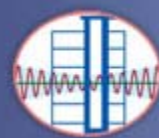




高強度鋼筋混凝土(New RC)

結構設計手冊研討會

2015.12.11



NAR Labs 國家實驗研究院

國家地震工程研究中心

National Center for Research on Earthquake Engineering

高強度鋼筋混凝土構架接頭之耐震設計 及鋼筋機械式續接

李宏仁

國立雲林科技大學 營建系副教授 & 營建材料檢測中心主任

Member of Joint ASCE-ACI Committee 352, Joints and
Connections in Monolithic Concrete Structures



YUNTECH

Acknowledgements

國科會補助

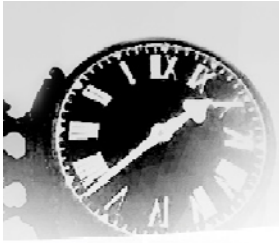
台灣新型高強度鋼筋混凝土結構研發

子計畫：梁柱接頭耐震性能研究及資料庫建構



YunTech

國立雲林科技大學
National Yunlin University of Science & Technology



Outline

6.1 剪力強度

接頭剪力需求 V_u

接頭標稱強度 ϕV_n

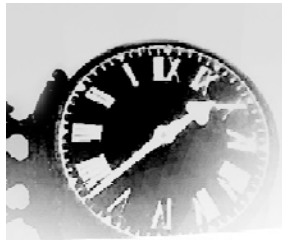
6.2 接頭箍筋—受梁圍束作用可以減半

6.3 接頭鋼筋伸展及錨定

梁主筋貫穿梁柱接頭之最小柱深

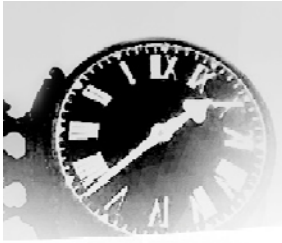
梁主筋終止於接頭內之錨定長度

8.2 鋼筋機械式續接



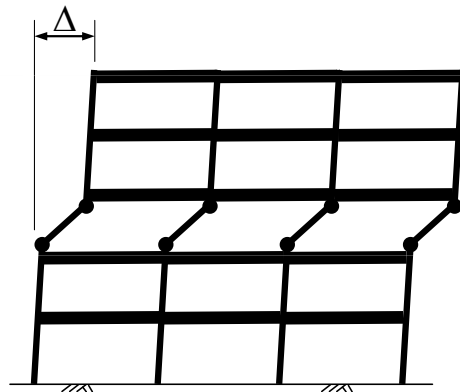
適用範圍

- 鋼筋混凝土造、特殊抗彎矩構架接頭
- 常重混凝土設計抗壓強度 ≤ 100 MPa (1000 kgf/cm²)
- 縱向鋼筋設計降伏強度不超過685 MPa (7000 kgf/cm²)
- 橫向鋼筋設計降伏強度不超過785 MPa (8000 kgf/cm²)

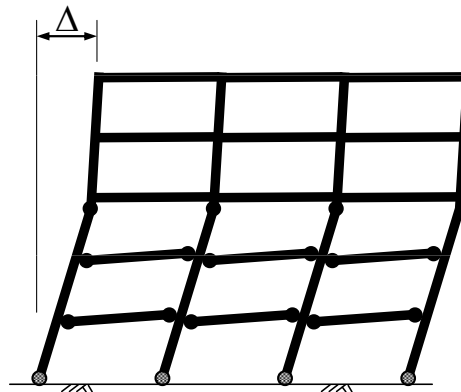


Frame Mechanisms

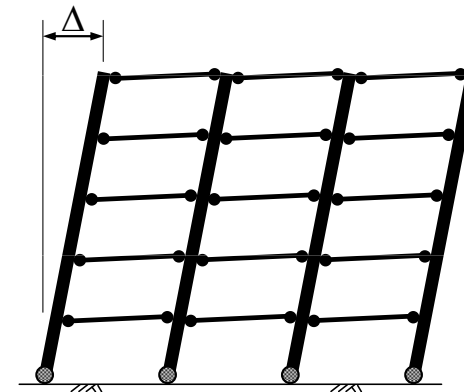
“strong column – weak beam”



(a) Story Mechanism



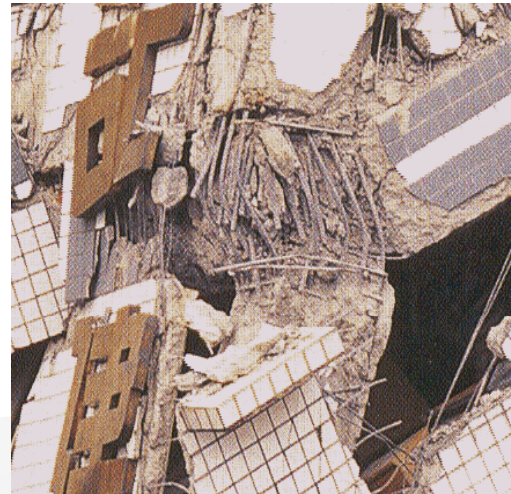
(b) Intermediate Mechanism



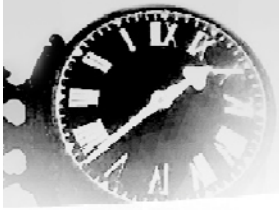
(c) Beam Mechanism



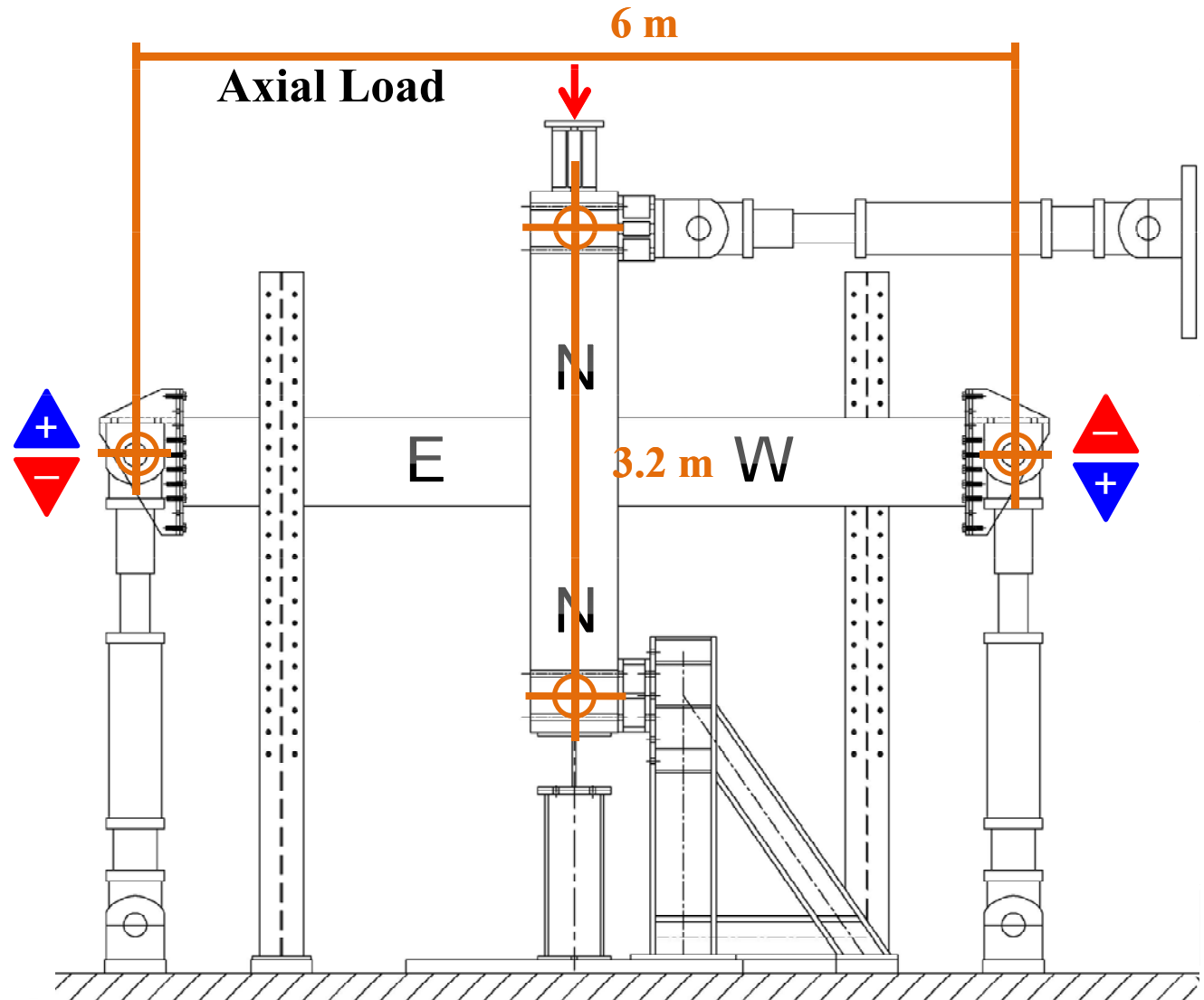
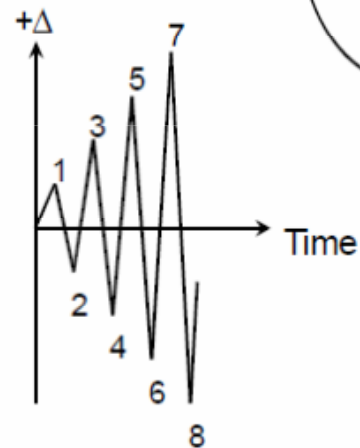
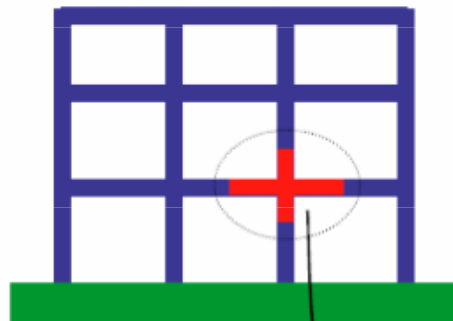
- Avoid story mechanism
- Avoid joint failure

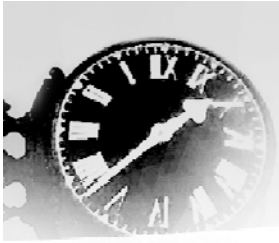


Inadequate
confinement



Laboratory Specimen under Cyclic Deformation Loading

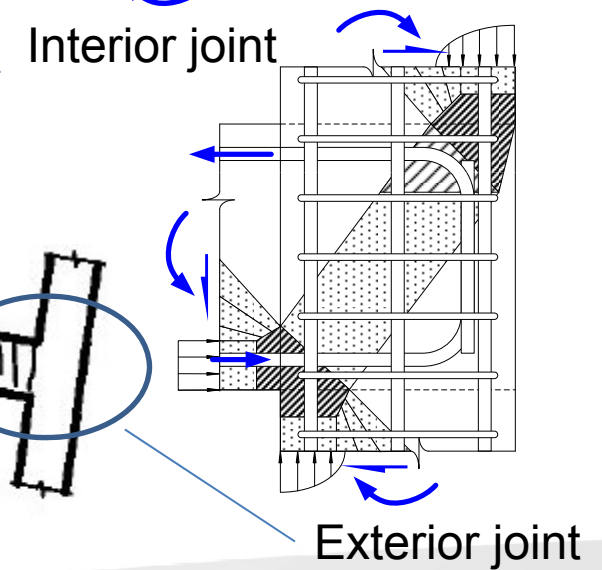
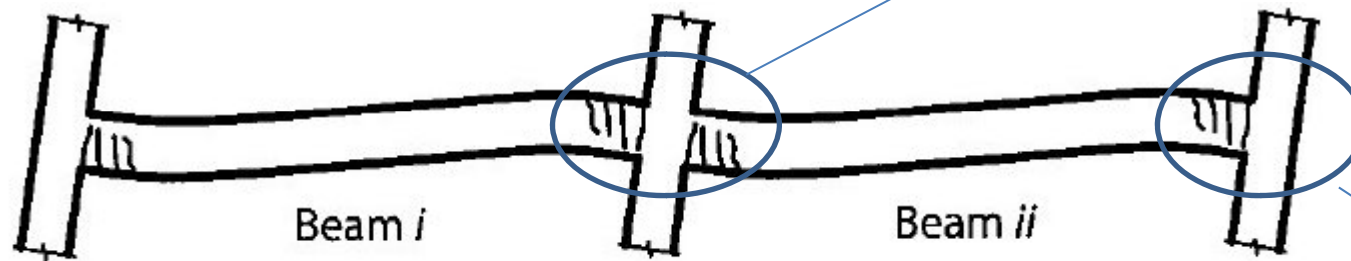
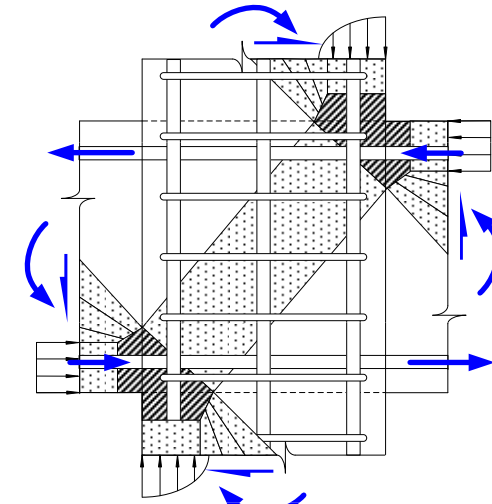
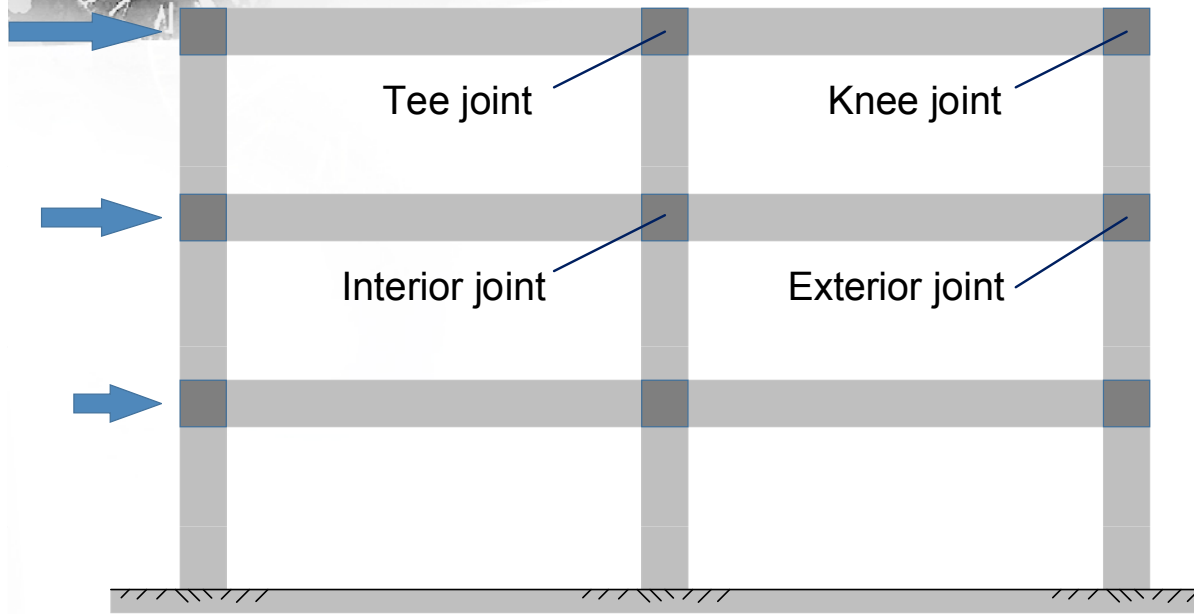


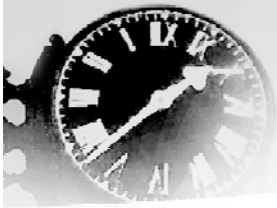


Laboratory testing



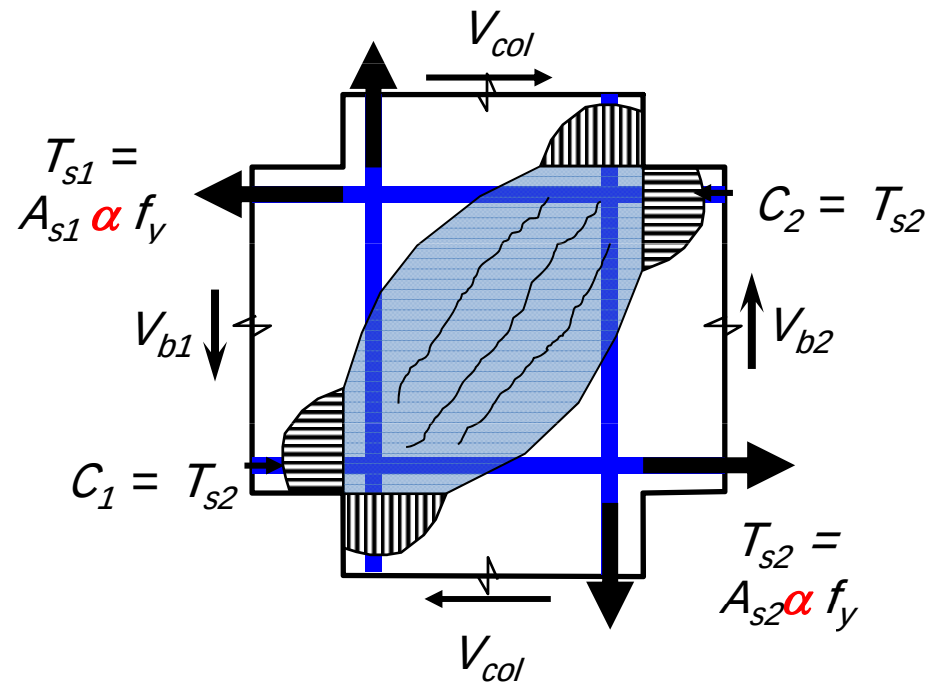
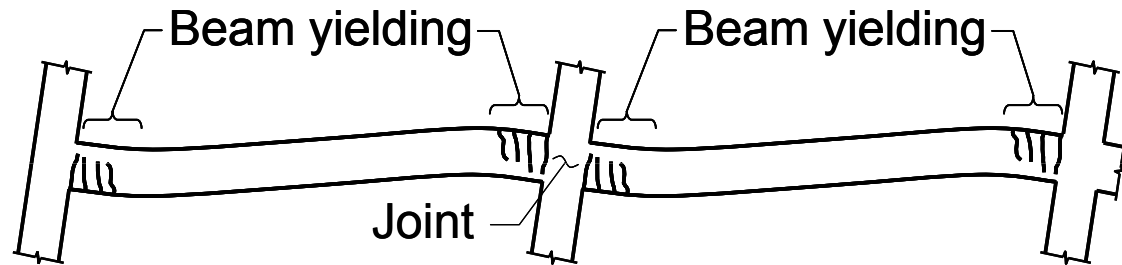
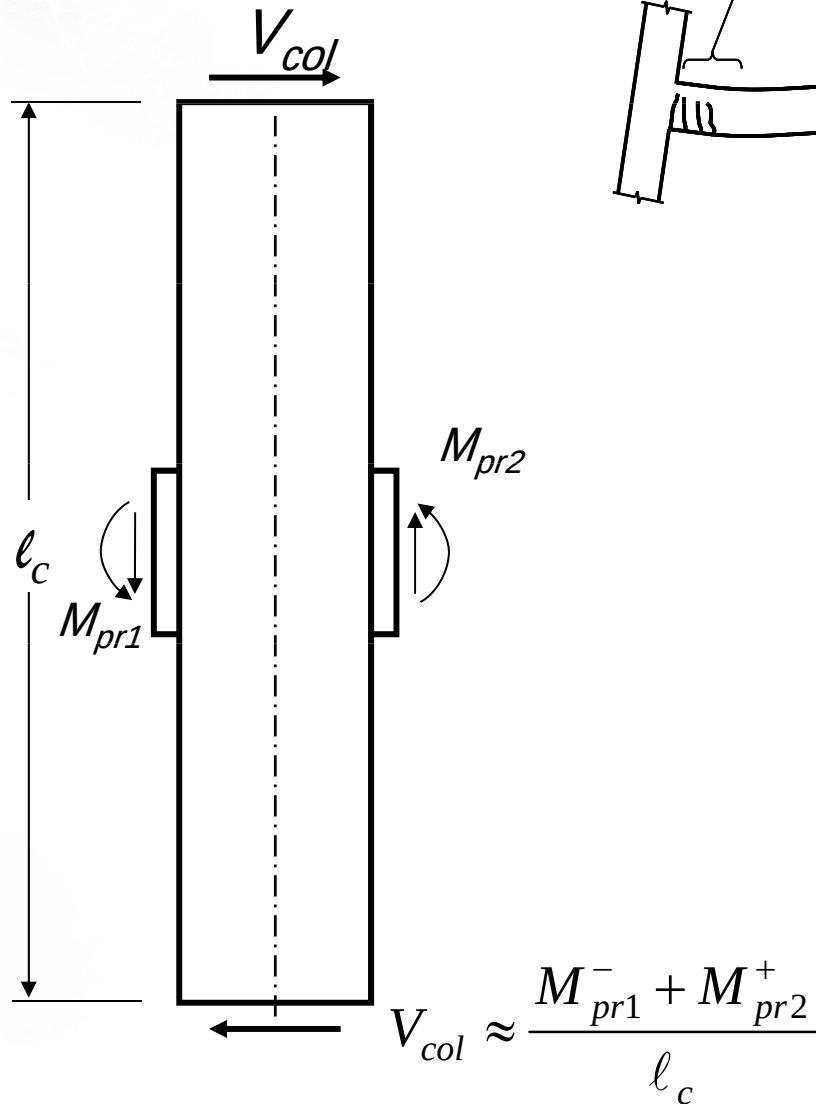
Frame subjected to Lateral Loading



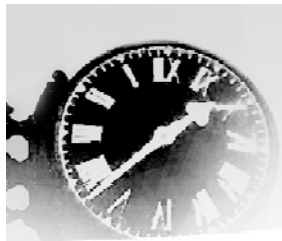


接頭剪力需求 V_u

Typical $\alpha = 1.25$ for SD420
For SD685, $\alpha = ?$



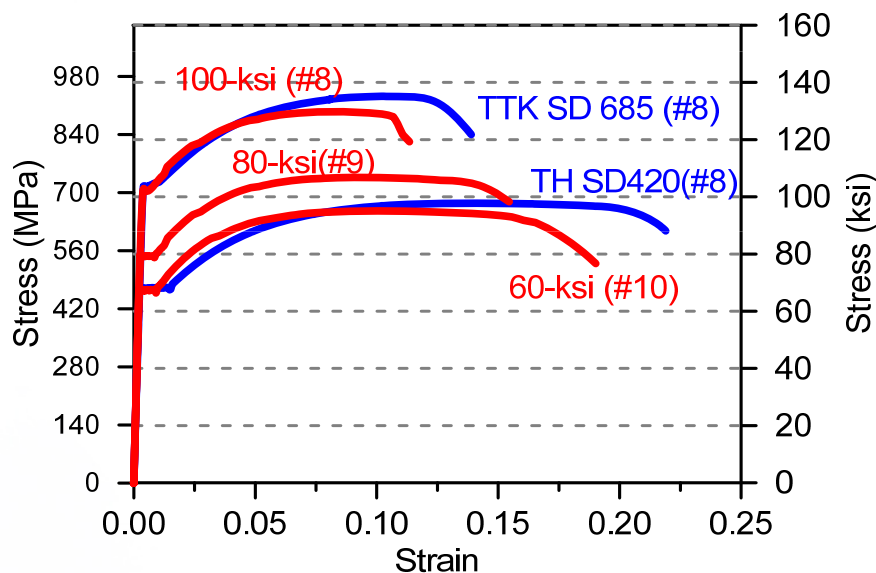
$$V_u = T_{s1} + C_2 - V_{col}$$



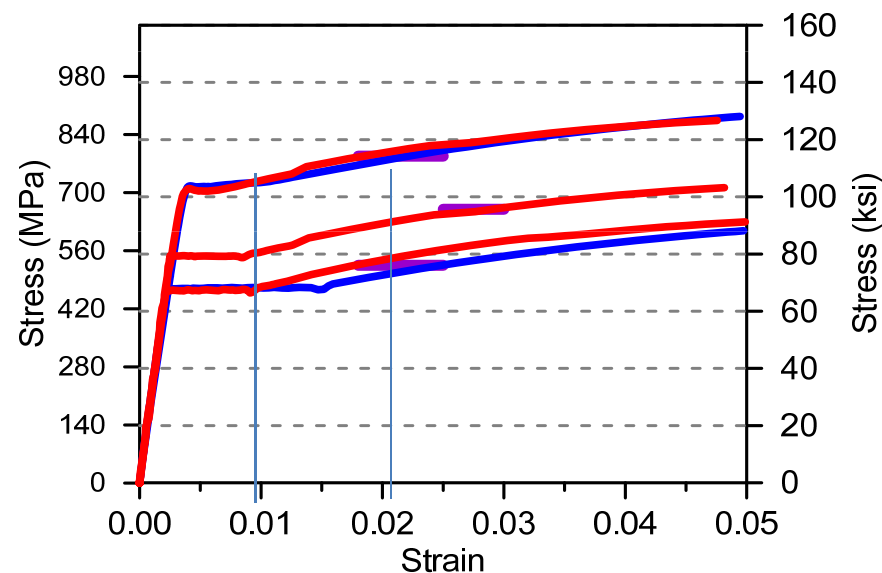
Over-strength factor for bar f_y

表6.1 鋼筋超額強度係數

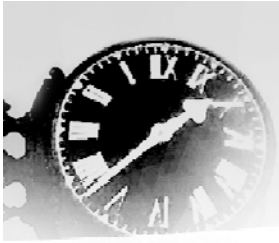
鋼筋強度等級	SD490以下	SD550	SD685
超額強度係數	$\alpha = 1.25$	$\alpha = 1.20$	$\alpha = 1.15$



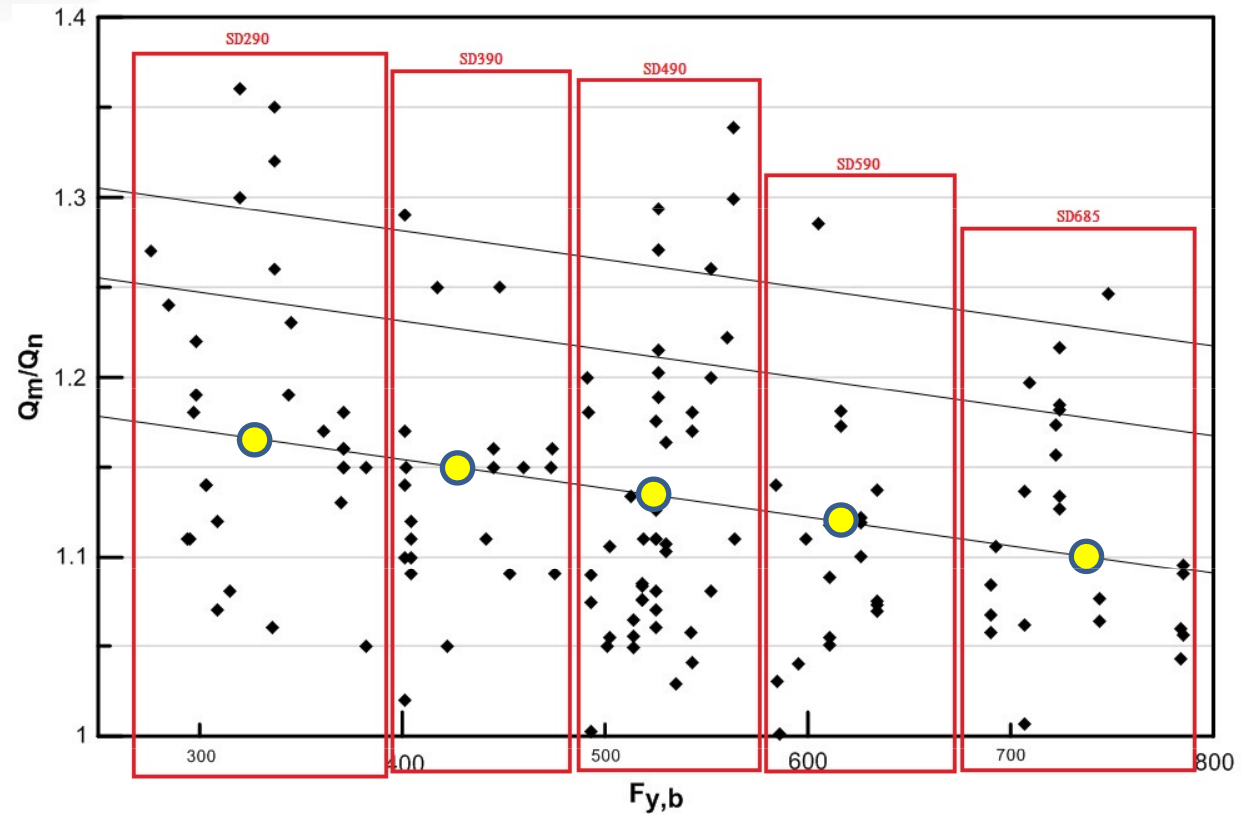
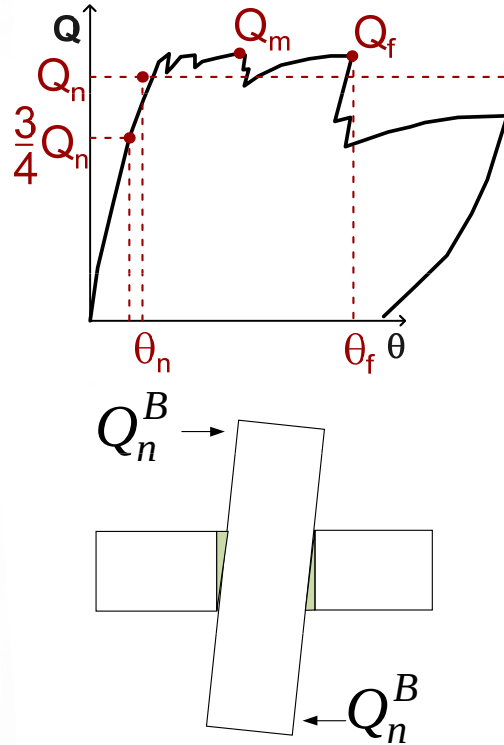
60, 80, 100 ksi 等級熱軋加釩鋼筋
應力應變曲線比較



