Brace On Demand

單斜與雙斜式配置槽接式挫屈束制支撐與接合雲端運算設計軟體之應用

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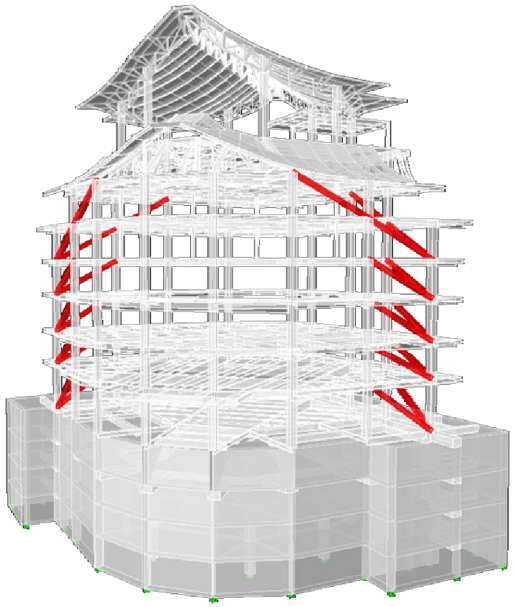
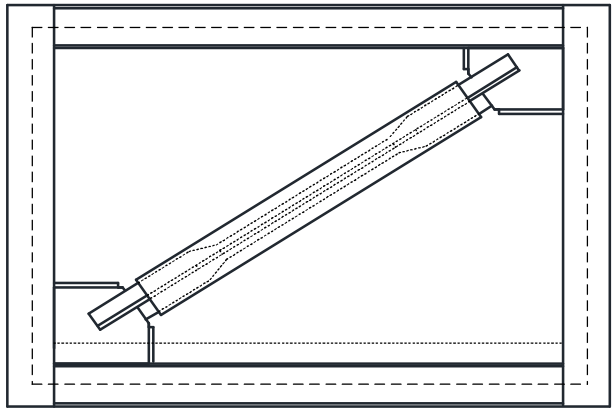
挫屈束制支撐構架 (BRBF)

分析



設計



製造

空間需求

強度需求

勁度需求

→ BOD Brace On Demand →

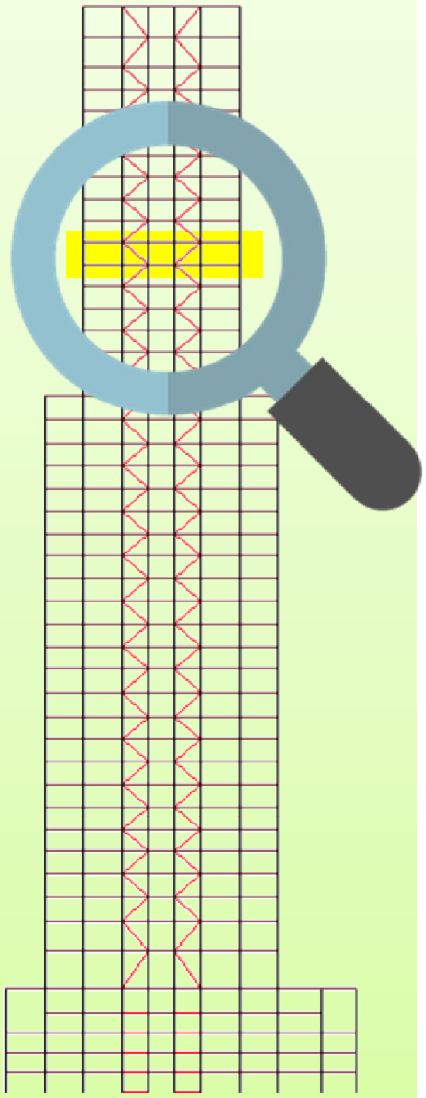
WES-BRB尺寸

接合板尺寸

銲接尺寸

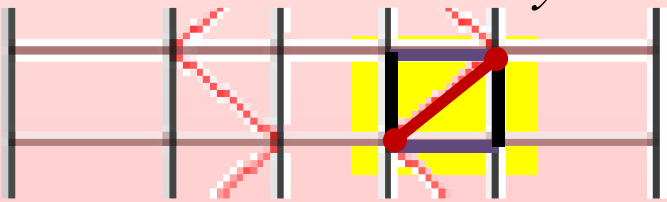
設計需求(Demands)

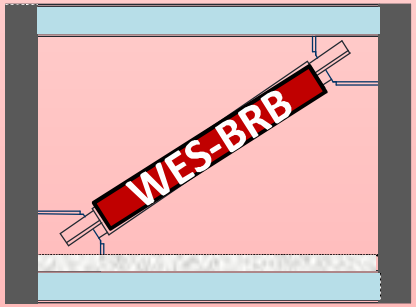
空間需求



強度需求

$$P_{BRB} < 0.9P_y$$





21
limit states

$$K_{eff} = Q\frac{EA_c}{L_{wp}}$$

勁度需求

1 最小值

$K_{eff,min}$

2 自訂值

$K_{eff,\ specified}$

最大可增加30%

設計需求(1/3)

空間需求

梁柱尺寸

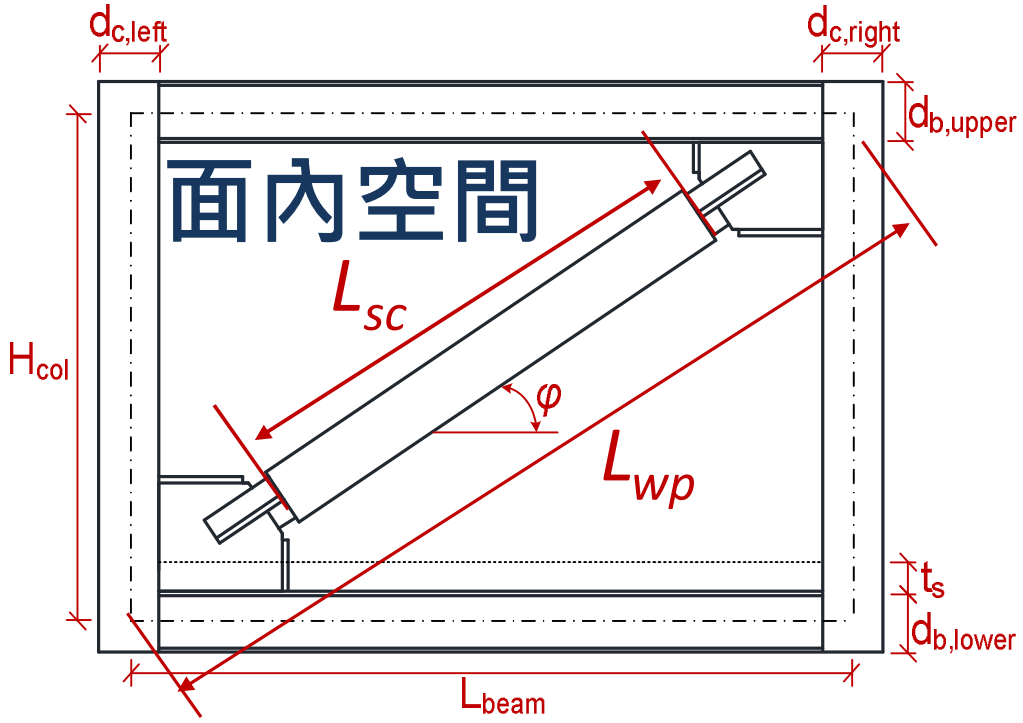
面內: BRB長度

面外: 外管寬度Dt = 20~60cm

(P_y = 75~1500tonf)

外管慣性矩需求

$$I_{sc} \geq \frac{P_{max} L_{sc}^{\ 2}}{\pi^2 E}$$

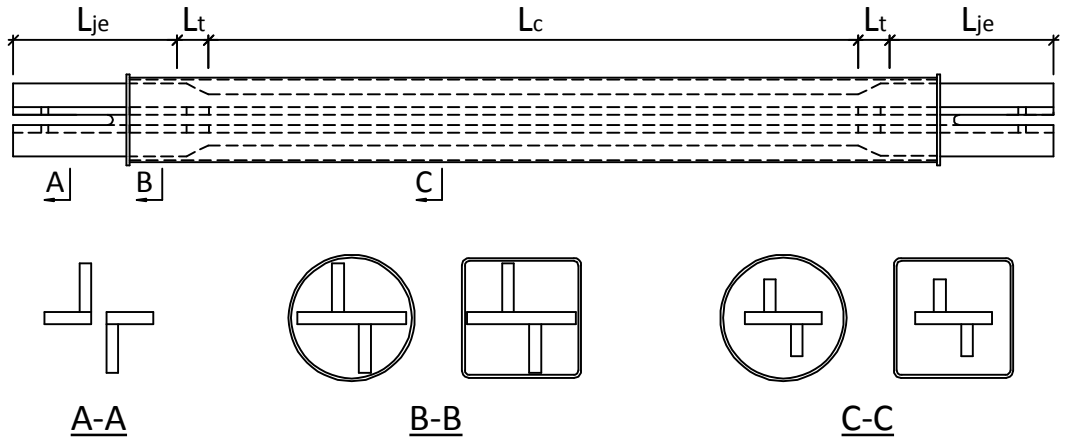


設計需求(2/3)

強度需求

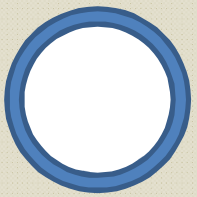
降伏強度Py (**75~1500tonf**)

