

建築物實施耐震能力評估及補強講習會

鋼筋混凝土建築物耐震補強理論與 分析模組介紹

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中華民國105年6月22日

報告內容

- 前言
- 國內外常用補強施工法探討
- 鋼筋混凝土構件補強理論探討與分析驗證
- 鋼斜撐框架補強理論探討與分析驗證
- SERCB耐震能力評估系統之補強分析模組開發
- 補強分析功能操作簡介 (*.SECT, *.MET)
- 結論

Part I

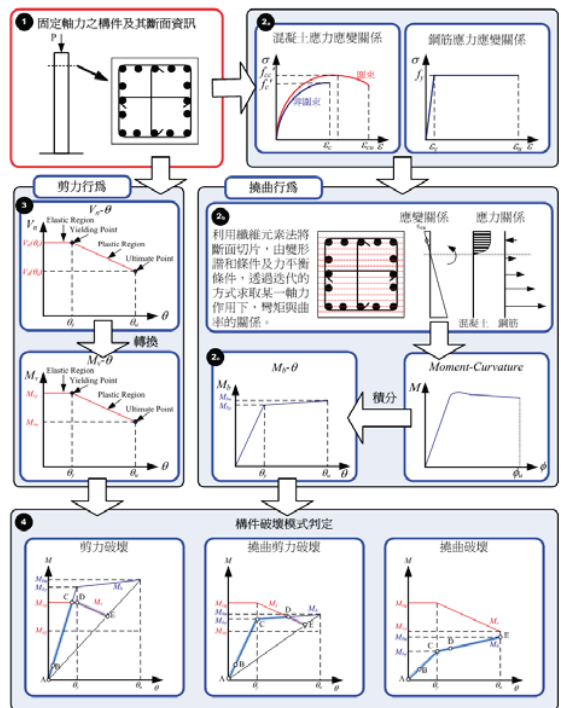
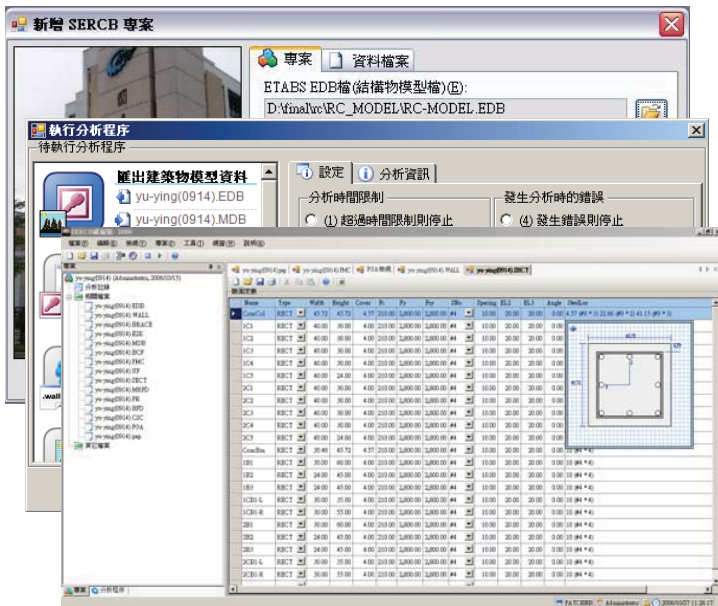
前言



前言



鋼筋混凝土建築物耐震能力
評估系統，自2006-迄今



前言



前言

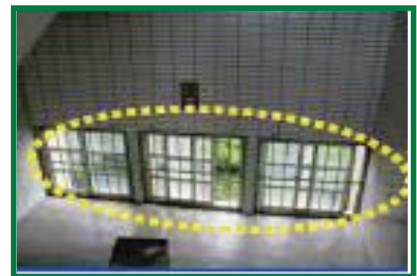


Part II

國內外常用補強施工法探討

國內常用補強工法

窗台填磚牆 -消除短柱



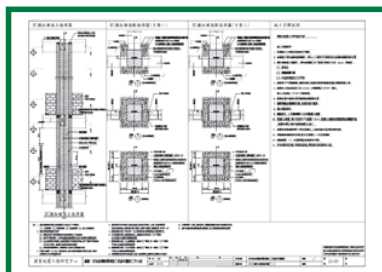
| 優點 | 缺點 |
|---|--|
| <ul style="list-style-type: none">消除短柱效應，避免剪力破壞。可提升結構物的勁度，並提升整體耐震能力。 | <ul style="list-style-type: none">影響原空間之採光與通風如位於樓梯間或側所之高窗，填磚後需設置通風系統及採光 |

資料來源：國家地震中心
東建工程顧問有限公司

國內常用補強工法

擴柱補強

校舍結構耐震補強工程參考圖說



| 優點 | 缺點 |
|--|--|
| <ul style="list-style-type: none"> □ 選用適當建材，可使外觀與原始教室較具一體性。 □ 對於教室採光影響小。 | <ul style="list-style-type: none"> □ 設置於樓梯與出入口角落時，需要設置保護墊，避免學生撞傷。 |

資料來源：國家地震中心
東建工程顧問有限公司

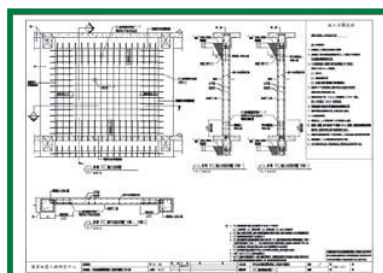


TAIPEI
TECH

國內常用補強工法

剪力牆補強

校舍結構耐震補強工程參考圖說



| 優點 | 缺點 |
|---|--|
| <ul style="list-style-type: none"> □ 可以較少的補強量，達到足夠的耐震需求，減少補強工程對學校的衝擊。 □ 新增牆面可提供作為公佈欄使用增加額外。 | <ul style="list-style-type: none"> □ 較容易影響通風與採光，應慎選配置地點。 □ 剪力牆下方基礎不易設計及施工。 |

資料來源：國家地震中心

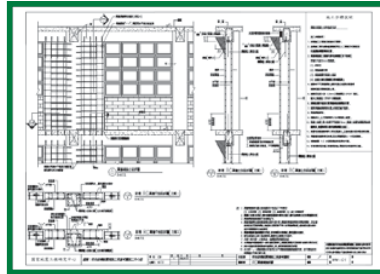


TAIPEI
TECH

國內常用補強工法

翼牆補強

校舍結構耐震補強工程參考圖說

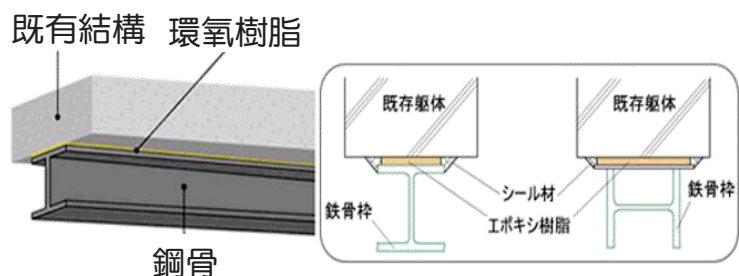
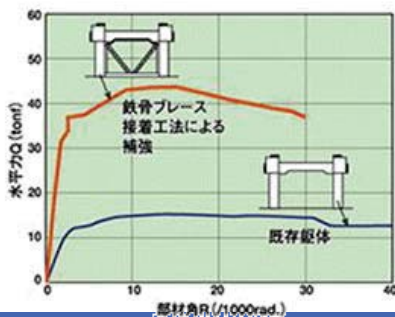
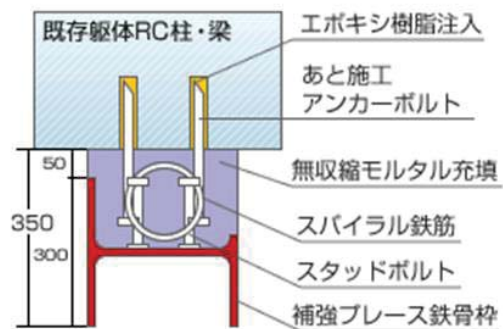


| 優點 | 缺點 |
|---|--|
| <ul style="list-style-type: none"> 對於教室採光影響較剪力牆小。 新增牆面可提供作為公佈欄使用。 | <ul style="list-style-type: none"> 補強位置若變更門窗，將會影響到教室動線。 |

資料來源：國家地震中心
東建工程顧問有限公司

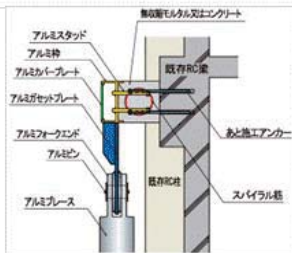
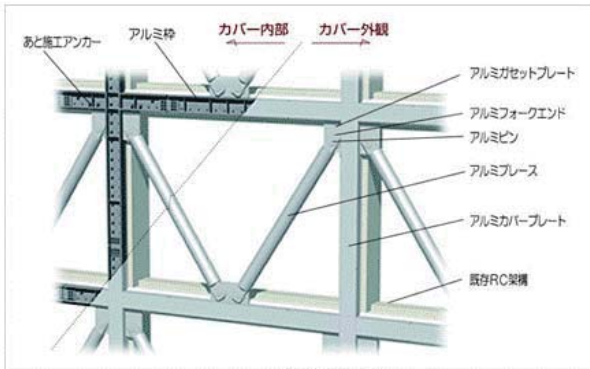
國外之補強工法

內嵌式鋼斜撐構架補強



國外之補強工法

外附式鋼斜撐構架補強

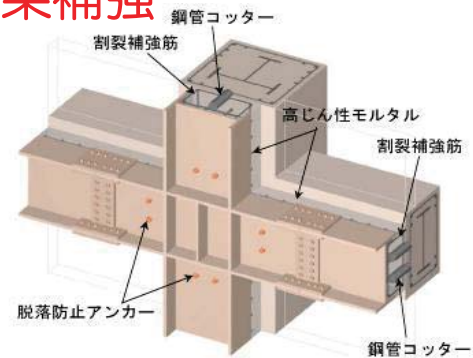


框架型示意圖

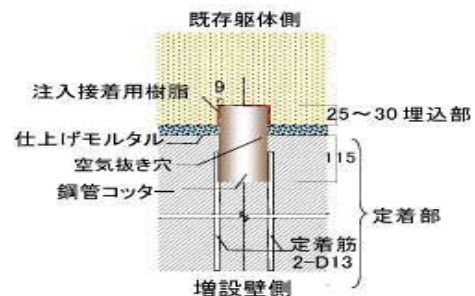
國外之補強工法

外附式鋼框架補強

耐震間柱付き外付け鉄骨フレーム

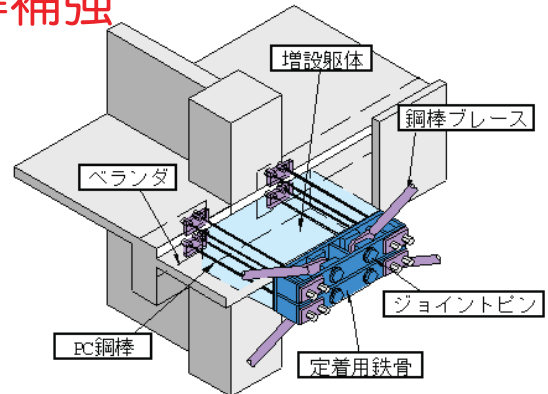
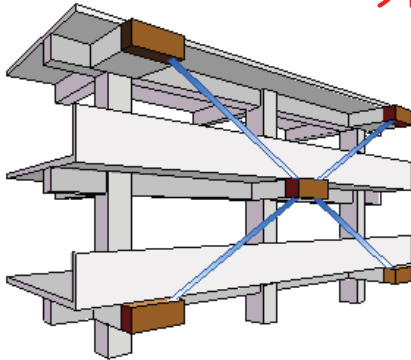


割裂補強筋 鋼管コッター 脱落防止アンカー



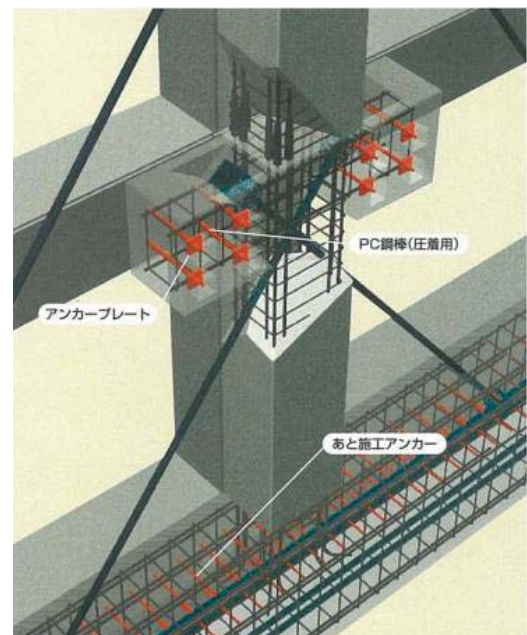
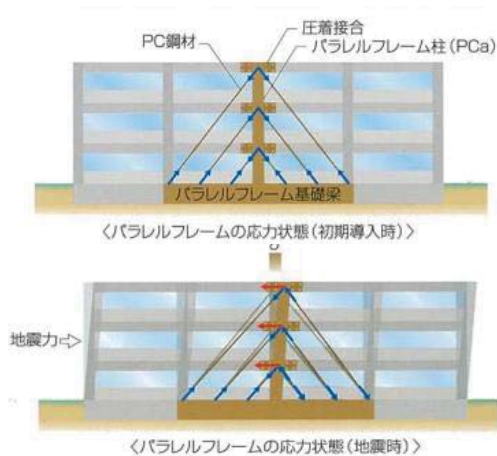
國外之補強工法