1%開始應變硬化，至5%應變斜率幾乎一樣
增加約 24 ksi (165 MPa) 至5% strain
增加約 30 ksi (210 Mpa) 至極限強度

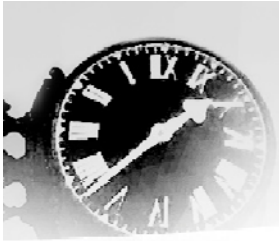


Database investigation



fy,measured
材料超強因子
硬固超強因子
材料*硬固超強因子

	SD290	SD390	SD490	SD590	SD685
average	331.31	427.43	529.17	617.94	731.16
α_{mat}	1.14	1.10	1.08	1.05	1.07
α_{har}	1.17	1.15	1.13	1.12	1.10
α_o	1.33	1.26	1.22	1.17	1.18



Outline

6.1 剪力強度

接頭剪力需求 V_u



接頭標稱強度 ϕV_n

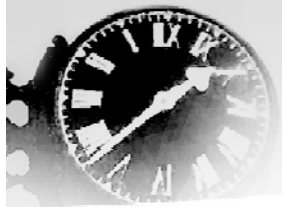
6.2 接頭箍筋—受梁圍束作用可以減半

6.3 接頭鋼筋伸展及錨定

梁主筋貫穿梁柱接頭之最小柱深

梁主筋終止於接頭內之錨定長度

8.2 鋼筋機械式續接



ACI 318 Code

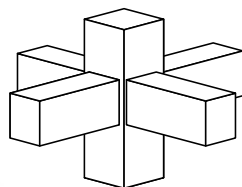
接頭標稱剪力強度 $V_n = \gamma \sqrt{f'_c} A_j$
(psi)

$$V_n = 0.083 \gamma \sqrt{f'_c} A_j \quad (\text{MPa})$$

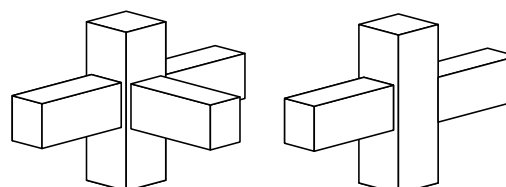
$$V_n = 0.265 \gamma \sqrt{f'_c} A_j \quad (\text{kgf/cm}^2)$$

Table 18.8.4.1 接頭剪力計算強度 V_n

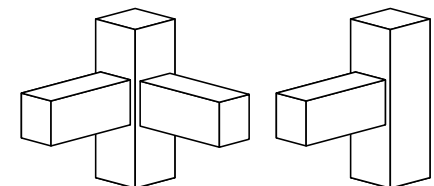
接頭配置	V_n for f'_c in psi	V_n for f'_c in MPa	V_n for f'_c in kgf/cm^2
接頭四面皆受梁圍束	$20\sqrt{f'_c} A_j$	$1.67\sqrt{f'_c} A_j$	$5.3\sqrt{f'_c} A_j$
接頭三面或一雙對面受梁圍束	$15\sqrt{f'_c} A_j$	$1.25\sqrt{f'_c} A_j$	$3.9\sqrt{f'_c} A_j$
其他	$12\sqrt{f'_c} A_j$	$1.00\sqrt{f'_c} A_j$	$3.2\sqrt{f'_c} A_j$



$$\gamma = 20$$



$$\gamma = 15$$

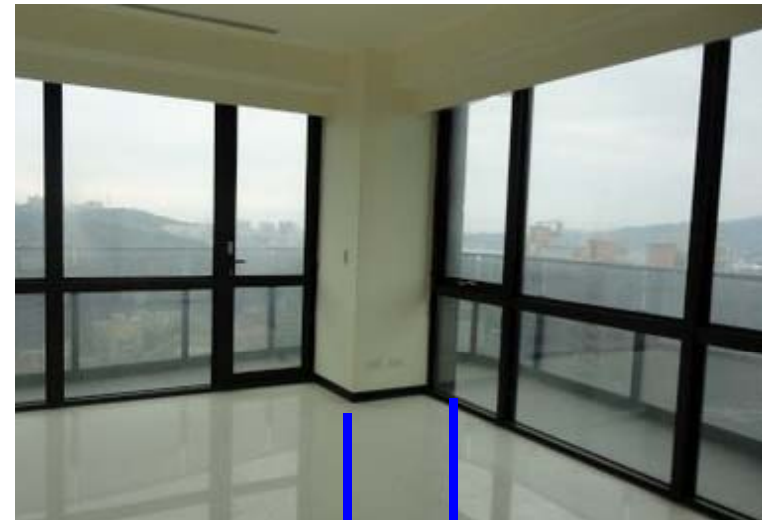


$$\gamma = 12$$

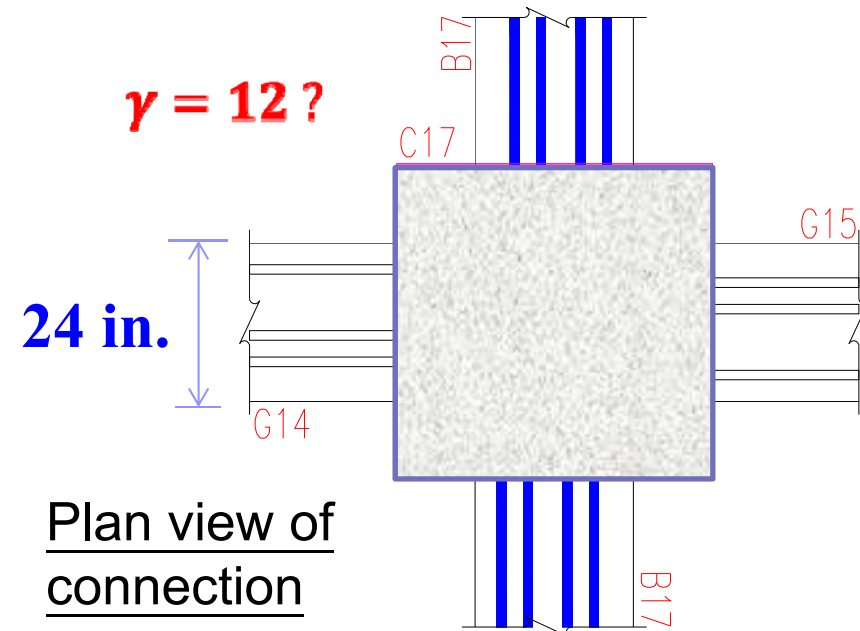
Example



Blue Ocean, 150-m, 38F residential building in Taipei, Taiwan.

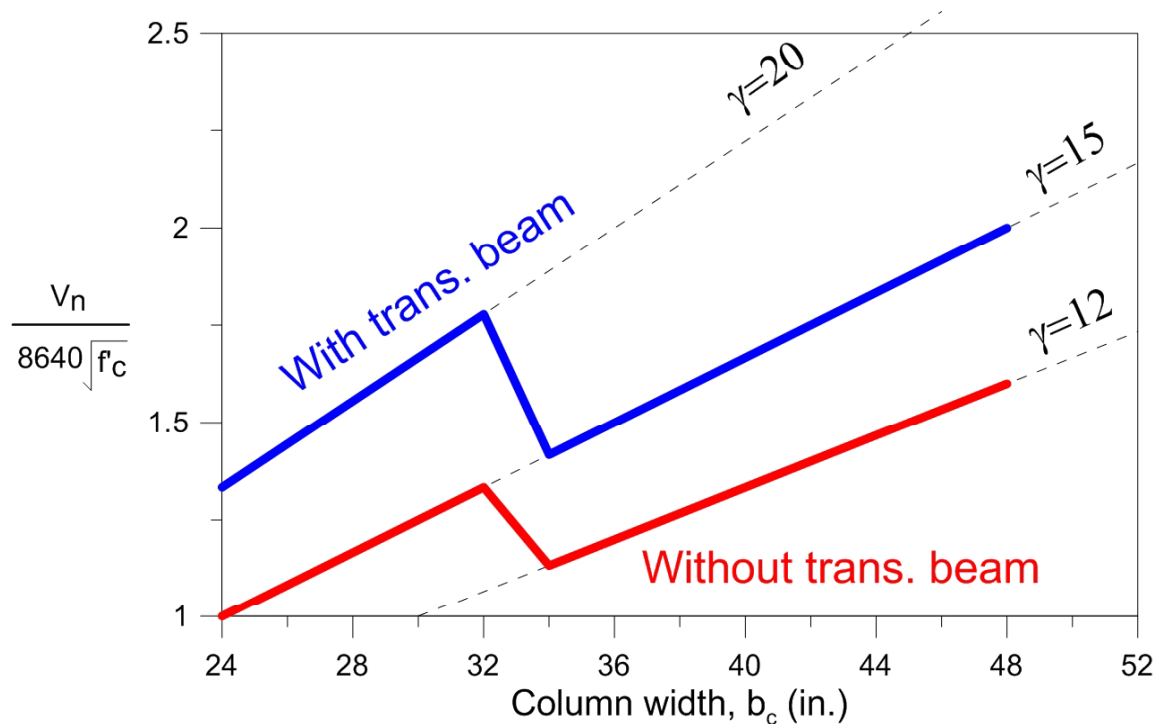


≈ 48 in.

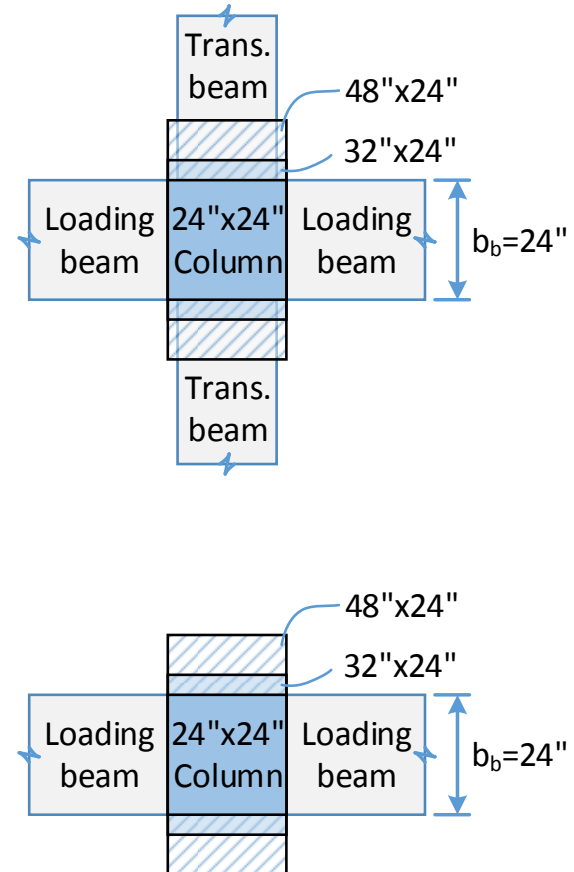


Case study, b_j and γ -value per ACI 318

- Column depth $h_c = 24$ in. ; Beam width $b_b = 24$ in.
- Column width range from 24 to 48 in.



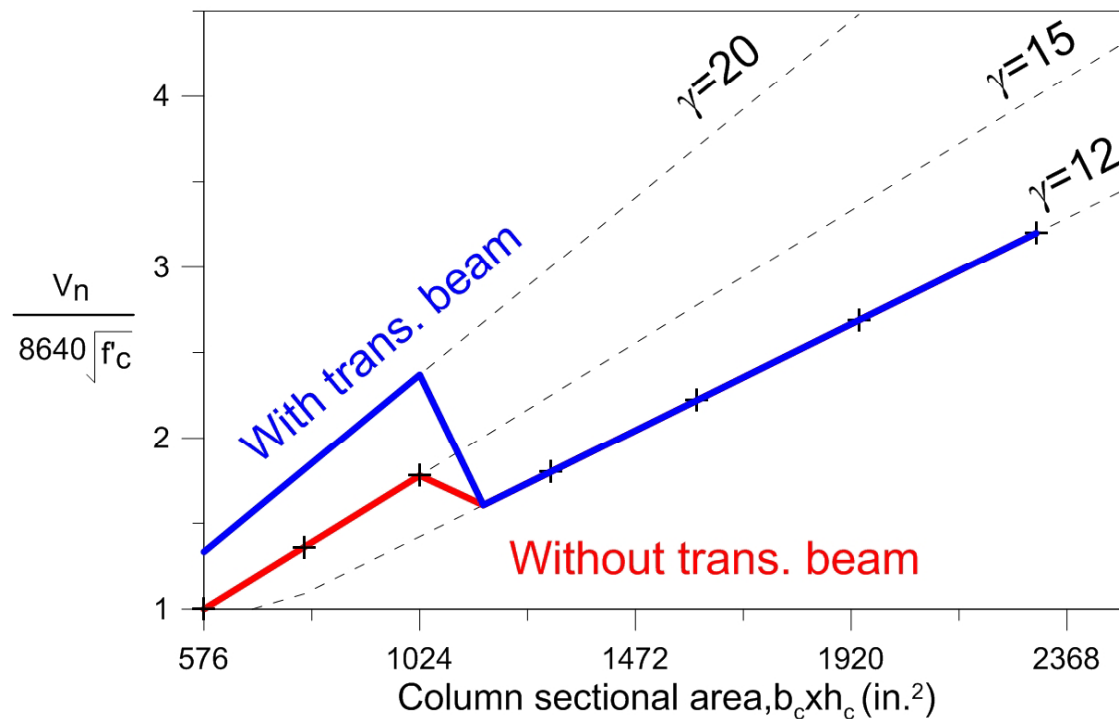
$M_b = T_s \cdot jd = C \cdot jd$



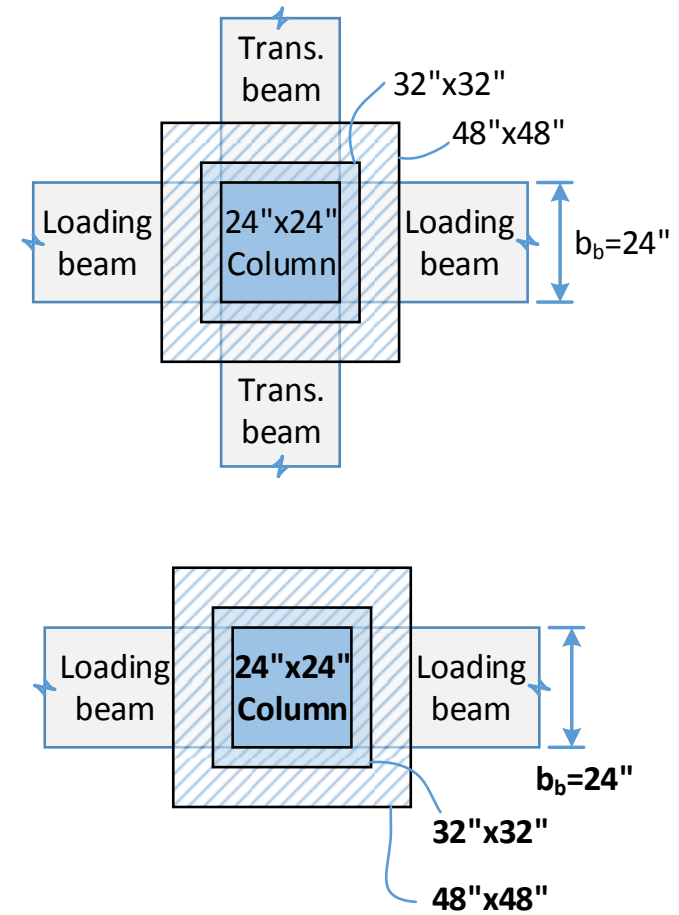
Plan view of connection

Case study, b_j and γ -value per ACI 318

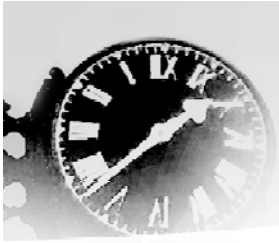
- Beam width $b_b = 24$ in.
- Increasing square column section from 24x24 in. to 48x48 in.



Beyond $b_c x h_c = 32 \times 32$, $\frac{b_b}{b_j} < 0.75$, both γ values drop to 12



Plan view of connection



6.1.2 接頭剪力強度 $V_n = \gamma \sqrt{f'_c} A_j$ (psi)

$$V_n = 0.083 \gamma \sqrt{f'_c} A_j \quad (\text{MPa})$$

$$V_n = 0.265 \gamma \sqrt{f'_c} A_j \quad (\text{kgf/cm}^2)$$

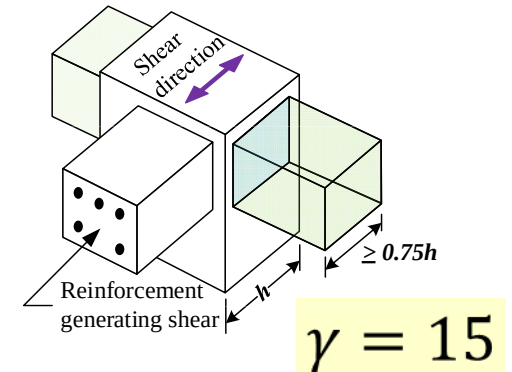
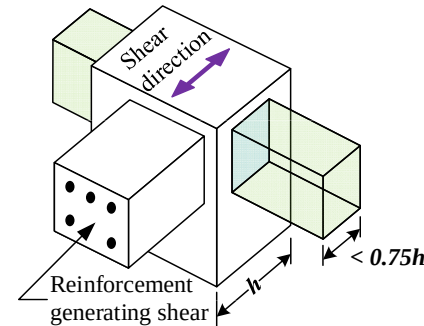
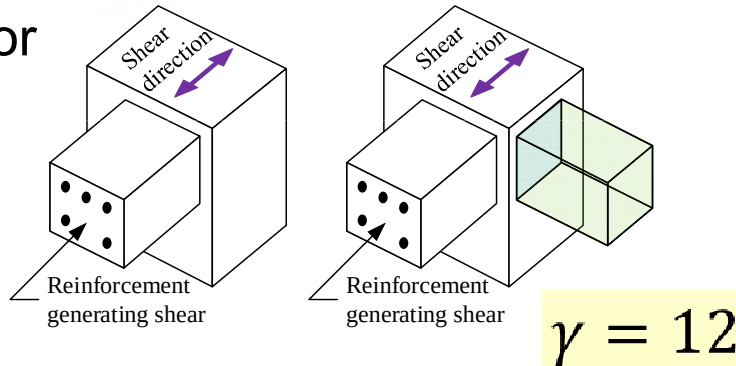
Joint **without** continuous transverse beams

Joint **with** continuous transverse beams

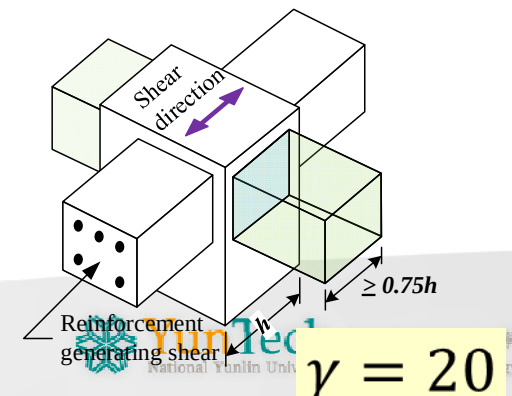
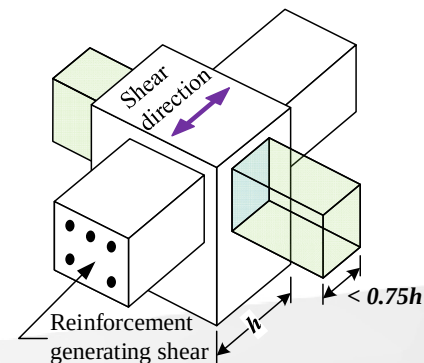
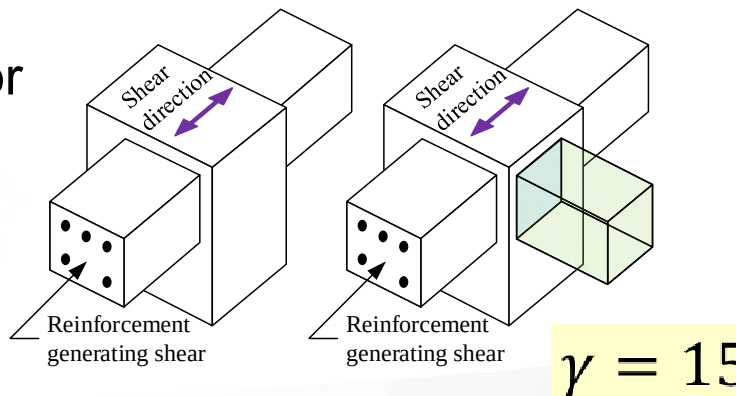
but $b_{b,tr} < \frac{1}{2} h_c$

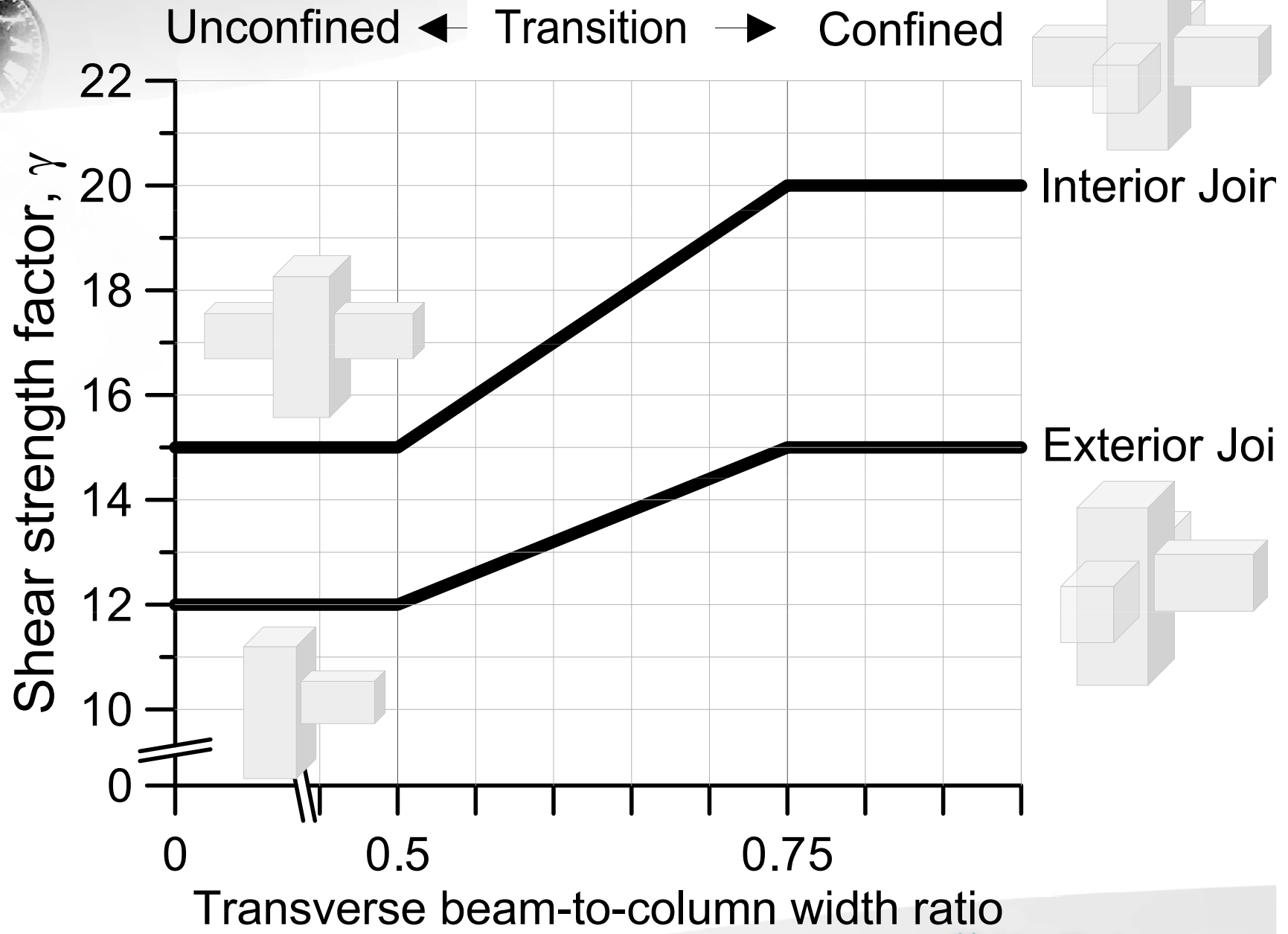
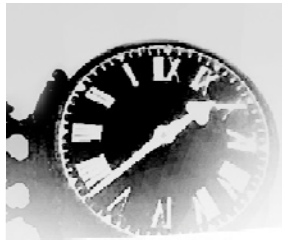
and $b_{b,tr} \geq \frac{3}{4} h_c$

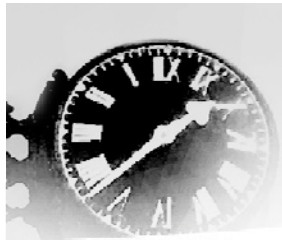
Exterior Joint



Interior Joint



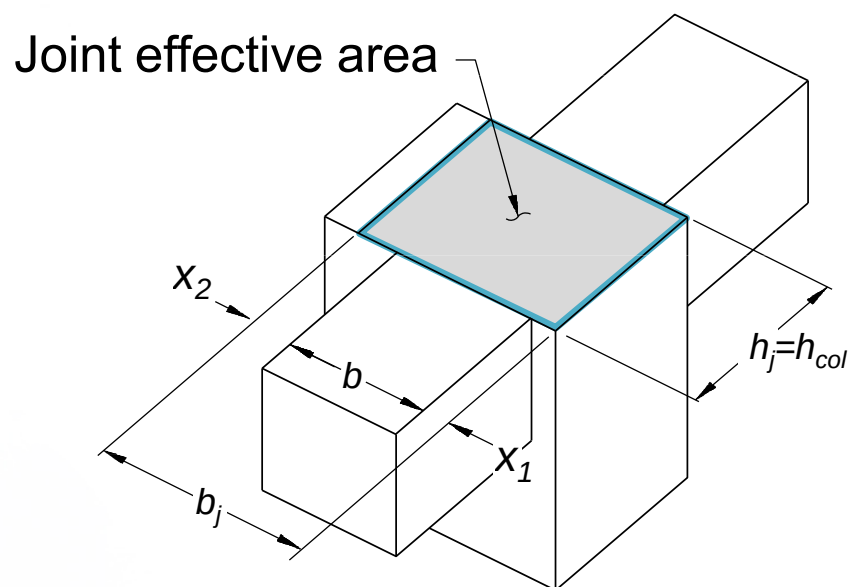




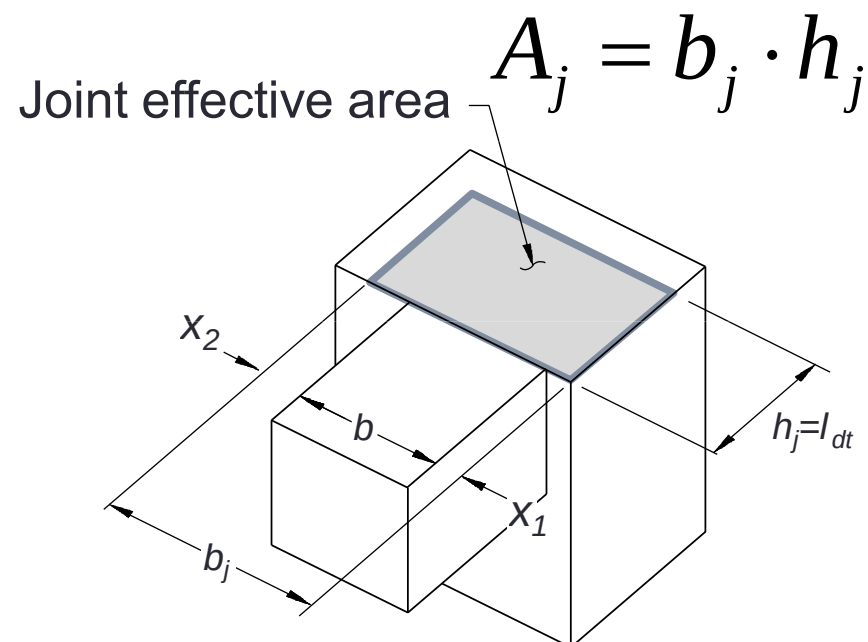
Effective Joint Area $A_j = b_j \cdot h_j$

$$b_j = b + x_1 + x_2 \leq b_{col}$$

其中 x_1 及 x_2 分別為梁兩邊至柱邊之距離，代入上式計算時， x_1 或 x_2 值不得超過 $h_{col}/4$ 。[黃世建等人(2014)]



