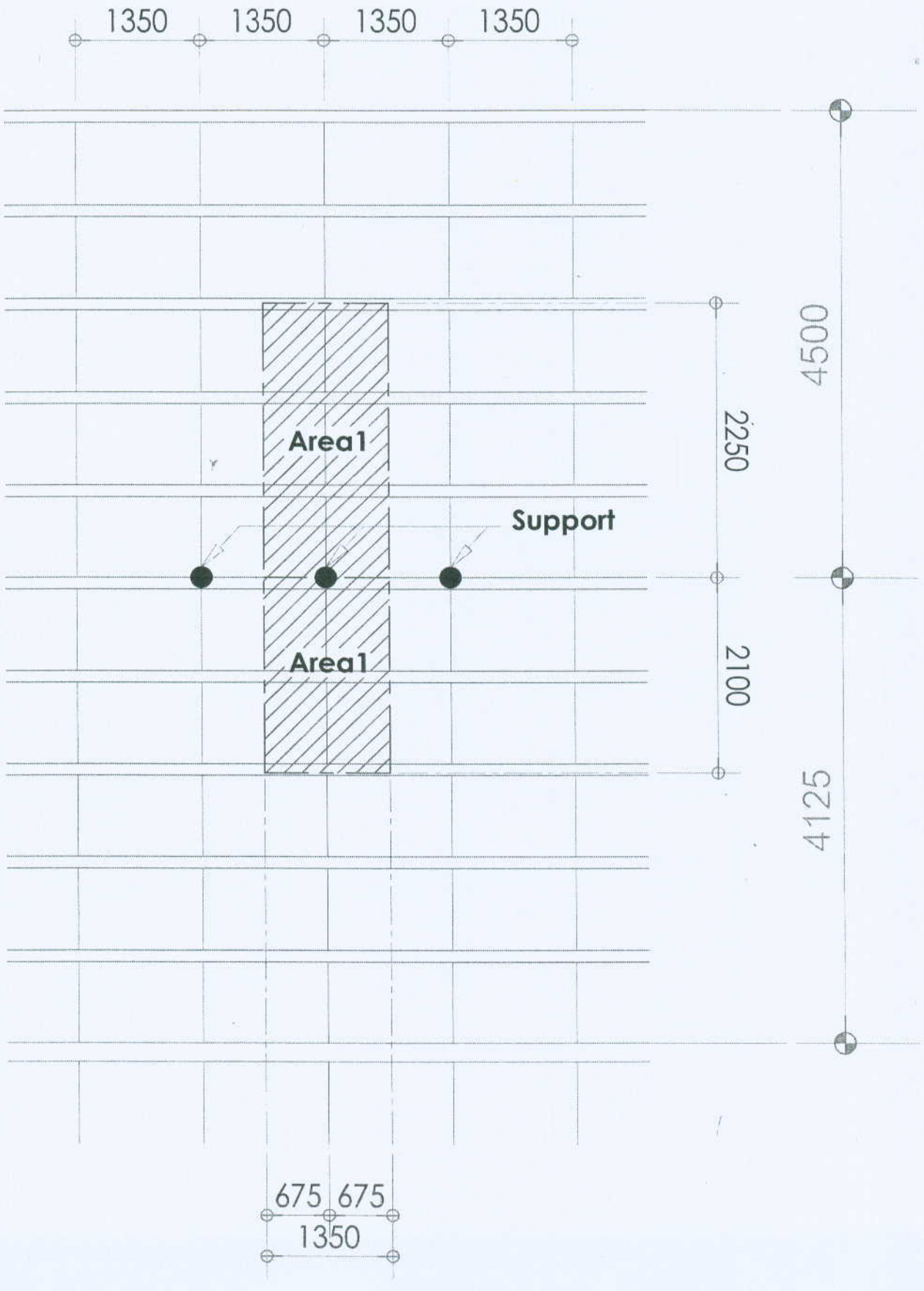
Load Area


1350
1350
1350
1350
4500
2250
2100
4125
Area1
Area1
Support
675
675
1350

วิเคราะห์แรงลม

Wind Load	160 kg/m^2				
Area 1 (per unit)	=	2.25x1.35	=	3.0375	m^2
Load (area 1)	=	(160x3.04)	=	486	kg
Area 2 (per unit)	=	2.10x0.675	=	1.42	m^2
Load (area 2)	=	(160x1.42)	=	227.2	kg
Combine load both Area1 and Area2					
	=	486+227	=	713.2	kg
	=	715x9.80	=	7007	N

วิเคราะห์น้ำหนักกระทำแนวดิ่ง

Aluminium

Mullion	=	(2782x0.01x0.27)*4.5x2	(data from Section Alu. Properties)		
		=	70	kg	
Transom	=	(1763x0.01x0.27)x1.35x4	(data from Section Alu. Properties)		
		=	30	kg	
Combine load both Muillion and Transom		=	100	kg	

Glass

Thickness of Glass = 18 mm.

(Refer. From glass of W1; 6 Green G.(H/S) + PVB Clear Dupont 1.52 mm. + 6 Green G.(H/S) + NTS230 on surface#4 + AS 12 mm. + 6 G.(A/N))

Weight	=	(4.5x1.35x0.018x2500)		
	=	275	kg	

Accessory

10% of both Aluminium and Glass	=	(100+275)x0.1		
	=	40	kg	
Sum all Load (Aluminium, Glass, Accessory)	=	415	kg	
	=	415x9.80		
	=	4067	N	

ตรวจสอบการรับแรงของสลักเกลียว

1. สลักเกลียวสำหรับการยึดระหว่าง Mullion และ Angle Aluminium

ใช้สลักเกลียวขนาดเส้นผ่าศูนย์กลาง = 12 mm.

ความสามารถในการรับแรงเฉือนของสลักเกลียว = $4/4 \times 1.2^{2}) \times 1480$

= 1673 kg./ตัว

จากข้อมูลการวิเคราะห์แรงกระทำแนวดิ่ง

รวม, F_y = 415 kg

แสดงว่าชิ้นงานสามารถรับแรงได้

2. สลักเกลียวสำหรับการยึดระหว่าง Steel Bracket และ Unistrud Support (concrete inserts)

ใช้สลักเกลียวขนาดเส้นผ่าศูนย์กลาง = 12 mm.

