RC構架填充磚牆補強試驗研究

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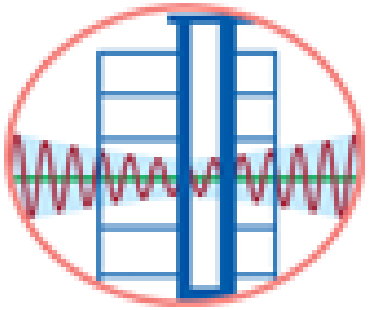
國震中心
邱聰智博士、曾建創博士、陳安村先生



107 年7 月16 日星期一

大綱

一. 研究動機

二. 試驗規劃

三. 試體施作

四. 試驗結果

五. 結論

研究動機

- 既有危老住宅結構
  - 常以填充磚牆作為隔間牆
  - 底層牆量較少
  - 二層以上居室較多隔牆

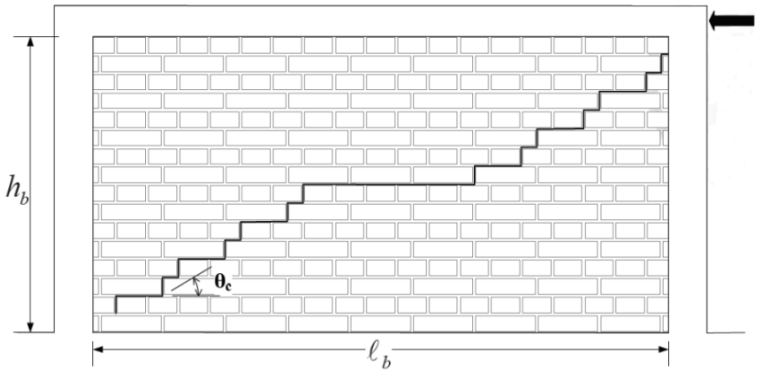
確保磚牆之耐震能力

維持老舊建築之可用性

補強工法

動機一

$$h_b/\ell_b \le \tan\theta_c$$



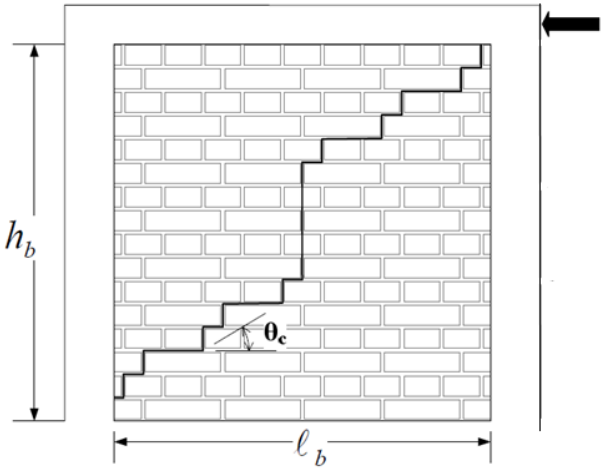
$$V_{bw4,NCREE} = \tau_f(\ell_b \times t_b) + 0.45 f_{mt}(h_b \times t_b)$$

(橫縫滑移強度+束縫劈裂強度)

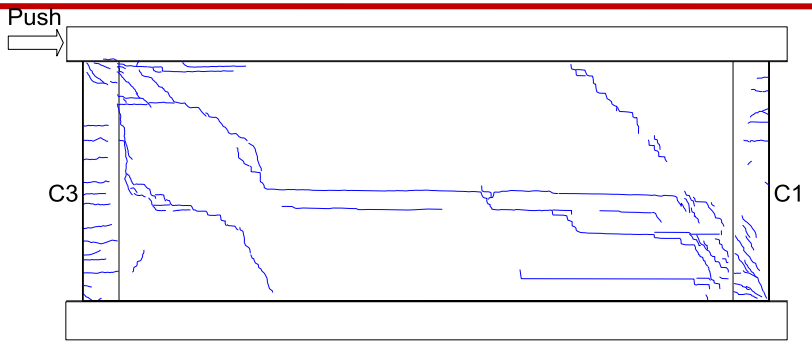
$$h_b/\ell_b > \tan\theta_c$$

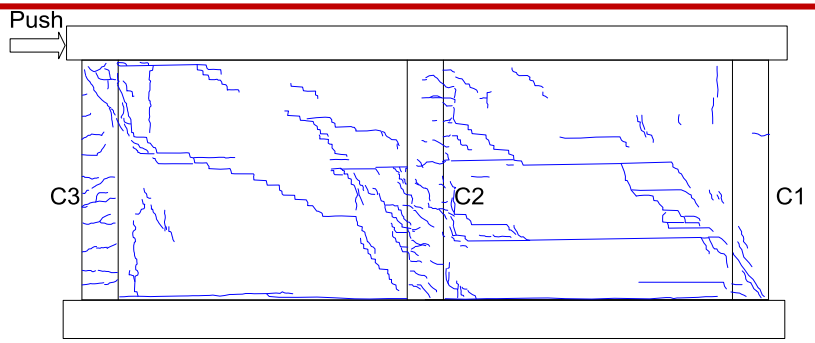
$$V_{bw4,NCREE} = \tau_f(\ell_b \times t_b) + 0.45 f_{mt}(\ell_b \tan\theta_c \times t_b)$$
$$+0.45\left(\frac{f_{mt} + f_{bt}}{2}\right)(h_b' - \ell_b \tan\theta_c) \times t_b$$

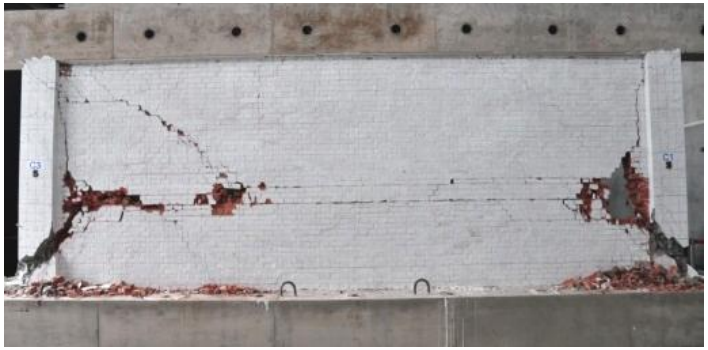
(橫縫滑移強度+束縫劈裂強度
+磚塊劈裂強度)

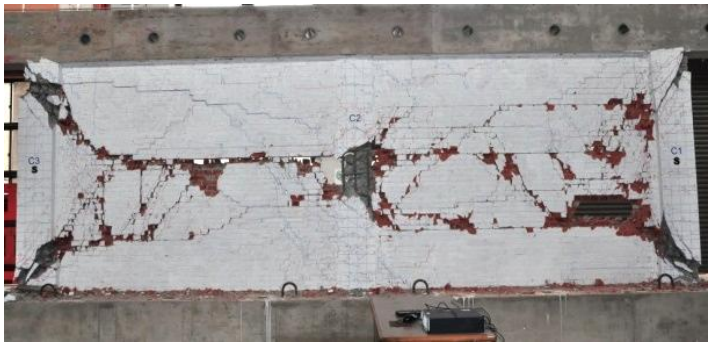


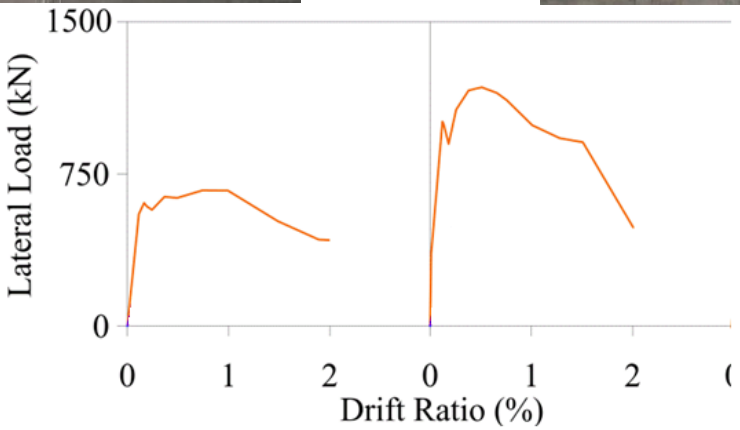
(磚構造規範)







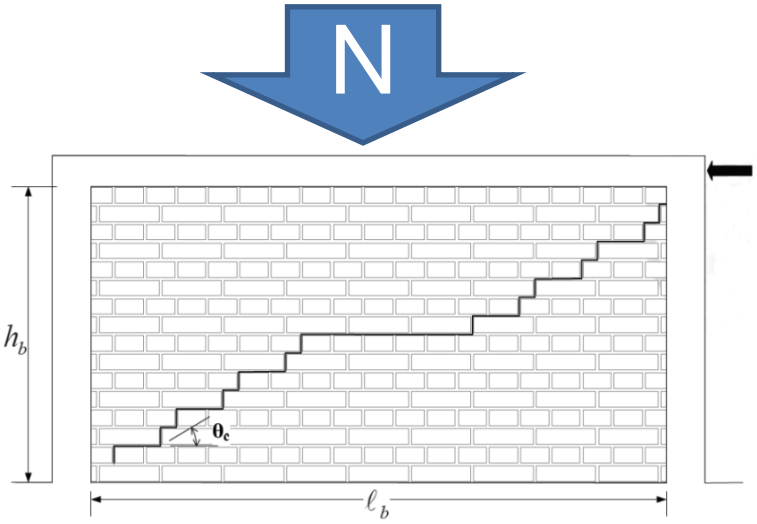




增設中間柱 → 改變破壞路徑 → 提升強度

Chiou and Hwang (2015)

