採托梁支承之字型配置挫屈束制支撐之新建RC構架設計、試驗與抗震性能

Speaker:

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簡報大綱

- 背景介紹
- 鋼筋混凝土構架設計
- 挫屈束制支撐與RC構架交界接頭設計
  - 接合板
  - U型鐵件
  - 托梁
- 施工流程
- 子結構試驗
- 非線性動力歷時分析
- 結論

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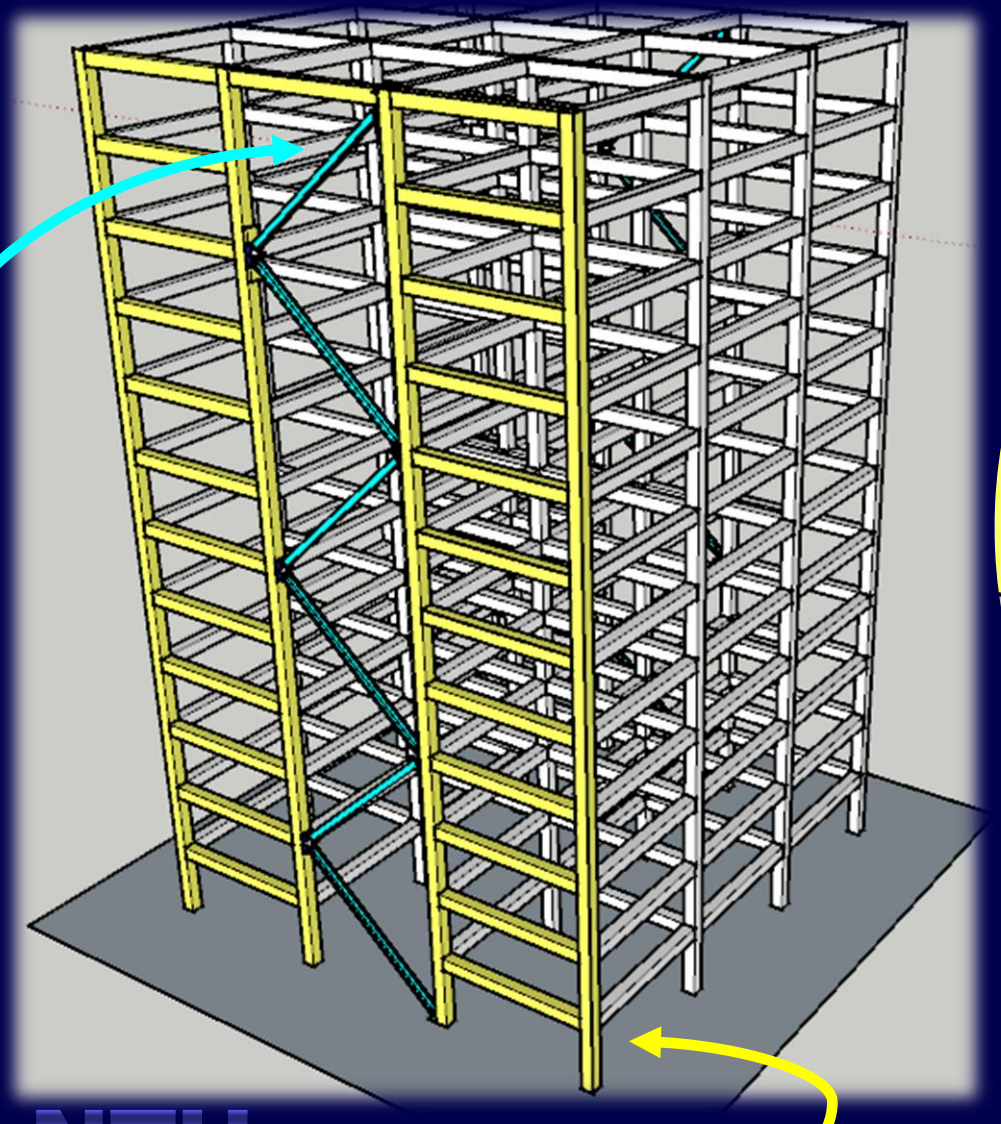
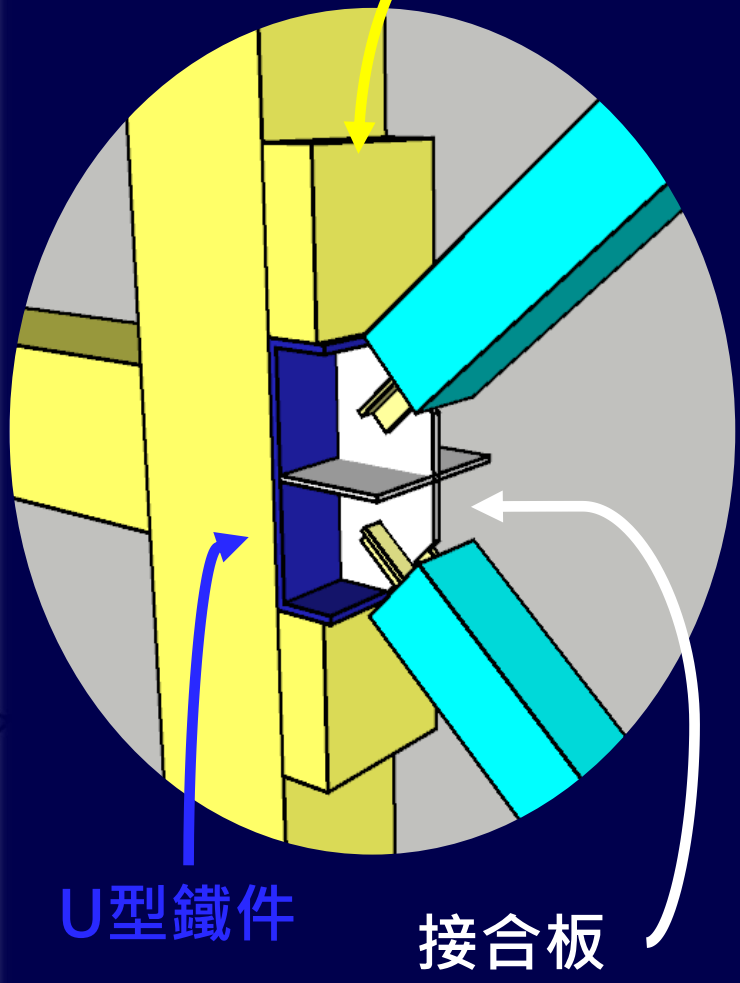
飛梁

BRB安裝於RC構架





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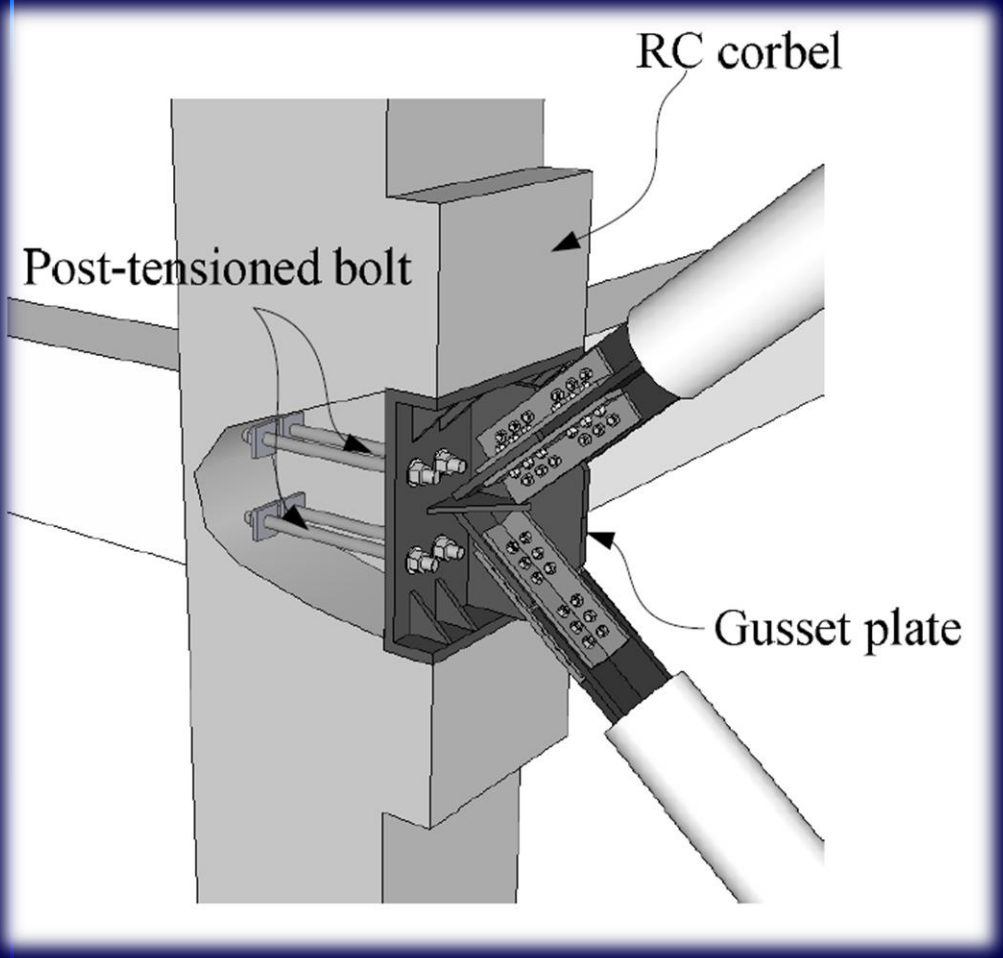
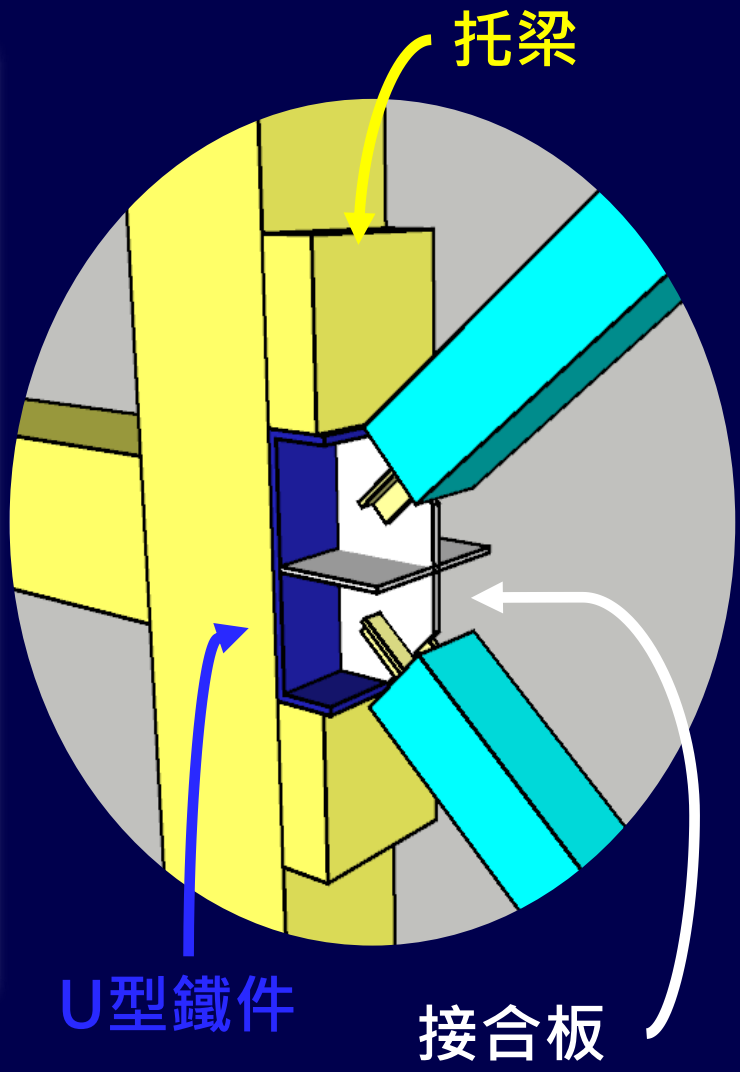
BRB與RC構架轉接接頭



Qu,Z, et al. (2013). Subassemblage cyclic loading test of RC frame with brbs in zigzag configuration



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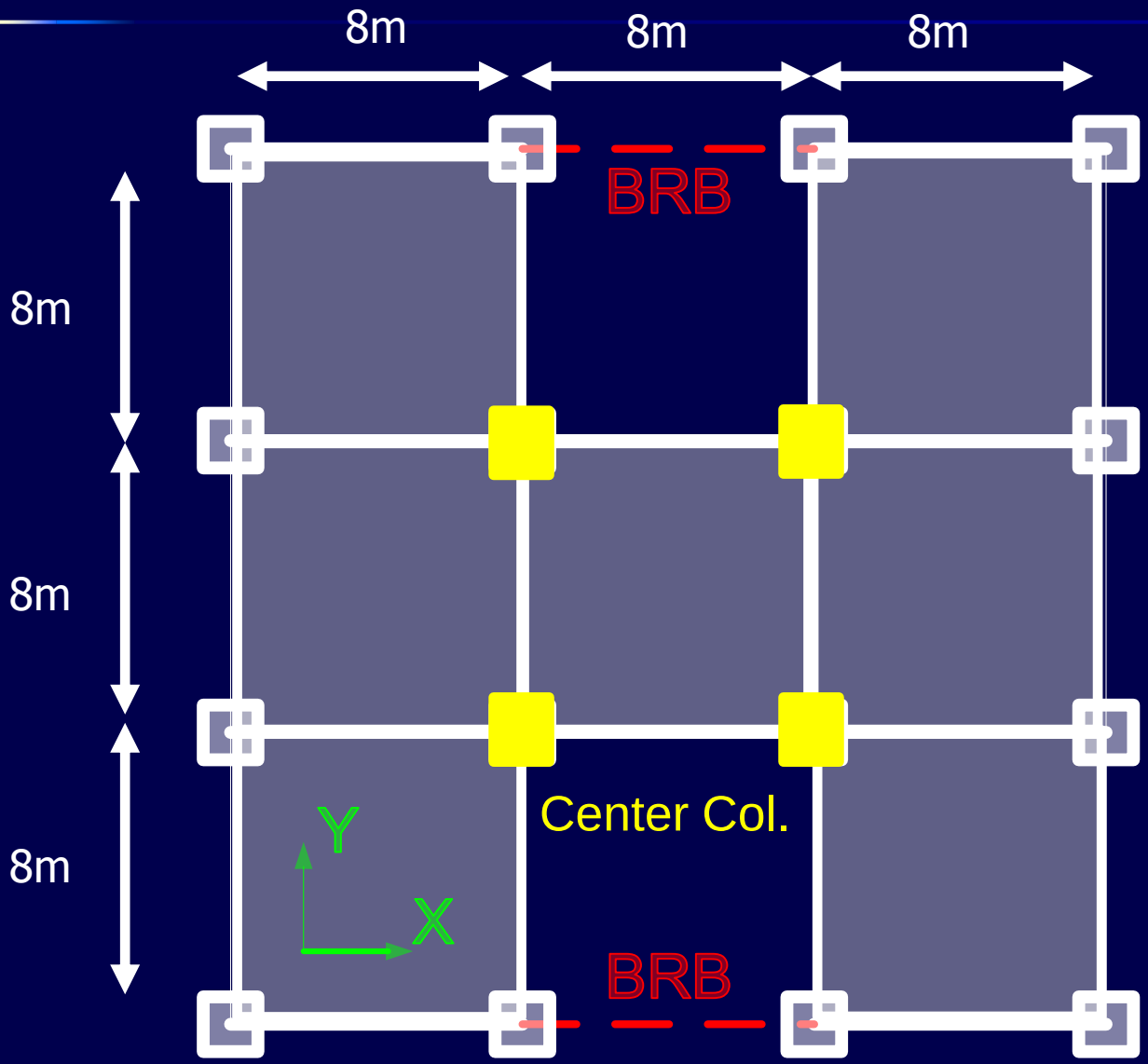
平面圖

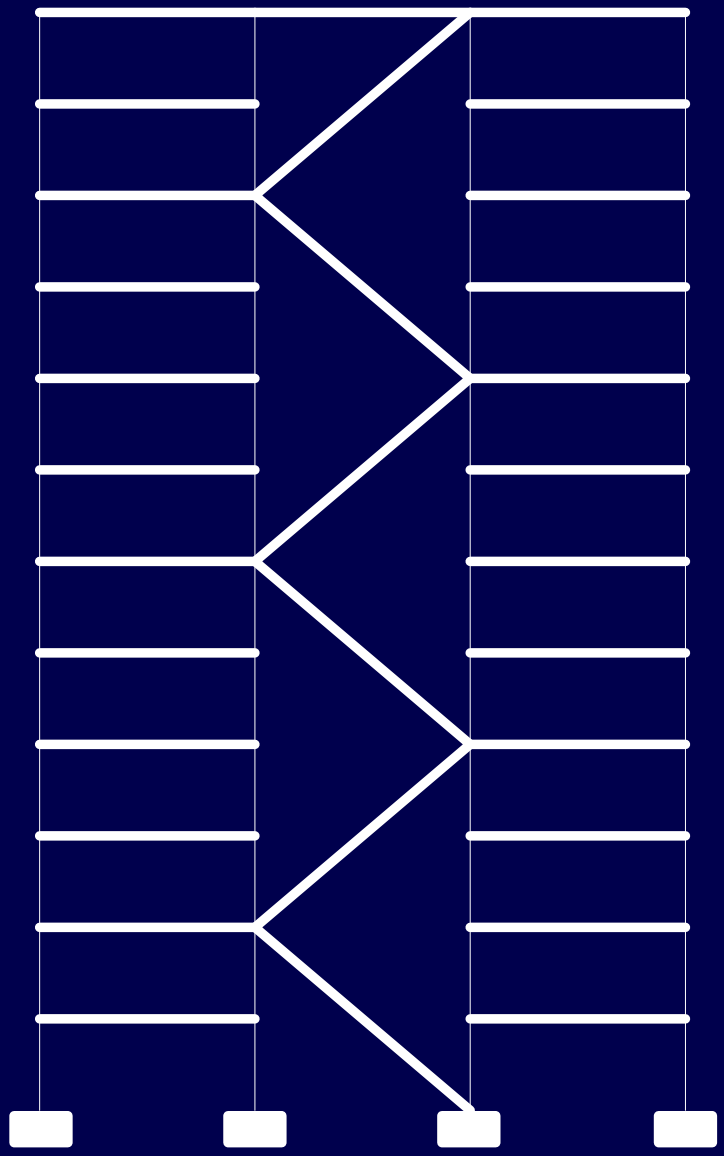


$LL = 0.3(\text{tf/ m}^2)$

$\text{SDL} = 0.35(\text{tf/ m}^2)$

Ave. weight: 1.2 tf/m²

立面圖



Z

X

$T_1 = 1.37\,\text{sec}$ (Y)

$T_2 = 1.28\,\text{sec}$ (X)

樓高: 3.4m

工址資訊

- 嘉義: $I = 1.25$ $R = 4.0$

$$S_S^D = 0.8 \quad S_1^D = 0.45 \quad F_a = 1.0$$

$$S_S^M = 1.0 \quad S_1^M = 0.55 \quad F_v = 1.0$$

$$T_{code} = 0.05H^{0.75}$$

$$T = \min\left\{1.4T_{code}, T_{SAP}\right\}$$

$$V_D = \max\left\{\begin{matrix} V = 0.1185W \\ V^* = 0.1185W \\ V_M = 0.1086W \end{matrix}\right\} = 0.1185W$$

設計結果 (BRB-RCF)

樓層	梁	柱 鋼筋比	中心柱	BRB (P_y)	DCR
12F	B40x60	C60x60 2.25%	C60x60 2.25%	30 tf	0.90
11F					
10F				120 tf	1.00
9F					
8F	B50x70	C80x80 2.54%	C80x80 2.54%	133 tf	0.86
7F					
6F				212 tf	0.92
5F					
4F				332 tf	0.90
3F					
2F		C90x90 2.81%	C100x100 2.60%	212 tf	0.81
1F					

Unit: cm

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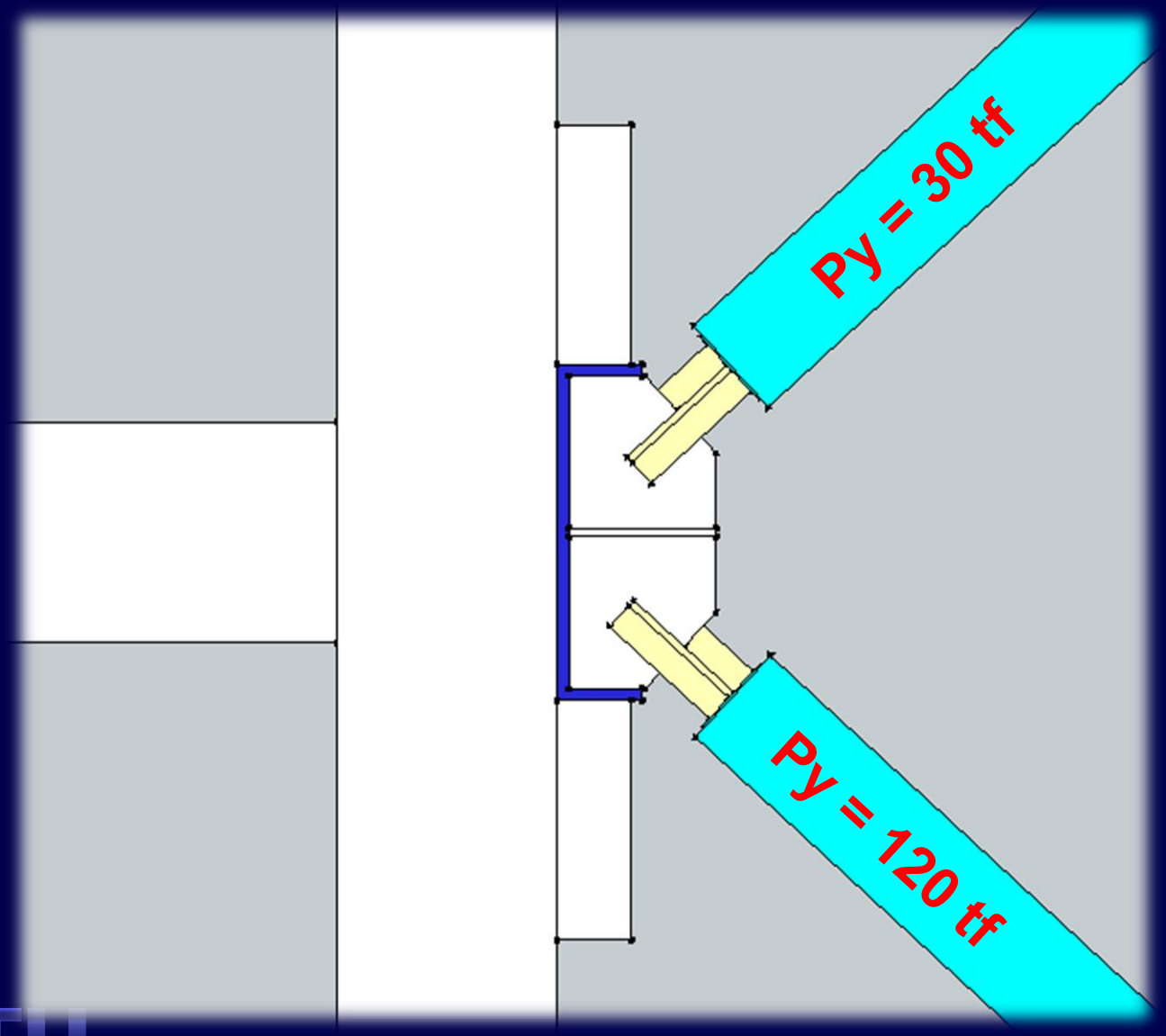
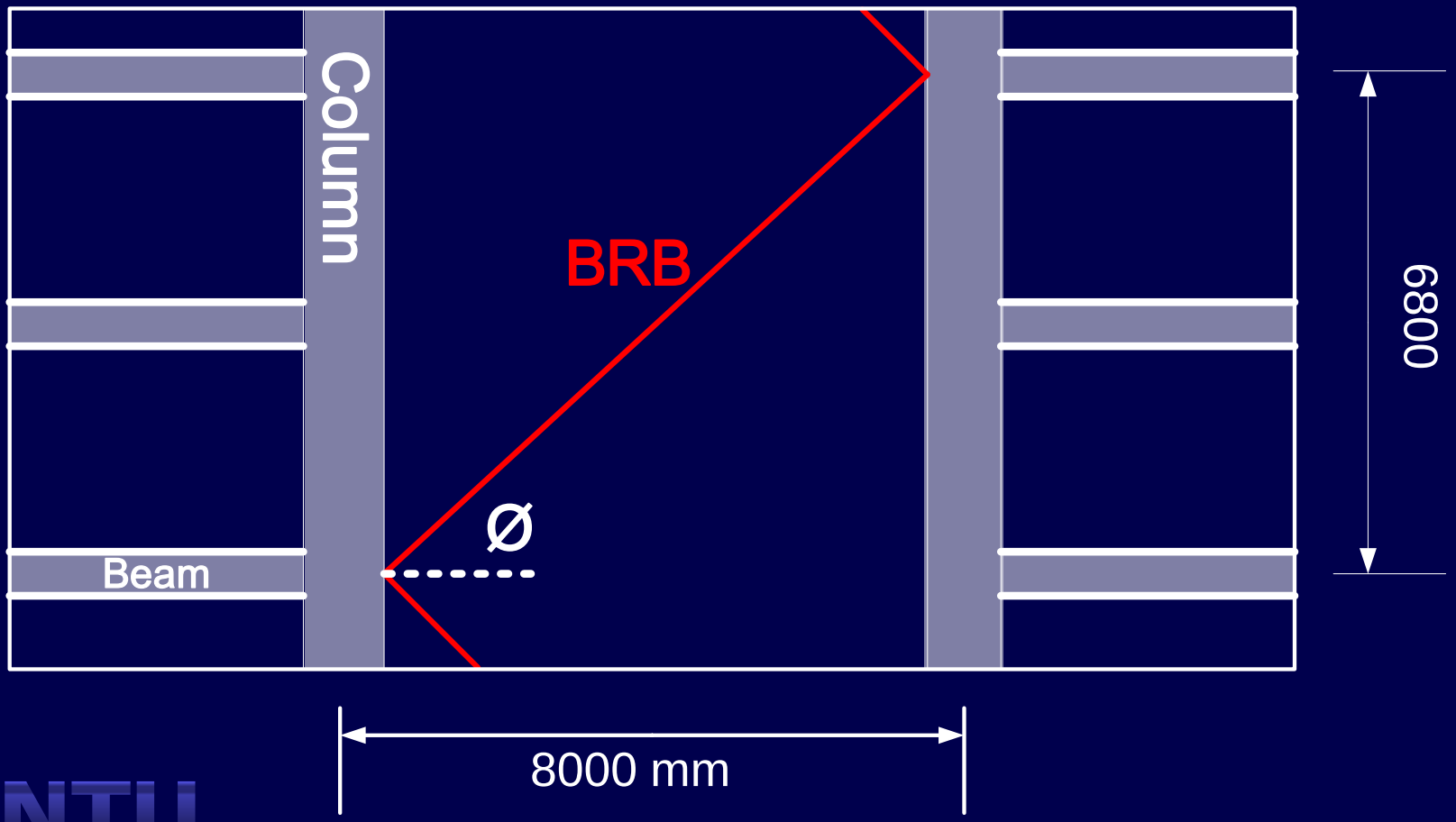
接合板

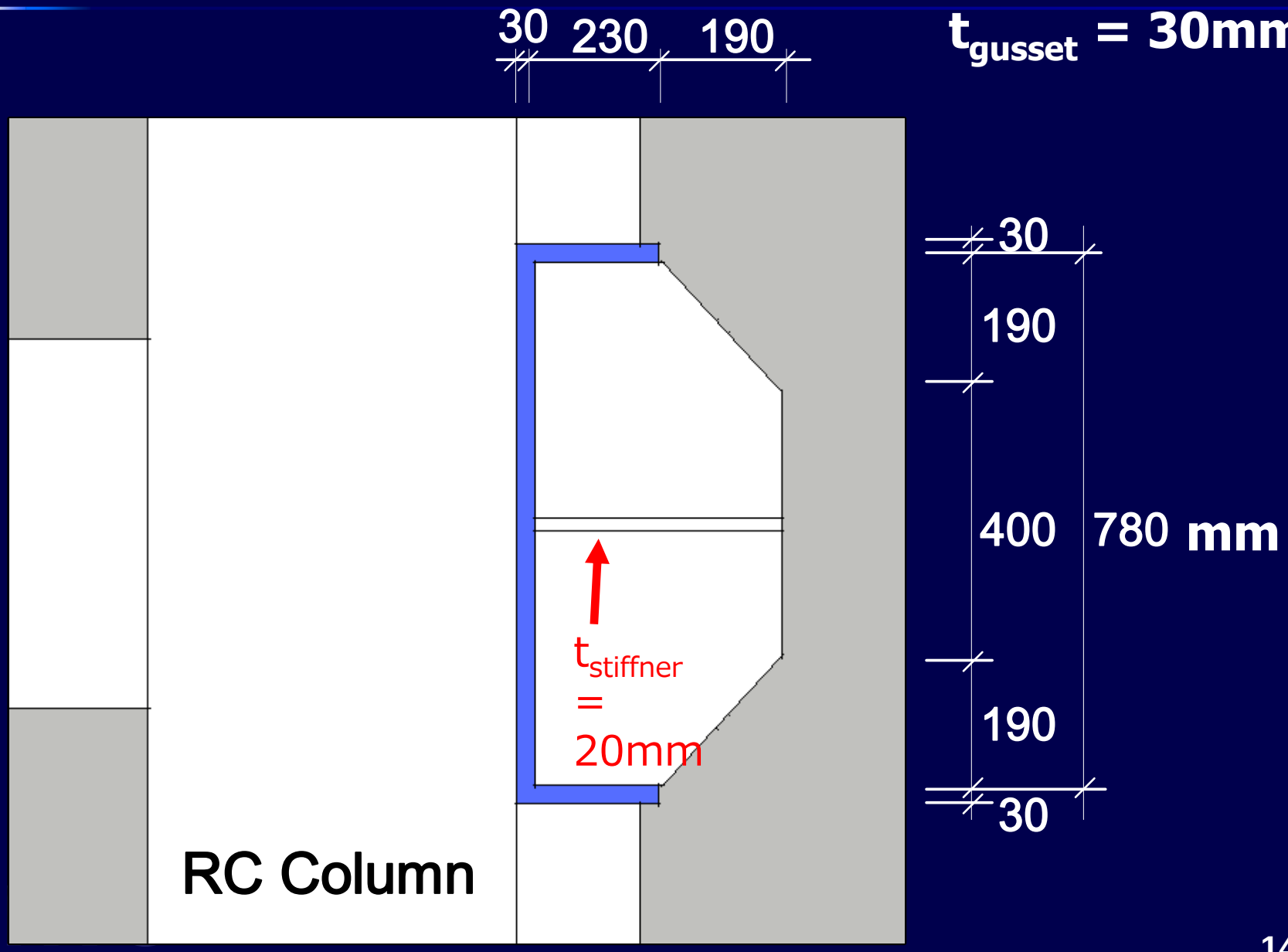


接合板設計

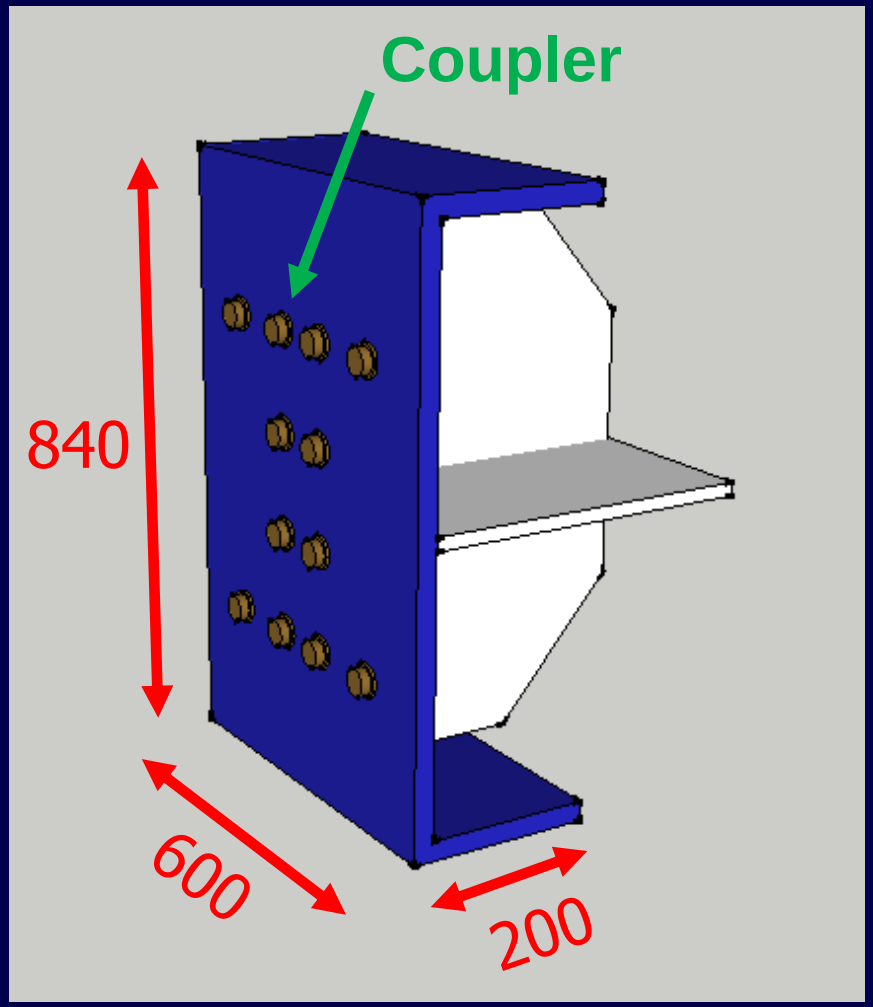
$$\emptyset = tan^{-1}\left(\frac{6800}{8000-600}\right) = 42.58^{o}$$