ความสามารถในการรับแรงเฉือนของสลักเกลียว = $(3.14/4 \times 1.2^{2}) \times 1480$

= 1673 kg./ตัว

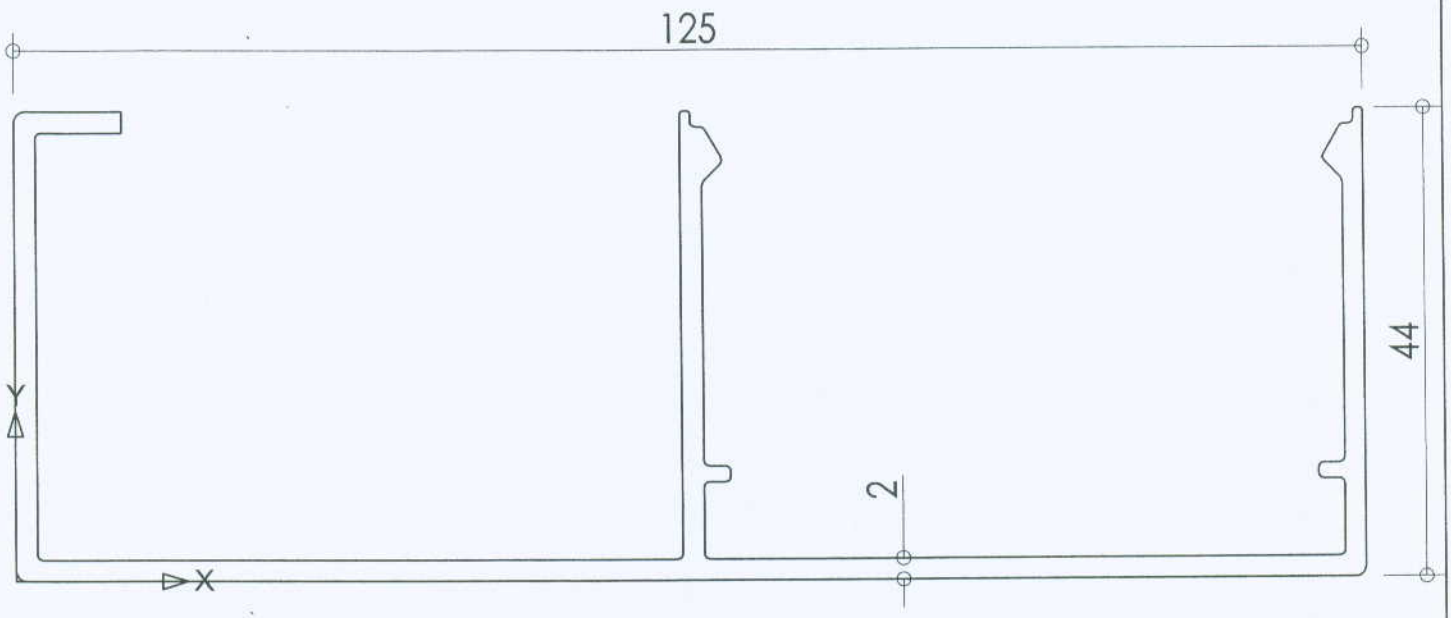
จากข้อมูลการวิเคราะห์แรงลม

F_x = 715 kg

แสดงว่าชิ้นงานสามารถรับแรงได้

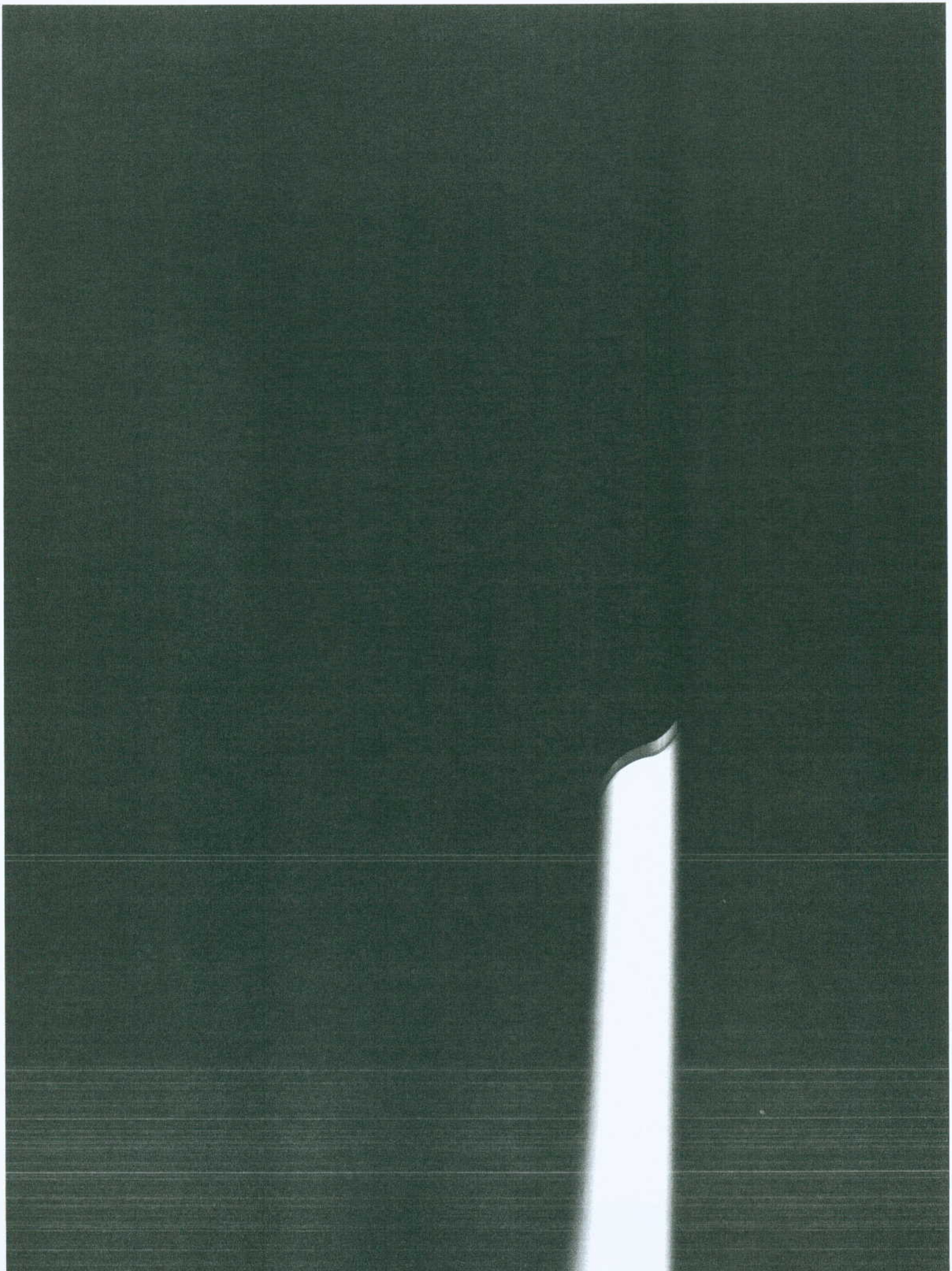
ตรวจสอบการรับแรงของ ALUMINIUM

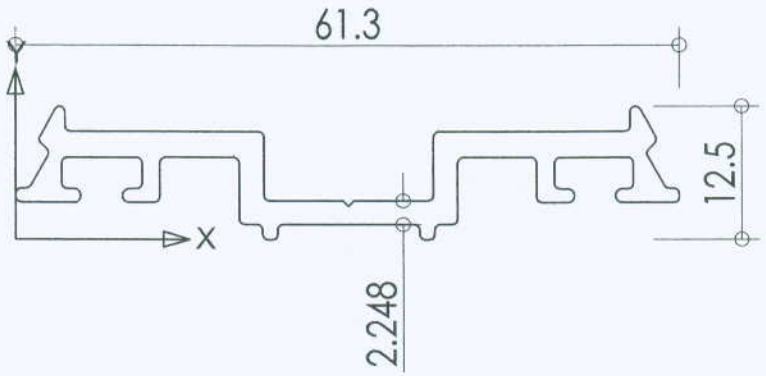
ALUMINIUM SECTION PROPRETIES



---------- REGIONS ----------

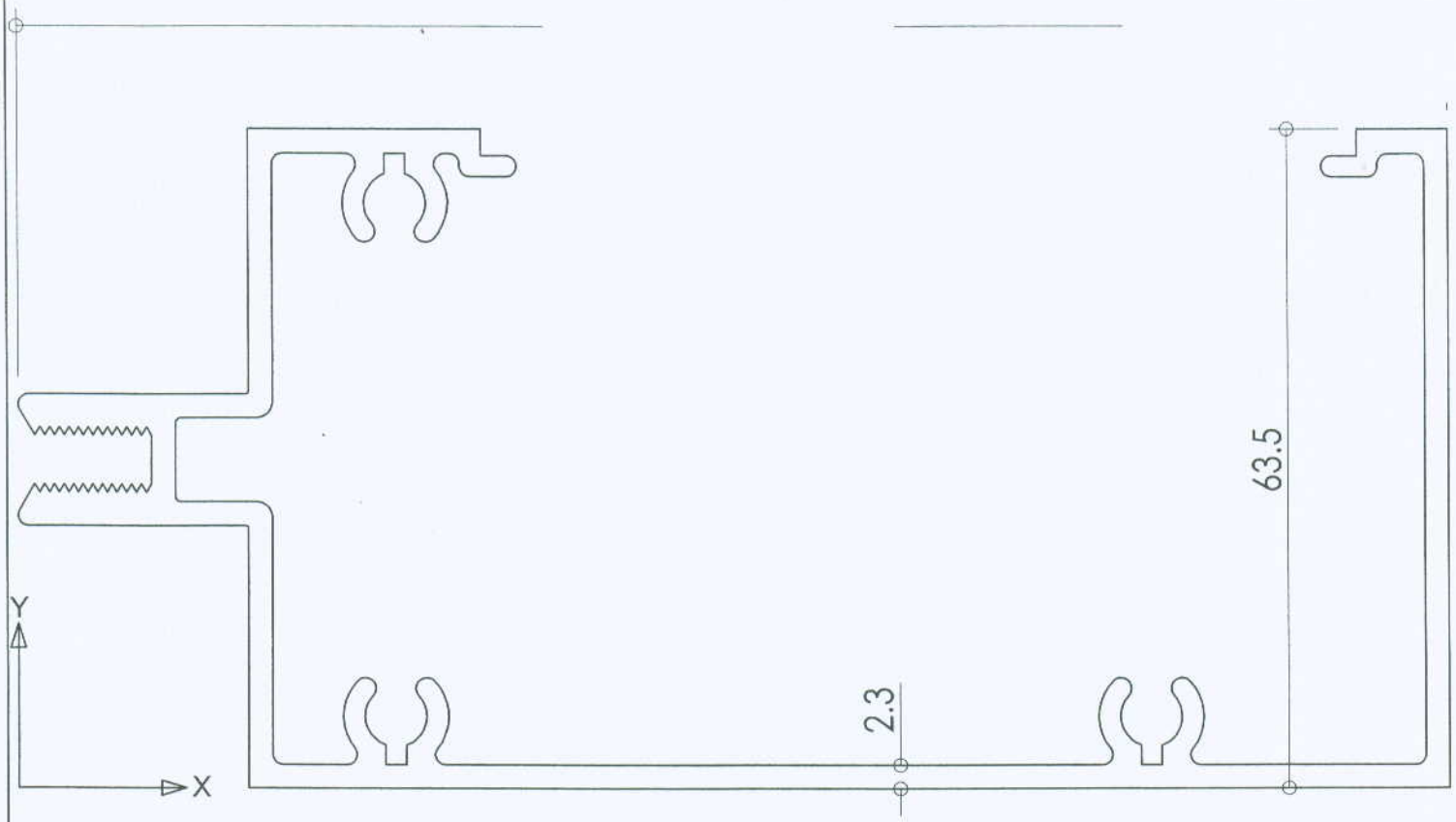
Area: 533.1373
Perimeter: 529.5991
Bounding box: X: 0.0000 -- 125.0000
Y: 0.0000 -- 44.0000
Centroid: X: 61.7181
Y: 13.3359
Moments of inertia: X: 212484.5957
Y: 3068082.7831
Product of inertia: XY: 417713.1350
Radii of gyration: X: 19.9638
Y: 75.8602
Principal moments and X-Y directions about centroid:
I: 117183.7398 along [0.9997 -0.0229]