WES-BRB種類



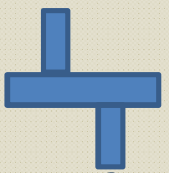
外管型式

Casing x



核心樣式

Type x



Cruciform

Flat

鋼材種類

Material x

A36

A572 GR50

SN 490B/CM

標稱降伏強度

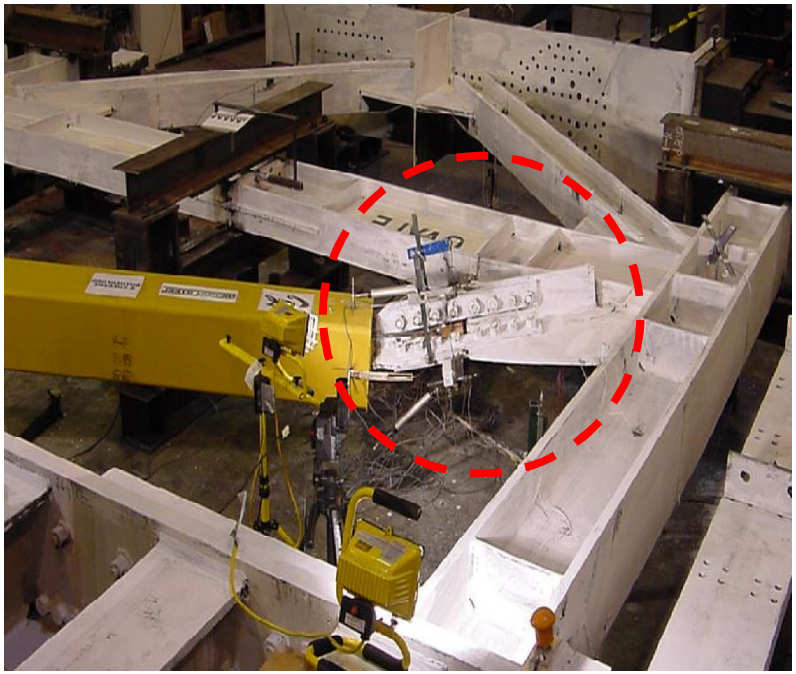
Yield Capacity

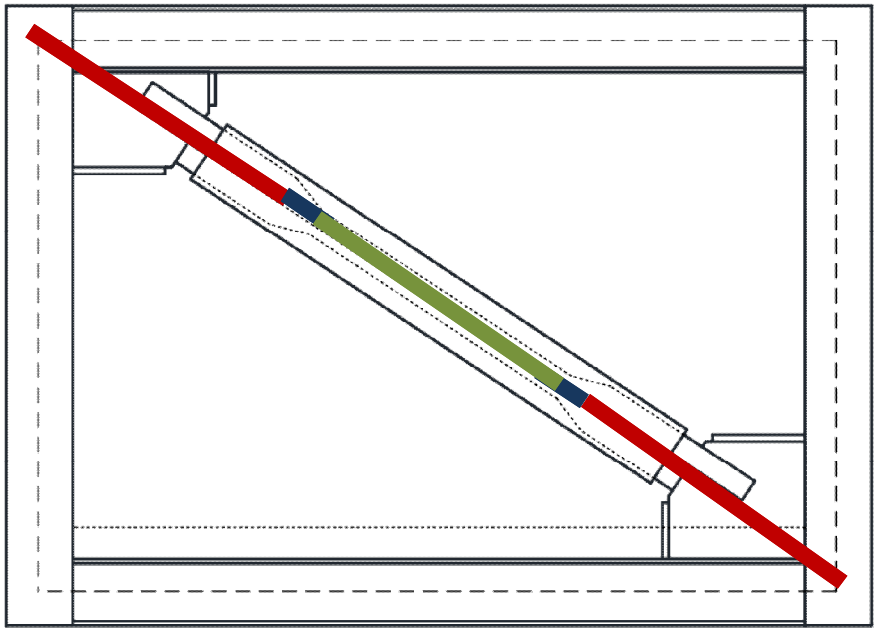
Min: 75tonf

Max 1500tonf

:

設計需求(3/3)





●增加核心消能段長度，提升構件疲勞壽命。

●縮短接合段長度，提高接合穩定性。

*一般情況，最小等效勁度(Q=1.2~1.5)。

勁度需求

$$K_{eff} = \frac{1}{\frac{1}{K_c} + \frac{1}{K_t} + \frac{1}{1.2K_j}} = \frac{EA_cA_tA_j}{L_cA_tA_j + 2L_tA_cA_j + \frac{L_{j,wp}A_cA_t}{1.2}}$$