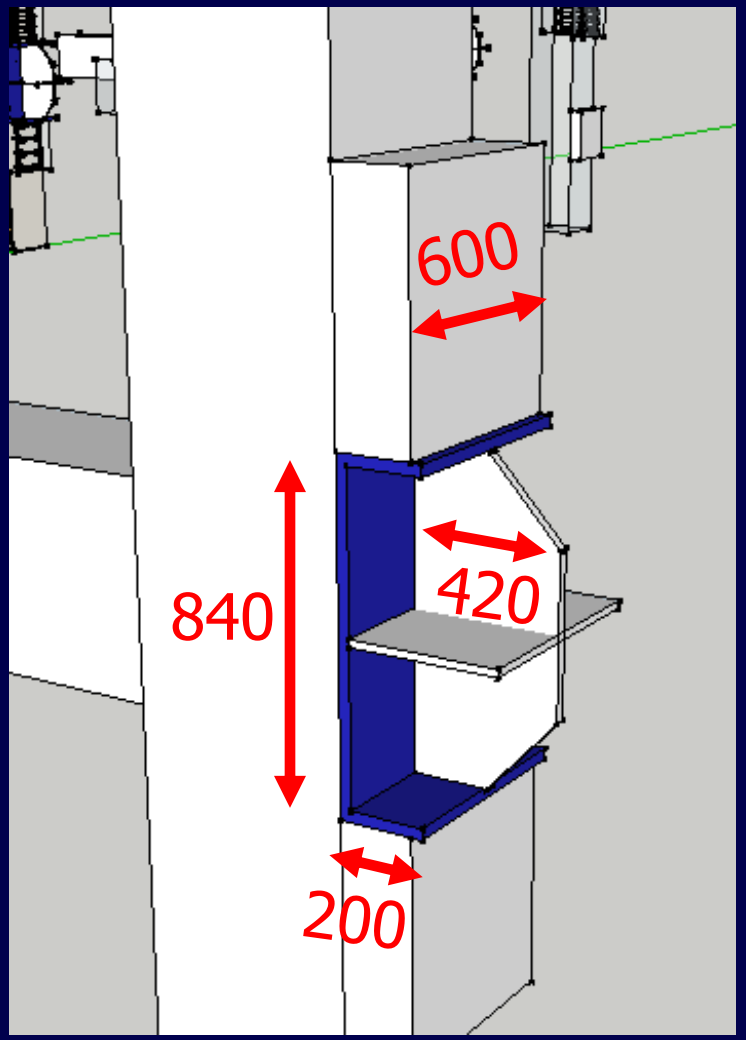


接合板設計


30
230
190
t_{gusset} = 30mm
30
190
400
780 mm
190
30
$t_{stiffner}$
=
20mm
RC Column

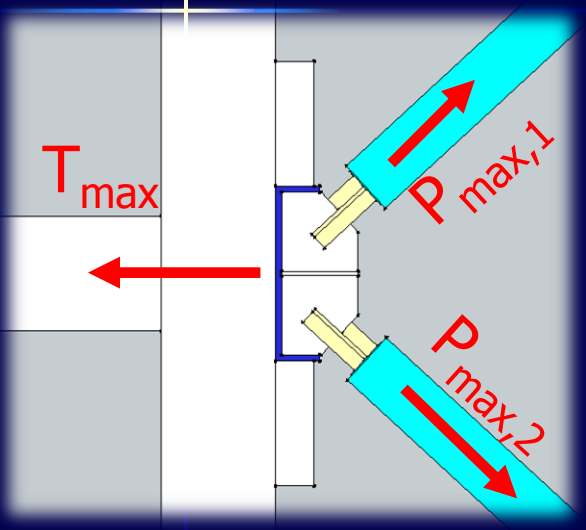
接合板 & U型鐵件





t_{gusset} = 30mm

U型鐵件 - 容量設計法

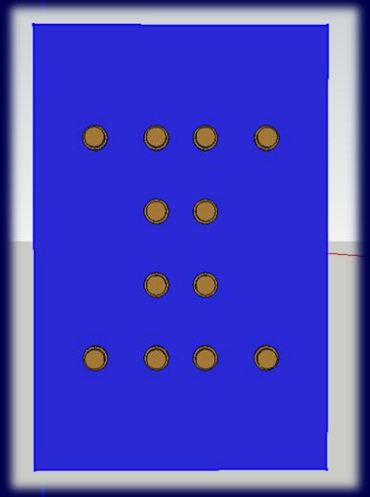


- **Demand:** $SN490: R_y = 1.2, \Omega = 1.3, \beta = 1.15$

$$T_{max} = (P_{max,1} + P_{max,2}) \times \cos\theta$$

$$= (30 + 120) \times 1.2 \times 1.3 \times 1.0 \times \cos 42.58^o$$

$$= 234\ (\text{tf}) \times 0.736 = 172(\text{tf})$$



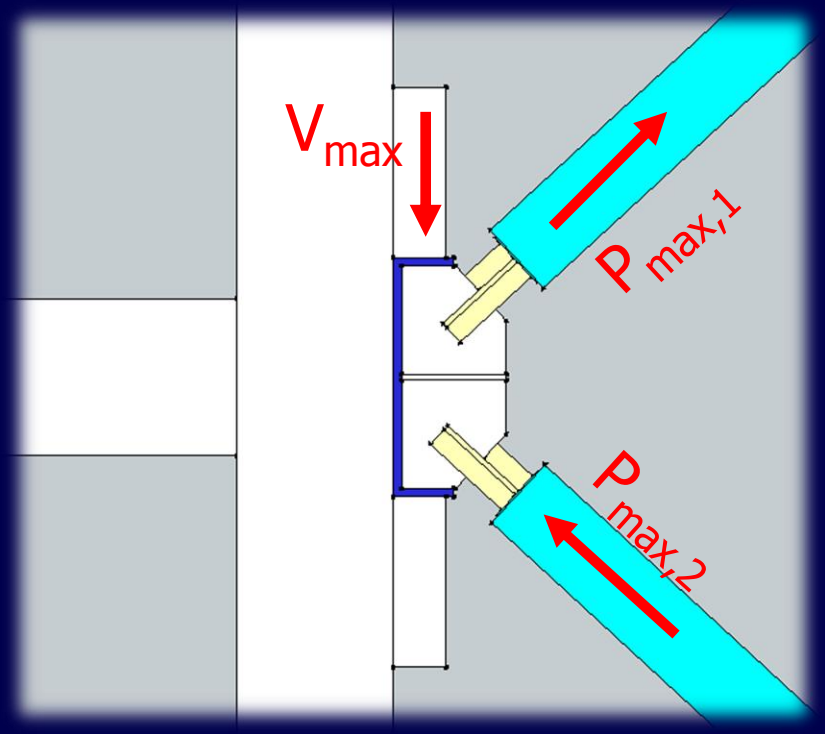
- **Capacity:** 梁主筋: **12-#8**

$$12 \times \frac{\pi \times 2.54^2}{4}(\text{cm}^2) \times 4200(\text{kgf/ cm}^2)$$

$$= 12 \times 21252(\text{kgf}) = 12 \times 21.3(\text{tf}) = 255.6(\text{tf})$$

$$\phi T_n = 0.9 \times 255.6 = 230 \geq T_{max} = 172$$

托梁－容量設計法

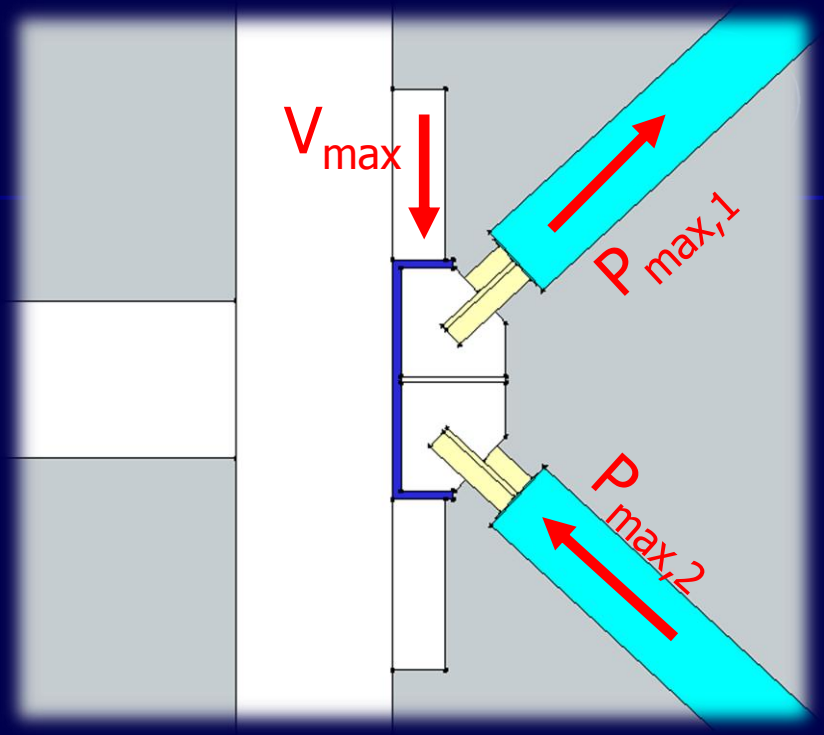


$$V_{\max} = (P_{\max,1} + P_{\max,2}) \times \sin\theta$$

$$= (30 + 120) \times 1.2 \times 1.3 \times 1.15 \times \sin 42.58^{o}$$

$$= 269\ (\text{tf}) \times 0.676 = 180(\text{tf})$$

托梁設計



- **Demand:**

  BRB one Tension and one Comp.

$$V_{\max} = (P_{\max,1} + P_{\max,2}) \times \sin\theta$$

- **Capacity:**

  1. Qu,Z Strut and Tie Model

$$V_n = \sigma_d \times b \times l \times \cos\theta$$

  2. Simplified Softened Strut and Tie method

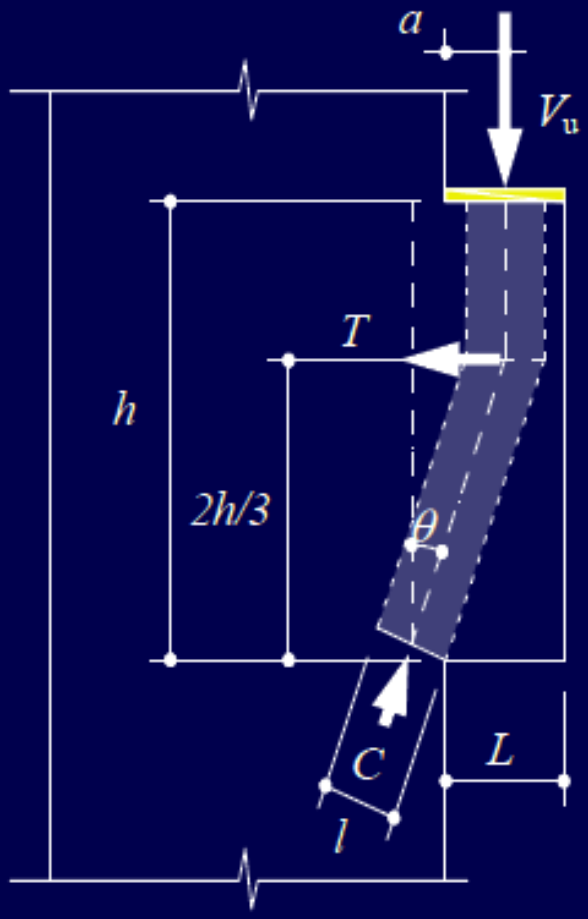
$$V_n = K\zeta f_c' A_{str} \sin\theta$$

  3. ACI318-14 Corbel

$$V_n = A_{vf} f_y \mu \le \left(0.2 f_c' bd, 56bd\right)$$

托梁設計

$$V_{\max} = 180(tf)$$



$$V_n = C \times \cos\theta = 175\,(tf)$$

$$C = \sigma_d \times b \times l$$

$$\sigma_d = \frac{0.9 f_c'}{\sqrt{1 + 400 \frac{f_{ct}}{E_c}}} \qquad n = \frac{E_s}{E_c} \qquad d = \frac{2}{3}h$$

$$l = kd = \left[\sqrt{(n\rho_s)^2 + 2n\rho_s} - n\rho_s\right] \times d$$

$$\theta = 2\tan^{-1}\left(\frac{-1 + \sqrt{\left(\frac{a}{d}\right)^2 + \left(1 + \frac{k^2}{4}\right)}}{\frac{a}{d} - \frac{k}{2}}\right)$$

$h = 600mm$

$b = 600mm$

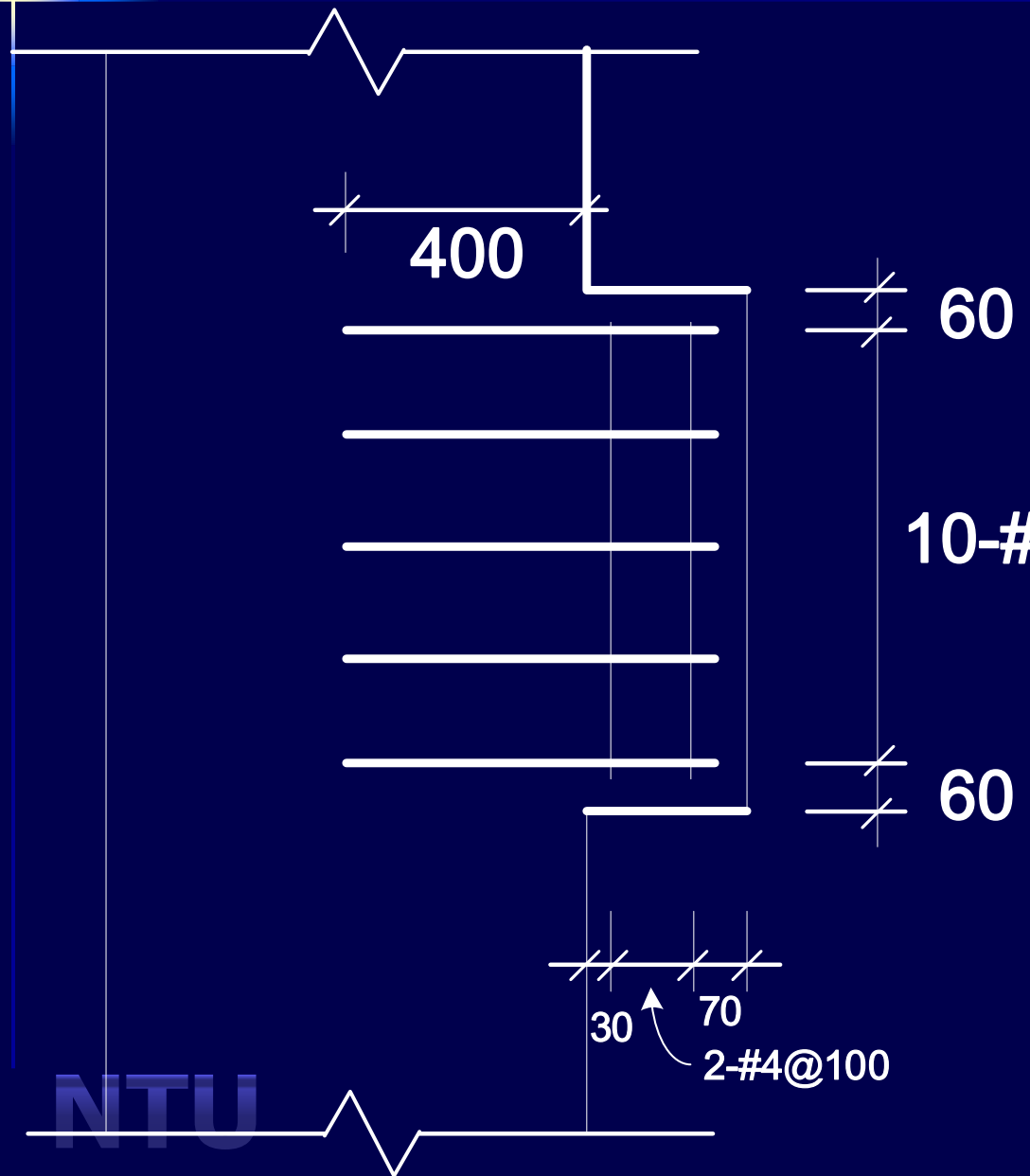
$L = 200mm$

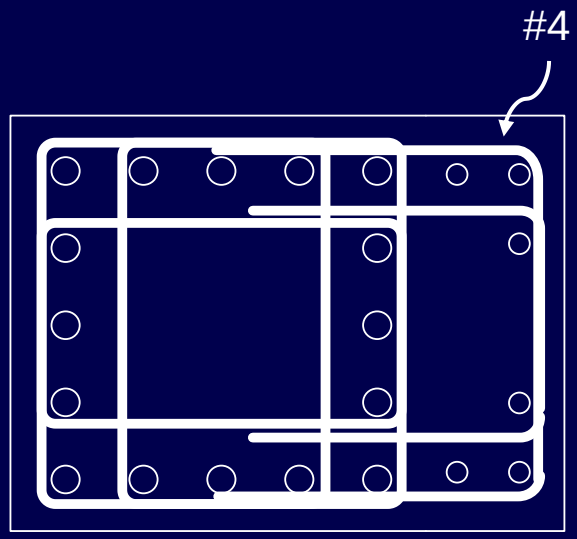
Qu,Z, et al. (2012). Shear resistance of reinforced concrete corbels for shear keys

托梁設計

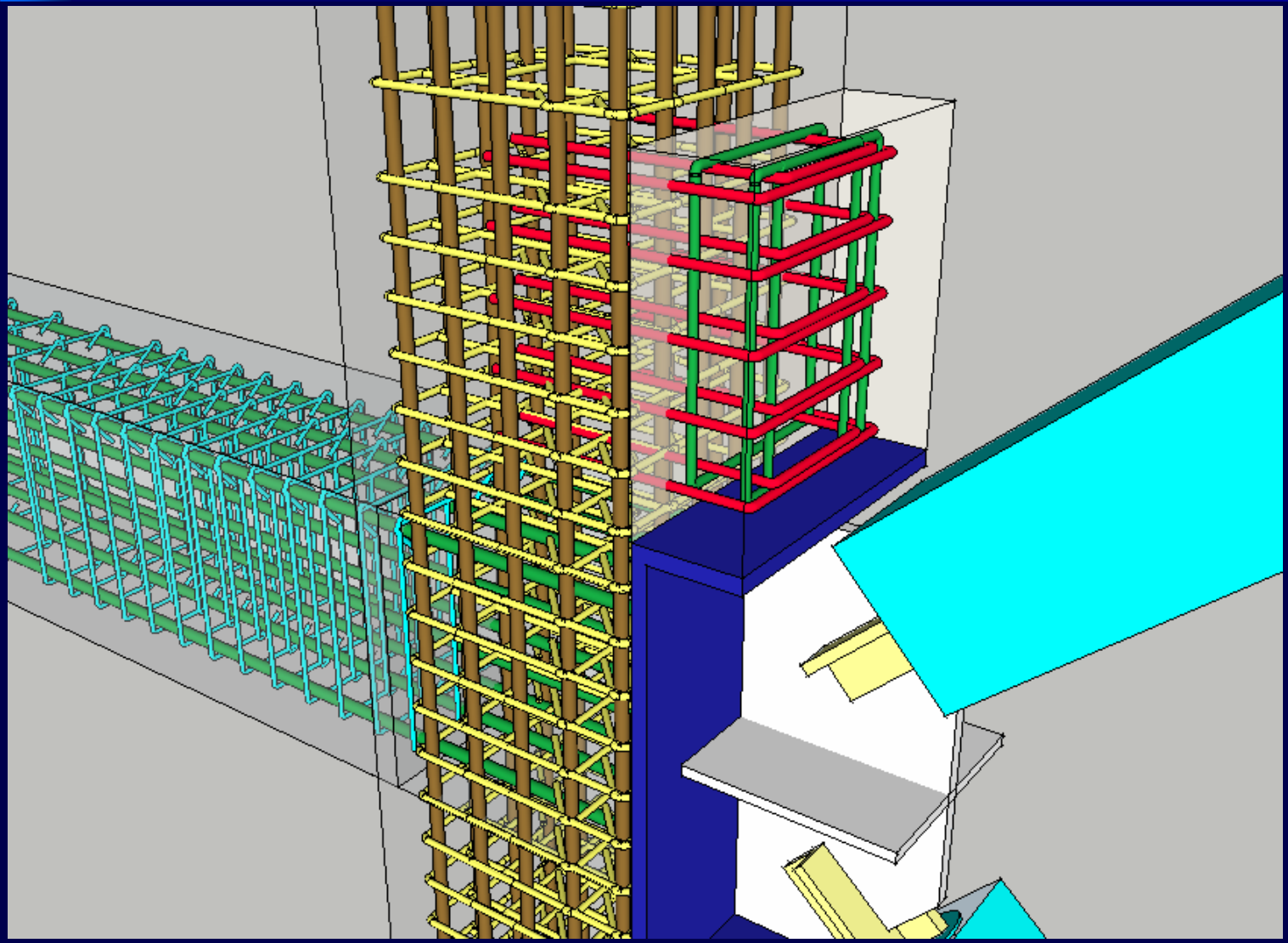
$$V_n = 175(tf)$$

h: 600 mm
b: 600 mm
L: 200 mm





托梁設計



托梁強度檢核

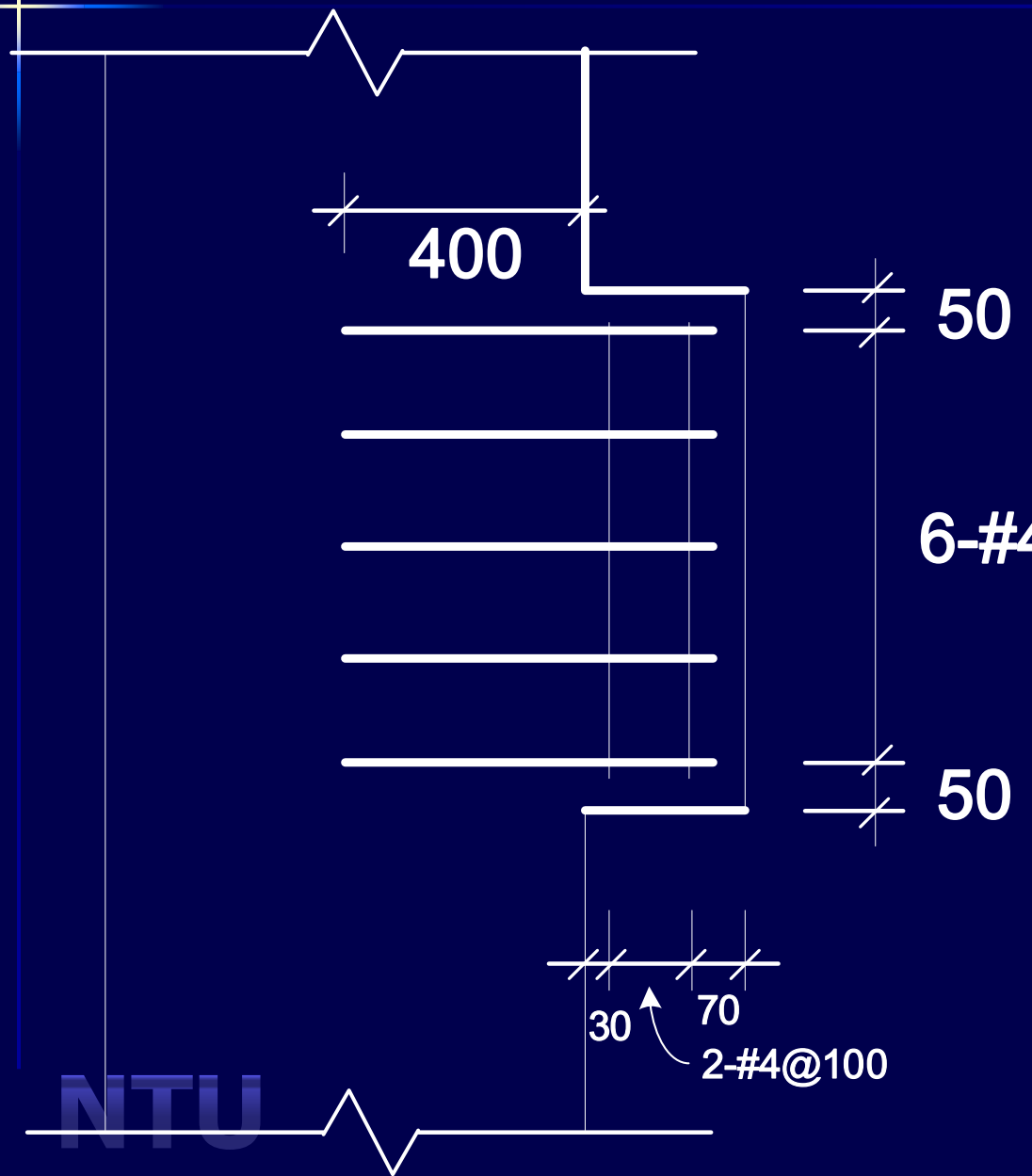
A1 vs A2: Length of Corbel
B1 vs B2: Width and Depth

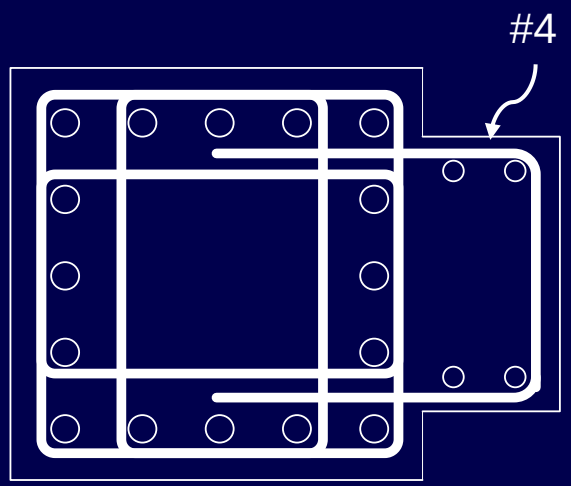
		A1	A2	B1	B2
h (cm)		60	60	60	40
b (cm)		60	60	40	60
L (cm)		20	15	20	20
Rebar		10-#4	10-#4	6-#4	6-#4
V_u (tf)		180			
拉壓桿模型	V_n (tf)	175	175	112	110
	DCR	1.03	1.03	1.61	1.64
簡化式軟化拉壓桿	V_n (tf)	160	160	139	130
	DCR	1.13	1.13	1.29	1.38
ACI-318托梁規範	V_n (tf)	149	149	89	89
	DCR	1.21	1.21	2.02	2.02