動機二



$$h_b/\ell_b \le \tan\theta_c$$

$$V_{bw4,NCREE} = \tau_f(\ell_b \times t_b) + 0.45 f_{mt}(h_b \times t_b)$$

(橫縫滑移強度+束縫劈裂強度)

$$\tau_f = 0.0258(f_{mc})^{0.885} + (0.654 + 0.00514 f_{mc})\frac{N}{\ell_b \times t_b}$$

增加軸力，可提高橫縫滑移強度

(磚構造規範)

試驗規劃

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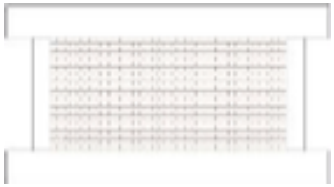
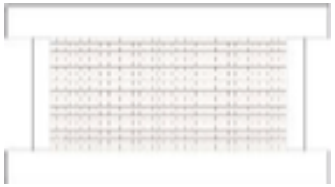
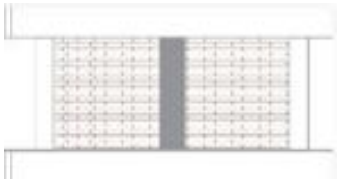
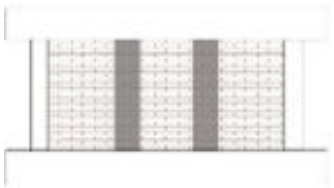
<tr><td colspan="2"> 
先砌磚牆(P)</td><td colspan="2"> 
後砌磚牆(A)</td><td rowspan="3"> 
空構架
(FRAME)</td></tr>
<tr><td> 
先砌單片CFRP
(P-CFRP1)</td><td> 
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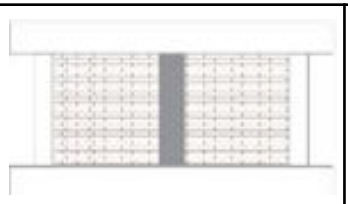
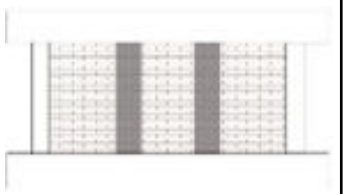
(P-CFRP2)</td><td> 
後砌單片CFRP
(A-CFRP1)</td><td> 
後砌兩片CFRP
(A-CFRP2)</td></tr>
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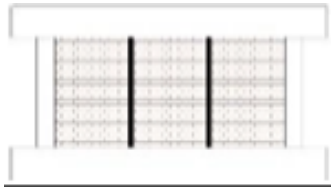
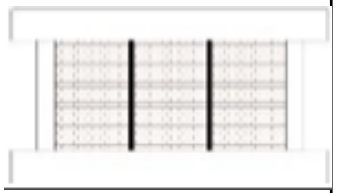
(P-S1)</td><td> 
先砌兩支鋼棒
(P-S2)</td><td> 
後砌單支鋼棒
(A-S1)</td><td> 
後砌兩支鋼棒
(A-S2)</td></tr>
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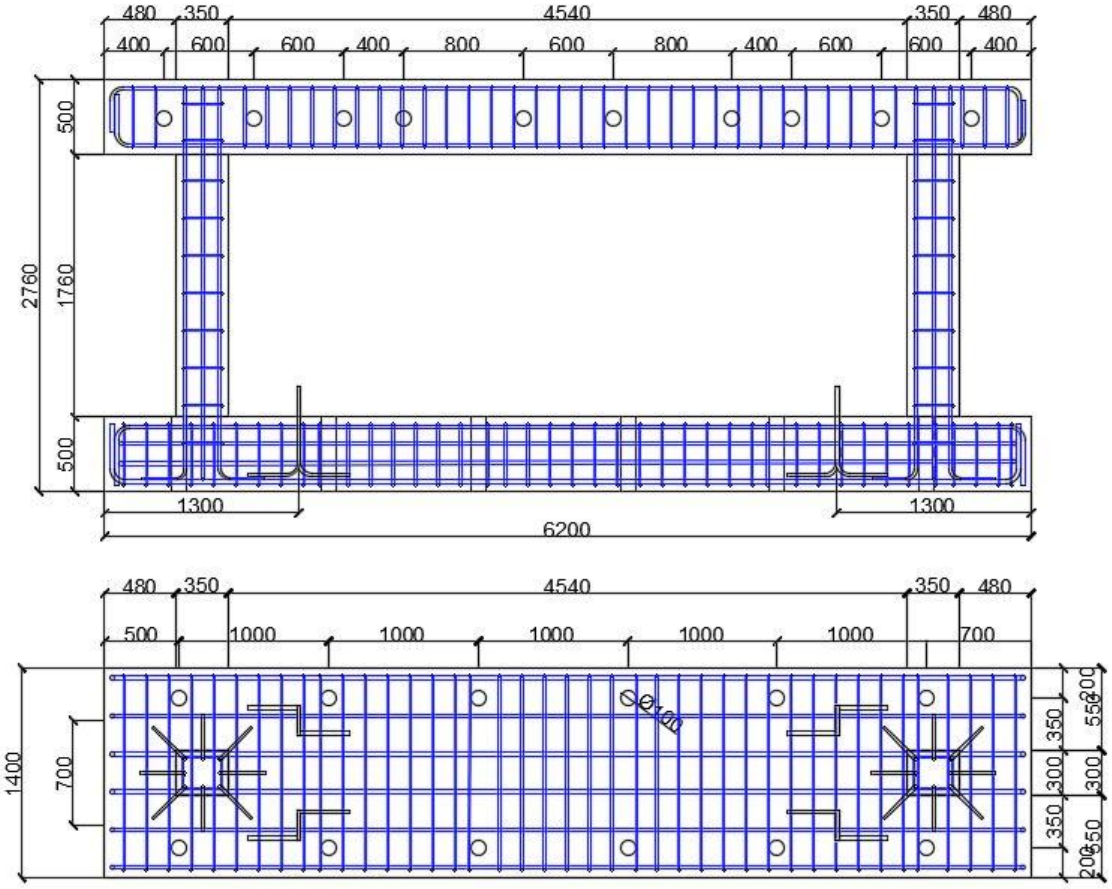
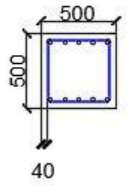
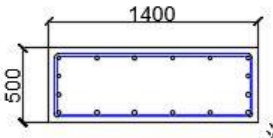


Section B-B



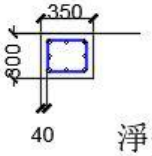
淨保護層4cm

Section C-C



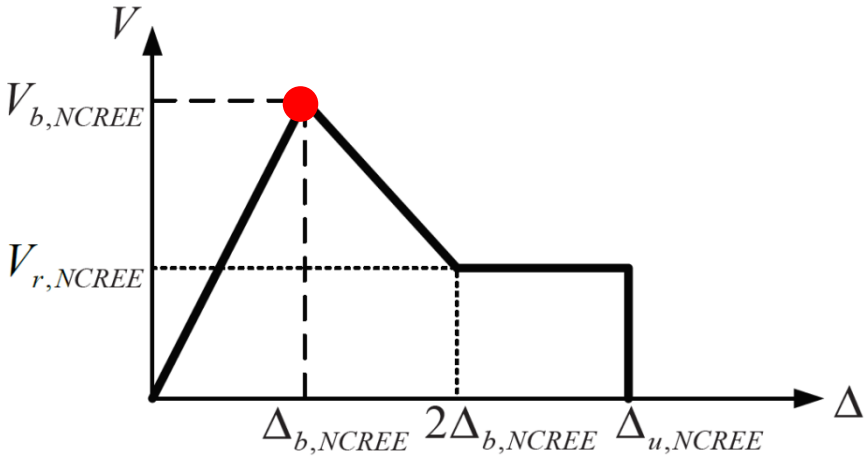
淨保護層4cm

Section A-A



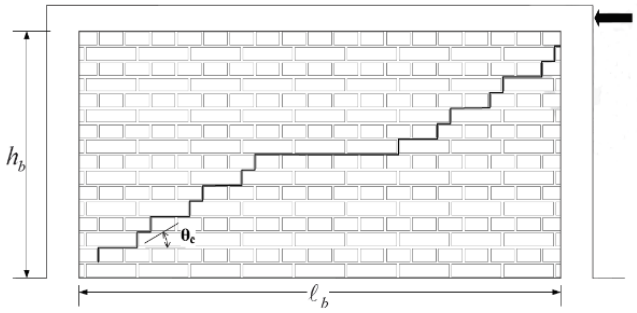
淨保護層4cm

補強元件設計



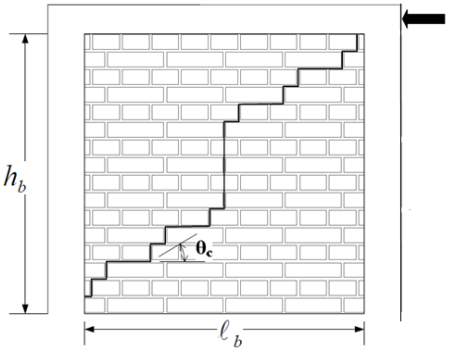
$$\boldsymbol{h_b/\ell_b \le \tan\theta_c}$$