(a) 梁主筋貫穿梁柱接頭, $h_j = h_{col}$

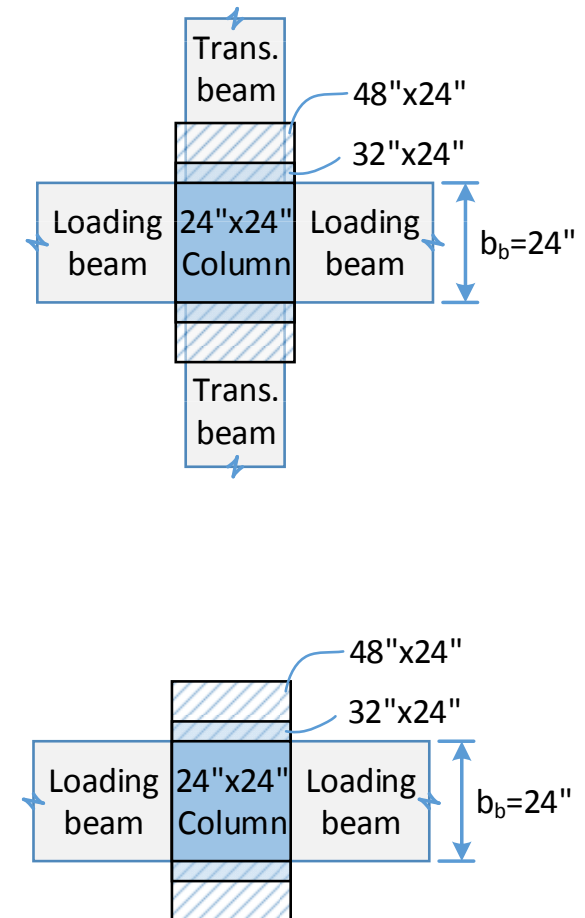
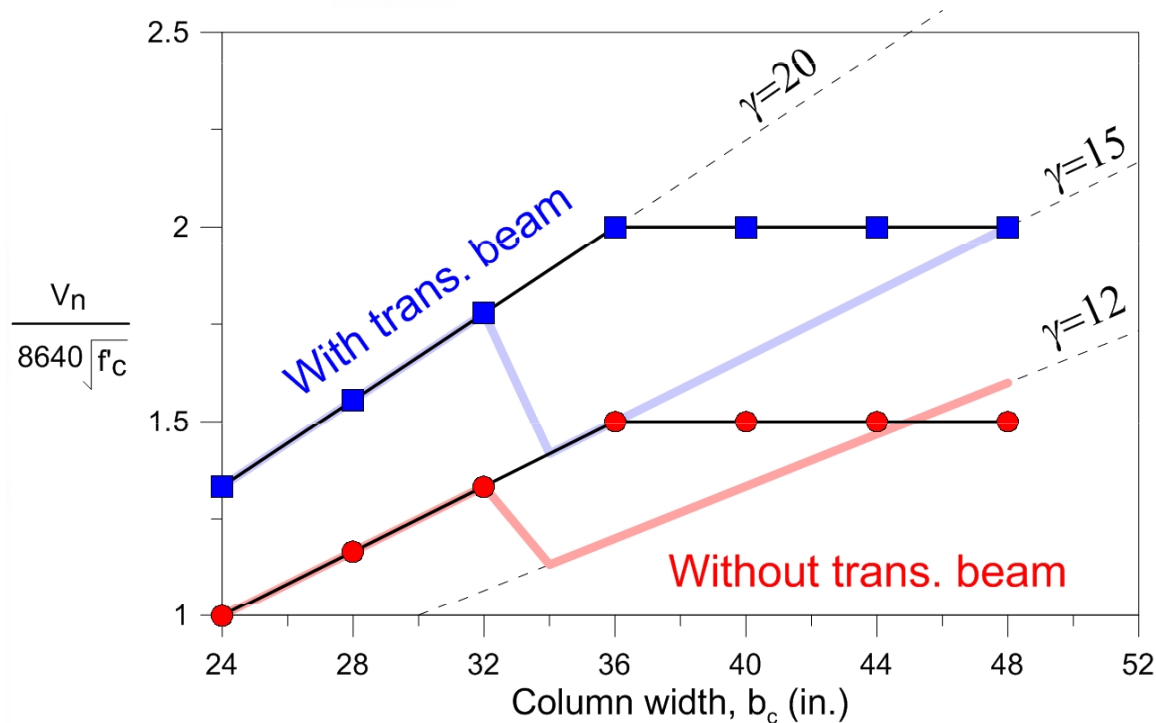


(b) 梁主筋錨定於接頭內, $h_j = l_{dt}$

除非梁主筋之錨定長度皆超過 $3/4$ 柱深度以上，
接頭有效深度 h_j 得為柱深度 h_{col}

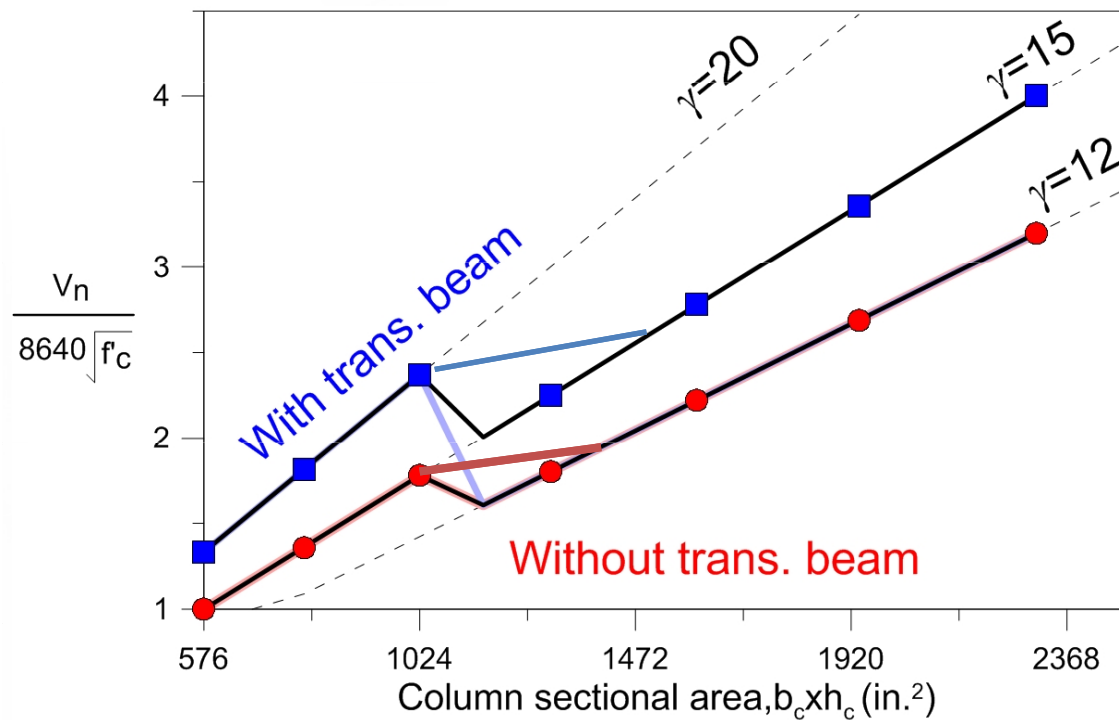
Case study, b_j and γ -value per ACI 318

- Column depth $h_c = 24$ in. ; Beam width $b_b = 24$ in.
- Column width range from 24 to 48 in.

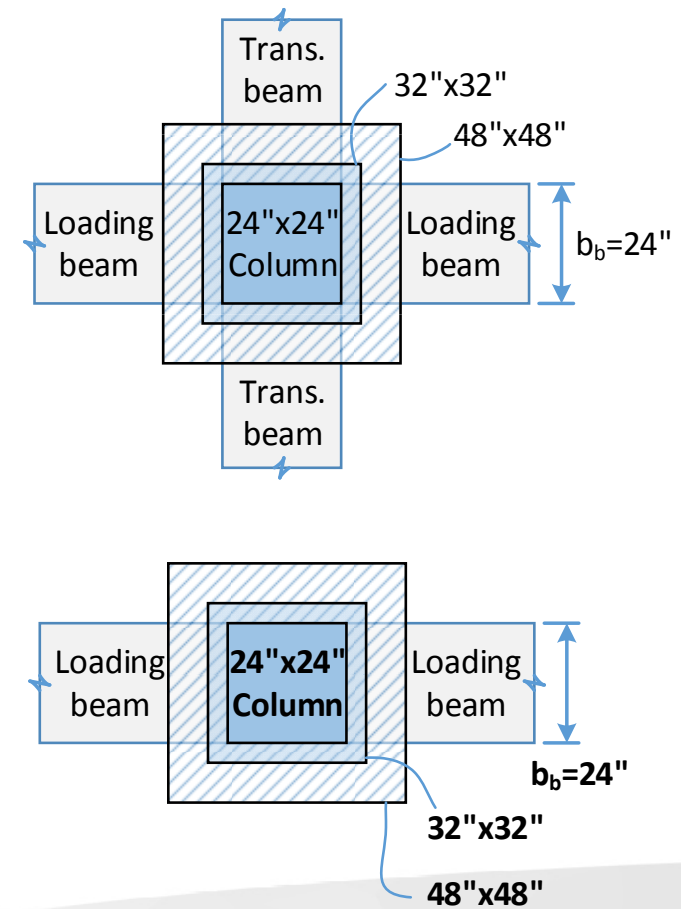


Case study, proposed b_i and γ -value

- Beam width $b_b = 24$ in.
- Increasing square column section from 24x24 in. to 48x48 in.



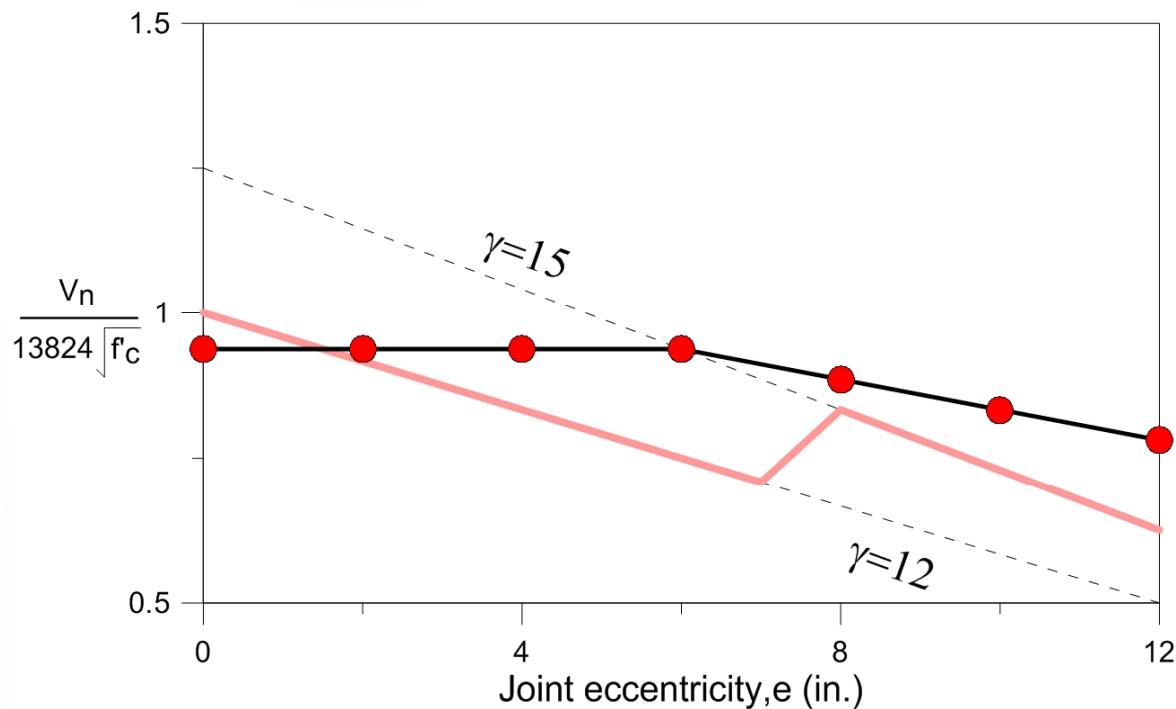
$\frac{b_{b,tr}}{h_c} < 0.75$, γ value drop down one category



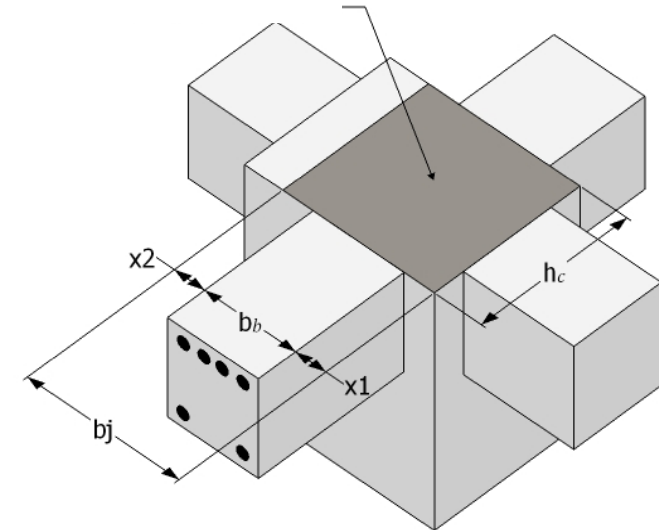
Plan view of connection

Case study for eccentric joints

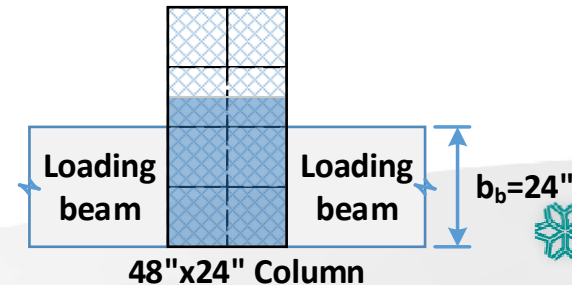
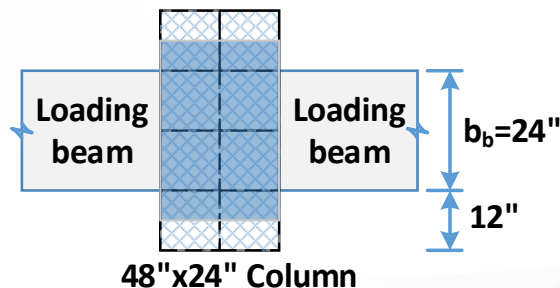
- 48x24-in. Column
- Beam width $b_b = 24$ in.
- Eccentricity range from 0 to 12 in.

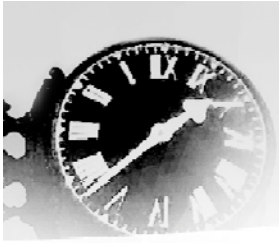


Joint effective area



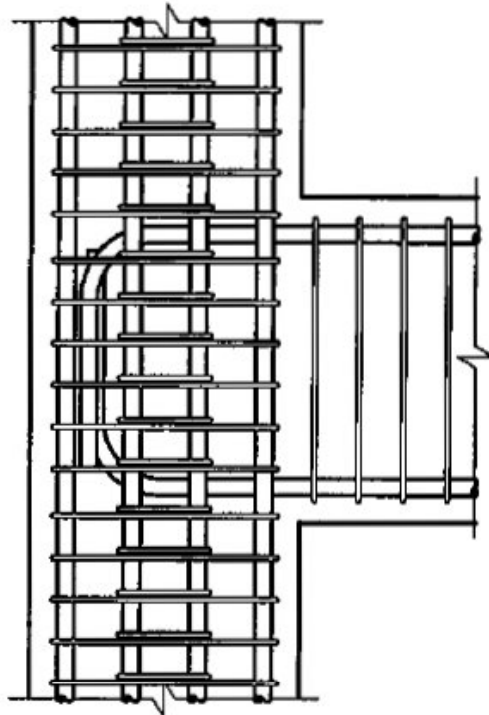
where x_1 and x_2 should be the lesser of $h_c/4$ and the edge distance between beam and column faces.





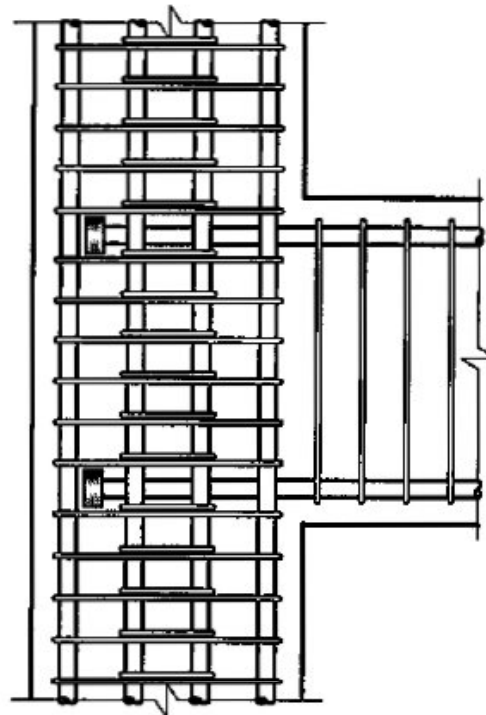
Exterior beam-column joints

$$\gamma = 12$$



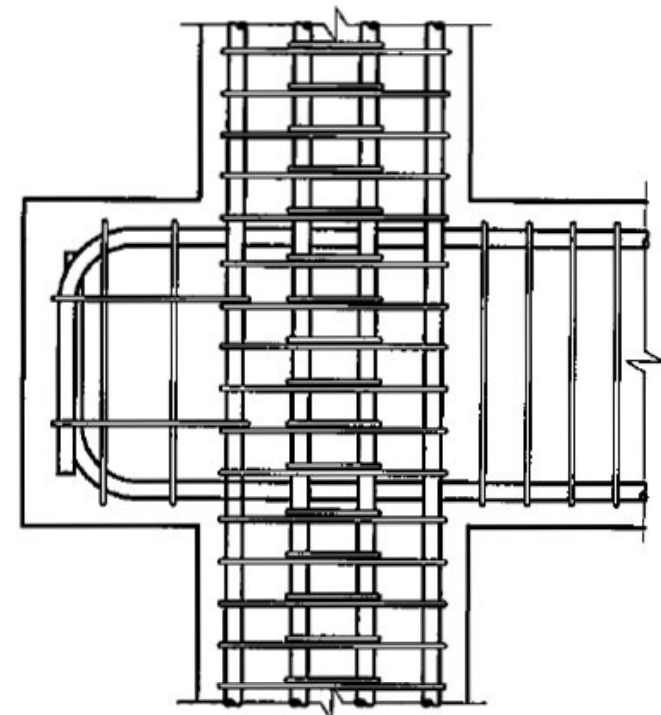
(a) Hooked reinforcement

$$\gamma = 12$$



(b) Headed reinforcement

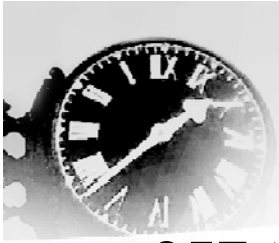
$$\gamma = 15$$



(c) Stub beam

FIGURE 9.24 Elevation views of typical reinforcement for exterior beam-column connections with joint transverse reinforcement.

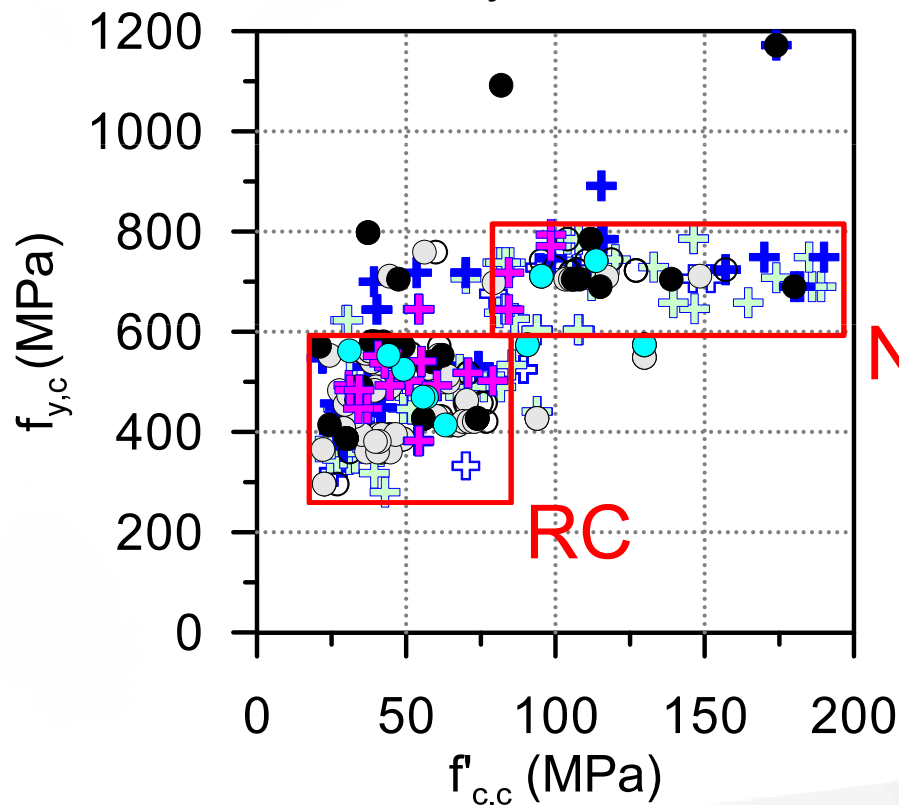
Source: Jack Moehle, [Seismic Design of Reinforced Concrete Buildings](#)



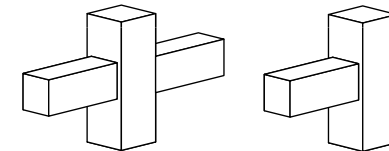
Database construction

- 357 test data published in Japan, US, NZ, and Taiwan
- Unified database for normal-strength and high-strength RC
- Beam-column joints without trans. beams/slabs, eccentricity

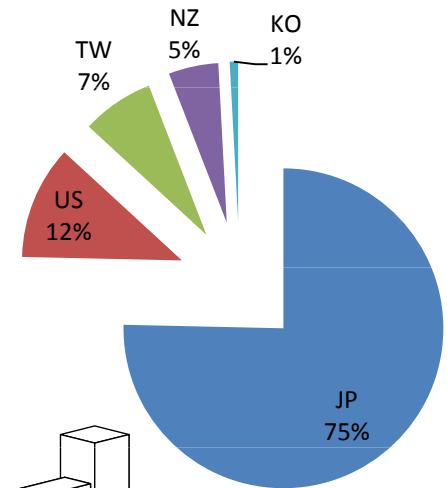
Column bar f_y versus f'_c



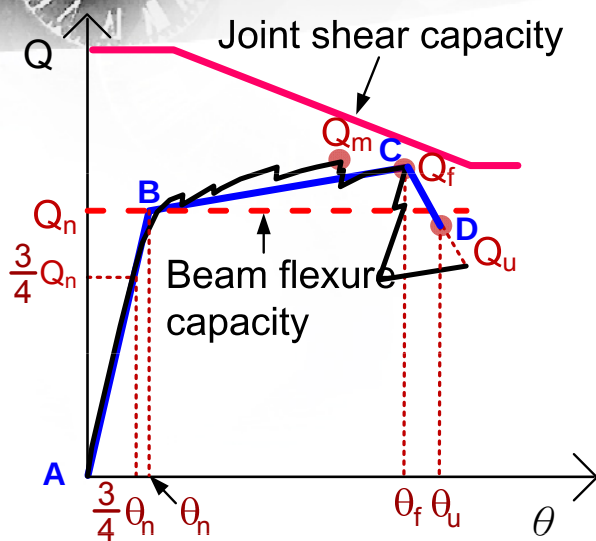
New RC



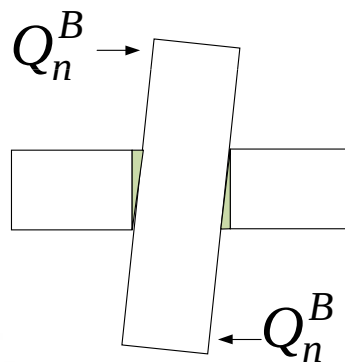
Type	Int.(202)	Ext.(155)
B	+	o
BJ	+	o
J	+	•
BJ _a	+	•