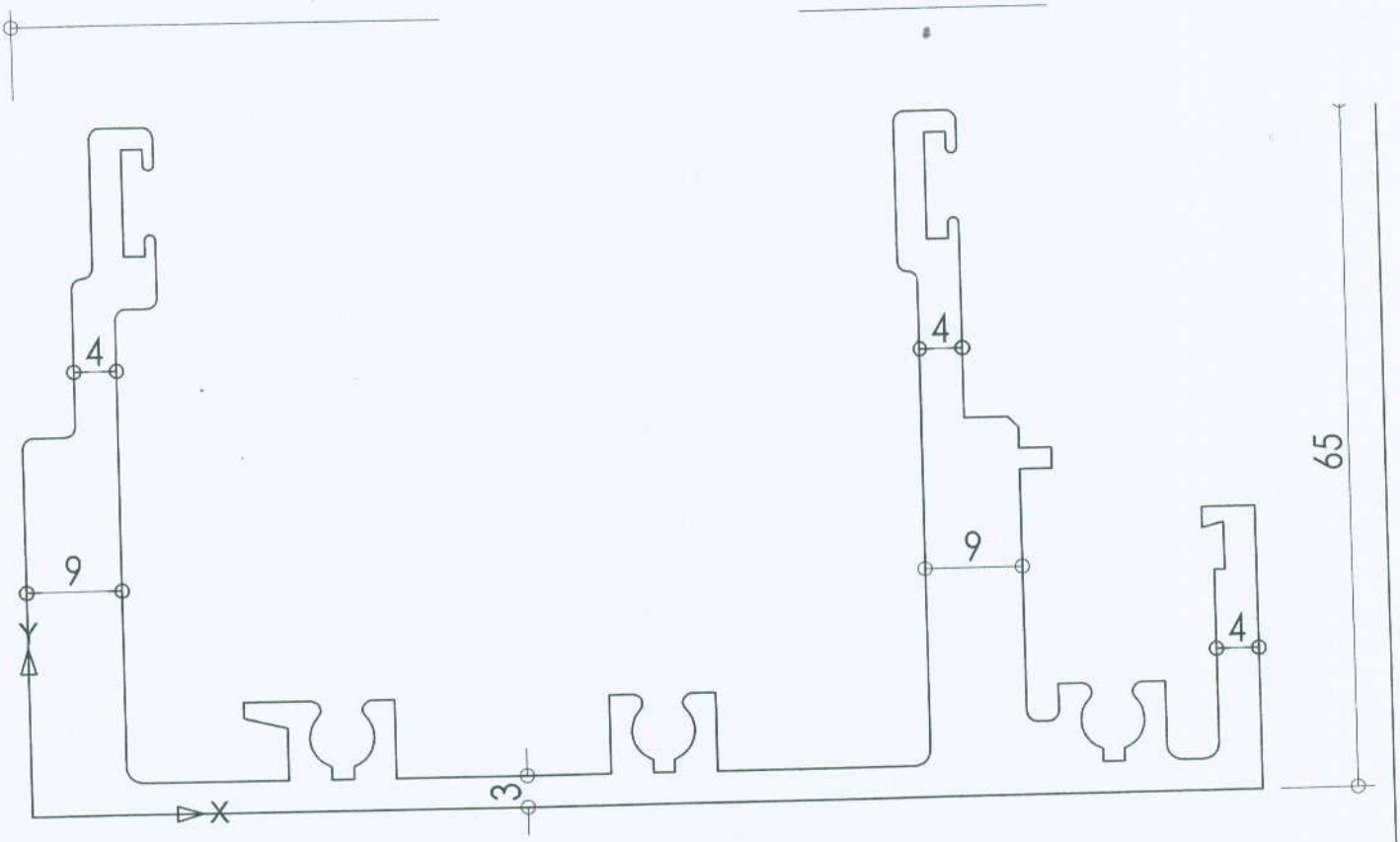
---------- REGIONS ----------

Area: 219.4172
Perimeter: 204.3067
Bounding box: X: 0.0000 -- 61.3000
Y: 0.0000 -- 12.5000
Centroid: X: 30.6495
Y: 6.4740
Moments of inertia: X: 11029.1808
Y: 277534.5975
Product of inertia: XY: 43537.5759
Radii of gyration: X: 7.0898
Y: 35.5650
Principal moments and X-Y directions about centroid.



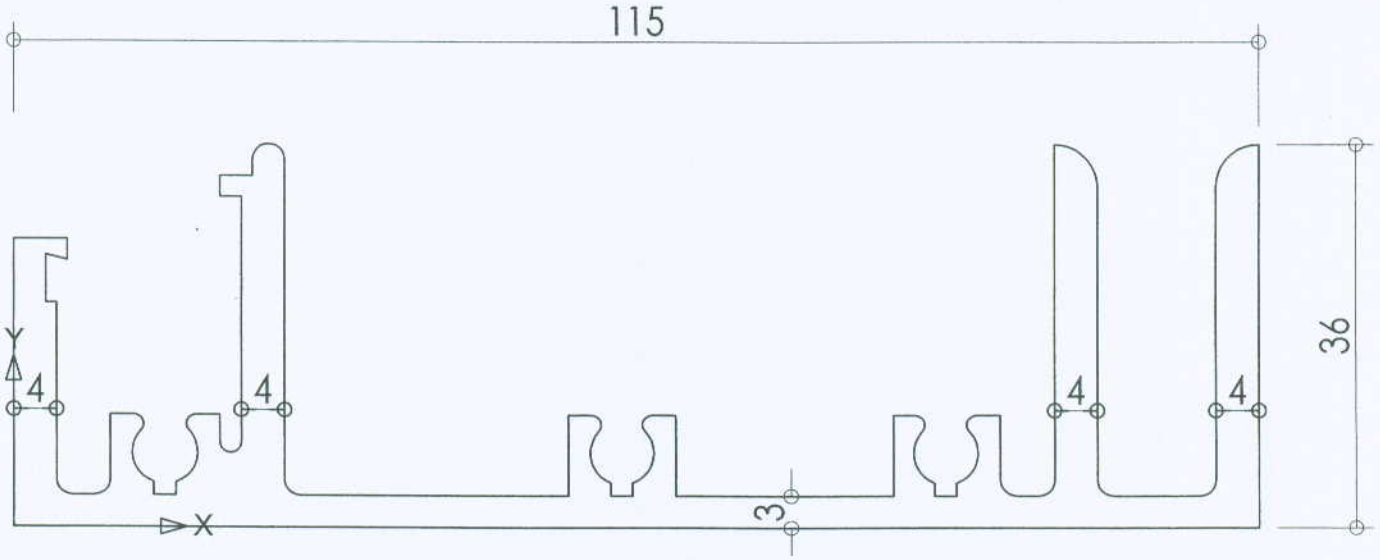
---------- REGIONS ----------

Area: 877.1300
Perimeter: 753.2813
Bounding box: X: 0.0000 -- 136.7500
Y: 0.0000 -- 63.5000
Centroid: X: 65.0090
Y: 24.5851
Moments of inertia: X: 977115.2863
Y: 5714461.8691
Product of inertia: XY: 1248010.1323
Radii of gyration: X: 33.3765
Y: 80.7153
Principal moments and X-Y directions about



---------- REGIONS ----------

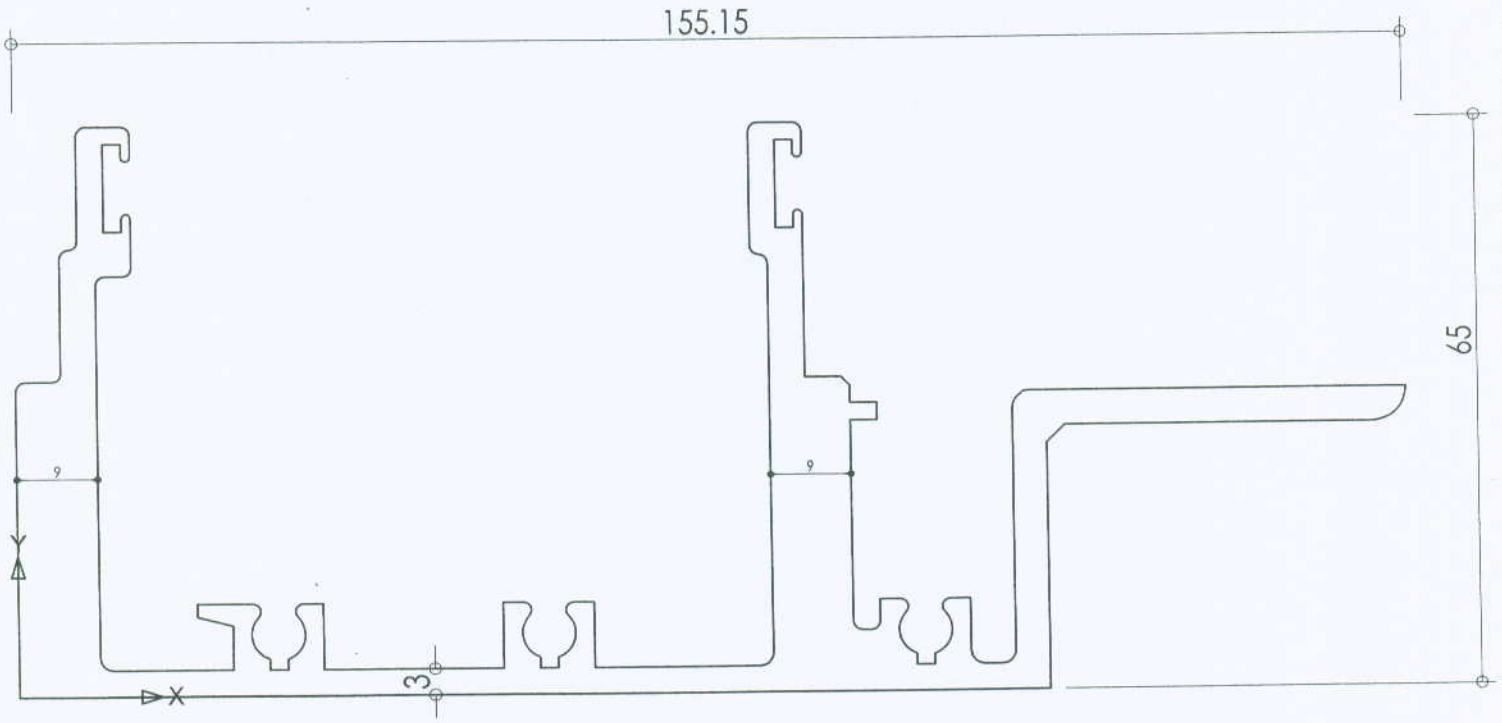
Area: 1565.4436
Perimeter: 655.7623
Bounding box: X: 0.0000 -- 115.0000
Y: 0.0000 -- 65.0000
Centroid: X: 54.0030
Y: 20.0881
Moments of inertia: X: 1142461.4194
Y: 7119537.5935
Product of inertia: XY: 1527597.3618
Radii of gyration: X: 27.0148
Y: 67.4384
Principal moments and X-Y directions about
I: 496607.6673 along [0.9966 -0.0826]