托梁 (B1)

$$V_n = 112(tf)$$

h: 600 mm
b: 400 mm
L: 200 mm

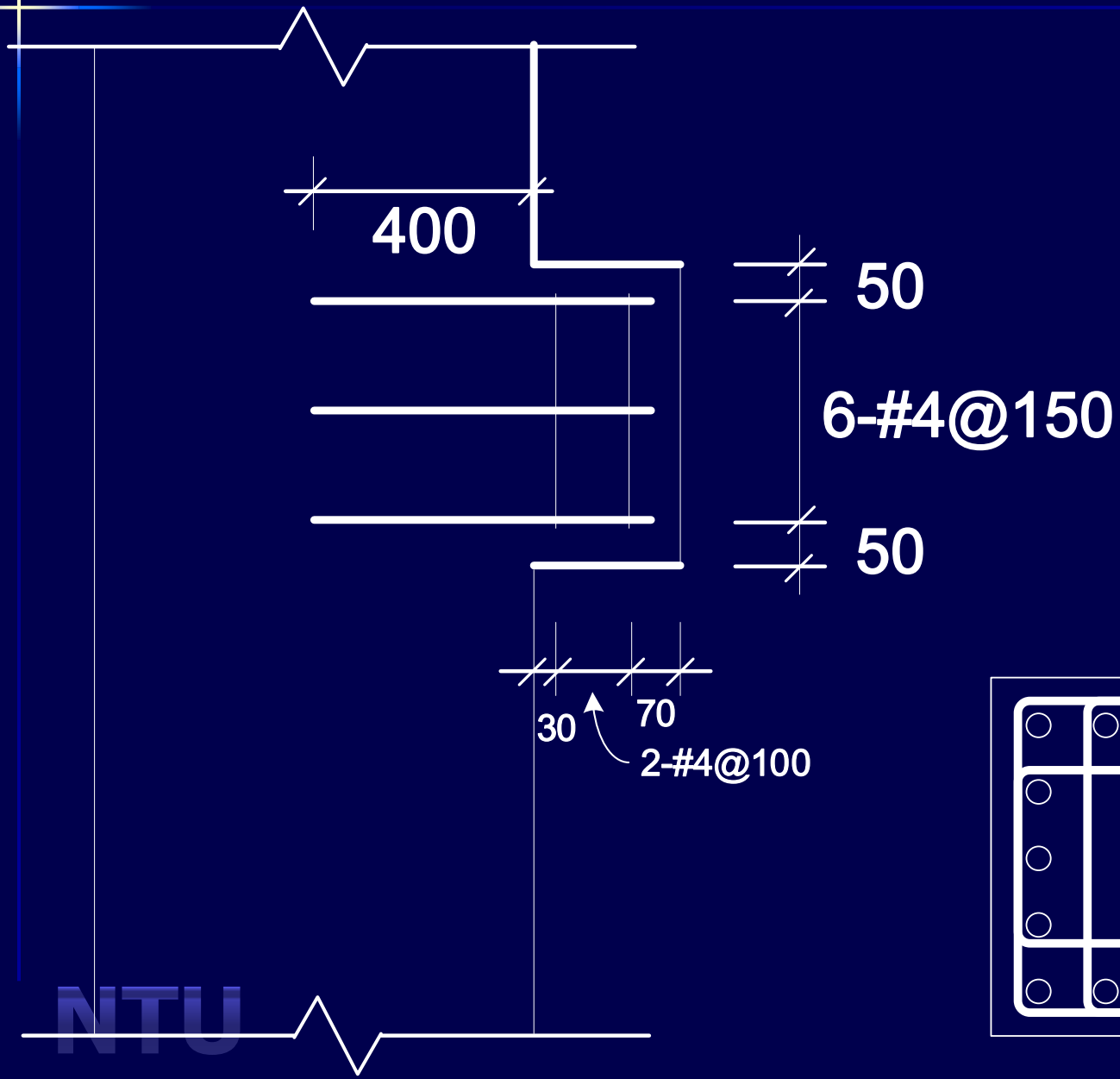


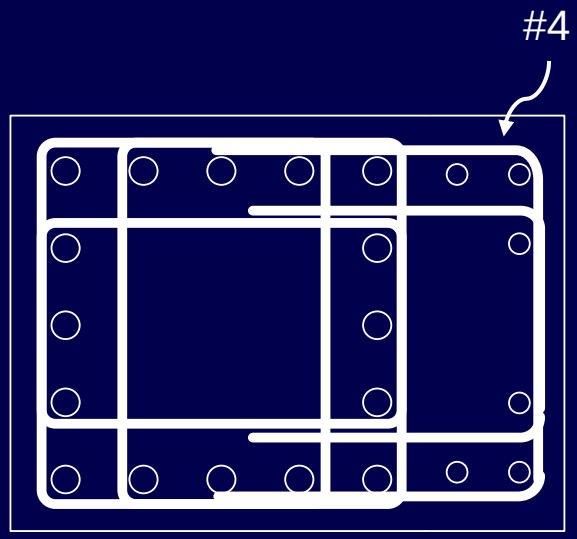


托梁 (B2)

$$V_n = 110(tf)$$

h: 400 mm
b: 600 mm
L: 200 mm





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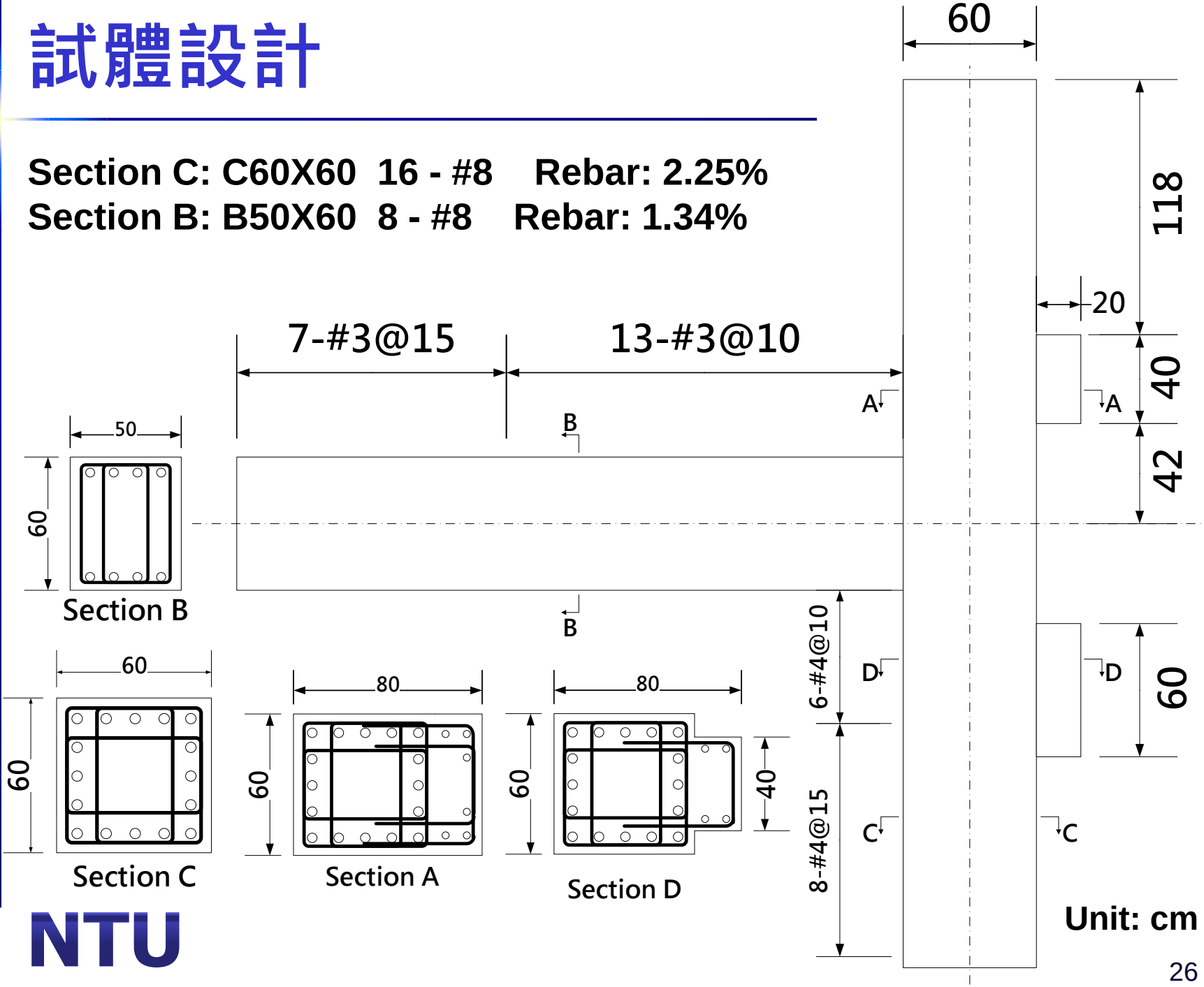
試體設計

Section C: C60X60 16 - #8 Rebar: 2.25%
Section B: B50X60 8 - #8 Rebar: 1.34%



定位

放入主筋

內外側焊接

柱

柱與托梁

托梁

U型鐵件

托梁

梁主筋

梁主筋

澆置混凝土

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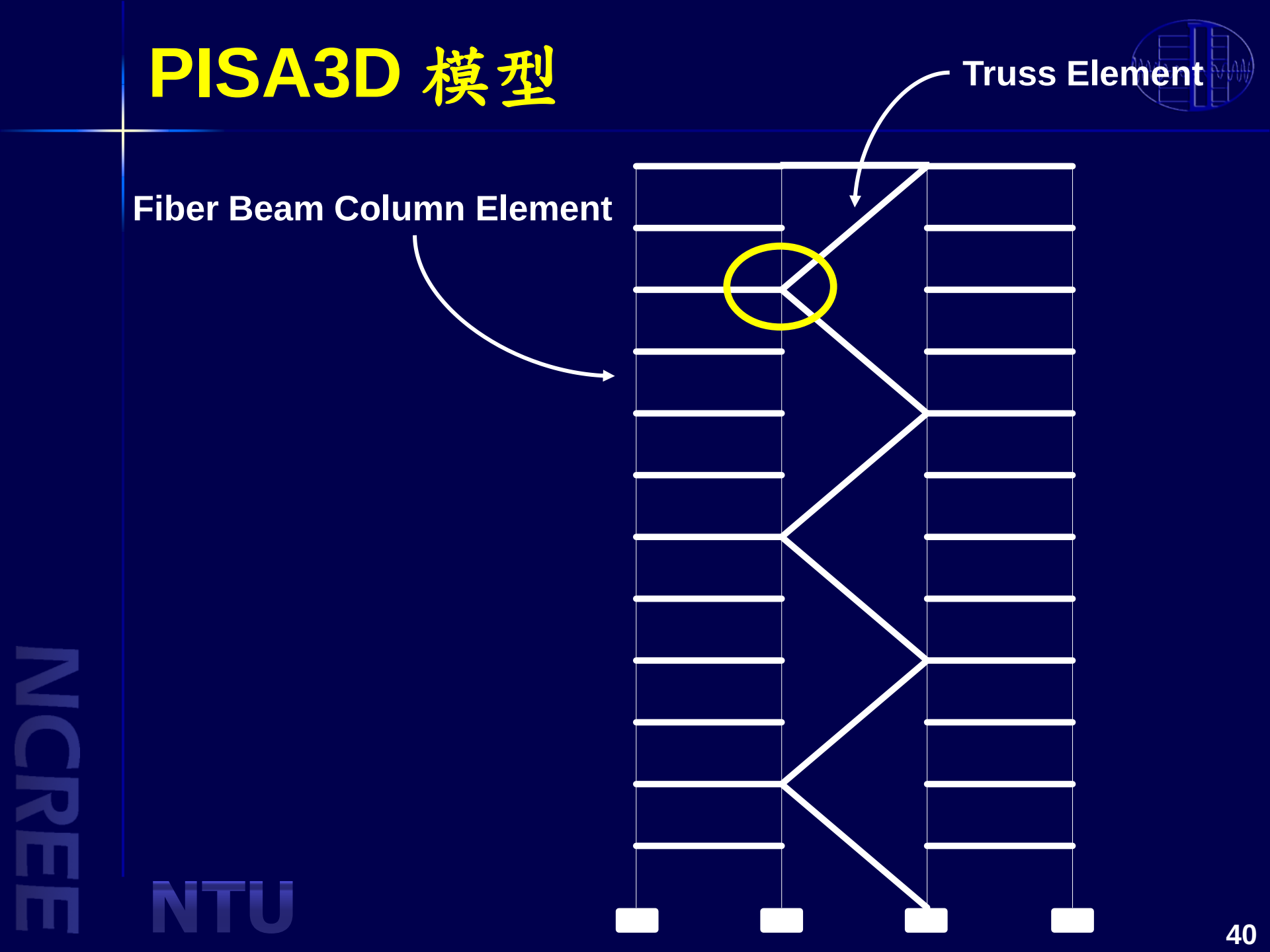
PISA3D 模型



PISA3D-Fiber Element

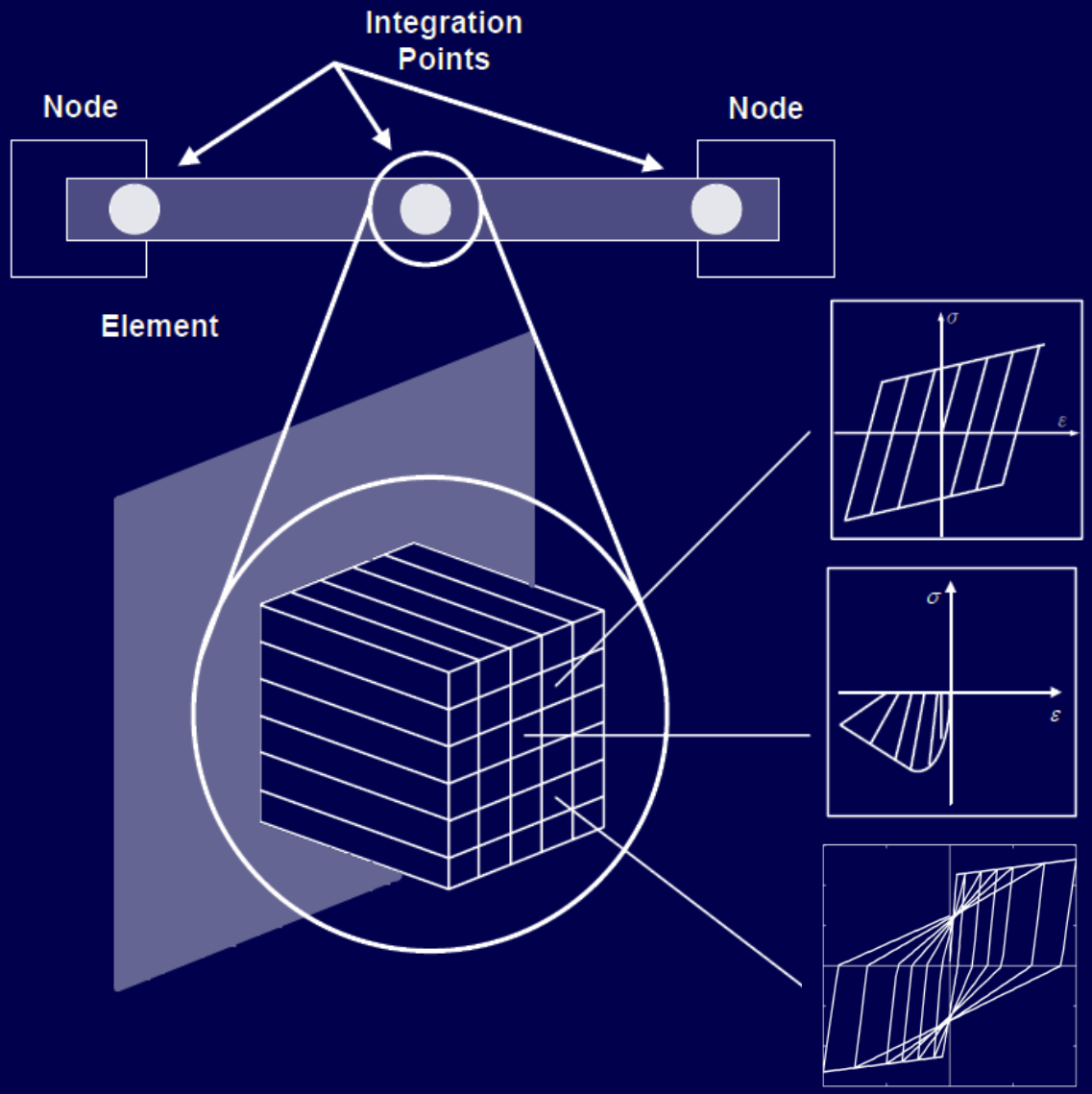


Fig. G18 Fiber BeamColumn Element

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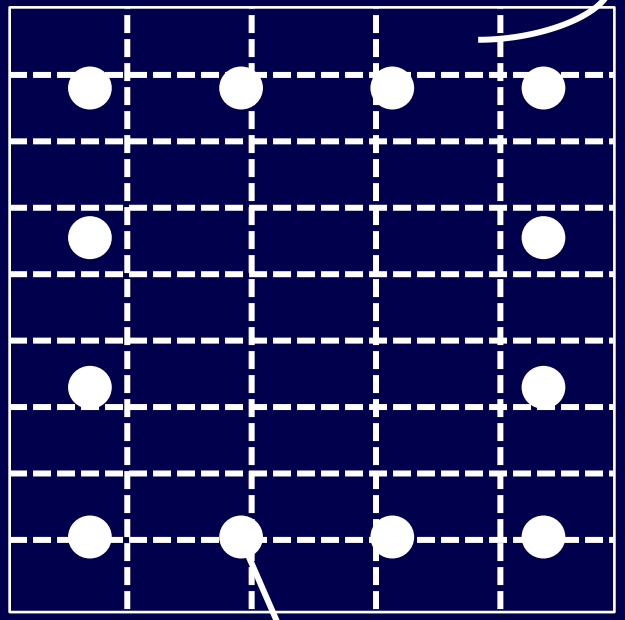
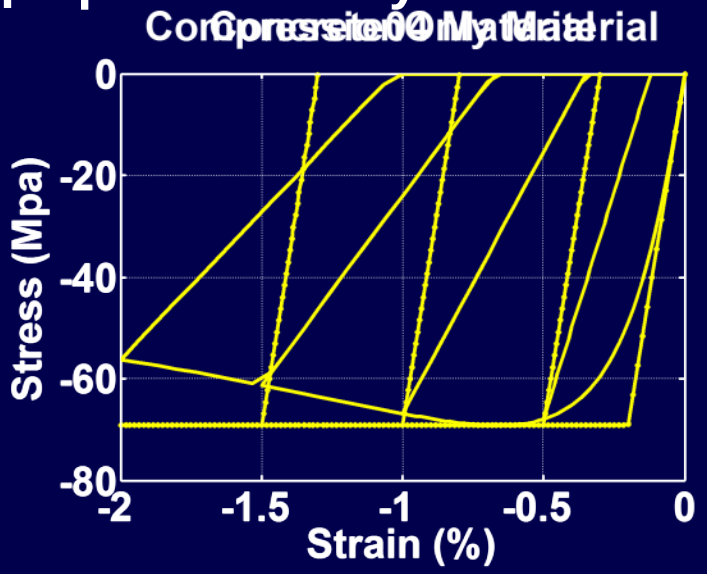
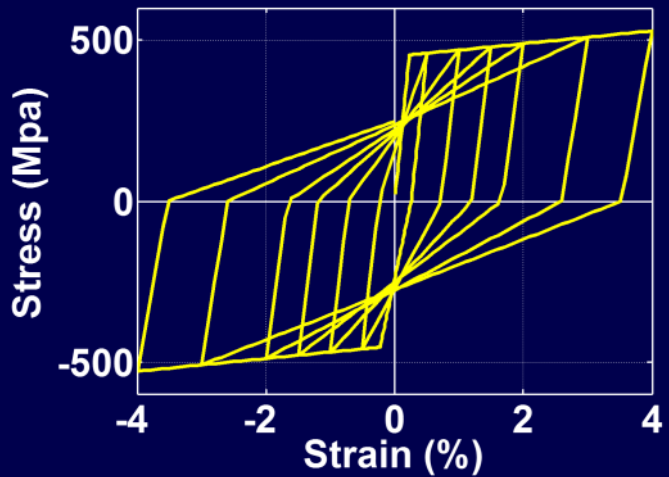
Column Fiber-Element



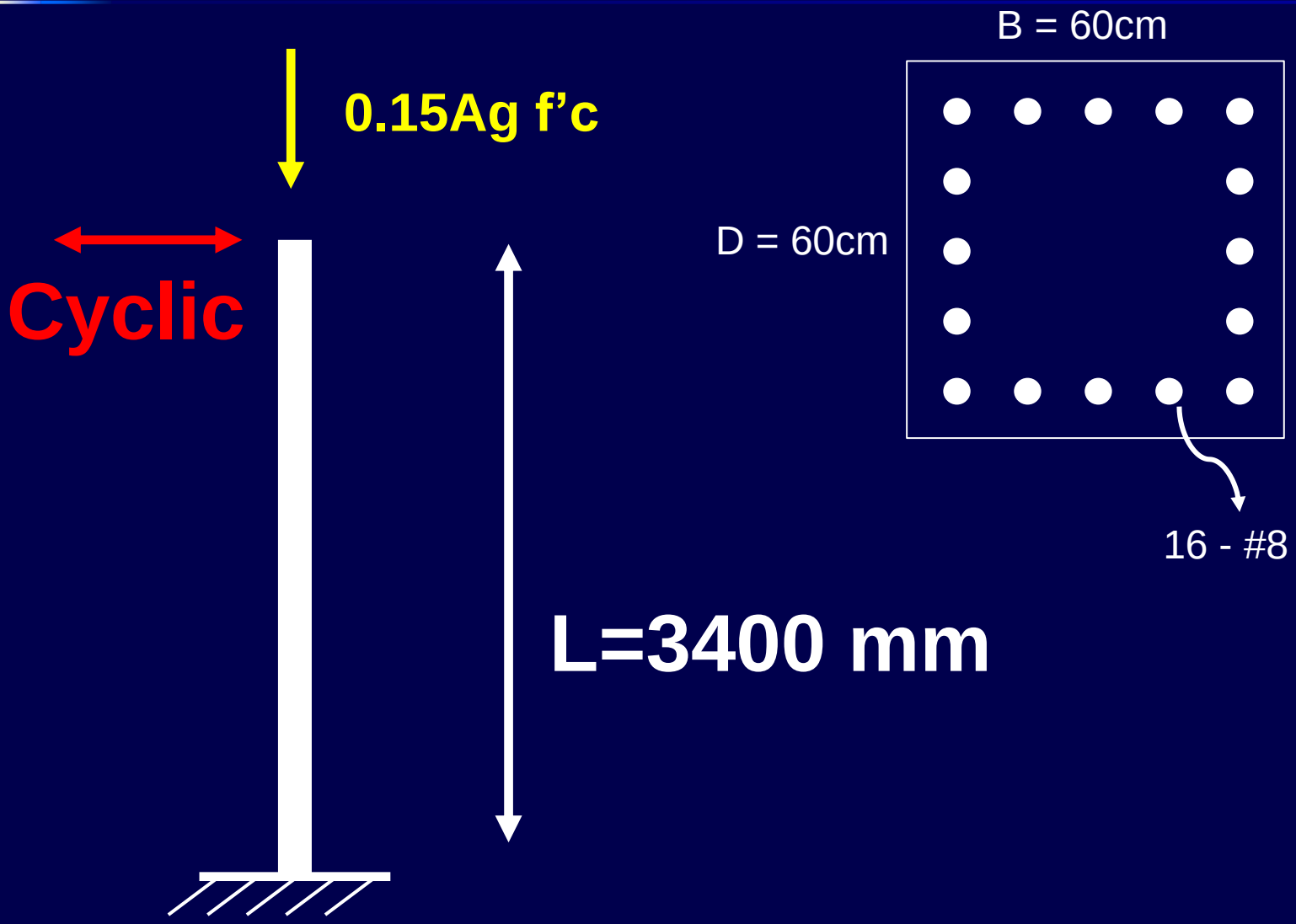
Concrete :



Rebar : Degrading



Column Cyclic Analysis



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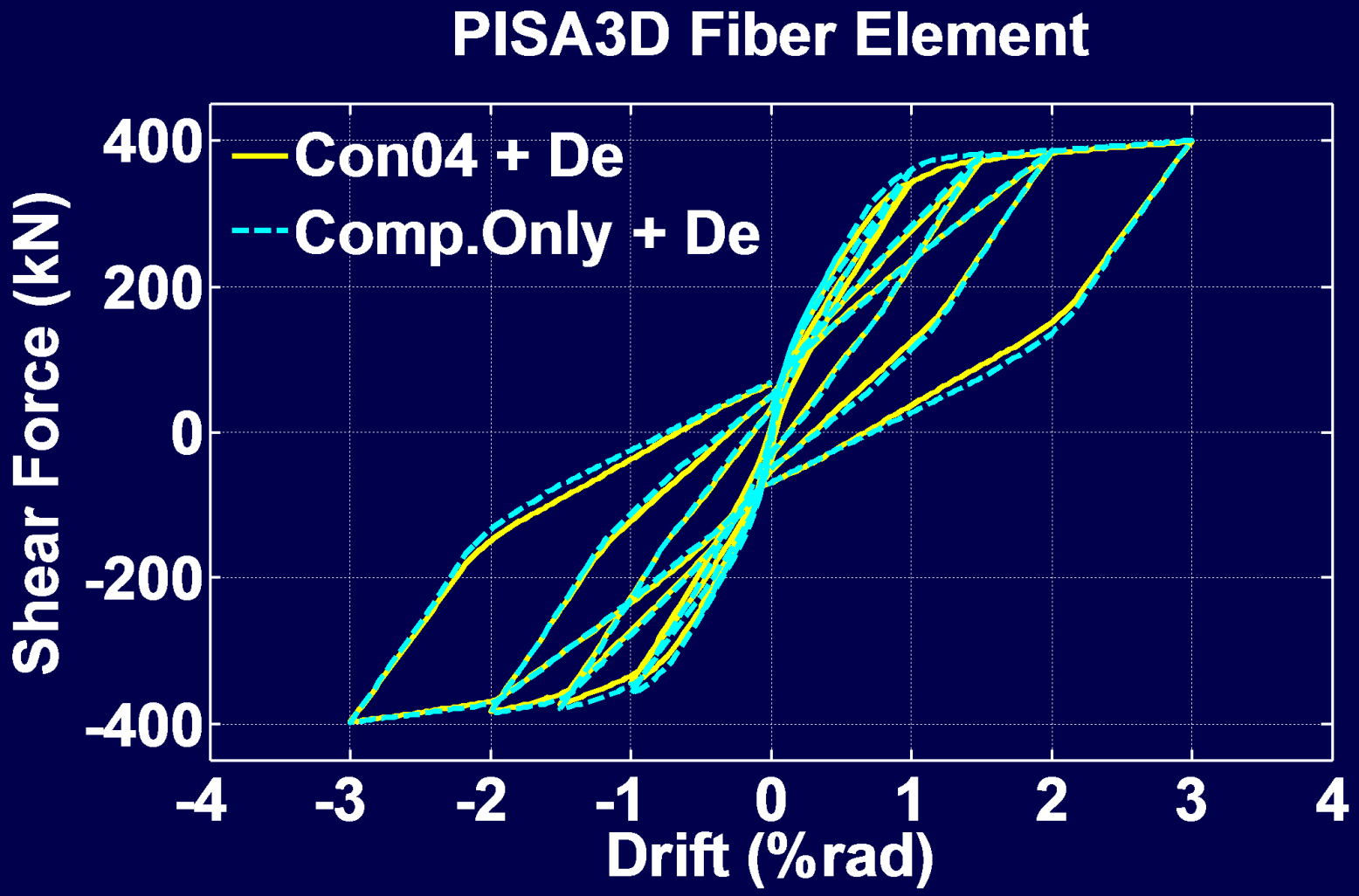
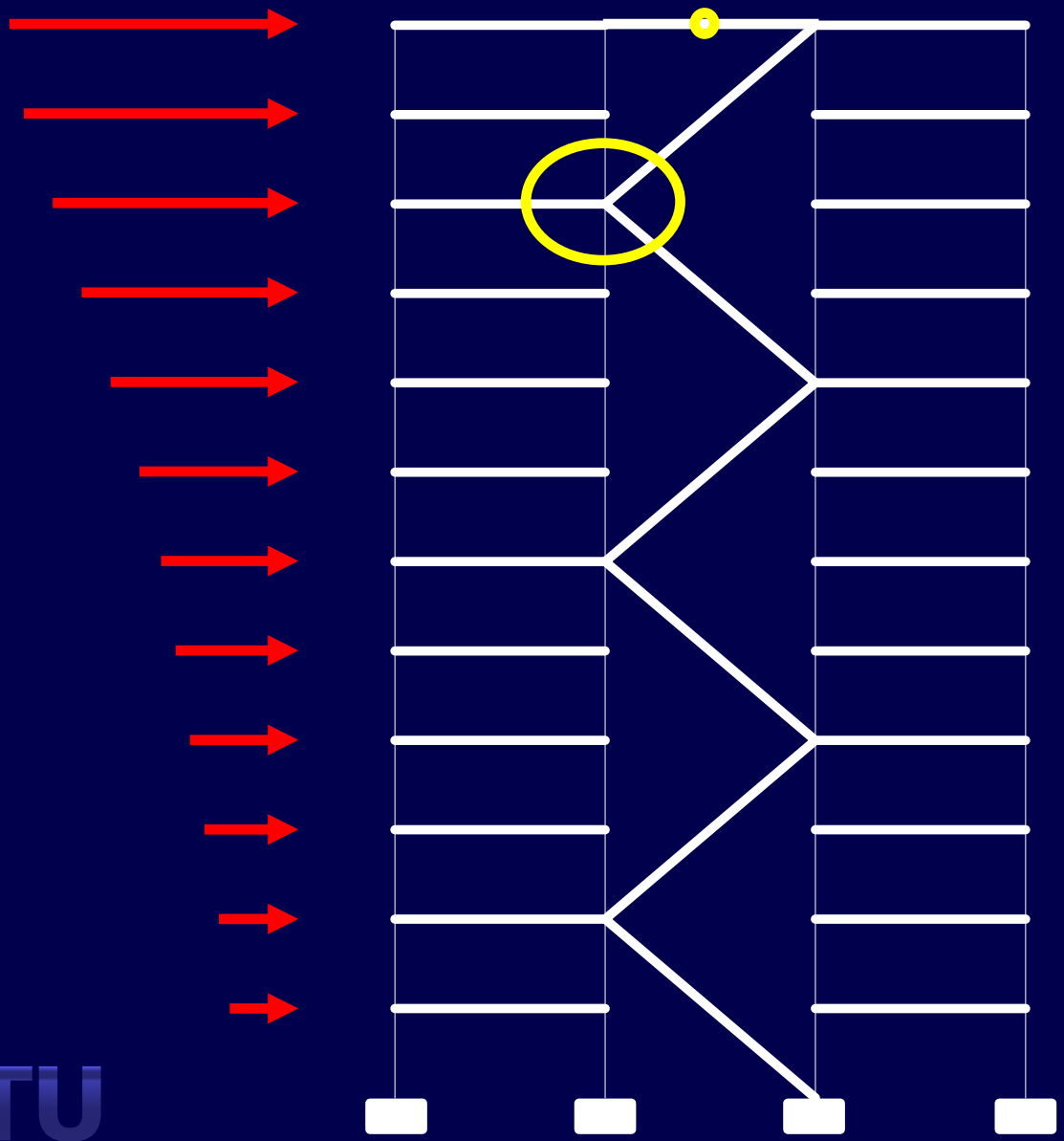
簡化模型


PISA3D Fiber Element
Con04 + De
Comp.Only + De
Shear Force (kN)
400
200
0
-200
-400
-4
-3
-2
-1
0
1
2
3
4
Drift (%rad)

Cyclic Test

Disp. Control



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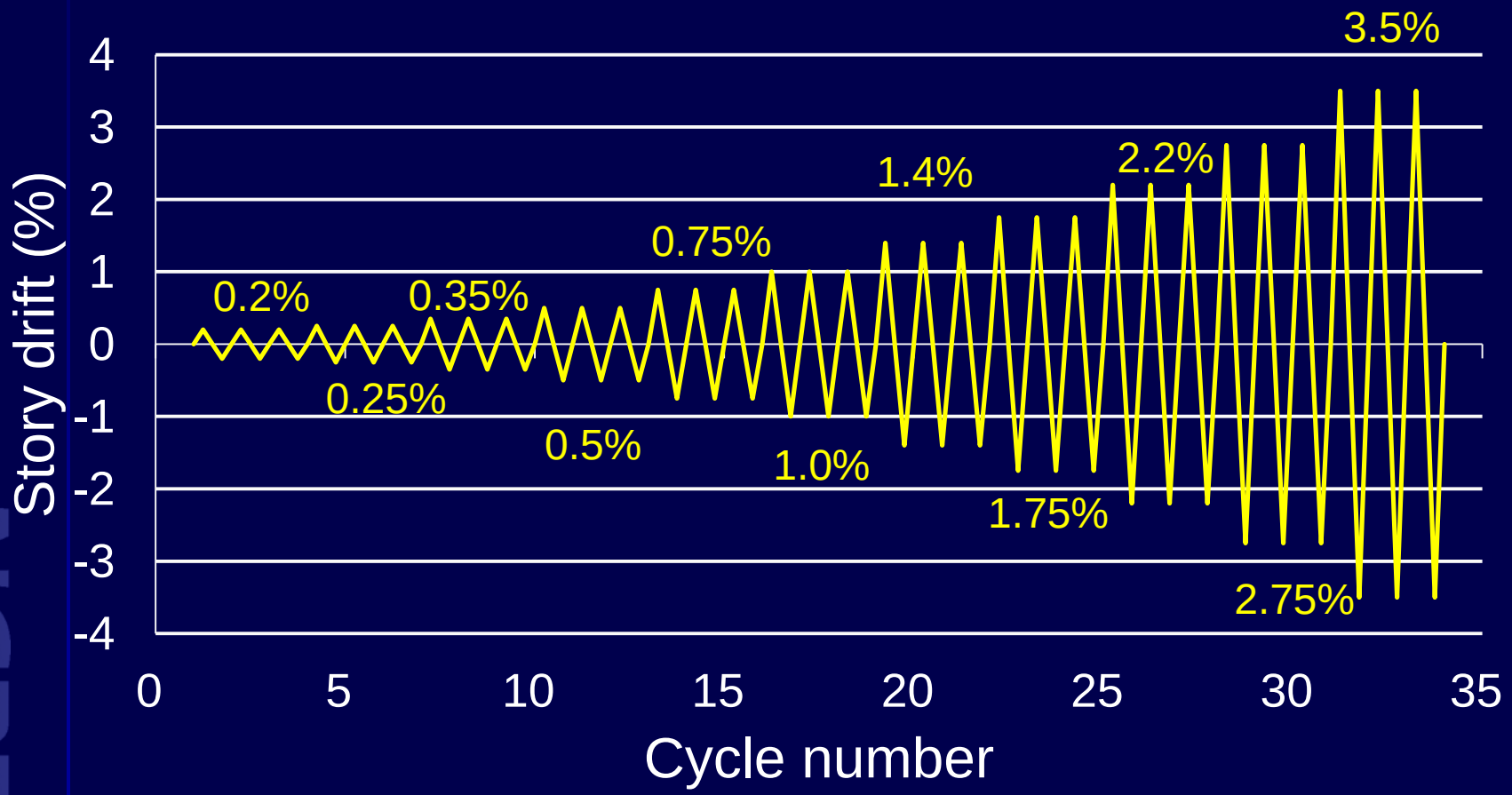
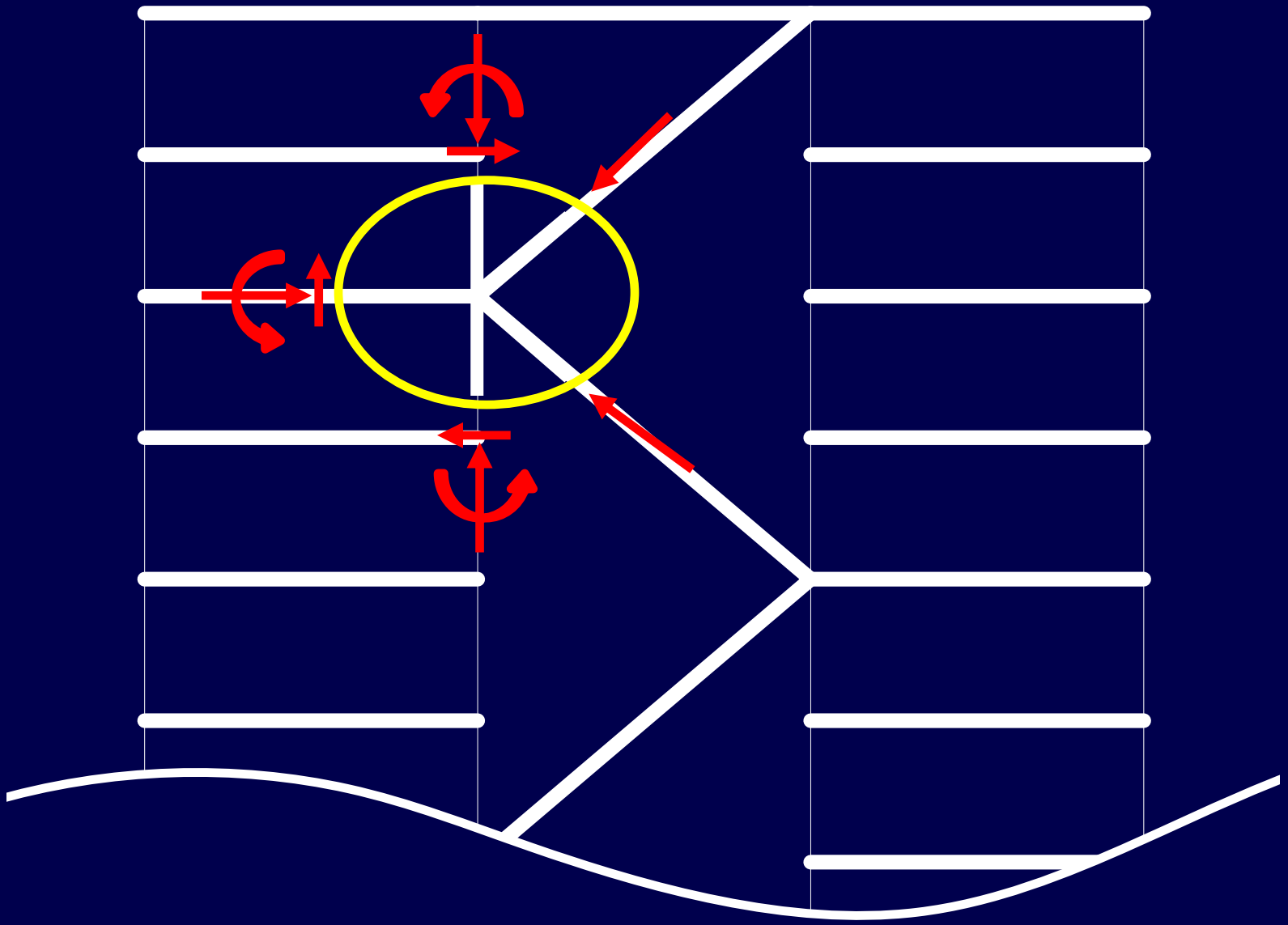
Cyclic Test