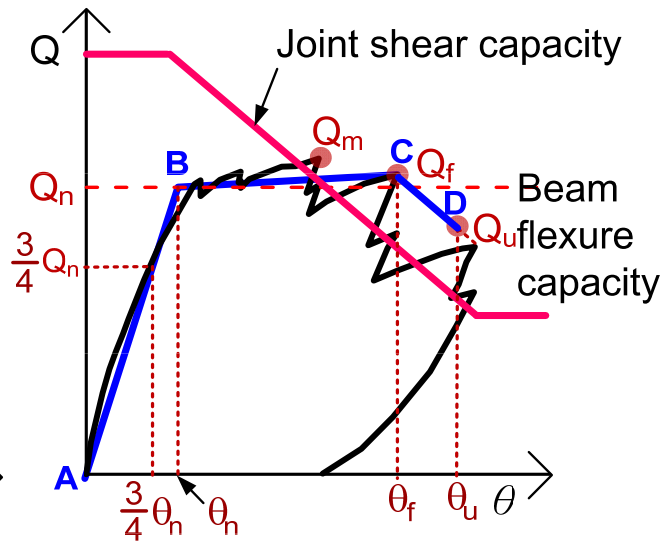
Failure modes and ductility



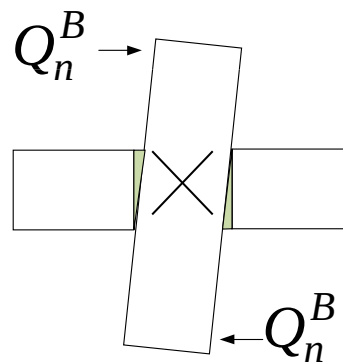
B-failure



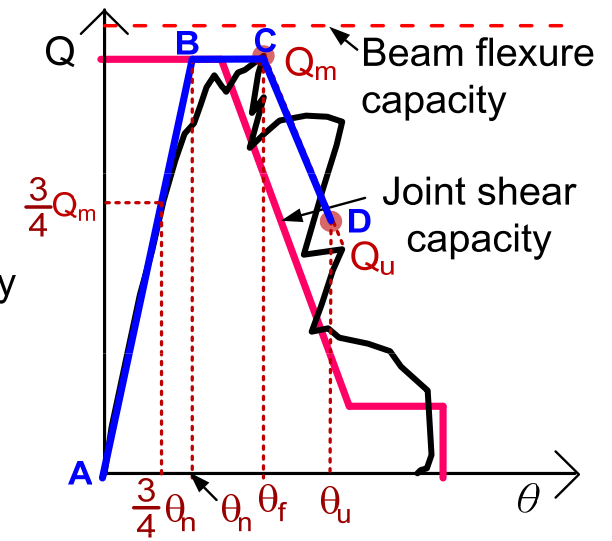
Definitely well



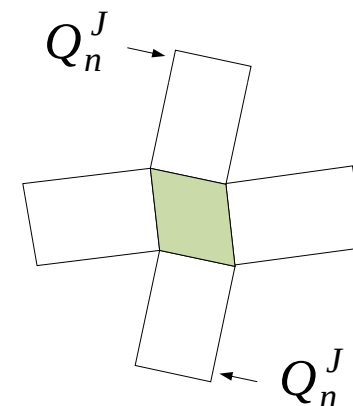
BJ-failure



Okay with ductility



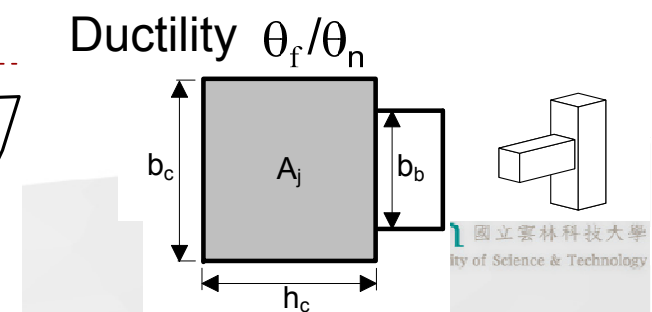
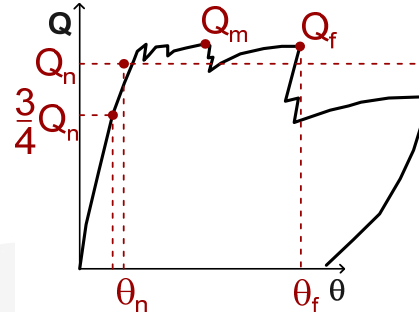
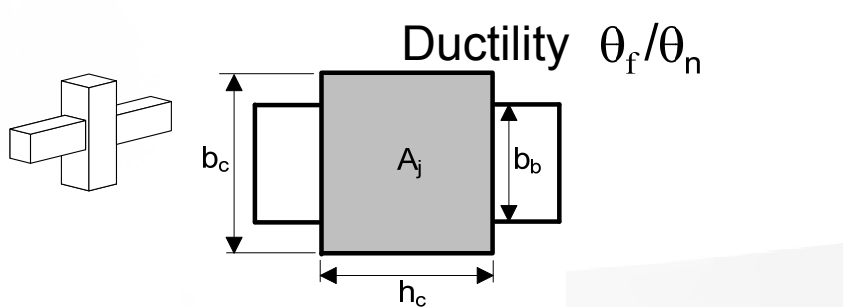
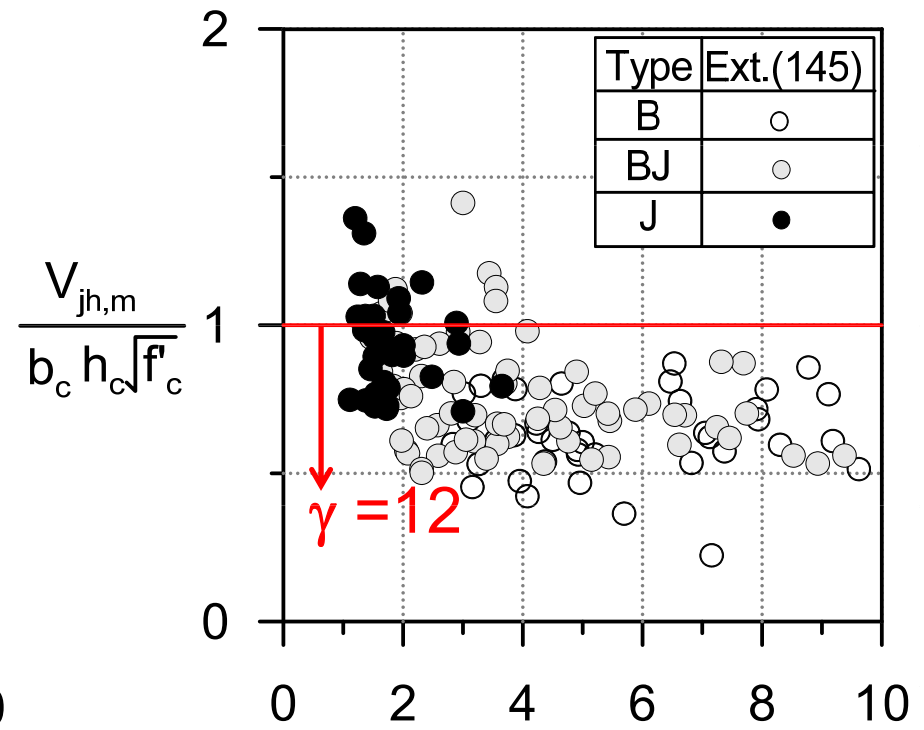
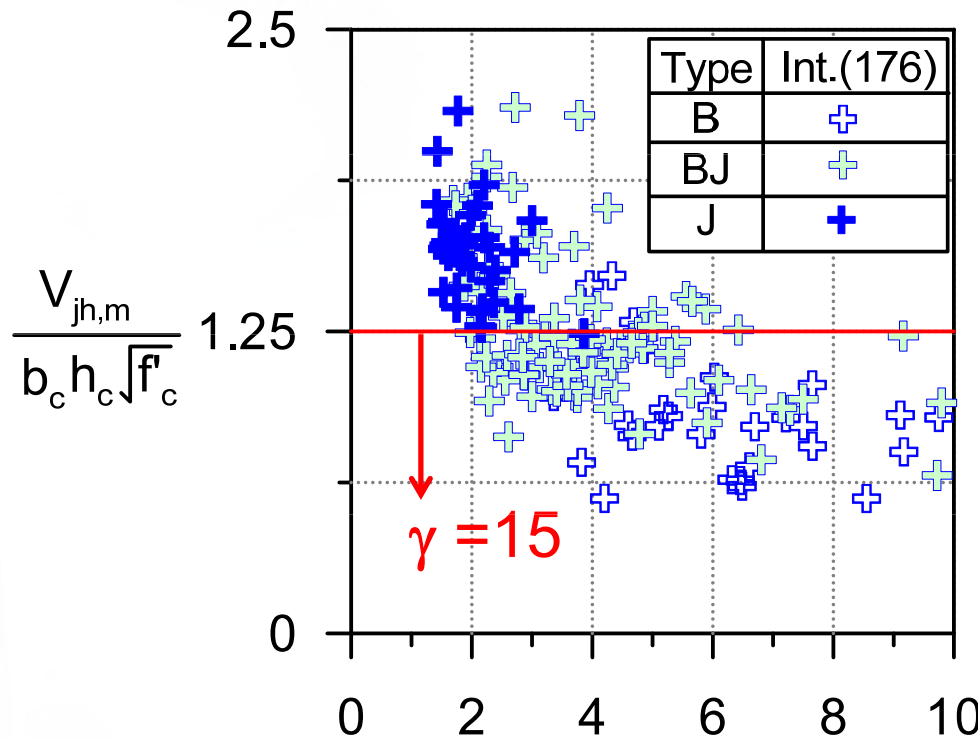
J-failure

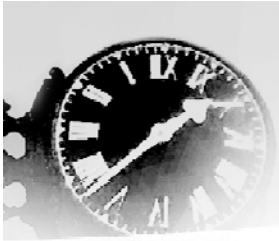


Not acceptable

Joint Shear Strength-Ductility Trends

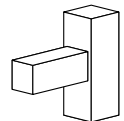
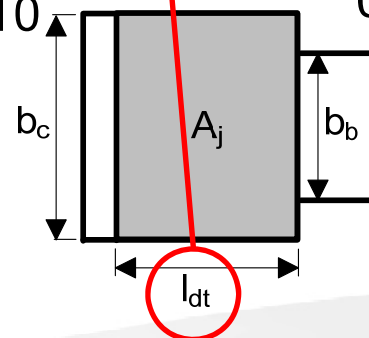
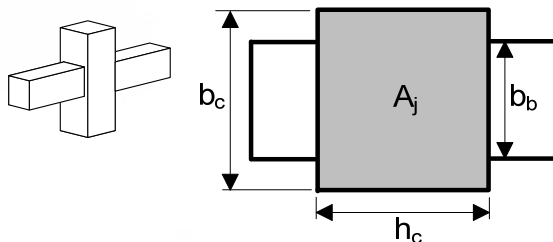
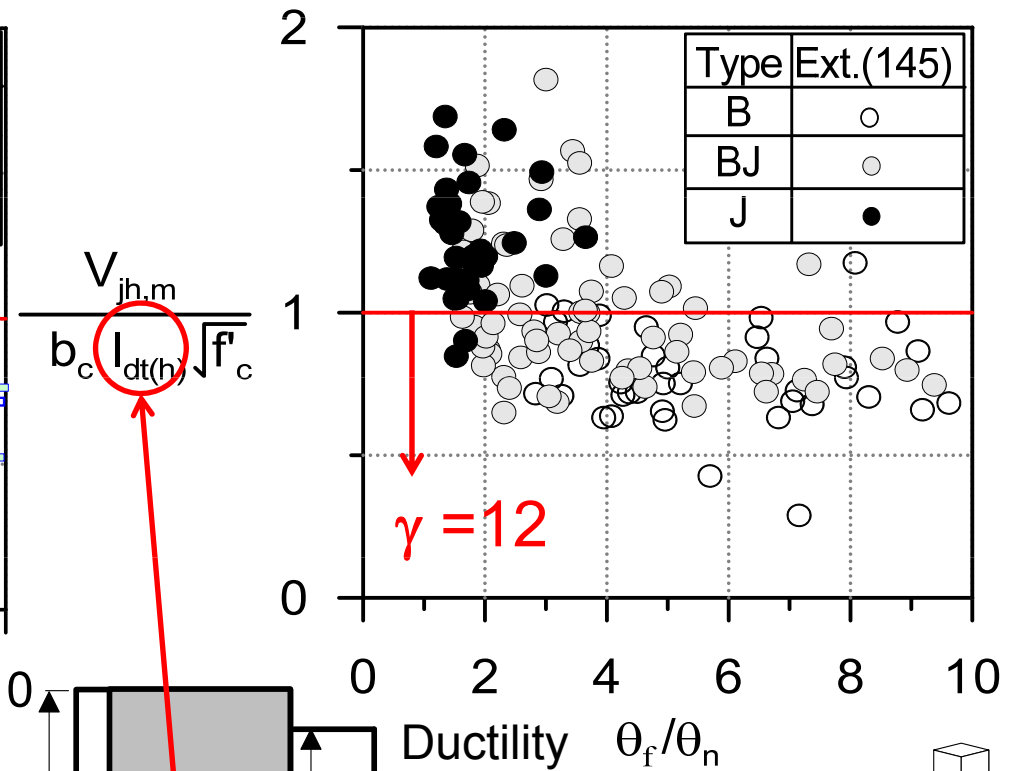
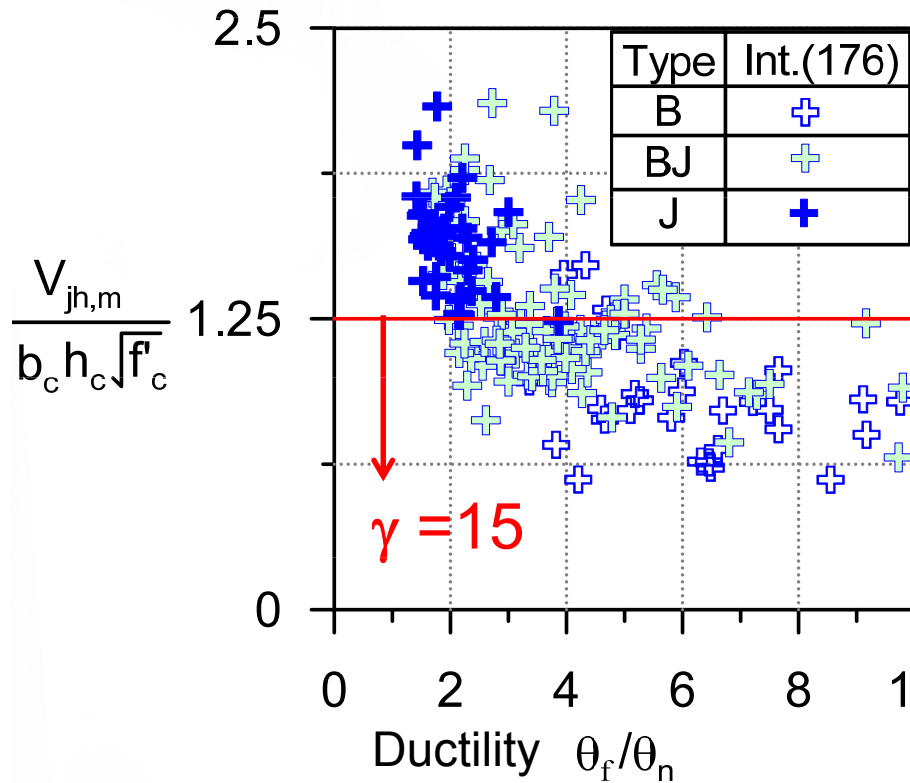
- Experimental joint shear force, normalized to effective joint area and $\sqrt{f'_c}$ in MPa
- There is no J failures below the γ -value of 15 for interior joints, but quite a few below the γ -value of 12 for exterior joints. (To be evaluated later)

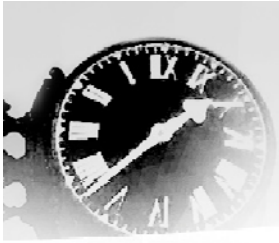




Change of Effective Joint Depth

- Obviously improved, but...

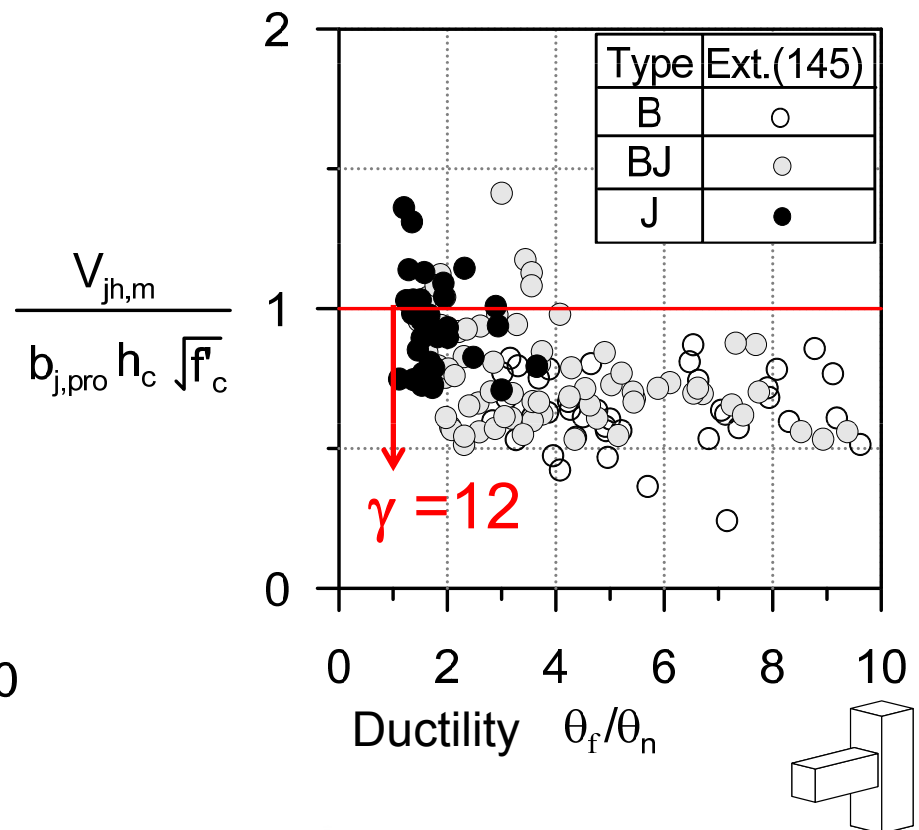
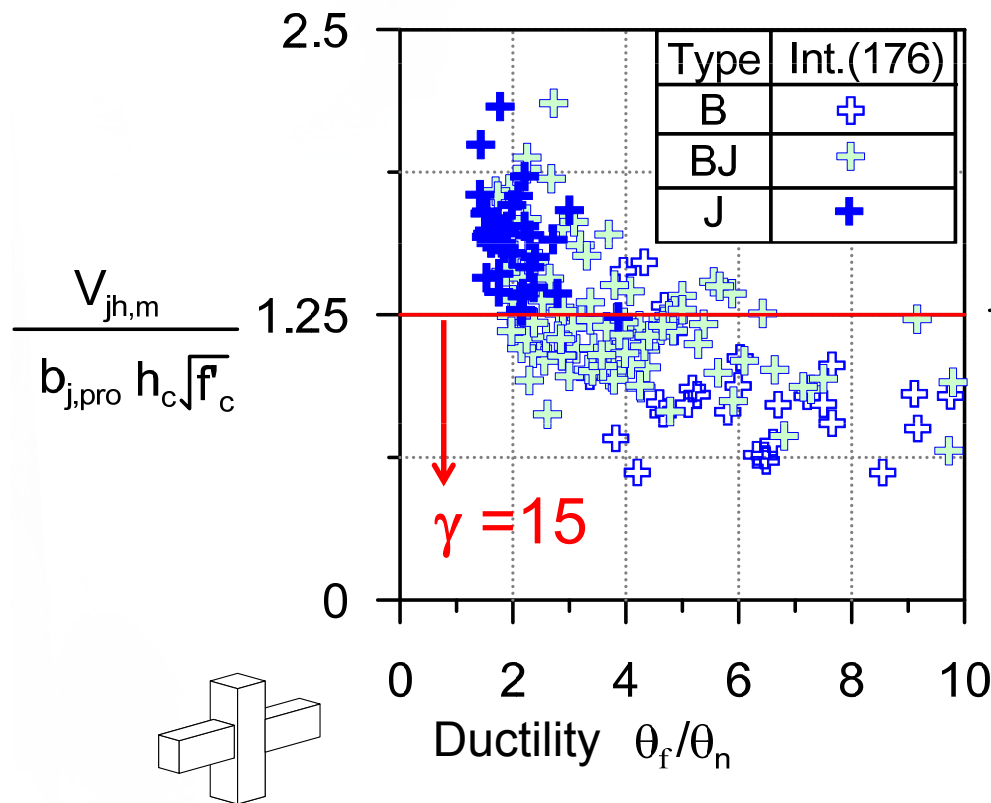


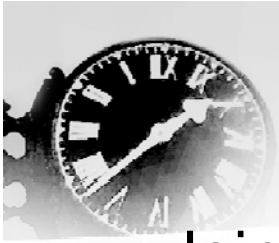


Change of Effective Joint Width

- All test data are concentric joints
- $b_j = b_c$ for the majority of the data

$$b_{j,pro} = b_b + \sum \min\left(\frac{h_c}{4}, x_i\right) \leq b_c$$

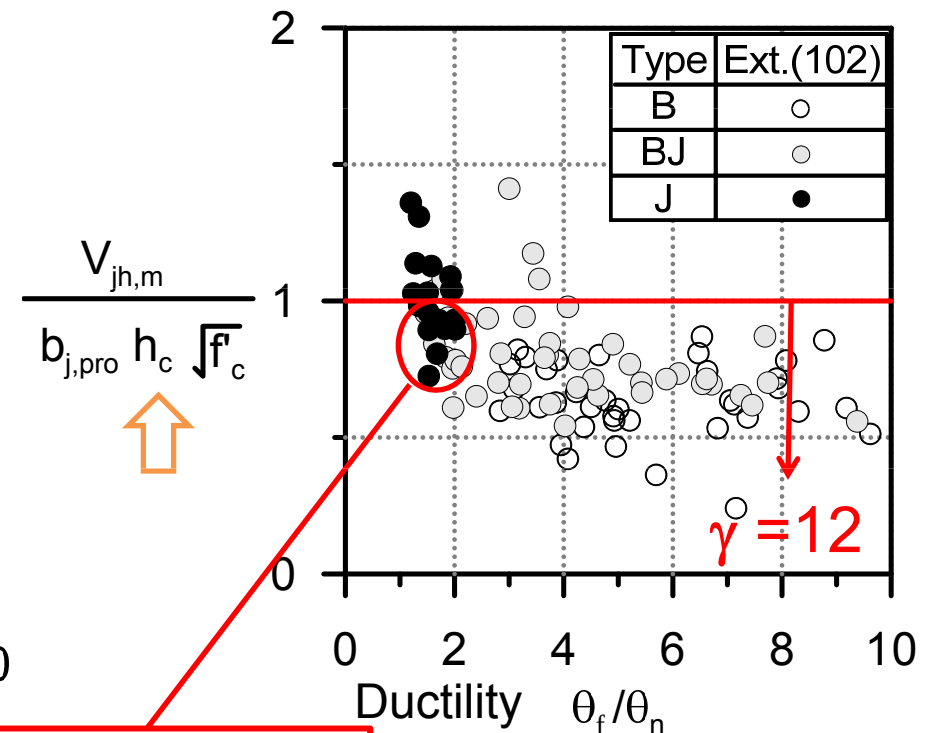
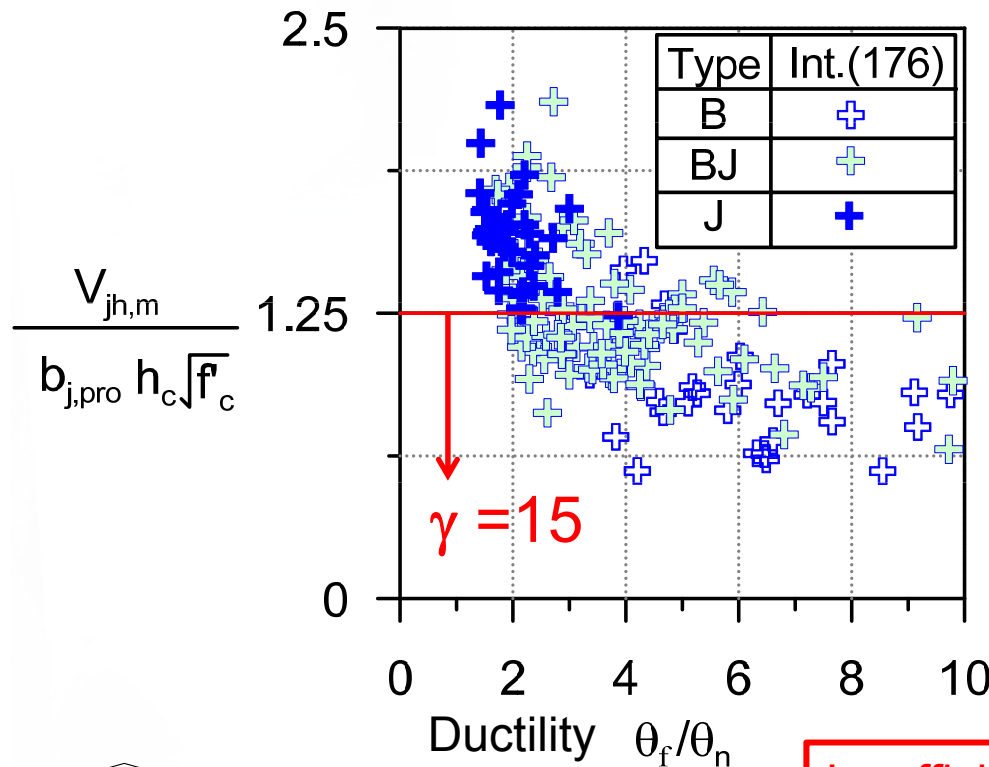




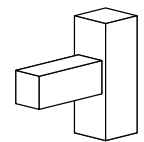
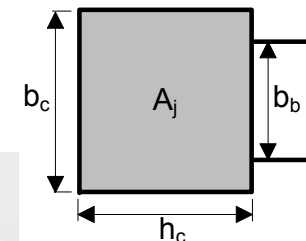
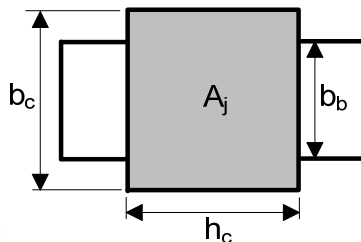
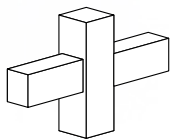
Change of Effective Joint Width + Conditions

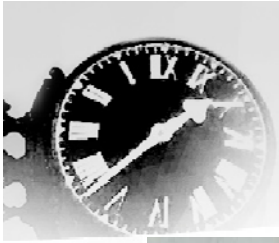
- Joint shear strength is quite sensitive to anchorage length
- Add a condition of $\ell_{dt(h)} \geq 0.75h_c$

145 – 43 = 102 joints herein

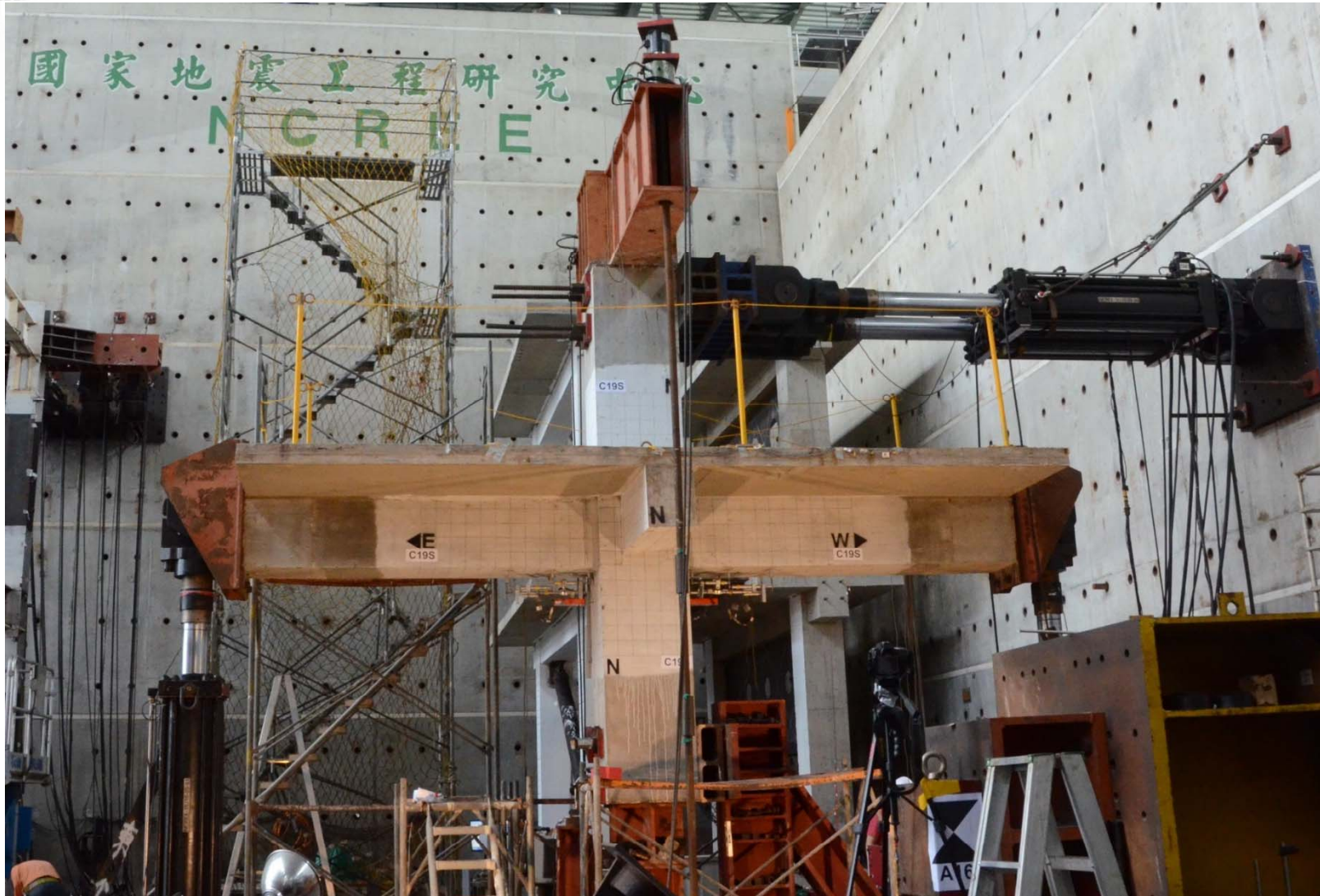


Insufficient confinement,
Ash, ratio < 1.0





Seismic Testing for Interior Beam-Column Joints

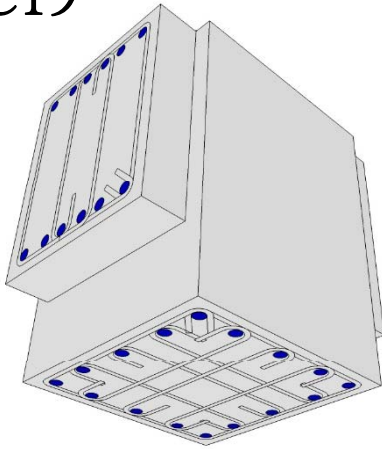




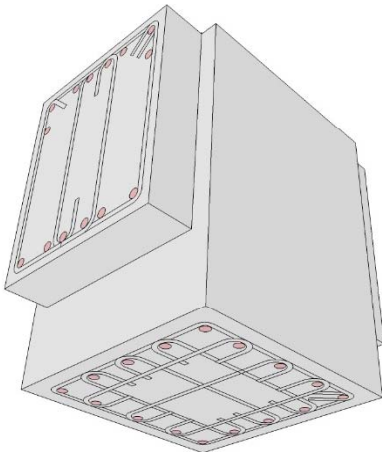
試體設計

前期實驗試體

C19



A24



試體設計參數

$$\sim 20\sqrt{f'_c} \text{ psi}$$

$$\frac{\Sigma M_{nc}}{\Sigma M_{nb}} = 1.26$$

600x600-mm Col.
16-D32
500x600 mm
6-D32 top & 6-D32 bot

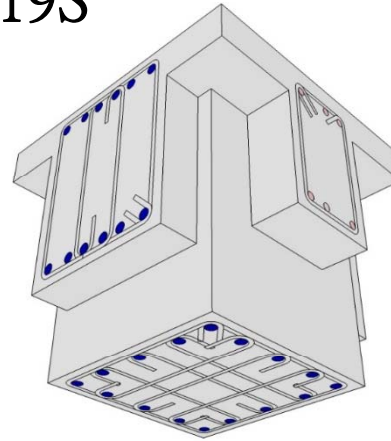
$$\sim 15\sqrt{f'_c} \text{ psi}$$

$$\frac{\Sigma M_{nc}}{\Sigma M_{nb}} = 1.16$$

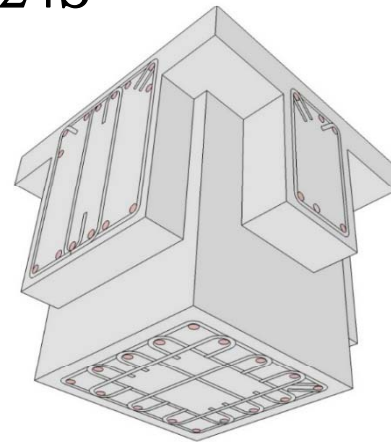
600x600-mm Col.
16-D25
500x600 mm
8-D25 top & 6-D25 bot.