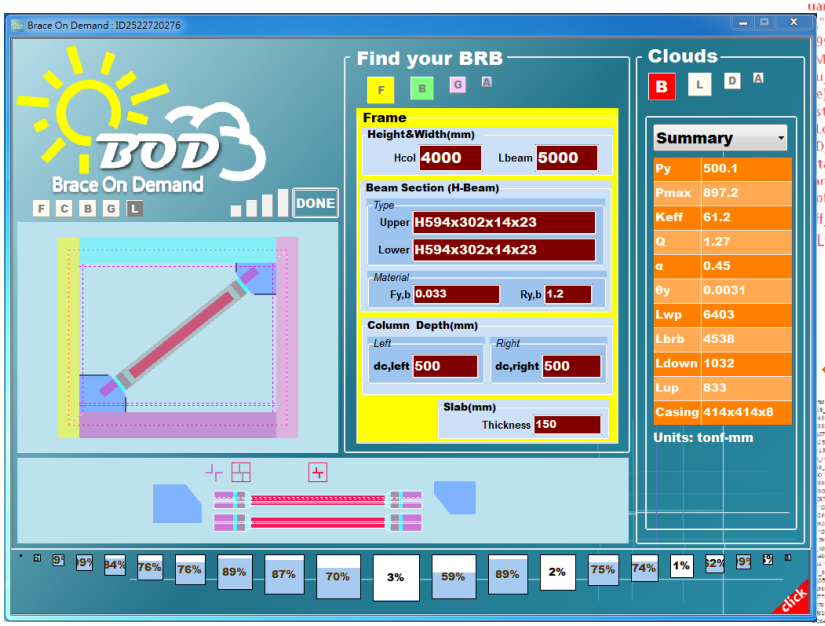
$$Q = \frac{K_{eff}}{EA_c / L_{wp}}$$

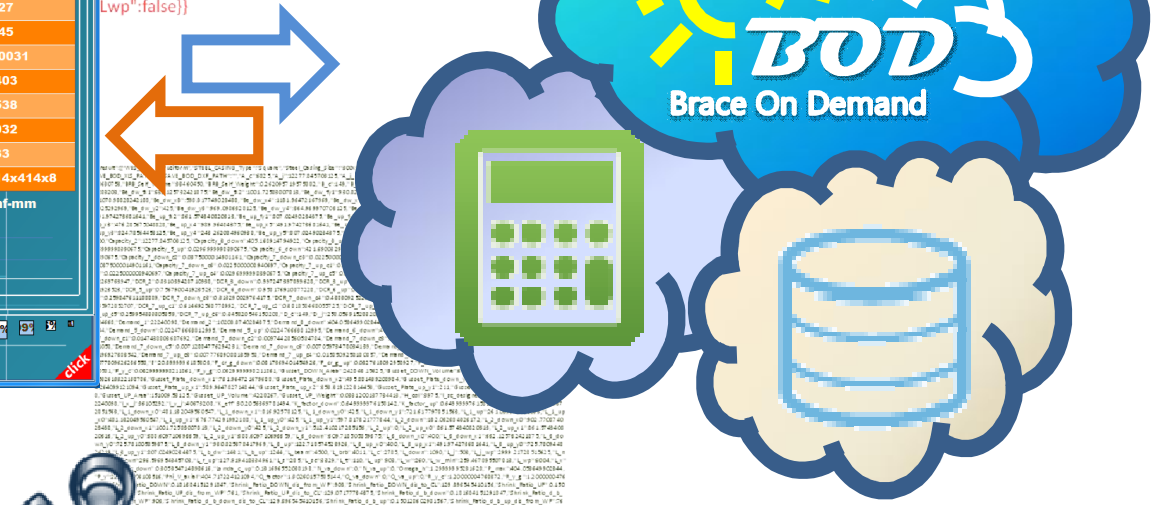
BOD雲端設計服務

客戶端瀏覽器

雲端伺服器

HTTP
Port:80
Port:8080





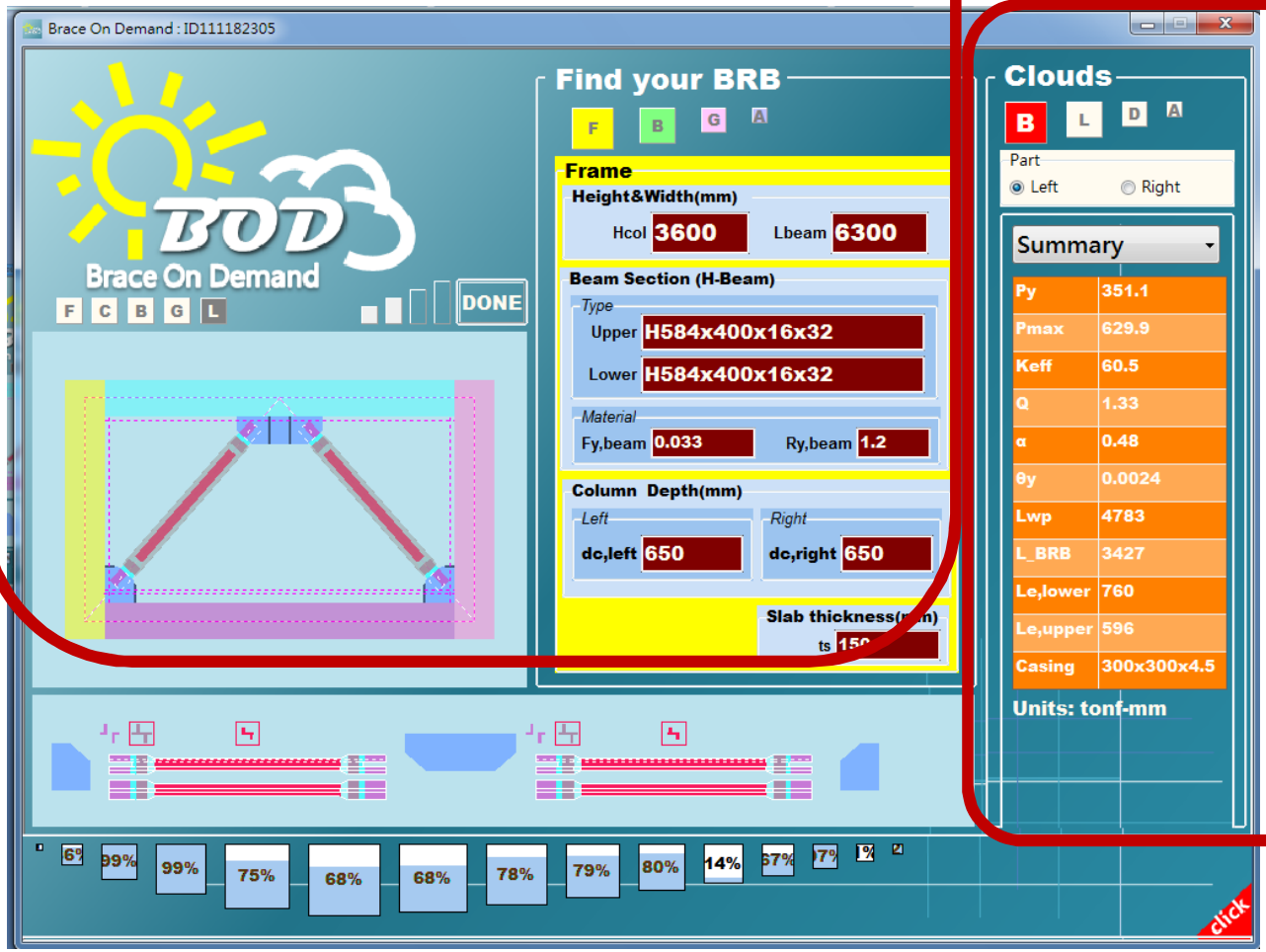
<0.1秒

BOD瀏覽器

輸入

設計需求

空間需求　強度需求　勁度需求



輸出

設計結果

1.WES-BRB
2.接合板
3.銲接尺寸
4.設計檢核

BOD自動化設計流程

Frame

1

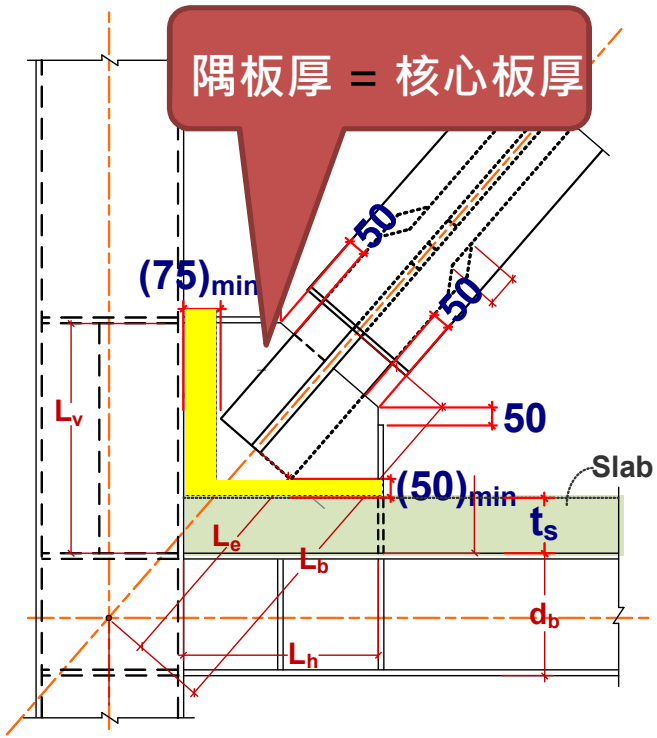
BRB

初步設計

2

Gussets

3



BOD自動迭代
滿足所有檢核

檢核項目

1.外鋼管挫屈檢核

2.接合段保持彈性

3.接合段受壓

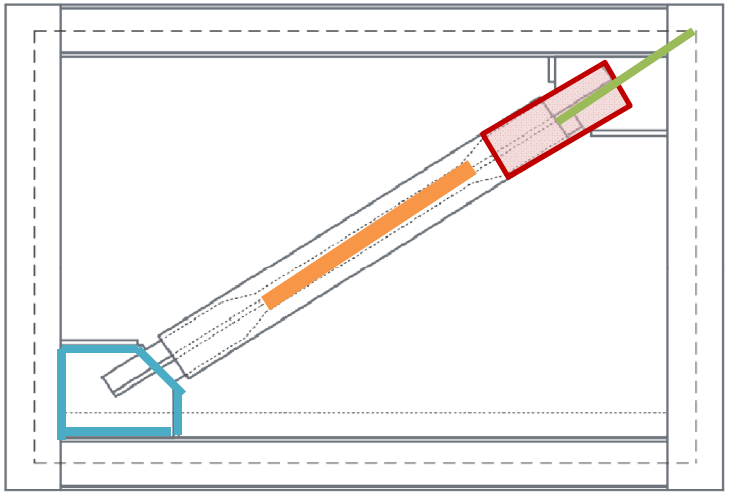
4.隅板塊狀剪力破壞

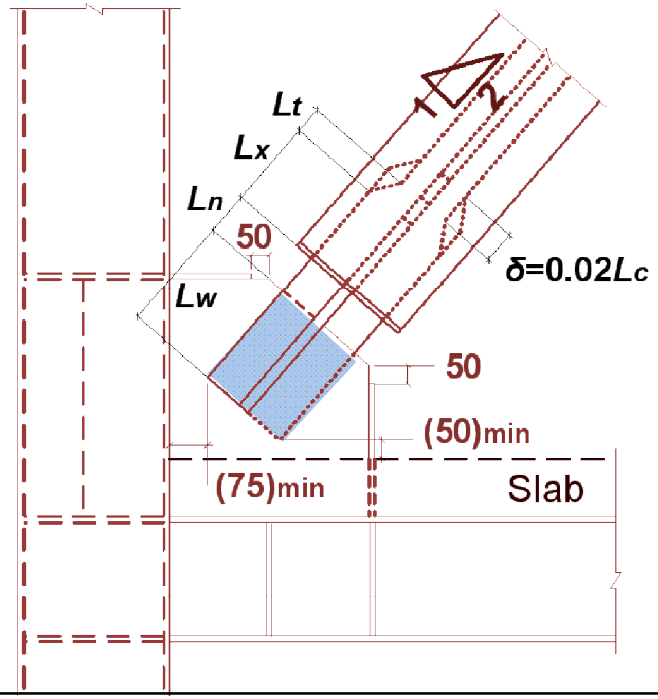
5.隅板拉力降伏

6.隅板挫屈破壞

7.隅板與梁柱接面強度

改善設計之對策





檢核項目/改善方法	放大端部尺寸	增加接合長度	縮短核心長度	放大隅板厚度
外鋼管挫屈檢核				
接合段保持彈性	◎			
接合段受壓	◎			
隅板塊狀剪力破壞		◎		◎
隅板拉力降伏		◎		◎
隅板挫屈破壞			◎	◎
隅板與梁柱接面強度				◎
等效勁度 K_{eff}	+	+	+	-

*同理，可調整等效勁度

單斜配置個案

1.材料列表

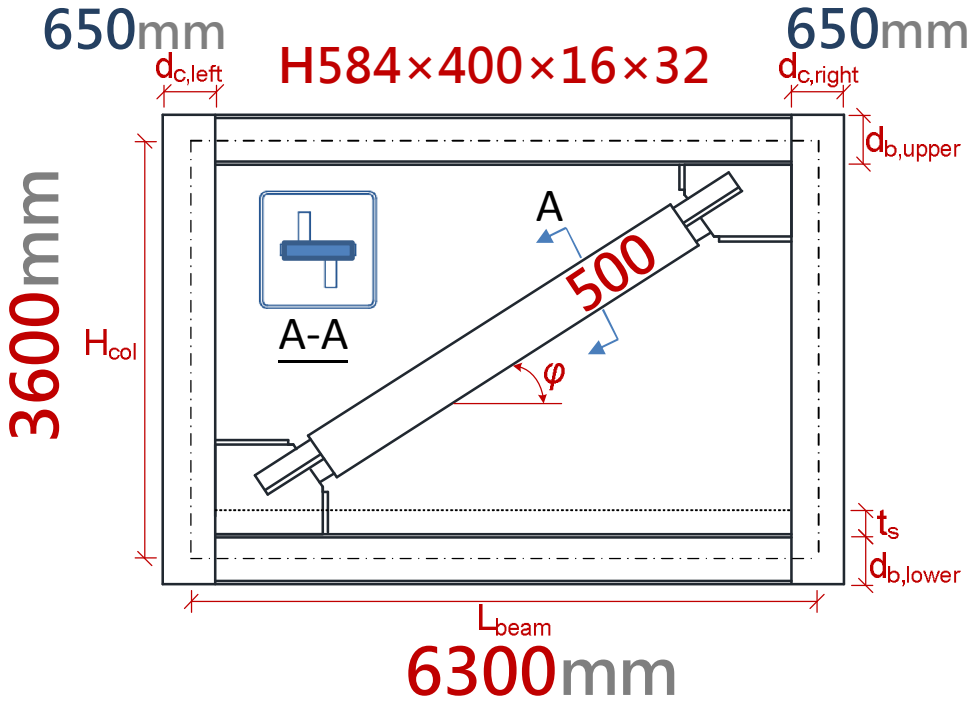
項目	鋼材	強度	單位
BRB	SN490B/CM	3.3	tonf/cm²
Gusset	SN490B/CM	3.3	tonf/cm²
Beam	SN490B/CM	3.3	tonf/cm²
Column	SN490B/CM	3.3	tonf/cm²