$$V_{bw4,NCREE} = \tau_f(\ell_b \times t_b) + 0.45 f_{mt}(h_b \times t_b)$$

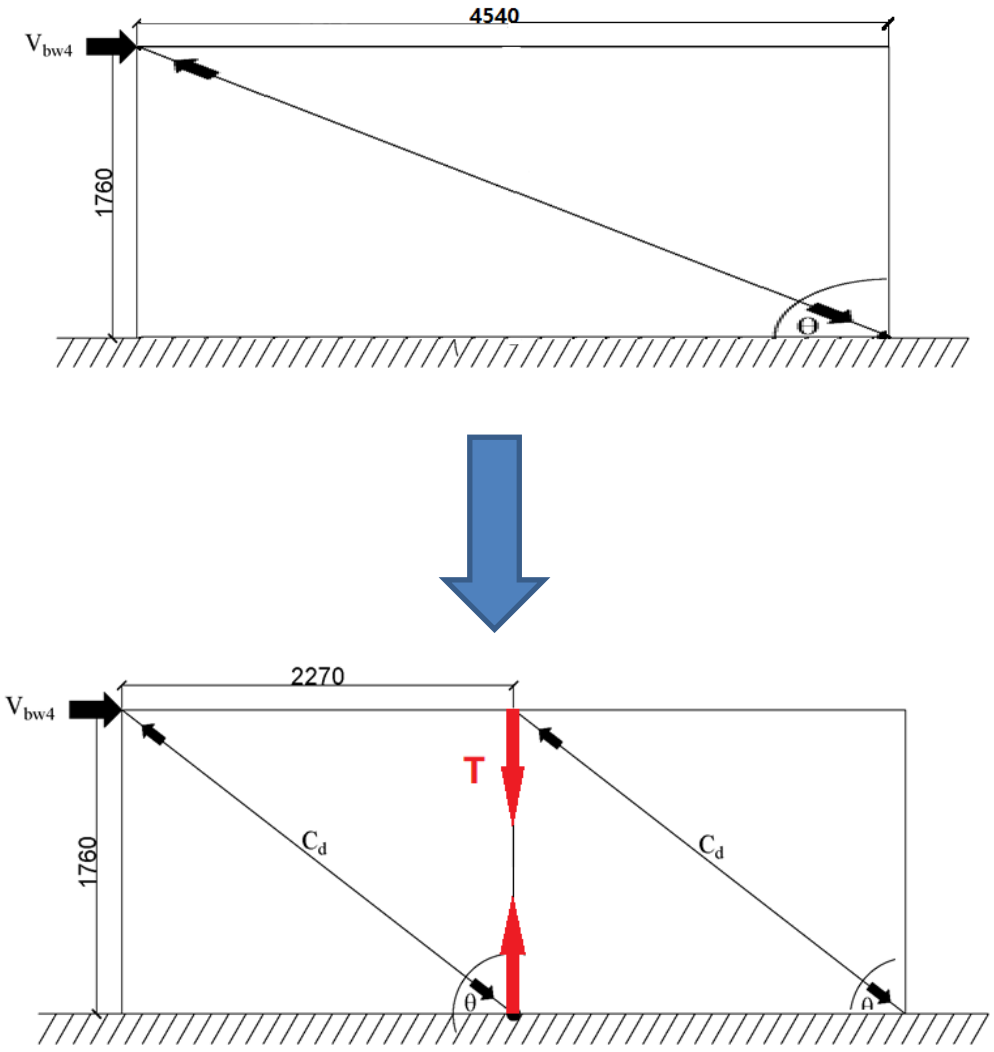


$$\boldsymbol{h_b/\ell_b > \tan\theta_c}$$

$$V_{bw4,NCREE} = \tau_f(\ell_b \times t_b) + 0.45 f_{mt}(\ell_b \tan\theta_c \times t_b) + 0.45\left(\frac{f_{mt} + f_{bt}}{2}\right)(h_b' - \ell_b \tan\theta_c) \times t_b$$



計算磚牆之側向強度→推測拉桿力



（1）CFRP設計

<1> 層數設計

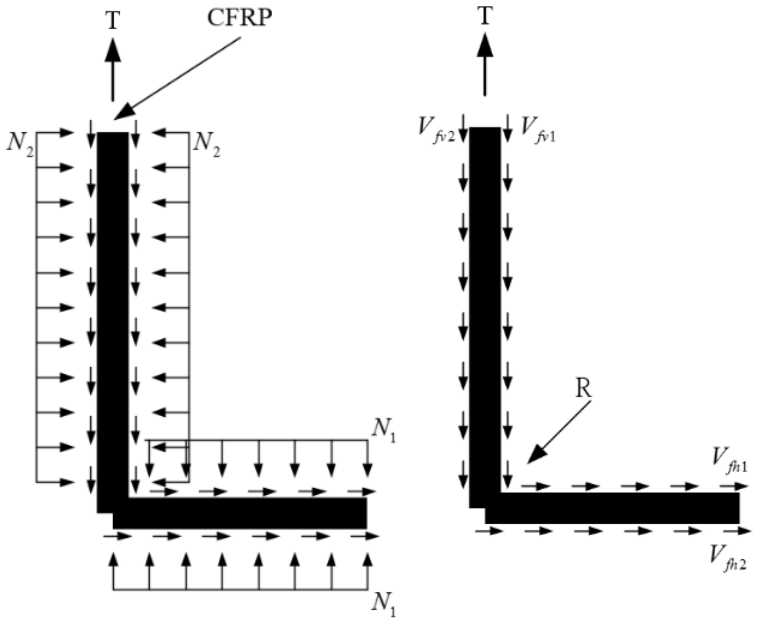
$$T = s \times n \times t \times E_f \times 0.002$$

單位面積重量	$300 g/m^2$
碳纖維厚度t_f(per ply)	$0.165\ mm$
碳纖維設計抗張強度f^*_{fu}	$4650\ N/mm^2$
碳纖維極限應變ε^*_{fu}	$0.017\ mm/mm$
設計抗張係數	$23500\ kgf/mm^2$