$$\frac{b_{b,tr}}{h_{col}} = \frac{1}{2}$$

C19S

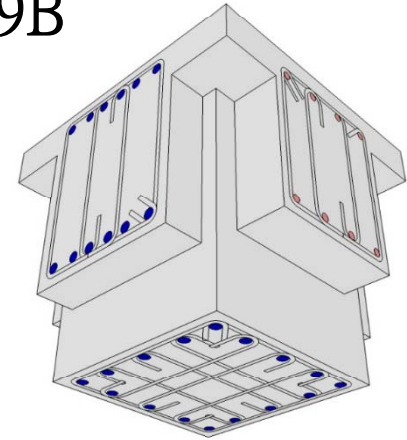


A24S

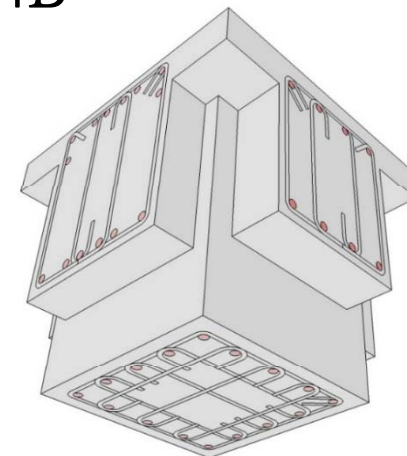


$$\frac{b_{b,tr}}{h_{col}} = \frac{3}{4}$$

C19B



A24B

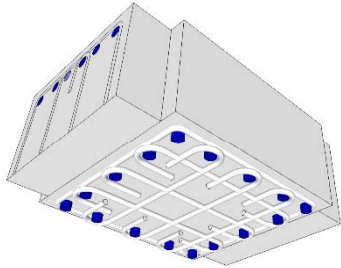




試體設計

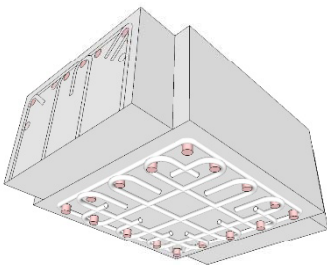
前期實驗試體

C19



$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = 0.90$$

A24



$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = 0.90$$

試體設計參數

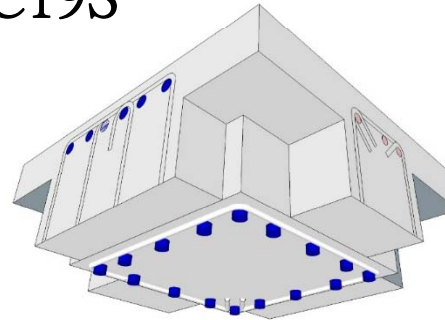
$$\sim 20\sqrt{f'_c} \text{ psi}$$

$$\frac{\Sigma M_{ac}}{\Sigma M_{ab}} = 1.26$$

600x600-mm Col.
16-D32

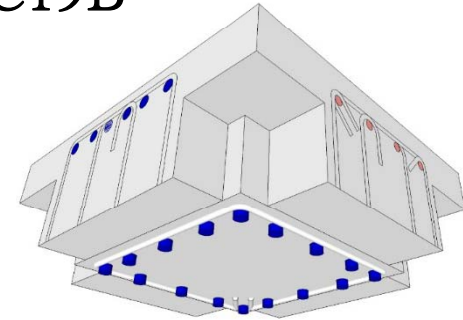
500x600 mm
6-D32 top & 6-D32 bot

C19S



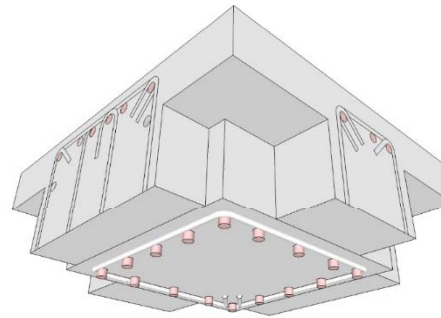
$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = \underline{0.40}$$

C19B



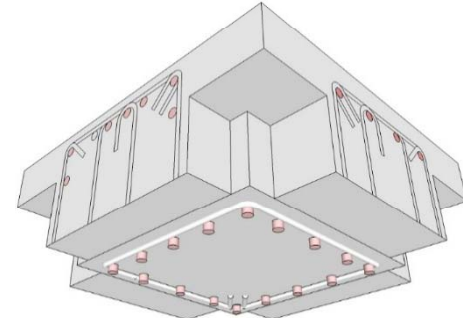
$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = \underline{0.40}$$

A24S



$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = \underline{0.40}$$

A24B



$$\frac{Ash_{\text{使用量}}}{Ash_{\text{需要量}}} = \underline{0.40}$$

材料強度

鋼筋強度測試

	#10 SD685	#8 SD686	#4 SD785	#3 SD420W
fy (Mpa)	697	717	844	484
fu (Mpa)	901	909	1020	687
伸長率(%)	14	12	15	21

混凝土強度測試

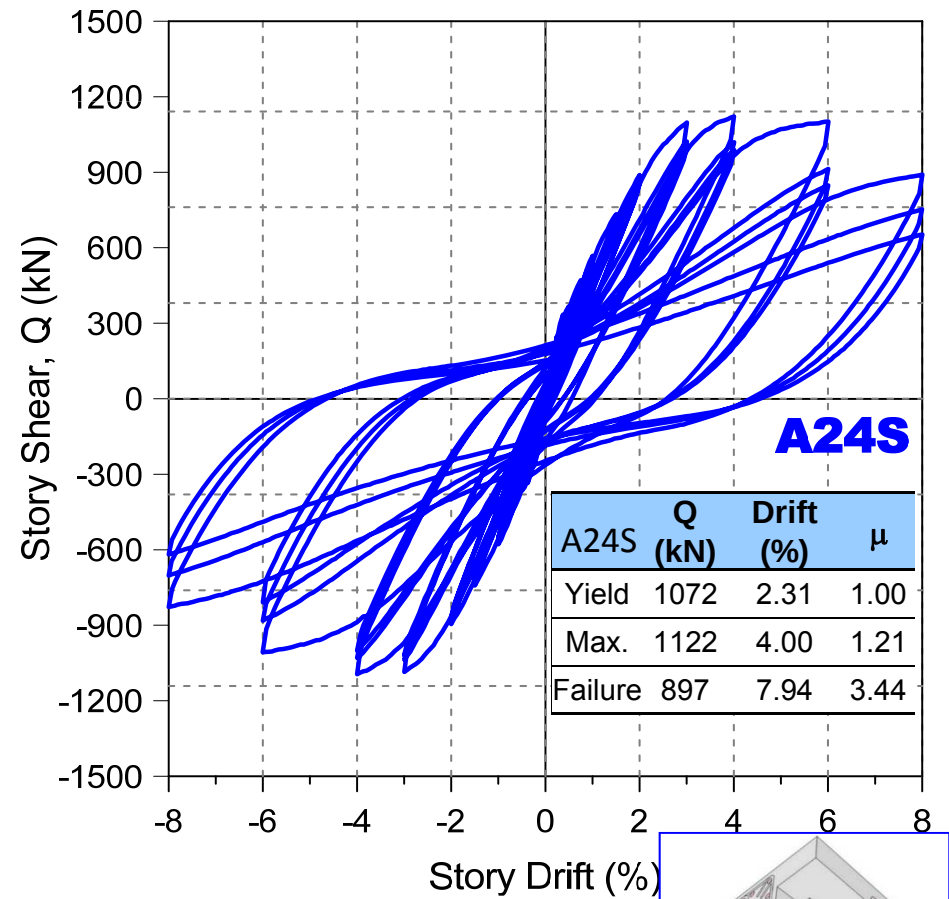
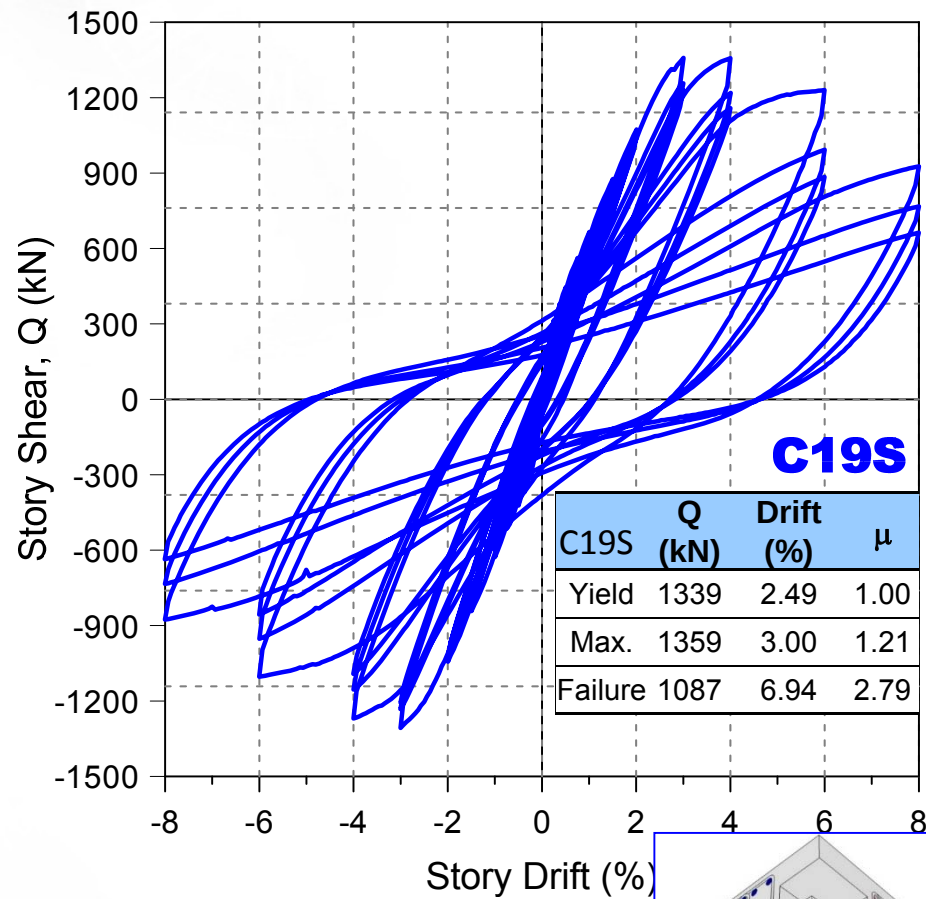
$f'_c = 100 \text{ MPa}$

	A24S	A24B	C19S	C19B
接頭&版	104 (122)	95 (119)	117 (129)	116 (132)
梁腹	109 (122)	104 (122)		
下半柱				
上半柱			110 (121)	108 (121)

*註:(實驗日強度)



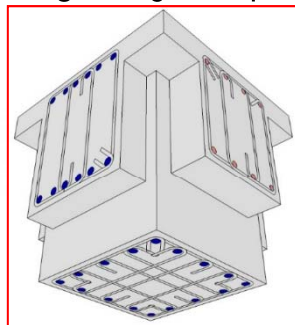
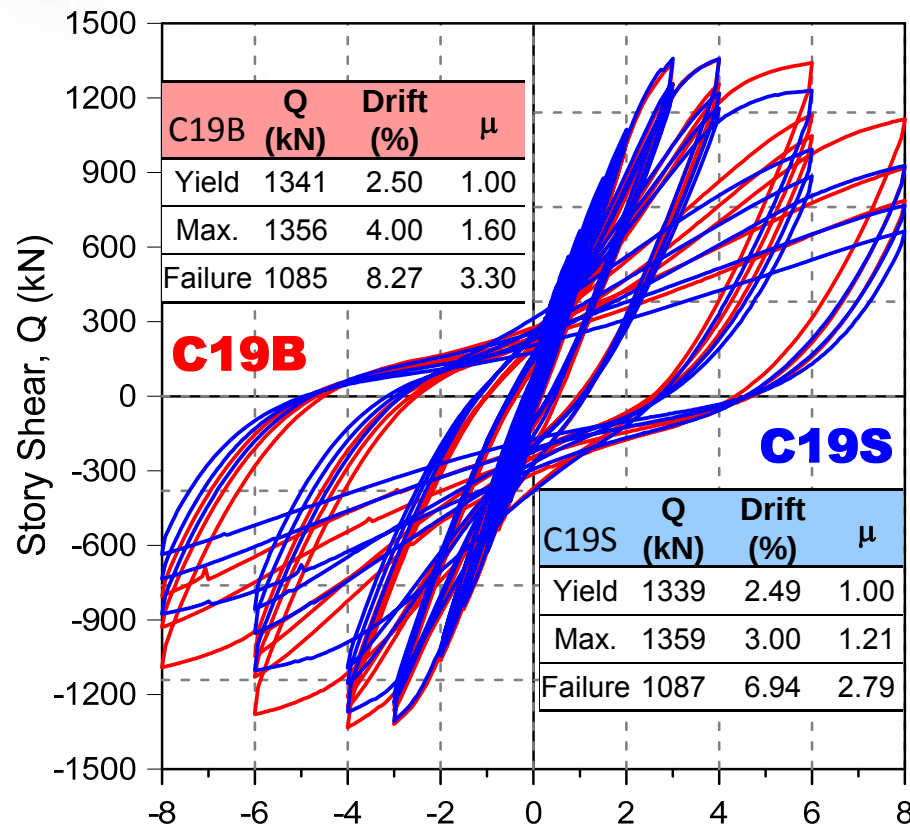
遲滯迴圈比較(1)



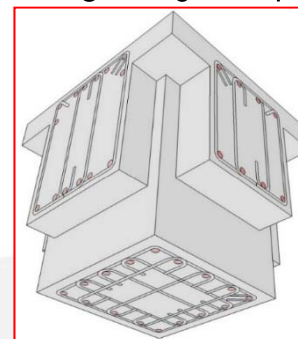
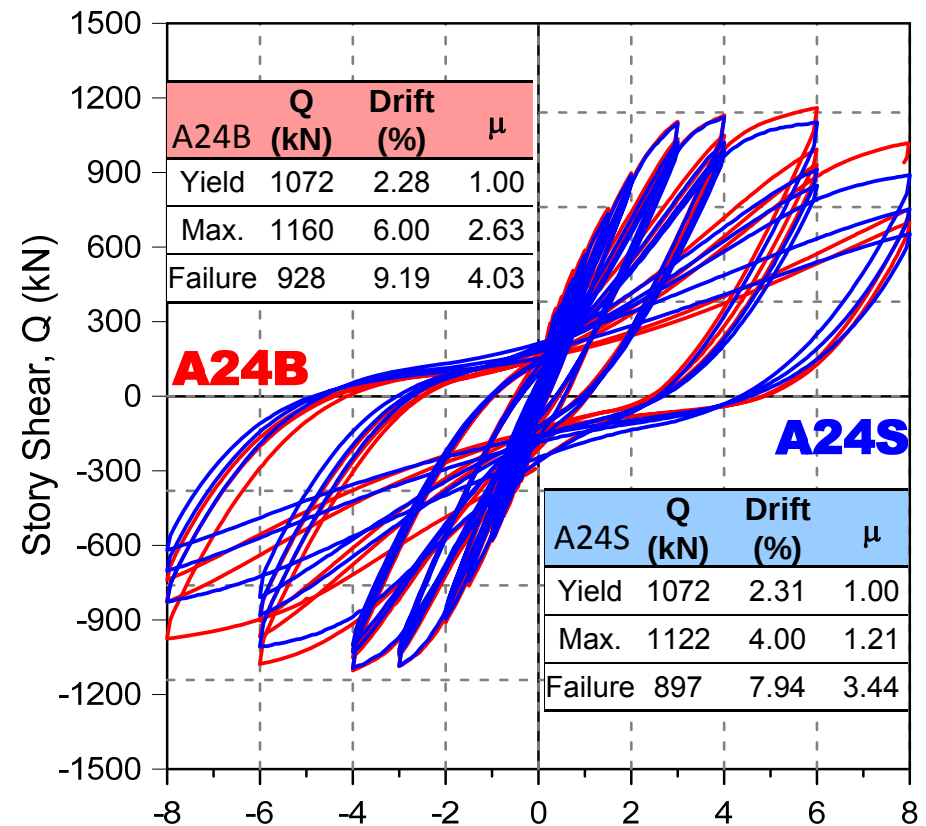
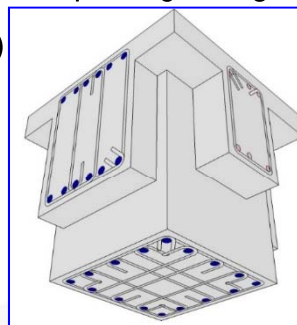


遲滯迴圈比較(1)

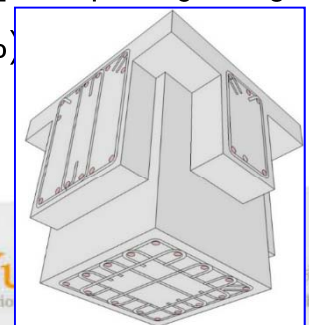
- 四支試體皆為 BJ 破壞
- 韌性表現 A24B 最佳 C19S最差



Story Drift (%)



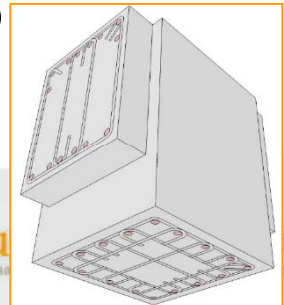
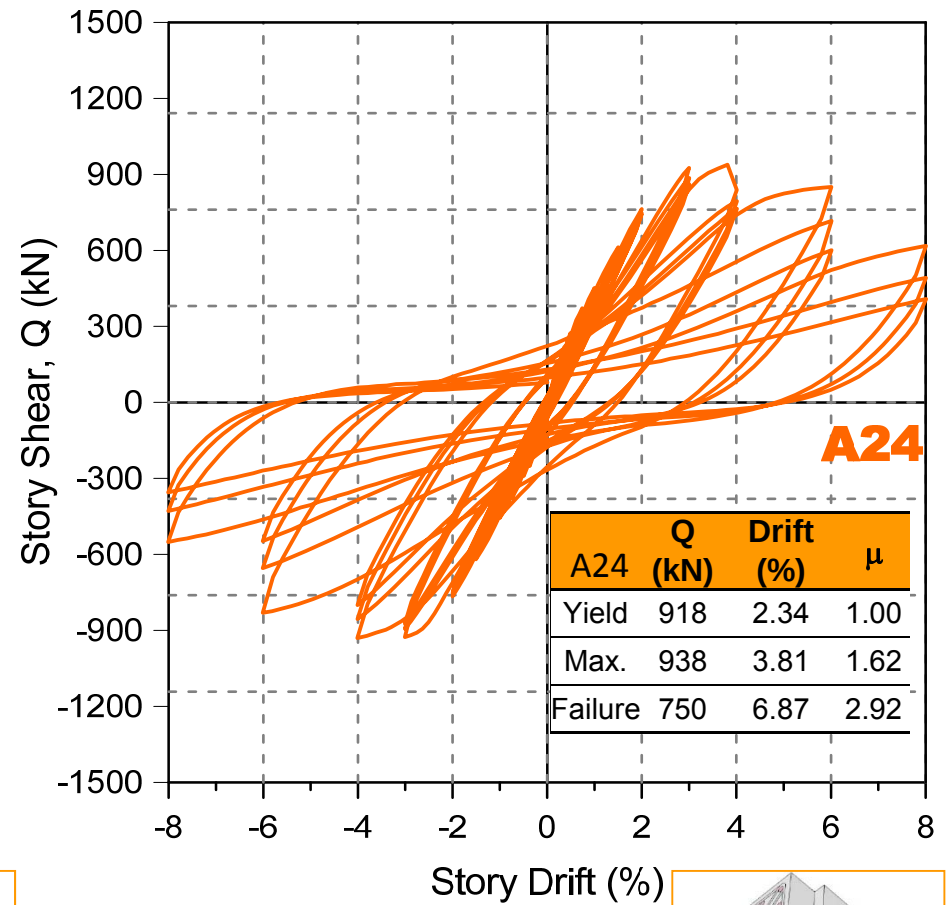
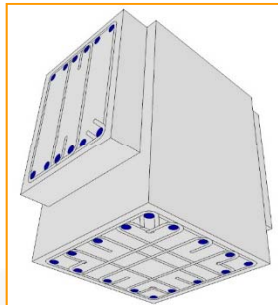
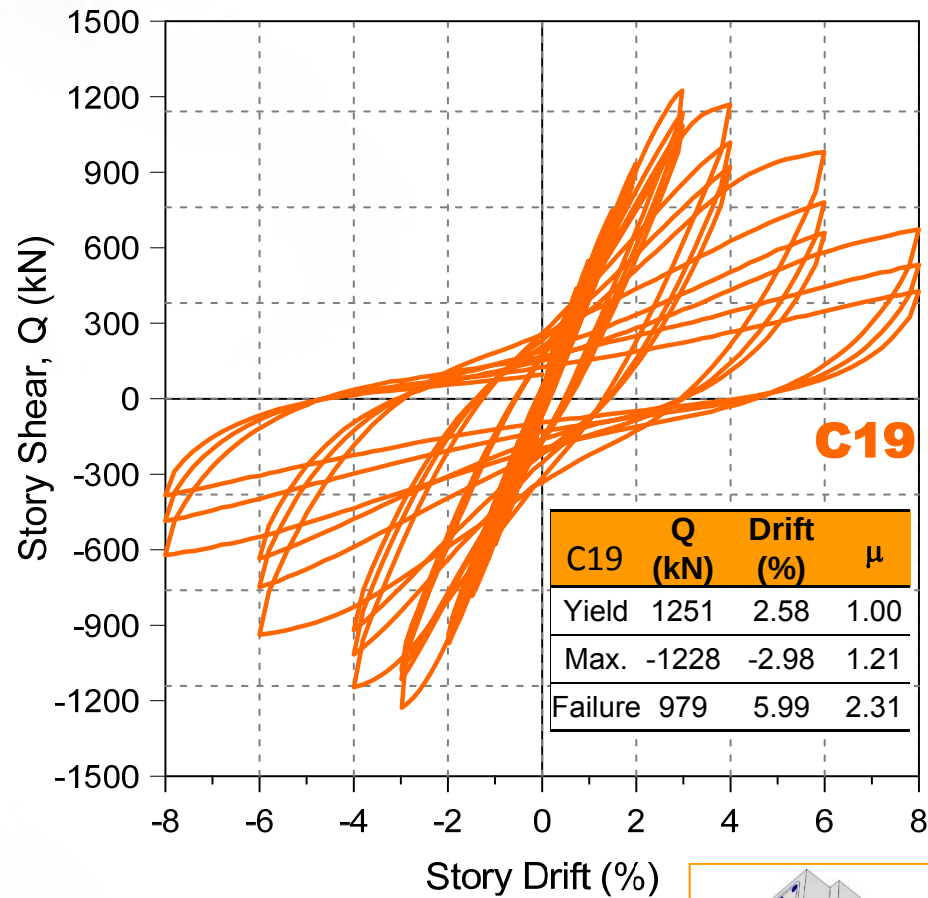
Story Drift (%)





遲滯迴圈比較(2)

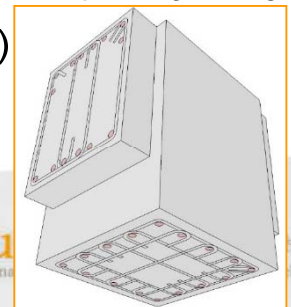
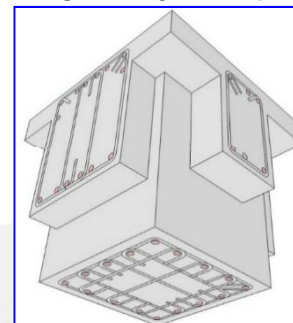
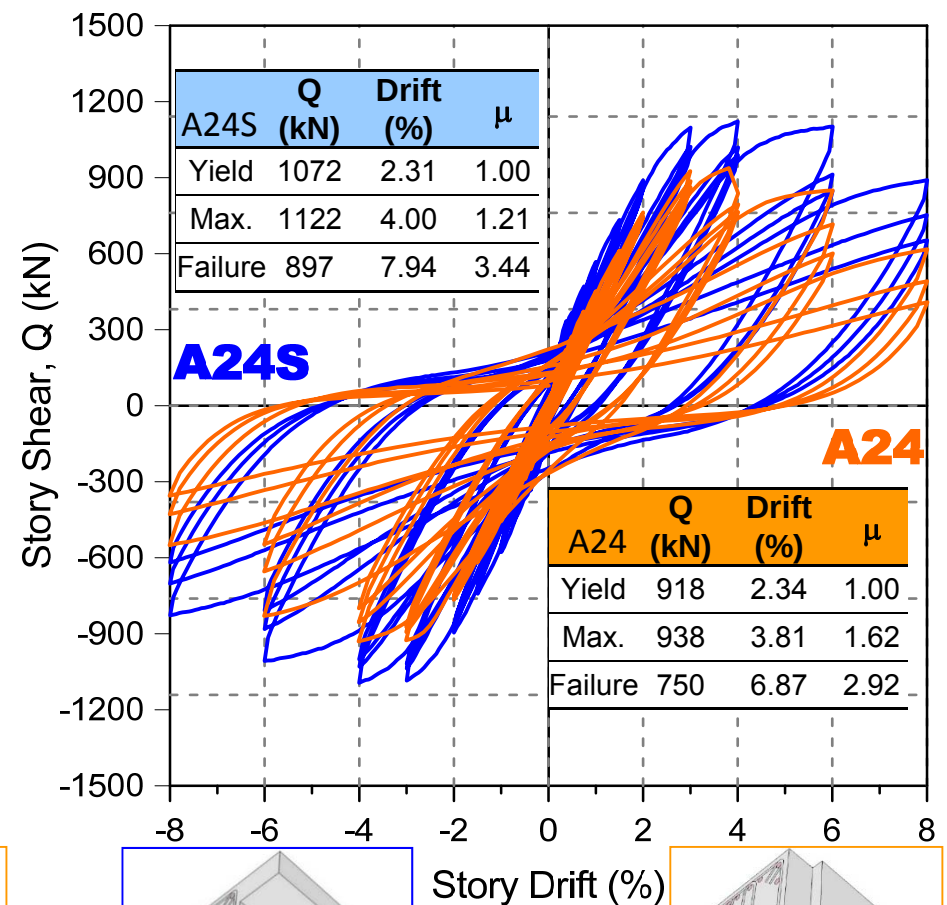
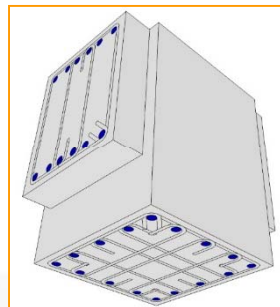
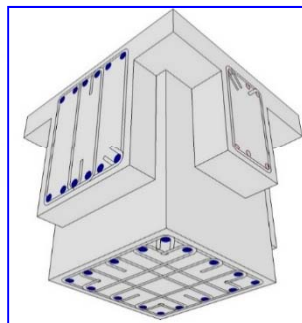
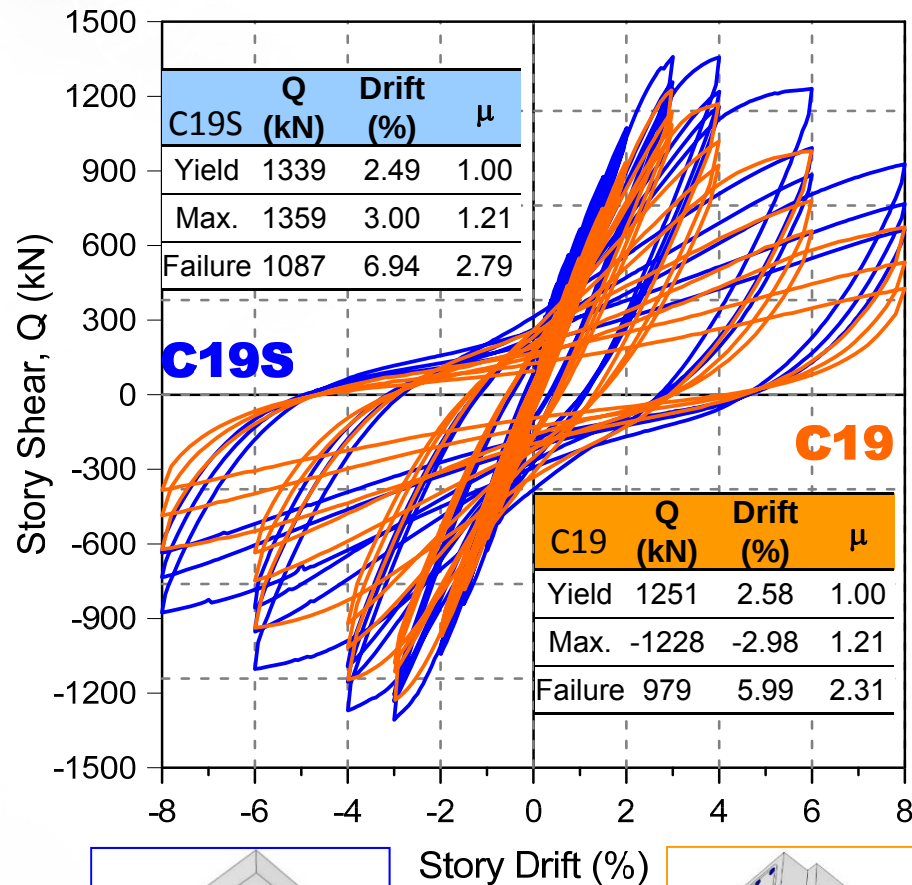
- 原C19為 J 破壞