2.構架尺寸列表

項目	尺寸	單位
H_{col}	3600	mm
L_{beam}	6300	mm
t_s	150	mm
Beam	H584×400×16×32	mm
Column	BOX650×650×45	mm

3.WES-BRB強度列表 (核心板厚45mm)

項目	強度	單位
P_y	500	tonf
P_{max}	900	tonf



$\because 0.7F_{yb}A_b = P_{max} \times \cos\varphi$

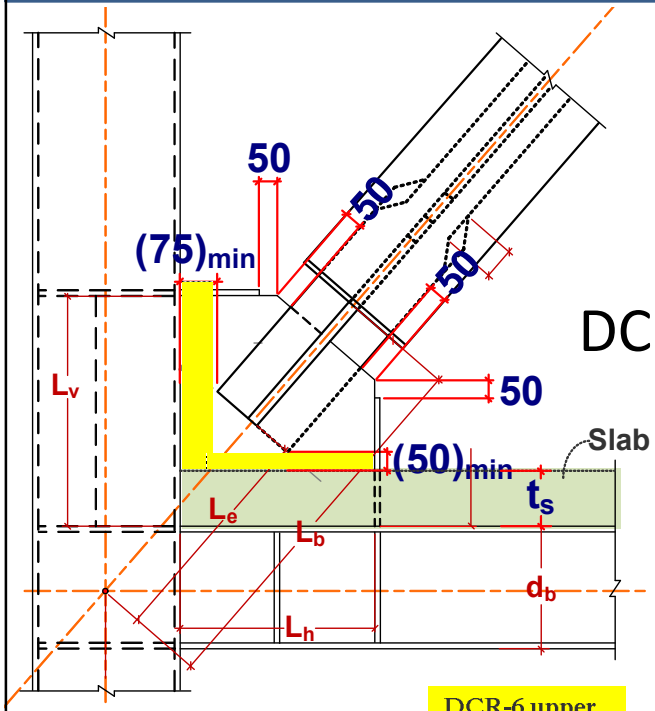
$\therefore$ 梁尺寸 = H584×400×16×32

$\because \dfrac{Z_c(F_{yc} - P_{uc}/A_g)}{Z_b F_{yb}} \geq 1.25$

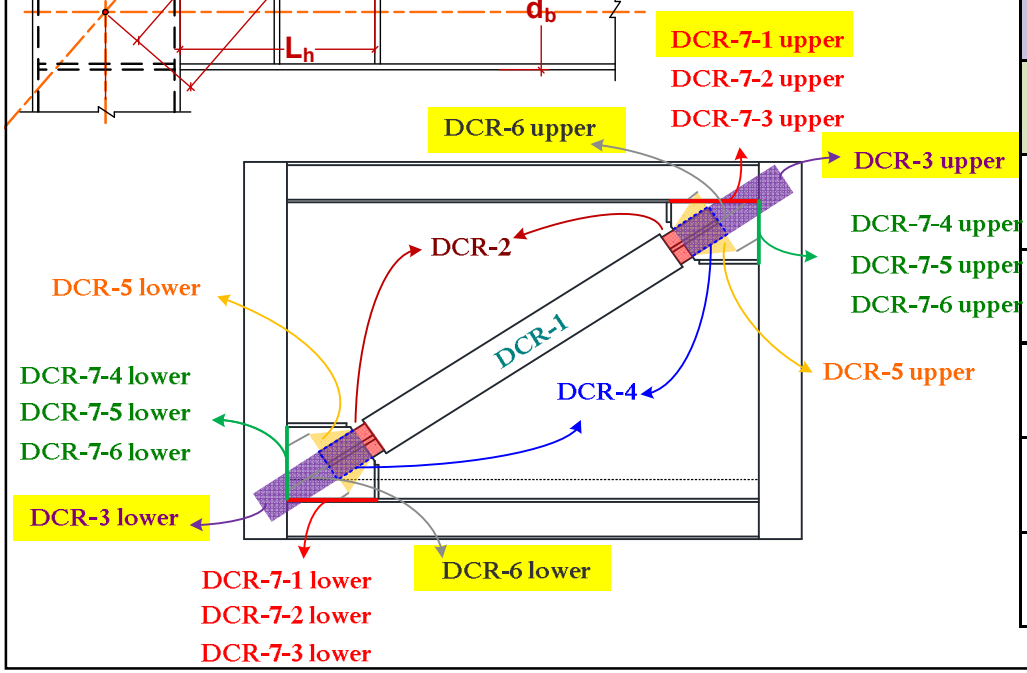
假設 $\dfrac{P_{uc}}{A_g} = 0.5F_{yc}$

$\therefore$ 柱尺寸 = BOX 650×650×45

初步設計檢核結果

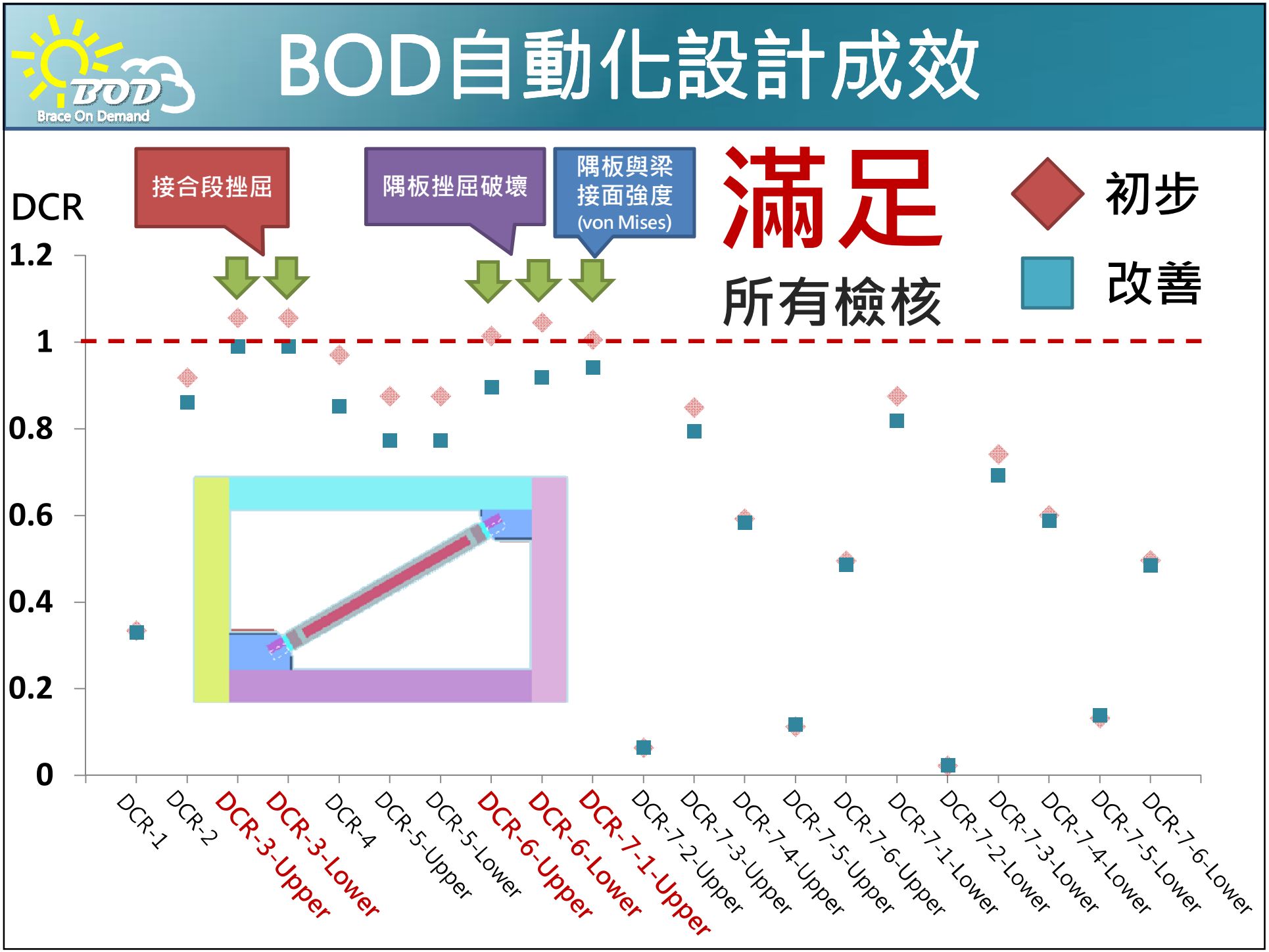


$$DCR = \frac{Demand}{Capacity}$$

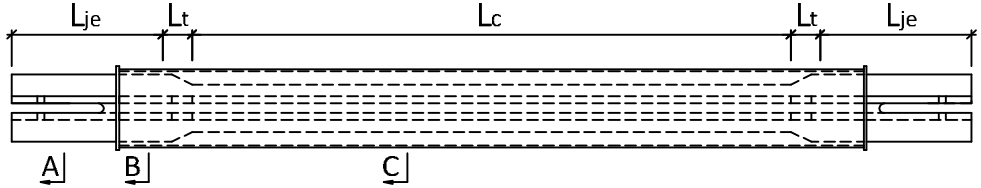


檢核項目		位置	
		上	下
DCR-1	外鋼管挫屈檢核	0.33	
DCR-2	核心元件接合段受拉保持彈性檢核	0.92	
DCR-3	核心元件接合段挫屈強度檢核	1.06	1.06
DCR-4	隅板塊狀剪力破壞檢核	0.97	
DCR-5	隅板拉力降伏檢核	0.88	0.88
DCR-6	隅板挫屈檢核	1.02	1.05
DCR-7-1	隅板與梁面強度檢核-von Mises降伏準則	1.01	0.88
DCR-7-2	隅板與梁面強度檢核-拉力斷裂破壞	0.06	0.02
DCR-7-3	隅板與梁面強度檢核-剪力斷裂破壞	0.85	0.74
DCR-7-4	隅板與柱面強度檢核-von Mises降伏準則	0.59	0.60
DCR-7-5	隅板與柱面強度檢核-拉力斷裂破壞	0.11	0.13
DCR-7-6	隅板與柱面強度檢核-剪力斷裂破壞	0.50	0.50