---------- REGIONS ----------

Area: 1075.8711
Perimeter: 559.9811
Bounding box: X: 0.0000 -- 115.0000
Y: 0.0000 -- 36.0000
Centroid: X: 59.8255
Y: 11.2990
Moments of inertia: X: 251097.8841
Y: 5635826.3090
Product of inertia: XY: 783955.6127
Radii of gyration: X: 15.2771
Y: 72.3767
Principal moments and X-Y directions about ce
I: 111822.4685 along [0.9994 0.0339]
I: 1787102.5532 along [-0.0339 0.9994]

92127



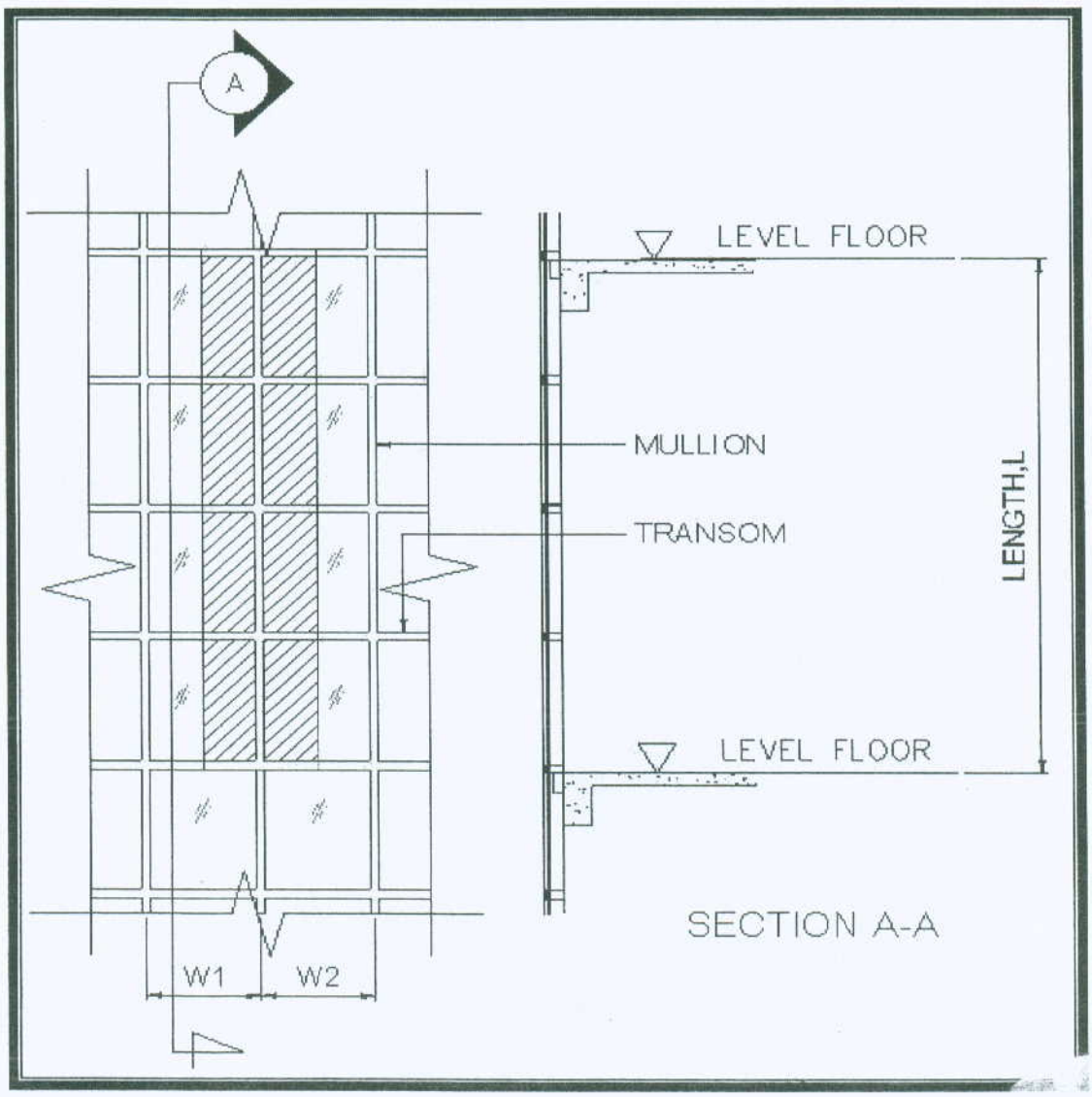
---------- REGIONS ----------

Area: 1625.1577
Perimeter: 746.1949
Bounding box: X: 0.0000 -- 155.1500
Y: 0.0000 -- 65.0000
Centroid: X: 64.0592
Y: 20.4405
Moments of inertia: X: 1162225.6029
Y: 10005750.5098
Product of inertia: XY: 2161894.1098
Radii of gyration: X: 26.7422
Y: 78.4652

MUL (CURTAIN WALL)

Project INSULATE, W1) **Date** 9/5/2007

Part W1



Data for calculation

1	Hight of building	41	m.	**(Wind Pressure at least = 160 kg/m^2)**
	Floor Level	-		
2	Length, L	4.125	m.	
3	Width, W1	1.2	m.	
4	Width, W2	1.2	m.	
5	Wind Load area on Mullion	4.95	m^2.	
	The total load	1.92	kg./cm	
6	Allowable Deflection, Δ_{all}	=	L / 175	
		=	2.36 cm.	
7	Safety factor	1		

From Deflection(Uniform Load) Fomular ; $I_{req} = \left[\frac{5 \times W \times L^3}{384 \times E \times \Delta_{max}}\right] \times SF.$

when ; I_{req} = Moment of Intertia Required (cm^4)

W = Total Uniform Distribution Load (kg./cm)

E = Modulus Elasticity of Aluminium ($E_{Alu} = 7x10^5$ kg./cm^2)

Δ_{all} = Allowable Deflection (= L/175)

L = Length of Million (cm.)

I_{req} = **438.7** cm^4

Define the Properties of Aluminium

Mechanical Properties

1	Type of Aluminium	6063 - T5		
2	Modulus of Elasticity	700,000	$kg./cm^2$	
3	Ultimate Tensile Strength, F_u	2,200	$kg./cm^2$	
4	Tensile Yield Strength, F_t	1,600	$kg./cm^2$	
5	Bending Stress, F_b	1,100	$kg./cm^2$	($F_b = 0.5*F_u$)

Data for Calculation

1	Code of Die	92127 + 92128				
2	Moment of Intertia, I_x	584.7	cm^4	>	I_{req}	**PASS**
3	Centroid of Section, C_x	6.5	cm.			
4	Section of Modulus, Z_x	89.95	cm^3			

Bending Moment Calculation

From Maximum Bend Moment for Continuous Beam (uniform load) Formular;

$$M_{max} = \frac{wl^2}{8}$$

$$= 40{,}837.50 \quad kg/cm^2$$

$$\text{Bending Stress, } \sigma_b = \frac{M_{max}}{Z_x}$$

$$= 453.98 \quad kg/cm^2 < F_b \quad \textbf{PASS}$$

Deflection Check

From Deflection(Uniform Load) Fomular ; Δ_{max}

$$\Delta_{max} = \frac{5wl^4}{384EI}$$

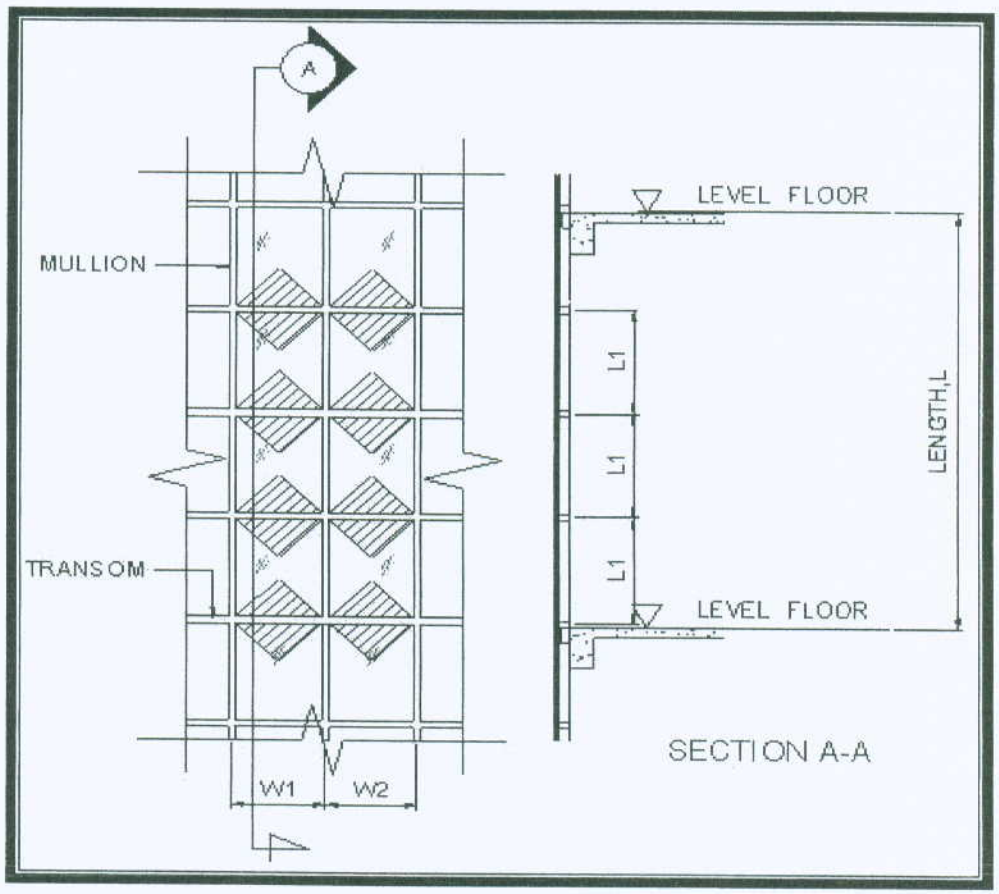
$$= 1.77 \text{ cm.} < \Delta_{all} \quad \textbf{PASS}$$

