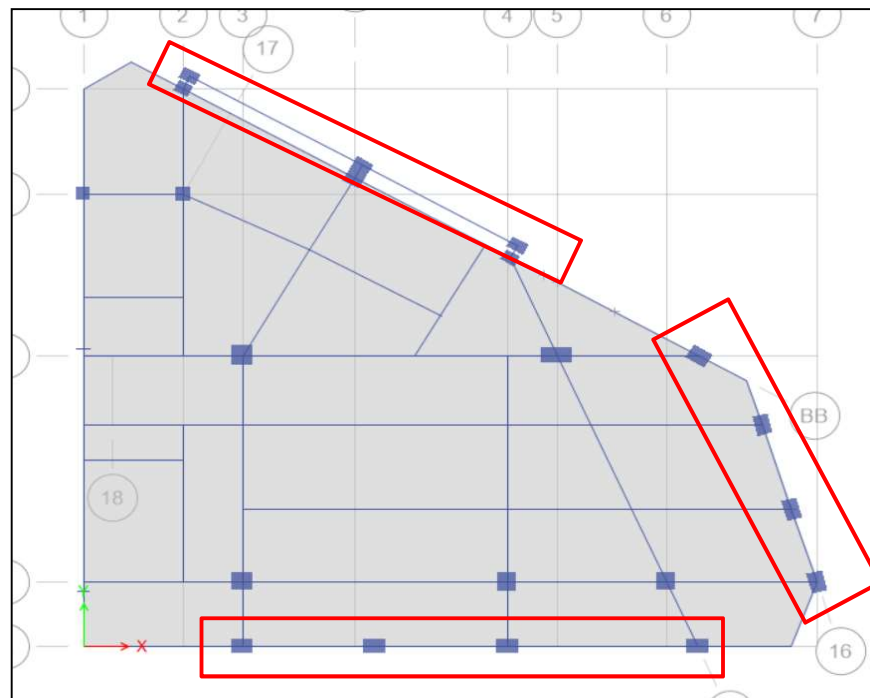
案例說明-耐震補強示範案例一



耐震補強設計



補強設計圖



模型平面圖

模態參與比例

補強前

扭轉行為

Case	Mode	Period	UX	UY	UZ	SumRX	SumRY	SumRZ
Modal	1	1.8270	32.44%	26.89%	0.00%	14.06%	19.62%	24.43%
Modal	2	1.4570	51.89%	17.73%	0.00%	22.37%	49.71%	40.42%
Modal	3	0.7550	0.00%	37.24%	0.00%	53.77%	49.73%	83.30%
Modal	4	0.5970	4.25%	3.77%	0.00%	65.62%	63.46%	85.39%