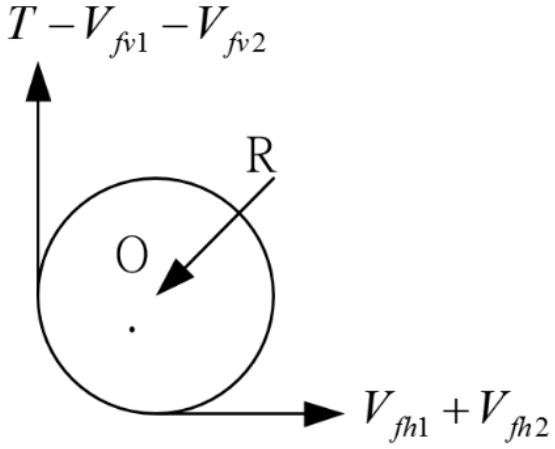
（1）CFRP設計

<2> 端部錨定設計

$$T = V_{fv1} + V_{fv2} + V_{fh1} + V_{fh2}$$
$$= 2\mu(N_1 + N_2)$$

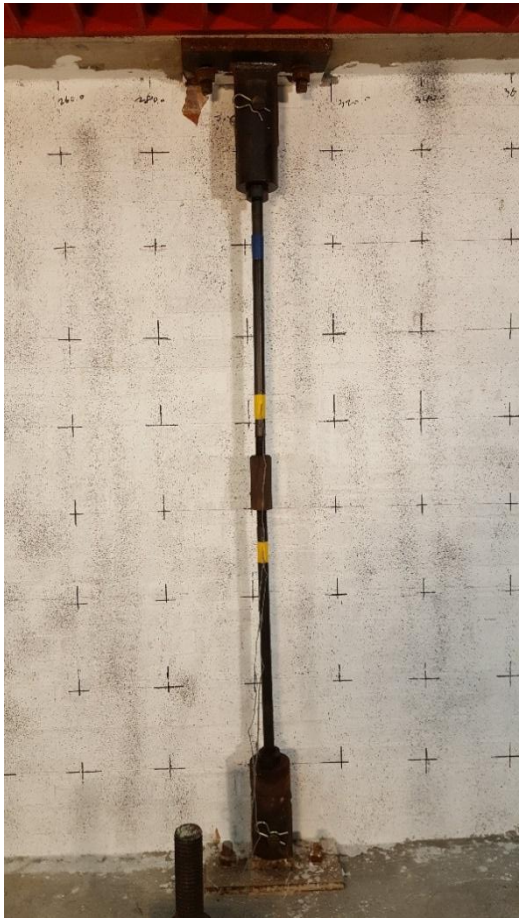


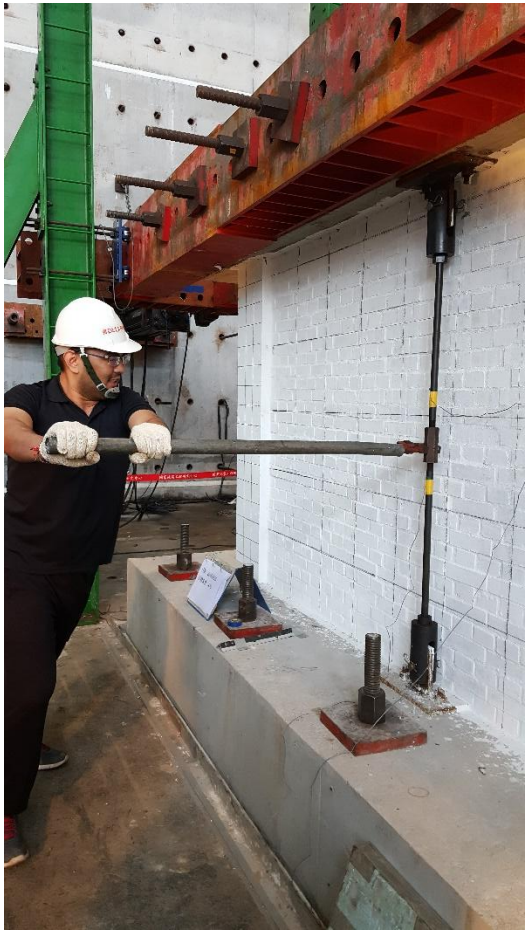
$$N_1 + N_2 = \frac{T}{2\mu}$$



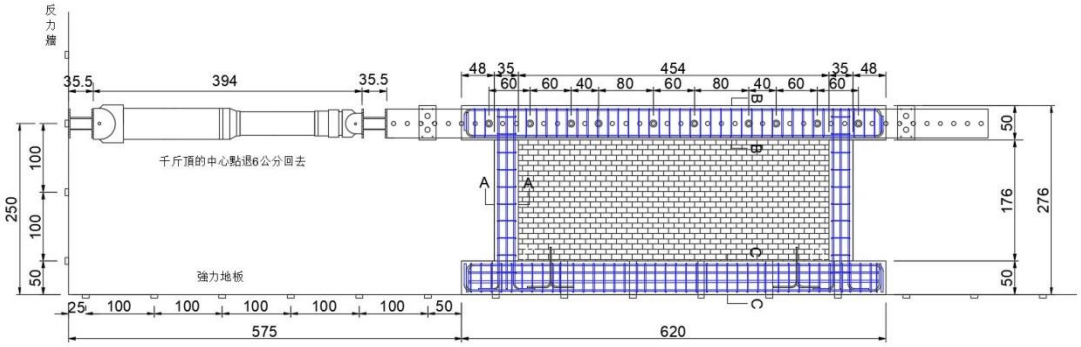
（2）拉力鋼棒設計

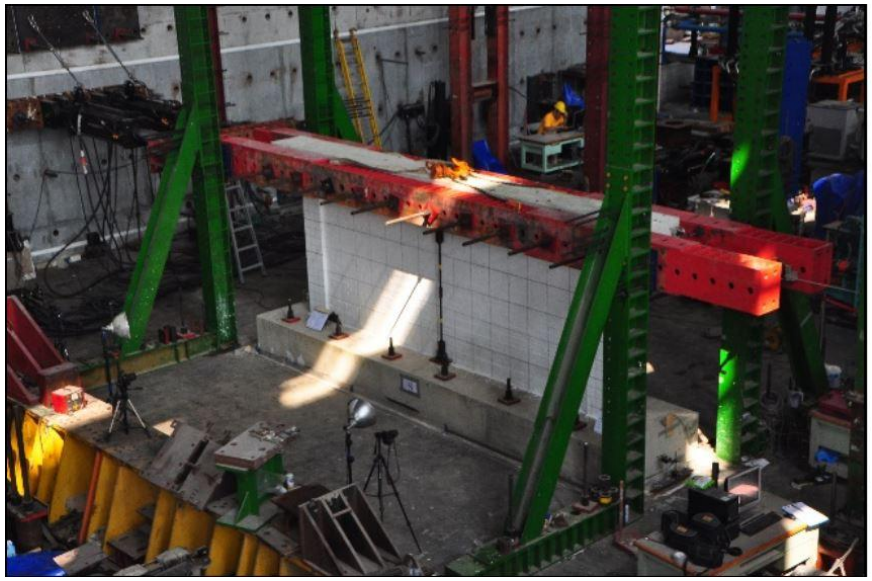
- 兩端正反螺牙鋼棒採用SNB7(63mm以下)鋼材，拉力鋼棒其他部件採用S45C鋼材
- 套筒為正反牙設計
- 同時拉伸上下兩根鋼棒
- 利用應力應變關係轉換預拉力

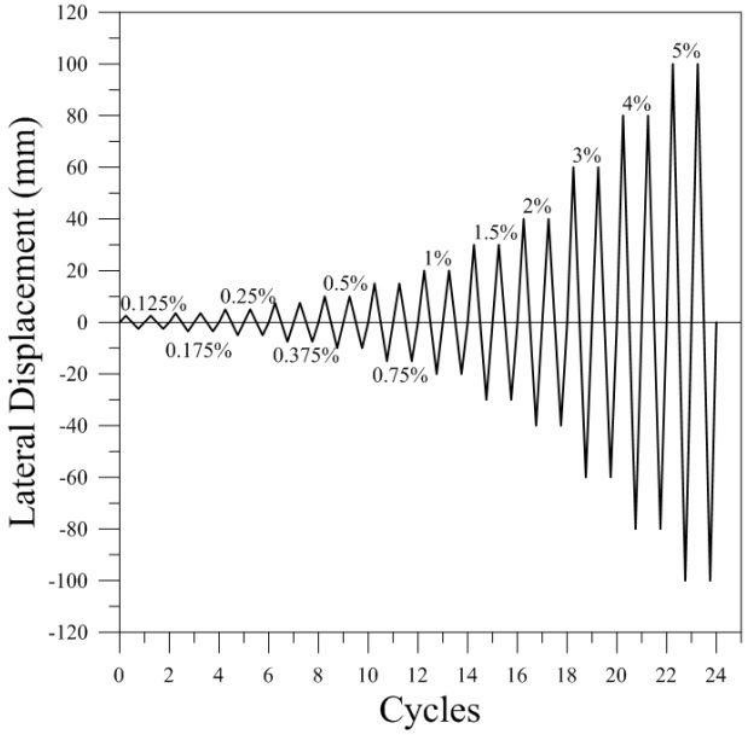




測試佈置


反力牆
35.5
394
35.5
48 35
60 60 40 80 60 80 40 60 60
454
35 48
千斤頂的中心點退6公分回去
A
A
B
B
C
C
250
100
100
50
176
276
50
50
強力地板
25 100 100 100 100 100 50
575
620




Lateral Displacement (mm)
Cycles
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0 2 4 6 8 10 12 14 16 18 20 22 24
0.125%
0.175%
0.25%
0.375%
0.5%
0.75%
1%
1.5%
2%
3%
4%
5%