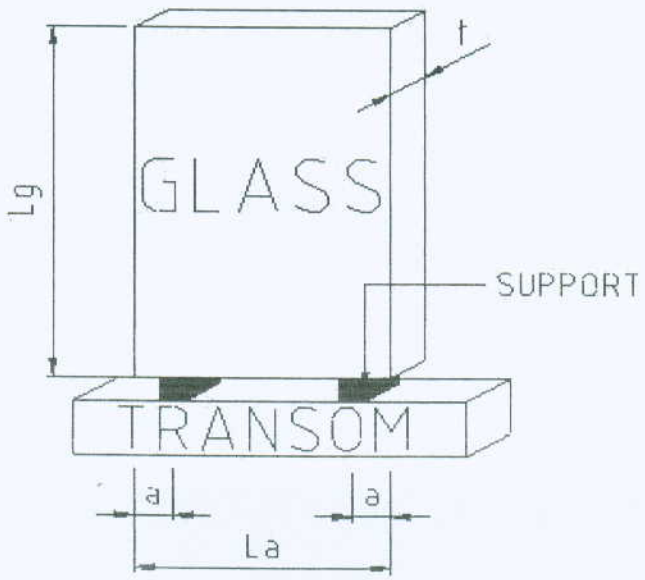
This Mullion is O.K.

TRANSOM DESIGN(CURTAIN WALL)

Project [illegible] ∩INSULATE, W1) **Date** 9/5/2007

Part W1





1	Type of Aluminium	6063 - T5		
2	Modulus of Elasticity	7.0E+05	$kg./cm^2$	
3	Ultimate Tensile Strength, F_u	2,200	$kg./cm^2$	
4	Tensile Yield Strength, F_t	1,600	$kg./cm^2$	
5	Bending Stress, F_b	1,100	$kg./cm^2$	($F_b = 0.5*F_u$)

Data for calculation

1	Hight of building	=	41	m.	**(Wind Pressure at least = 160 kg/m^2)**
	Floor Level		-		
2	Length of Glass, L_g		2	m.	
3	Width of Glass, L_a		1.2	m.	
4	Distance of Support, a		30	cm.	
5	Thickness of Glass, t		18	mm.	
6	Width of Transom		1.2	m.	
7	Code of Die		3025 + 9263 + 92118 + 32121		
8	Moment of Intertia, I_x		212.63	cm^4	
9	Moment of Intertia, I_y		50.319	cm^4	
10	Centroid of Section, C_x		7.4	cm.	
11	Centroid of Section, C_y		4	cm.	
12	Section of Modulus, Z_x		28.73	cm^3	
13	Section of Modulus, Z_y		12.58	cm^3	
14	Wind Load area on Transom				

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Applied Load to Transom, W_g = $2 \times \left[\frac{ws}{3} \right]$

S = Short Length

Short Length = 1.2 m.

Applied Load to Transom, W_g = 1.28 kg./cm

6	Allowable Deflection, Δ_{all}	=	L	/	175
		=	0.69	cm.	
7	Safety factor	1			

Dead Load Condition;

Weight of Glass 108 kg.

Applied Weight of Glass to Support, P_{g1} 54 kg.

Maximum Moment, M_{max} = P_g x a

= 1620.00 kg.-cm.

Bending Stress, $\sigma_{b(DL)}$ = $\frac{M_{alu}}{Z_{alu}}$

= 128.78 kg./cm^2 < F_b **PASS**

Deflection Check, Δ_{max}

From Deflection(Point Load) Fomular ; Δ_{max}

= $\frac{w_g \times a}{24EI_y} \times \left(3l^2 - 4a^2\right)$

= 0.08 cm. < Δ_{all} **PASS**

Wind Load Condition;

From Maximum Bend Moment for Continuous Beam (uniform load) Formular;

M_{max} = $\frac{w \times L_a^2}{12}$

= 1536.00 kg./cm^2

Bending Stress, $\sigma_{b(WL)}$ = $\frac{M_{alu}}{Z_{alu}}$

= 53.46 kg./cm^2 < F_b **PASS**

Deflection Check, Δ_{max}

From Deflection(Triangular Load) Fomular ; Δ_{max}

= $\frac{w \times L_a^4}{120EI_y}$

= 0.01 cm. < Δ_{all}

Combined Bending Stress Condition;

Combined Bending Stress, $\sigma_{b(ALL)}$ = $\sigma_{b(DL)} + \sigma_{b(WL)}$

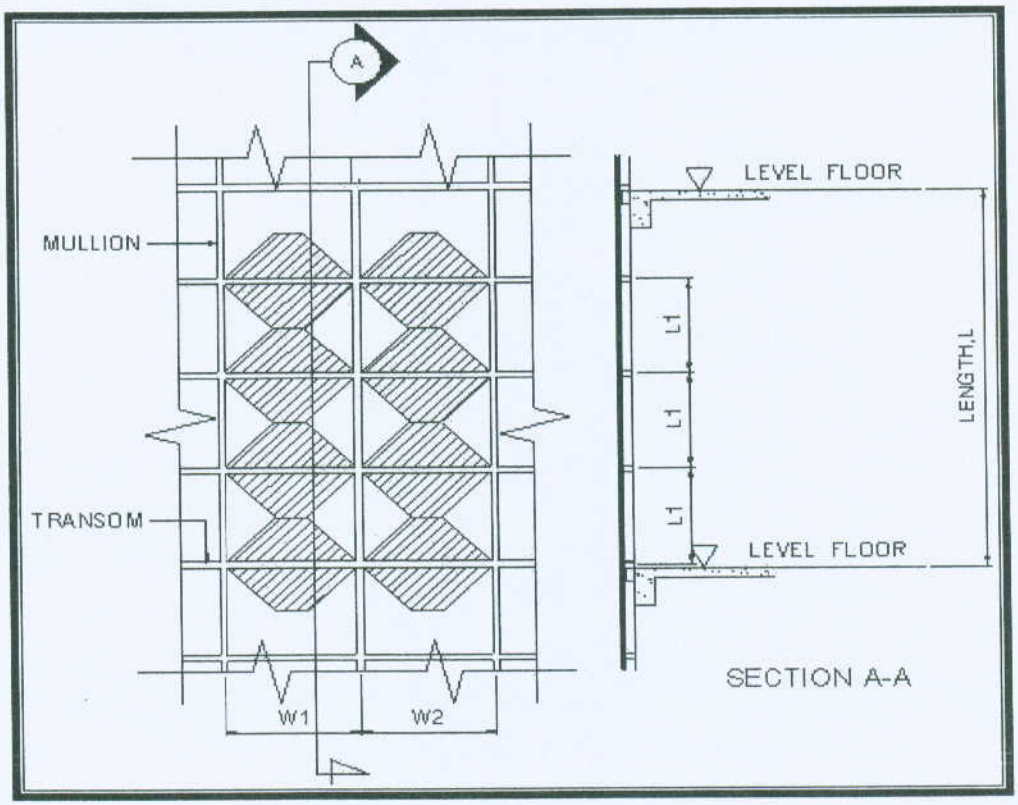
= 182.23 < F_b **PASS**

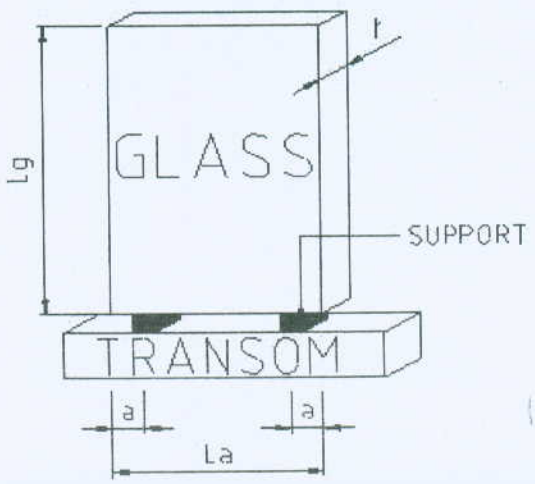
Thus; This Transom is O.K.

TRANSOM DESIGN(CURTAIN WALL)

Project _aminate, W2,W3) **Date** 9/5/2007

Part W2, W3





Mechanical Properties of Aluminium

1	Type of Aluminium	6063 - T5		
2	Modulus of Elasticity	700,000	$kg./cm^2$	
3	Ultimate Tensile Strength, F_u	2,200	$kg./cm^2$	
4	Tensile Yield Strength, F_t	1,600	$kg./cm^2$	
5	Bending Stress, F_b	1,100	$kg./cm^2$	($F_b = 0.5*F_u$)

Data for calculation

1	Hight of building	=	41	m.	**(Wind Pressure at least = 160 kg/m^2)**
	Floor Level		-		
2	Length of Glass, L_{g1}		1.2	m.	
3	Width of Glass, L_{a1}		1.35	m.	
4	Length of Glass, L_{g2}		1.2	m.	
5	Width of Glass, L_{a2}		1.35	m.	
6	Distance of Support, a		33.75	cm.	
7	Thickness of Glass, t		18	mm.	
8	Width of Transom		1.35	m.	
9	Code of Die		3025 + 9263 + 92118 + 32121		
10	Moment of Intertia, I_x		212.63	cm^4	
11	Moment of Intertia, I_y		50.319	cm^4	
12	Centroid of Section, C_x		7.4	cm.	
13	Centroid of Section, C_y		4	cm.	
14	Section of Modulus, Z_x		28.73	cm^3	
15	Section of Modulus, Z_y		12.58	cm^3	
16	Allowable Deflection, Δ_{all}		0.77	cm.	

15 Wind Load area on Transom

First Side; Short Length = 1.2 m.