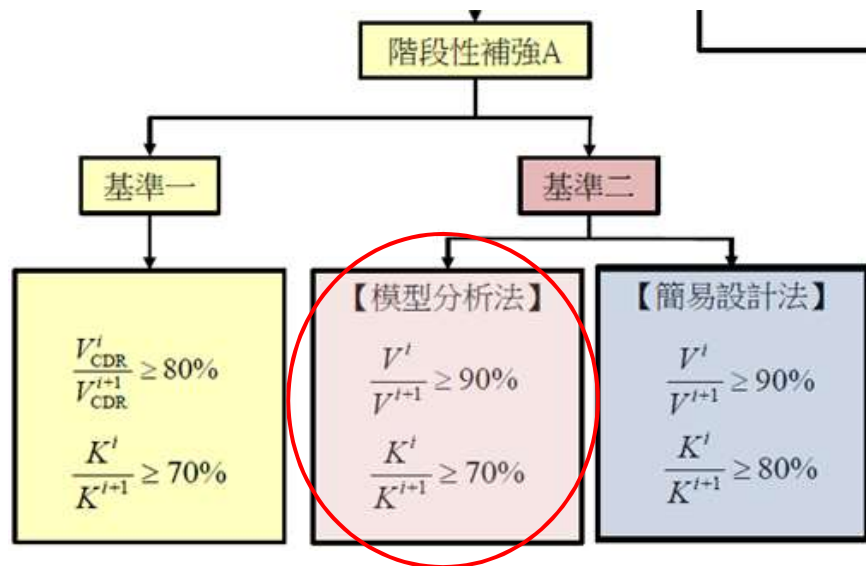
補強後

降低

Case	Mode	Period	UX	UY	UZ	SumRX	SumRY	SumRZ
Modal	1	1.5870	32.08%	17.74%	0.00%	10.94%	20.22%	12.17%
Modal	2	1.2690	32.73%	18.31%	0.00%	21.68%	39.35%	25.21%
Modal	3	1.0010	0.00%	27.96%	0.00%	40.17%	39.36%	62.40%