試驗施作

錨栓系統組裝

預埋錨栓固定

基礎模版組立

水平尺定拉力鋼棒之垂直

梁底版鑽孔

預埋螺桿錨定安裝

梁柱灌漿

後砌式磚牆砌築

牆體表面處理

刷上積層樹脂

貼覆CFRP

鑽孔

清孔

氣槍清孔

注入植筋膠

底面膠膏整平

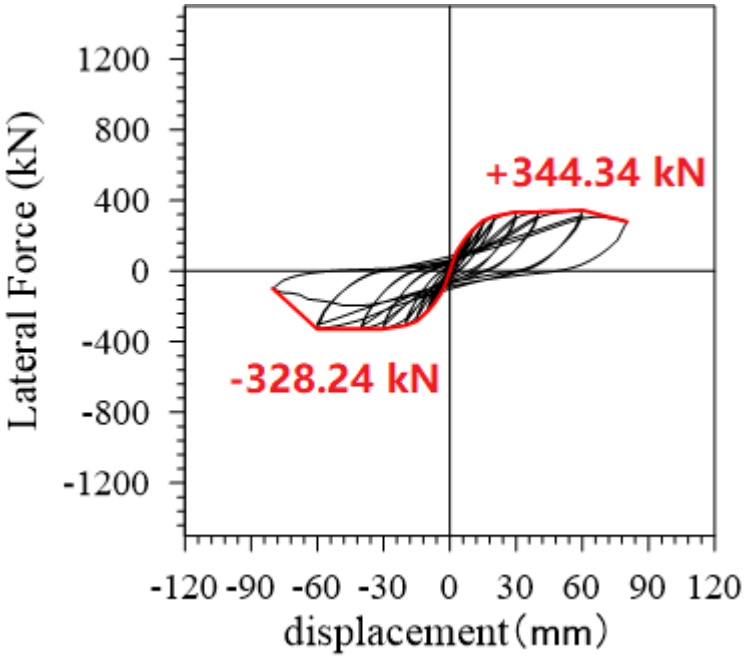
錨定系統固定

試驗結果

FRAME試驗結果

FRAME
空構架

	Frame
Drift Ratio(%)	3
強度 kN	344



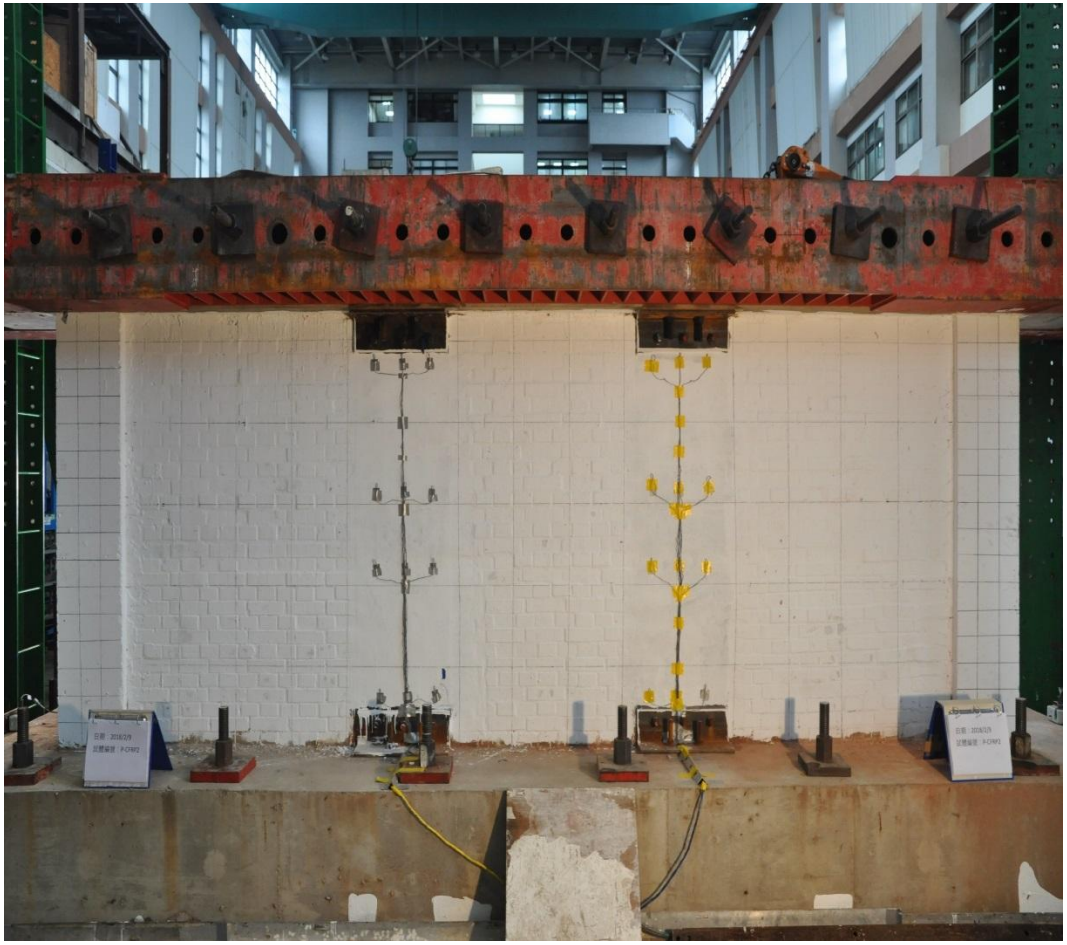

FRAME
強度點

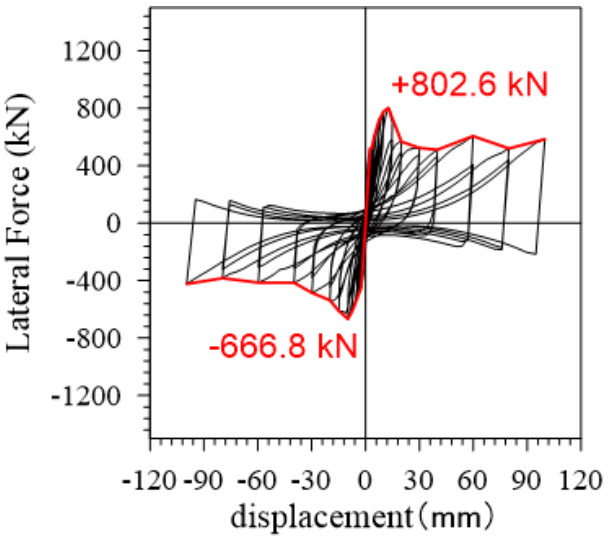
先砌式磚牆碳纖貼片補強試驗結果

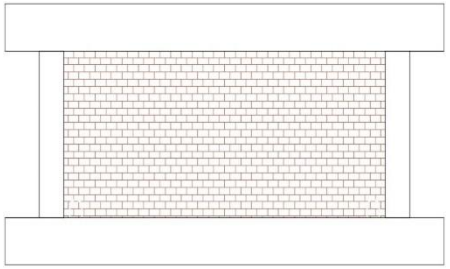
P-CFRP2

- 兩道CFRP補強，單道2層
- CFRP總層數保持不變（8層）

CFRP1: 一道CFRP補強，4層貼前後兩面，共8層。

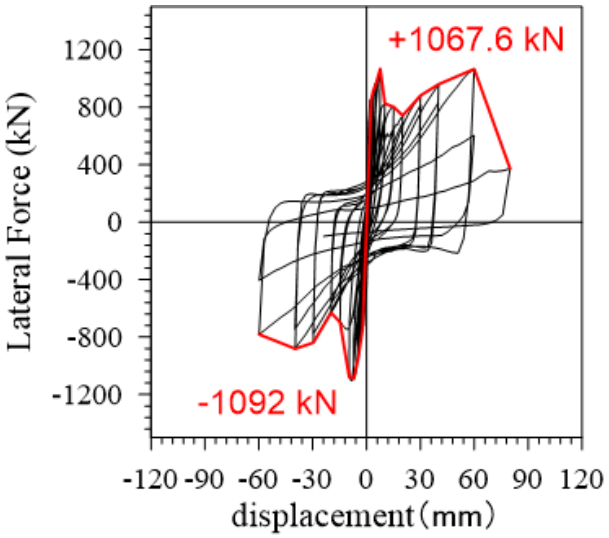


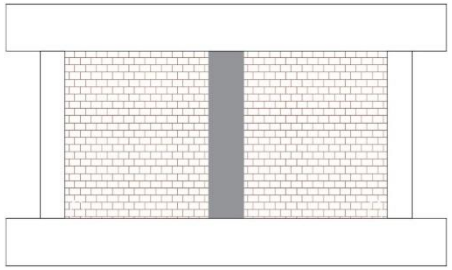




P

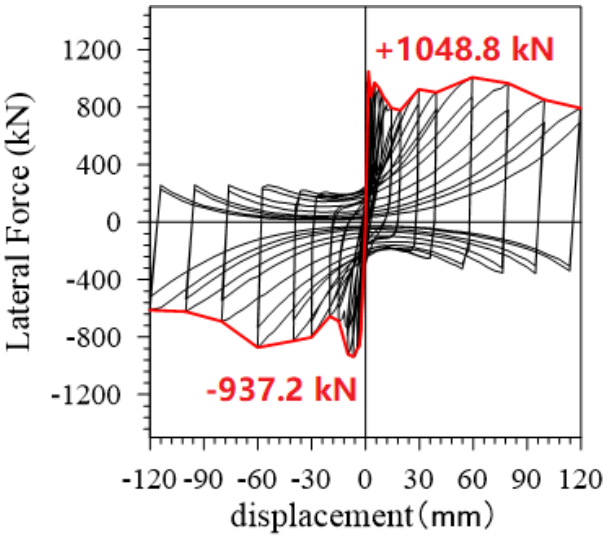
先砌式無補強試體