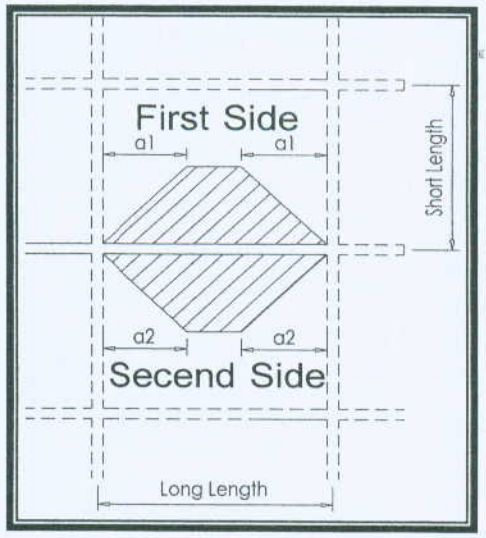
Long Length = 1.35 m.

a_1 = 0.6 m.

Secend Side ; Short Length = 1.2 m.

Long Length = 1.35 m.

a_2 = 0.6 m.



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Applied Load to Mullion. = $\frac{W \times S}{3} \times \frac{\left[3 - m^2\right]}{2}$

when ; m = $\frac{S}{L}$

S = Short Length

L = Long Length

m_1 = 0.8889

m_2 = 0.8889

Applied Load to Mullion, w_1 = 0.7072 kg./cm

Applied Load to Mullion, w_2 = 0.7072 kg./cm

Applied Load to Mullion, w_{all} = 1.4143 kg./cm

Dead Load Condition;

Weight of Glass 72.9 kg.

Applied Weight of Glass to Support, P_{g1} 36.45 kg.

Maximum Moment, M_{max} = P_g x a

= 1230.19 kg.-cm.

Bending Stress, $\sigma_{b(DL)}$ = $\frac{M_{alu}}{Z_{alu}}$

= 97.79 kg./cm^2 < F_b **PASS**

Deflection Check, Δ_{max}

From Deflection(Point Load) Fomular ; Δ_{max}

= $\frac{w_g \times a}{24EI_y} \times \left(3l^2 - 4a^2\right)$

= 0.07 cm. < Δ_{all} **PASS**

Wind Load Condition;

From Maximum Bending Moment for Continuous Beam (Trapezoid load) Formular;

M_{max} = $\left[\frac{w_1}{24} \times \left(3l^2 - 4a_1{}^2\right)\right] + \left[\frac{w_2}{24} \times \left(3l^2 - 4a_2^2\right)\right]$

= 2373.41 kg./cm^2

Bending Stress, $\sigma_{b(WL)}$ = $\frac{M_{alu}}{Z_{alu}}$

= 82.60 kg./cm^2 < F_b **PASS**

Deflection Check, Δ_{max}

From Deflection(Triangular Load) Fomular ; Δ_{max}

= $\left[\frac{w_{all}}{1920EI_x} \times \left(5l^2 - 4a_1^2\right)\right]$

= 0.03 cm. < Δ_{all}

Combined Bending Stress Condition;

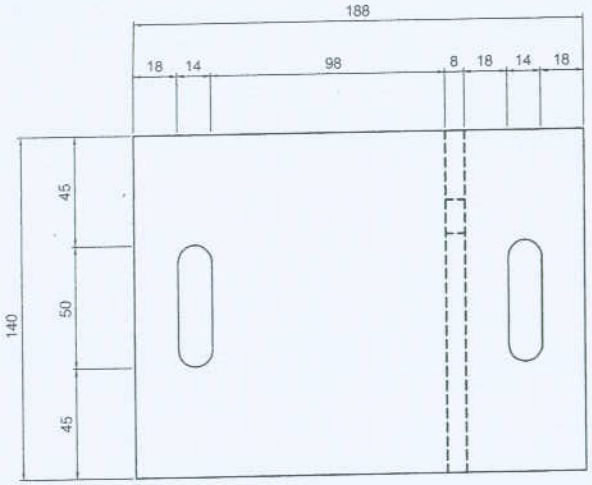
Combined Bending Stress, $\sigma_{b(ALL)}$ = $\sigma_{b(DL)} + \sigma_{b(WL)}$

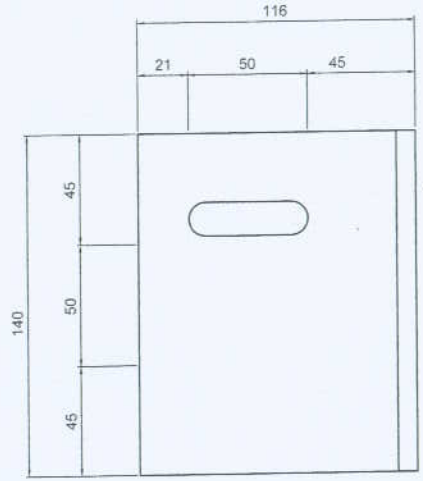
= 180.39 < F_b **PASS**

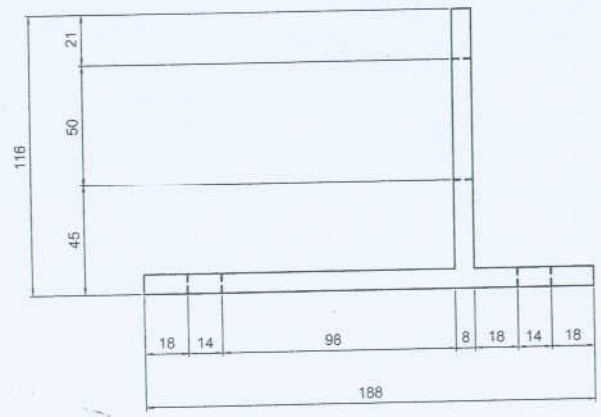
Thus; This Transom is O.K.

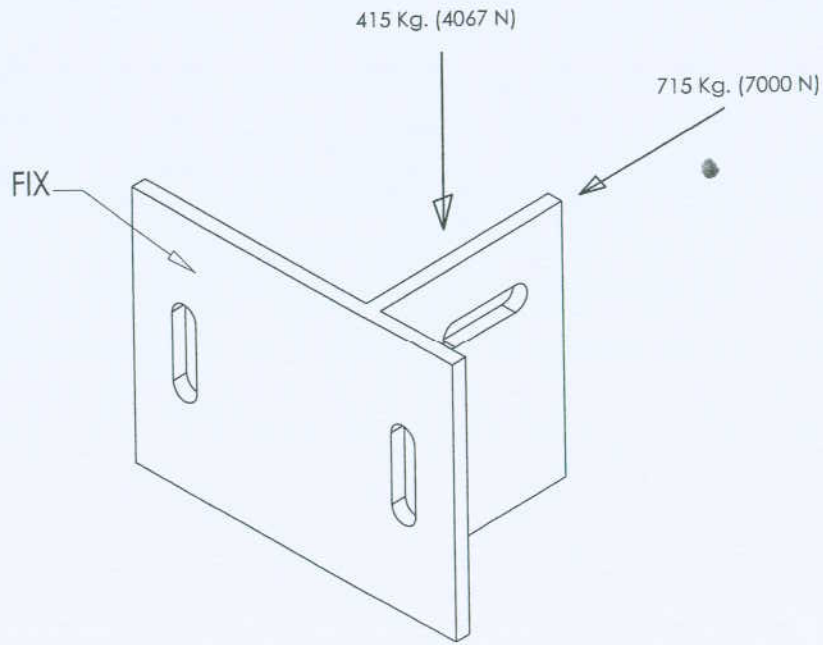
ตรวจสอบการรับแรงของ

BRACKET ALUMINIUM FOR CURTAIN WALL


188
18
14
98
8
18
14
18
140
45
50
45


116
21
50
45
140
45
50
45


116
21
50
45
18
14
98
8
18
14
18
188


415 Kg. (4067 N)
715 Kg. (7000 N)
FIX

ตรวจสอบการรับแรงของ Bracket Alu. For Curtain Wall

ตามข้อมูล Finite Element Method(FEM) ของ T_ALU27035

(เป็นการวิเคราะห์รวมแรงระหว่างแรงลมและแรงกระทำแนวดิ่ง)

การวิเคราะห์พิจารณาที่สภาวะประลัย (Ultimate Point, Ft = 0.50 x Fu)

Stress Max.	=	6.85E+07	N/m^2
Yield Stress(for aluminium)	=	1.60E+08	N/m^2
$F_{t(aluminium)}$	=	0.5x1.60E+07	
	=	8.00E+07	N/m^2

แสดงว่าชิ้นงานสามารถรับแรงได้

Materials

No.	Part Name	Material	Mass	Volume
1	T_ALU 270350	[SW]~~6061~~ Alloy	0.85247 kg	0.000315729 m^3

B3 Alu. 6063-T

. Load & Restraint Information

Restraint

Restraint1 <T_ALU 270350>	on **1 Face(s)** immovable (no translation).
Description:	

Load

Load1 <T_ALU 270350>	on **1 Face(s)** apply normal force **7000 N** using uniform distribution
Description:	
Load2 <T_ALU 270350>	on **1 Face(s)** apply normal force **4100 N** using uniform distribution
Description:	

. Study Property

Mesh Information

Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	5 mm
Tolerance:	0.25 mm
Quality:	High
Number of elements:	20686
Number of nodes:	35264
Time to complete mesh(hh;mm;ss):	00:00:10
Computer name:	DE01