Modal	4	0.5240	5.66%	2.75%	0.00%	44.19%	48.18%	64.81%

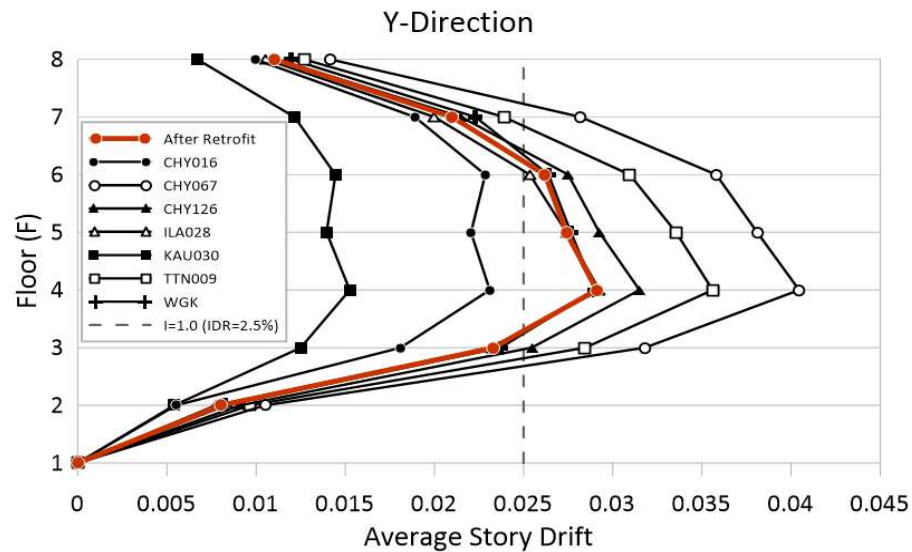
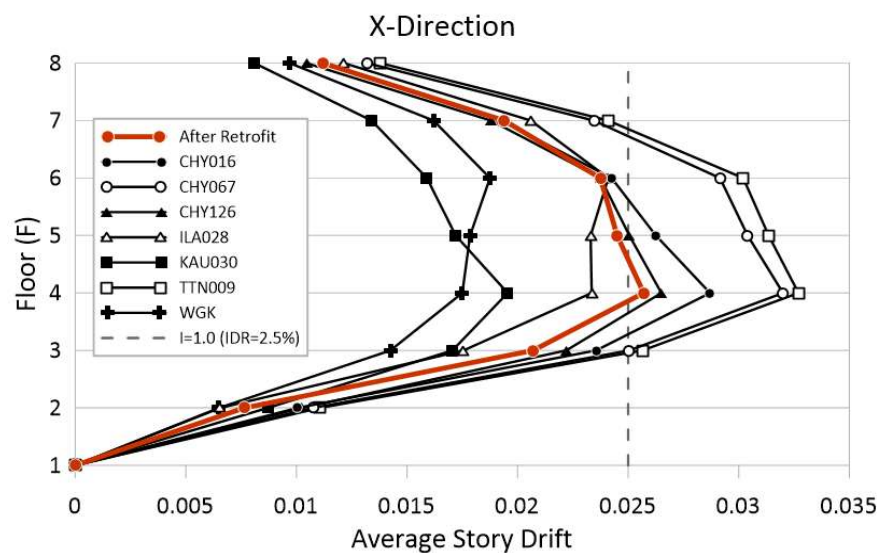
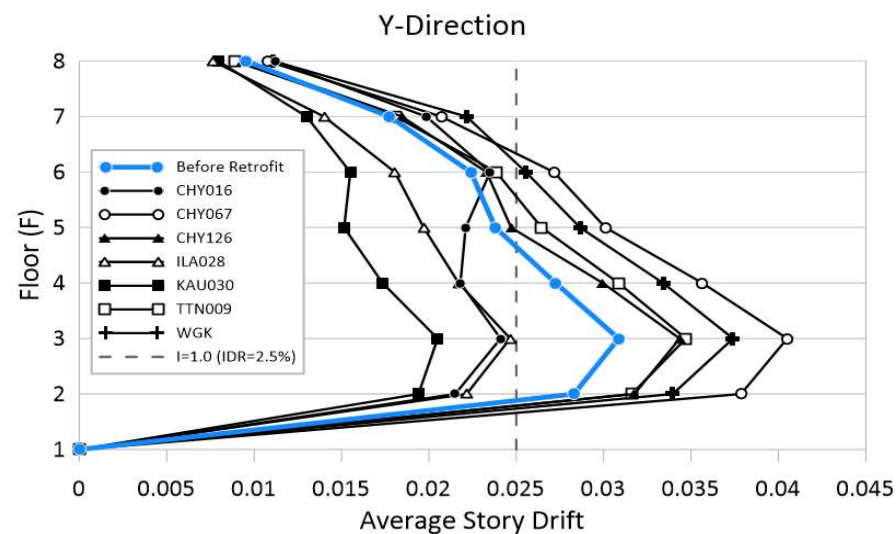
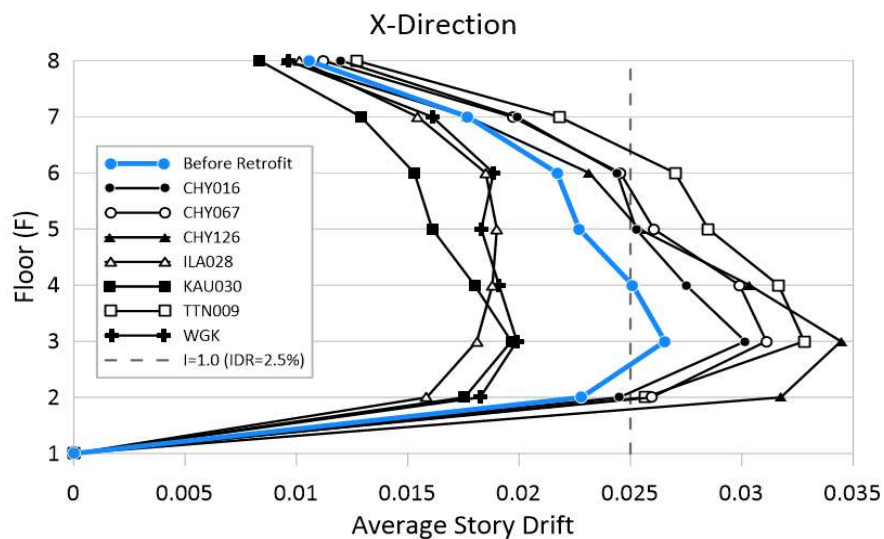
側推分析