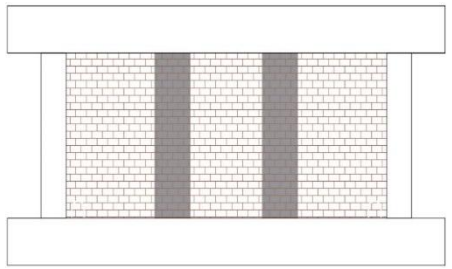




P-CFRP1

先砌式一道CFRP補強試體





P-CFRP2

先砌式兩道CFRP補強試體

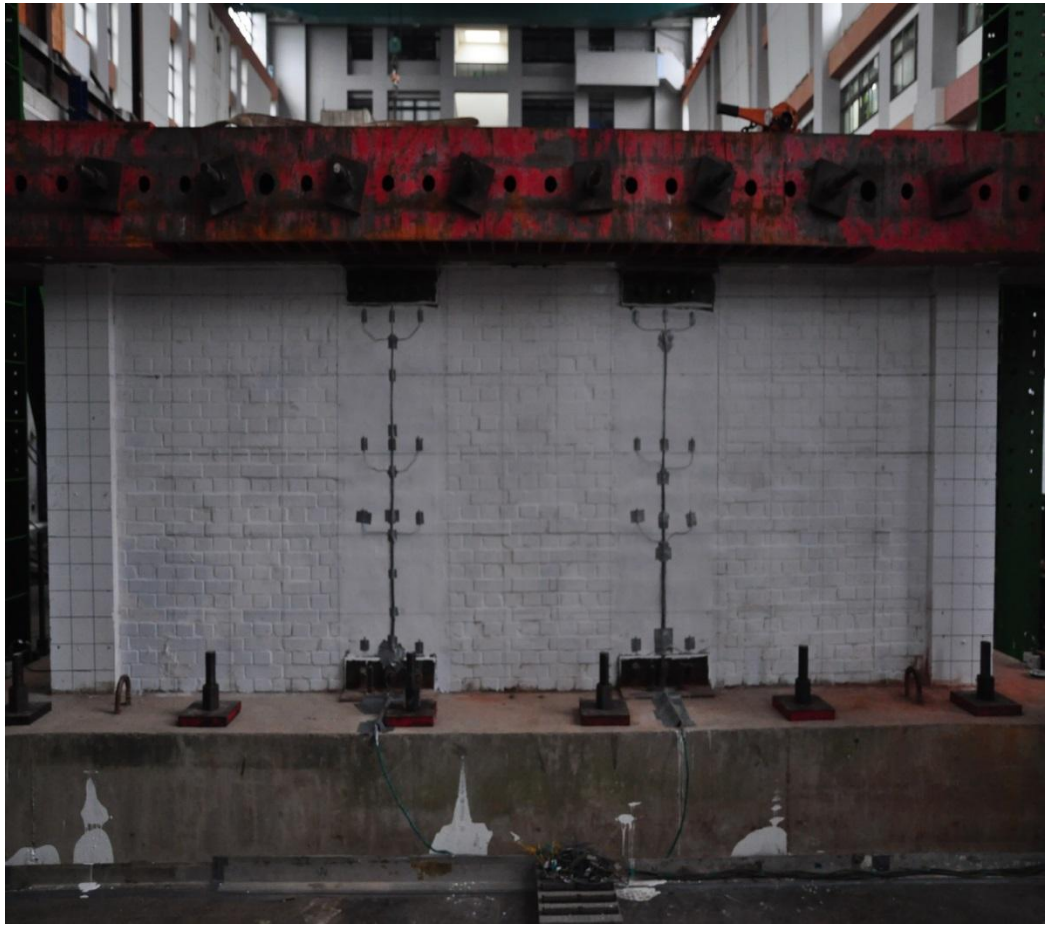
P-CFRP2
強度點

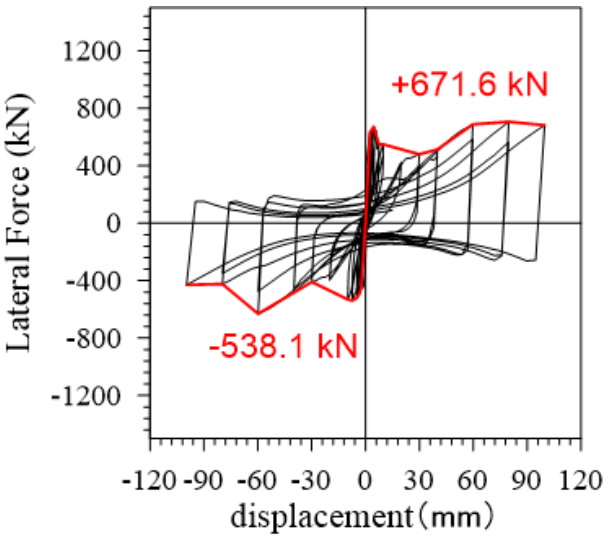
後砌式磚牆碳纖貼片補強試驗結果

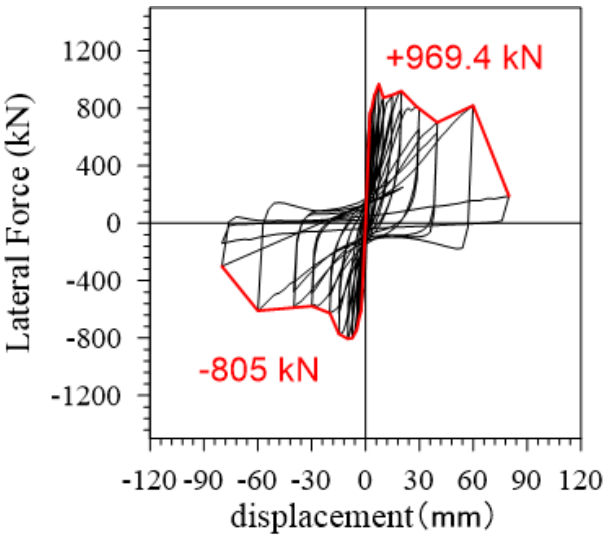
A-CFRP2

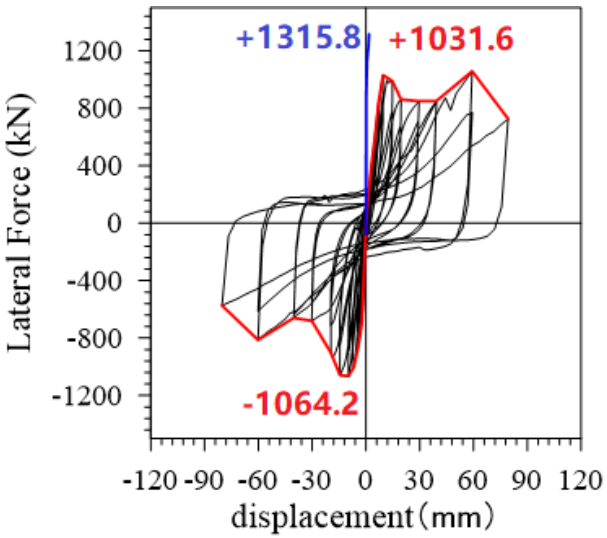
- 兩道CFRP補強，單道2層
- CFRP總層數保持不變（8層）

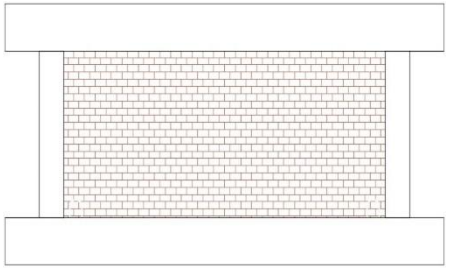
CFRP1:一道CFRP補強，4層貼前後兩面，共8層。

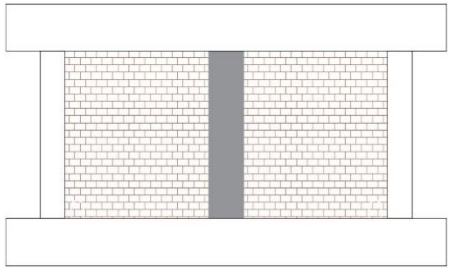


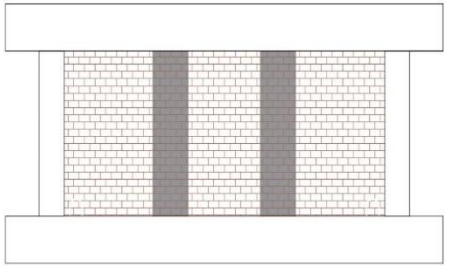












A

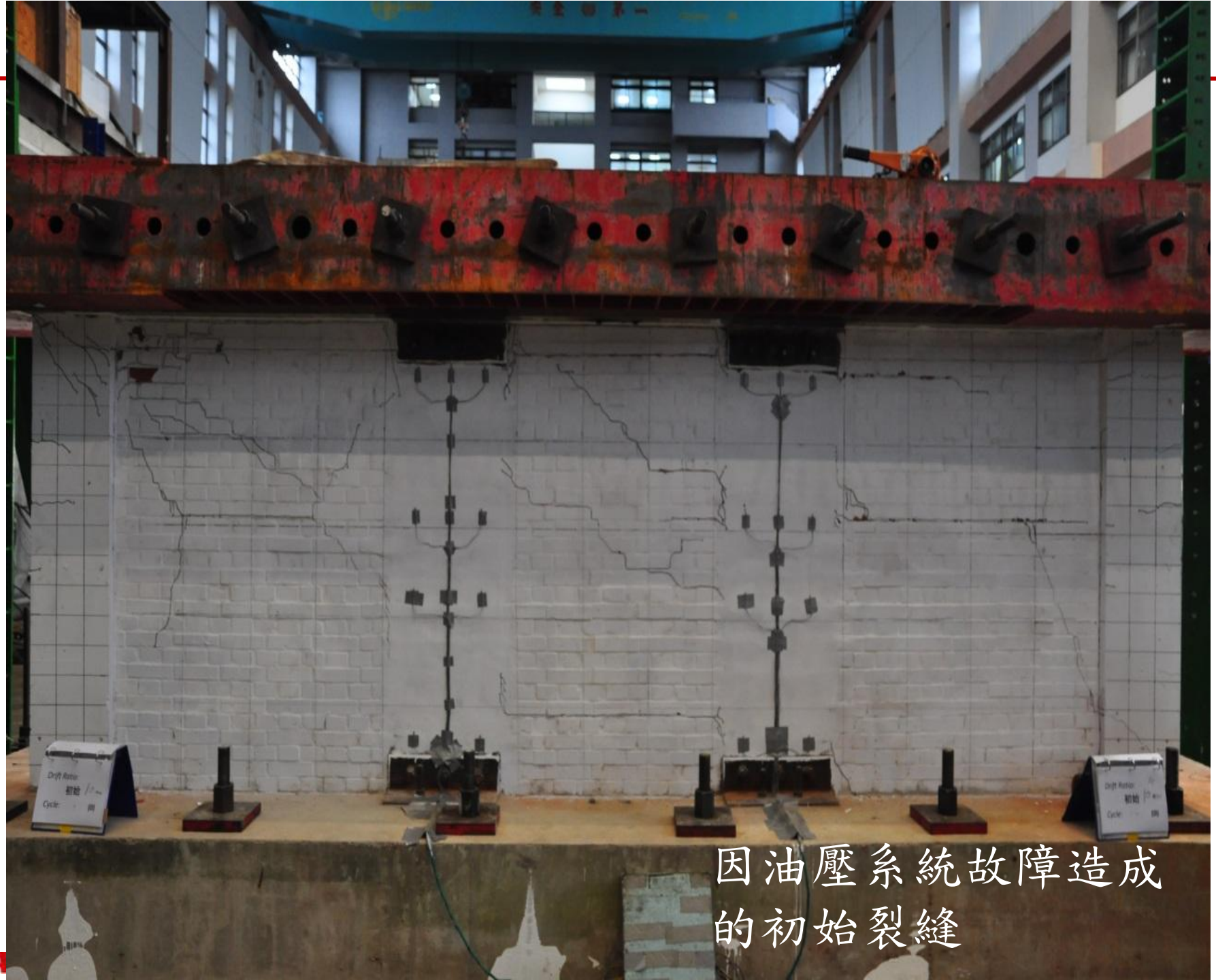
後砌式無補強試體

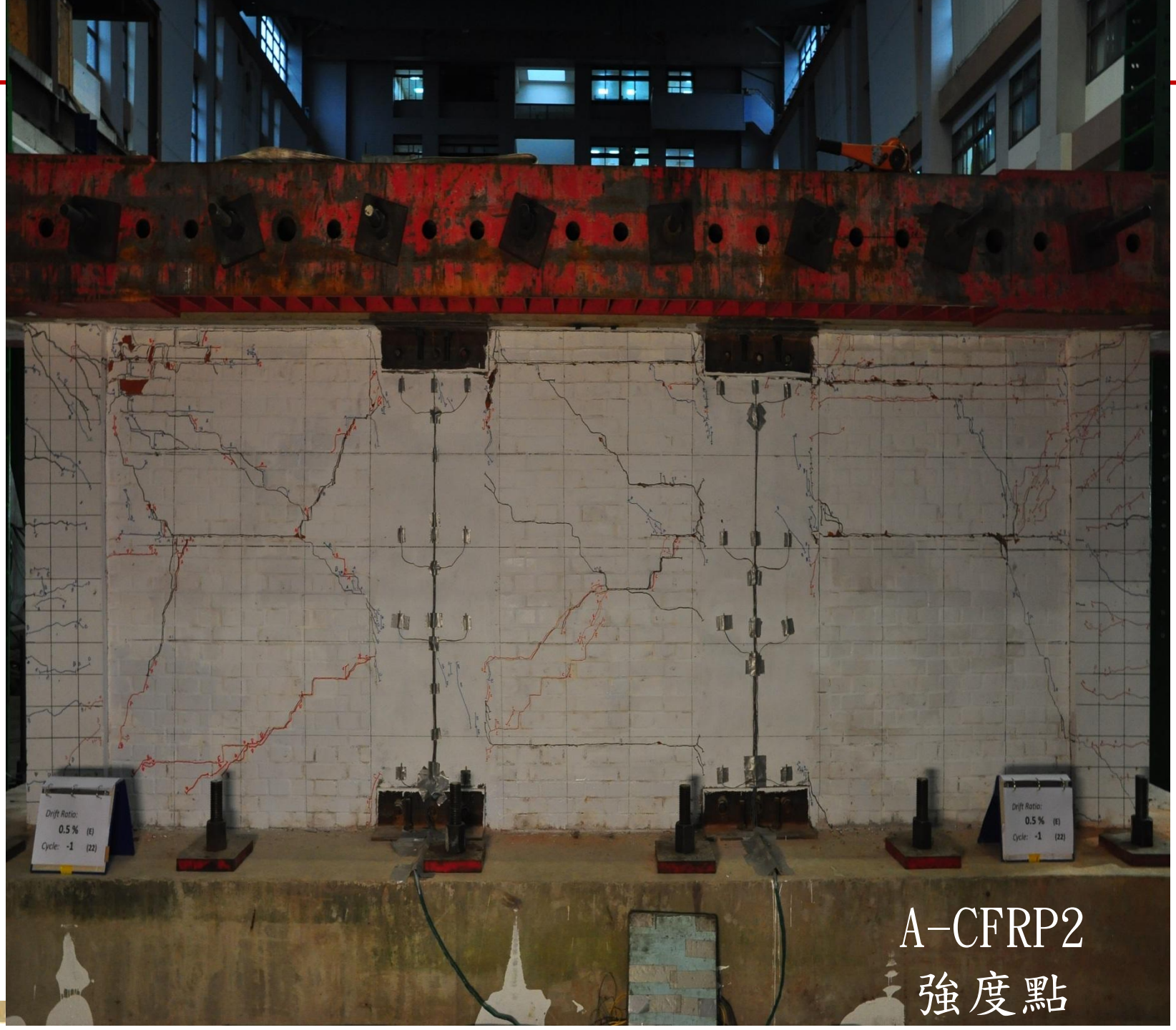
A-CFRP1

後砌式一道CFRP補強試體

A-CFRP2