外部支撐補強



國外之補強工法

平行預力鋼索補強工法



<http://www.fujips.co.jp/technology/t-reinforce/sub16010>

國外補強案例探討

外加式鋼構架補強



外加式鋼斜撐構架補強



外加式鋼構架補強



預鑄RC柱構架補強

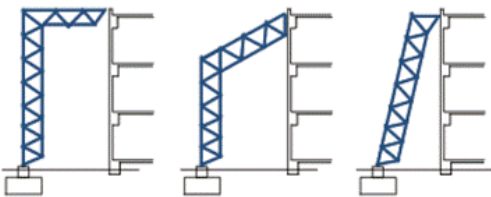


<http://www.sho-bond.co.jp/html/51-bc.html>

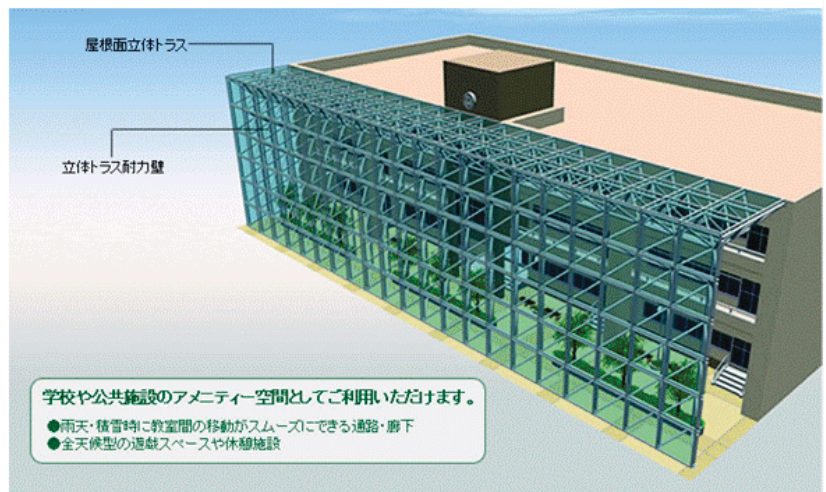


國外工法回顧

外加式鋼斜撐構架補強



桁架中庭型補強概念圖



桁架中庭型模擬圖



桁架中庭型

國立臺北科技大學土木與防災研究所

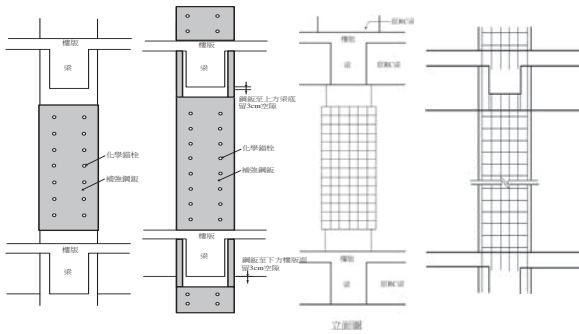
小結

構件補強

- RC包覆強度補強
- RC包覆圍束補強
- 鋼板包覆圍束補強
- 翼牆補強

結構系統補強

- 增設RC牆補強
- 內嵌式鋼斜撐框架補強
- 外附式鋼斜撐框架補強



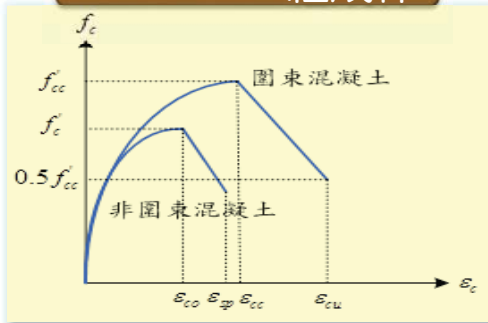
Part III

鋼筋混凝土構件補強理論 探討與分析驗證



混凝土組成律

Kawashima組成律



圍束區

$$f_c = E_c \varepsilon_c \left[1 - \frac{1}{n} \left(\frac{\varepsilon_c}{\varepsilon_{cc}} \right)^{n-1} \right], 0 \leq \varepsilon_c < \varepsilon_{cc}$$

$$f_c = f'_c - E_{des} (\varepsilon_c - \varepsilon_{cc}), \varepsilon_{cc} \leq \varepsilon_c < \varepsilon_{cu}$$

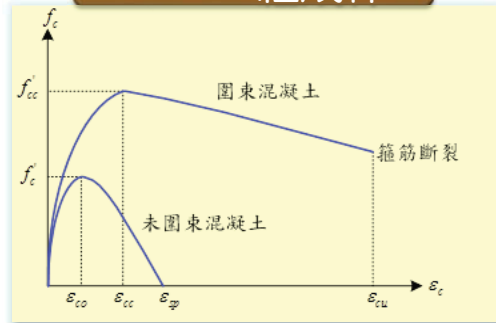
$$f_c = 0.5 f'_c, \varepsilon_{cu} \leq \varepsilon_c$$

非圍束區

$$f_c = E_c \varepsilon_c \left[1 - \frac{1}{n} \left(\frac{\varepsilon_c}{\varepsilon_{co}} \right)^{n-1} \right], 0 \leq \varepsilon_c < \varepsilon_{co}$$

$$f_c = f'_c - E_{des} (\varepsilon_c - \varepsilon_{co}), \varepsilon_{co} \leq \varepsilon_c < \varepsilon_{sp}$$

Mander組成律



圍束區

$$f_c = \frac{f'_{cc} x r}{r - 1 + x^r}$$

$$f'_{cc} = f'_c \left(-1.254 + 2.254 \sqrt{1 + \frac{7.94 f'_c}{f'_c} - 2 \frac{f'_c}{f'_c}} \right)$$

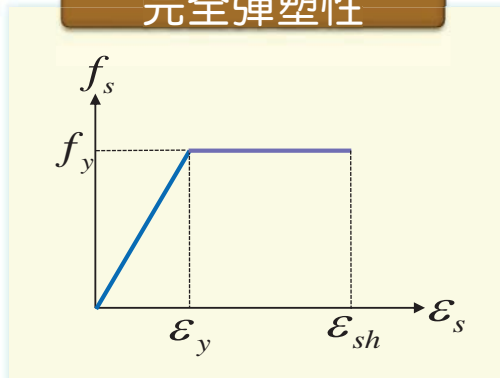
非圍束區

$$f_c = \frac{f'_{cc} x r}{r - 1 + x^r} \quad f'_{cc} = f'_c$$



鋼筋組成律

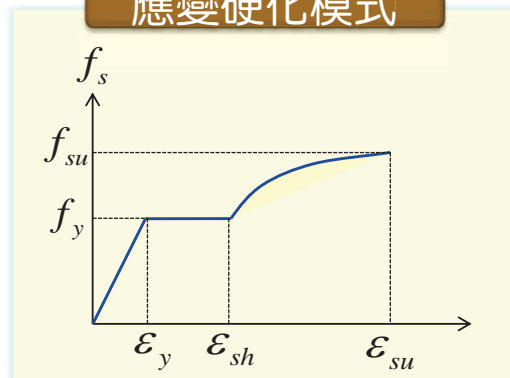
完全彈塑性



$$f_s = E_s \varepsilon_s, \varepsilon_s \leq \varepsilon_y$$

$$f_s = f_y, \varepsilon_y < \varepsilon_s \leq \varepsilon_{sh}$$

應變硬化模式



$$f_s = E_s \varepsilon_s, \varepsilon_s \leq \varepsilon_y$$

$$f_s = f_y, \varepsilon_y < \varepsilon_s \leq \varepsilon_{sh}$$

$$\varepsilon_{sh} < \varepsilon_s \leq \varepsilon_{su}$$

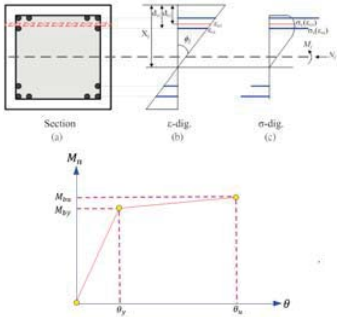
$$f_s = \left[\frac{m(\varepsilon_s - \varepsilon_{sh}) + 2}{60(\varepsilon_s - \varepsilon_{sh}) + 2} + \frac{(\varepsilon_s - \varepsilon_{sh})(60 - m)}{2(30r_s + 1)^2} \right]$$



柱構件非線性行為探討

撓曲行為

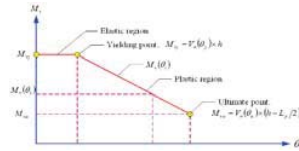
- 彎矩-曲率分析
- 彎矩-轉角關係建立



柱構件非線性行為探討

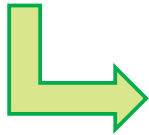
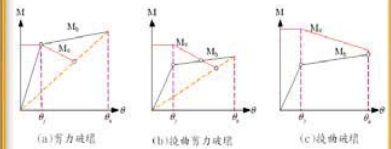
剪力行為

- 柱剪力-轉角關係建立
- 剪力-轉角轉換彎矩-轉角



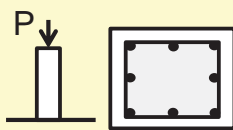
破壞模式

- 撓曲破壞
- 撓剪破壞
- 剪力破壞

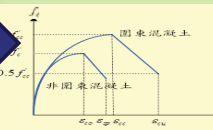


撓曲分析

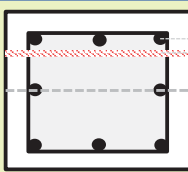
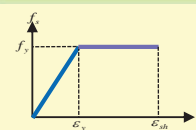
固定軸力及斷面資訊



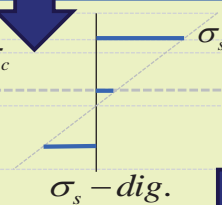
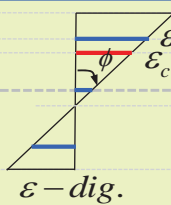
混凝土組成律



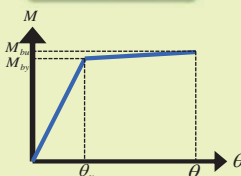
鋼筋組成律



Section



M_b - θ



Moment - Curvature



$$\theta = \delta/h \quad \delta = \int_0^h \phi_c x dx$$

剪力分析

$$V_n = V_c + V_s$$

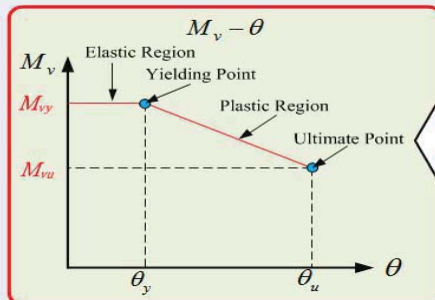
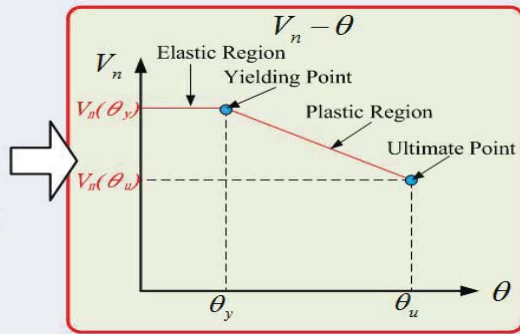
$$V_s = \frac{\pi A_h f_{yh} D}{2 a}, \text{圓型}$$

$$V_s = A_{sh} f_{yh} \frac{d}{a}, \text{矩型}$$

$$V_c = 0.53(k + F) \sqrt{f'_c} A_e \geq 0$$

$$k = \frac{R_{\max} - R}{R_{\max} - 1} \geq 0$$

$$R_{\max} = \theta_u / \theta_y, R = \theta / \theta_y$$



轉換

$$\theta \leq \theta_y$$

$$M_{vy} = V_n(\theta) \times h$$

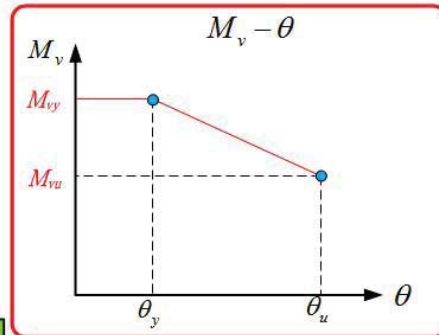
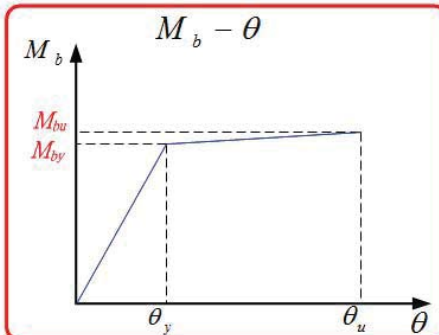
$$\theta = \theta_u$$

$$M_{vu} = V_n(\theta) \times (h - L_p / 2)$$

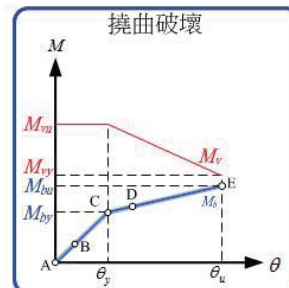
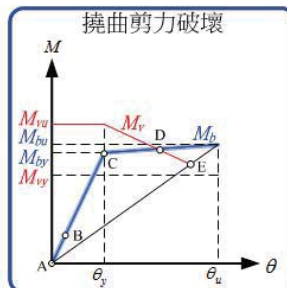
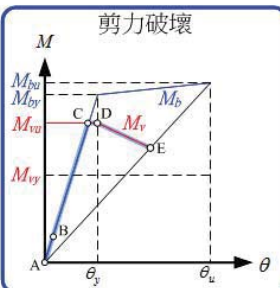
$$\theta_y \leq \theta < \theta_u$$