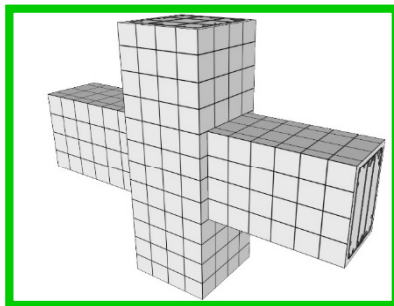
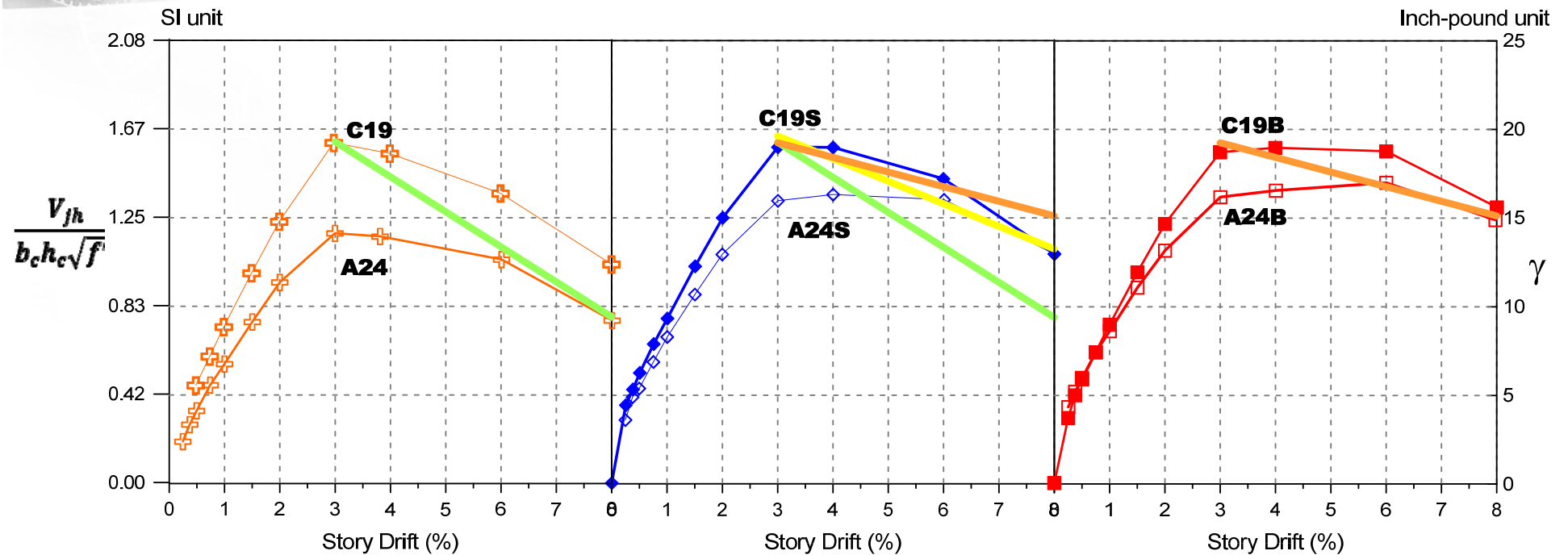
遲滯迴圈比較(2)

- 原C19為 J 破壞 → C19S為 BJ 破壞
- 含有橫向梁試體，韌性表現明顯提升

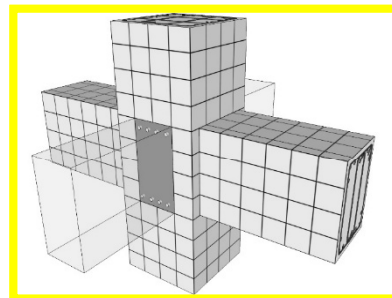




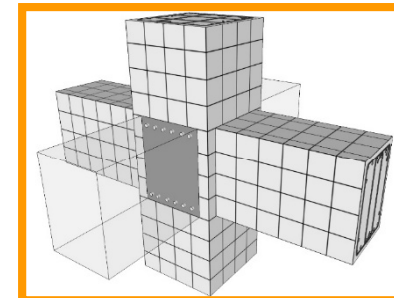
接頭剪力強度包絡線比較(1)



$$\frac{b_{b,tr}}{h_{col}} = 0$$

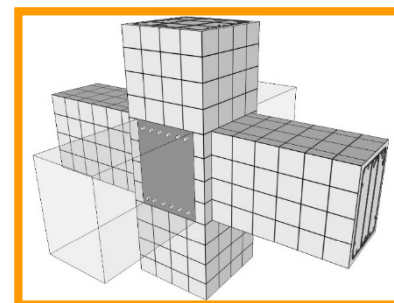
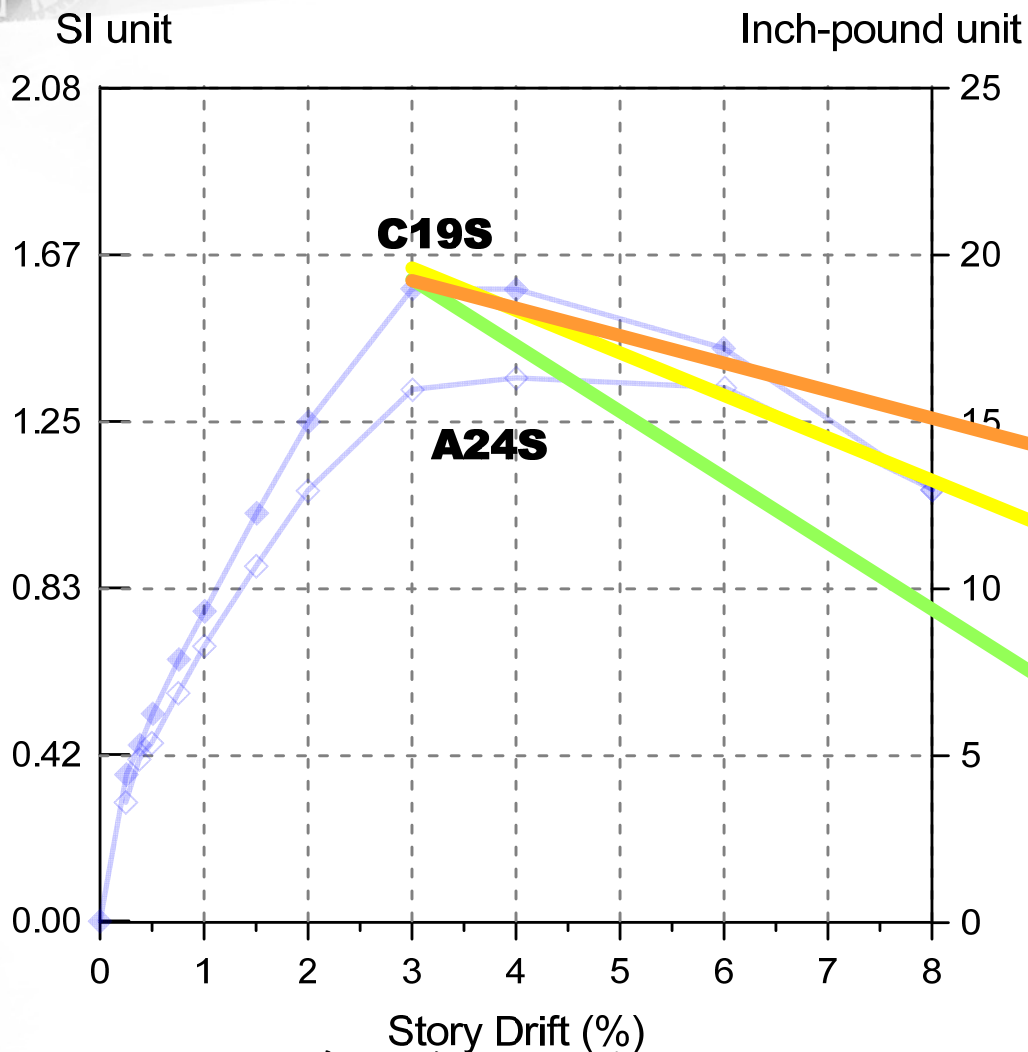


$$\frac{b_{b,tr}}{h_{col}} = 0.5$$

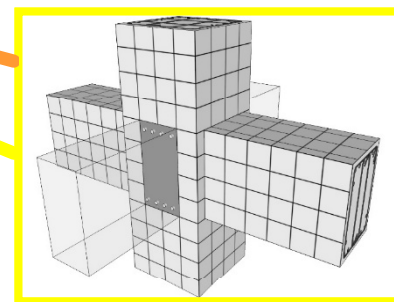


$$\frac{b_{b,tr}}{h_{col}} = 0.75$$

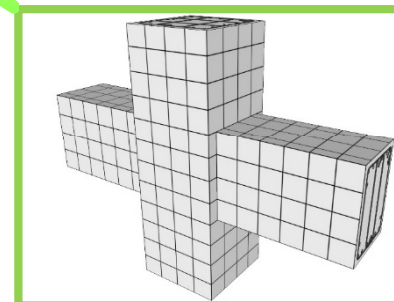
接頭剪力強度包絡線比較(2)



$$\frac{b_{b,tr}}{h_{col}} = 0.75$$

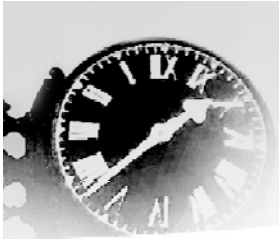


$$\frac{b_{b,tr}}{h_{col}} = 0.5$$



$$\frac{b_{b,tr}}{h_{col}} = 0$$

- 0.5橫向梁寬試體接頭強度，略低於0.75橫向梁寬的試體，，且明顯大於無橫向梁圍束試體。



Outline

6.1 剪力強度

接頭剪力需求 V_u

接頭標稱強度 ϕV_n

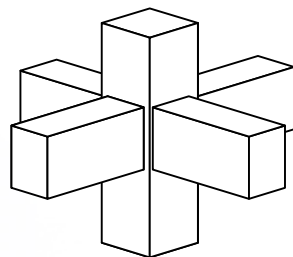
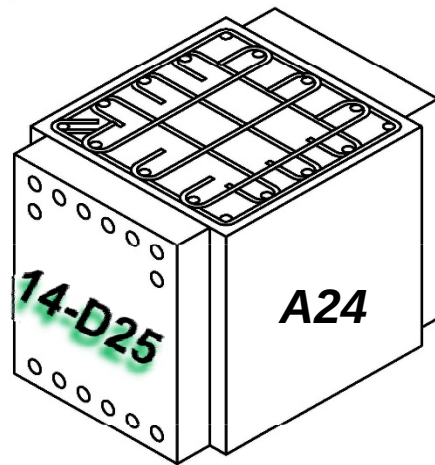
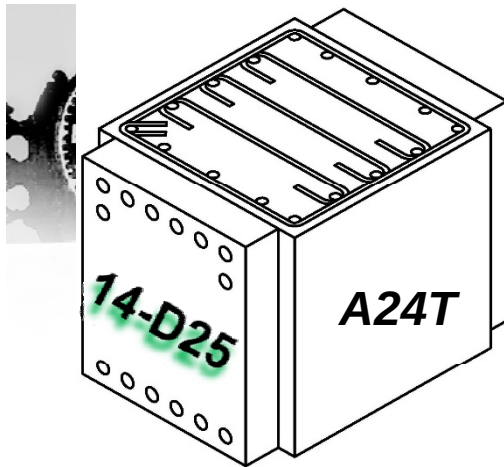
➡ 6.2 接頭箍筋—受梁圍束作用可以減半

6.3 接頭鋼筋伸展及錨定

梁主筋貫穿梁柱接頭之最小柱深

梁主筋終止於接頭內之錨定長度

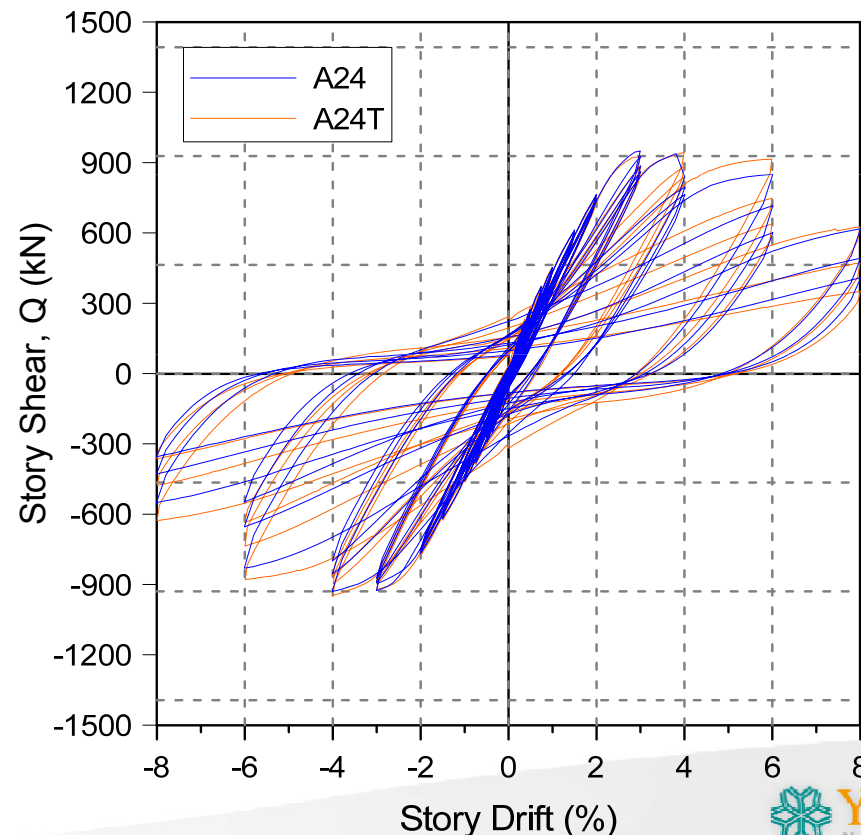
8.2 鋼筋機械式續接



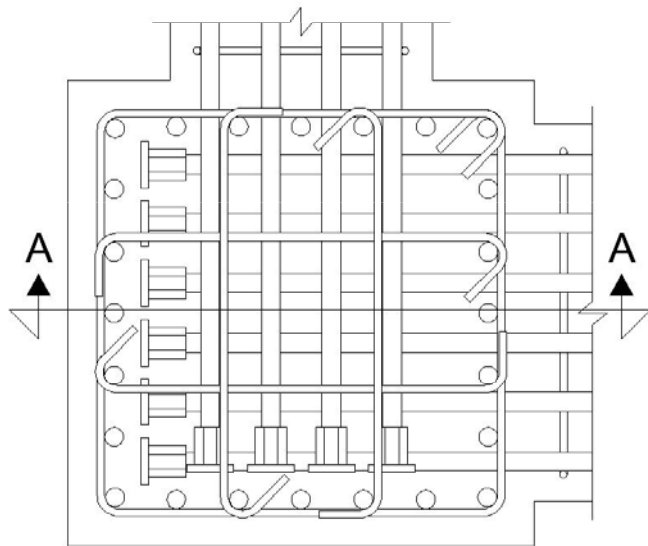
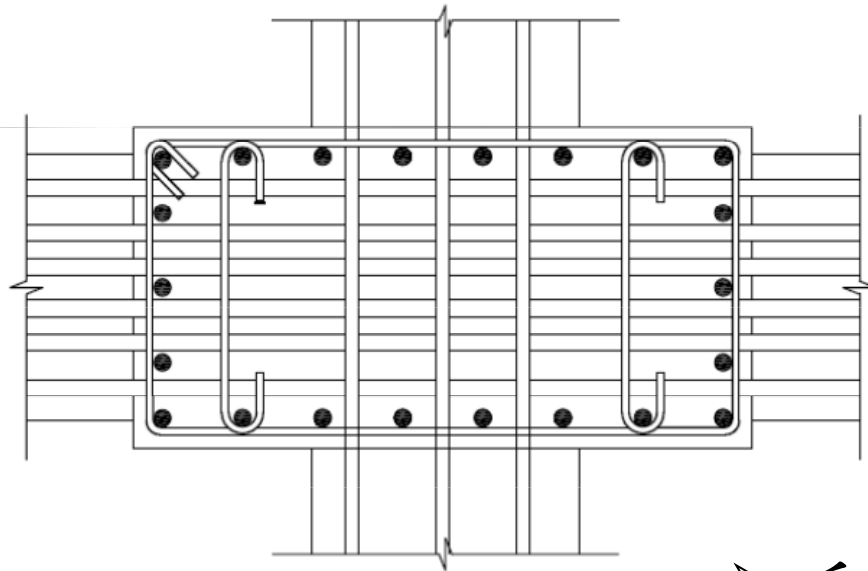
ACI

接頭四面皆受梁圍束
接頭箍筋量至少為 $0.5A_{sh}$

除非梁主筋貫穿接頭且梁寬最少為柱寬度之 $3/4$ ，視為具有圍束作用時，則在該梁構材構入範圍內，平行該梁構材方向可配置較少之繫筋，每組橫向鋼筋之總斷面積得為規定值之半，垂直間距仍不得超過 $6d_b$ 及15 cm。



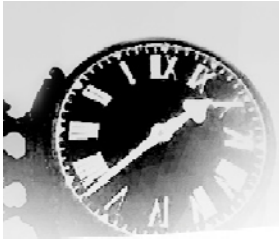
(Lee et al. 2014)



➤ 受梁圍束作用方向橫向鋼筋量可以減半(減少繫筋)

➤ 不受梁圍束作用之柱主筋，須以閉合箍筋之轉角或繫筋之彎鉤作橫向支撐

Plan View of Connection



Outline

6.1 剪力強度

接頭剪力需求 V_u

接頭標稱強度 ϕV_n

6.2 接頭箍筋—受梁圍束作用可以減半

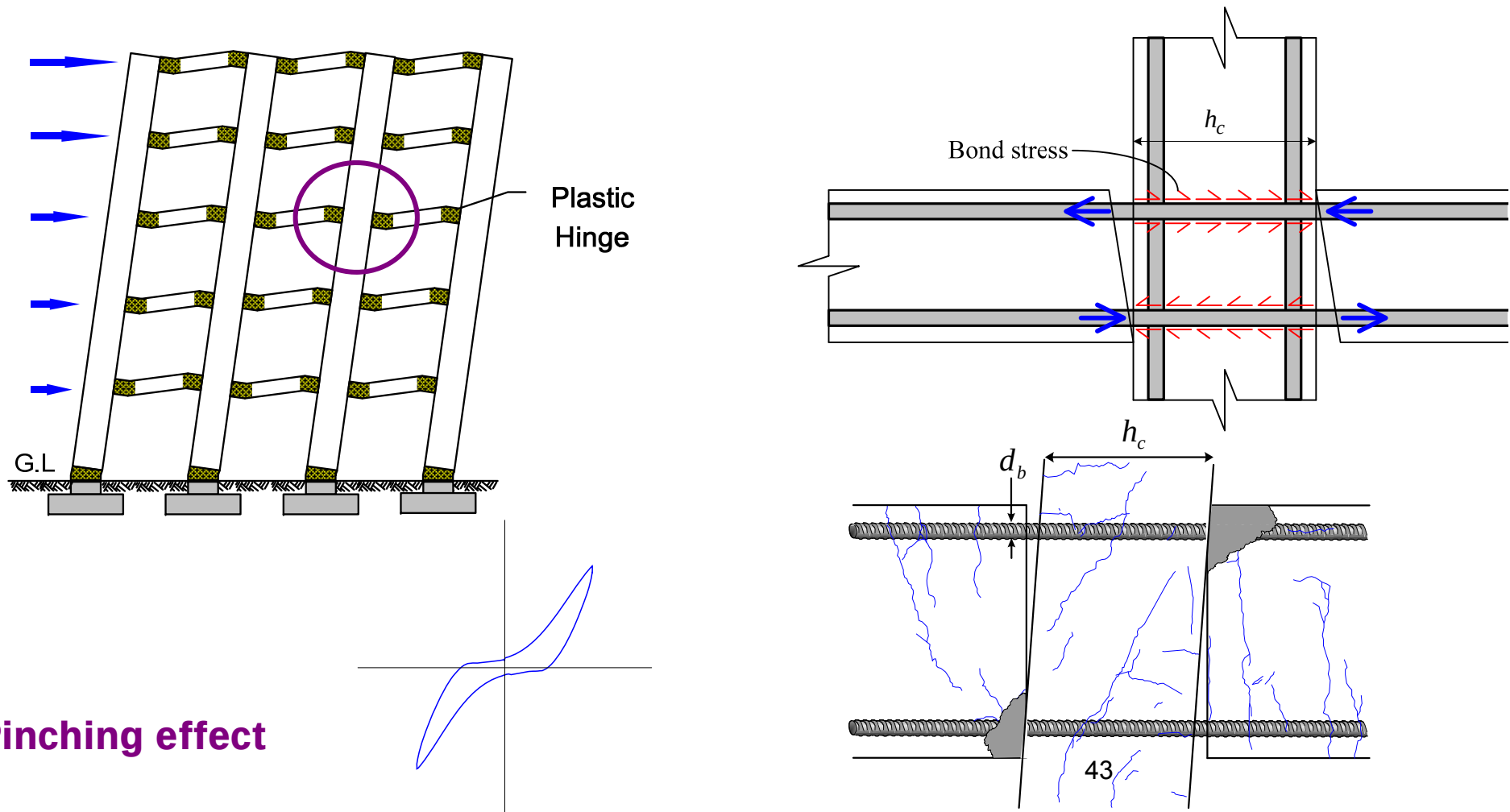
➡ 6.3 接頭鋼筋伸展及錨定

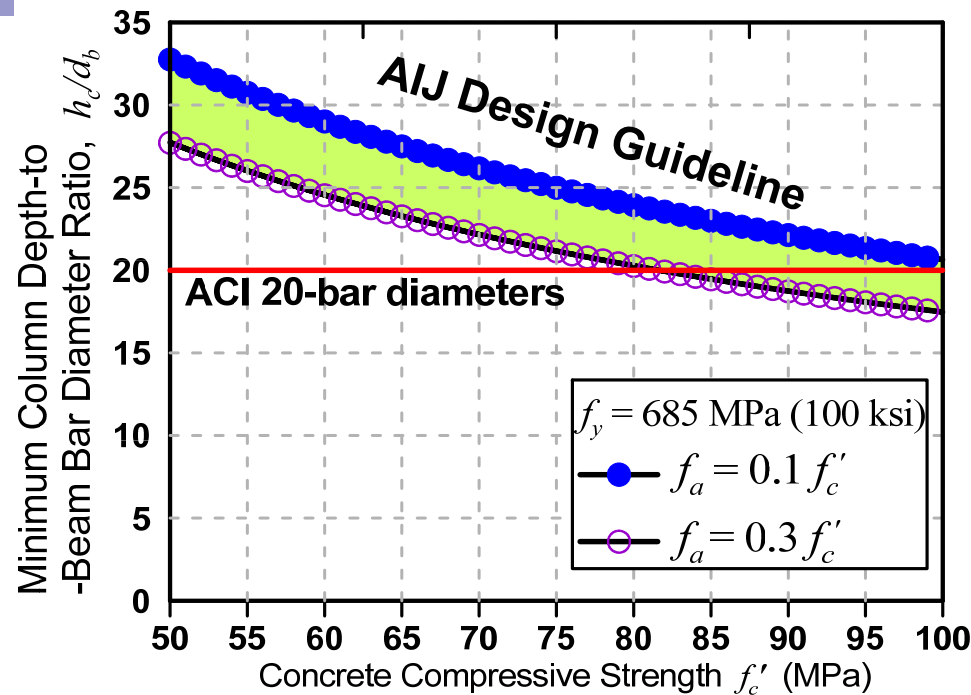
梁主筋貫穿梁柱接頭之最小柱深

梁主筋終止於接頭內之錨定長度

8.2 鋼筋機械式續接

Bond shearing failures or Bond deterioration along beam bars in beam-column joint (BJa failures)





NZS 3101

$$\frac{d_b}{h_c} \leq \left(\frac{\alpha_t \alpha_p}{\alpha_s} \right) \alpha_f \frac{6\sqrt{f'_c}}{\alpha_o f_y} \text{ in N - mm}$$

AIJ Design Guideline

$$\frac{d_b}{h_c} \leq \frac{2.8}{(1 + \beta)} \left(1 + \frac{f_a}{f'_c} \right) \frac{(f'_c)^{\frac{2}{3}}}{\alpha_o f_y} \text{ in N - mm}$$

ACI 318 Code

$$\frac{d_b}{h_c} \leq \frac{1}{20}$$

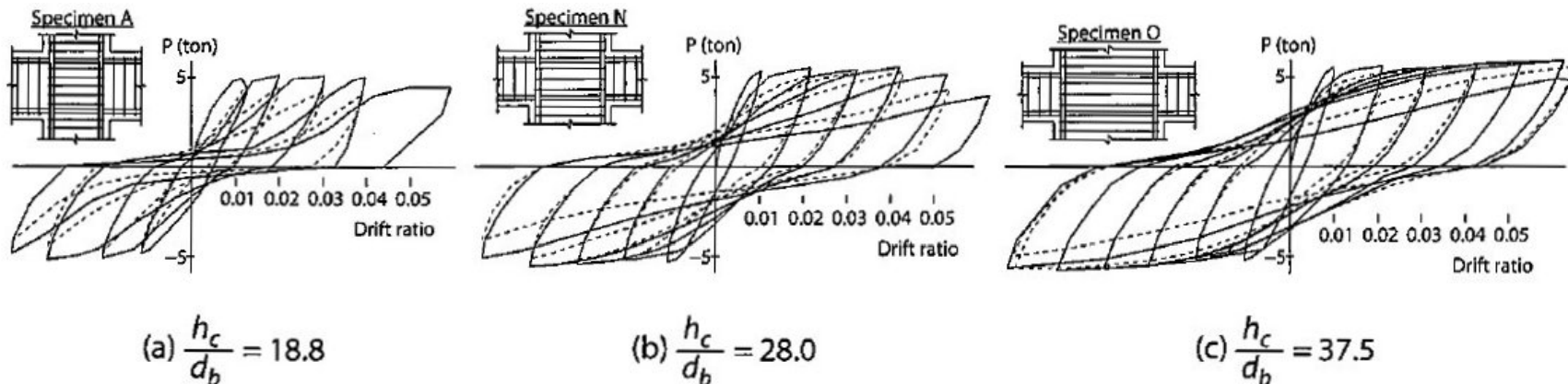
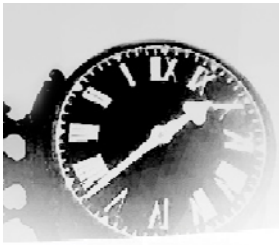
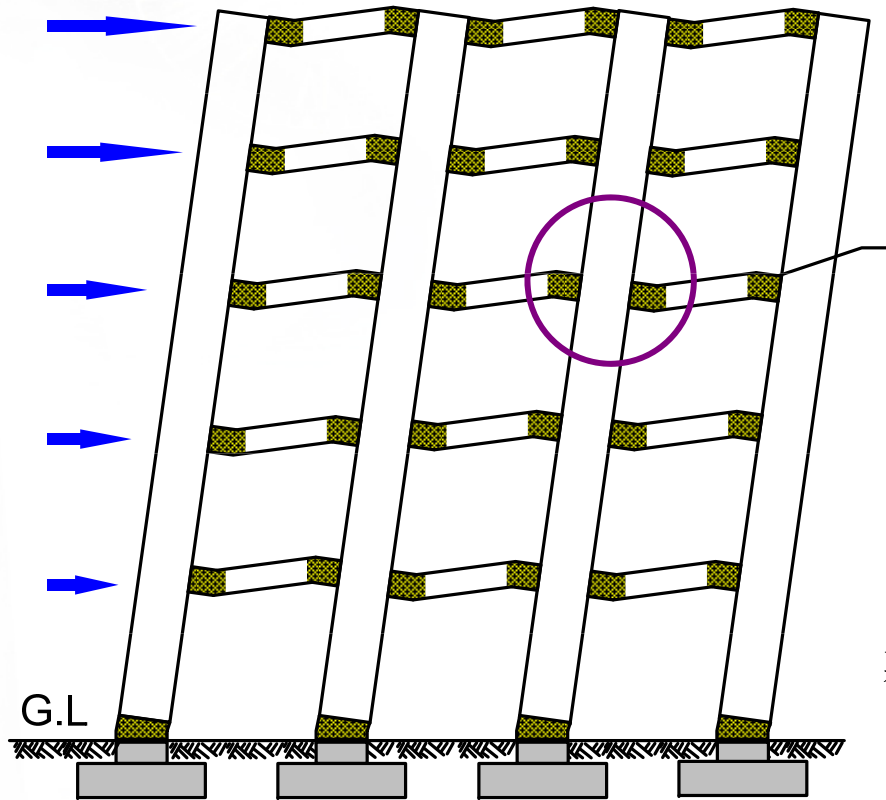


FIGURE 9.20 Column shear versus story displacement for interior beam-column joints with different values of h_c/d_b . (After Kaku and Asakusa, 1991, Courtesy of American Concrete Institute.)