後砌式兩道CFRP補強試體


因油壓系統故障造成
的初始裂縫

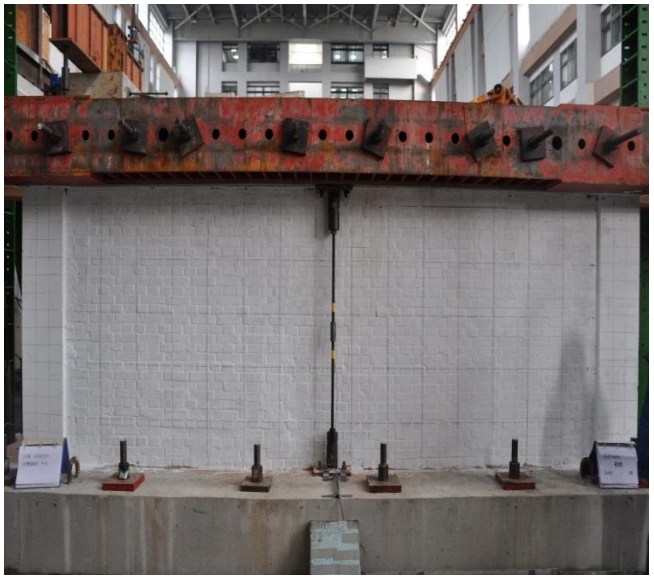


A-CFRP2
強度點

P-S1及P-S2試驗結果

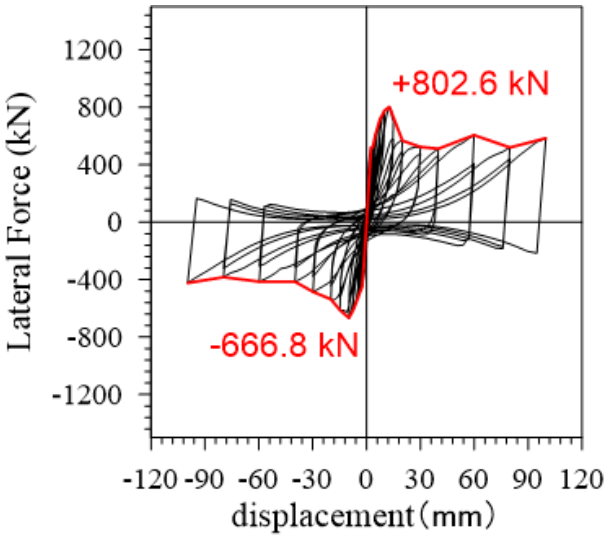
P-S1:先砌式一道拉力鋼棒補強

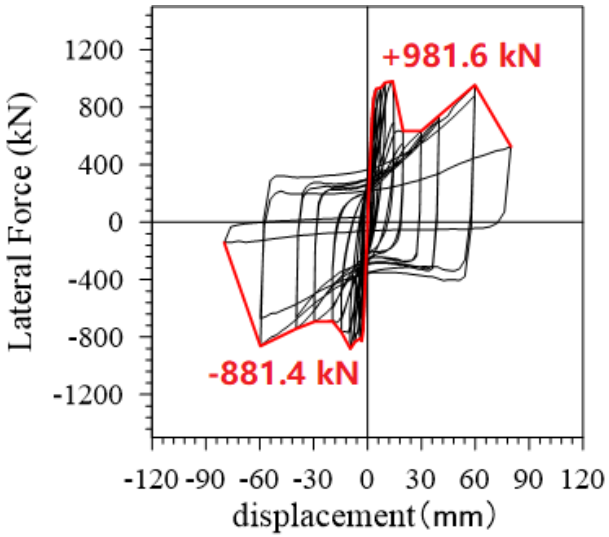
每根鋼棒施加15tf預力

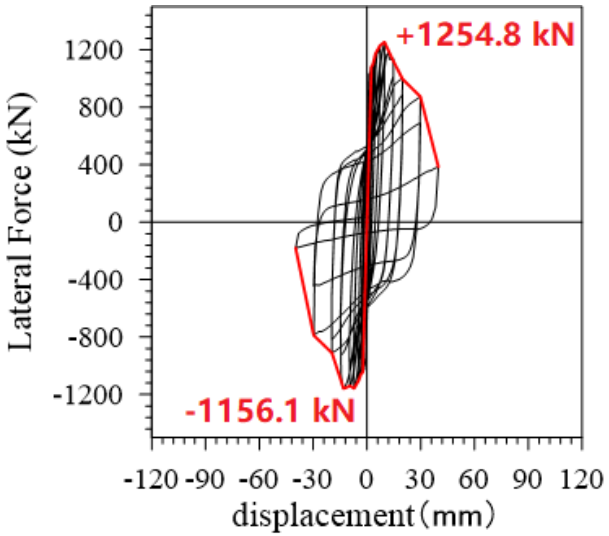


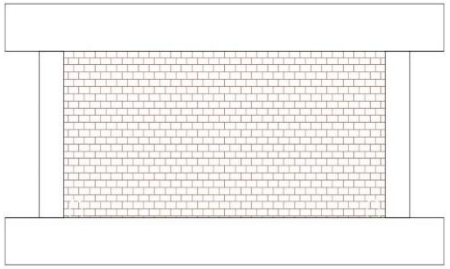
P-S2:先砌式兩道拉力鋼棒補強

每根鋼棒施加20tf預力



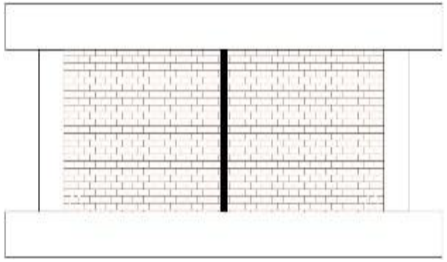






P

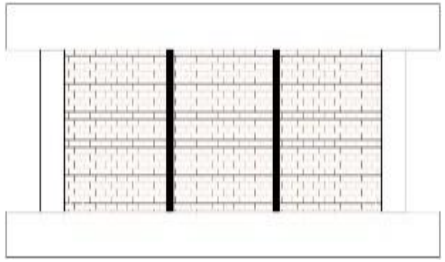
先砌式無補強試體



P-S1

先砌式一道鋼棒

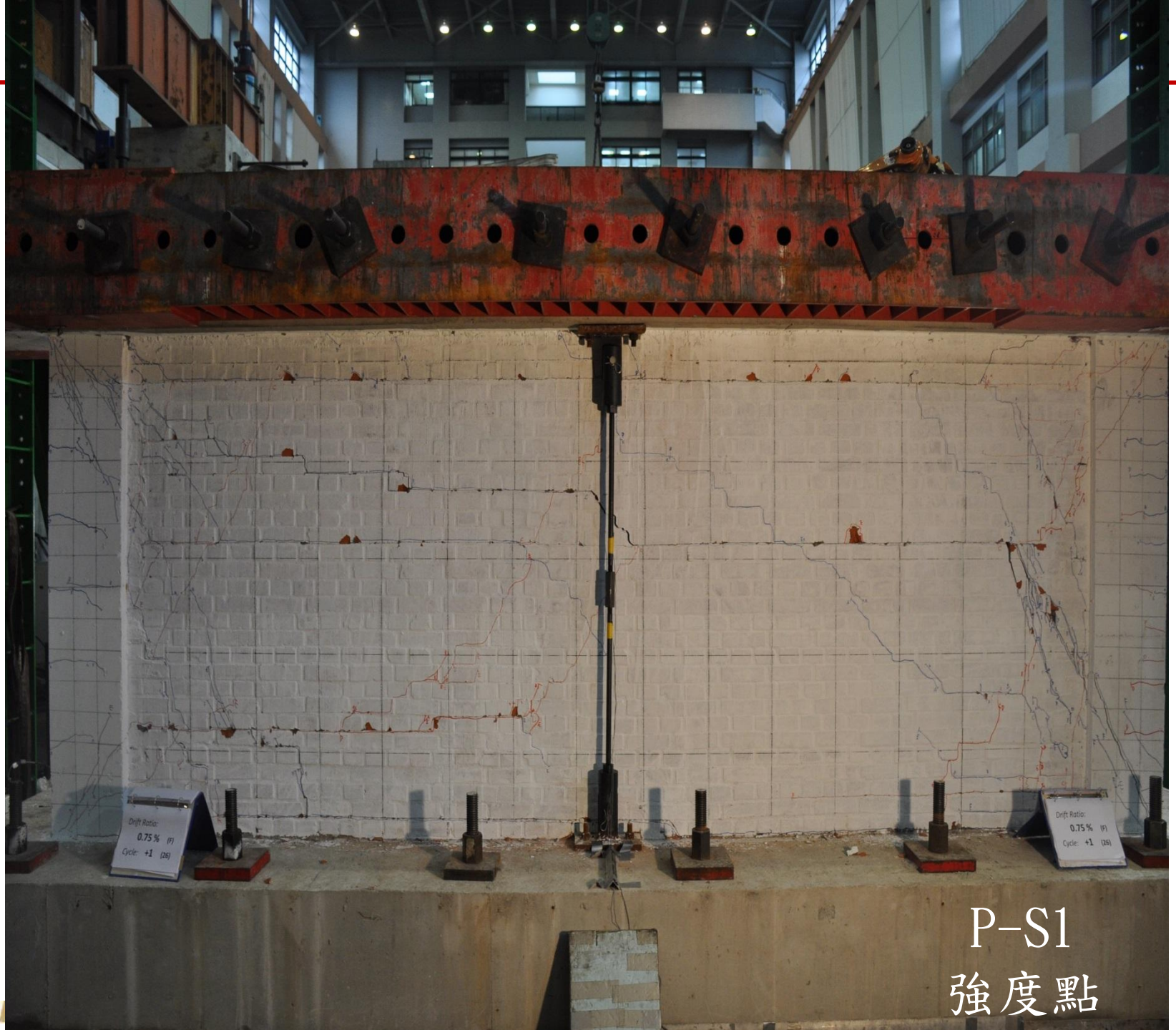
軸力增加30 tf



P-S2

先砌式兩道鋼棒

軸力增加80 tf



P-S1
強度點

P-S2
強度點

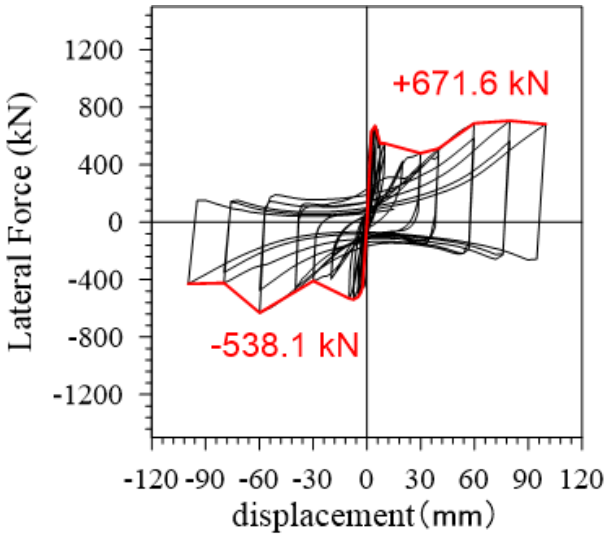
A-S1及A-S2試驗結果