$$M_v = M_{vy} + (M_{vu} - M_{vy}) \times \frac{R - 1}{R_{\max} - 1}$$

破壞模式

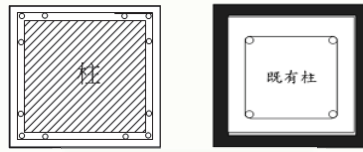


構件破壞模式判定



鋼筋混凝土構件補強理論探討與分析驗證

RC柱包覆補強
非線性行為探討

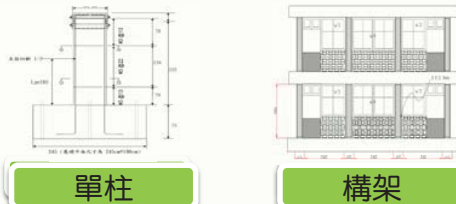


強度、圍束補強

分析方法

- 切片法
- 撓曲分析
- 剪力分析
- 破壞模式

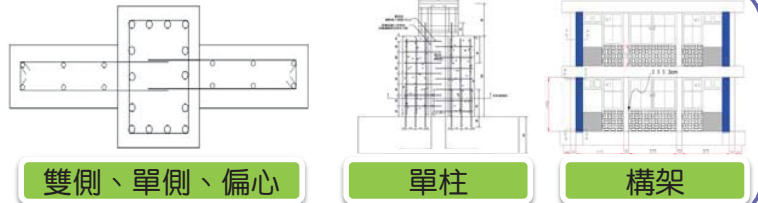
RC柱包覆補強
分析與驗證



單柱

構架

翼牆補強
分析與驗證



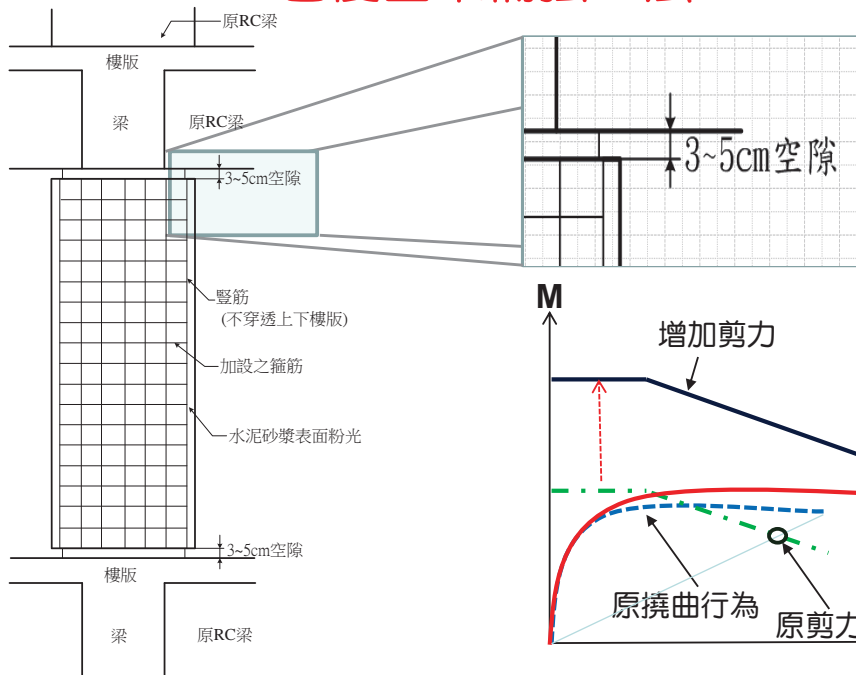
雙側、單側、偏心

單柱

構架

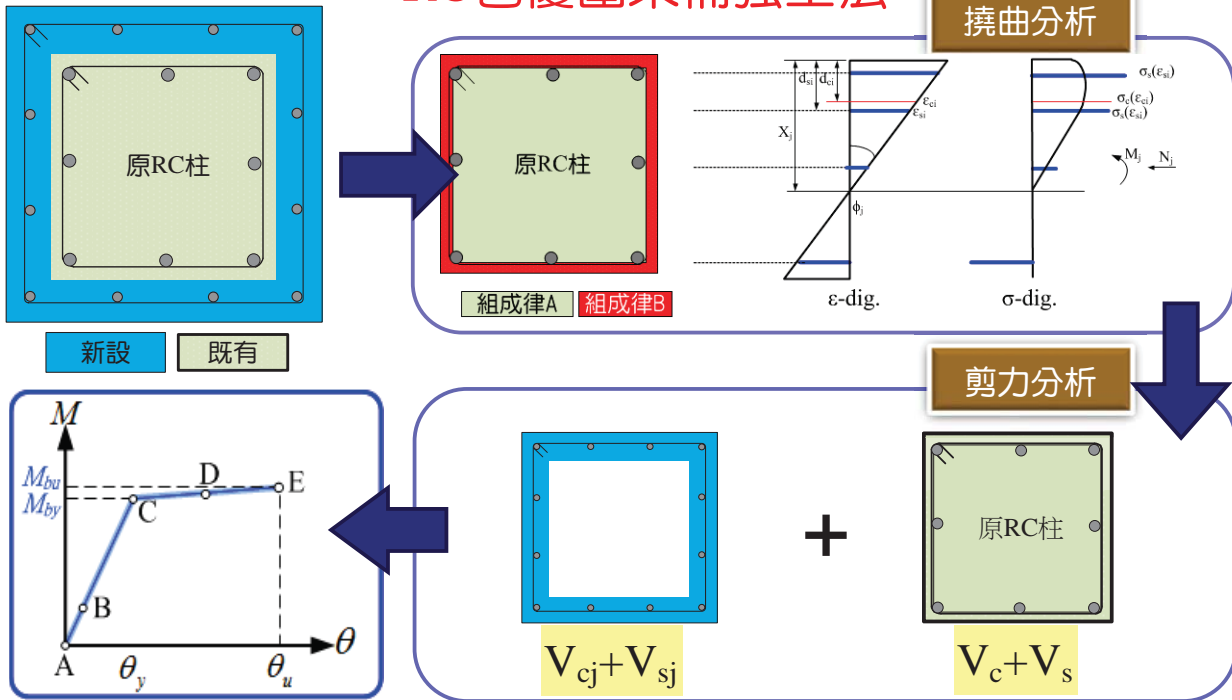
構件補強非線性行為分析方法

RC包覆圍束補強工法



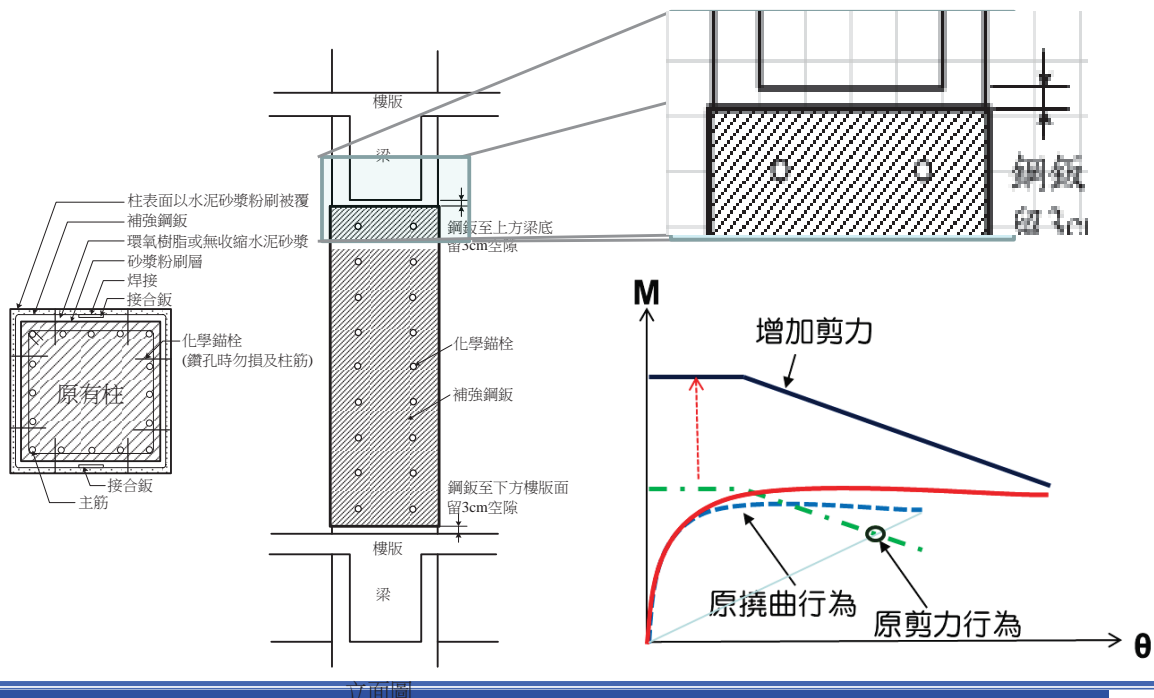
構件補強非線性行為分析方法

RC包覆圍束補強工法



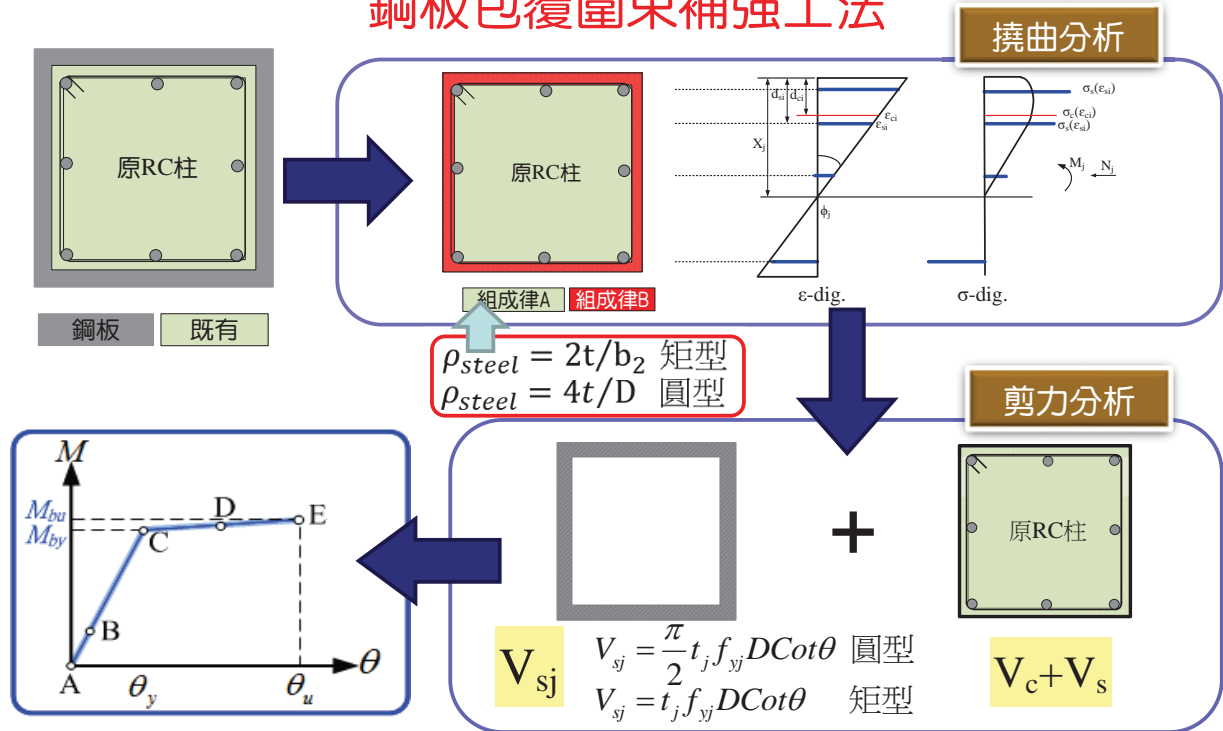
構件補強非線性行為分析方法

鋼板包覆圍束補強工法



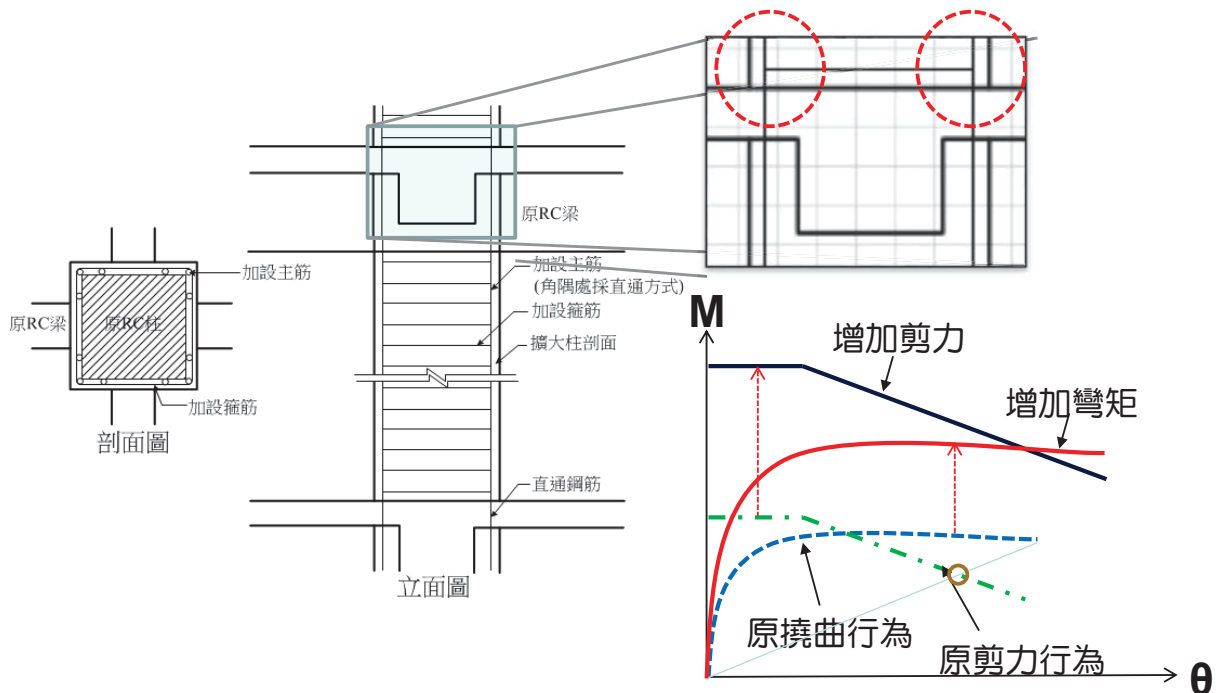
構件補強非線性行為分析方法

鋼板包覆圍束補強工法



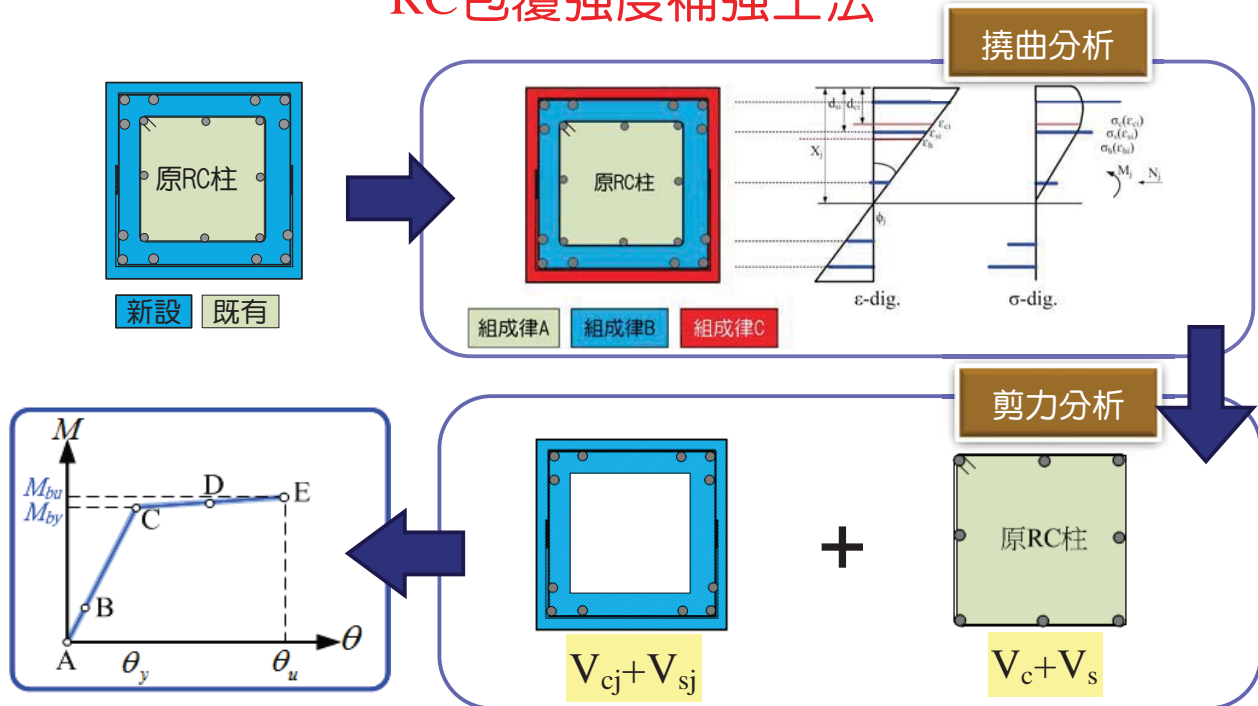
構件補強非線性行為分析方法

RC包覆強度補強工法



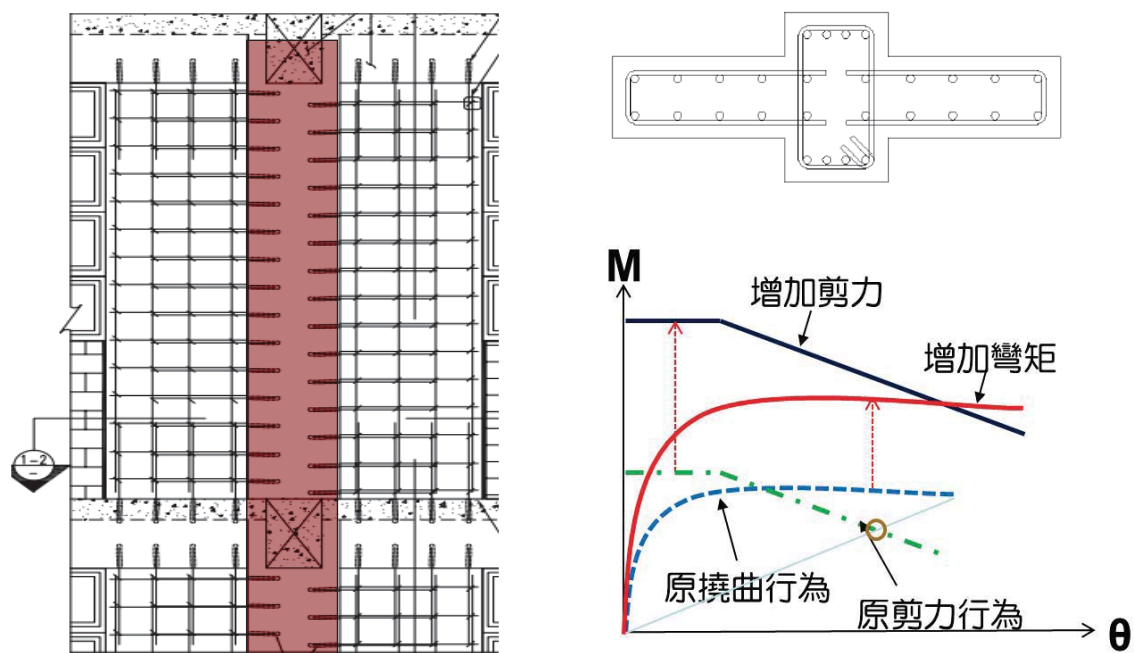
構件補強非線性行為分析方法

RC包覆強度補強工法



構件補強非線性行為分析方法

翼牆補強工法

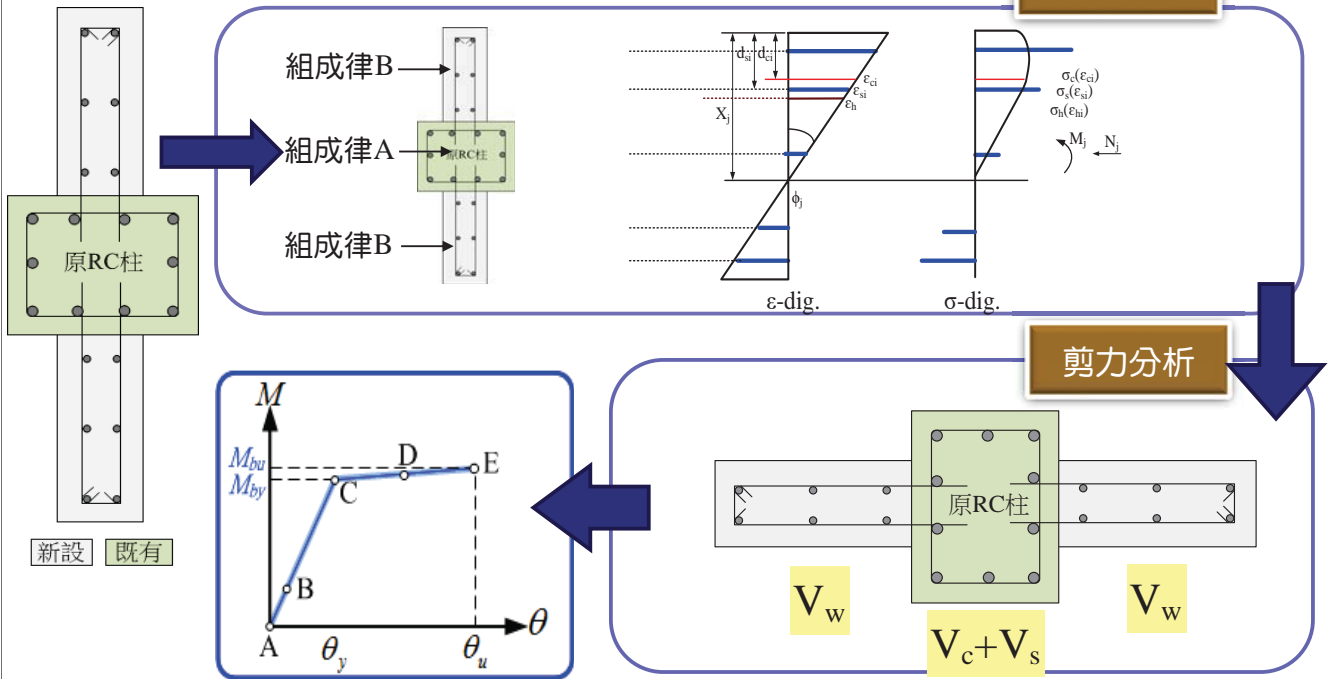


構件補強非線性行為分析方法

翼牆補強工法分析

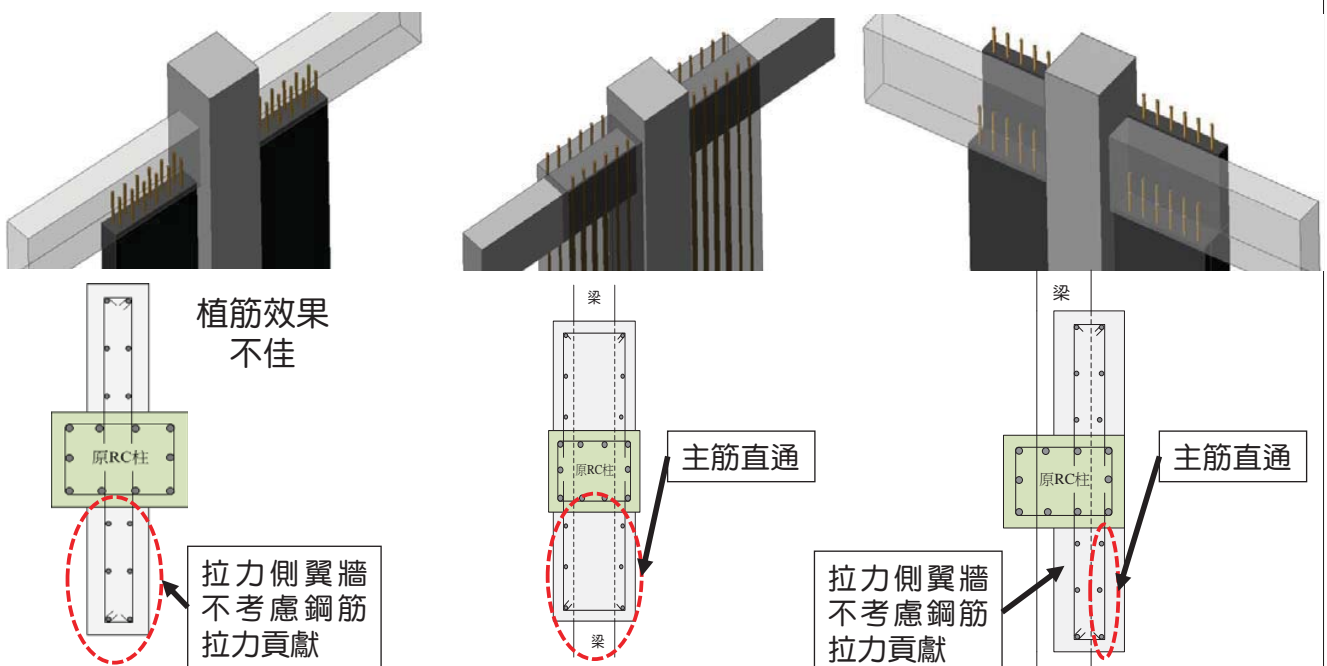
撓曲分析

剪力分析



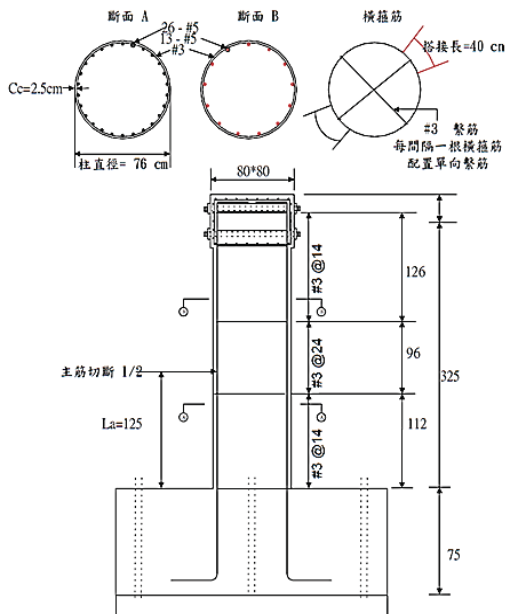
構件補強非線性行為分析方法

翼牆補強工法分析種類



構件補強非線性行為分析驗證

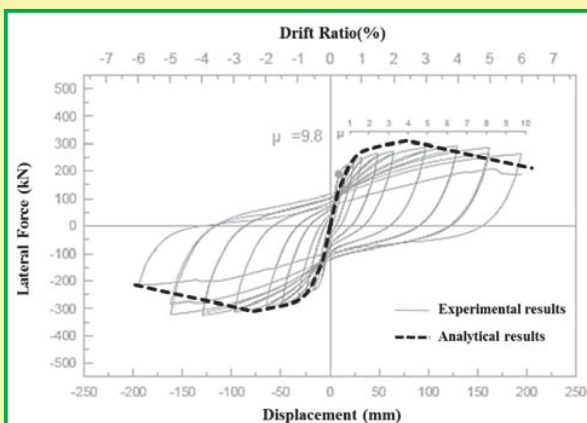
鋼板包覆圍束補強



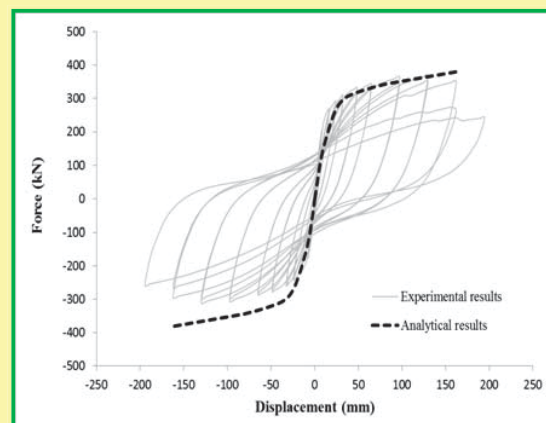
試體SC2(SC1) 配筋示意圖(黃震興, 1999)

| 試體編號 | SC2 | SC3 |