- 階段性補強A OK!

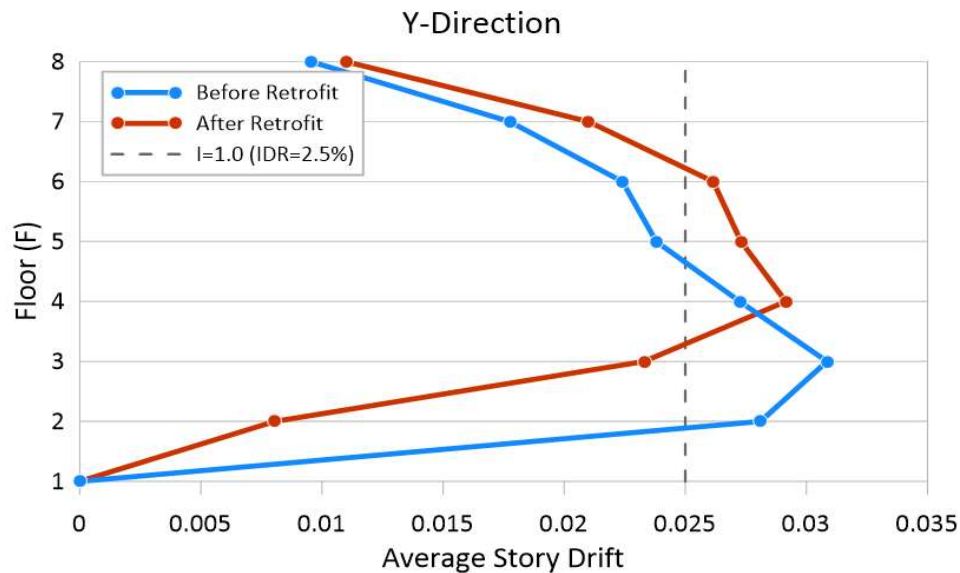
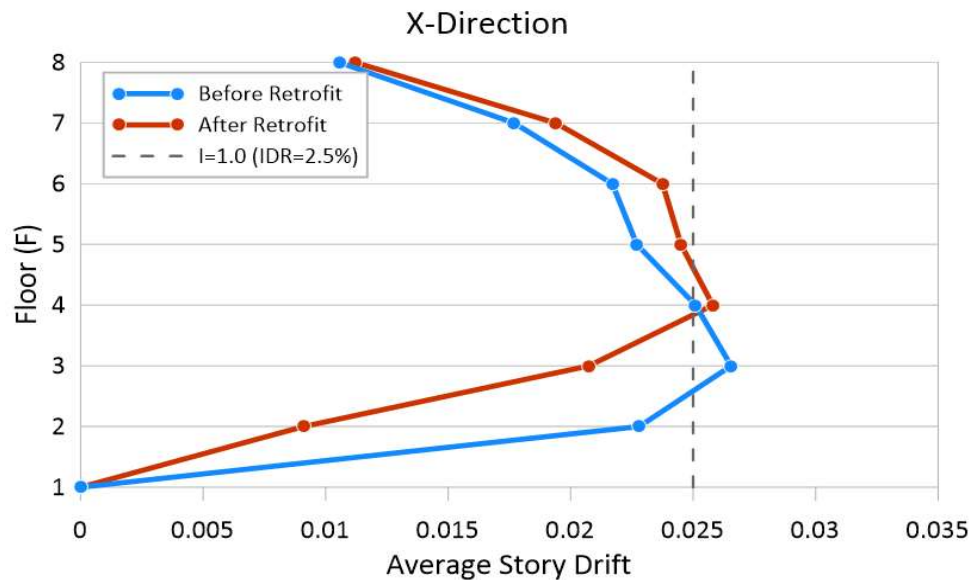


Direction	Before Retrofit		After Retrofit	
	$\frac{V^1}{V^2}$	$\frac{K^1}{K^2}$	$\frac{V^1}{V^2}$	$\frac{K^1}{K^2}$
X+	1.07	1.03	1.61	1.71
Y+	0.85	0.93	1.77	2.25