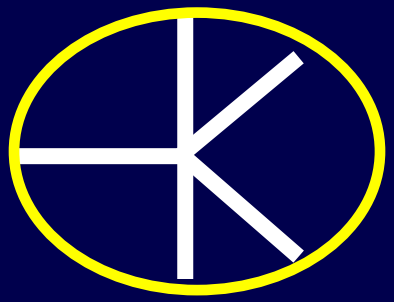
- Cyclic Loading Protocol (ACI 374.1-05)



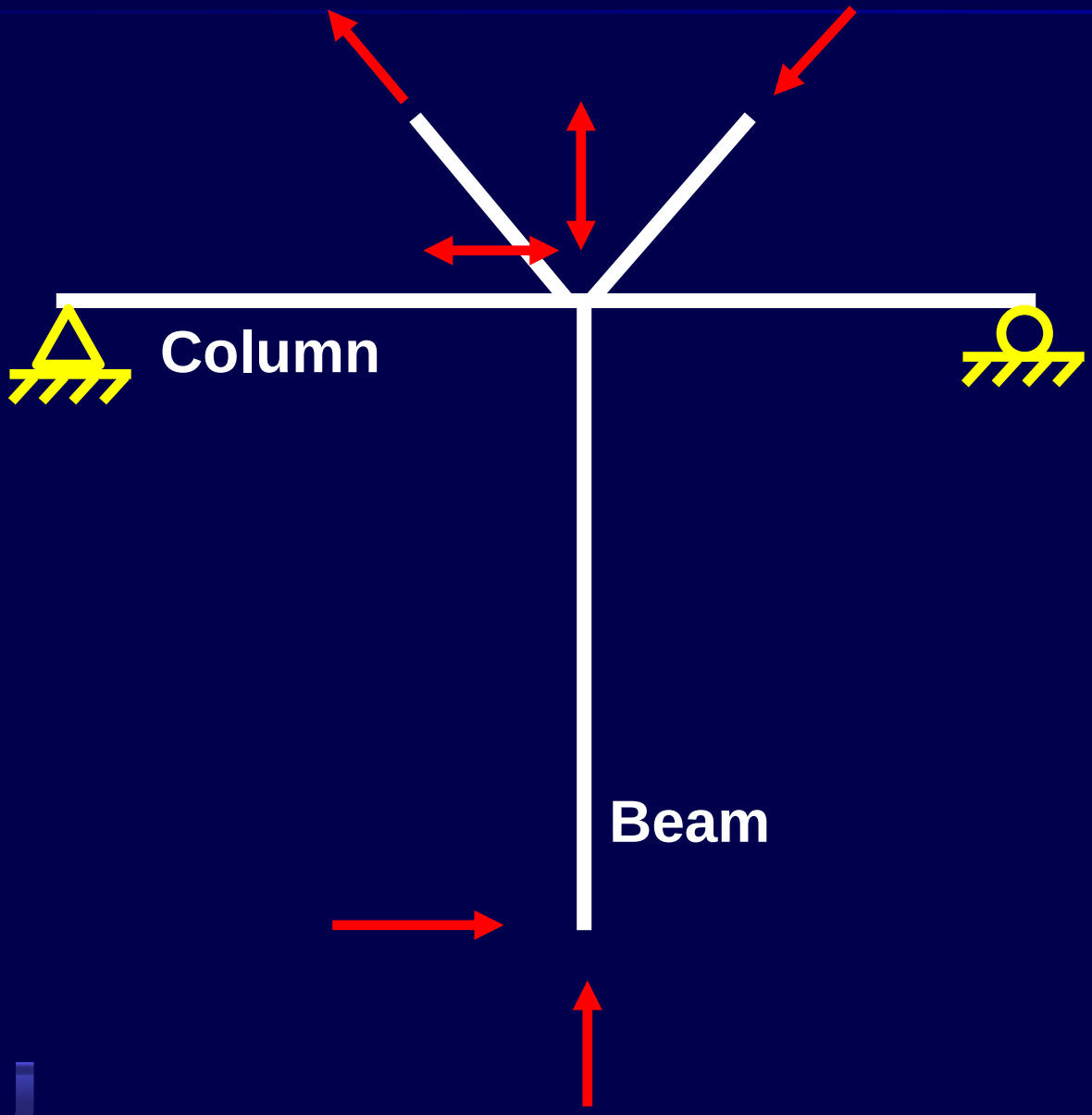
10F Joint



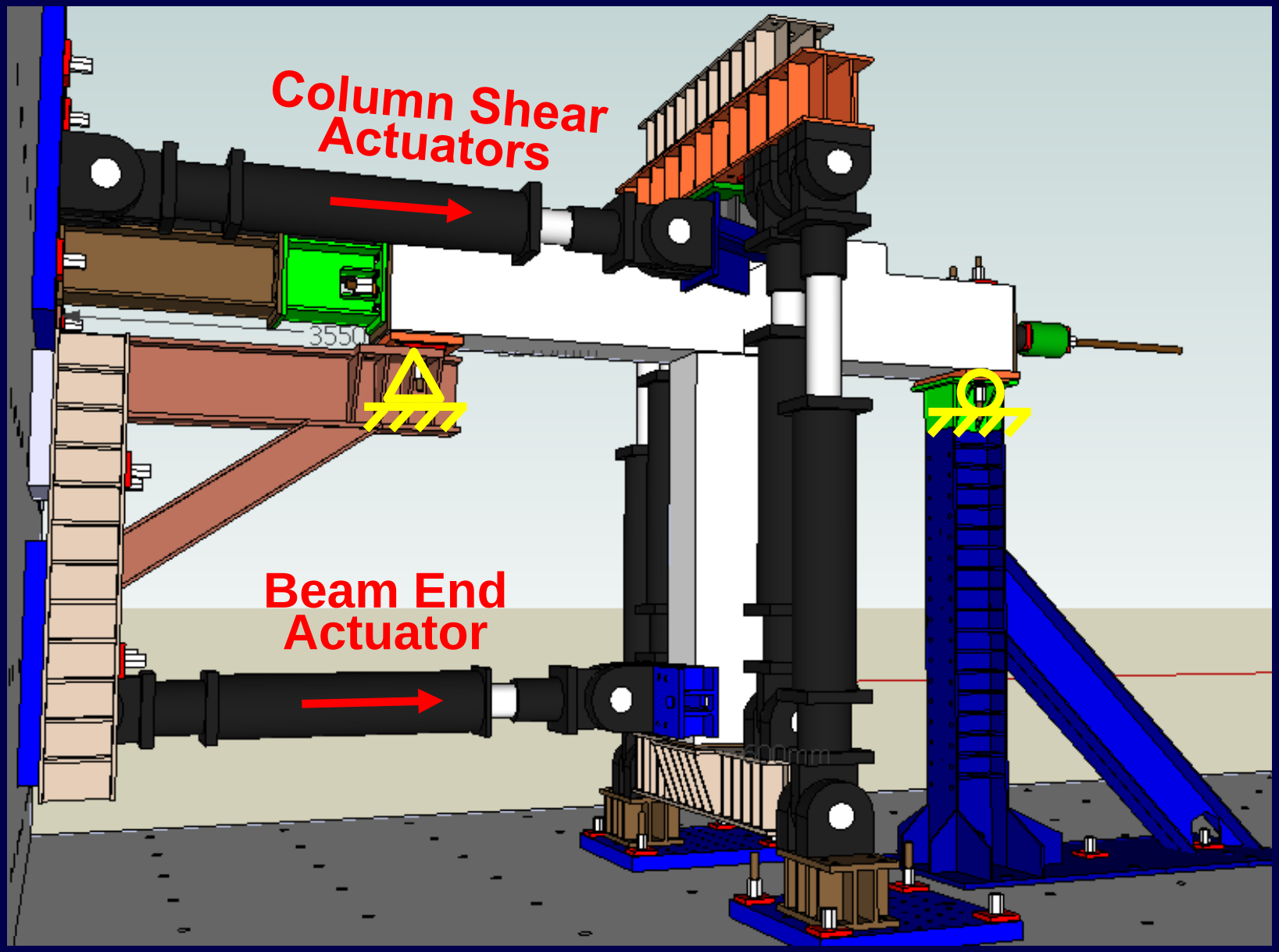
10F Joint



10F Joint

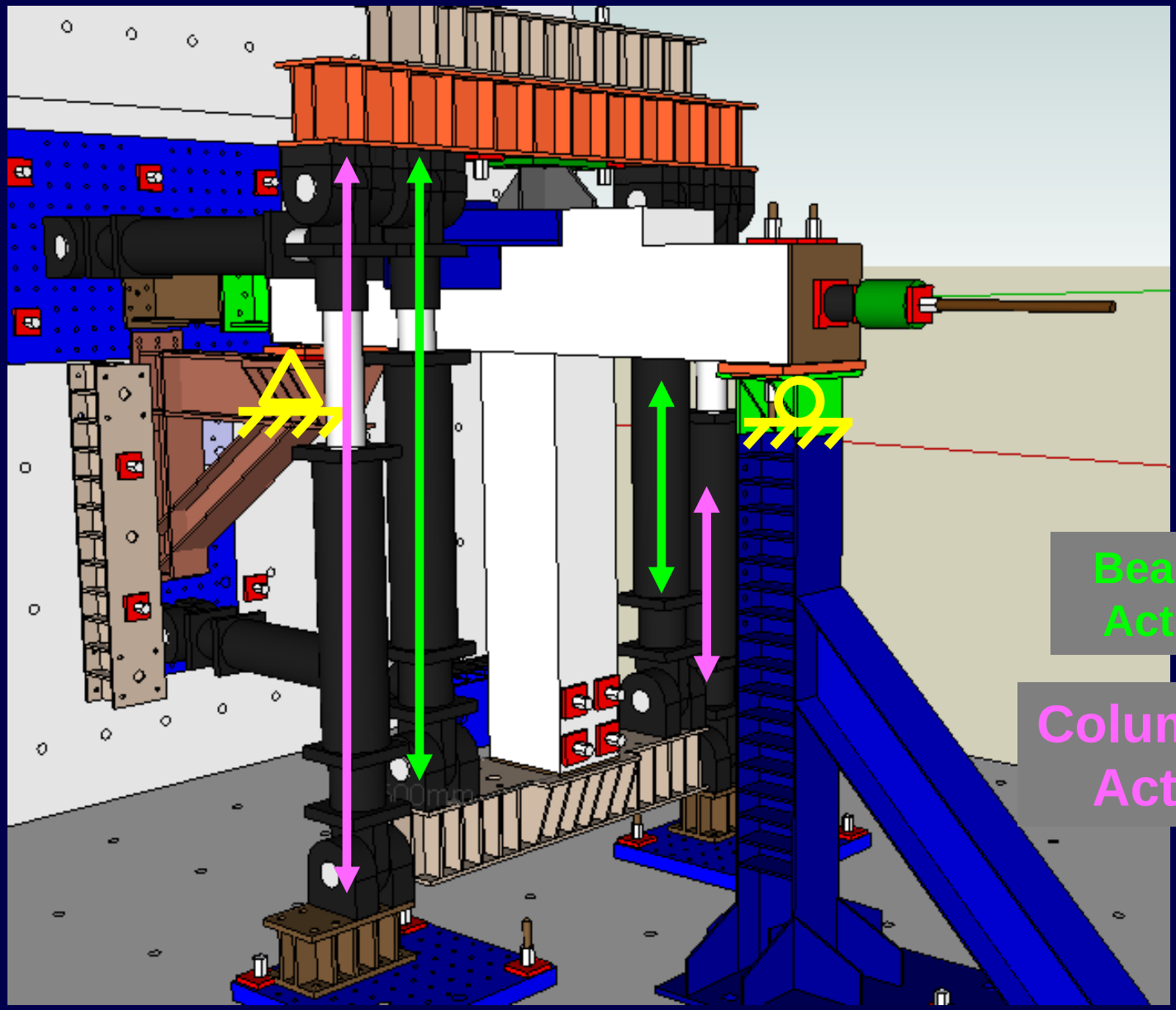


試驗配置

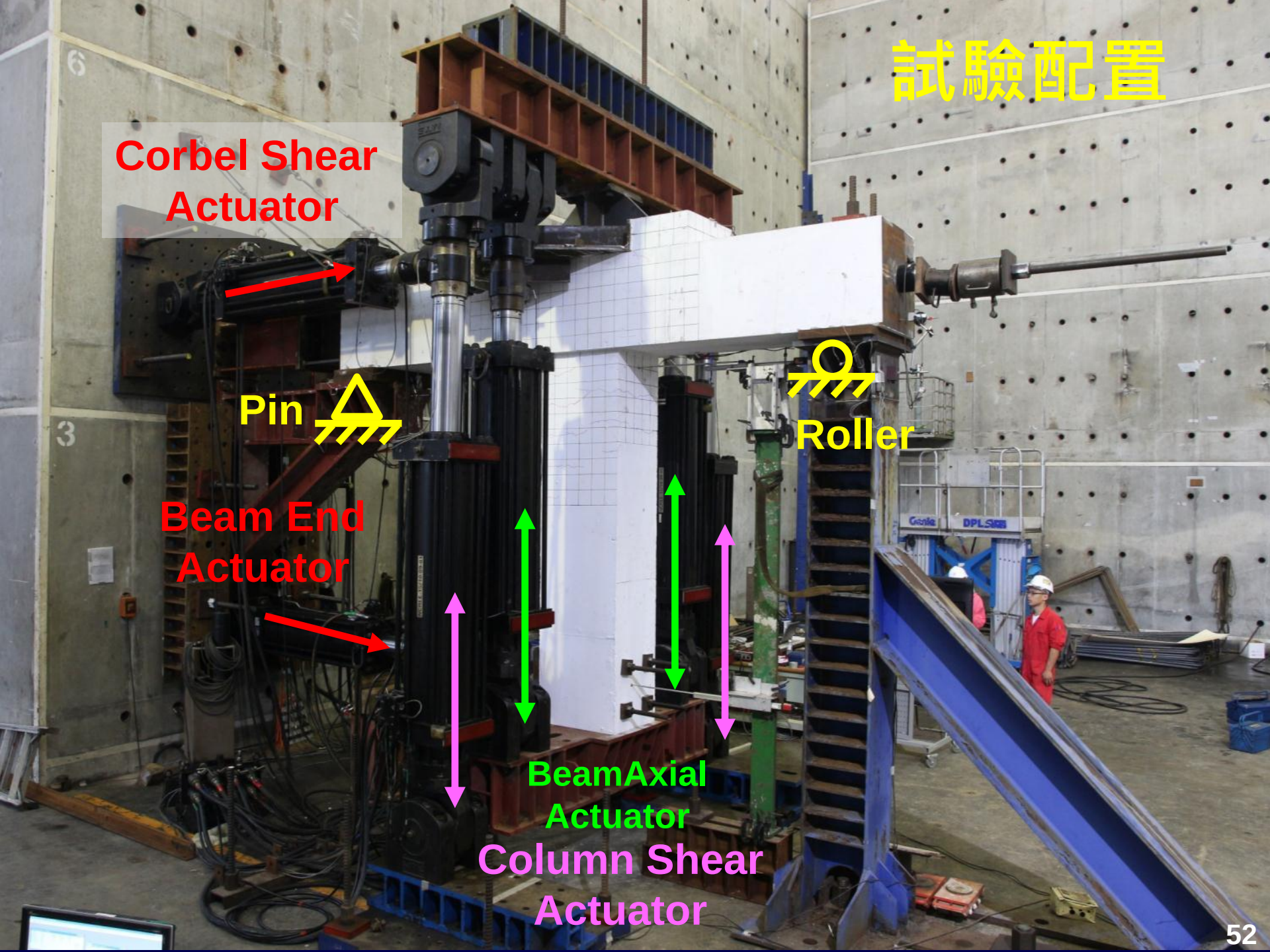


NCREE

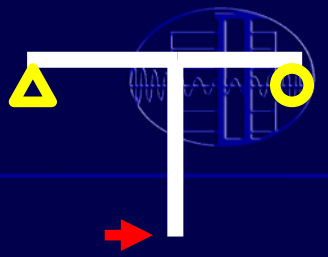
試驗配置

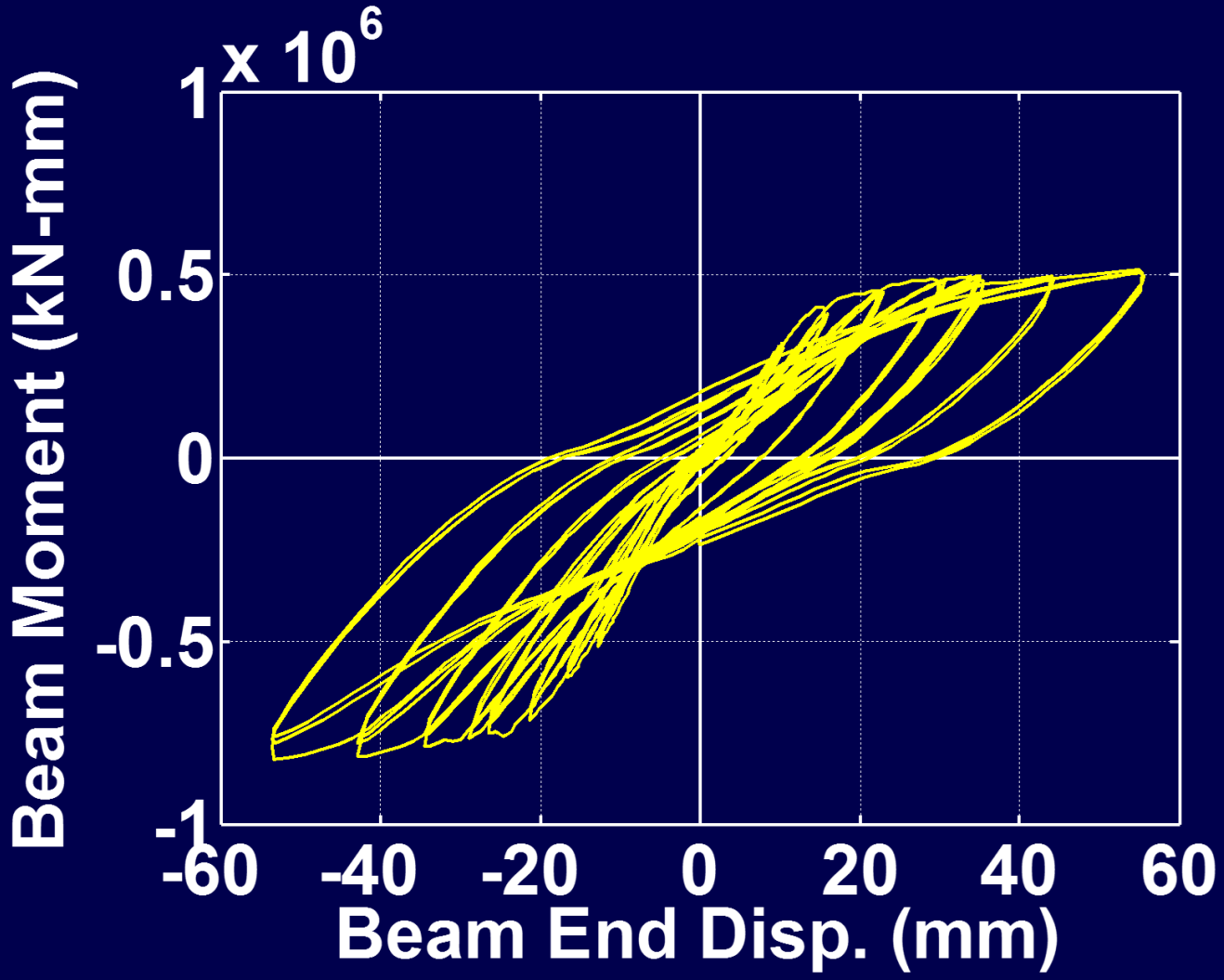


NCREE


試驗配置
Corbel Shear Actuator
Pin
Roller
Beam End Actuator
BeamAxial Actuator
Column Shear Actuator

梁桿件反應





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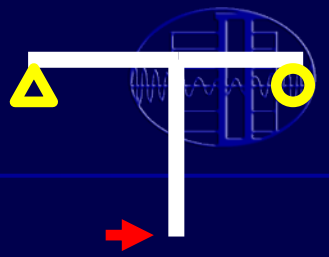
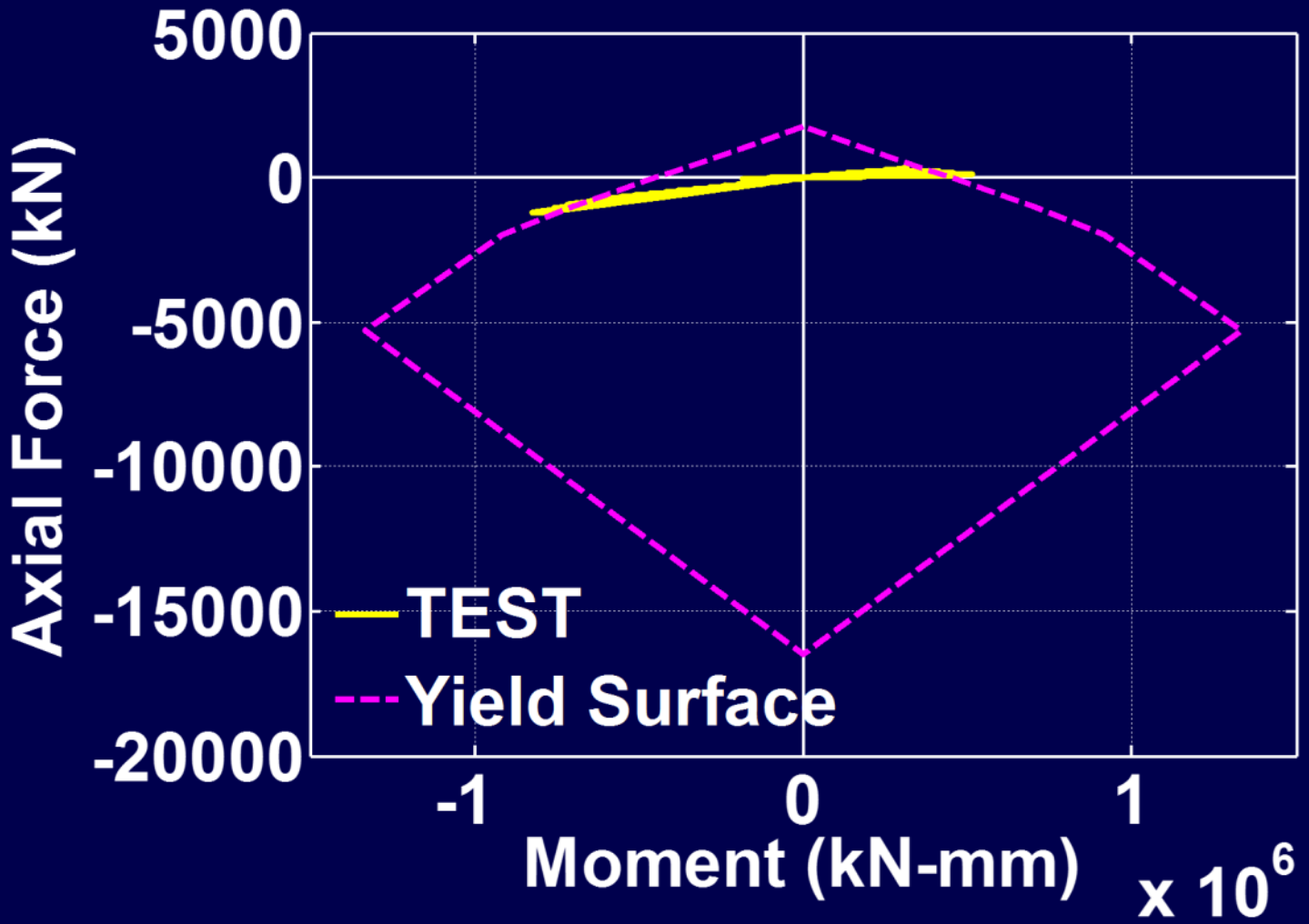
梁桿件反應