|-----------|---------------------|---------|
| 斷面形狀 | 圓形 | 圓形 |
| 混凝土抗壓強度 | kgf/cm ² | 260 |
| 混凝土保護層 | cm | 2.5 |
| 斷面尺寸(深×寬) | cm | 76 × 76 |
| 柱高 | cm | 325 |
| 主筋降伏強度 | kgf/cm ² | 3500 |
| 主筋配置 | — | 26-#5 |
| 箍筋降伏強度 | kgf/cm ² | 5000 |
| 塑鉸區箍筋間距 | cm | #3@13 |
| 補強鋼板厚度 | cm | 0.3 |
| 柱軸力 | tonf | 143 |

構件補強非線性行為分析驗證



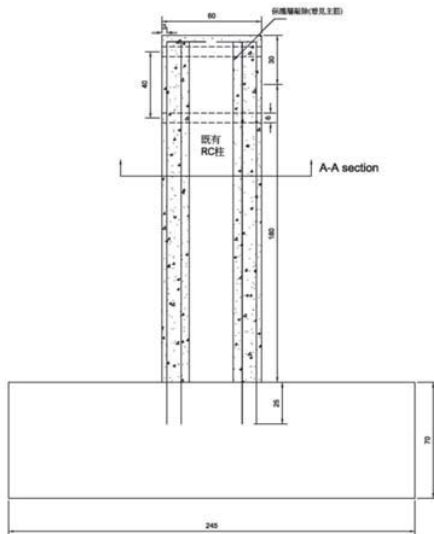
試體編號：SC2



試體編號：SC3

構件補強非線性行為分析驗證

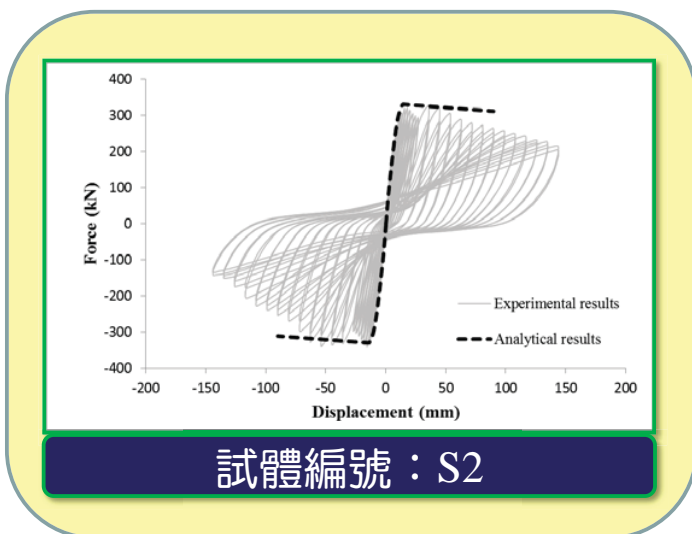
RC包覆強度補強



擴柱補強柱S2之立面圖(張順益, 2010)

| | | |
|-----------|---------------------|---------|
| 試體編號 | S2 | |
| 斷面形狀 | 矩形 | |
| 混凝土抗壓強度 | kgf/cm ² | 175 |
| 混凝土保護層 | cm | 4 |
| 斷面尺寸(深×寬) | cm | 40 × 30 |
| 柱高 | cm | 180 |
| 主筋降伏強度 | kgf/cm ² | 3547 |
| 主筋配置 | - | 14-#5 |
| 箍筋降伏強度 | kgf/cm ² | 4257 |
| 塑鉸區箍筋間距 | cm | #3@25 |

構件補強非線性行為分析驗證

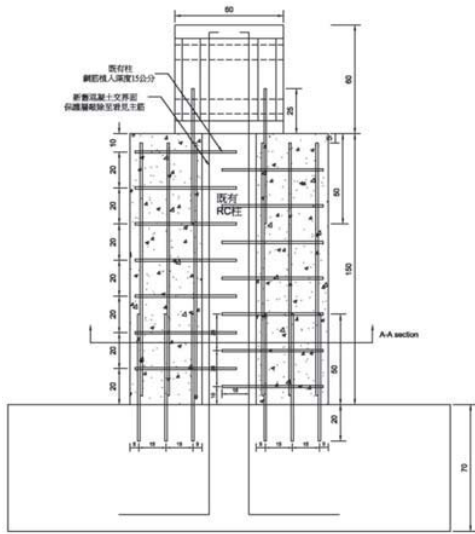


試體編號：S2

| | | |
|------------|---------------------|---------|
| 試體編號(補強資料) | S2 | |
| 斷面形狀 | 矩形 | |
| 補強混凝土厚度 | cm | 15 |
| 補強斷面(深×寬) | cm | 70 × 60 |
| 補強區保護層 | cm | 3 |
| 補強混凝土強度 | kgf/cm ² | 245 |
| 補強主筋配置 | - | 12-#6 |
| 補強箍筋配置 | cm | #3@10 |
| 補強主筋降伏強度 | kgf/cm ² | 4995 |
| 補強箍筋降伏強度 | kgf/cm ² | 4257 |
| RC包覆與基礎間隙 | cm | - |
| 柱軸力 | Tonf | 28 |