Source: Jack Moehle, [Seismic Design of Reinforced Concrete Buildings](#)



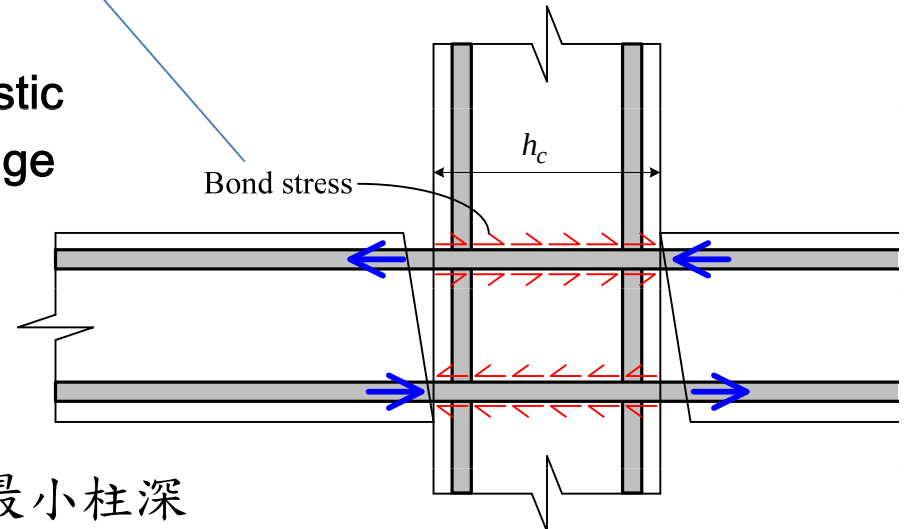
梁主筋在接頭握裹劣化、鋼筋滑移、 將導致構架消能能力的下降



$$\alpha_p k \sqrt{f'_c} \times \pi d_b h_{col} \geq \frac{\pi d_b^2}{4} (\alpha f_y + \beta f_y)$$

Plastic
Hinge

Bond stress

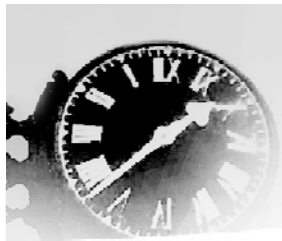


建議最小柱深

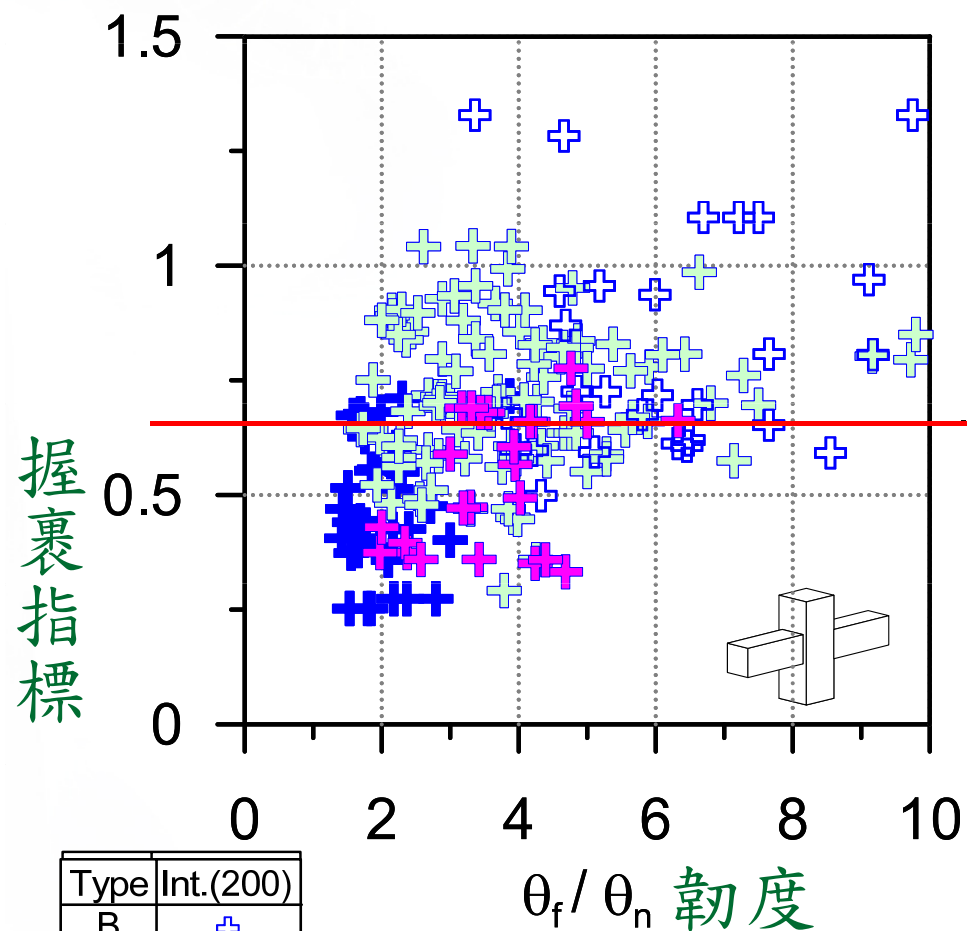
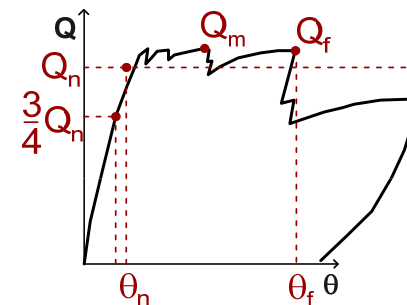
$$\frac{h_{col}}{d_b} \geq \frac{2}{4} \cdot \frac{f_y}{\alpha_p k \sqrt{f'_c}}$$

軸力修正因數 $\alpha_p = 1 + \frac{P}{A_g f'_c} \quad 1.0 \leq \alpha_p \leq 1.25$

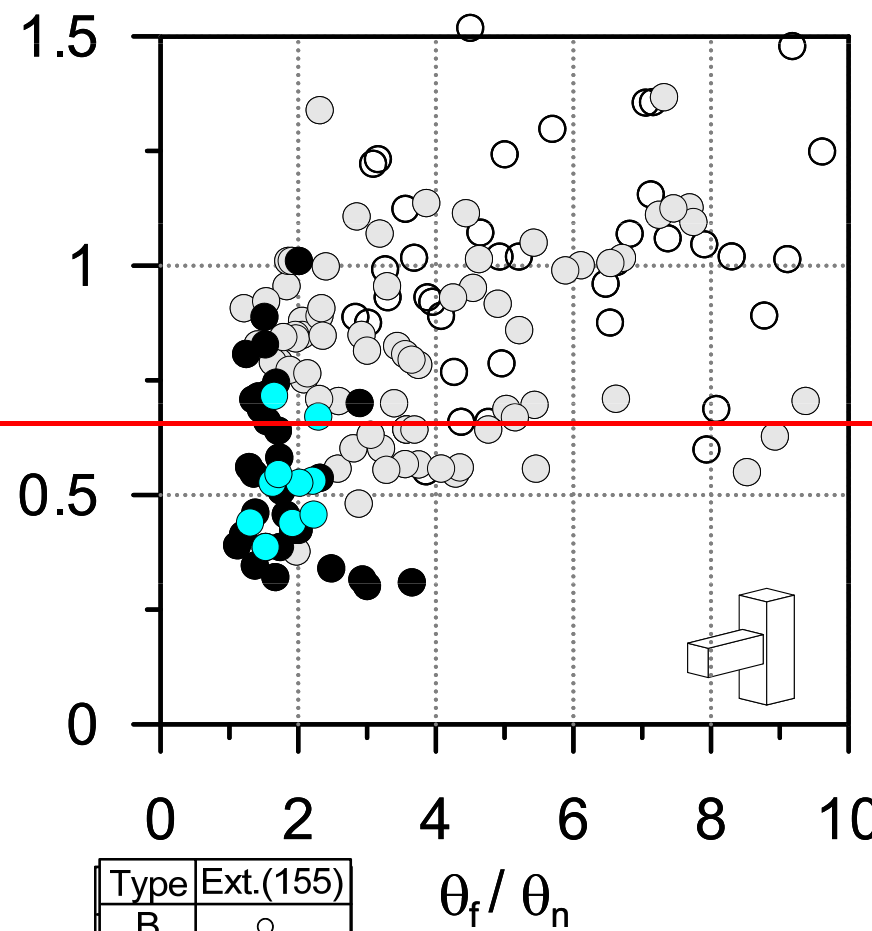
握裹應力規定值 $k \sqrt{f'_c} = 1.5 \sqrt{f'_c} \text{ MPa} = 18 \sqrt{f'_c} \text{ psi} = 4.77 \sqrt{f'_c} \frac{\text{kgf}}{\text{cm}^2}$



握裏指標 = $\frac{1}{k}$



Type	Int.(200)
B	+
BJ	+
J	+
BJ _a	+



Type	Ext.(155)
B	○
BJ	○
J	●
BJ _a	●

6.3.1 梁主筋貫穿梁柱接頭之最小柱深

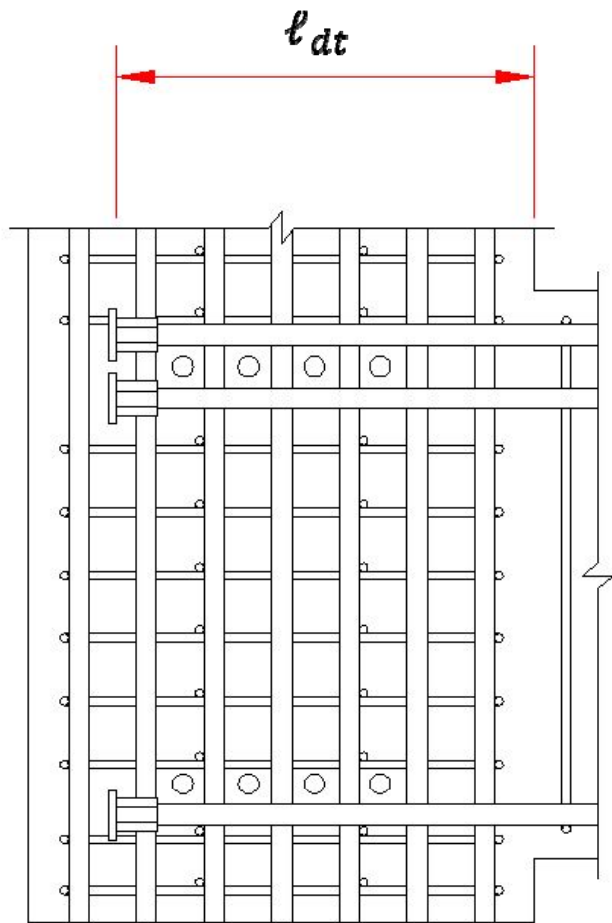
$$\frac{h_{col}}{d_b} \geq \frac{2}{4} \cdot \frac{f_y}{\alpha_p k \sqrt{f'_c}} \quad \text{and not less than } \mathbf{20}$$

$$\alpha_p = 1 + \frac{P}{A_g f'_c} \quad 1.0 \leq \alpha_p \leq 1.25 \quad (\text{Ref to AIJ Guidelines})$$

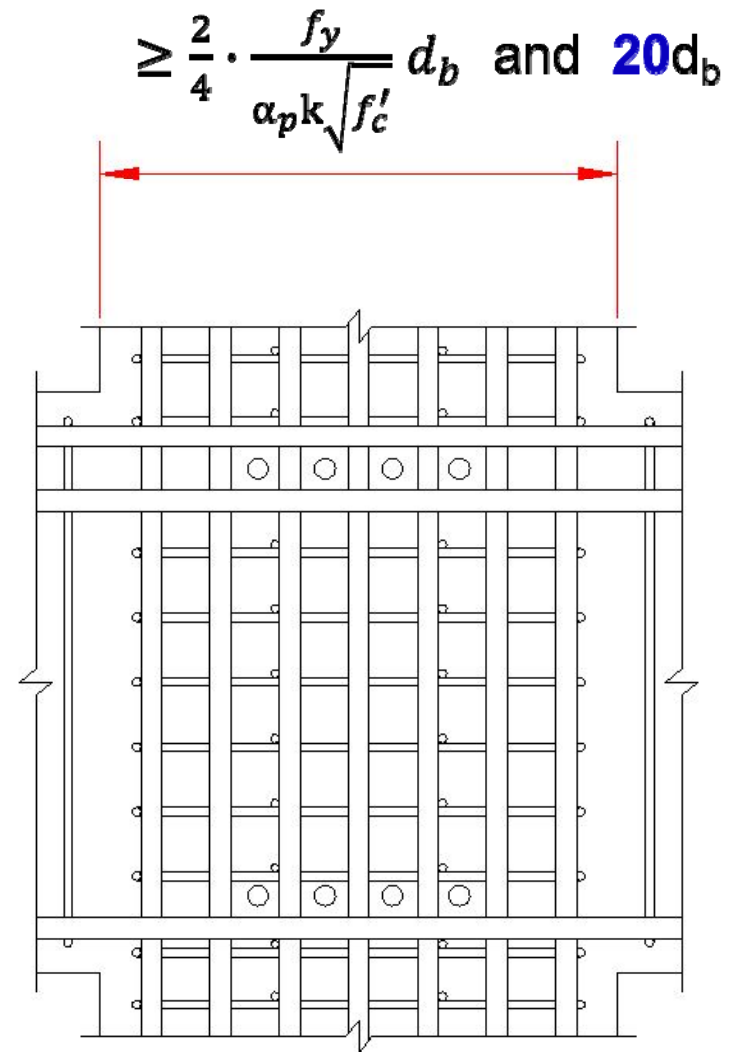
$$k \sqrt{f'_c} = 1.5 \sqrt{f'_c} \text{ MPa} = 18 \sqrt{f'_c} \text{ psi} = 4.8 \sqrt{f'_c} \frac{\text{kgf}}{\text{cm}^2} \quad (\text{Lee et al. 2014})$$

f'_c		SD420		SD550		SD685	
$\frac{\text{kgf}}{\text{cm}^2}$	MPa	$\alpha_p = 1.0$	$\alpha_p = 1.25$	$\alpha_p = 1.0$	$\alpha_p = 1.25$	$\alpha_p = 1.0$	$\alpha_p = 1.25$
280	28	26	21				
350	35	24	20				
420	42	22	20	28	23		
490	49	20	20	26	21		
560	56	20	20	24	20	31	24
630	63	20	20	23	20	29	23
700	70	20	20	22	20	27	22
840	84	20	20	20	20	25	20

Anchorage and Bond



Elevation
(section A-A)



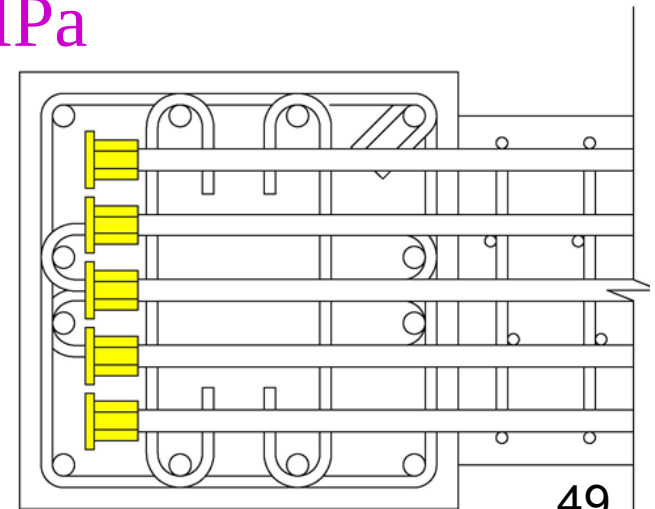
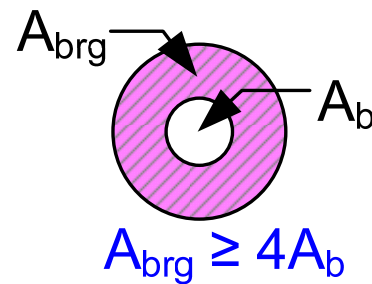
Elevation
(section A-A)

6.3.2 梁主筋終止於接頭內之錨定長度

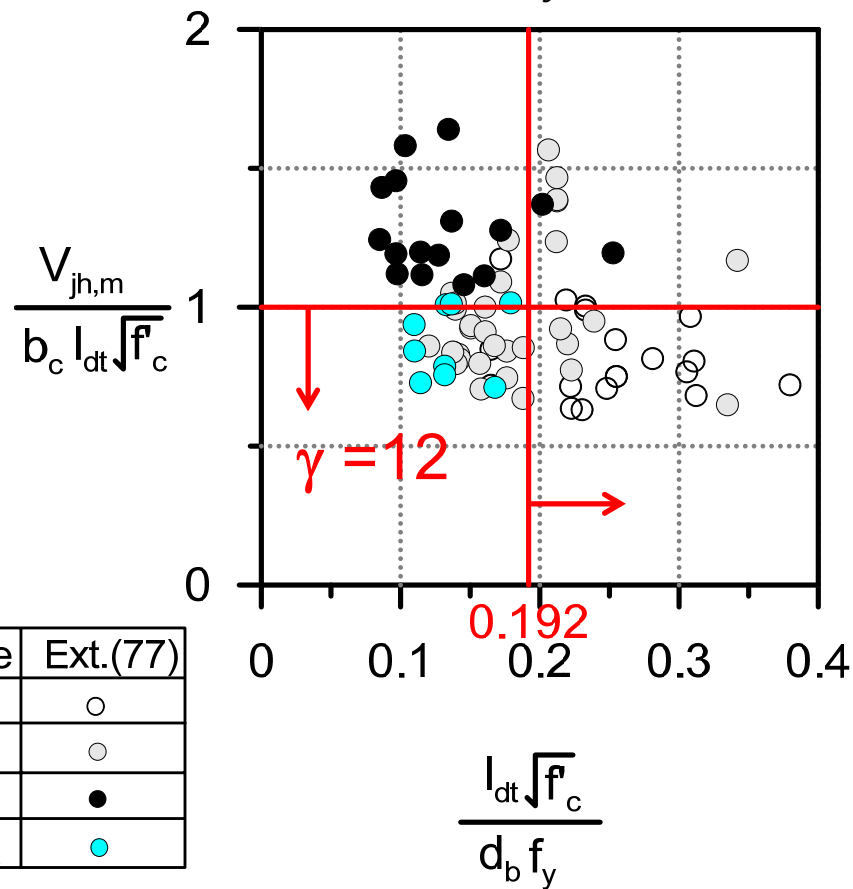
$$\ell_{dt} = 0.016 \frac{f_y d_b}{\sqrt{f'_c}} (f'_c \text{ in psi}) \text{ or } 0.192 \frac{f_y d_b}{\sqrt{f'_c}} (f'_c \text{ in MPa})$$

- $f_y \leq 420 \text{ MPa}$ ➤ 685 MPa 建議放寬
- Minimum bar spacing $3d_b$ ➤ $2d_b$ 限制條件
- $f'_c \leq 42 \text{ MPa}$ ➤ 100 MPa

(ACI 318-14)

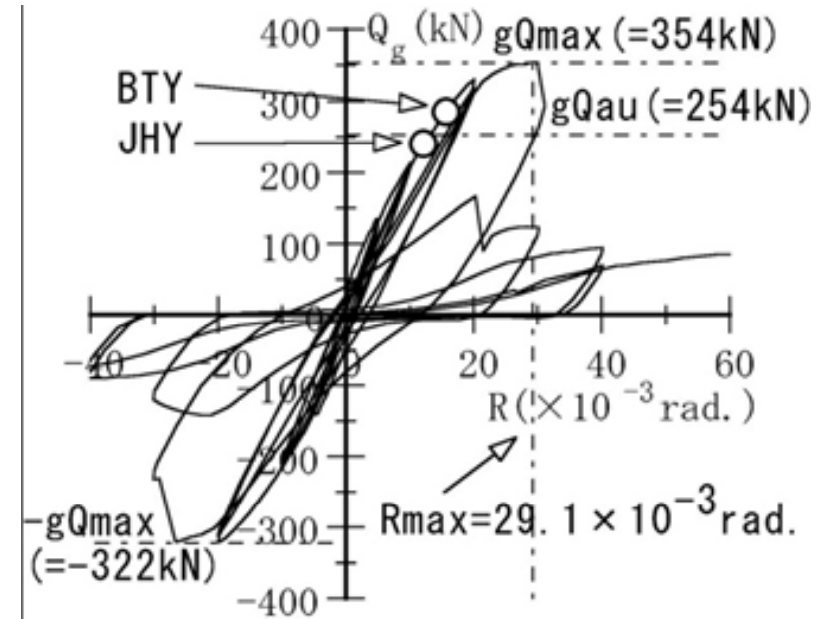


錨定長度 *解除 f_y & f_c' 上限

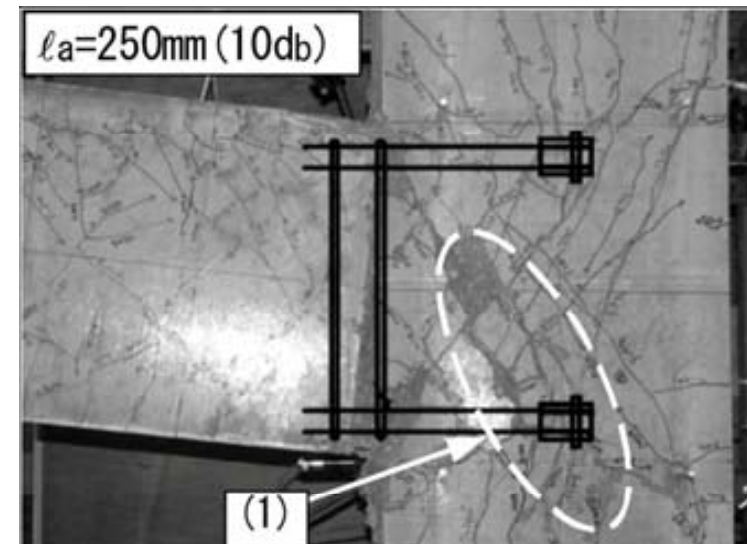


Headed bars

$$\text{Required } \ell_{dt} \geq 0.192 \frac{f_y d_b}{\sqrt{f_c'}}$$



(c) 試験体AH12-2-45A



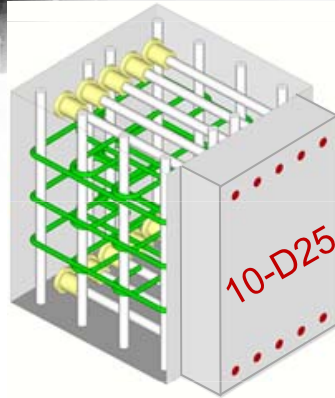
Masuo, K., Adachi, M., and Imanishi, T. (;



Seismic Testing for Exterior Beam-Column Joints



Test results (1/5)



A5

D13@125m

f'_c

70 (70) MPa

M_R

2.13
(2.05)

γ

9.45
(10.21)

$\overline{A}_{sh, ratio}$

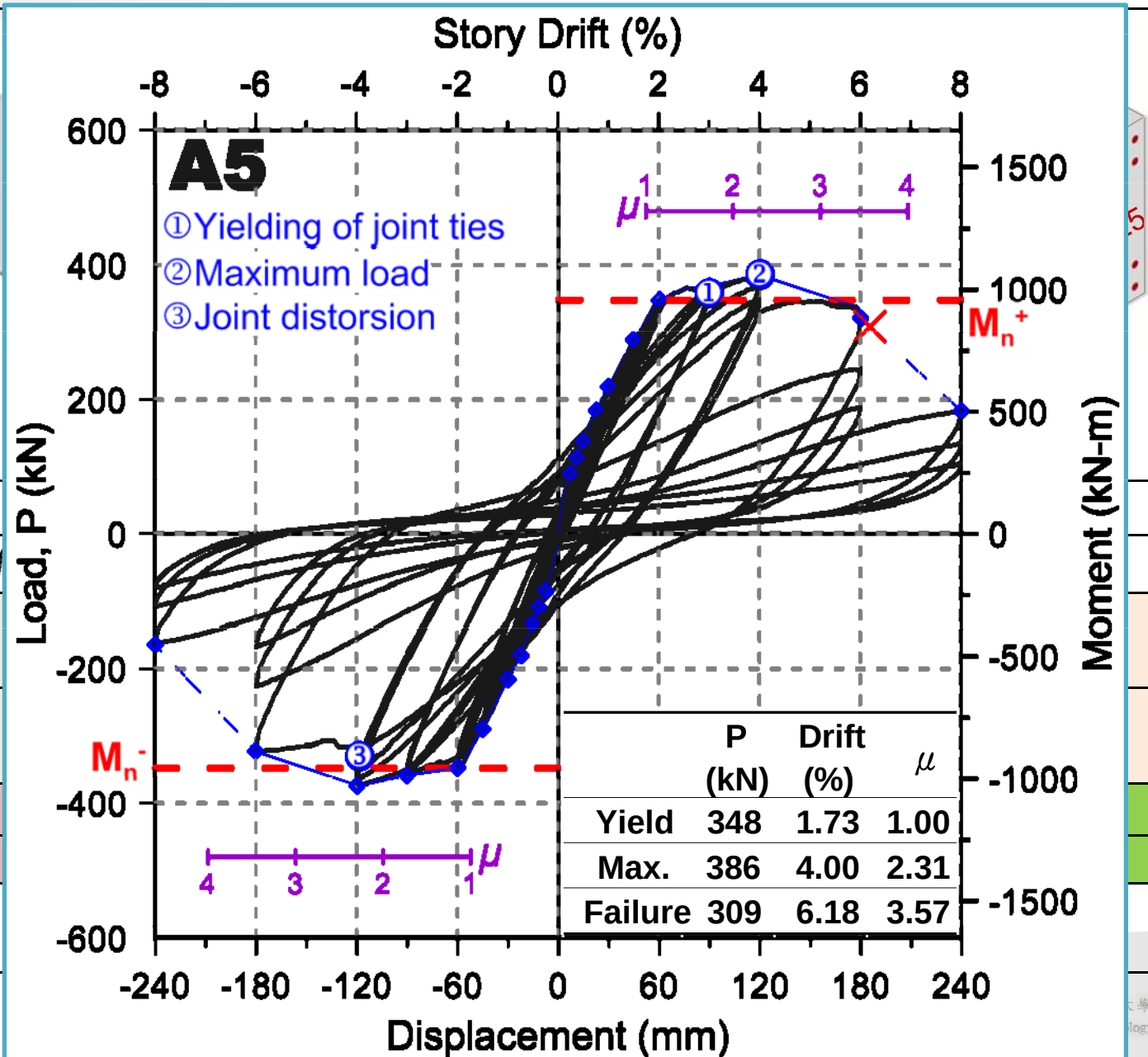
0.99

$A_{sh, ratio}$

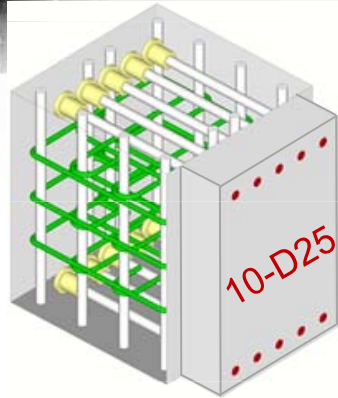
1.20

BJ-Failure

Remark : $\overline{A}_{sh, ratio}$ use



Test results (1/5)



A5

D13@125m

f'_c

70 (70) MPa

M_R

2.13
(2.05)

γ

9.45
(10.21)

$\overline{A}_{sh, ratio}$

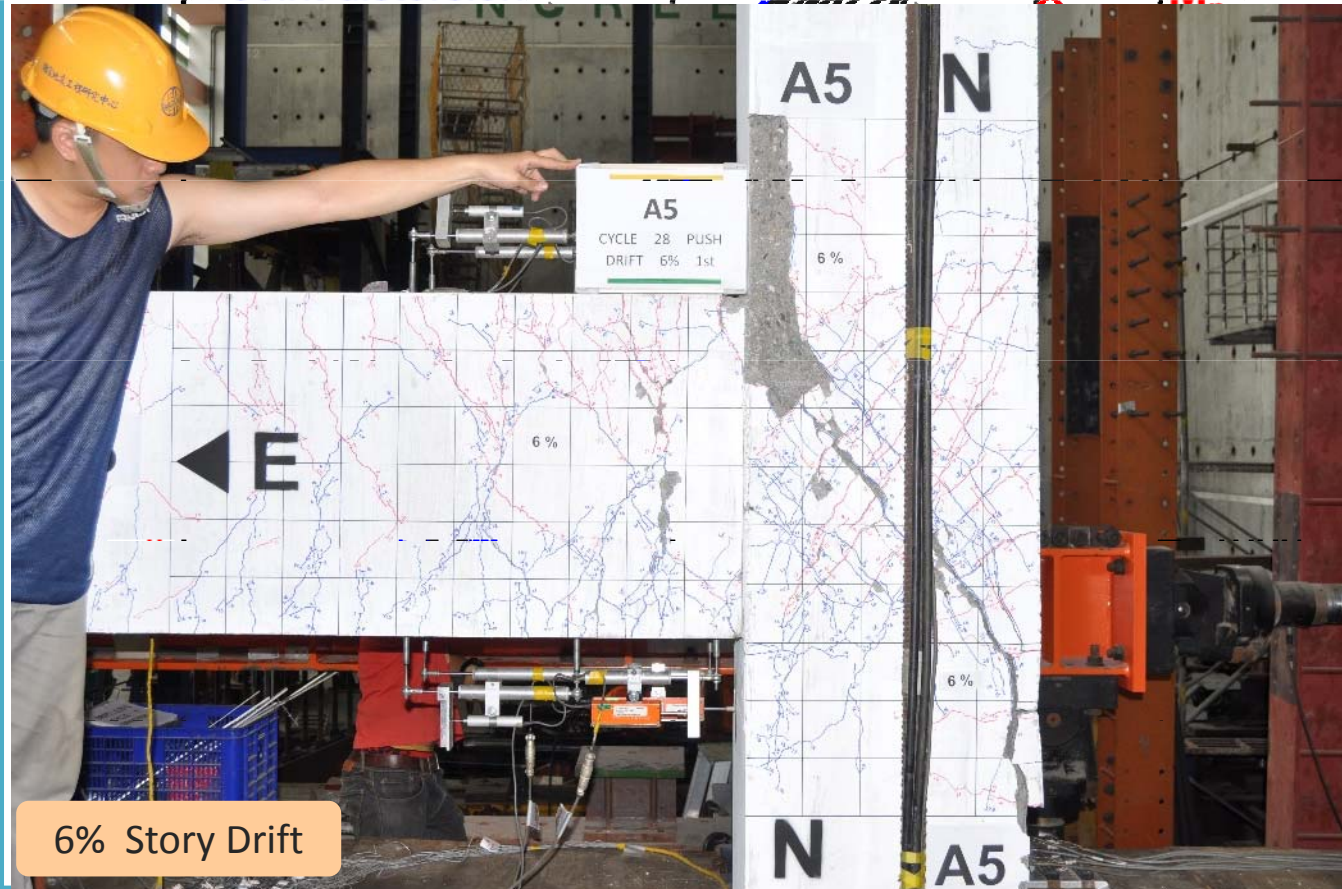
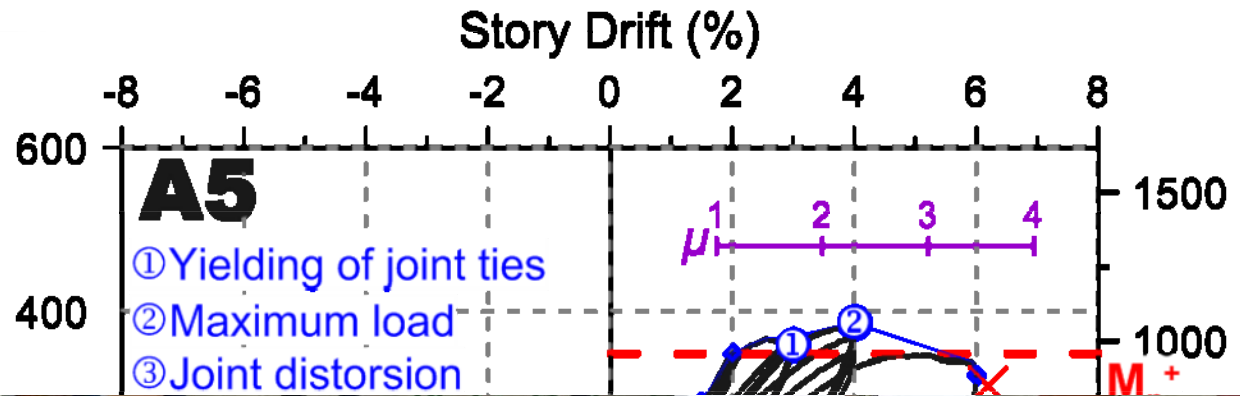
0.99

$A_{sh, ratio}$

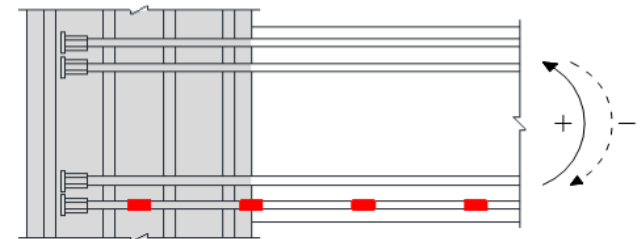
1.20

BJ-Failure

Remark : $\overline{A}_{sh, ratio}$ use



A technical drawing of a mechanical assembly. It features a base plate with several vertical slots and a central horizontal slot. A yellow component, which appears to be a piston or a similar mechanical part, is shown in a vertical position, partially inserted into the central slot. The drawing includes various lines and dimensions to specify the geometry and assembly details.