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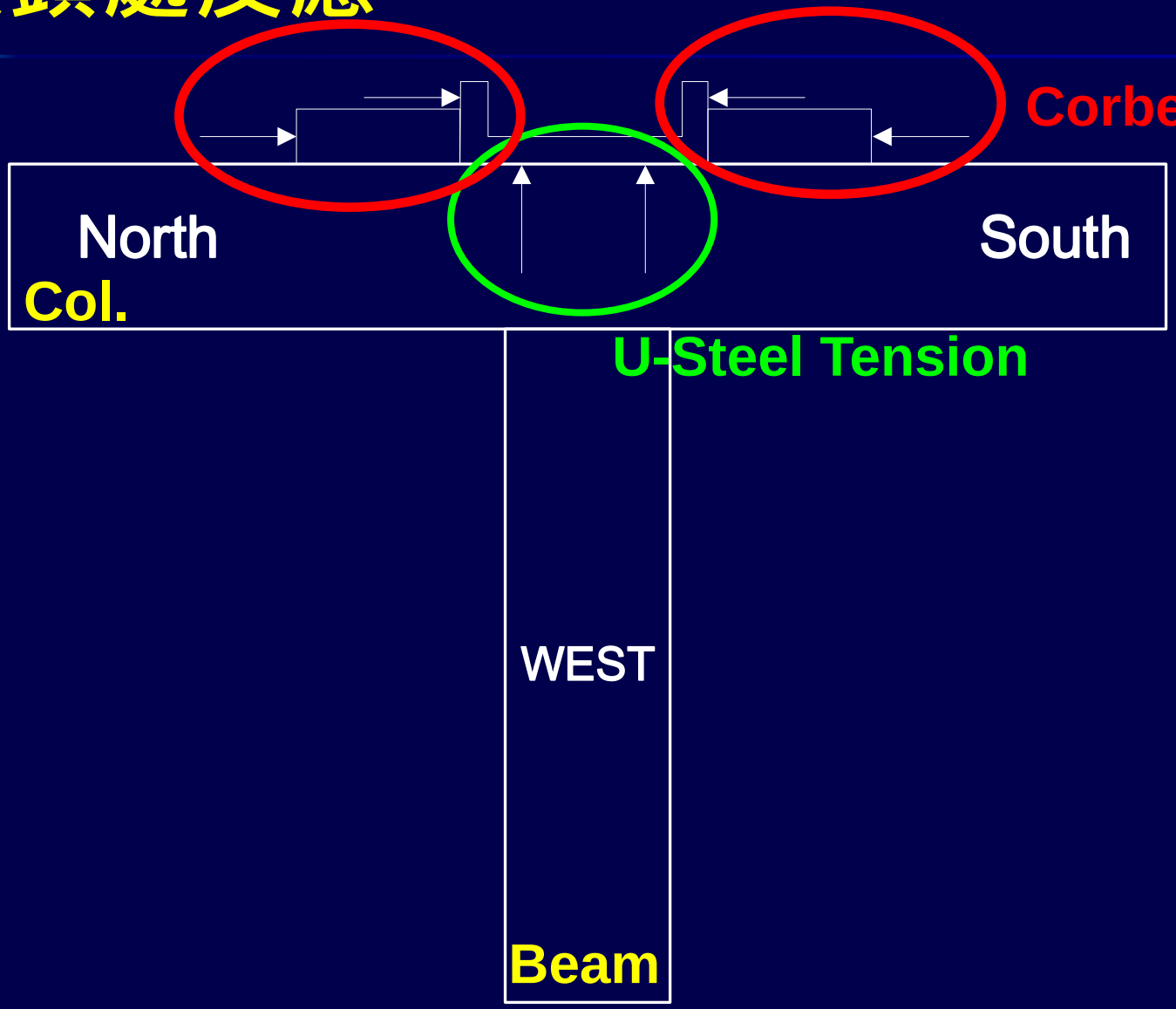
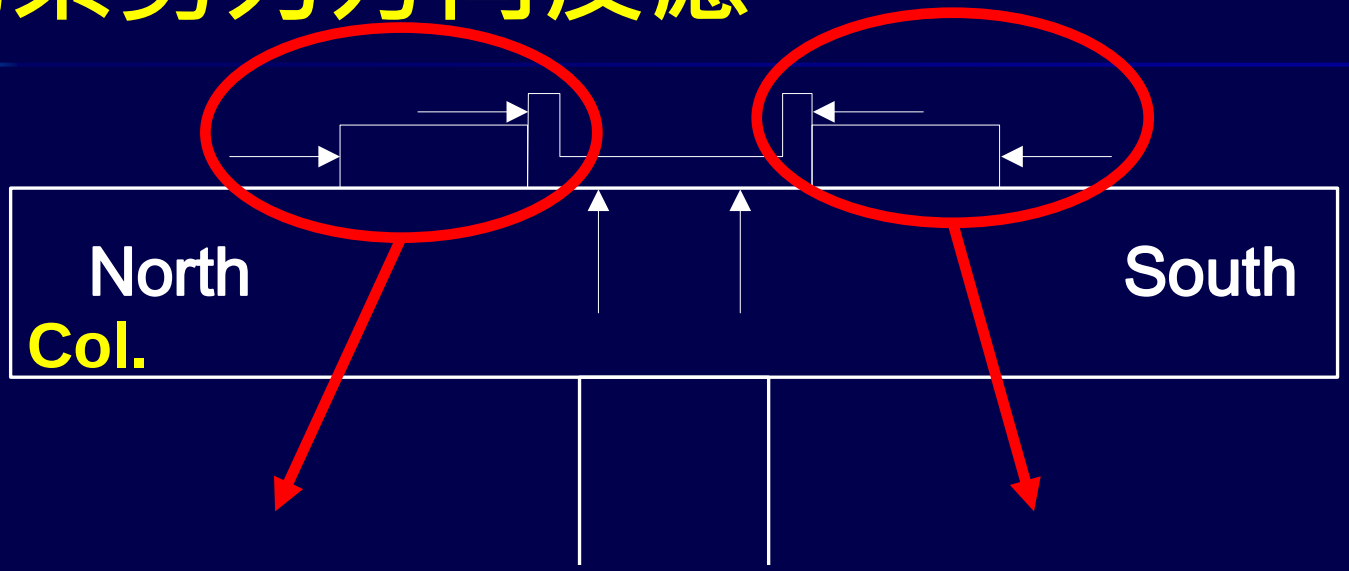
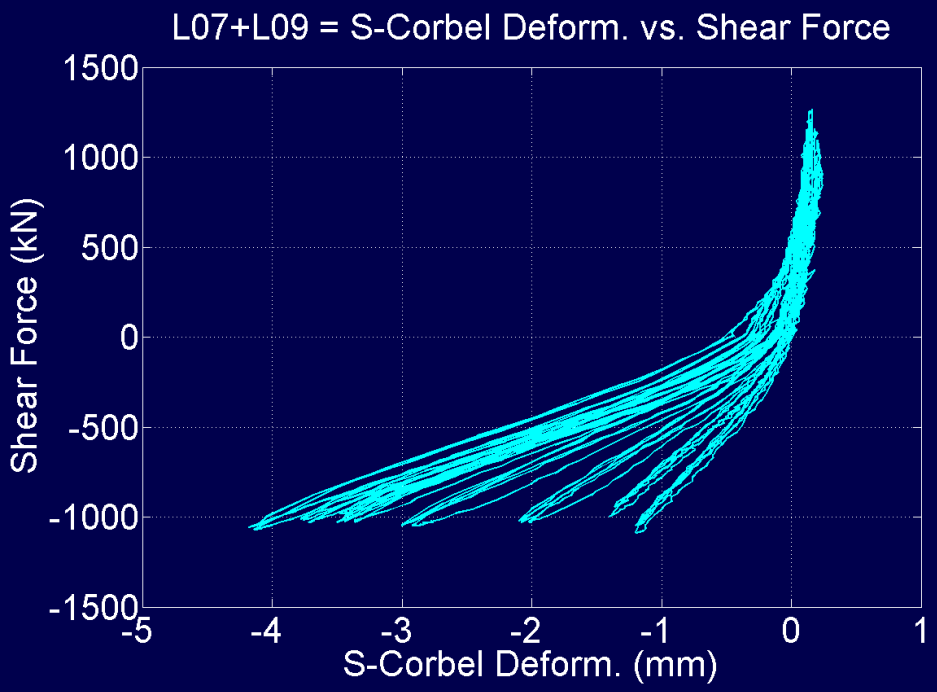
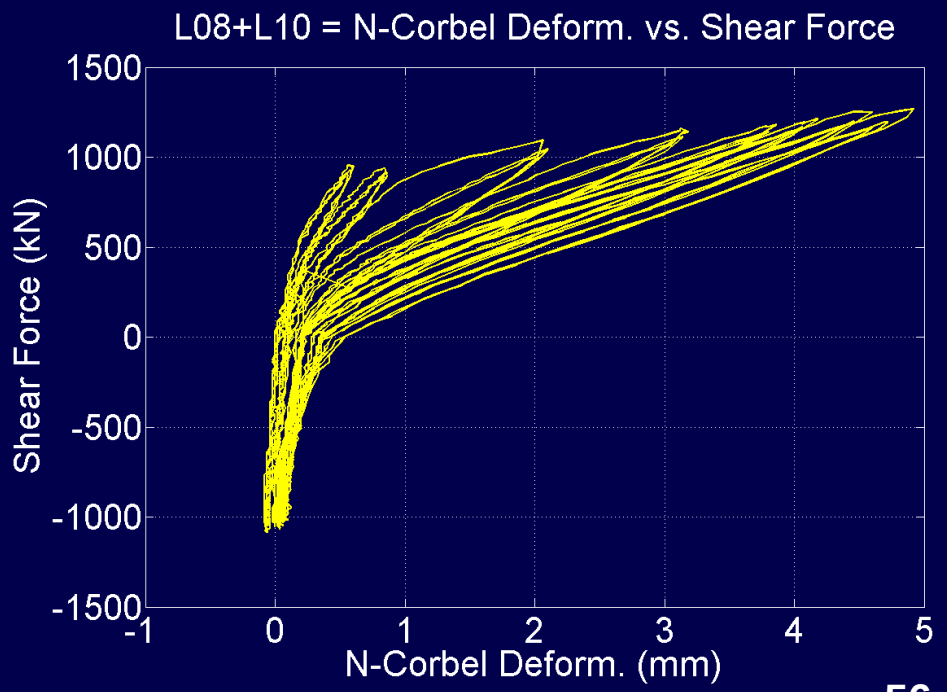
接頭處反應



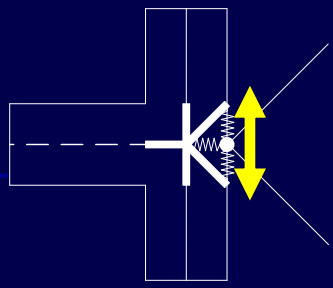
托梁剪力方向反應

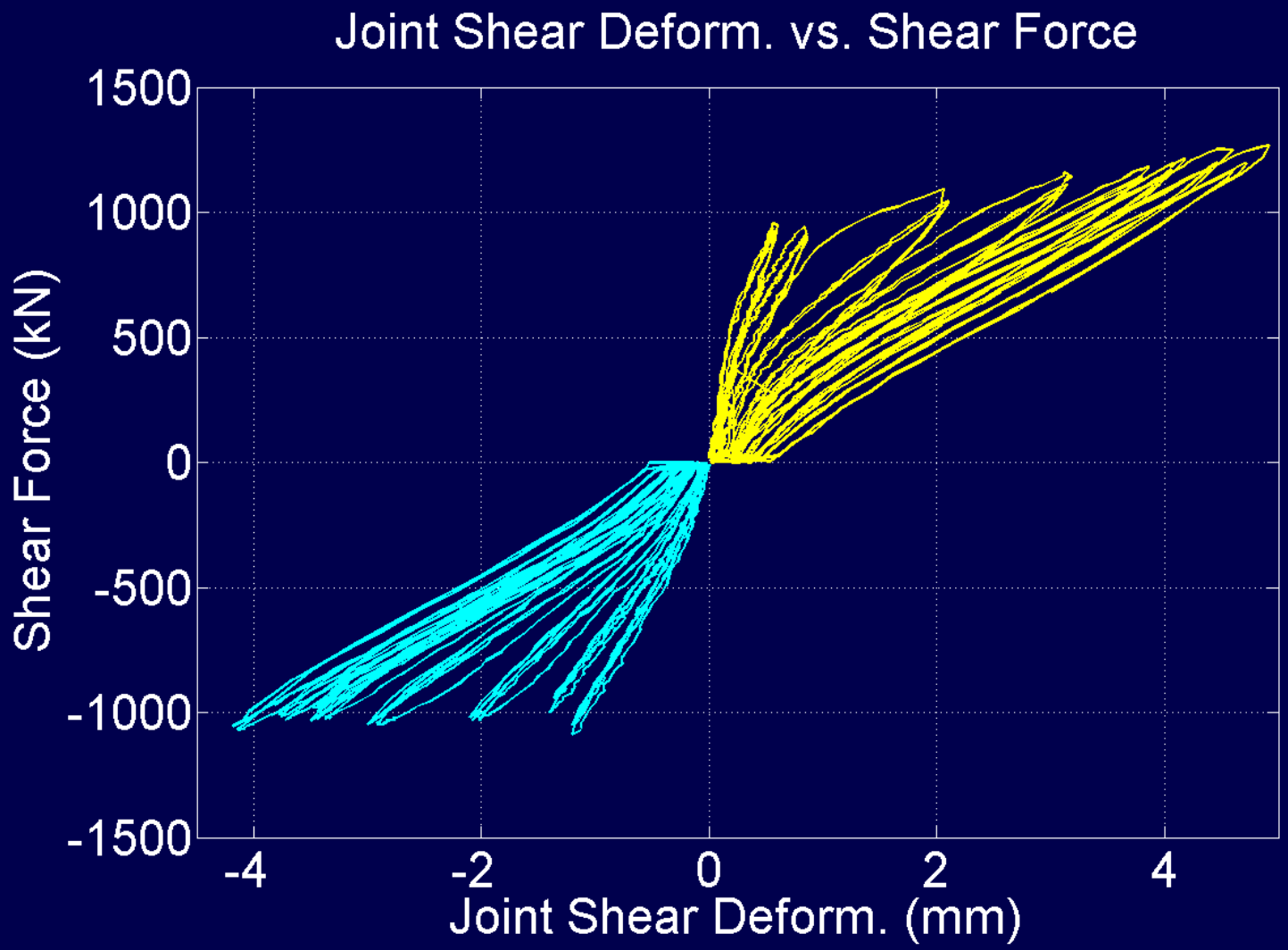

North
Col.
South


L07+L09 = S-Corbel Deform. vs. Shear Force
Shear Force (kN)
1500
1000
500
0
-500
-1000
-1500
-5
-4
-3
-2
-1
0
1
S-Corbel Deform. (mm)

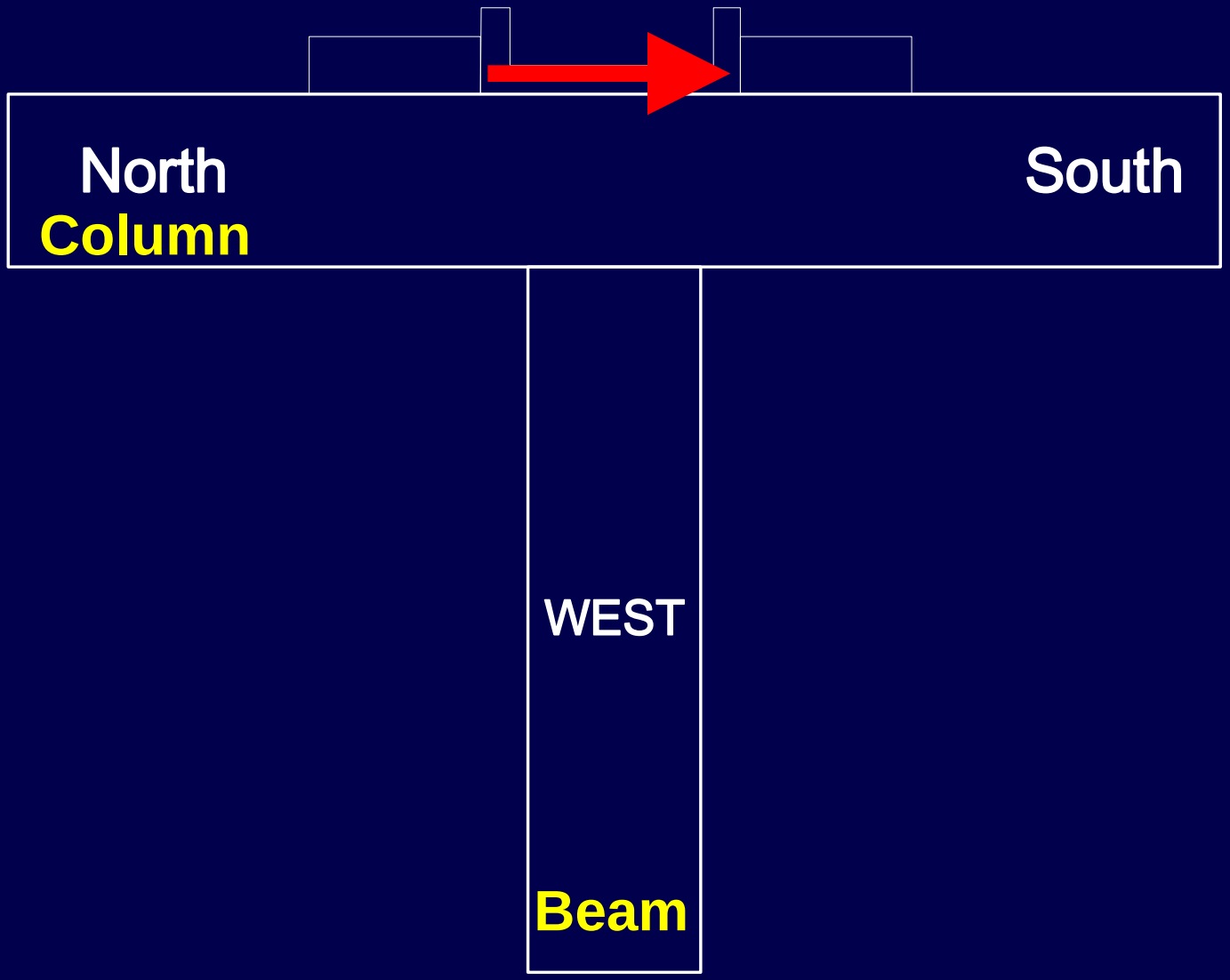

L08+L10 = N-Corbel Deform. vs. Shear Force
Shear Force (kN)
1500
1000
500
0
-500
-1000
-1500
-1
0
1
2
3
4
5
N-Corbel Deform. (mm)

托梁剪力方向變形

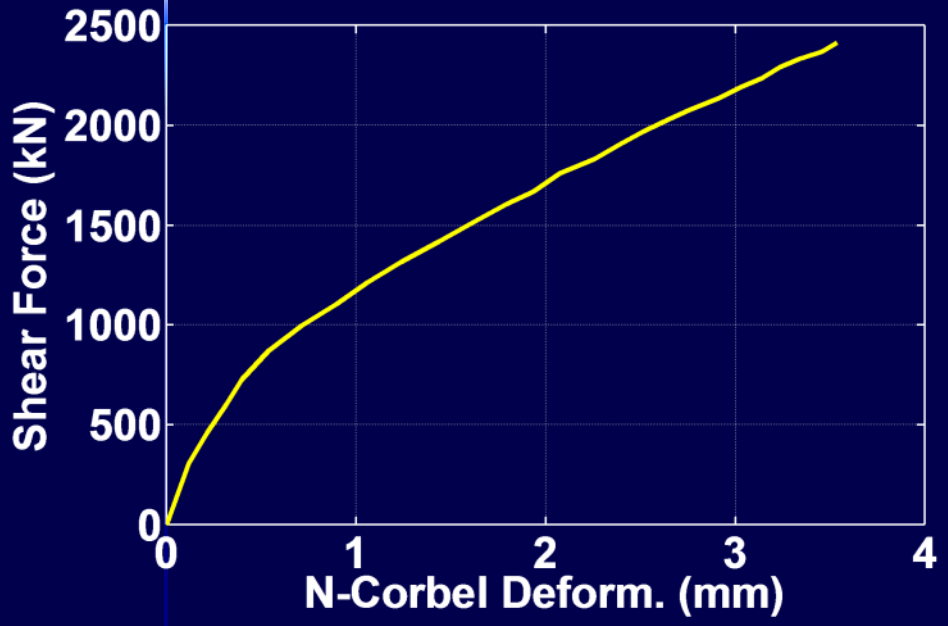


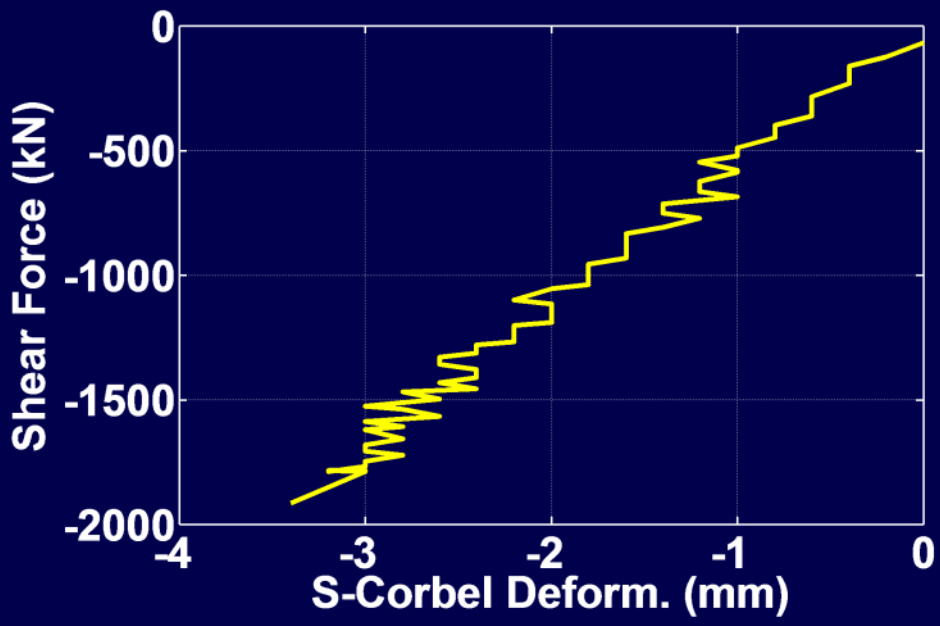


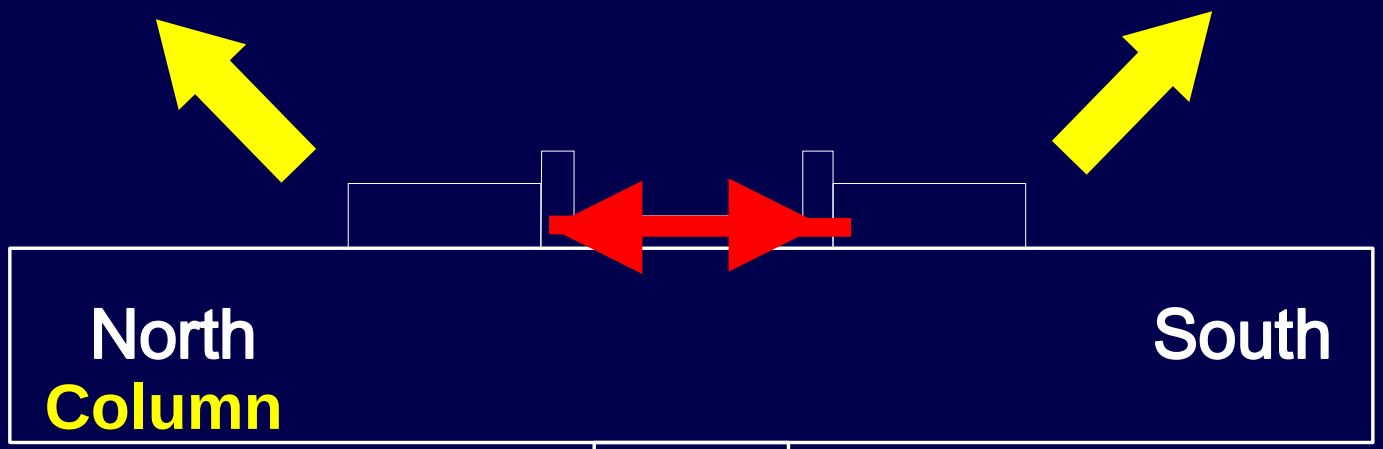
托梁強度測試



托梁強度測試







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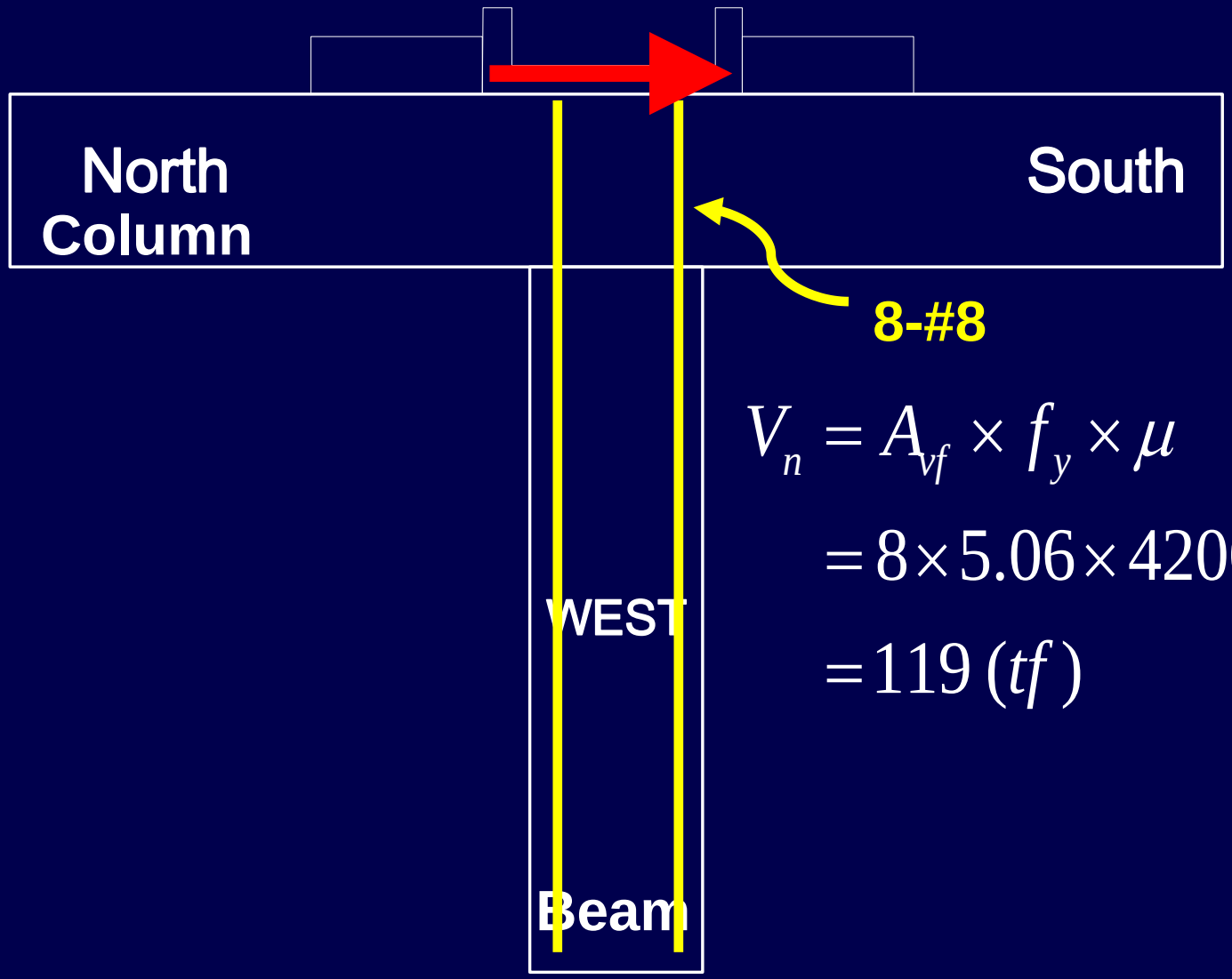
托梁強度檢核

		B1	B2
h (cm)		60	40
b (cm)		40	60
L (cm)		20	20
Rebar		6-#4	6-#4
V_u (tf)		180	
拉壓桿模型	V_n (tf)	112	110
	DCR	1.61	1.64
簡化式軟化拉壓桿	V_n (tf)	139	130
	DCR	1.29	1.38
ACI-318托梁規範	V_n (tf)	89	89
	DCR	2.02	2.02

梁主筋剪力摩擦

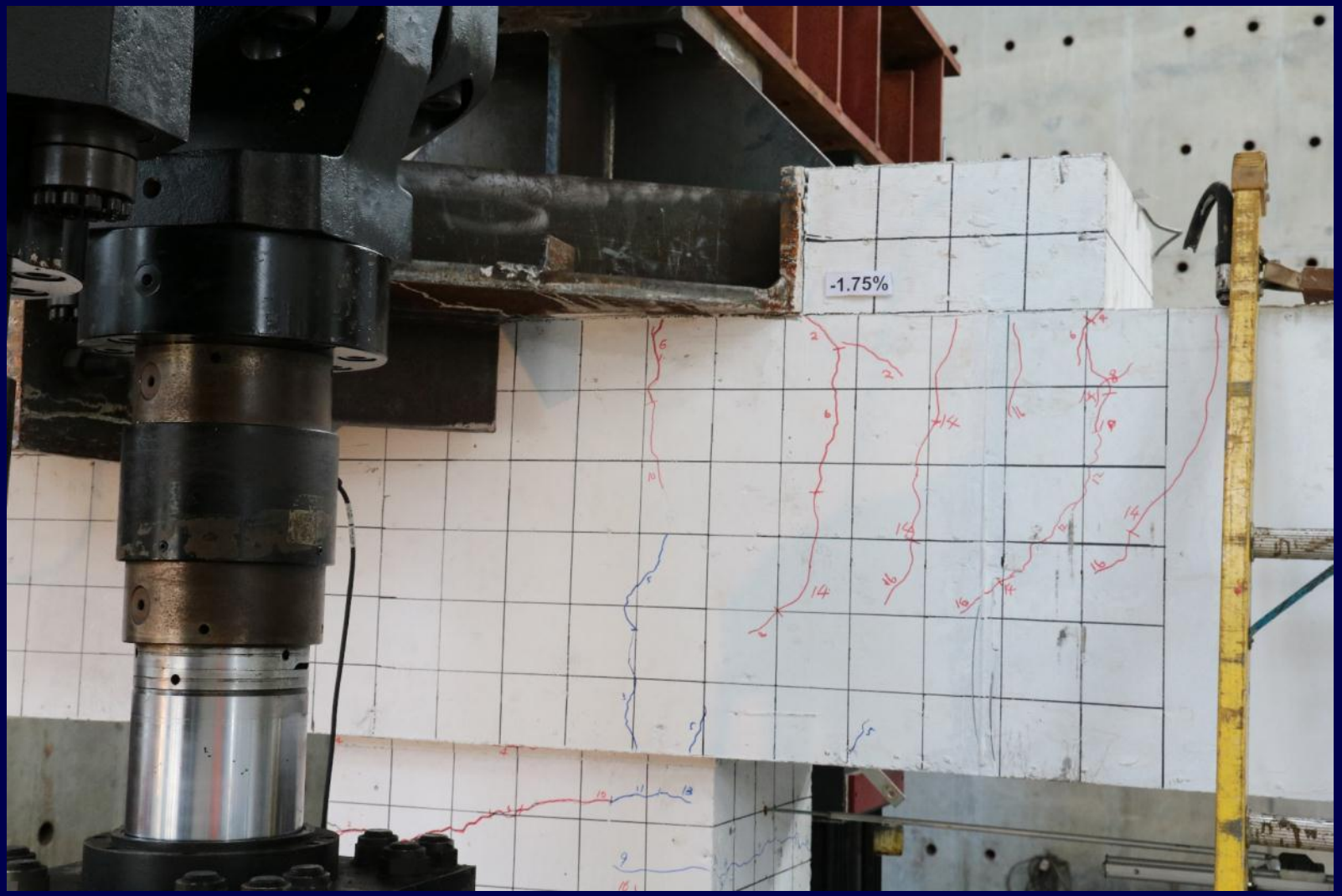


$$V_n = A_{vf} \times f_y \times \mu$$

$$= 8 \times 5.06 \times 4200 \times 0.7$$

$$= 119\ (tf)$$

托梁試驗反應



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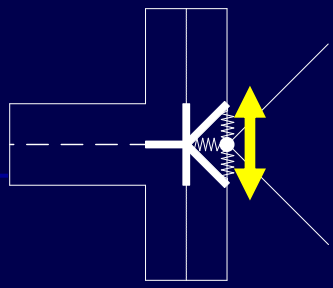
托梁試驗反應

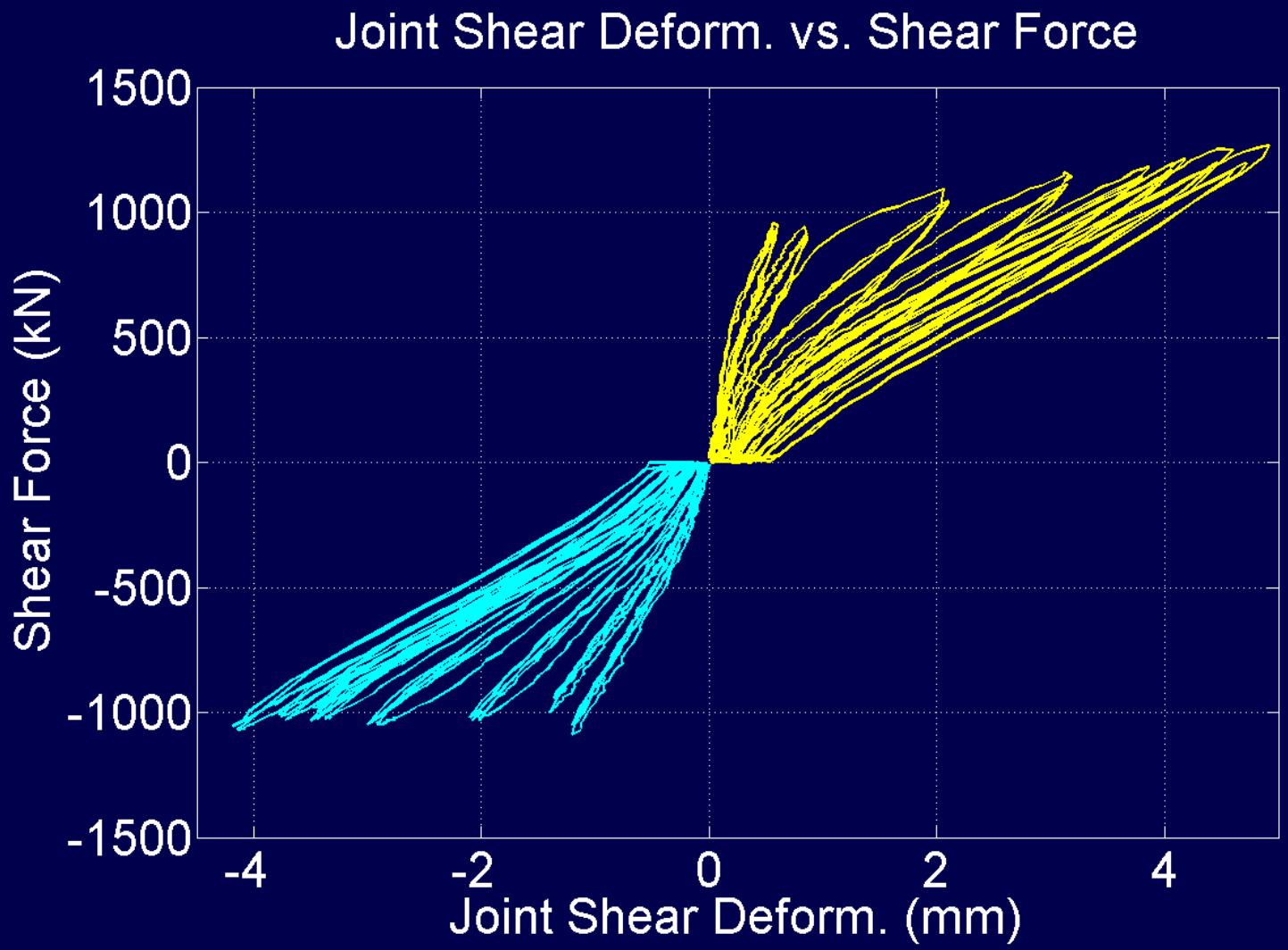
托梁與U型鐵件縫隙 (上視圖)

托梁與U型鐵件縫隙 (上視圖)

托梁與U型鐵件縫隙 (側視圖)