構件補強非線性行為分析驗證

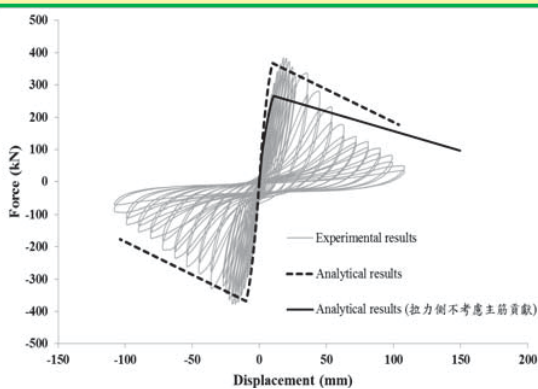
翼牆補強



翼牆補強柱S5之立面圖(張順益, 2010)

| | | |
|-----------|---------------------|---------|
| 試體編號 | S5 | |
| 斷面形狀 | 矩形 | |
| 混凝土抗壓強度 | kgf/cm ² | 175 |
| 混凝土保護層 | cm | 4 |
| 斷面尺寸(深×寬) | cm | 40 × 30 |
| 柱高 | cm | 150 |
| 主筋降伏強度 | kgf/cm ² | 3547 |
| 主筋配置 | - | 14-#5 |
| 箍筋降伏強度 | kgf/cm ² | 4257 |
| 塑鉸區箍筋間距 | cm | #3@25 |

構件補強非線性行為分析驗證

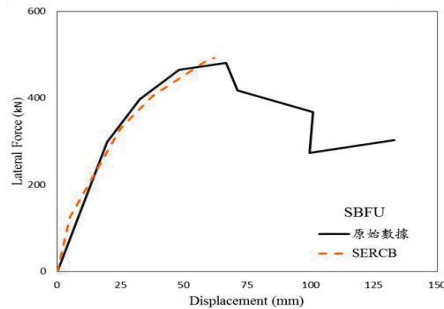
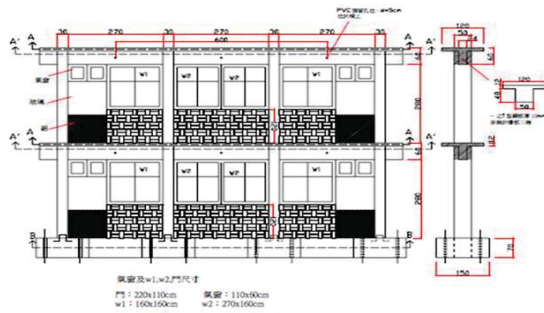


試體編號：S5

| | | |
|------------|---------------------|---------|
| 試體編號(補強資料) | S5 | |
| 斷面形狀 | 矩形 | |
| 翼牆斷面(深×寬) | cm | 18 × 40 |
| 補強區保護層 | cm | 2.7 |
| 補強混凝土強度 | kgf/cm ² | 245 |
| 補強主筋配置 | - | 6-#4 |
| 補強箍筋配置 | cm | #4@20 |
| 補強主筋降伏強度 | kgf/cm ² | 4159 |
| 補強箍筋降伏強度 | kgf/cm ² | 4159 |
| 基礎間隙 | cm | - |
| 柱軸力 | Tonf | 28 |

含磚牆構架試體分析驗證

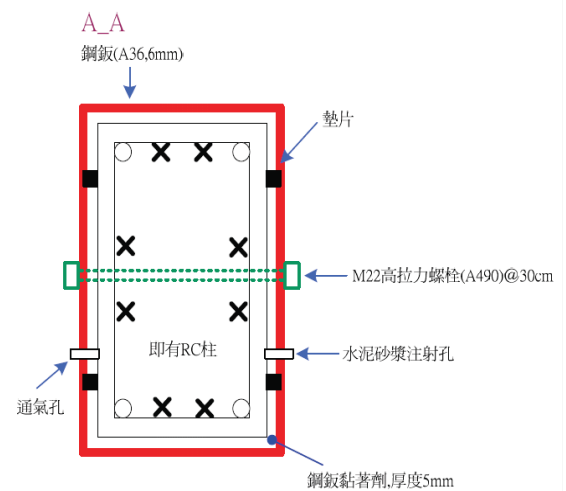
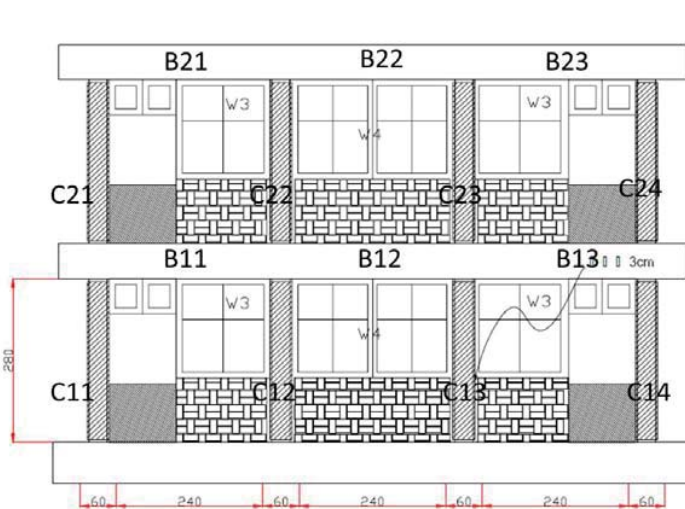
鋼筋混凝土構架-柱鋼板包覆韌性補強(SBFS)



(典型校舍耐震補強設計與驗證, 邱聰智、邱建國、葉勇凱、簡文郁、鐘立來、周德光, 2008)

構件補強非線性行為分析驗證

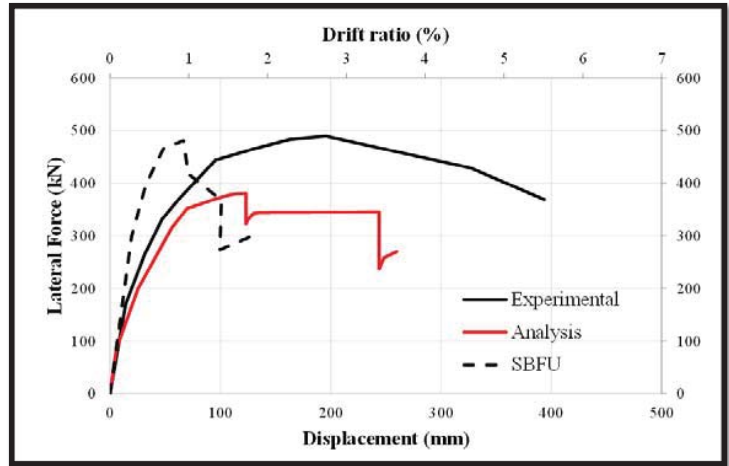
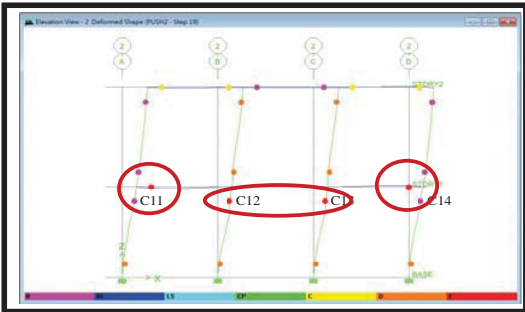
鋼筋混凝土構架-柱鋼板包覆韌性補強(SBFS)



國家地震中心SBFS試體

構件補強非線性行為分析驗證

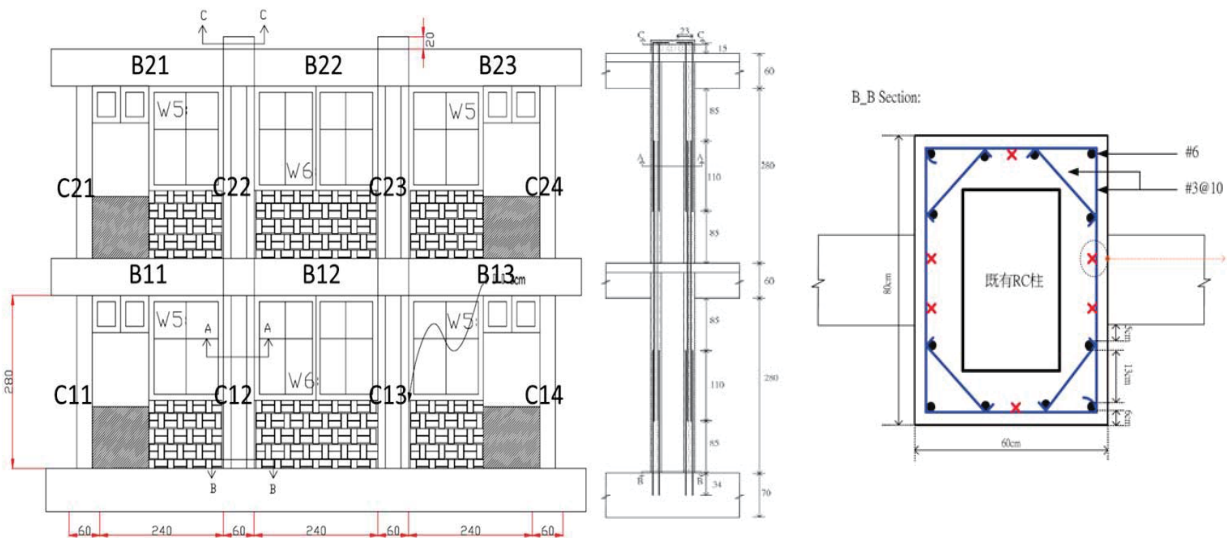
鋼筋混凝土構架-柱鋼板包覆韌性補強(SBFS)



- 結構系統改變
- 高拉力螺栓

構件補強非線性行為分析驗證

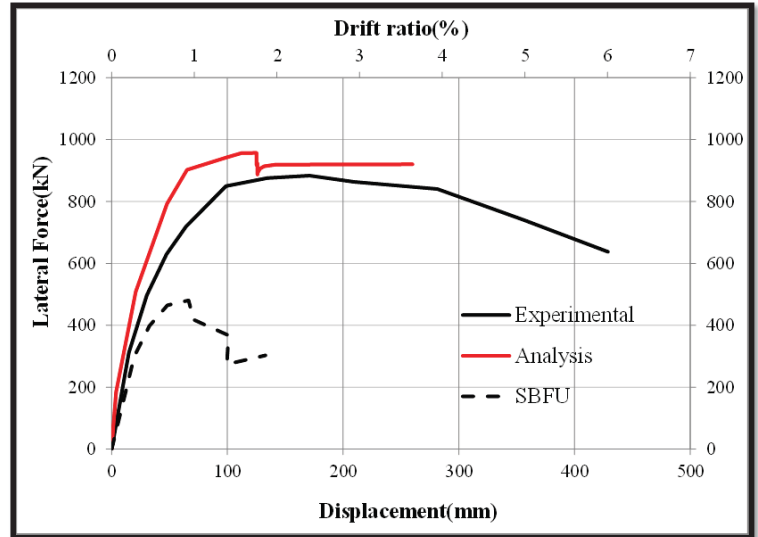
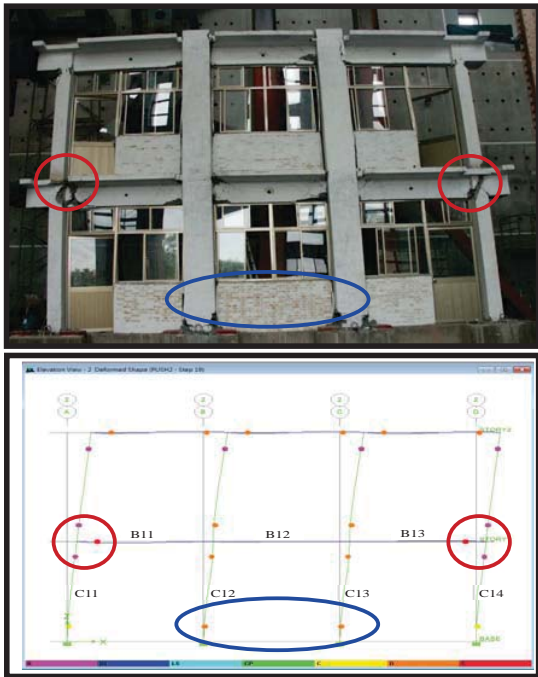
鋼筋混凝土構架- RC包覆強度補強(SBFU-C)



國家地震中心SBFU-C試體

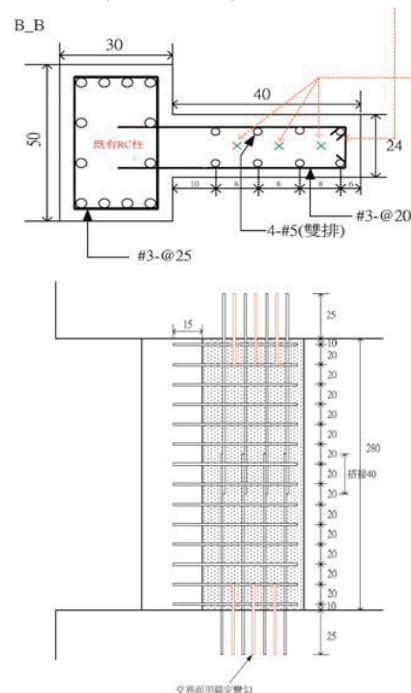
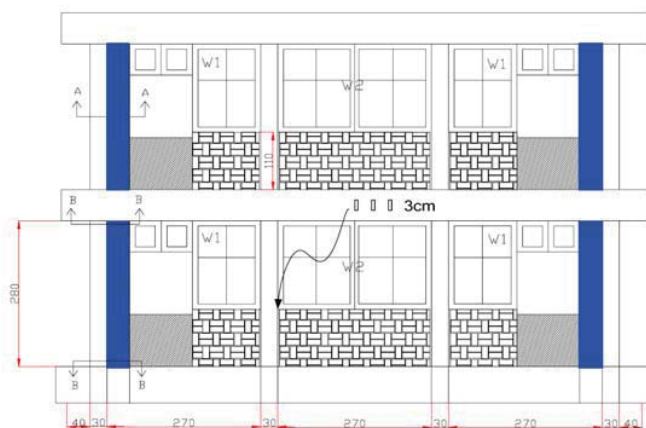
構件補強非線性行為分析驗證

鋼筋混凝土構架- RC包覆強度補強(SBFU-C)