BOD自動化設計成效

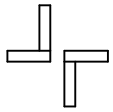

BOD
Brace On Demand
接合段挫屈
隅板挫屈破壞
隅板與梁
接面強度
(von Mises)
滿足
所有檢核
初步
改善
DCR
1.2
1
0.8
0.6
0.4
0.2
0
DCR-1
DCR-2
DCR-3-Upper
DCR-3-Lower
DCR-4
DCR-5-Upper
DCR-5-Lower
DCR-6-Upper
DCR-6-Lower
DCR-7-1-Upper
DCR-7-2-Upper
DCR-7-3-Upper
DCR-7-4-Upper
DCR-7-5-Upper
DCR-7-6-Upper
DCR-7-1-Lower
DCR-7-2-Lower
DCR-7-3-Lower
DCR-7-4-Lower
DCR-7-5-Lower
DCR-7-6-Lower

設計結果比較

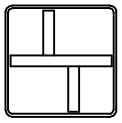


標稱降伏強度P_y = 500 tonf

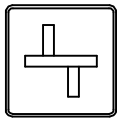
核心板厚 = 45mm



A-A



B-B



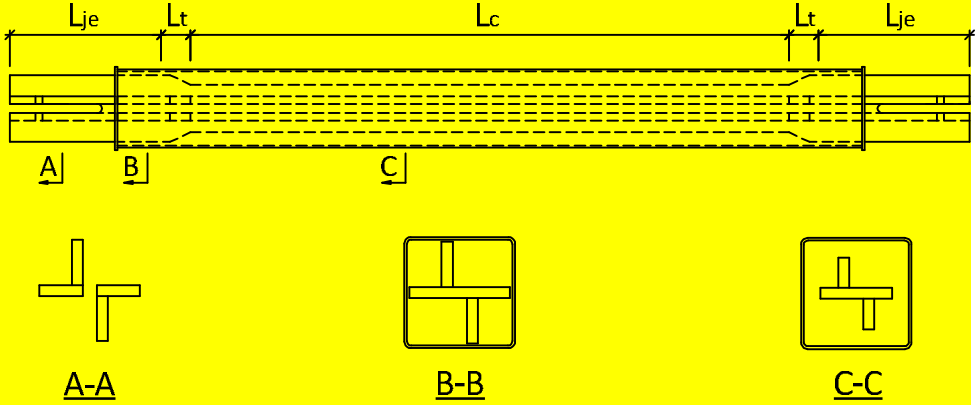
C-C

	初步設計	自動化設計	單位
L_{BRB}	5021	4989 ↓	mm
L_c	3587	3535 ↓	mm
A_j/A_c	1.57	1.68 ↑	
α (L_c/L_{wp})	0.494	0.487 ↓	
Q	1.30	1.33 ↑	
K_{eff}	55	57 ↑	tonf/mm
外管尺寸	350×350×9	350×350×9	
隅板厚	45	50 ↑	mm
上隅板重量	185	185	kgf
下隅板重量	285	288	kgf

單斜配置通案研究

1.材料列表

項目	鋼材	強度	單位
BRB	SN490B/CM	3.3	tonf/cm^2
Gusset	SN490B/CM	3.3	tonf/cm^2
Beam	SN490B/CM	3.3	tonf/cm^2
Column	SN490B/CM	3.3	tonf/cm^2



2.構架尺寸列表

項目	尺寸	單位
H_{col}	3600	mm
L_{beam}	{3600, 4500, 5400, 6300, 7200, 8100, 9000 }	mm
L_{beam}/H_{col}	{1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5 }	
t_s	150	mm