接頭剪力方向反應





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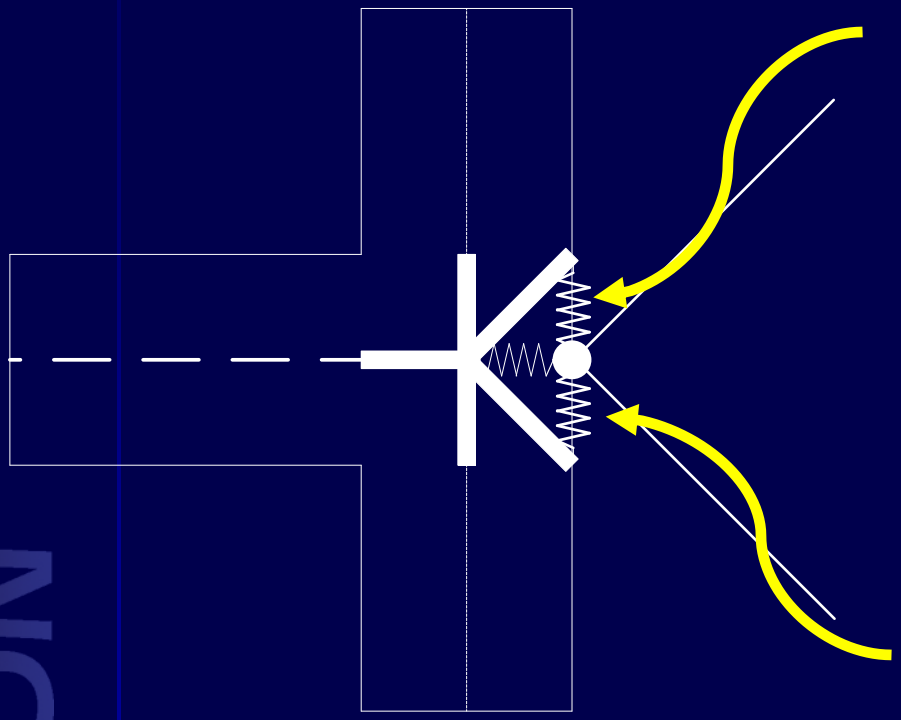
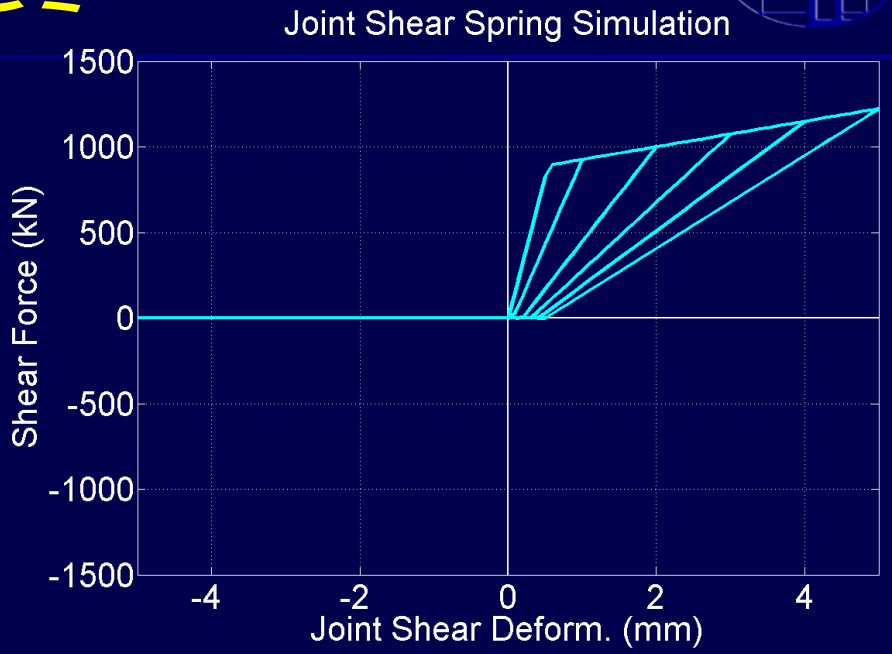
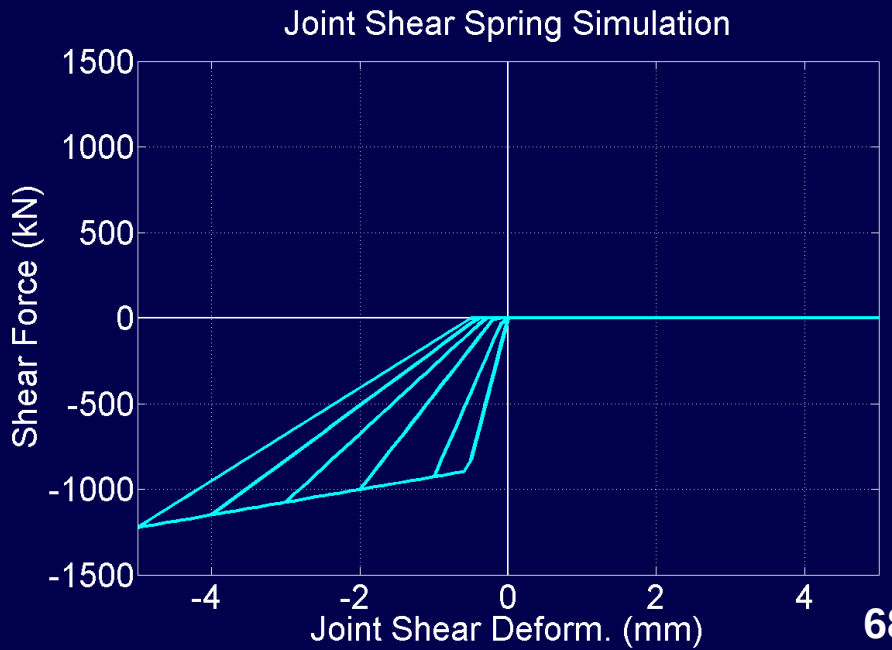
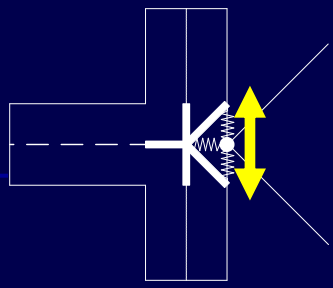
接頭剪力方向彈簧

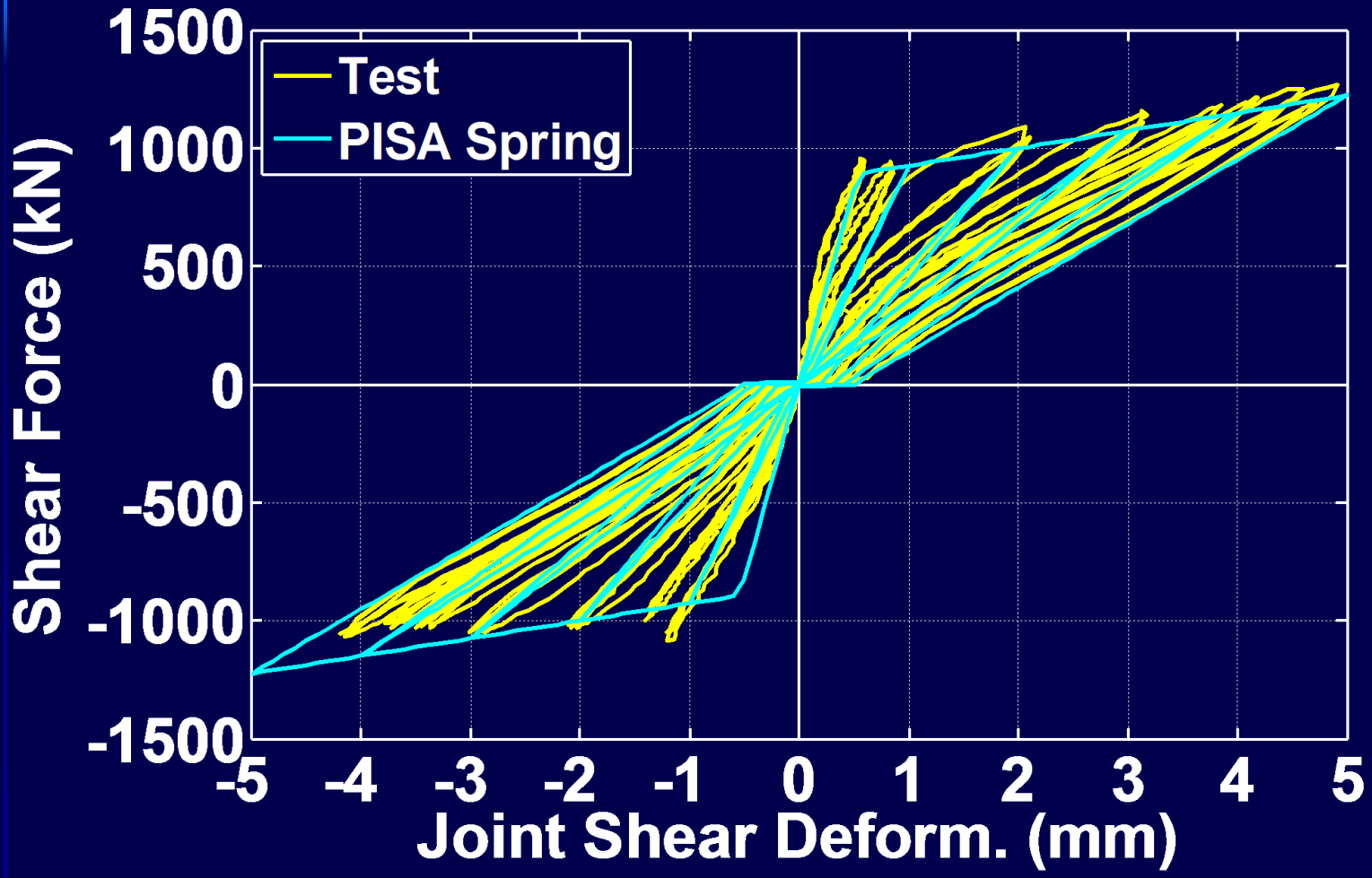



Joint Shear Spring Simulation
1500
1000
500
0
-500
-1000
-1500
Shear Force (kN)
-4
-2
0
2
4
Joint Shear Deform. (mm)


Joint Shear Spring Simulation
1500
1000
500
0
-500
-1000
-1500
Shear Force (kN)
-4
-2
0
2
4
Joint Shear Deform. (mm)

接頭剪力方向彈簧模擬





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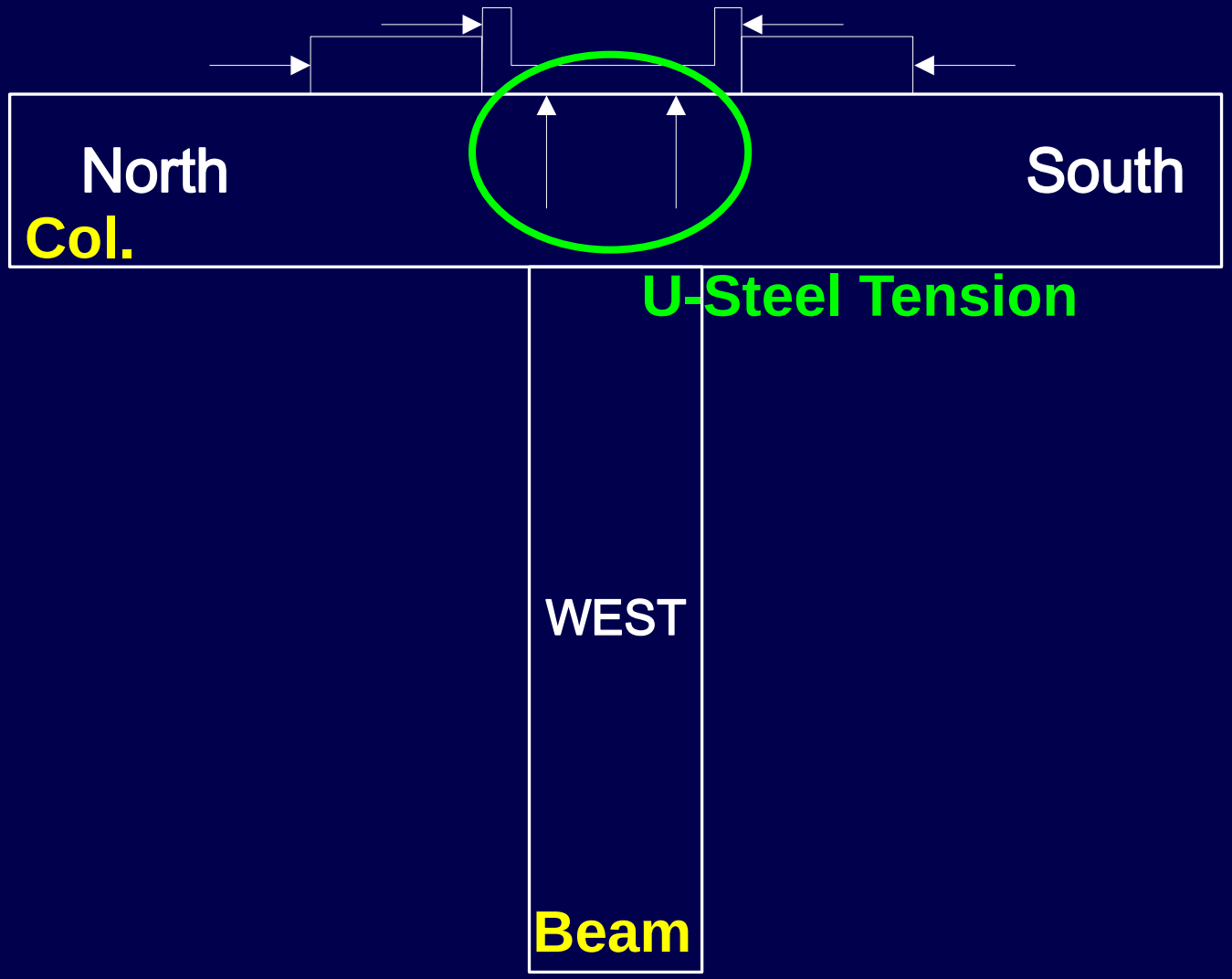
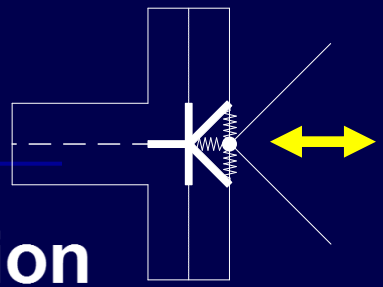
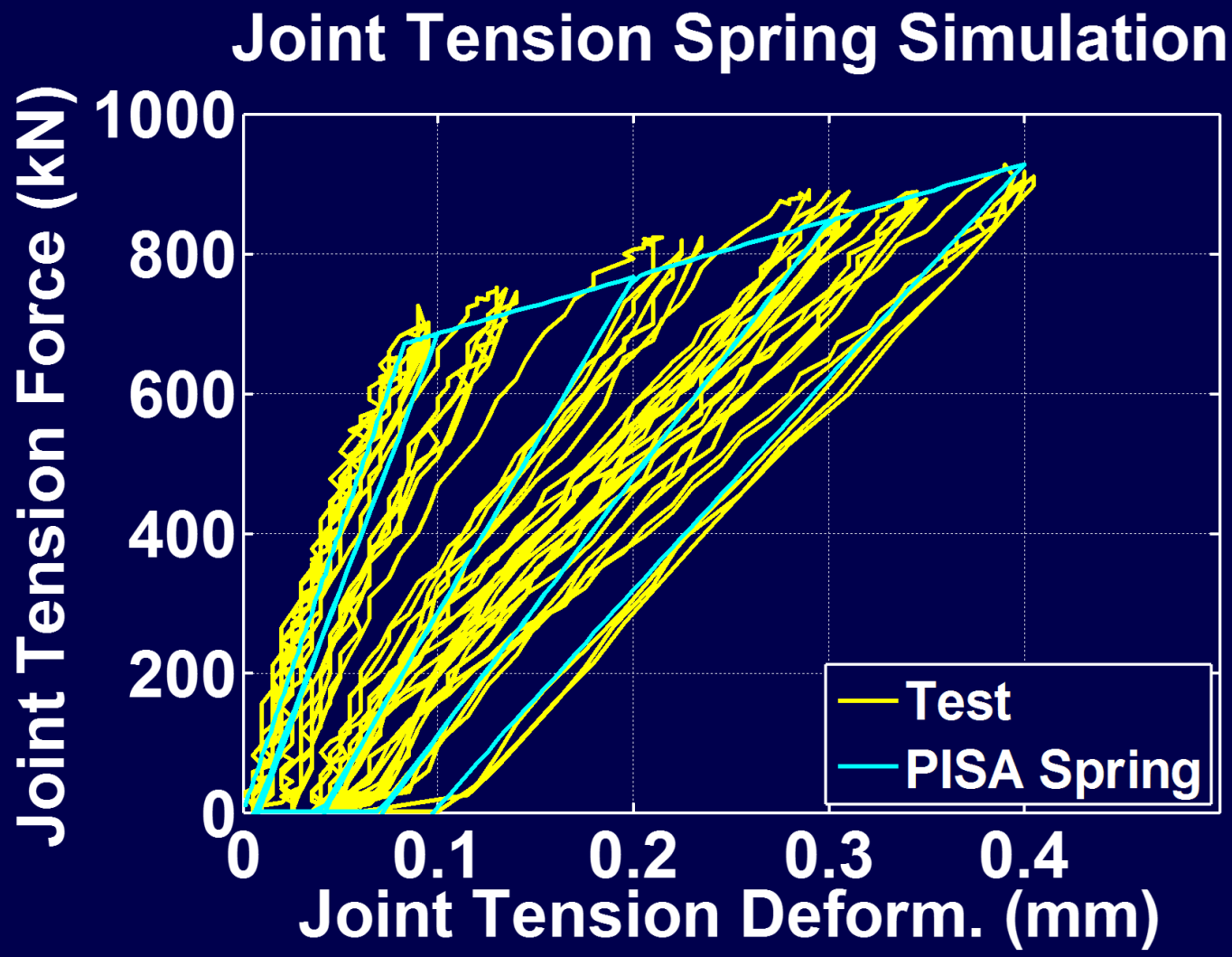
U型鐵件拉力方向反應



U型鐵件拉力變形





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簡報大綱

- 背景介紹
- 鋼筋混凝土構架設計
- 挫屈束制支撐與RC構架交界接頭設計
  - 接合板
  - U型鐵件
  - 托梁
- 施工流程
- 子結構試驗
- 非線性動力歷時分析
- 結論

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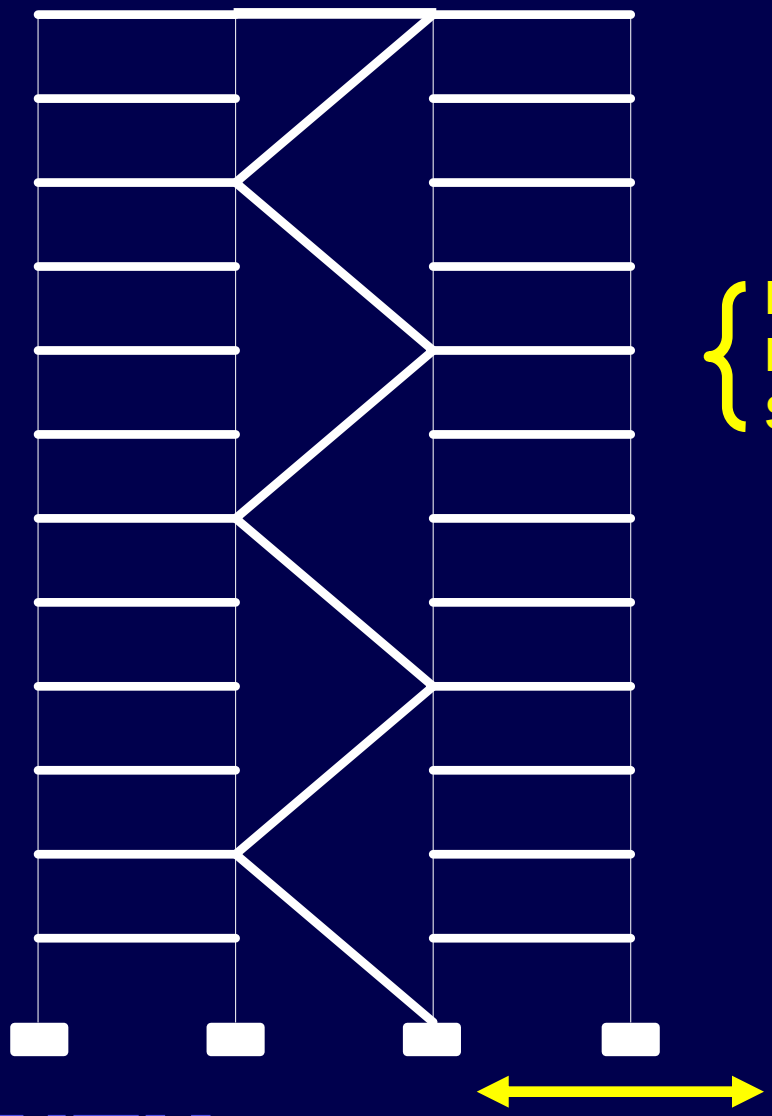
非線性動力歷時分析



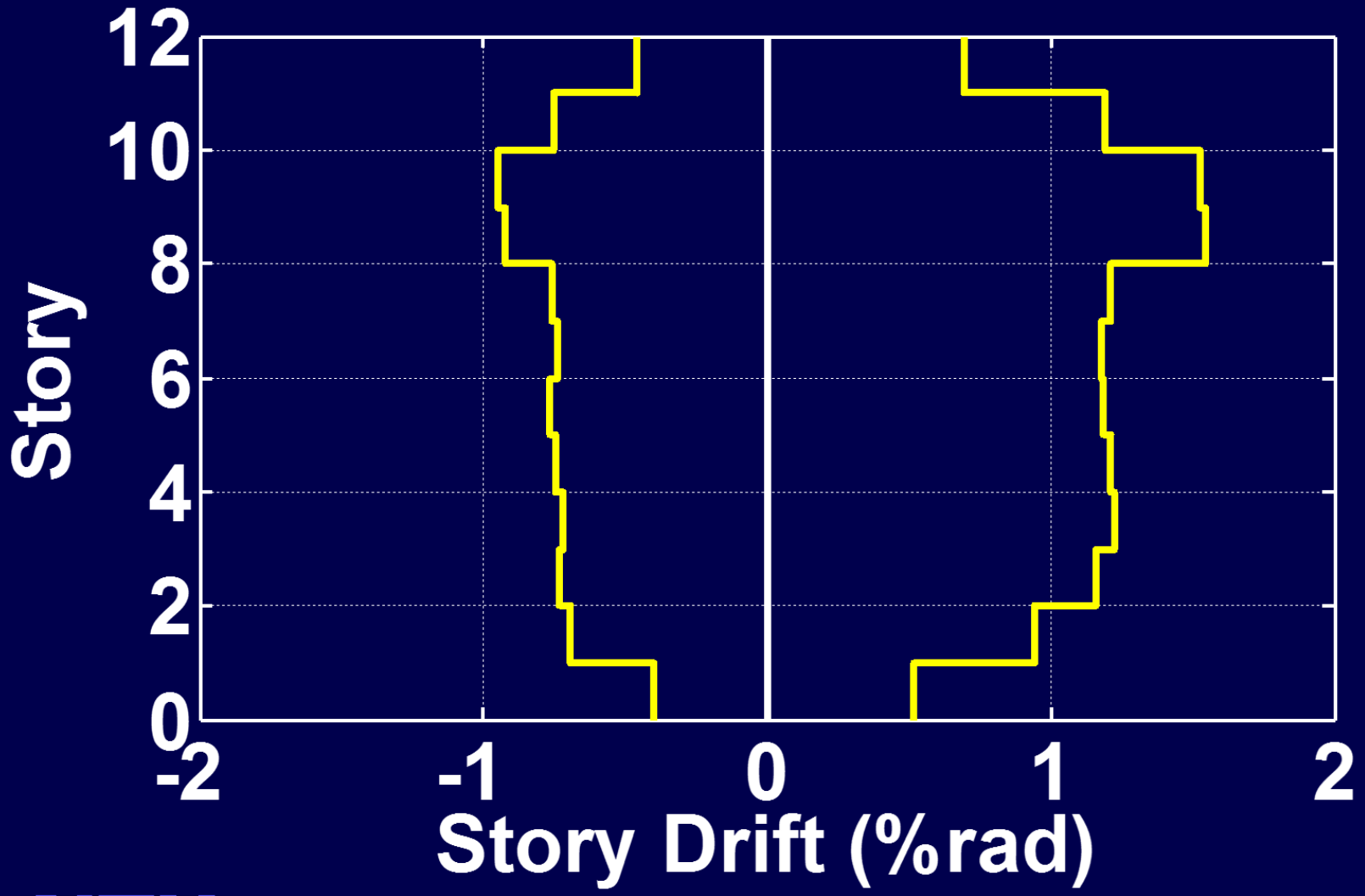
Baker, J. (2010). PEER site-specific ground motions for **Oakland**

MCE Level: 40 site records with 2 dir.
DBE Level: 40 site records with 2 dir.
SLE Level: 40 site records with 2 dir.

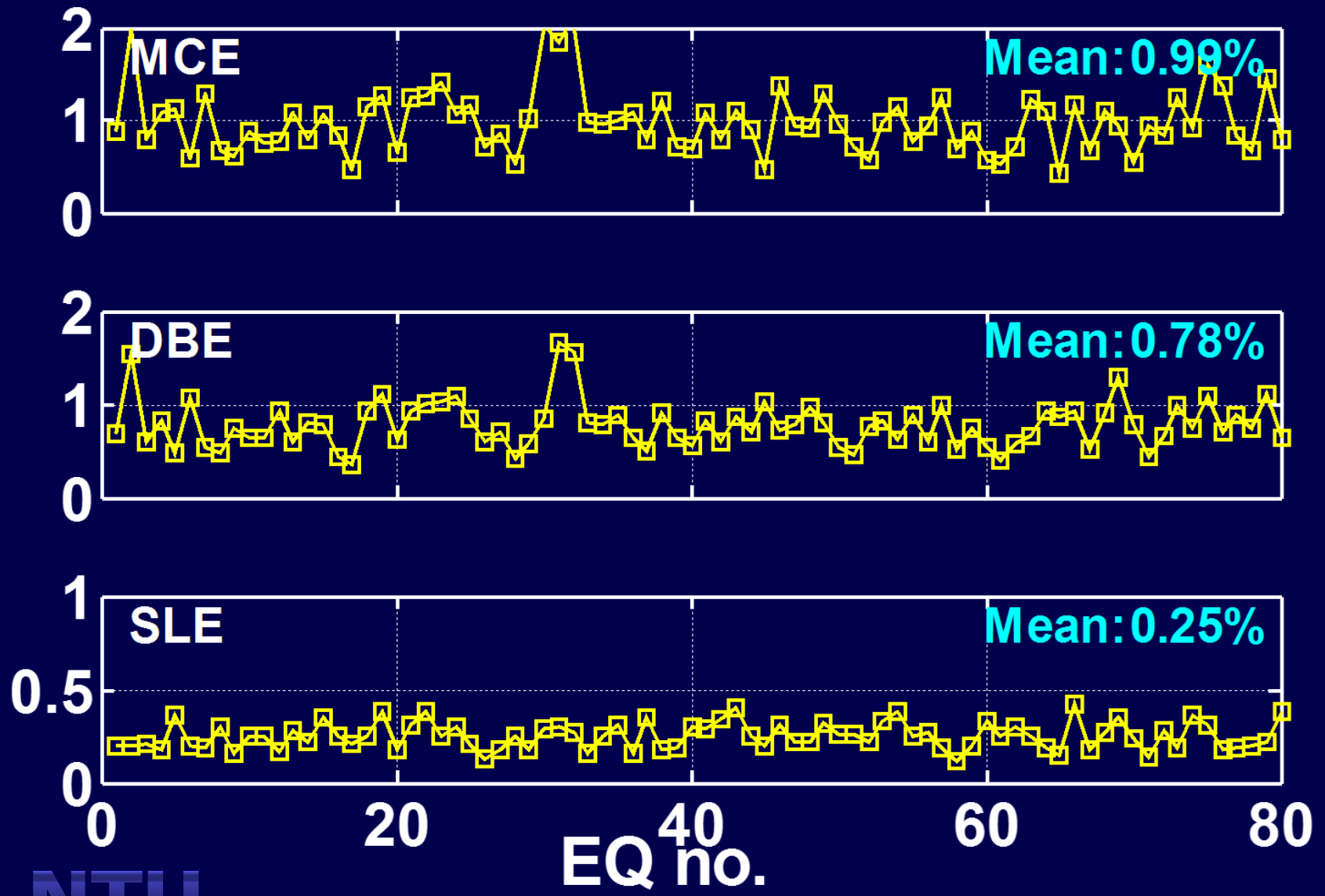
共 240 組地震紀錄

層間側位移角

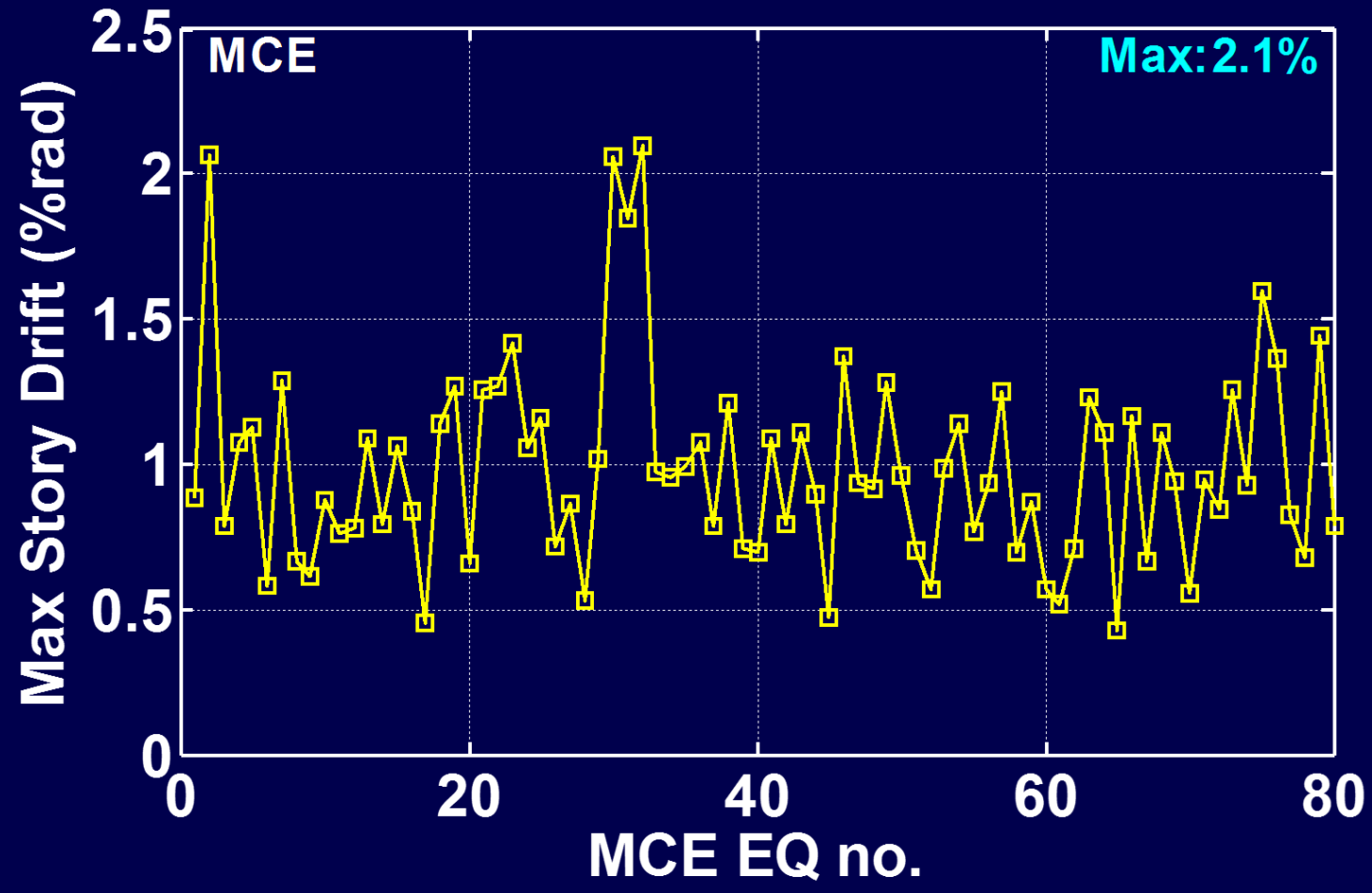
GM: Oak 10/50 FN_2



最大層間側位移角



最大層間側位移角 (MCE)