動力分析結果



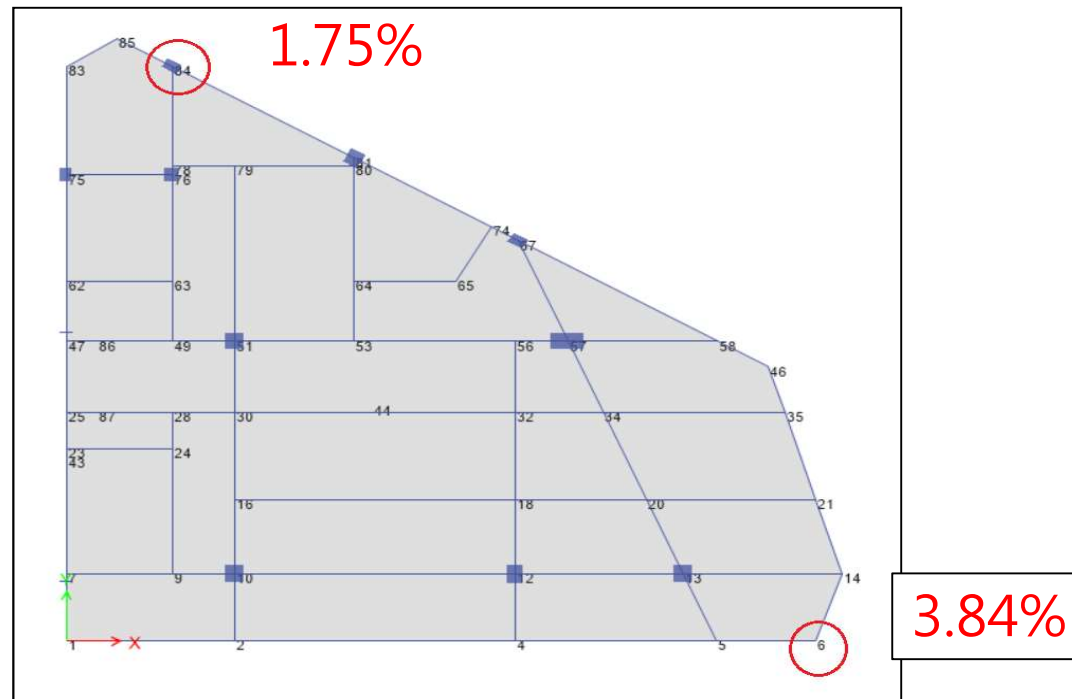
小結



- 補強對於低矮樓層效果明顯，合理反映側推分析結果。
- 一樓之層間變位分散至其他樓層。
- 可能造成軟弱層轉移至高樓層。

小結

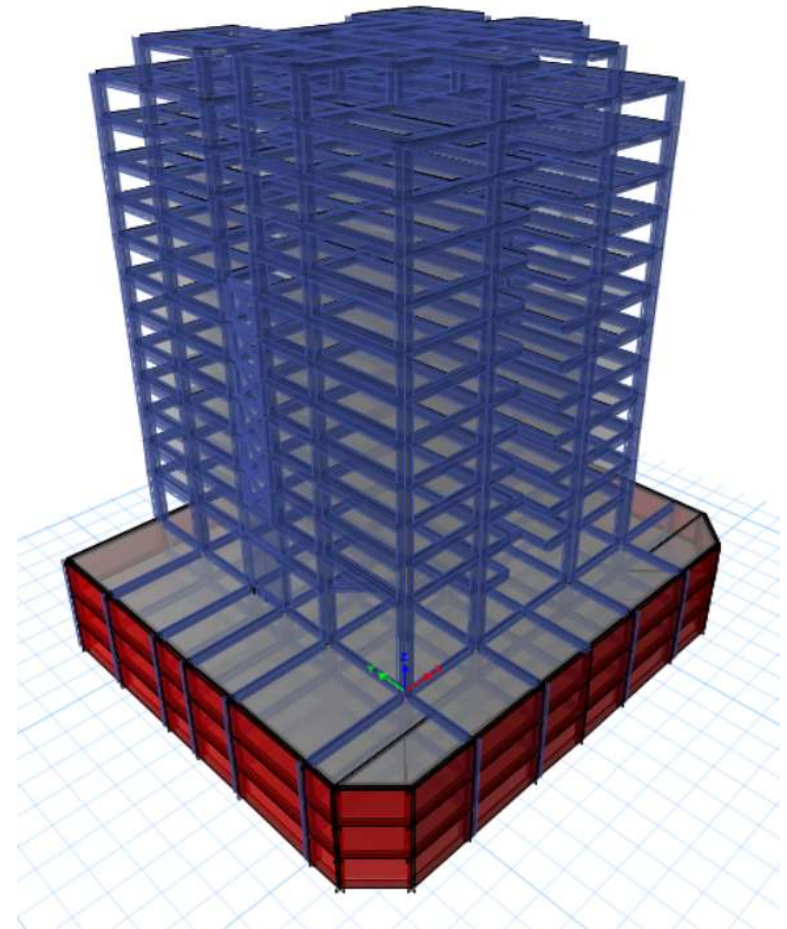
- 動力分析優異處：
對於補強前結構，兩角點所得到的最大與最小數值分別為3.84%及1.75%，計算平均值為2.76%，最大值與平均值之比值為1.39，顯示出雙向的動力分析可以協助釐清單向定性評估法的不足之處。