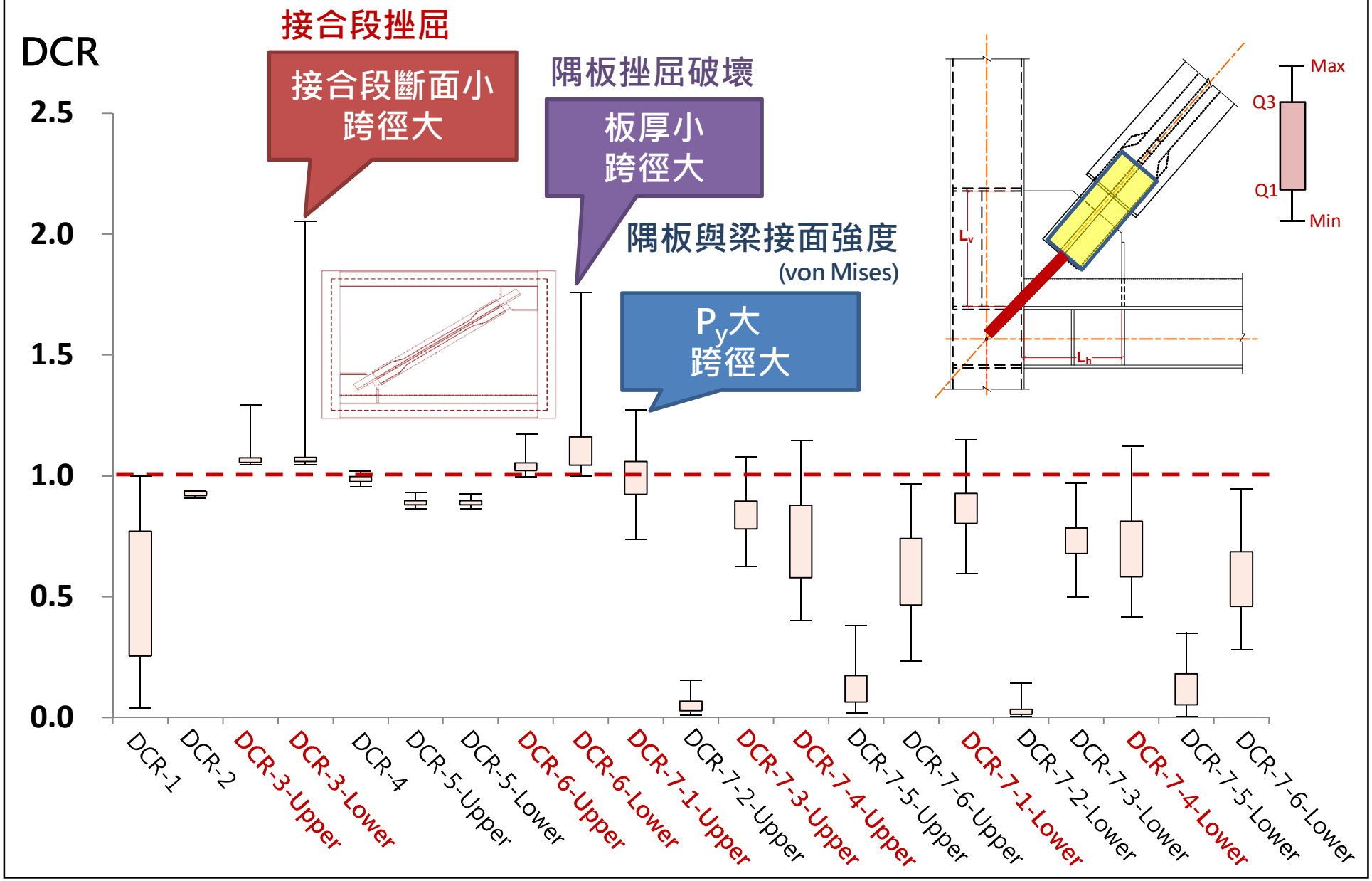
標稱 x **核心** x **構架** = **581** 案例

降伏強度 共17種 100~800tf

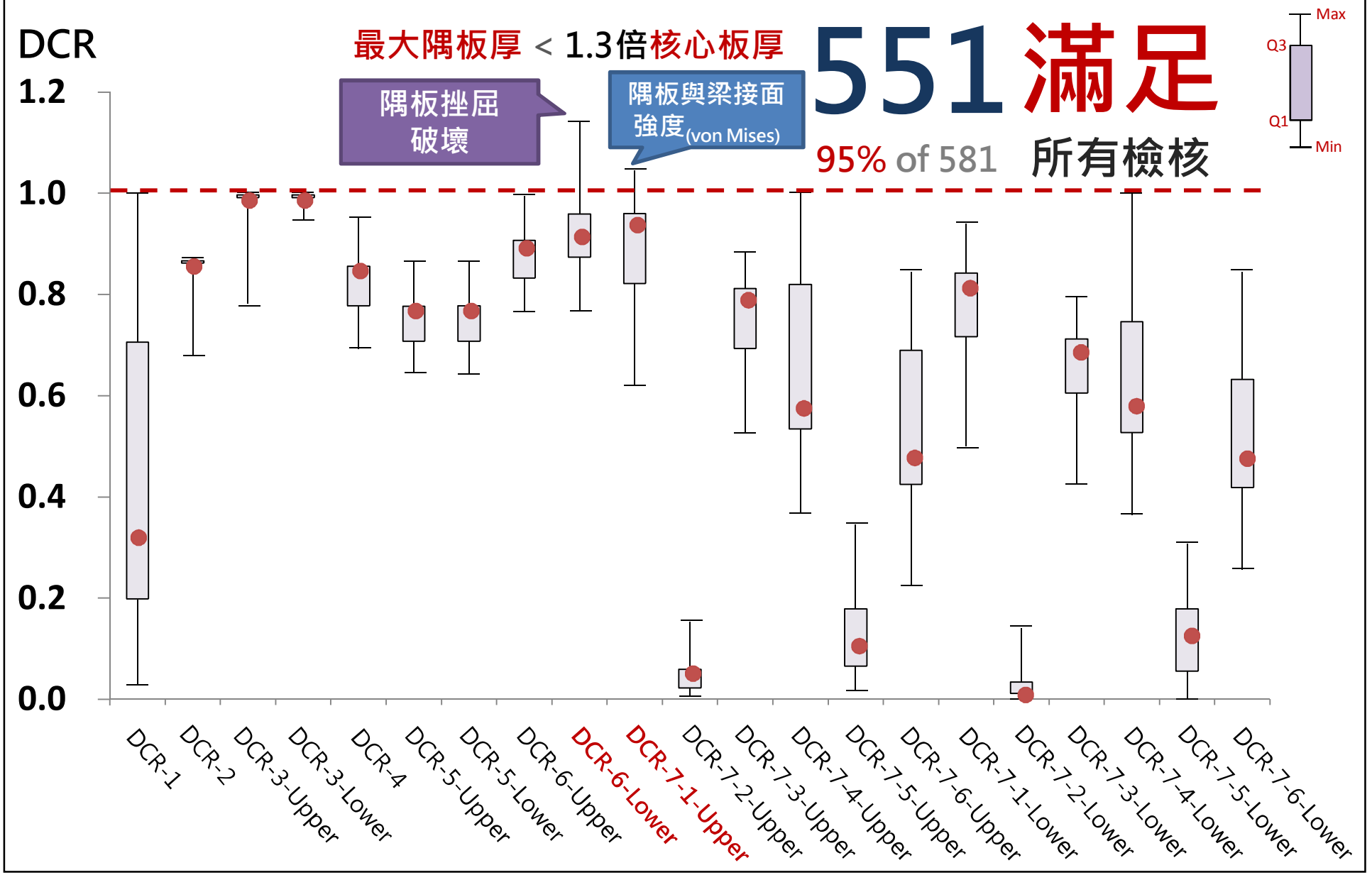
配置樣式 約5種

高寬比 共7種 1.0~2.5

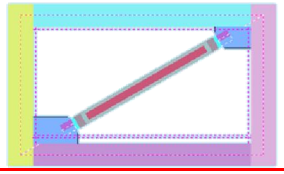
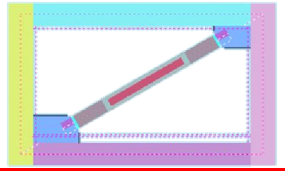
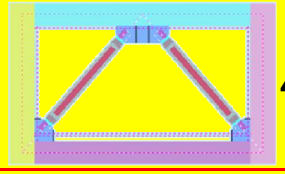
大跨徑梁常造成的問題


DCR
2.5
2.0
1.5
1.0
0.5
0.0
接合段挫屈
接合段斷面小
跨徑大
隅板挫屈破壞
板厚小
跨徑大
隅板與梁接面強度
(von Mises)
Py大
跨徑大
Max
Q3
Q1
Min
Lv
Lh
DCR-1
DCR-2
DCR-3-Upper
DCR-3-Lower
DCR-4
DCR-5-Upper
DCR-5-Lower
DCR-6-Upper
DCR-6-Lower
DCR-7-1-Upper
DCR-7-2-Upper
DCR-7-3-Upper
DCR-7-4-Upper
DCR-7-5-Upper
DCR-7-6-Upper
DCR-7-1-Lower
DCR-7-2-Lower
DCR-7-3-Lower
DCR-7-4-Lower
DCR-7-5-Lower
DCR-7-6-Lower

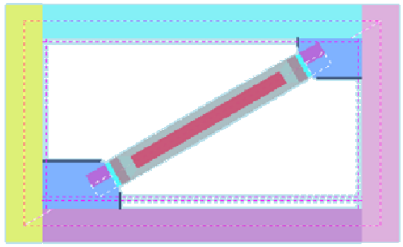
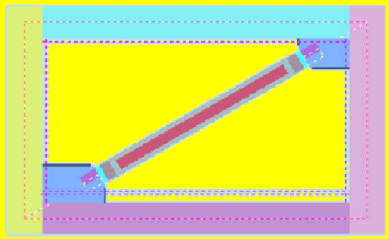
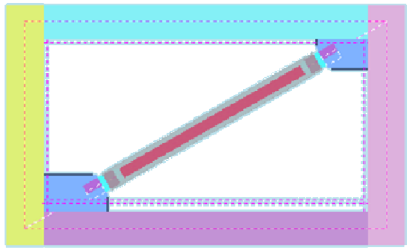
自動化設計檢核結果


DCR
最大隅板厚 < 1.3倍核心板厚
551 滿足
95% of 581 所有檢核
隅板挫屈
破壞
隅板與梁接面
強度(von Mises)
Max
Q3
Q1
Min
1.2
1.0
0.8
0.6
0.4
0.2
0.0
DCR-1
DCR-2
DCR-3-Upper
DCR-3-Lower
DCR-4
DCR-5-Upper
DCR-5-Lower
DCR-6-Upper
DCR-6-Lower
DCR-7-1-Upper
DCR-7-2-Upper
DCR-7-3-Upper
DCR-7-4-Upper
DCR-7-5-Upper
DCR-7-6-Upper
DCR-7-1-Lower
DCR-7-2-Lower
DCR-7-3-Lower
DCR-7-4-Lower
DCR-7-5-Lower
DCR-7-6-Lower

單斜VS.雙斜差異比較

SN490B/CM	BOD設計 (例1) ($K_{eff,min}$)	BOD設計 (例2) ($K_{eff,max}$)	BOD設計 (例3) (雙斜配置)	單位
φ	 29.7	 29.7	 48.8	degree
P_y	500 (tc=45mm)	500 (tc = 45mm)	350 (tc=40mm)	tonf
L_c	3535	2193 ↓	2303	mm
L_{BRB}	4989	4939 ↓	3427	mm
α (L_c/L_{wp})	0.49	0.30 ↓	0.48	
Q	1.33	1.60 ↑	1.33	
K_{eff}	57	68 ↑	60.5	tonf/mm
外管尺寸	350×350×9	370×370×8 ↑	300×300×4.5	
θ_y	0.0028	0.0023 ↓	0.0024	radian
隅板厚	50	50	50	mm
水平勁度K_h	43	51.3	52.5	tonf/mm
水平強度V_y	434	434	461	tonf

(例1)鋼材差異比較

	A36 (例1A)	SN490B (例1)	A572GR50(例1B)	單位
設計結果				
P_y	500 (tc=45mm)	500 (tc=45mm)	500 (tc=45mm)	tonf
L_c	↓ 3036	3535	3625 ↑	mm
L_{BRB}	↓ 4738	4989	5019 ↑	mm
A_j/A_c	↑ 1.92	1.68	1.66 ↓	
α (L_c/L_{wp})	↓ 0.42	0.49	0.5 ↑	
Q	↑ 1.46	1.33	1.32 ↓	
K_{eff}	↑ 82	57	53 ↓	tonf/mm
外管尺寸	↑ 486×486×8	350×350×9	350×350×9	
θ_y	↓ 0.0021	0.0028	0.0030 ↑	radian
隅板厚	50	50	50	mm