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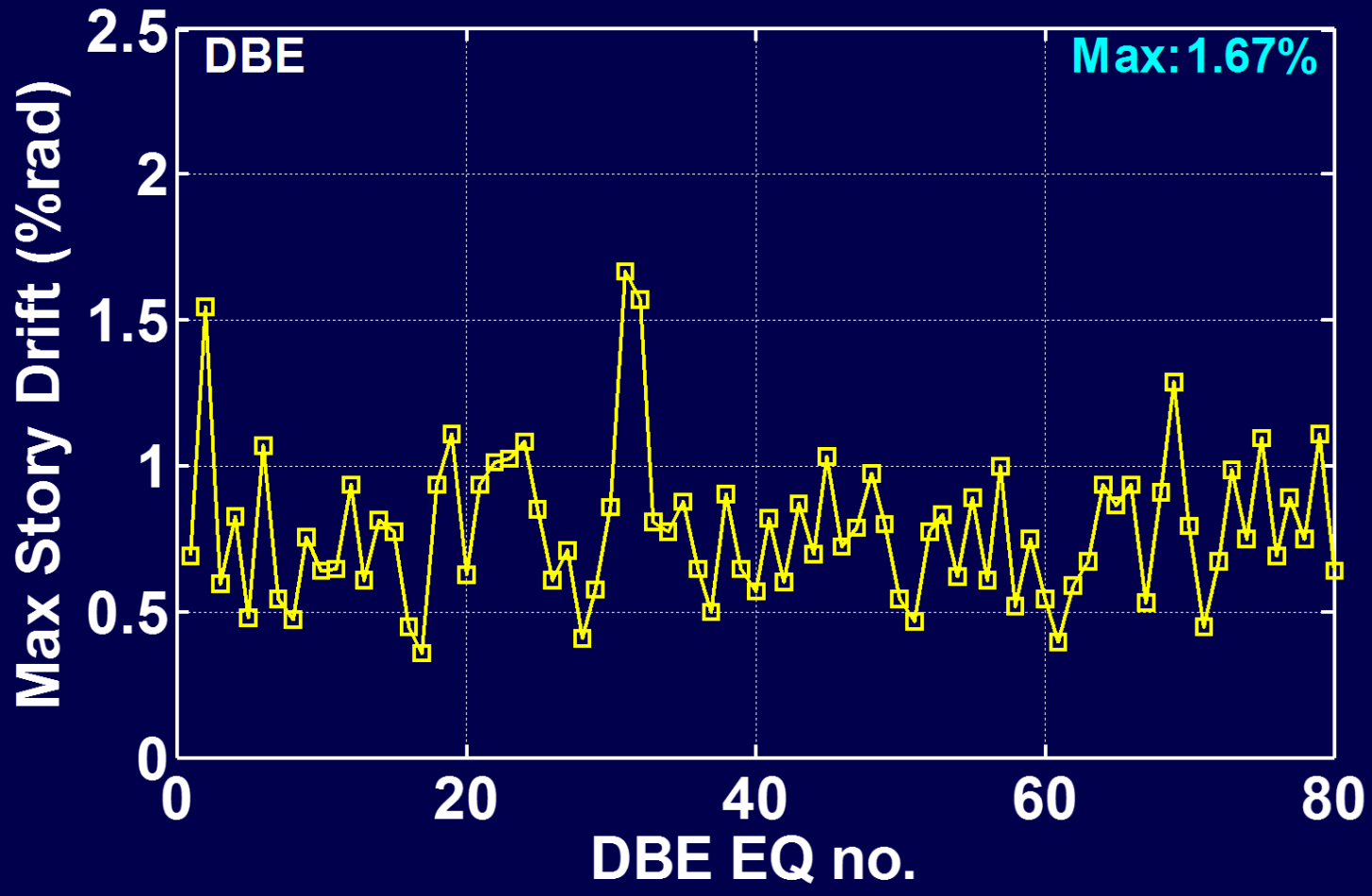
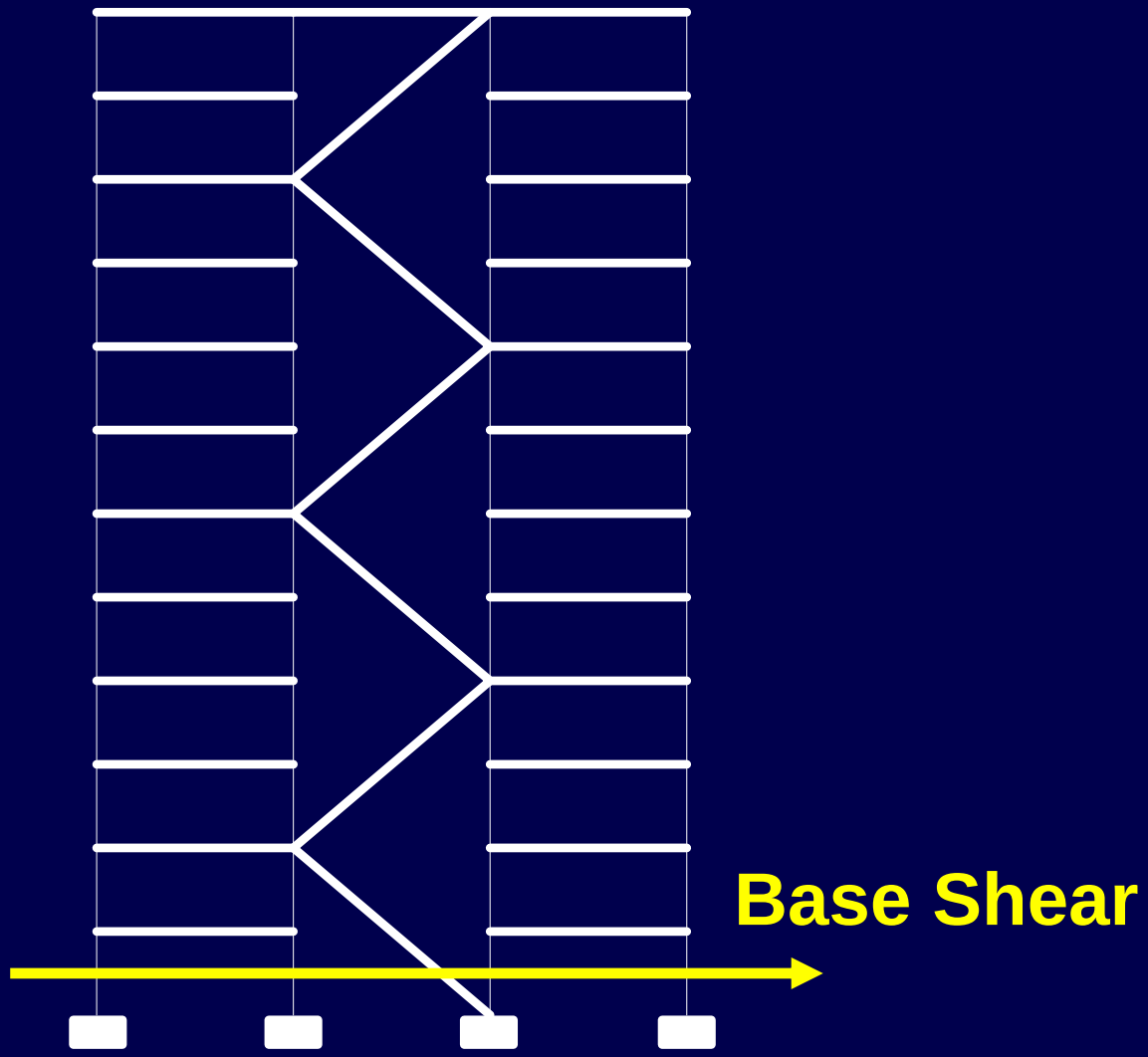
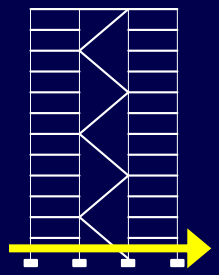
最大層間側位移角 (DBE)

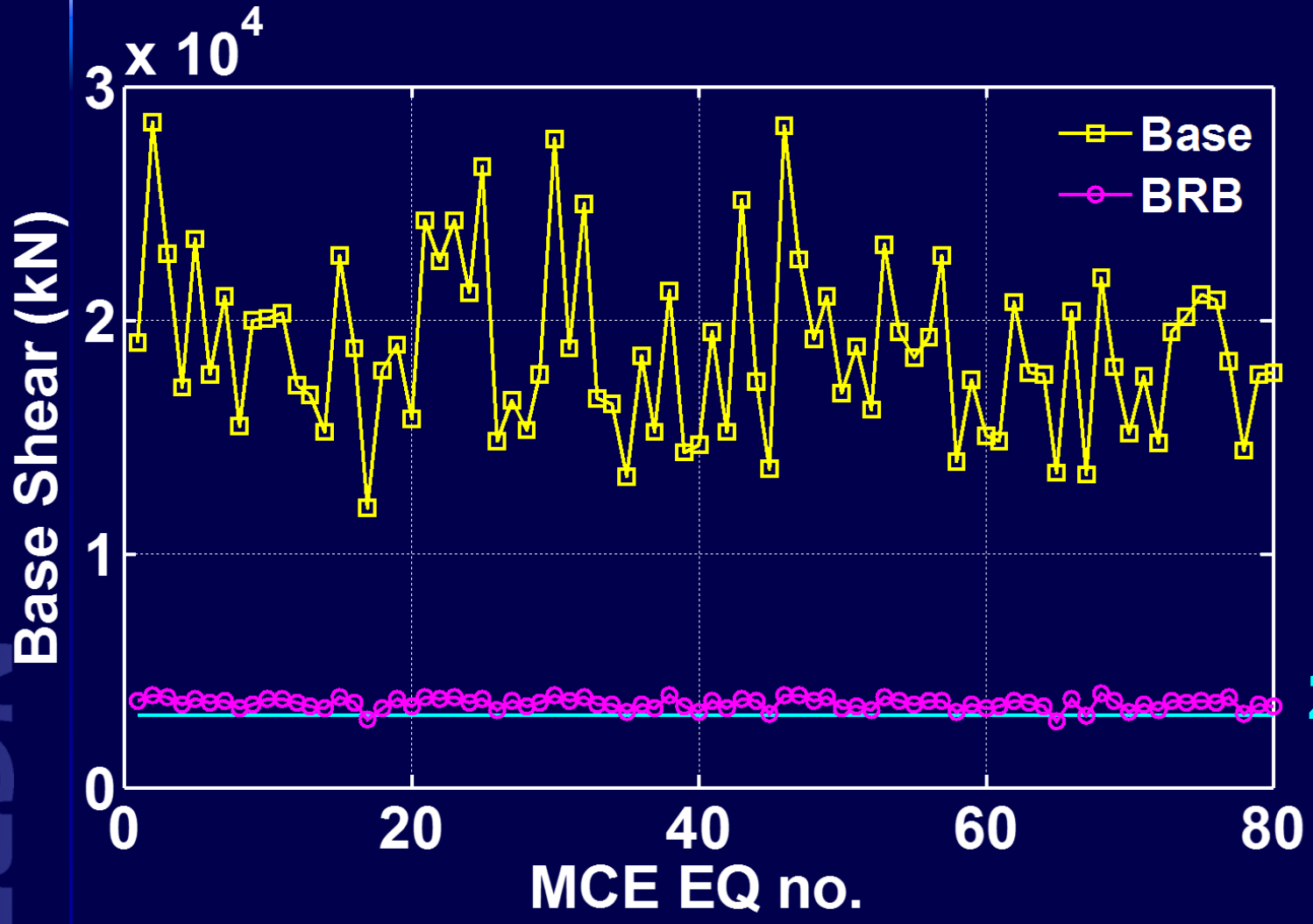


基底剪力



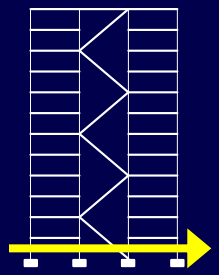
基底剪力 (MCE)

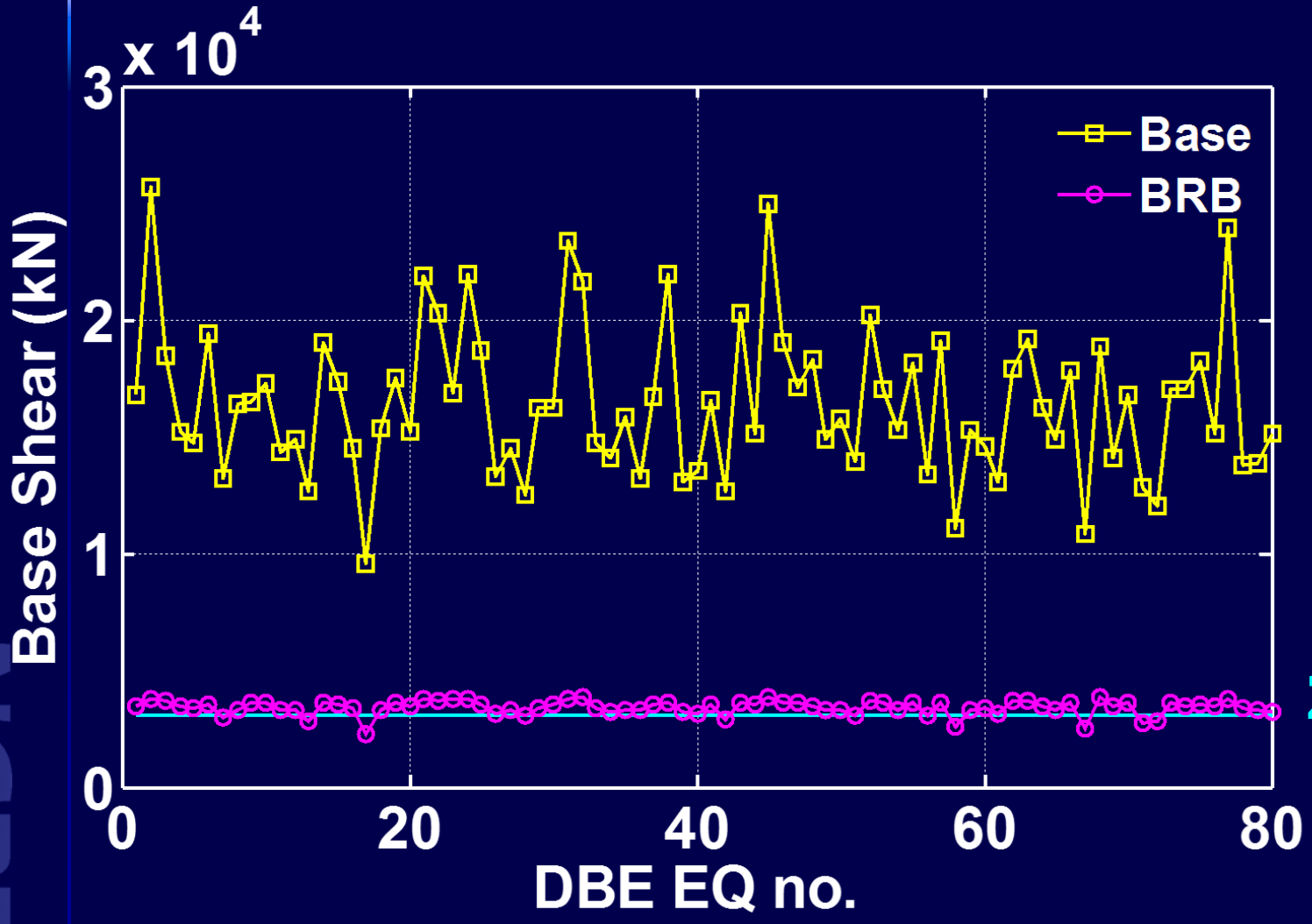




$2P_y \cos\phi$

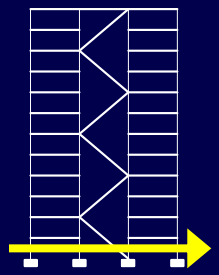
基底剪力 (DBE)

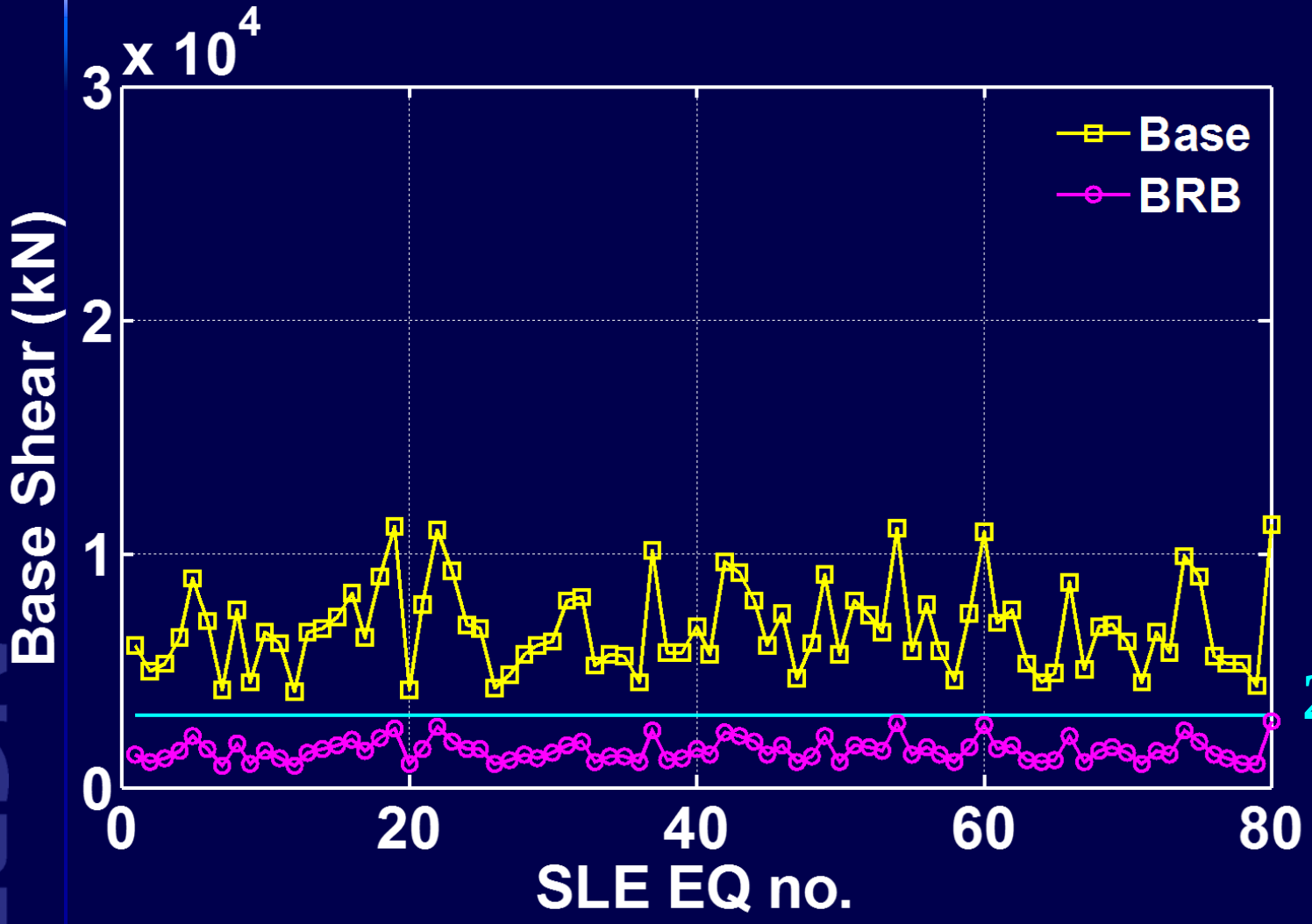




$2P_y \cos\phi$

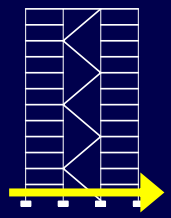
基底剪力 (SLE)

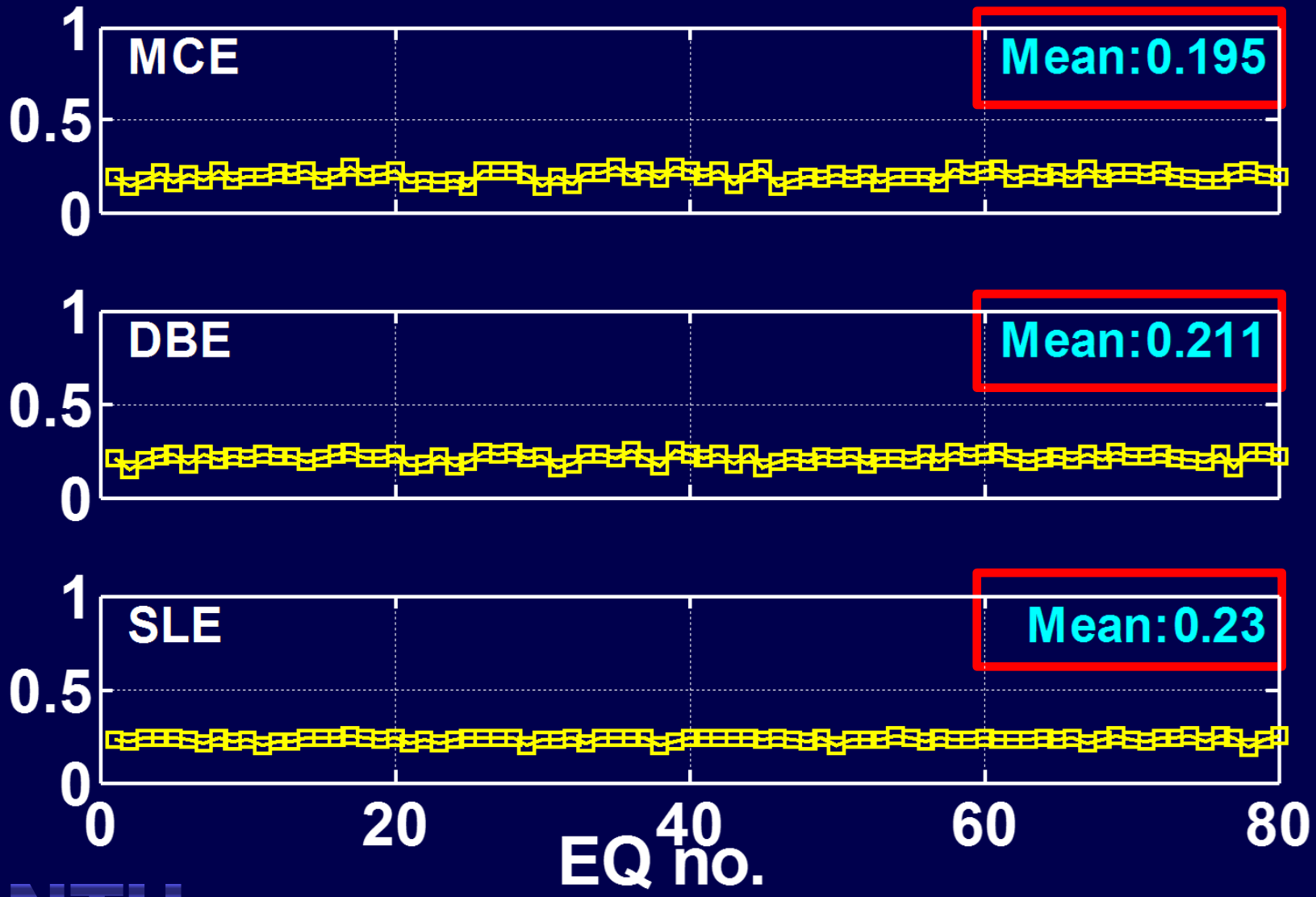




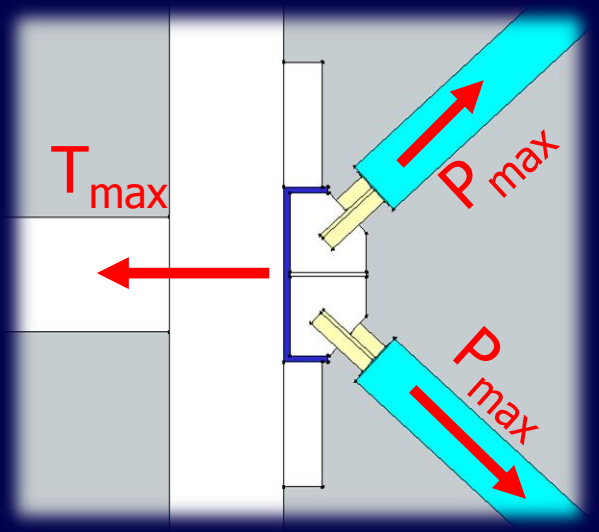
$2P_y \cos\phi$

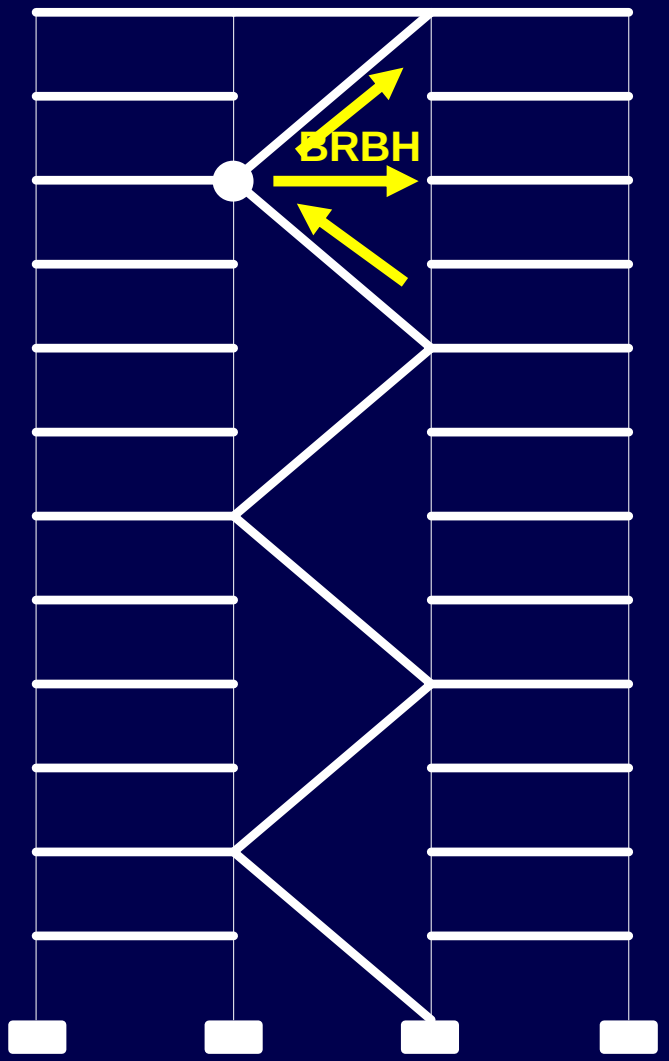
BRB剪力 / 基底剪力




BRB Shear / Base Shear
MCE
Mean:0.195
DBE
Mean:0.211
SLE
Mean:0.23
1
0.5
0
0
20
40
60
80
EQ no.