案例說明-耐震補強示範案例二

耐震補強示範案例二

建築物種類	十三層樓住商混合大樓
構造形式	RC鋼筋混凝土造
平面尺寸	長30.6(m)、寬25.6(m)
結構規模	地上十三層、地下兩層
總樓高	約43.1(m)
現況	中高樓





側推分析結果

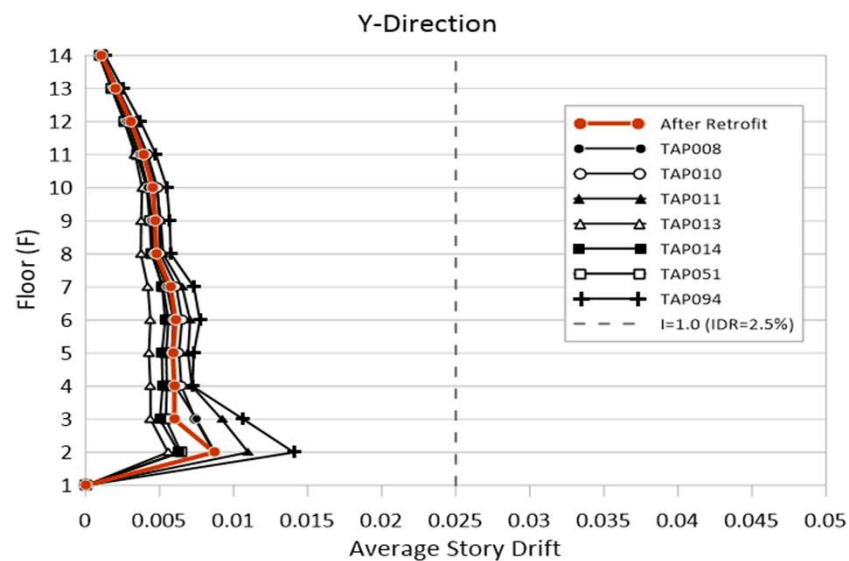
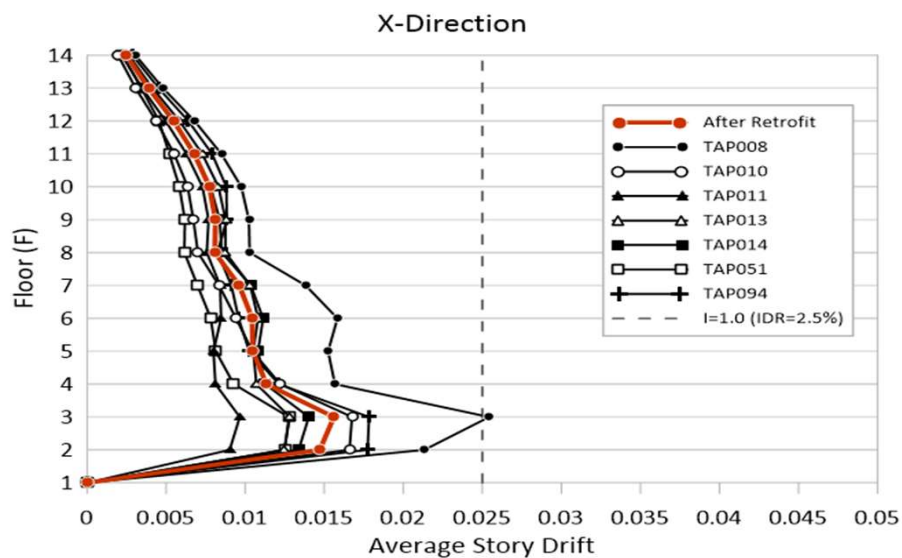
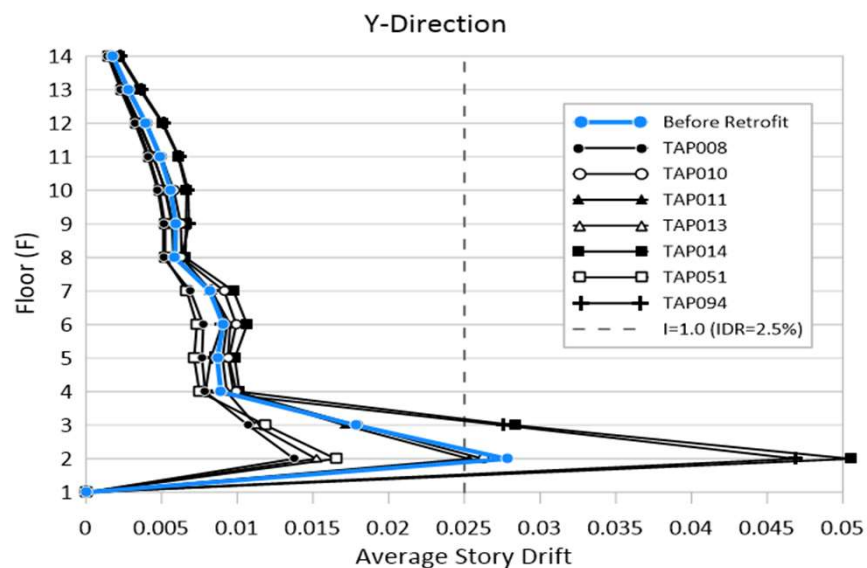
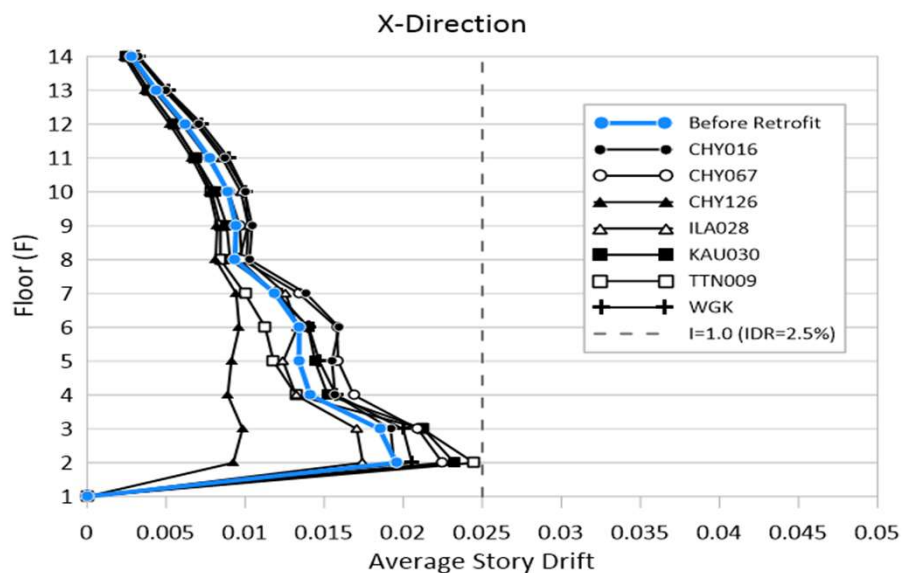
→ 階段性補強B

性能目標點，不會有任一垂直承載構件發生軸向破壞或完全喪失側向強度之虞， A_p 值須大於補強前的 A_p 值，且不得低於0.8倍的 A_T 值

耐震能力需求 A_T (g)	$A_T=0.4S_{DS}=0.24$ $I=1.0$; 475年回歸期地震地表加速度			
補強前後	前		後	
方向	X	Y	X	Y
耐震能力 A_p (g)	0.207	0.1807	0.21	0.2608
性能點基底剪力 (kgf)	3,589,636.8	3,650,007.8	3,455,214.1	4,810,025.7 7
CDR值	0.863 < 1.0	0.753 < 1.0	0.875	1.087 > 1.0