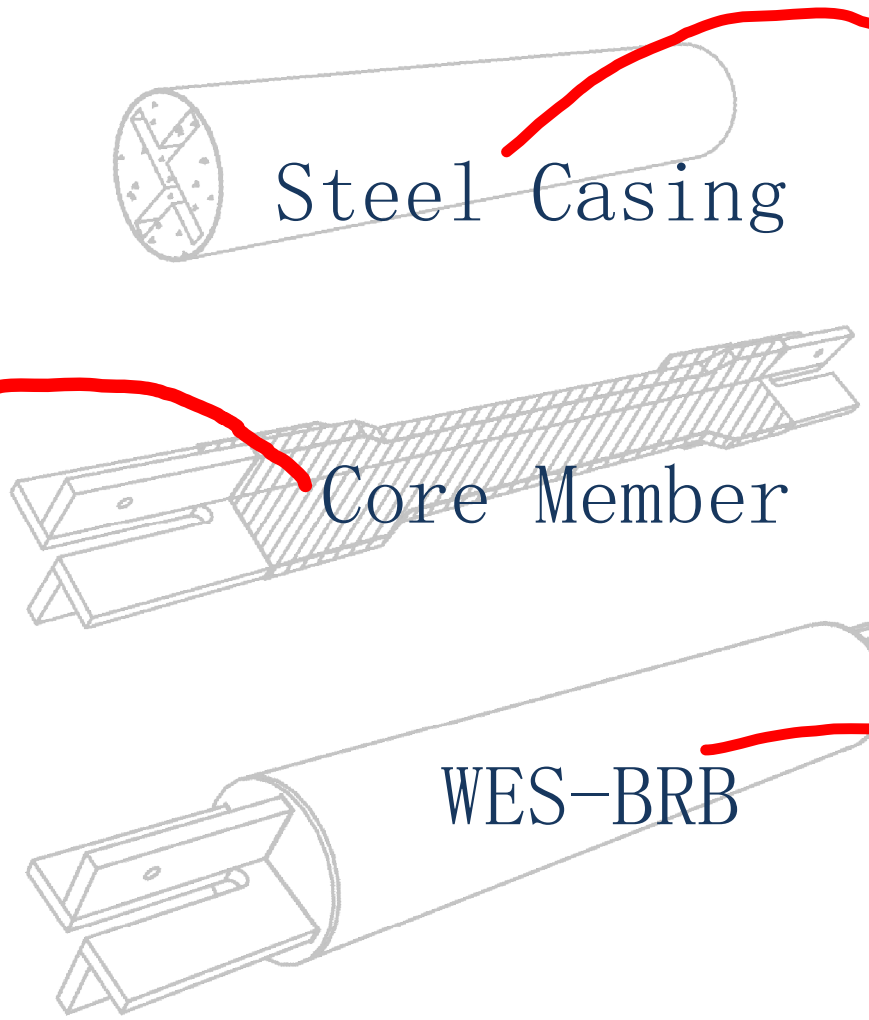
WES-BRB設計結果

Brace On Demand

Core

Core	
Lc	2591
tc	25
Bc	195
Dc	195
Ac	9125
Transition	
Lt	99
At	11587.5
Joint	
Lj	591
Lx	154
Ln	77
Lw	360
Tw	20
tj	25
Bj	293.5
Dj	293.5
Aj	14050
End Slot	
Ls	385
tg,s	53

Units: tonf-mm



Casing

Type	355x6.3
Product	Available
Dt,req	319.6
Dt	355.6
t	6.3
Isc,req	2.26E+07
Isc	1.05E+08
Lsc	2903

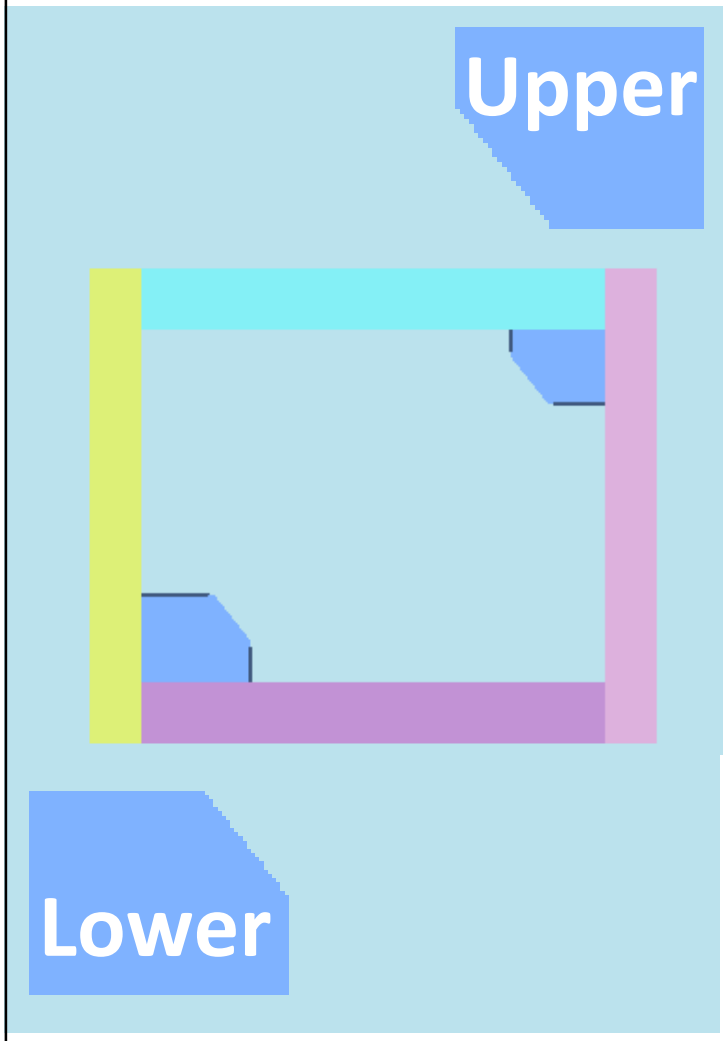
Units: tonf-mm

Summary

Py	301.1
Pmax	540.2
Keff	38.5
Q	1.24
α	0.43
Lwp	6004
Lbrb	3971
Ldown	1111
Lup	922

Units: tonf-mm

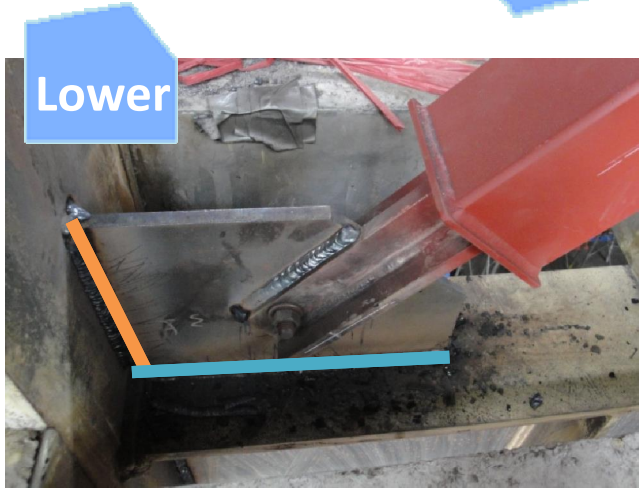
接合板設計結果



Gusset

Lower	
tg	40
Lh	1062.3
Tb	29
Lv	832.5
Tc	23
tsf	20
Lsf,h	658.3
Lsf,v	340
Upper	
tg	40
Lh	906.3
Tb	32
Lv	707.7
Tc	25
tsf	20
Lsf,h	502.1
Lsf,v	215

Units: tonf-mm



下載設計結果

txt	xls	dwg	pdf
結構 計算書	結構 試算表	標準圖	標準圖

結構計算書

http://bodwebse... ncree.org

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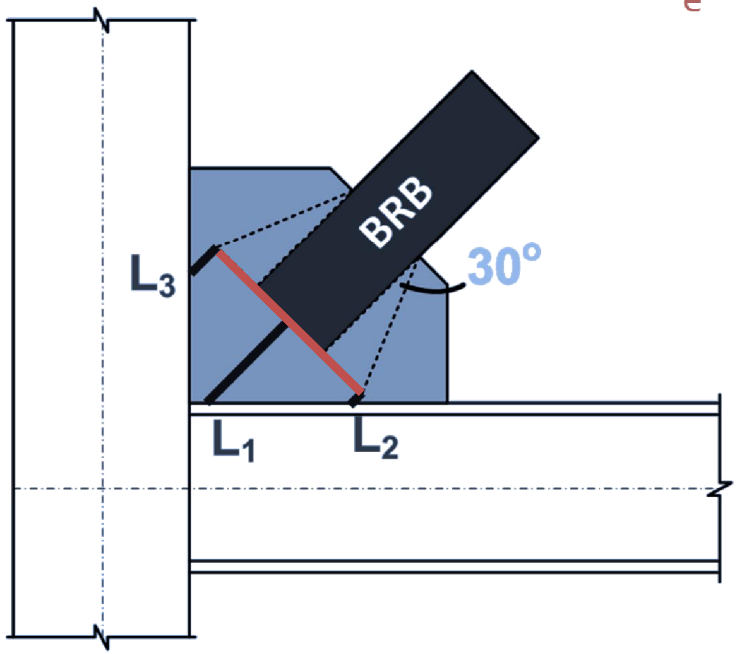
```
==========================================================
[Limit State 6]Gusset Plate Buckling(隅板挫屈破壞檢核)
==========================================================

[>>Inputted]
  [Lower]
   L1 = 556.6mm
   L2 = 17.6mm
   L3 = 366.9mm
   (L1 + L2 + L3)/3 = 313.7mm
   Lr = max( (L1 + L2 + L3)/3, 0) = 313.7mm
   Be = 862.4mm
   tg = 40mm
   K factor = 0.65
   λc = 0.23
   Fcr,g = 0.0323tonf/mm^2

[<<Determined]
   [Demand-6/Lower] = Pmax = 897.2tonf
   [Capacity-6/Lower] = 0.9*Fcr,g*Be*tg = 1002.8tonf
   [DCR-6/Lower] = 0.895
```

隅板挫屈破壞檢核

$$L_r = \frac{L_1 + L_2 + L_3}{3} \qquad \lambda_c = \frac{KL_r}{\pi r}\sqrt{\frac{F_{y,g}}{E}}$$

$$\begin{cases} \lambda_c \le 1.5, & F_{cr,g} = 0.658^{\lambda_c^2} F_{y,g} \\ \lambda_c > 1.5, & F_{cr,g} = \dfrac{0.877}{\lambda_c^2} F_{y,g} \end{cases}$$