接頭處容量設計法檢討





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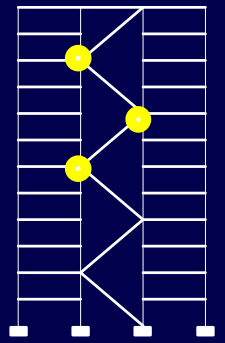
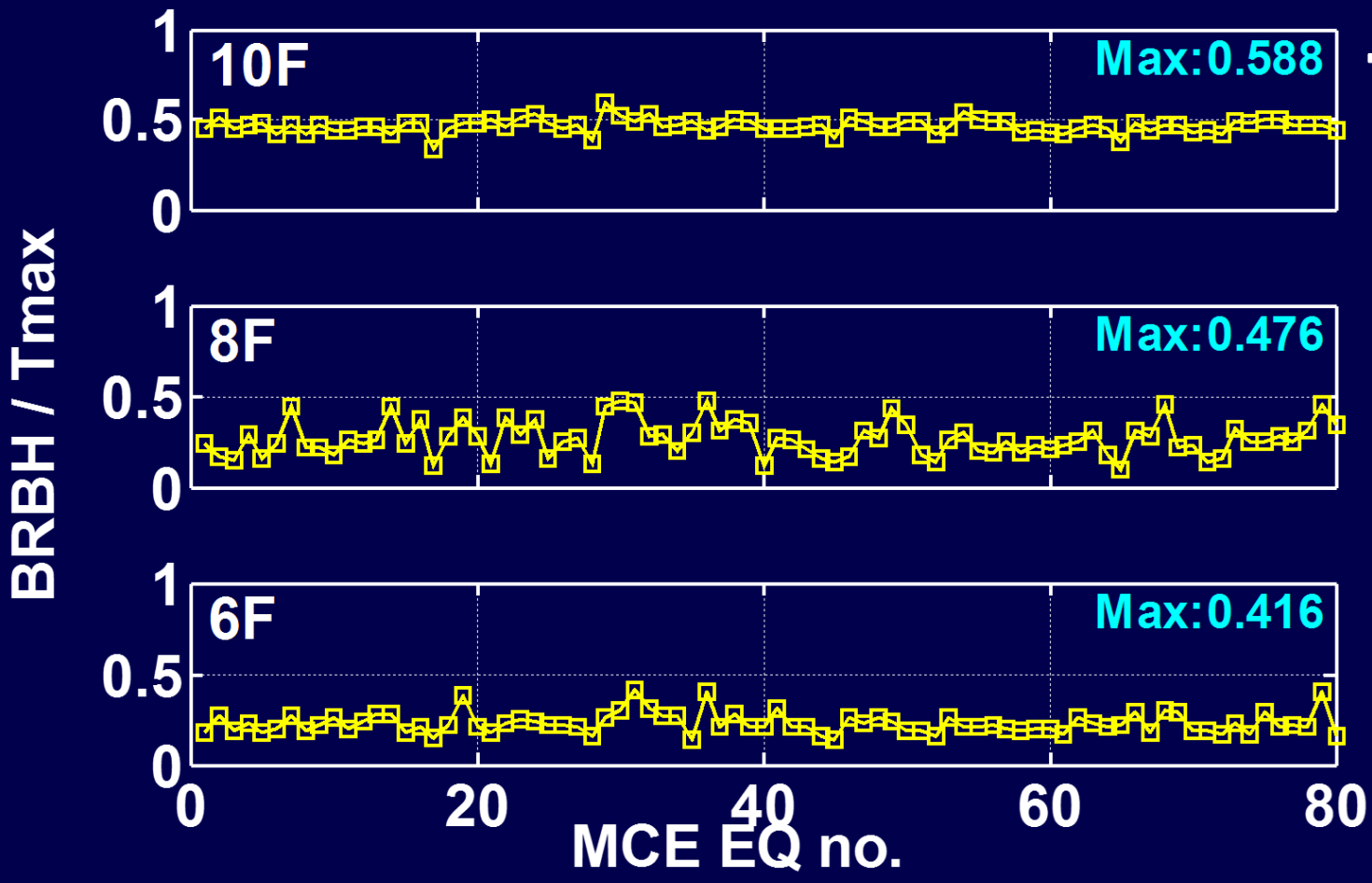
BRBH / T_{max} (MCE)

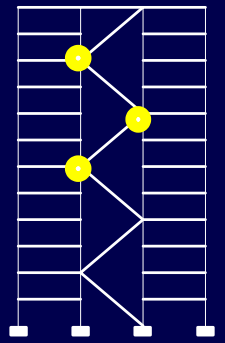


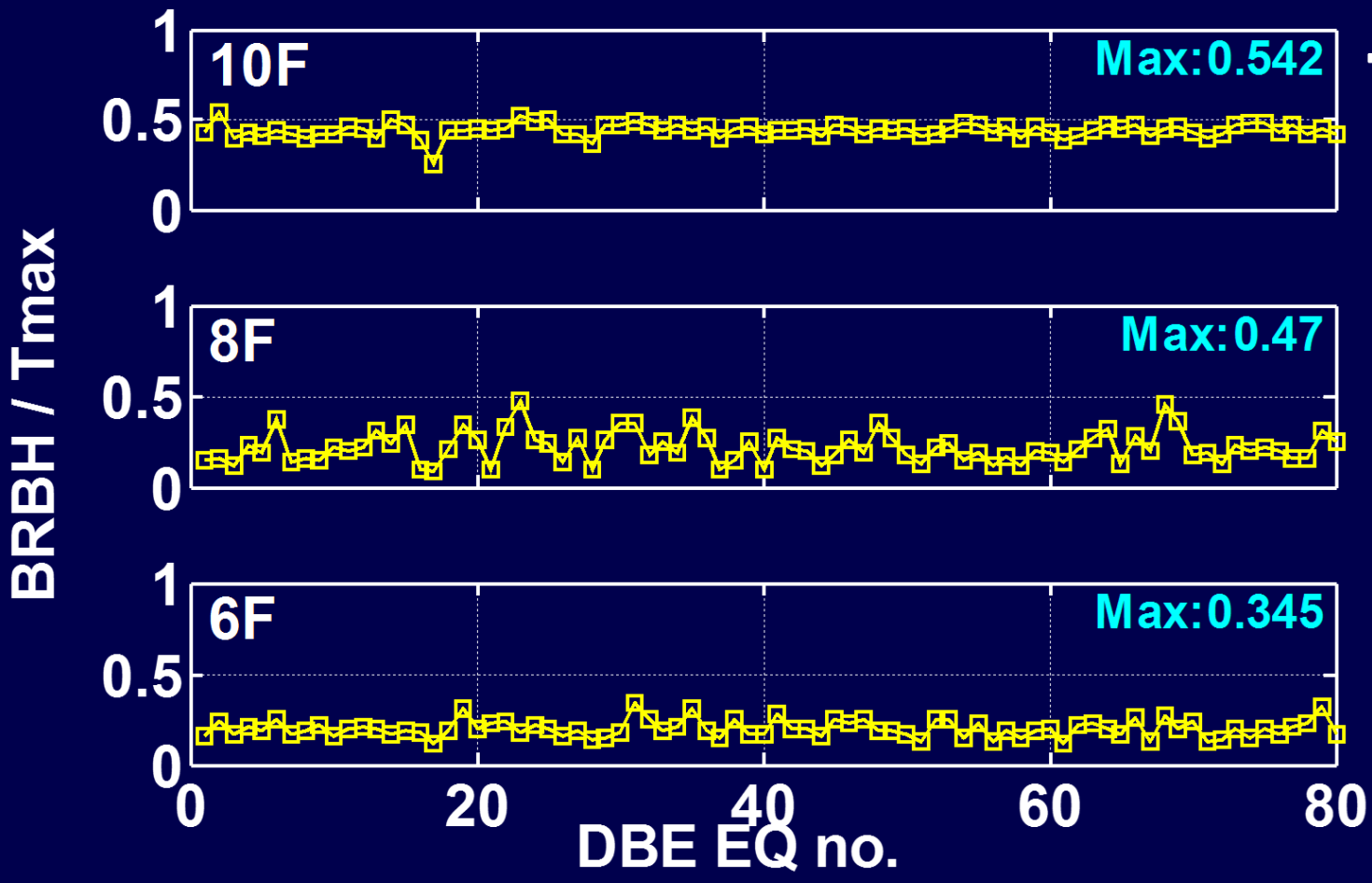


NCREE

NTU

BRBH / T_{max} (DBE)

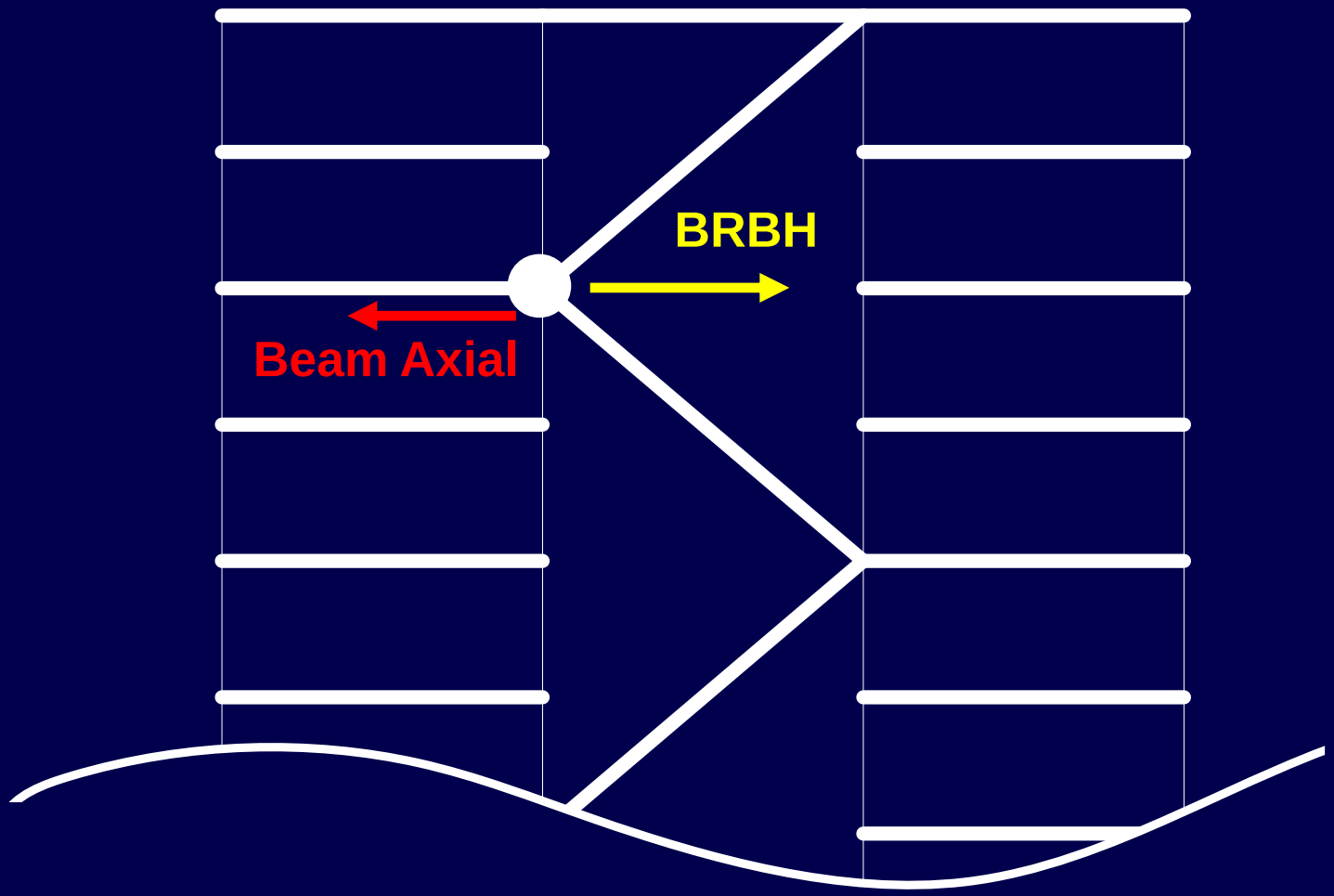




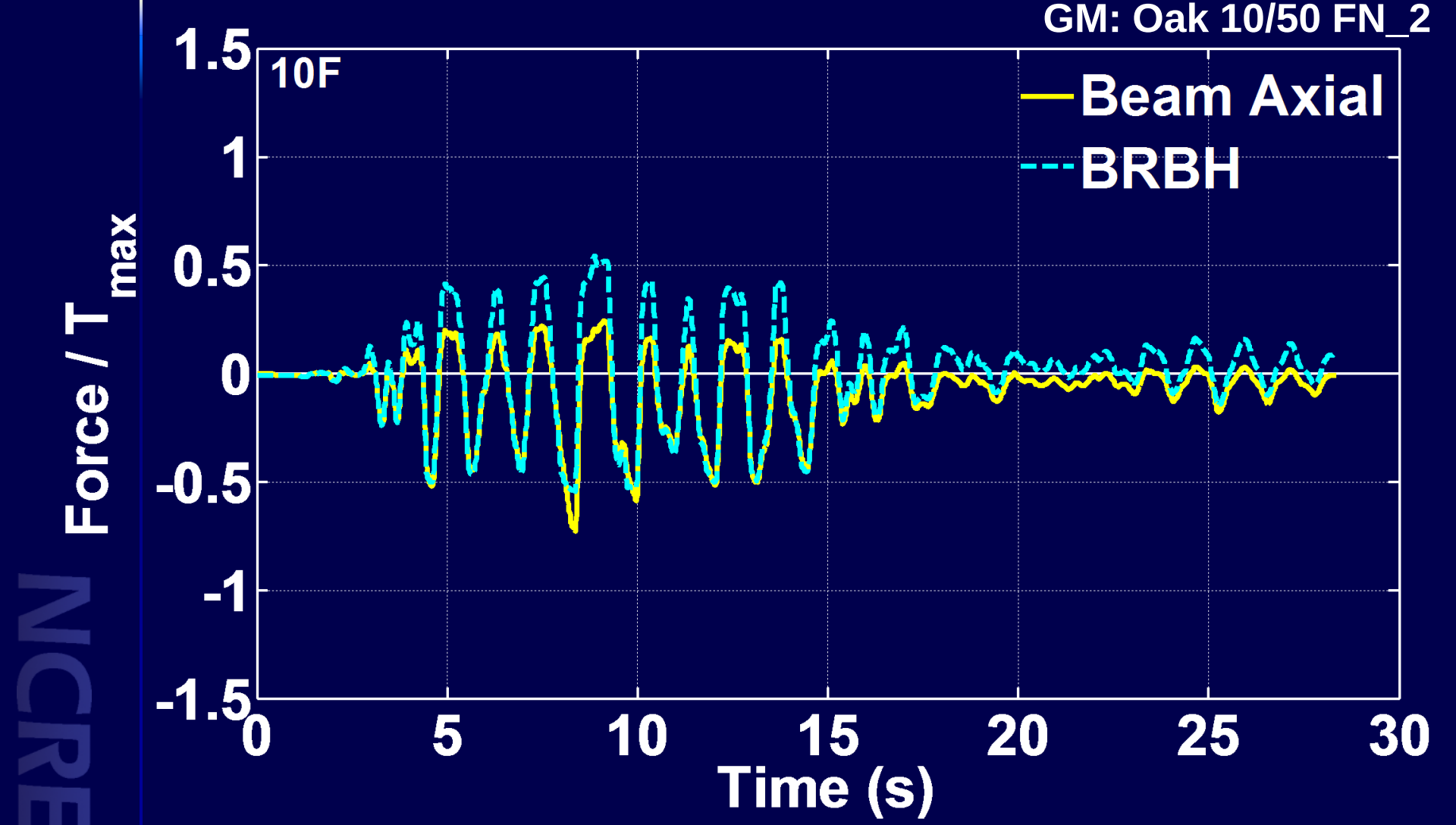
NCREE

NTU

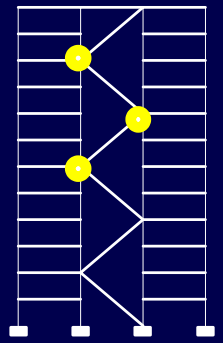
梁軸力 vs. BRBH

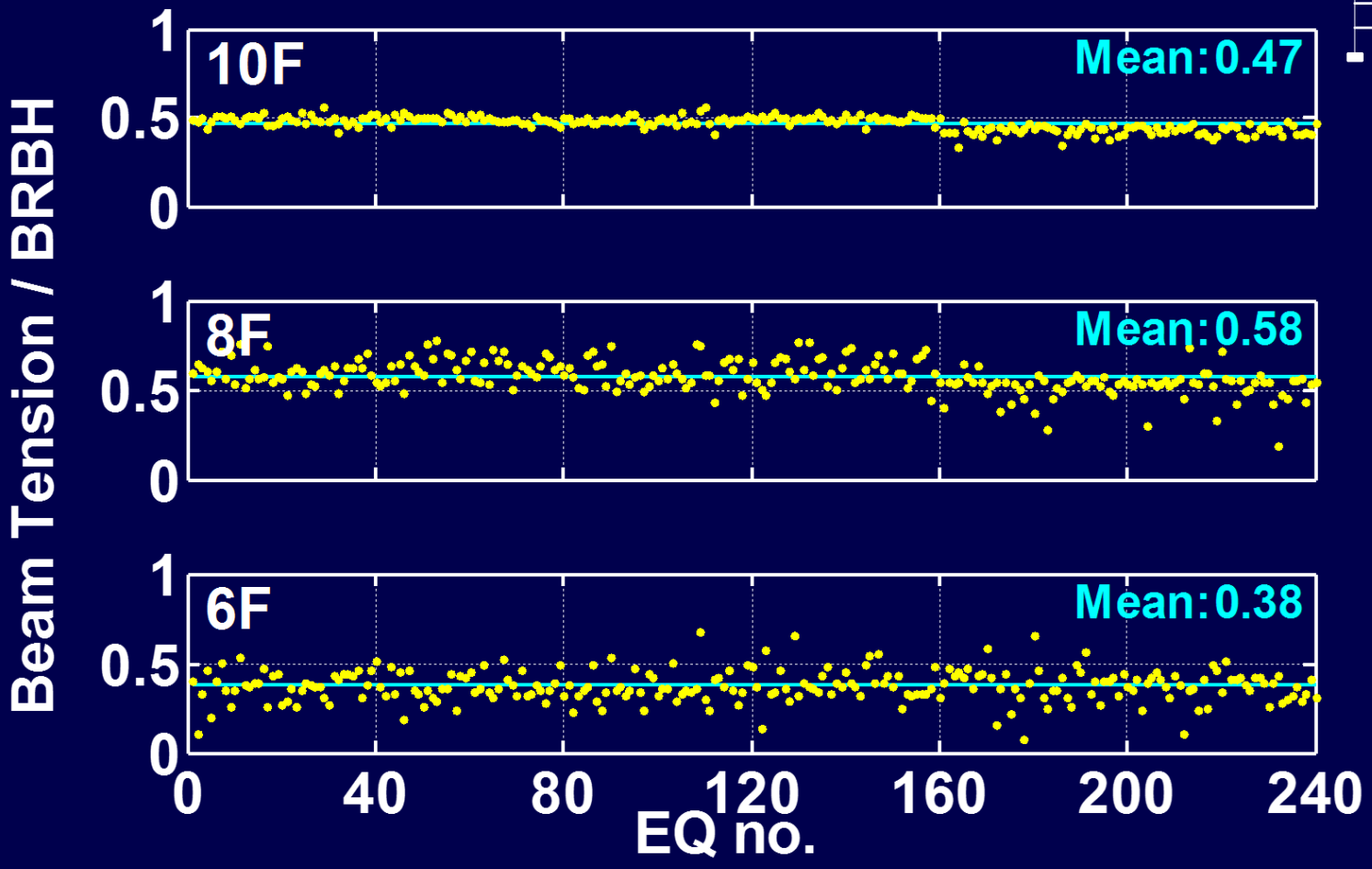


梁軸力 vs. BRBH


GM: Oak 10/50 FN_2
10F
Beam Axial
BRBH
Force / T max
1.5
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
Time (s)

梁軸拉力 / BRBH





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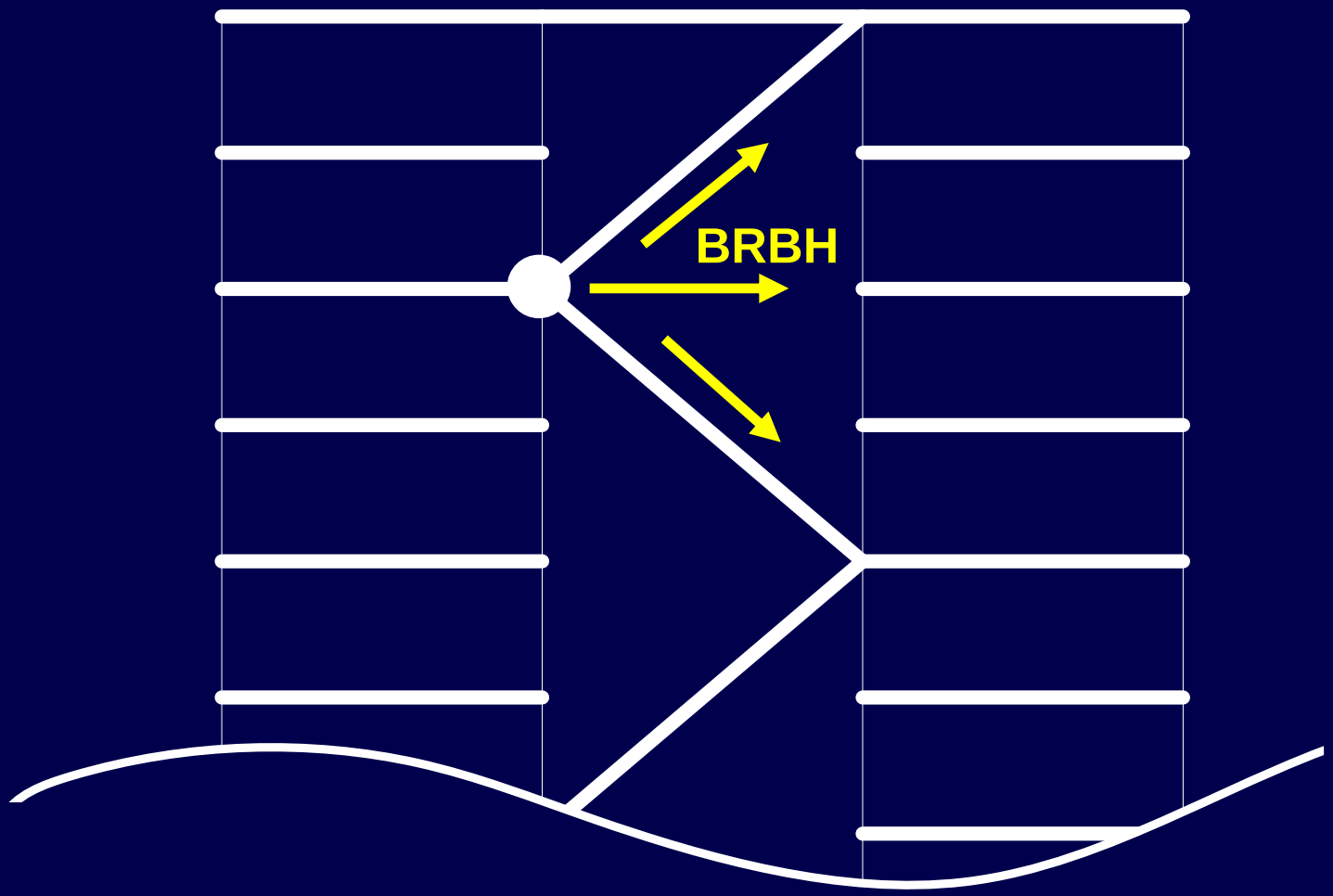
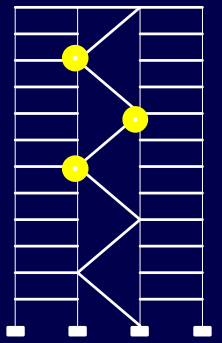
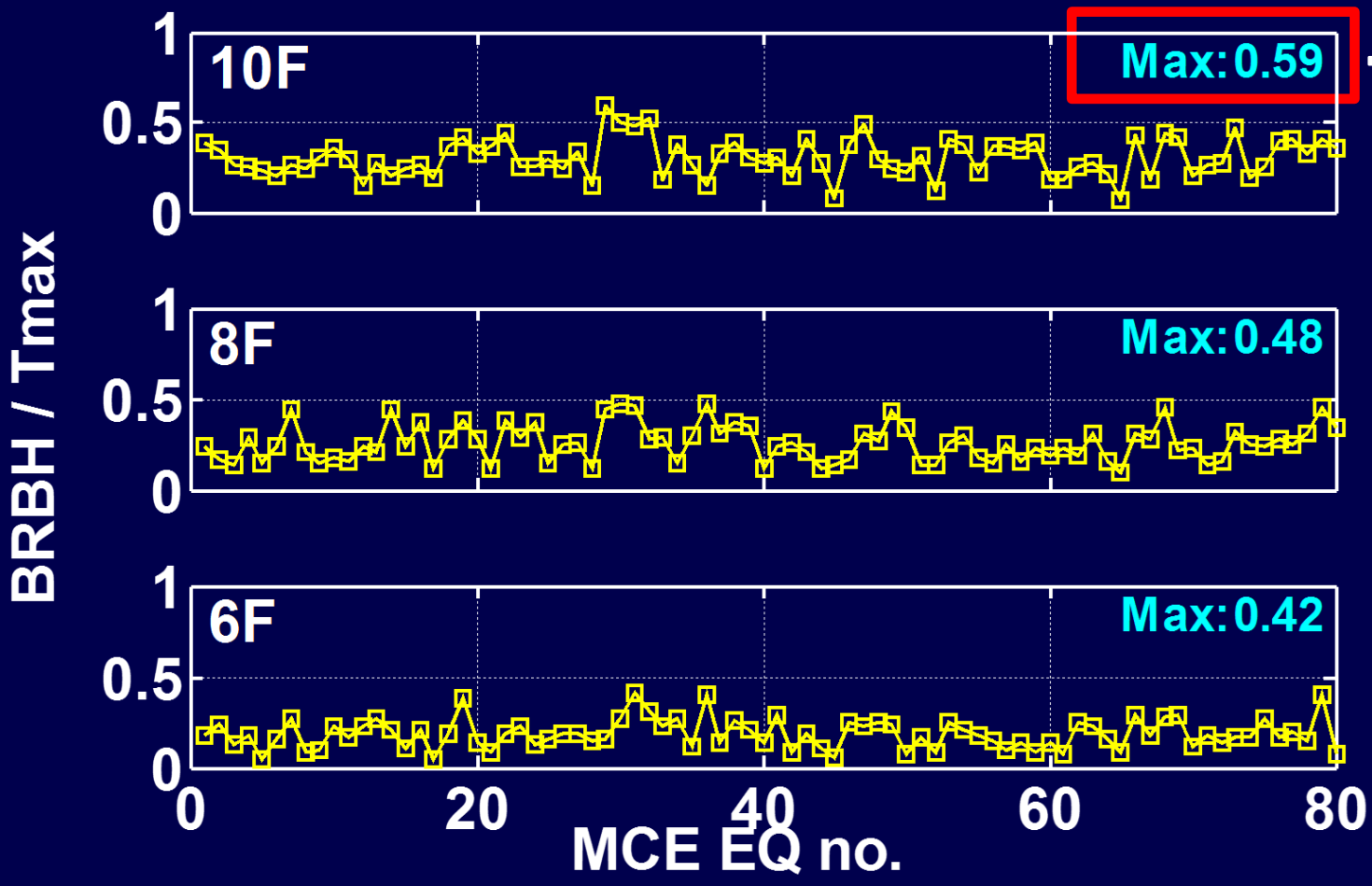
高模態反應探討

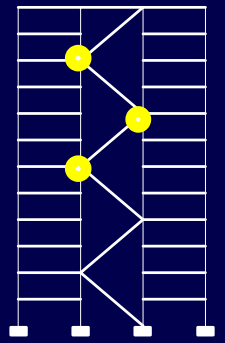


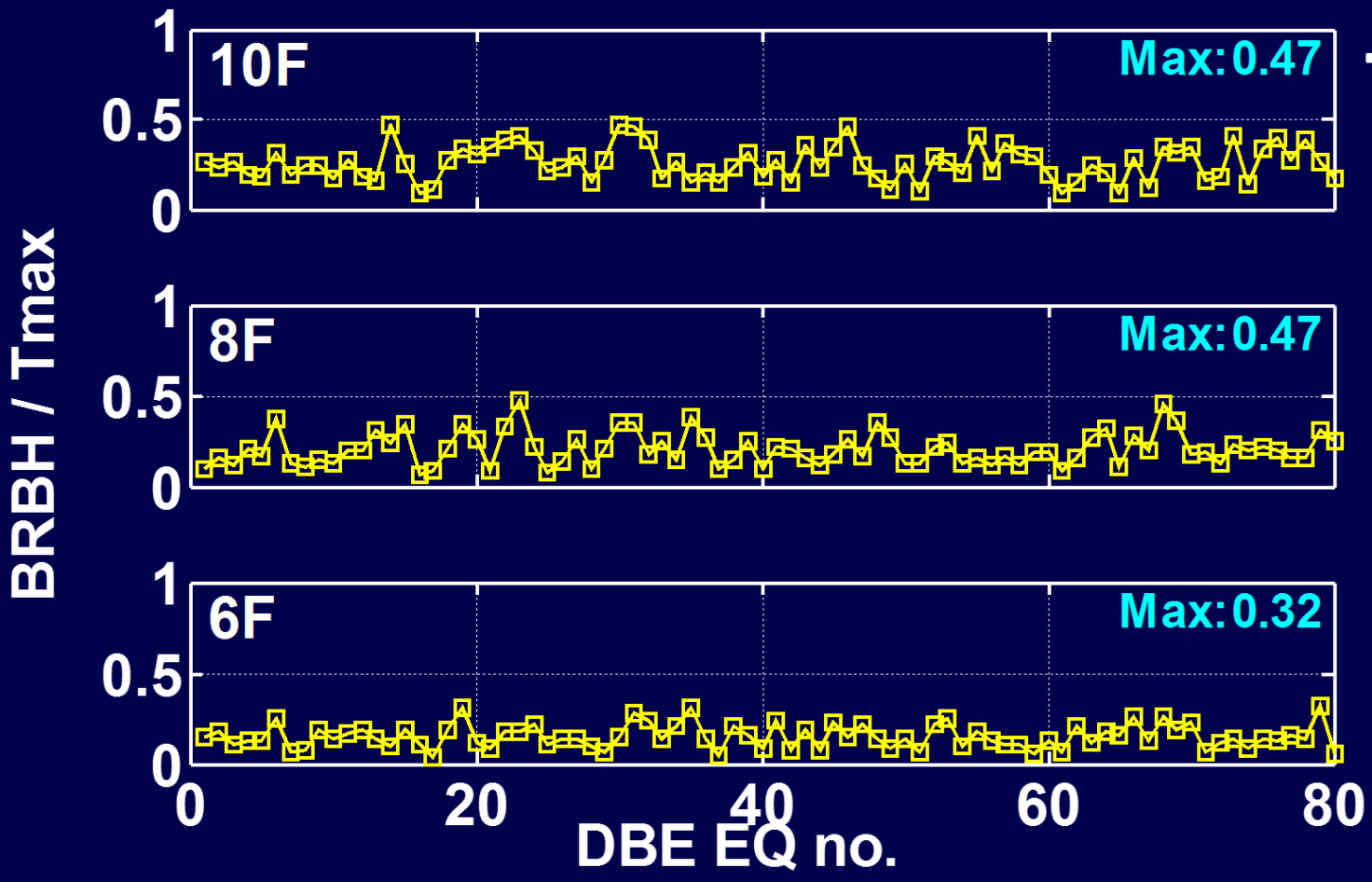
高模態反應 (MCE)



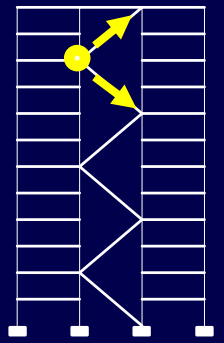

10F
Max:0.59
8F
Max:0.48
6F
Max:0.42
BRBH / Tmax
1
0.5
0
0
20
40
60
80
MCE EQ no.

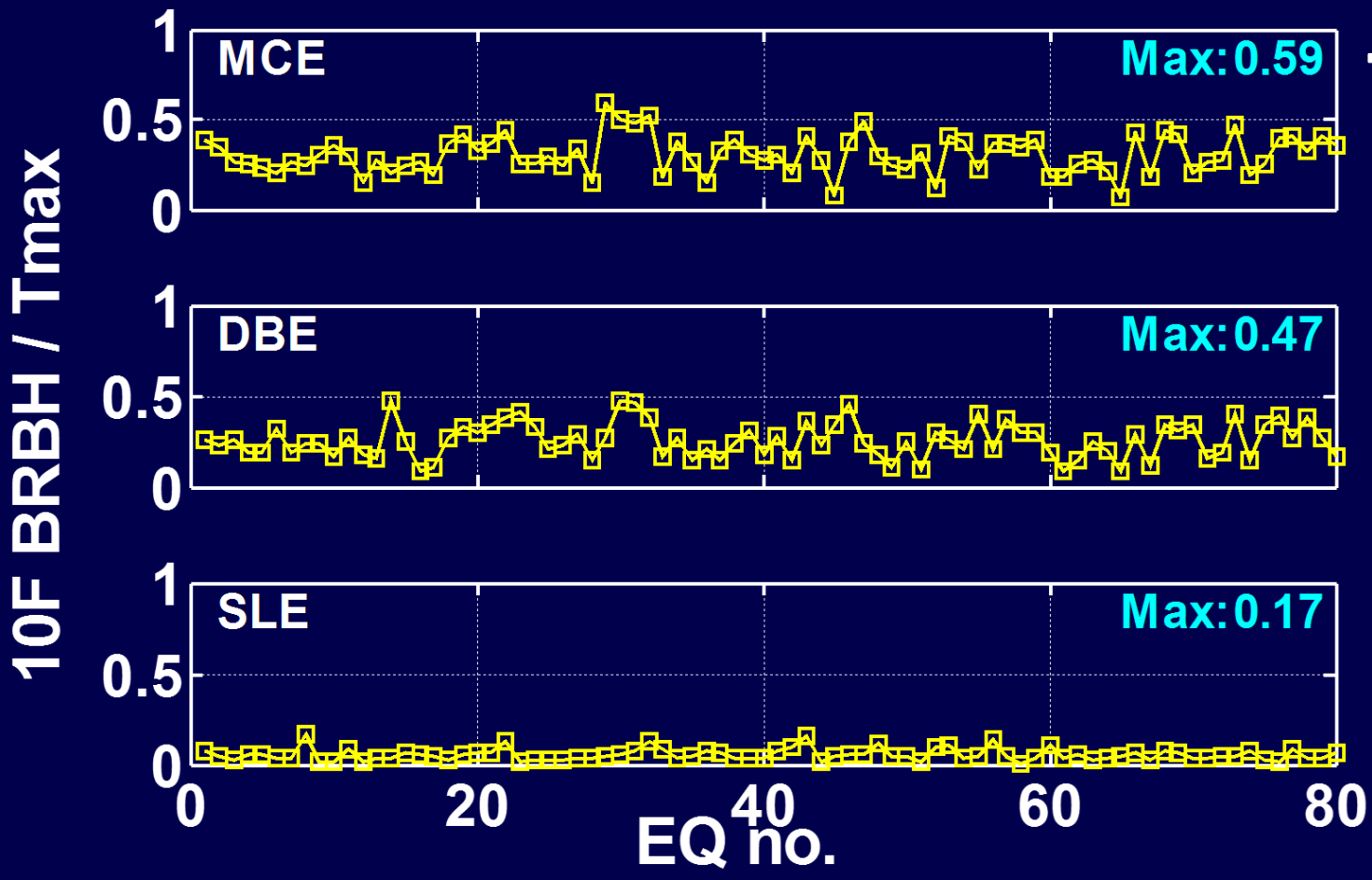
高模態反應 (DBE)





高模態反應 (10F)





簡報大綱

- 背景介紹
- 鋼筋混凝土構架設計
- 挫屈束制支撐與RC構架交界接頭設計
  - 接合板
  - U型鐵件
  - 托梁
- 施工流程
- 子結構試驗
- 非線性動力歷時分析
- 結論

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結論

1. U型鐵件施工可行，定位後可使梁柱鋼筋順利綁紮，以梁主筋錨定U型鐵件可確保其不被拉出柱表面，不影響原主筋性能。
2. 短深型托梁設計方法較保守，但因其破壞模式為脆性破壞，仍建議採保守設計
3. 動力分析結果顯示，底層BRB抗側力比約為20%~23%。
4. 高模態效應在高樓層較明顯，但兩支BRB同時受拉達最大可能拉力的機率不高，依容量設計法設計時考慮0.6Tmax即可。

致謝

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