構件補強非線性行為分析驗證

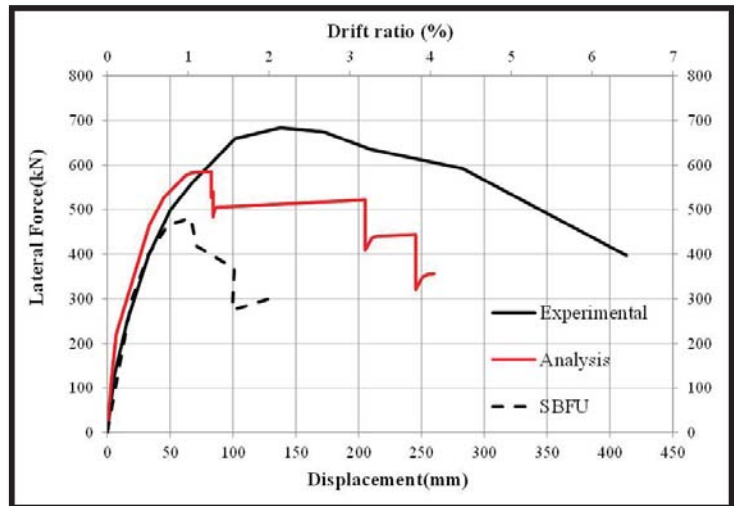
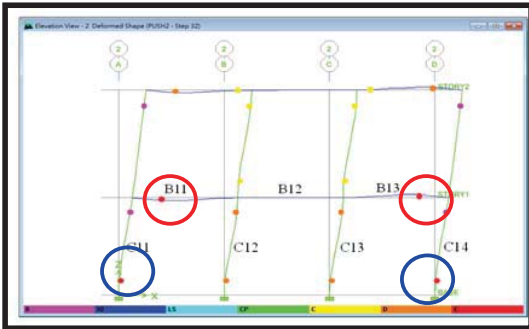
鋼筋混凝土構架-翼牆補強(SBFW)



國家地震中心SBFW試體

構件補強非線性行為分析驗證

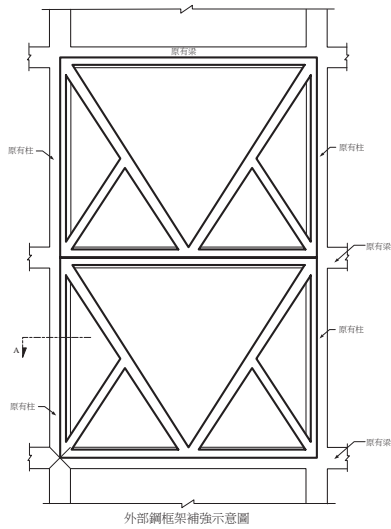
鋼筋混凝土構架-翼牆補強SBFW



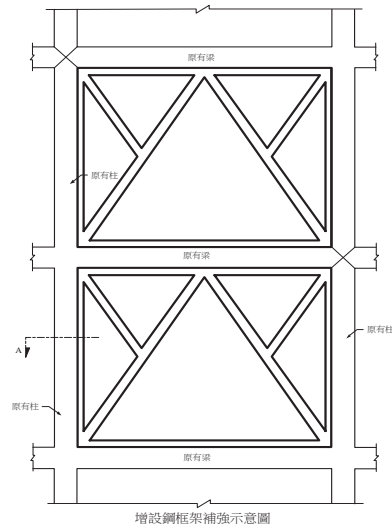
Part IV

鋼斜撐框架補強理論探討 與分析驗證

鋼斜撐框架補強理論探討與分析驗證



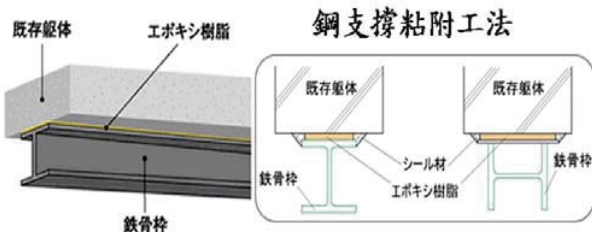
外附式鋼斜撐框架補強



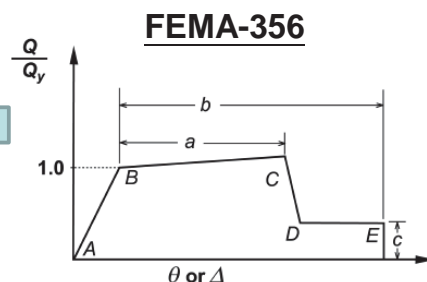
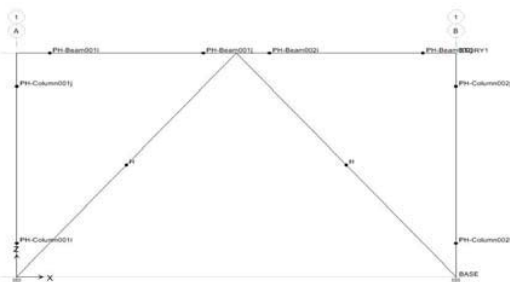
內嵌式鋼斜撐框架補強

鋼斜撐框架補強理論探討與分析驗證

內嵌式-環氧樹脂接合

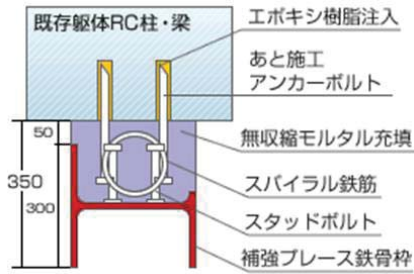


忽略鋼框架
僅考慮鋼斜撐



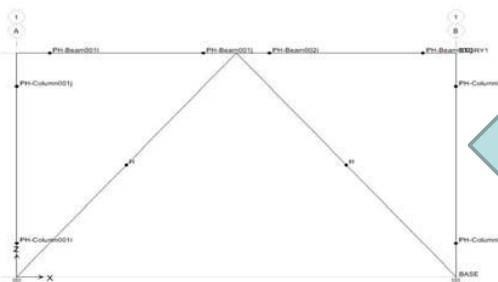
鋼斜撐框架補強理論探討與分析驗證

內嵌式-錨碇接合



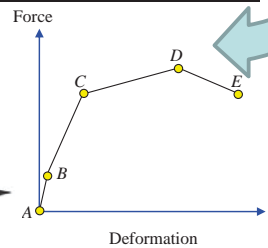
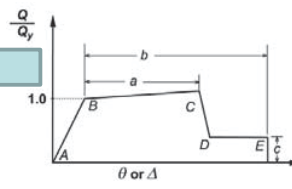
梁、柱以合成断面
進行切面法分析

鋼斜撐-FEMA-356



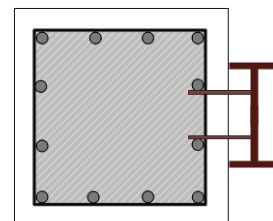
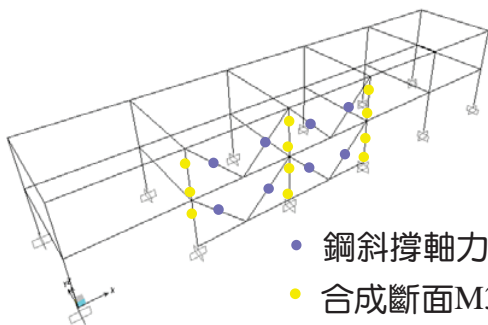
FEMA-356

SERCB-合成断面

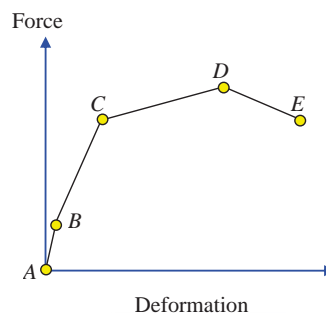


鋼斜撐框架補強理論探討與分析驗證

外附式鋼斜撐框架

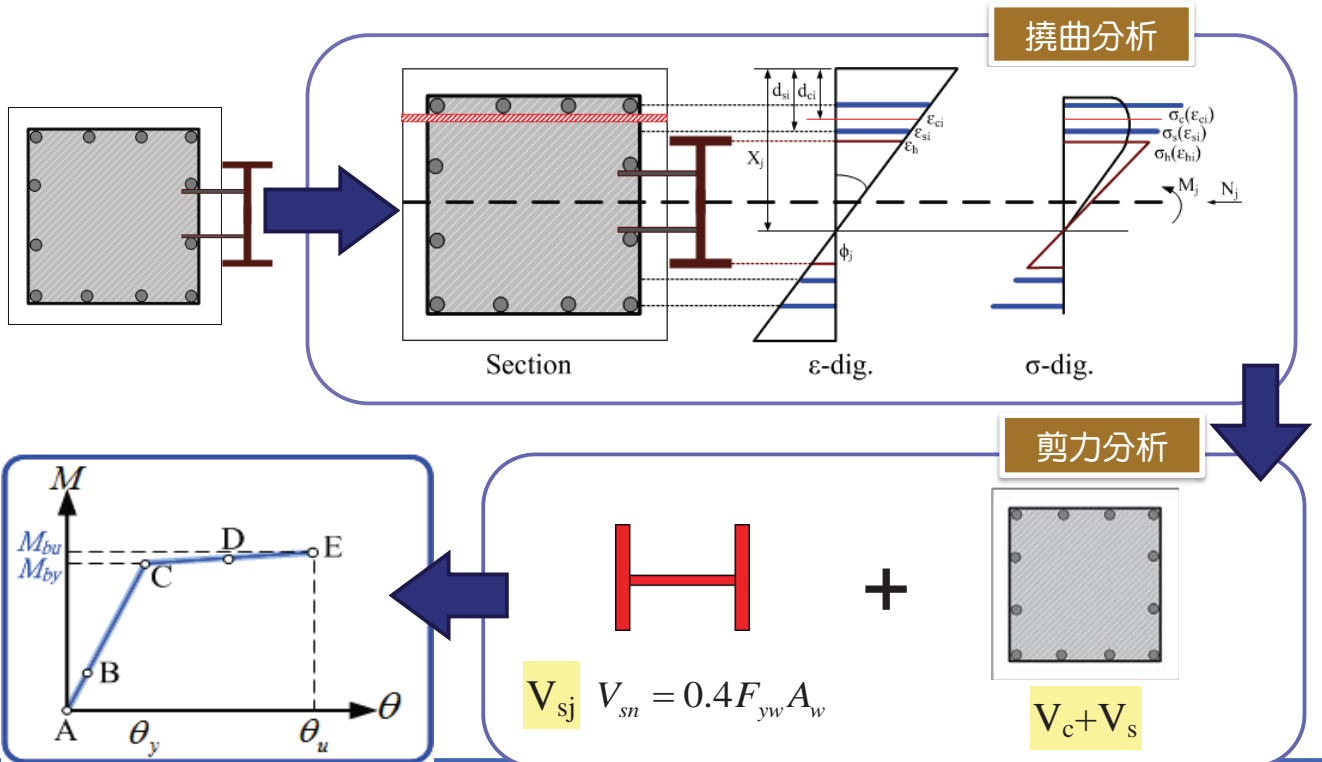


切片法



塑性鉸

合成斷面非線性行為分析



鋼斜撐軸力塑性鉸求取

拉力構件

$$Q_{CE} = T_n = A_g F_y$$

A_g 斜撐斷面積

壓力構件

$$Q_{CE} = P_n = A_g F_{cr}$$

$$\lambda_c \leq 1.5$$

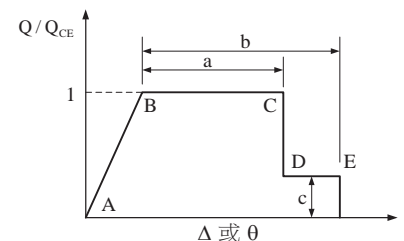
$$F_{cr} = 0.658 \lambda_c^2 F_y$$

$$\lambda_c > 1.5$$

$$F_{cr} = 0.877 F_y / \lambda_c^2$$

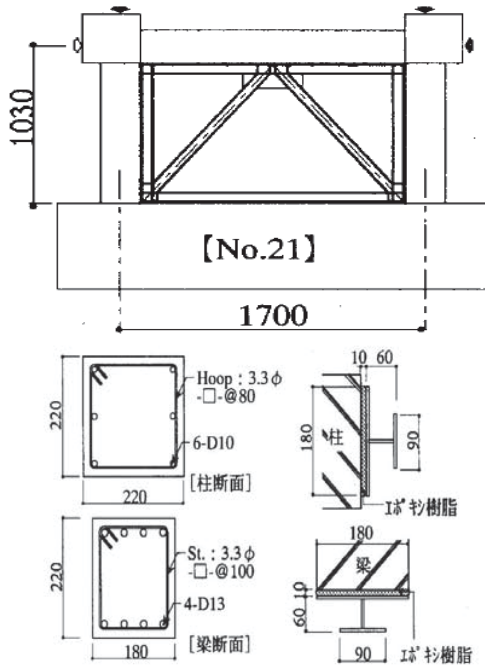
| 桿件 | 模型參數 | | | 可接受標準 | | | | |
|----------------|---------------|--------------|-------|----------------|-------------|-------------|--------------|--------------|
| | 塑性變形 | | 殘餘強度比 | 塑性變形 | | | | |
| | a | b | | IO | 主要桿件 | | 次要桿件 | |
| | | | | | LS | CP | LS | CP |
| 受壓斜撐 (EBF斜撐除外) | | | | | | | | |
| a. 雙角鋼面內挫屈 | $0.5\Delta_c$ | $9\Delta_c$ | 0.2 | $0.25\Delta_c$ | $5\Delta_c$ | $7\Delta_c$ | $7\Delta_c$ | $8\Delta_c$ |
| b. 雙角鋼面外挫屈 | $0.5\Delta_c$ | $8\Delta_c$ | 0.2 | $0.25\Delta_c$ | $4\Delta_c$ | $6\Delta_c$ | $6\Delta_c$ | $7\Delta_c$ |
| c. W或I型 | $0.5\Delta_c$ | $8\Delta_c$ | 0.2 | $0.25\Delta_c$ | $5\Delta_c$ | $7\Delta_c$ | $7\Delta_c$ | $8\Delta_c$ |
| d. 雙槽型鋼面內挫屈 | $0.5\Delta_c$ | $9\Delta_c$ | 0.2 | $0.25\Delta_c$ | $5\Delta_c$ | $7\Delta_c$ | $7\Delta_c$ | $8\Delta_c$ |
| e. 雙槽型鋼面外挫屈 | $0.5\Delta_c$ | $8\Delta_c$ | 0.2 | $0.25\Delta_c$ | $4\Delta_c$ | $6\Delta_c$ | $6\Delta_c$ | $7\Delta_c$ |
| f. 鋼管混凝土 | $0.5\Delta_c$ | $7\Delta_c$ | 0.2 | $0.25\Delta_c$ | $4\Delta_c$ | $6\Delta_c$ | $6\Delta_c$ | $7\Delta_c$ |
| 受拉斜撐 (EBF斜撐除外) | | | | | | | | |
| | $11\Delta_T$ | $14\Delta_T$ | 0.8 | $0.25\Delta_T$ | $7\Delta_T$ | $9\Delta_T$ | $11\Delta_T$ | $13\Delta_T$ |