Width of Whitmore section=B_e



結構試算表

設計結果列表與驗證 $(P_{max} = P_y R_y \Omega_h \beta)$

BOD-Diagonal-BRBF-147195433_my_bod [唯讀] [相容模式] - Micro

常用 插入 版面配置 公式 資料 校閱 檢視 Load Test PDF Team

BOD Server: S13101901			xls template: ver2013.09.6					Date: 2013/10/18 下午 01:04:00					Client Version: C13
斜撐編號 Tag	斜撐型式 Type of BRB	標稱降伏強度 Py(tonf)	極限壓力強度 Pmax(tonf)	等效勁度 Keff(tonf/mm)	等效勁度因子Q	消能長度因子α	框架幾何Frame						
							Hcol(mm)	Lbeam(mm)	Lwp (mm)	Le,lower (mm)	Le,upper (mm)	Lsrb (mm)	
My Brace	Welded End-Slot BRB	500.4	897.8	56.86	1.33	0.49	3600.0	6300.0	7256.0	1259.0	1008.0	4989.0	

[免責聲明]本軟體所引用之設計學理均為目前所認可者，其分析方法及設計程序尚屬適宜，惟設計人據以完成之各項計算、細部設計、設計圖說及施工說明和品質仍應依法自行負責。

<<DEFAULT SETTINGS>>		
Units	tonf-mm	
Steel Young's modulus: E	20.4	tonf/mm^2
Weld material tensile strength: Fexx	0.049	tonf/mm^2
<<FRAME>>		

<<SUMMARY>>	
Nominal yielding strength: Py	500.4
The maximum BRB compressive axial force capacity: Pmax	897.8
Effective stiffness: Keff	56.86
Effective stiffness factor: Q = Keff/(EAc/Lwp)	1.33
Energy dissipation section length ratio: α	0.49

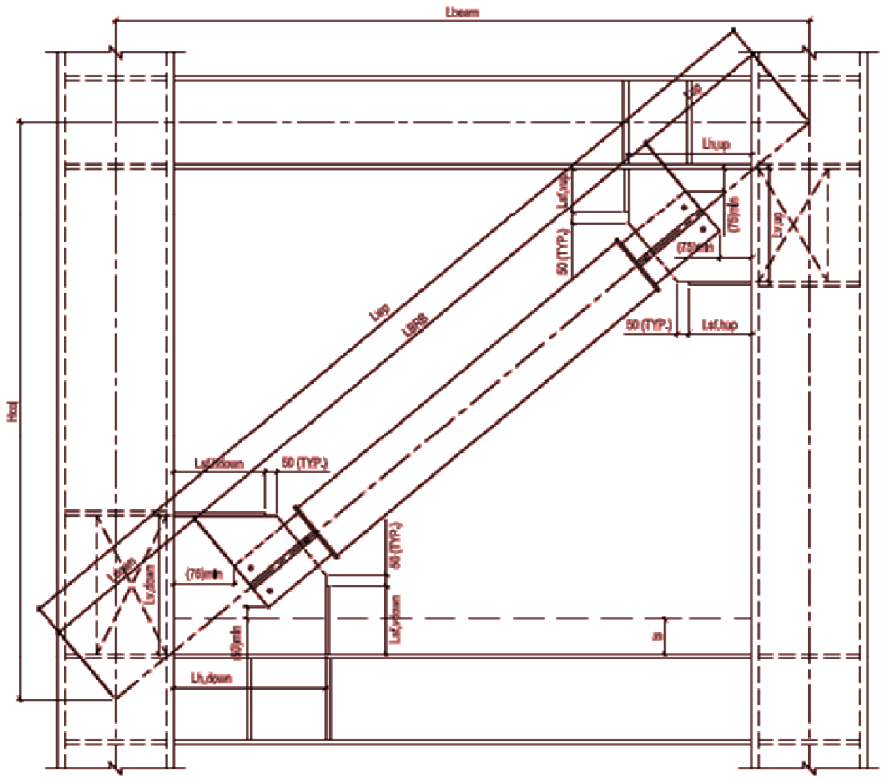
=P16*B52

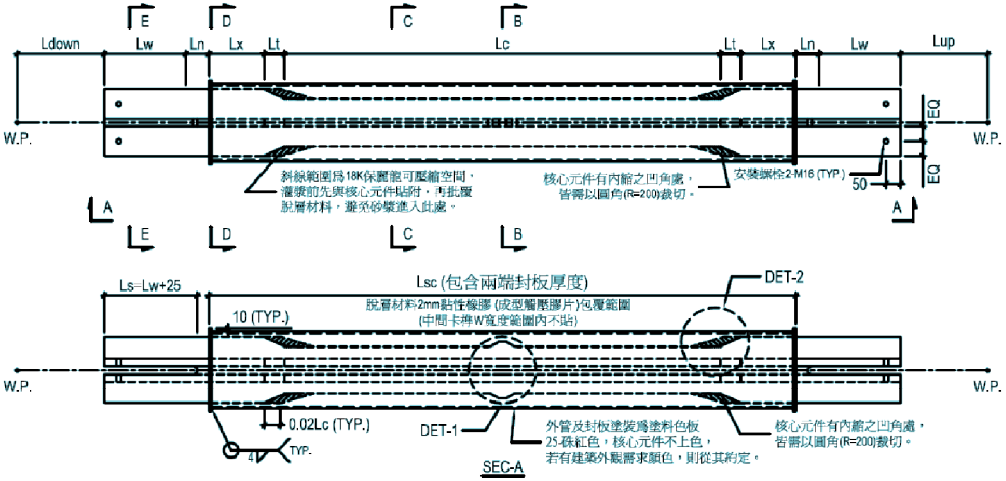
=J11*B53*B54*B55

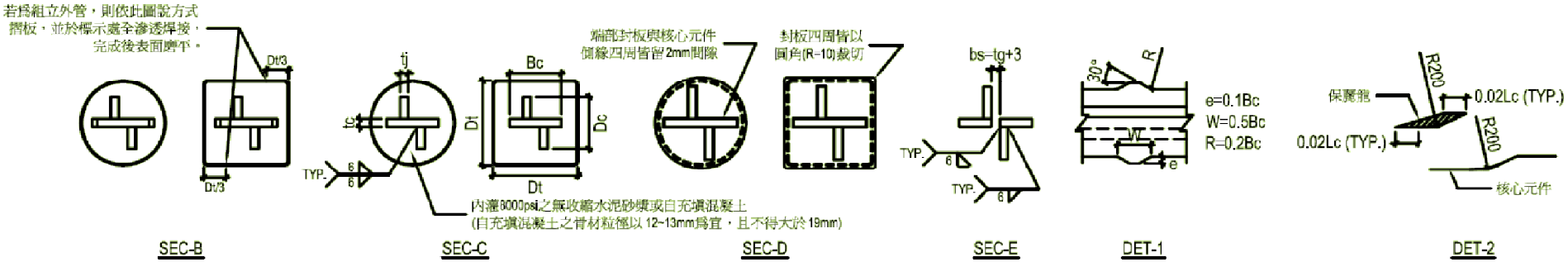
=B12*P16*P19*P29/

=J13*J16/(B12*P16)

標準圖


Lbeam
Lup
Lt,up
Lsc,up
50 (TYP.)
(75)min
Lsc
Lsc,up
50 (TYP.)
Lsc,down
Lt,down
Hbeam


Ldown
Lw
Ln
Lx
Lt
Lc
Lt
Lx
Ln
Lw
Lup
E
D
C
B
W.P.
W.P.
斜線範圍為18K保麗龍可壓縮空間，灌漿前先與核心元件貼附，剝掉脫層材料，避免砂漿進入此處。
核心元件有內縮之凹角處，皆需以圓角(R=200)裁切。
安裝螺栓2-M16 (TYP.)
50
E50
E50
A
A
Ls=Lw+25
Lsc (包含兩端封板厚度)
DET-2
脫層材料≥2mm黏性極膠(成型發泡膠片)包覆範圍
(中間卡榫W寬度範圍內不貼)
10 (TYP.)
0.02Lc (TYP.)
DET-1
TYP.
外管及封板塗裝烤漆色板
25-珠紅色，核心元件不上色，
若有建築外觀需求顏色，則從其約定。
核心元件有內縮之凹角處，
皆需以圓角(R=200)裁切。
SEC-A


若爲組立外管，則依此圖說方式
摺板，並於標示處全滲透焊接，
完成後表面磨平。
Dt/3
Dt/3
tj
tg
TYP.
6
6
Bc
Dt
Dc
Dt
內灌8000psi之無收縮水泥砂漿或自充填混凝土
(自充填混凝土之骨材粒徑以 12~13mm爲宜，且不得大於19mm)
端部封板與核心元件
側緣四周皆留2mm間隙
封板四周皆以
圓角(R=10)裁切
bs=tg+3
TYP.
6
TYP.
6
30°
R
W
e
e=0.1Bc
W=0.5Bc
R=0.2Bc
保麗龍
R200
0.02Lc (TYP.)
0.02Lc (TYP.)
R200
核心元件
SEC-B
SEC-C
SEC-D
SEC-E
DET-1
DET-2

結論

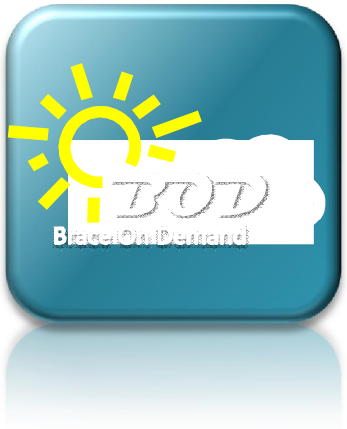
提升效率!

BOD可協助結構工程師提升WES-BRB設計工作的「質」與「量」。

過程透明!

BOD將設計工作自動化的同時，仍舊保有設計結果的可驗證性。

感謝聆聽　敬請指教



http://BOD.ncree.org.tw