Outline

6.1 剪力強度

接頭剪力需求 V_u

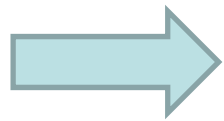
接頭標稱強度 ϕV_n

6.2 接頭箍筋-受梁圍束作用可以減半

6.3 接頭鋼筋伸展及錨定

梁主筋貫穿梁柱接頭之最小柱深

梁主筋終止於接頭內之錨定長度



8.2 鋼筋機械式續接

鋼筋組立工法之改良

最經濟

經濟、快速、
品質

工法 比較	傳統 現場組立	預組工法	預鑄工法
混凝土 /模板	現場一體澆置	現場一體澆置	工廠預鑄構件 現場澆置接合部
鋼筋續接	搭接 螺紋式續接	搭接 螺紋式續接	套管式續接 螺紋式續接
人力	多	中	少
工期	慢	中	快



TOTAL COST DOWN !! 總成本降低 56



YunTech

國立雲林科技大學
National Yunlin University of Science & Technology



鋼筋規格及續接器、錨定頭規範

	Grade	#6 D19	#7 D22	#8 D25	#9 D29	#10 D32	#11 D36	#12 D39	#14 D43
 社團法人 台灣混凝土學會 Taiwan Concrete Institute	685	 社團法人 台灣混凝土學會 Taiwan Concrete Institute							 台灣混凝土學會 Concrete Institute
鋼筋混凝土用鋼筋 Steel bars for Concrete Reinforcement —SD550W、SD685、SD785 新高強度鋼筋混凝土技術委員會報告	550	高強度鋼筋續接器續接性能規範 Guidelines for Performance Evaluation of Mechanical Splices for High-Strength Steel Reinforcing Bars 新高強度鋼筋混凝土技術委員會報告							鋼筋錨定頭規範 for Concrete Reinforcement 新高強度鋼筋混凝土技術委員會報告

CNS 77-140-60

— 1 —

中華民國國家標準	鋼筋混凝土用鋼筋	總號	5 6 0
CNS		類號	A 2 0 0 6

Steel bars for concrete reinforcement

1. 適用範圍：本標準適用於鋼筋混凝土用鋼筋，但不包括月廢鋼再軋製之鋼筋。

2. 種類及符號：鋼筋混凝土用鋼筋分爲表 1 所示 7 種。

表 1. 鋼筋混凝土用鋼筋種類及符號

種類	符號	備註
光面鋼筋	SR 240	—
	SR 300	
竹節鋼筋	SD 280	—
	SD 280W	1. 增強鋼線性 2. 較適合反覆彎曲加工
	SD 420	—
	SD 420W	1. 增強鋼線性 2. 較適合反覆彎曲加工
	SD 490	—

490	〔土木401-86a〕 混凝土工程設計規範與解說 編著者：中華民國土木及水利工程學會 土木401-86 & 附錄乙 5	中華民國結構工程學會 鋼筋混凝土結構委員會 鋼筋續接器續接規範 工作小組工作報告 (CSSE 96-01)  7
420	5	7

續接器性能分級與使用條件

TCI					ACI
續接性能	強度	變形能力	伸長率 韌性	鋼筋可能降 伏區	分類
SA級	○	○	○	無條件使用	第二類
SA級	○	○	構件試驗	有條件使用	第二類
B級	○			禁止	第一類

○ 表示性能與母材鋼筋相近

Type 1: 抗拉強度 $\geq 1.25f_y$

Type 2: 抗拉強度 $\geq 1.25f_y$ & f_u

雖然美國、日本以及我國相關規範，皆准許第二類機械式續接可以使用於構材可能的降伏區，但前提是續接器施工品質要受到有效的監督和查驗。

本規範參考日本規範訂定SA級續接允許使用於任何位置，並沒有錯置之規定。B級續接則不允許使用於鋼筋可能降伏區域。

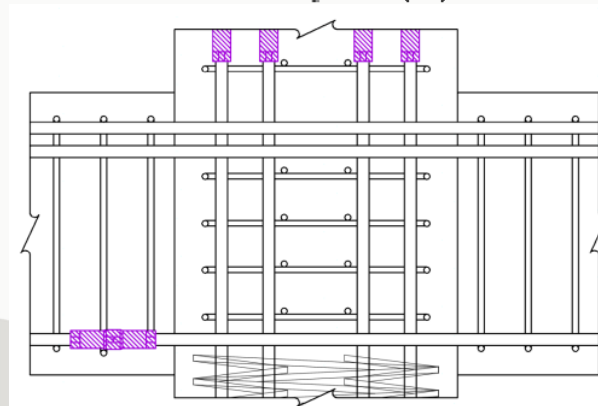
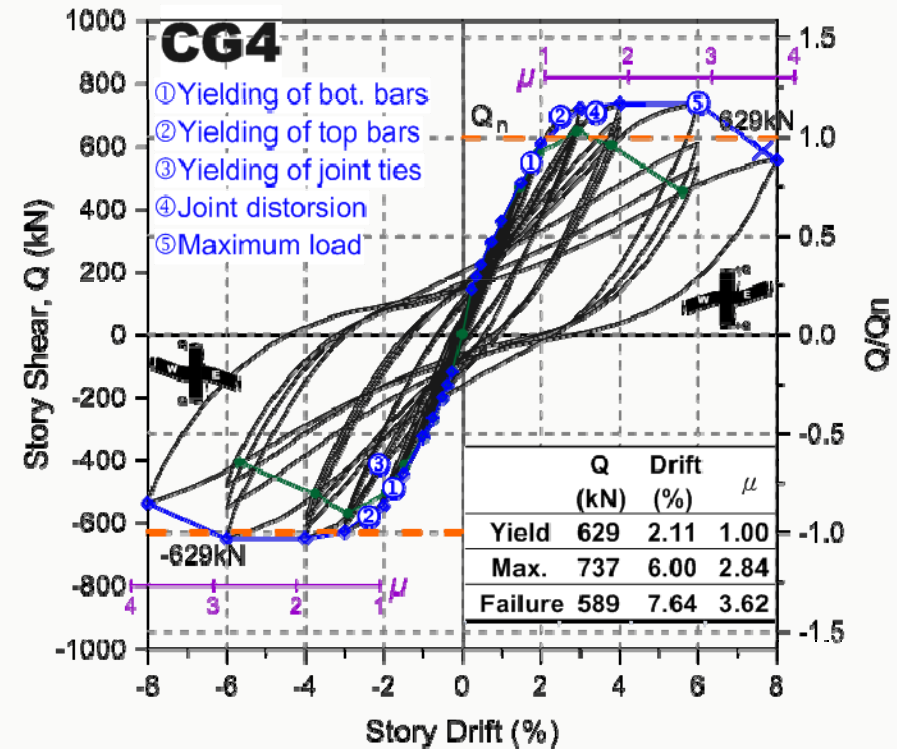
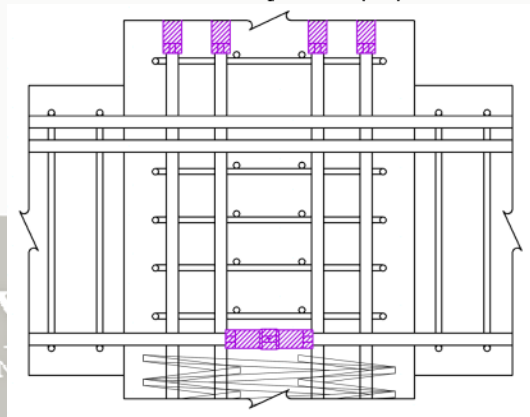
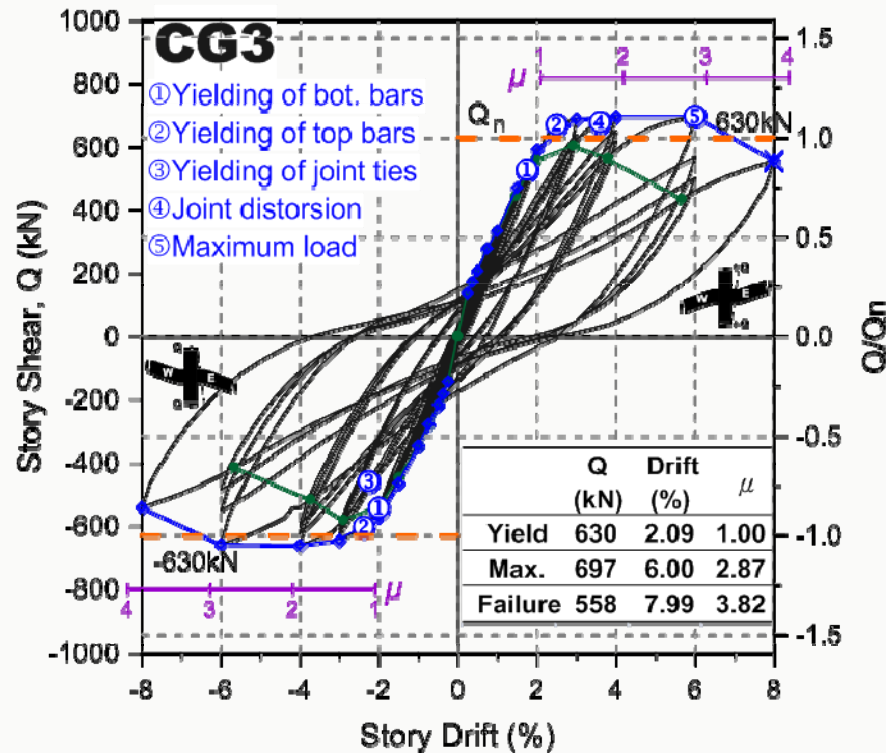
SD685鋼筋續接器性能測試結果(2013~2014)

Grade	Couplers and Sleeves	Nov	Dec	Jan	Feb	Mar	Apr	判定
SD685 D25	ACE JOINT 	●						SA
	EPOCH JOINT 	●						SA
	TOPS JOINT 	X	●					A~SA

強度及滑動量符合SA級規定

且經構件試驗證明其韌性符合耐震性能要求，亦可視為SA級續接器，或稱之為「有條件的SA級」，仍可考慮使用於塑鉸區。

梁下層筋以不同型式續接錨定之預鑄梁柱 接頭耐震性能-李宏仁等(2012)

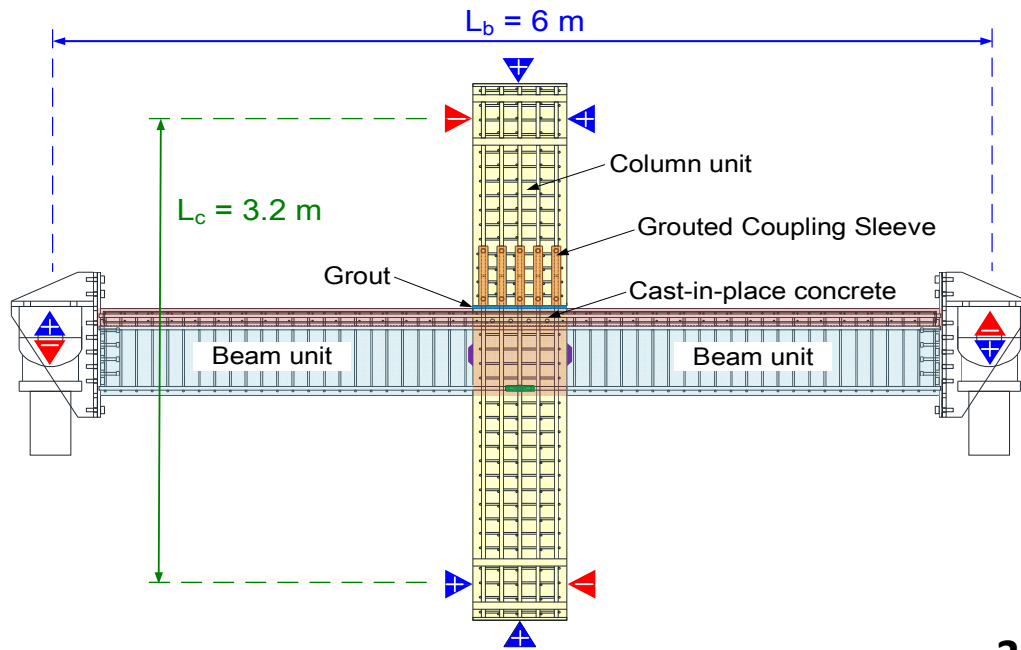


彈性模數

續接器		E_{sa}	E_j	E_j/E_{sa}
ACE JOINT		226, 076	216, 844	0. 96
EPOCH JOINT		226, 076	224, 174	0. 99
TOPS JOINT		226, 076	284, 505	1. 26
TOPS JOINT		212, 084	297, 543	1. 40



預鑄型試體製造 (A24S and A24B)



2. 模板組立與綁紮版筋。



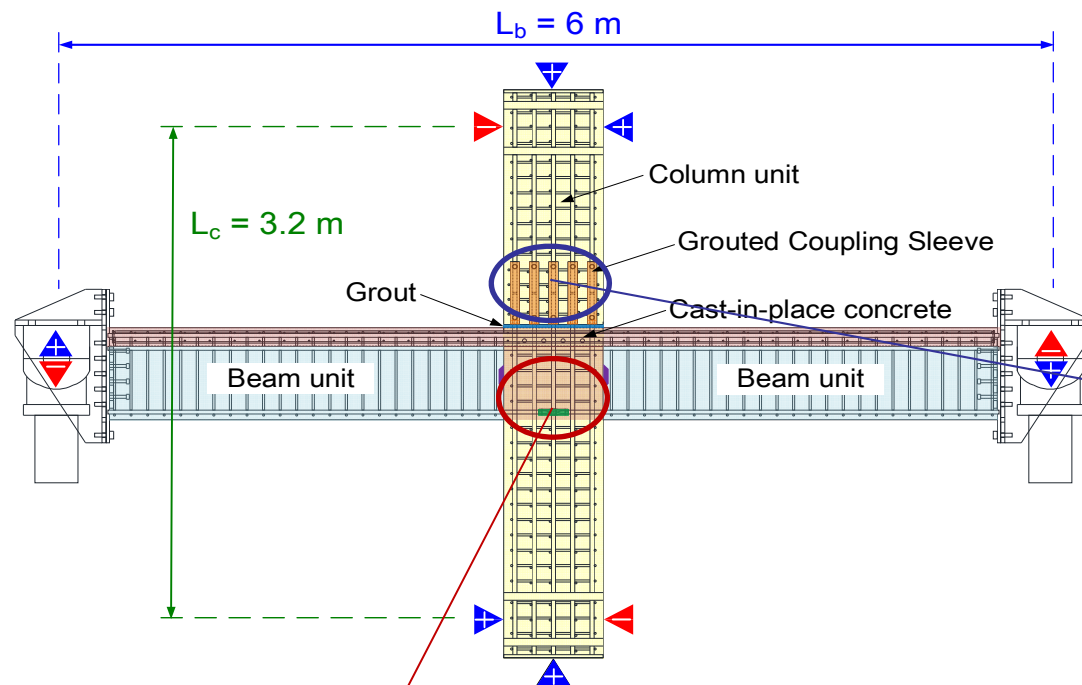
1. 梁柱構件分別鑄造完成後續接。



3. 樑柱接頭與版混凝土澆置。



續接器



TOPS JOINT



ACE JOINT

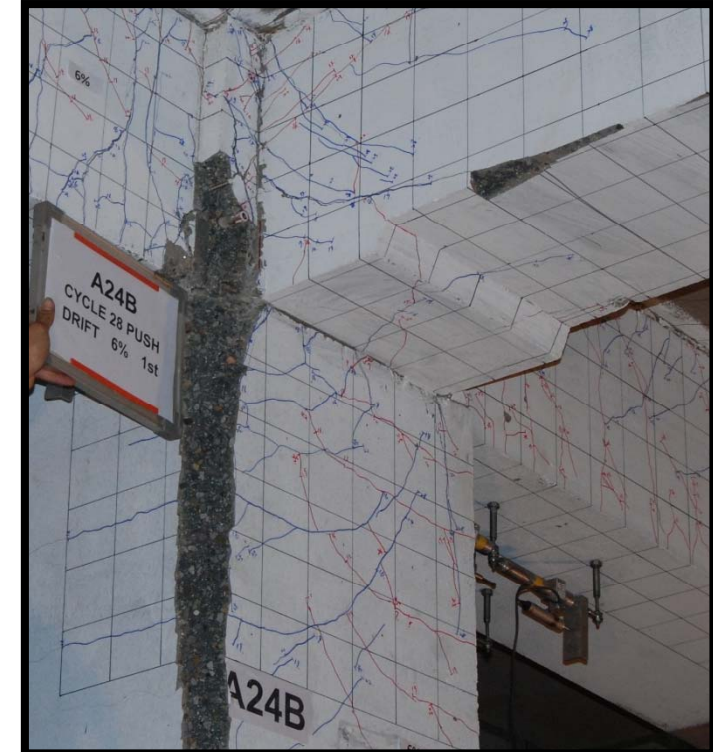
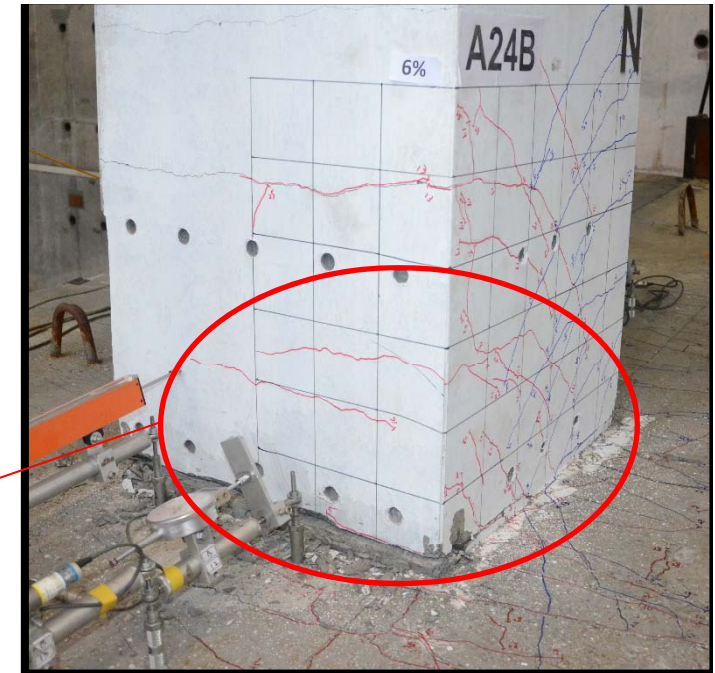
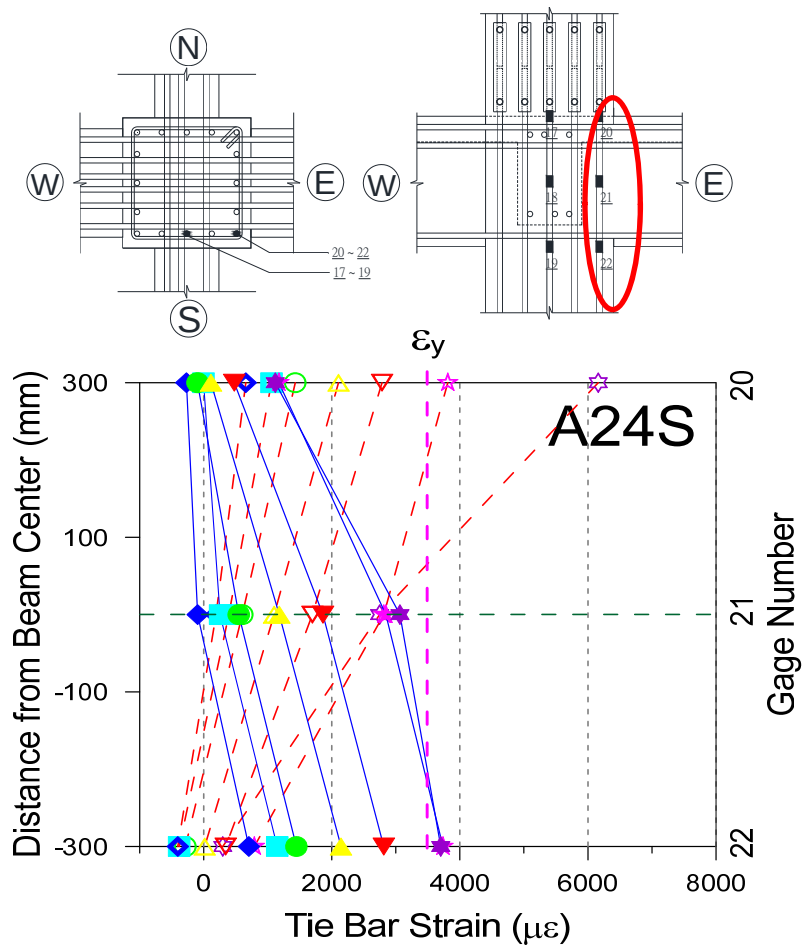


預鑄柱頭續接



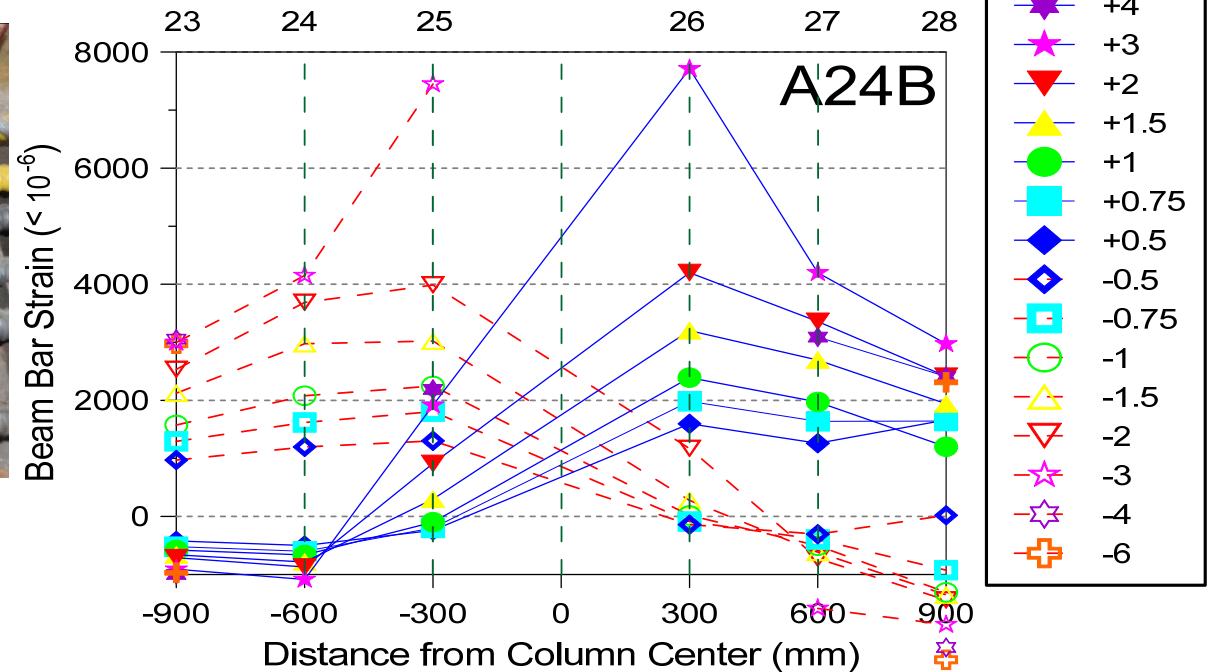
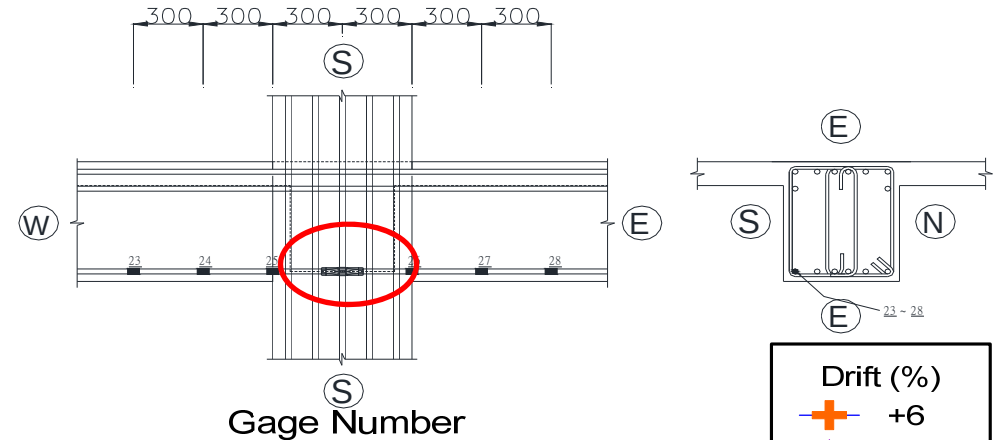
柱續接鋼筋之應變

- 接頭上下端柱筋皆可達到降伏
- 上柱續接器端無明顯損壞



梁續接鋼筋之應變

- 梁柱交接面鋼筋可達降伏強度
- 接頭區應變梯度明顯
- 能充分續接鋼筋貫穿接頭區



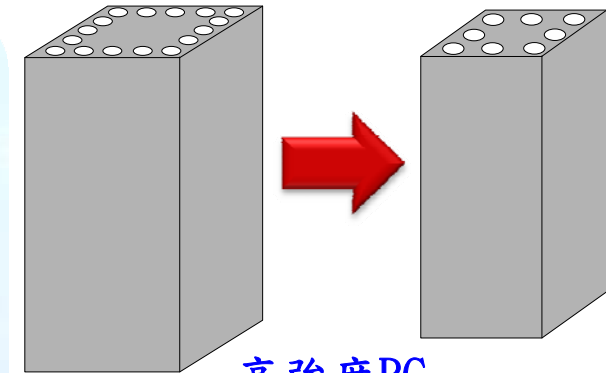
BOLTOPS 在預鑄梁之應用



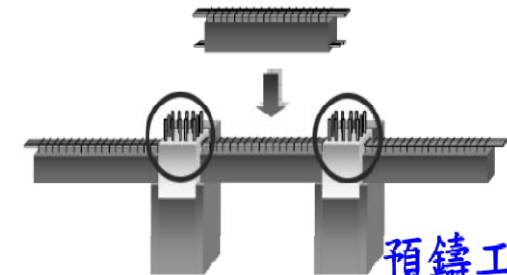
- 預鑄柱 + 預鑄梁下半部及接頭
- BOLTOPS套管續接避開梁塑鉸區



Thanks for your attention



高強度RC



預鑄工法

省工! 省時! 省料!
較好的經濟效率!