Δ_c 為挫屈軸向變形， Δ_T 為拉力降伏軸向變形

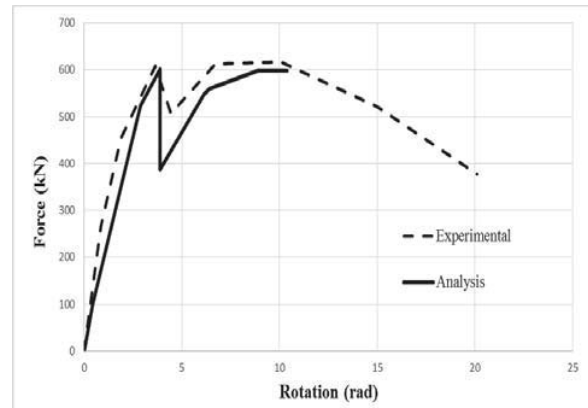


FEMA-356 軸力位移關係圖

内嵌式鋼斜撐框架補強試體分析比對

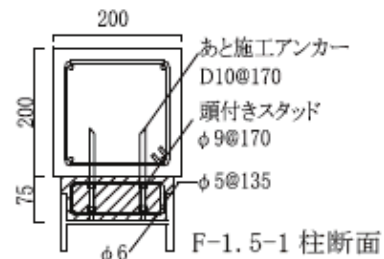
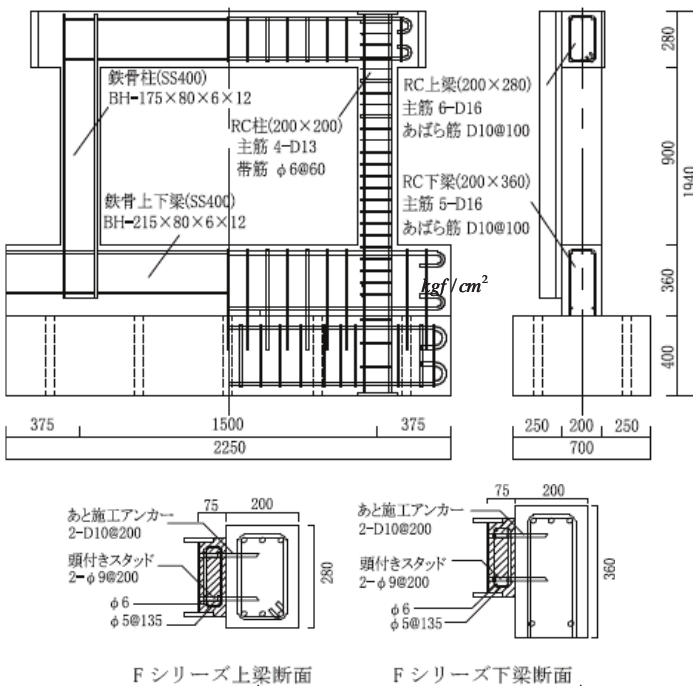


| 試體編號 | | No.21 |
|------------|---------------------|-------|
| 混凝土抗壓強度 | kgf/cm ² | 330 |
| 型鋼降伏應力 | kgf/cm ² | 3180 |
| D10 主筋降伏應力 | kgf/cm ² | 3720 |
| D13 主筋降伏應力 | kgf/cm ² | 3710 |
| 箍筋降伏應力 | kgf/cm ² | 4821 |



大塚真祐，毛井崇博(1999)

外附式鋼框架補強試體分析比對

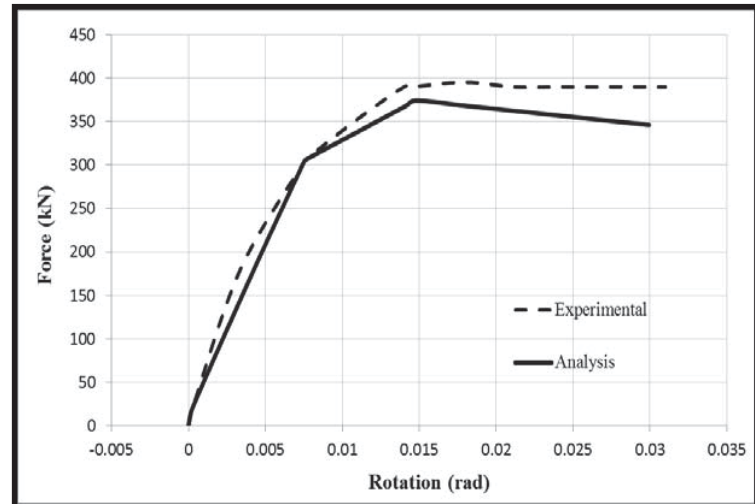
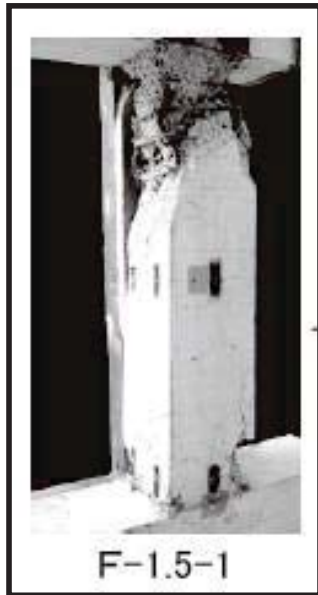


| 試體編號 | | F-1.5-1 |
|------------|---------------------|---------|
| 混凝土抗壓強度 | kgf/cm ² | 277 |
| 型鋼降伏應力 | kgf/cm ² | 3506 |
| D10 主筋降伏應力 | kgf/cm ² | 3792 |
| D13 主筋降伏應力 | kgf/cm ² | 3578 |

(Rieko UEKI, Katsuhiko IMAI)

外附式鋼框架補強試體分析比對

外加鋼框架試體F-1.5-1



Part V

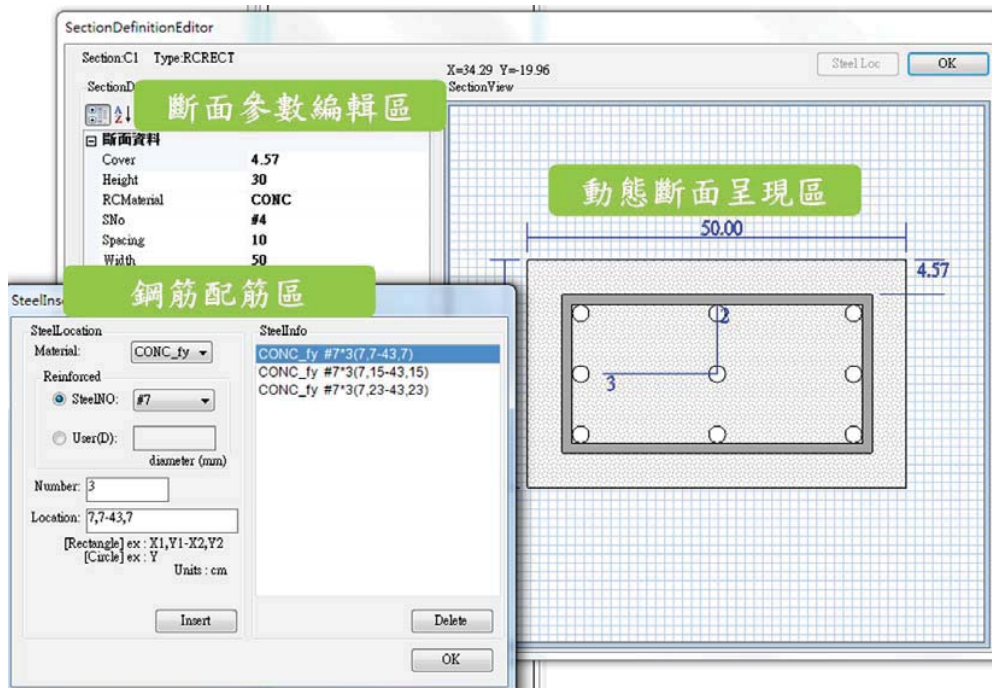
SERCB耐震能力評估系統之補強 分析模組開發

補強模組與視覺化展示功能設計

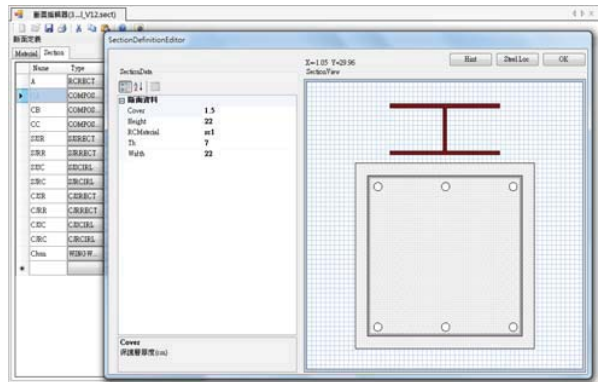
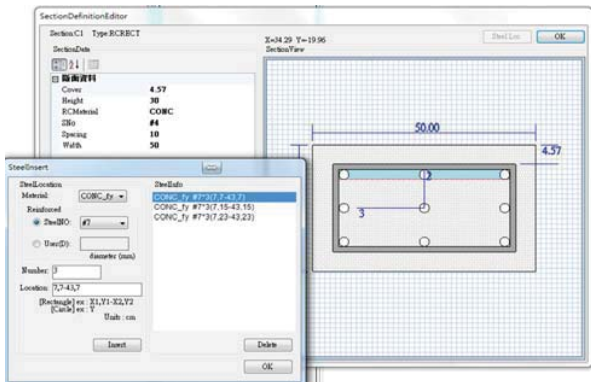
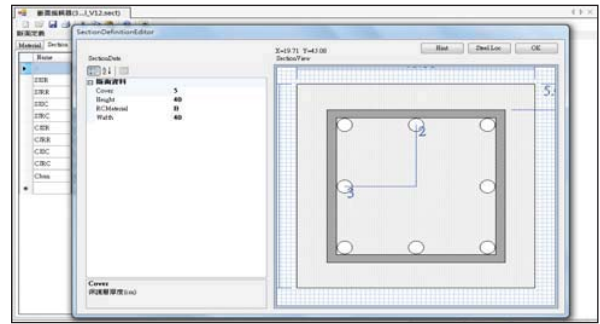
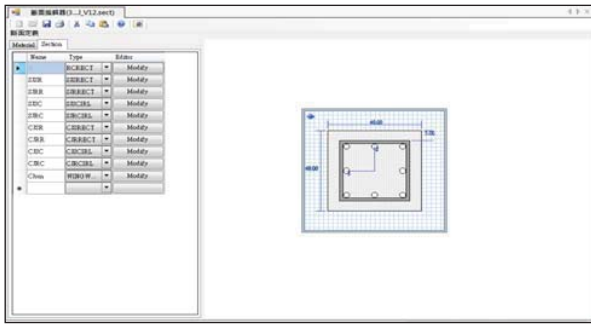
斷面與材料編輯視窗設計



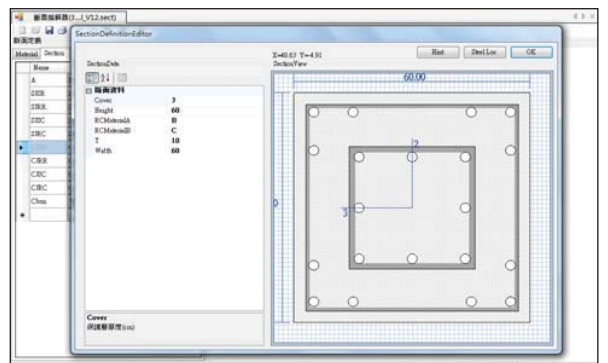
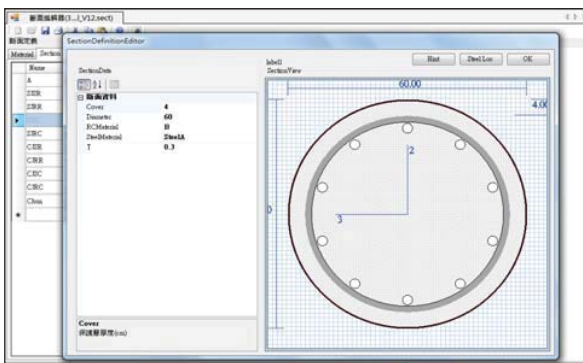
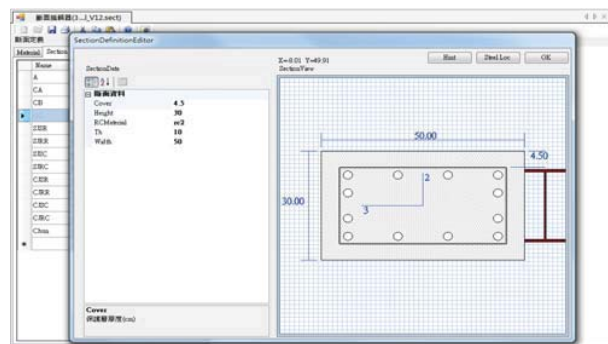
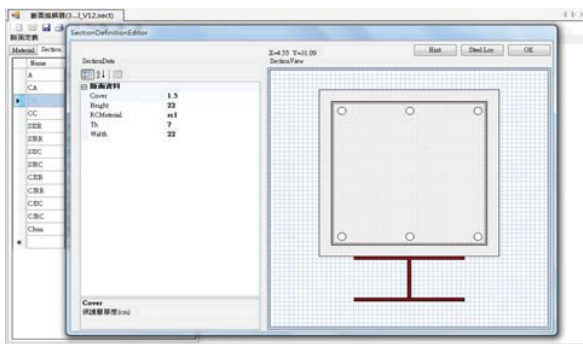
補強模組與視覺化展示功能設計



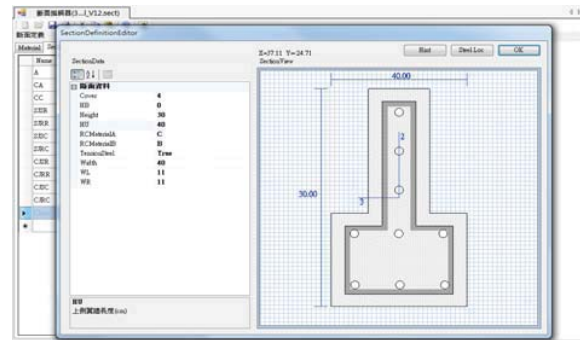
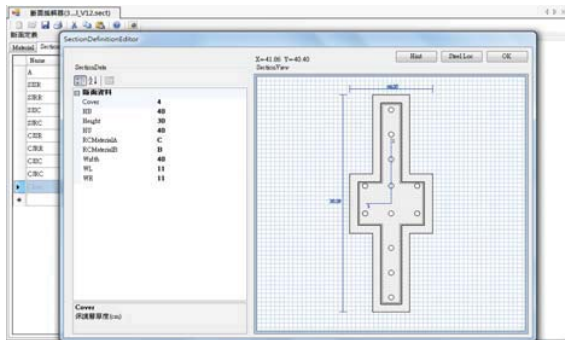
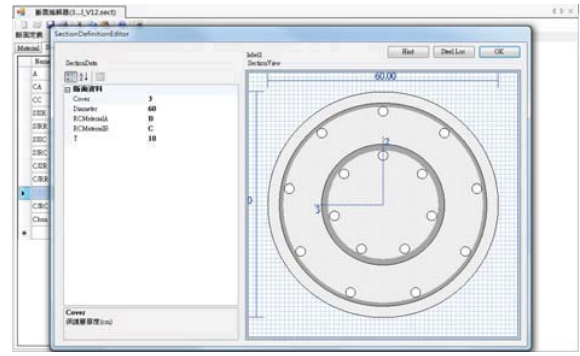
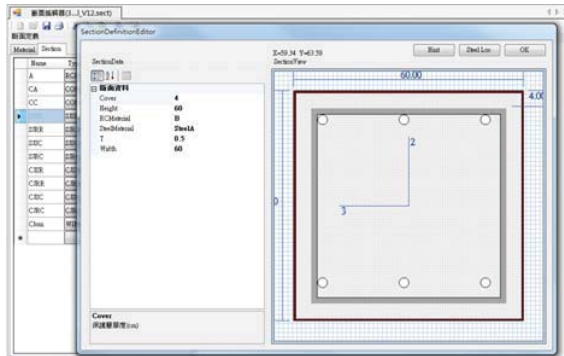
補強模組與視覺化展示功能實作成果