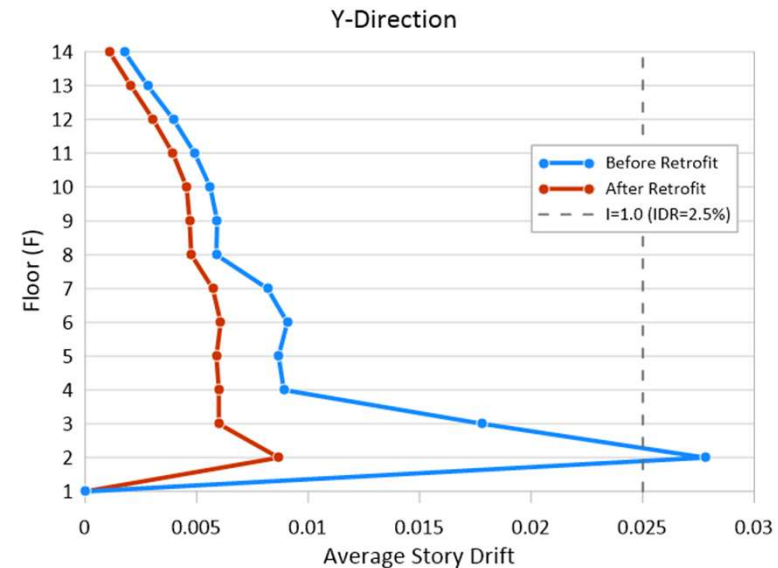
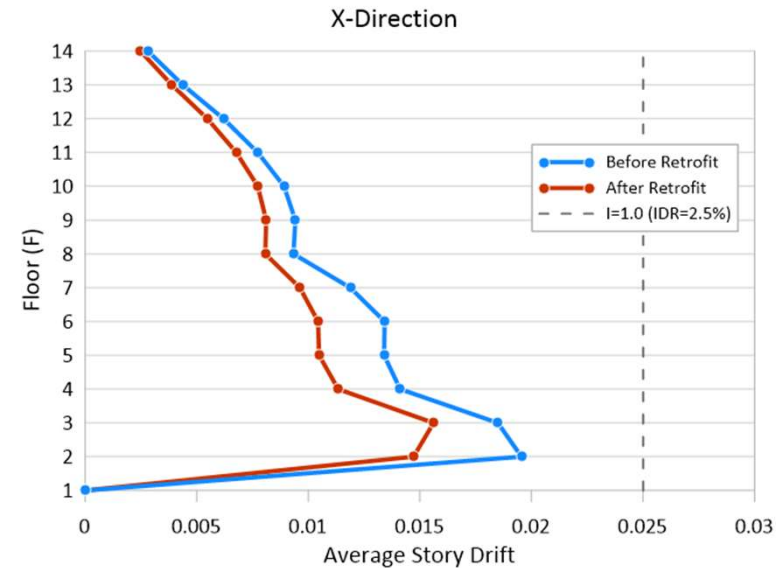
僅補強Y軸，符合階段性補強B之 $CDR > 0.8$ 之規定

動力分析結果



小結

- 可以看到Y軸的補強效果明顯。
- 藉由動力分析能看出不同時間點的構件塑鉸狀態。
- 繪製成圖能看出結構之高模態反應。



結論

TEASDA方法對於各案例皆有不錯的成效，以下兩點結論供參：

1. 非線性動力分析方法搭配TEASDA所定義塑鉸，針對**中高樓**或是低矮樓層，甚至**不規則結構物**，其結果皆有一定代表性。建議與側推分析方法同時進行搭配參考，合併成一份完整的耐震評估報告。
2. 針對不同地震歷時產生的塑鉸進行**量化統計**，顯示動力分析可表現較多關鍵性評估結果。

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Thanks for your attention

Facebook groups
Taiwan Earthquake Assessment for
RC Structures by Dynamic Analysis
(TEASDA)