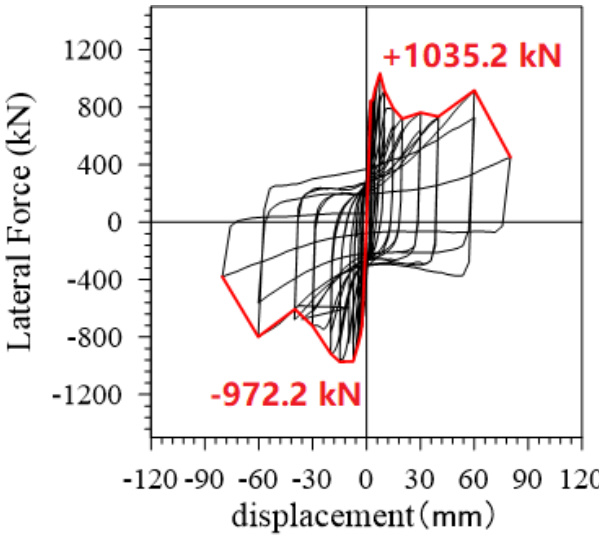
A-S1:後砌式一道拉力鋼棒補強

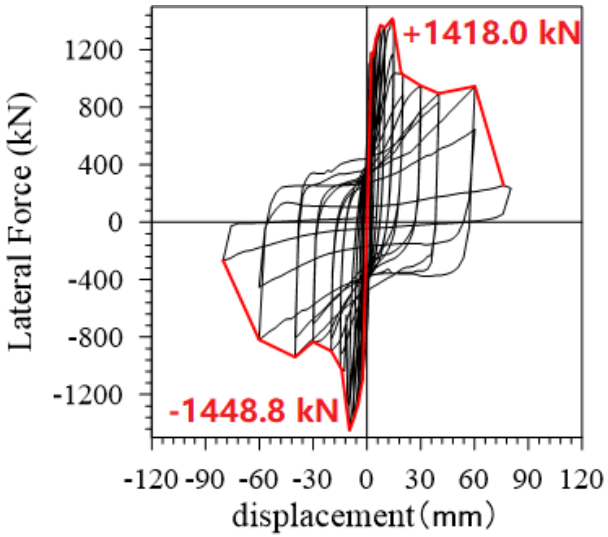
每根鋼棒施加15tf預力

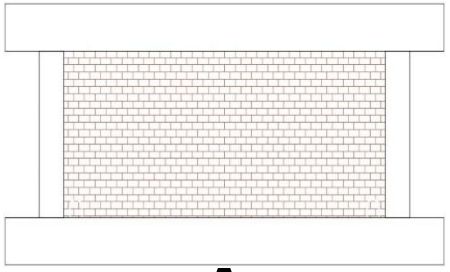
A-S2:後砌式兩道拉力鋼棒補強

每根鋼棒施加20tf預力



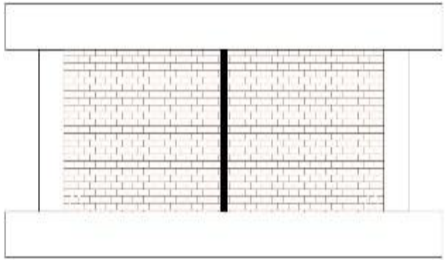






A

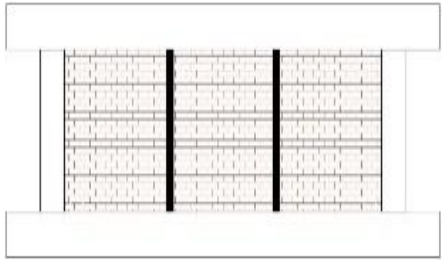
後砌式無補強試體



A-S1

後砌式一道鋼棒

軸力增加30 tf



A-S2

後砌式兩道鋼棒

軸力增加80 tf

A-S1
強度點

A-S1

強度點過後（2%）


A-S2
強度點

A-S2
強度點過後（2%）

結論

- 原則上先砌磚牆強度還是比後砌磚牆的高，惟鋼棒補強(S1及S2)提升的軸壓力影響遠超過砌法的影響。
- 碳纖維貼片為被動提供軸力，增加橫縫滑移強度二道補強，讓軸應力分布更均勻，也增加變形能力（P-CFRP2）。
- 拉力鋼棒為主動提供軸力，顯著增加橫縫滑移強度，軸力越高，補強的側向強度越高。
- 碳纖維貼片（CFRP）及拉力鋼棒補強都沒有明顯地改變磚牆之破壞路徑。應該再增加水平束制才能發展出如增設中間柱之效果。

感謝聆聽！