補強模組與視覺化展示功能實作成果



補強模組與視覺化展示功能實作成果



Part VI

補強分析功能操作簡介 (* .SECT, *.MET)

*.SECT說明

單位

\$ Unit
kgf-cm

斷面

\$ RC Rectangle Section Definitions

| \$ Name | RCMaterial | Width | Height | Cover | Angle |
|---------|------------|-------|--------|-------|-------|
| SC3Me | S3RCMe | 50.0 | 50.0 | 5.0 | 0.0 |

\$ End RC Rectangle Section Definitions

主筋
配置

\$ Steels Location

\$ Name Material No. X Y

SC3Me Steel #4*3 (2.6, 2.6-19.4, 2.6)

SC3Me Steel #4*2 (2.6, 11-19.4, 11)

SC3Me Steel #4*3 (2.6, 19.4-19.4, 19.4)

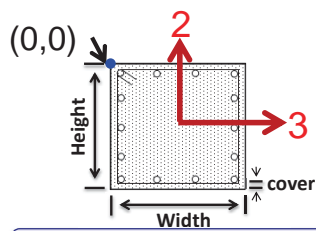
型鋼
配置

\$ H Steel Datas And Locations

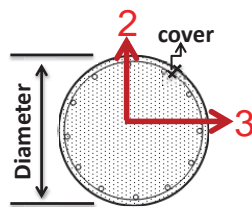
| \$Name | Material | Width | Height | tw | tu | tb | X | Y | Angle |
|--------|----------|-------|--------|-----|-----|-----|------|------|-------|
| SC3Me | SteelC | 15.0 | 20.0 | 1.2 | 0.8 | 0.8 | 47.5 | 20.0 | 0 |

\$ End H Steel Datas And Locations

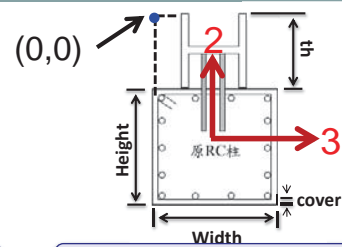
*.SECT說明-斷面清單



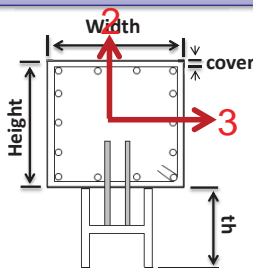
RC Rectangle



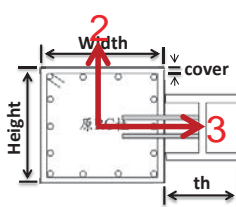
RC Circle



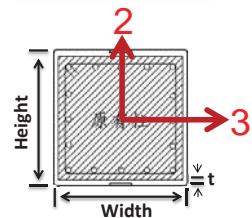
CompositeA



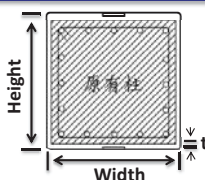
CompositeB



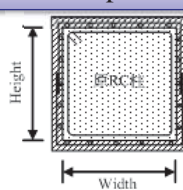
CompositeC



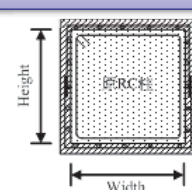
SJS 鋼板包覆強度補強



SJR 鋼板包覆韌性補強

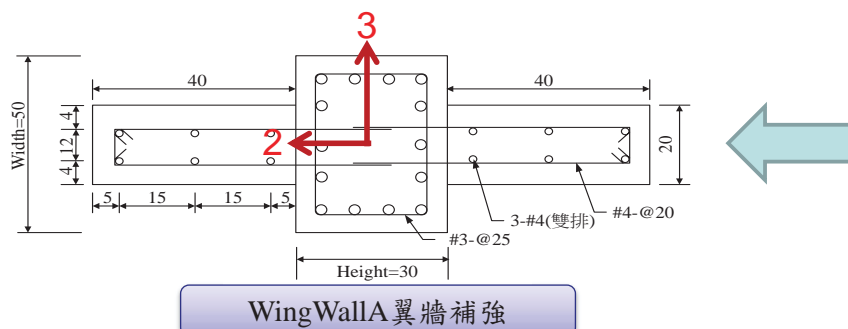


CJS RC 包覆強度補強



CJR RC 包覆韌性補強

*.SECT說明-斷面清單

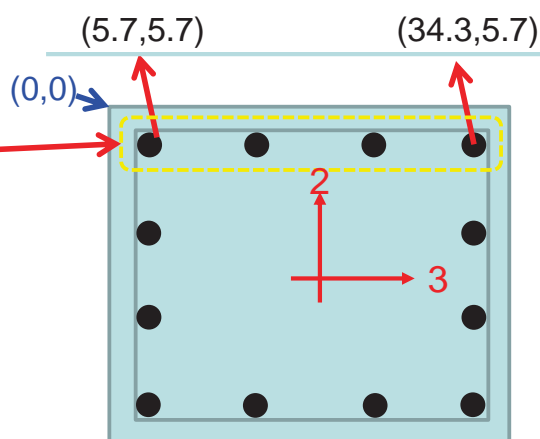


*.SECT說明-主筋及型鋼配置

主筋配置

```

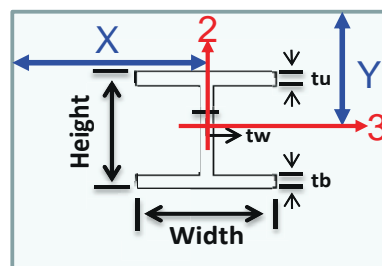
$ Steels Location
$ Name Material No. X Y
Chun Steela D16*4 (5.7, 5.7-34.3, 5.7)
Chun Steela D16*2 (5.7, 12.23-34.3, 12.23)
Chun Steela D16*2 (5.7, 24.76-34.3, 26.76)
Chun Steela D16*4 (5.7, 34.3-34.3, 34.3)
$ End Steels Location
    
```



H型鋼配置

```

$ H Steel Datas And Locations
$Name Material Width Height tw tu tb X Y Angle
SC3Me SteelC 15.0 20.0 1.2 0.8 0.8 47.5 20.0 0
$ End H Steel Datas And Locations
    
```



*.met說明

單位

Kawashima

Mander

Steel

```

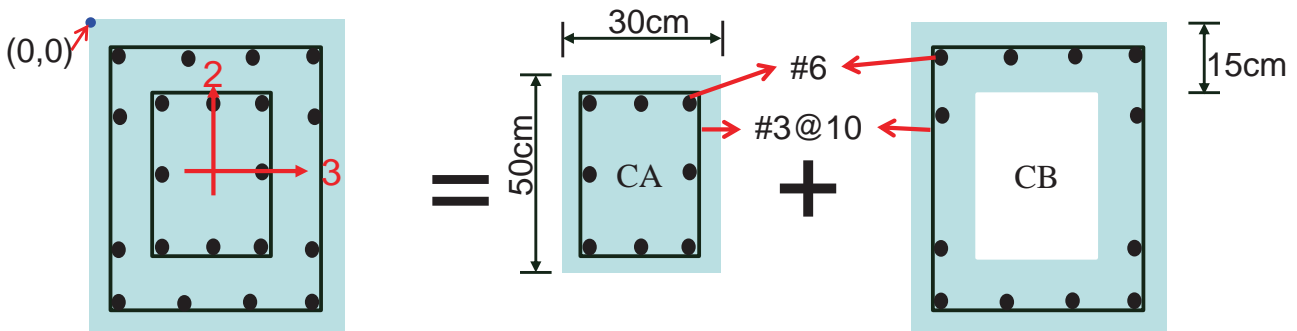
$Unit
KGF-CM

$ Kawashima constitutive law
$ Name Fc Fsy Av EL(2) EL(3)
$      (kgf/cm^2) (kgf/cm^2) (cm^2) (cm) (cm)
$ End Kawashima constitutive law

$ Mander constitutive law
$ Name Fc Fsy Av N2 N3
$      (kgf/cm^2) (kgf/cm^2) (cm^2)
Ma 210.00 4200.00 1.42 4.00 4.00
Mb 210.00 2800.00 2.53 4.00 4.00
$ End Mander constitutive law

$ Steel stress strain
$ Name YieldingStress Es
$      (kgf/cm^2) (kgf/cm^2)
SteelA 4200.00 2040000.00
SteelB 4200.00 2040000.00
End steel stress strain
    
```

RC包覆強度補強斷面輸入範例



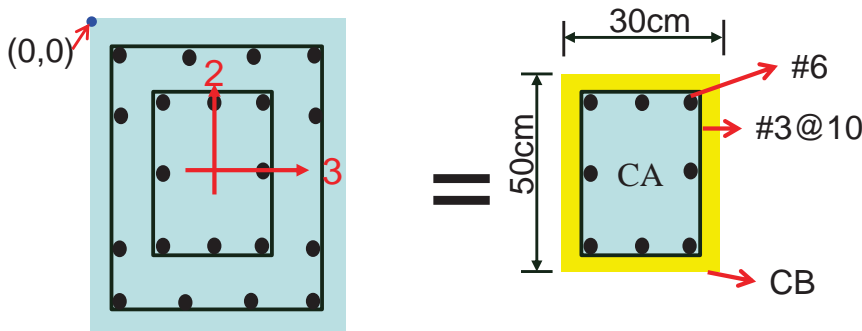
```

$ CJS Retrofit Rectangle Section Definitions
$ Name RCMaterialA RCMaterialB Width Height Cover t Angle
C11 CA CB 30.0 50.0 4.0 15.0 0
$ End CJS Retrofit Rectangle Section Definitions
    
```

```

$ Mander constitutive law
$Name Fc Fsy SNo Av Spacing N2 N3
CA 175.0 2800.0 #3 1.42 20.0 2 2
CB 245.0 2800.0 #3 1.42 20.0 2 2
$ End Mander constitutive law
    
```

RC包覆圍束補強斷面輸入範例



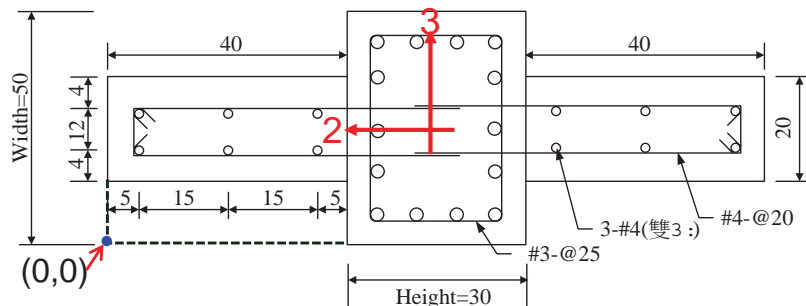
```

$ CJS Retrofit Rectangle Section Definitions
$ Name RCMaterialA RCMaterialB Width Height Cover t Angle
C11 CA CB 30.0 50.0 4.0 15.0 0
$ End CJS Retrofit Rectangle Section Definitions
    
```

```

$ Mander constitutive law
$Name Fc Fsy SNo Av Spacing N2 N3
CA 175.0 2800.0 #3 1.42 20.0 2 2
CB 245.0 2800.0 #3 1.42 20.0 2 2
$ End Mander constitutive law
    
```

翼牆補強斷面輸入範例



```

$ WingWall A Section Definitons
$ Name RCMaterialA RCMaterialB Width Height Cover WL WR HU HB TSteel Angle
Chun CA CB 50 30 4 15 15 40 40 True 0
$ End WingWall A Section Definitions
    
```

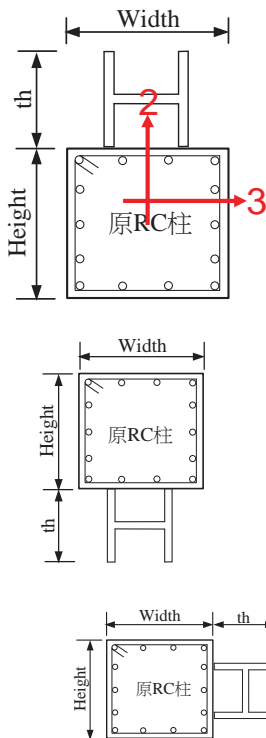
```

$ Steels Location
$ Name Material No. X Y
Chun SteelB D13*2 (16.6, 5.65-23.4, 5.65)
Chun SteelB D13*2 (16.6, 20.6-23.4, 20.6)
Chun SteelB D13*2 (16.6, 35.6-23.4, 35.6)
Chun SteelB D13*2 (16.6, 74.4-23.4, 74.4)
Chun SteelB D13*2 (16.8, 89.4-23.4, 89.4)
Chun SteelB D13*2 (16.6, 104.4-23.4, 104.4)
Chun SteelA D16*5 (5.7, 45.8-34.3, 45.8)
Chun SteelA D16*2 (5.7, 51.9-34.3, 51.9)
Chun SteelA D16*2 (5.7, 58.1-34.3, 58.1)
Chun SteelA D16*5 (5.7, 64.2-34.3, 64.2)
$ End Steels Location

$ Mander constitutive law
$Name Fc Fsy SNo Av Spacing N2 N3
CA 175.0 2800.0 #3 1.42 20.0 2 2
CB 245.0 2800.0 #4 2.53 20.0 2 2
$ End Mander constitutive law

$ Steel stress strain
$Name Fy Es
SteelA 3500 2040000
SteelB 4200 2040000
End steel stress strain
    
```


合成斷面輸入範例



*.sect

```

$ Composite A Section Definitions
$ Name RCMaterial Width Height Cover th Angle
CA Ca 40.0 40.0 4.0 15 0
$ End Composite A Section Definitions
    
```

```

$ H Steel Datas And Locations
$Name Material Width Height tw tu tb X Y Angle
CA SteelC 15.0 20.0 1.2 0.8 0.8 47.5 20.0 90
$ End H Steel Datas And Locations
    
```

*.met

```

$ Mander constitutive law
$Name Fc Fsy SNo Av Spacing N2 N3
Ca 175.0 2800.0 #3 1.42 20.0 2 2
$ End Mander constitutive law
    
```

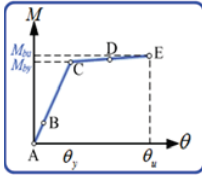
```

$ Steel stress strain
$Name Fy Es
SteelA 4200 2040000
SteelC 3500 2040000
End steel stress strain
    
```

Part VII

結論

結論

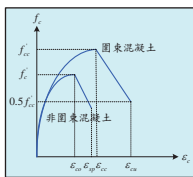


本研究建立補強後構件非線性行為的分析方法，並擴充於SERCBWin2013中，以作為工程師補強分析的工具，提升國內補強分析之效率及精確性。

目前針對各補強工法所完成之分析斷面型式共計10餘種，且提供使用者於補強分析時有更簡便的輸入視窗介面。



結論



提供Kawashima及Mander兩種混凝土組成律；在鋼筋部份，提供**完全彈塑性**之組成律，但在同一斷面如有不同強度之鋼筋，則可定義不同組成律參數。



現場進行翼牆補強施工時，**植筋效果不容易掌控**，因此建議工程師在分析時可保守的**忽略拉力側翼牆主筋貢獻**，而目前程式也提供此選項的分析功能。

報告完畢
敬請指教