Solver Information

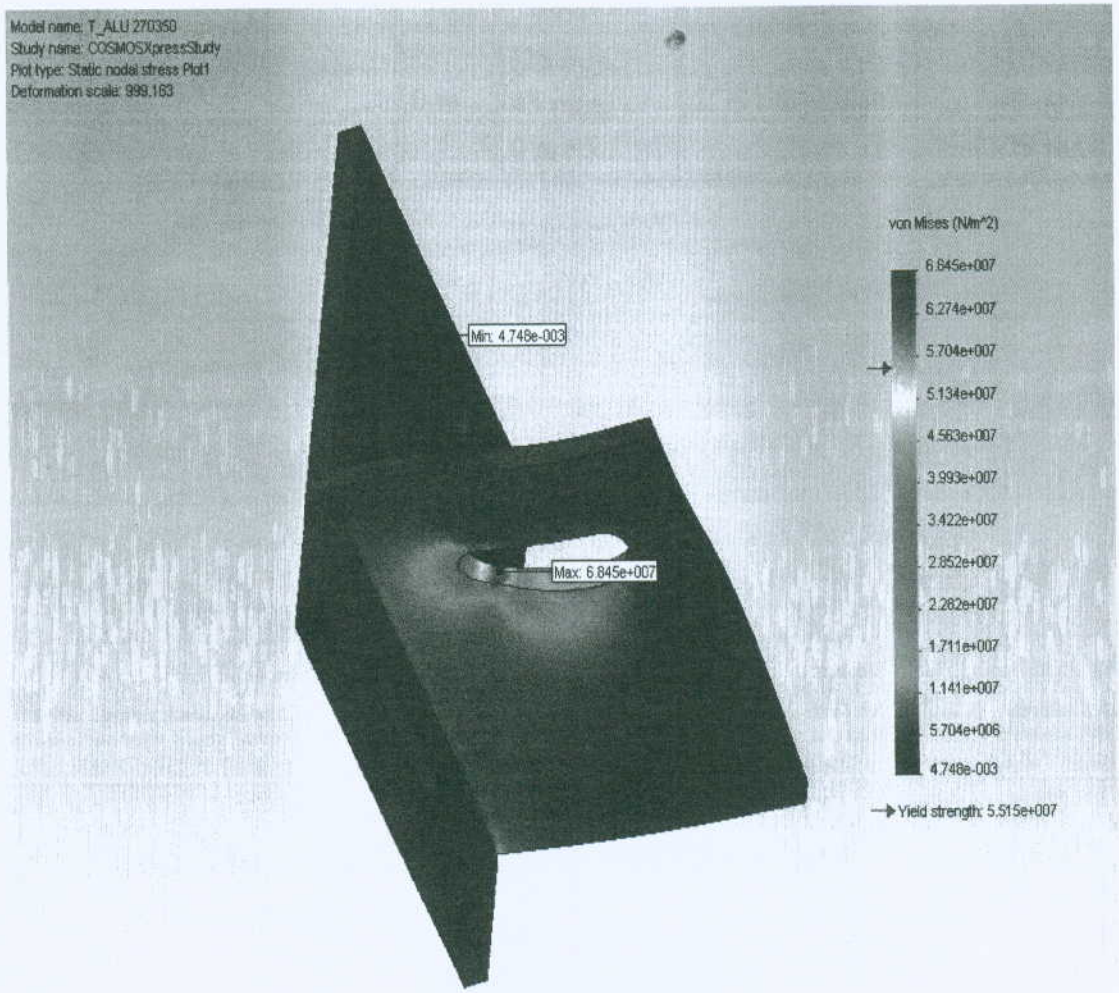
Quality:	High
Solver Type:	Automatic

Stress

Name	Type	Min	Location	Max	Location
Plot1	VON: von Mises stress	0.004748 N/m^2	(12.3684 mm, 75 mm, 0 mm)	6.84476e+007 N/m^2	(132 mm, 98.2385 mm, -50.1883 mm)

T_ALU 270350-COSMOSXpressStudy-Stress-Plot1

JPEG



. Displacement

Name	Type	Min	Location	Max	Location
Plot2	URES: Resultant displacement	0 m	(25 mm, 45 mm, 0 mm)	1.9919e-005 m	(138 mm, 98 mm, -79 mm)

. Appendix

Ref Alu. 6063 - T5.

Material name: [SW]~~6061~~ Alloy

Description:

Material Source: Used SolidWorks material

Material Library Name:

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	6.9e+010	N/m^2
Poisson's ratio	0.33	NA
Mass density	2700	kg/m^3
Yield strength	~~5.5149e+007~~	N/m^2

Yield Strength = $1.6 E+08$ N/m^2

F_t = $0.5 \times 1.6 E+08$

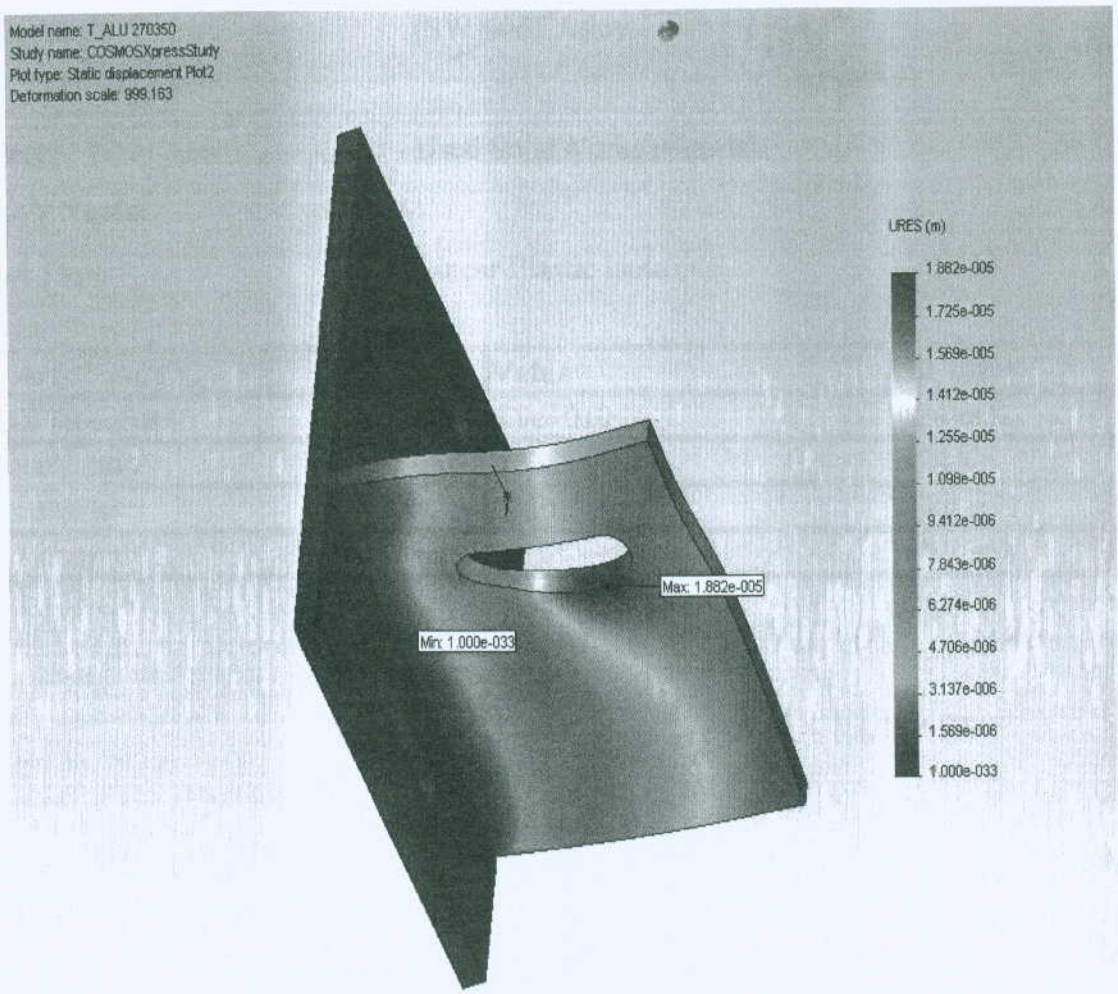
= $8.00 E+07$

b. Displacement

Name	Type	Min	Location	Max	Location
Plot2	URES: Resultant displacement	0 m	(25 mm, 45 mm, 0 mm)	1.9919e-005 m	(138 mm, 98 mm, -79 mm)

T_ALU 270350-COSMOSXpressStudy-Displacement-Plot2

JPEG



5. Appendix

Al Alu. 6063 - T5.

Material name: [SW]~~6061~~ Alloy

Description:

Material Source: Used SolidWorks material

Material Library Name:

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	6.9e+010	N/m^2
Poisson's ratio	0.33	NA
Mass density	2700	kg/m^3
Yield strength	~~5.5149e+007~~	N/m^2

Yield Strength = 1.6E+08 N/m²

F_t = 0.5 × 1.6E+08

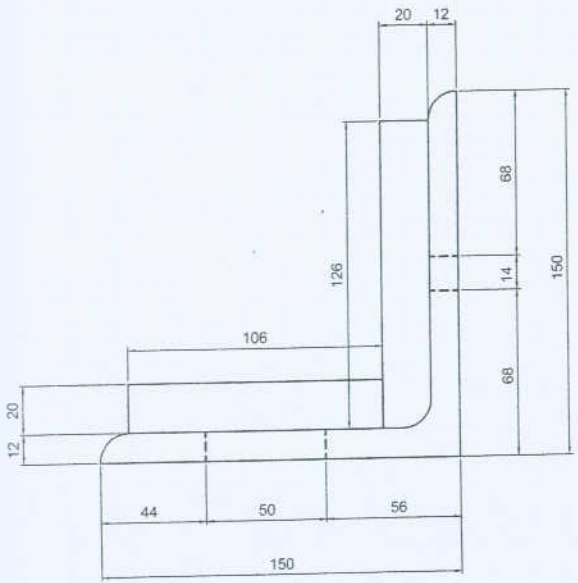
=

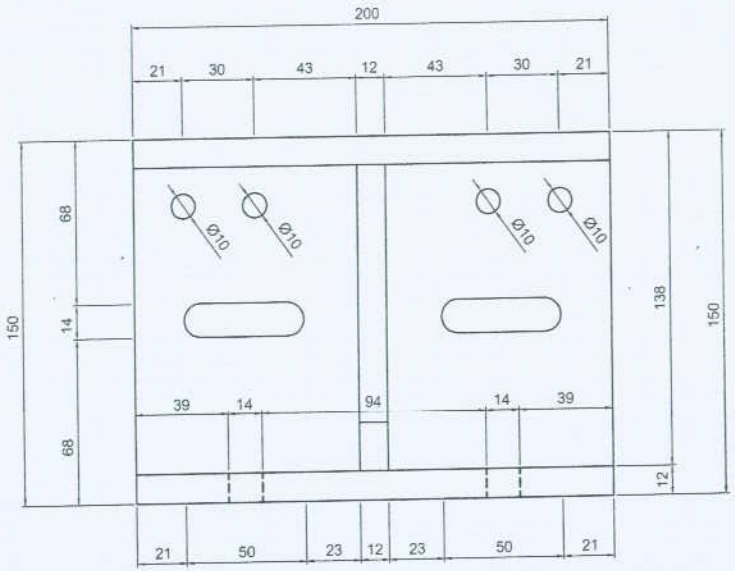
Note:

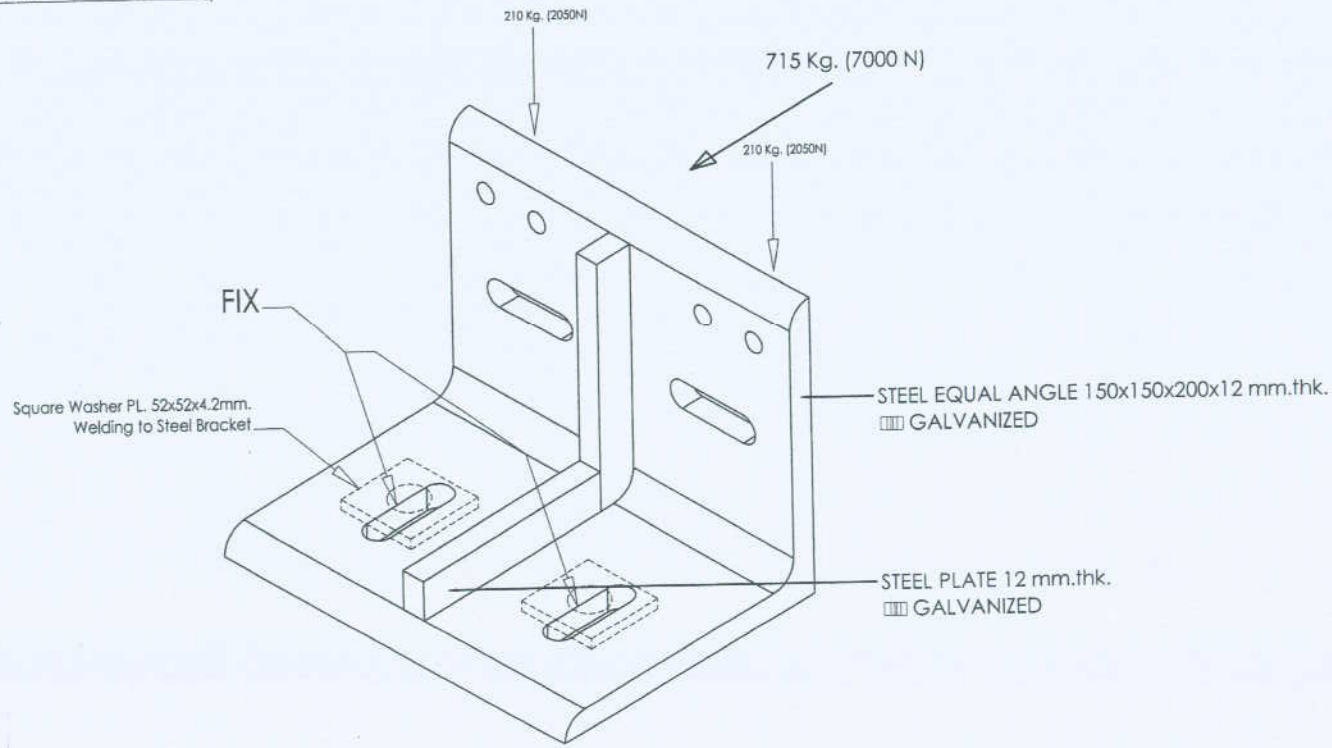
ตรวจสอบการรับแรงของ

BRACKET SUPPORT FOR CURTAIN WALL

INNOVATION IN STYLE







ตรวจสอบการรับแรงของ Bracket Support for Curtain wall

ตามข้อมูล Finite Element Method(FEM) ของ BRACKET SUPPORT FOR CURTAIN WALL

การวิเคราะห์พิจารณาที่สภาวะประลัย (Ultimate Point, Ft = 0.50 x Fu)

Stress Max.	=	1.35E+08	N/m^2
Yield Stress(for Steel)	=	2.40E+08	N/m^2
$F_{t(steel)}$	=	0.6x2.40E+08	
	=	1.44E+08	N/m^2

แสดงว่าชิ้นงานสามารถรับแรงได้

BRACKET SUPPORT FOR CURTAIN WALL

2. Materials

No.	Part Name	Material	Mass	Volume
1	BRACKET_NO SIDE RIB_2_2_4	[SW]Galvanized Steel	6.87804 kg	0.000873957 m^3

3. Load & Restraint Information

Restraint

Restraint1 <BRACKET SUPPOR FOR CURTAIN WALL>	on **2 Face(s)** immovable (no translation).
Description:	
Restraint2 <BRACKET SUPPOR FOR CURTAIN WALL>	on **8 Face(s)** immovable (no translation).
Description:	

Load

Load1 <BRACKET SUPPOR FOR CURTAIN WALL>	on **1 Face(s)** apply normal force **7000 N** using uniform distribution
Description:	
Load2 <BRACKET SUPPOR FOR CURTAIN WALL>	on **2 Face(s)** apply normal force **2050 N** using uniform distribution
Description:	

4. Study Property

Mesh Information

Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	5 mm
Tolerance:	0.25 mm
Quality:	High
Number of elements:	51500
Number of nodes:	81859
Time to complete mesh(hh;mm;ss):	00:00:21
Computer name:	DE01

Solver Information

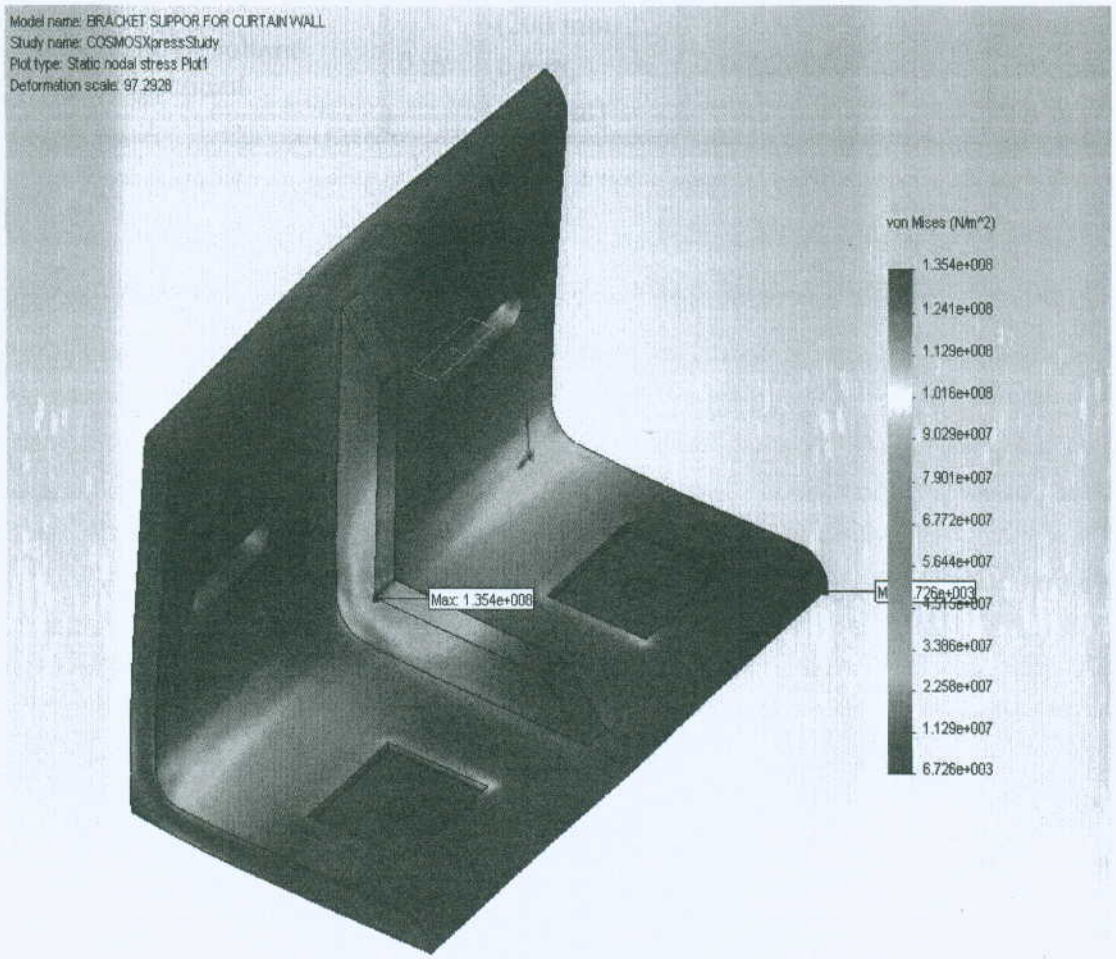
Quality:	High
Solver Type:	Automatic

a. Stress

Name	Type	Min	Location	Max	Location
Plot1	VON: von Mises stress	6725.57 N/m^2	(2.5 mm, 0 mm, -150 mm)	1.35435e+008 N/m^2	(135 mm, 32 mm, -32 mm)

BRACKET SUPPOR FOR CURTAIN WALL-COSMOSXpressStudy-Stress-Plot1

JPEG

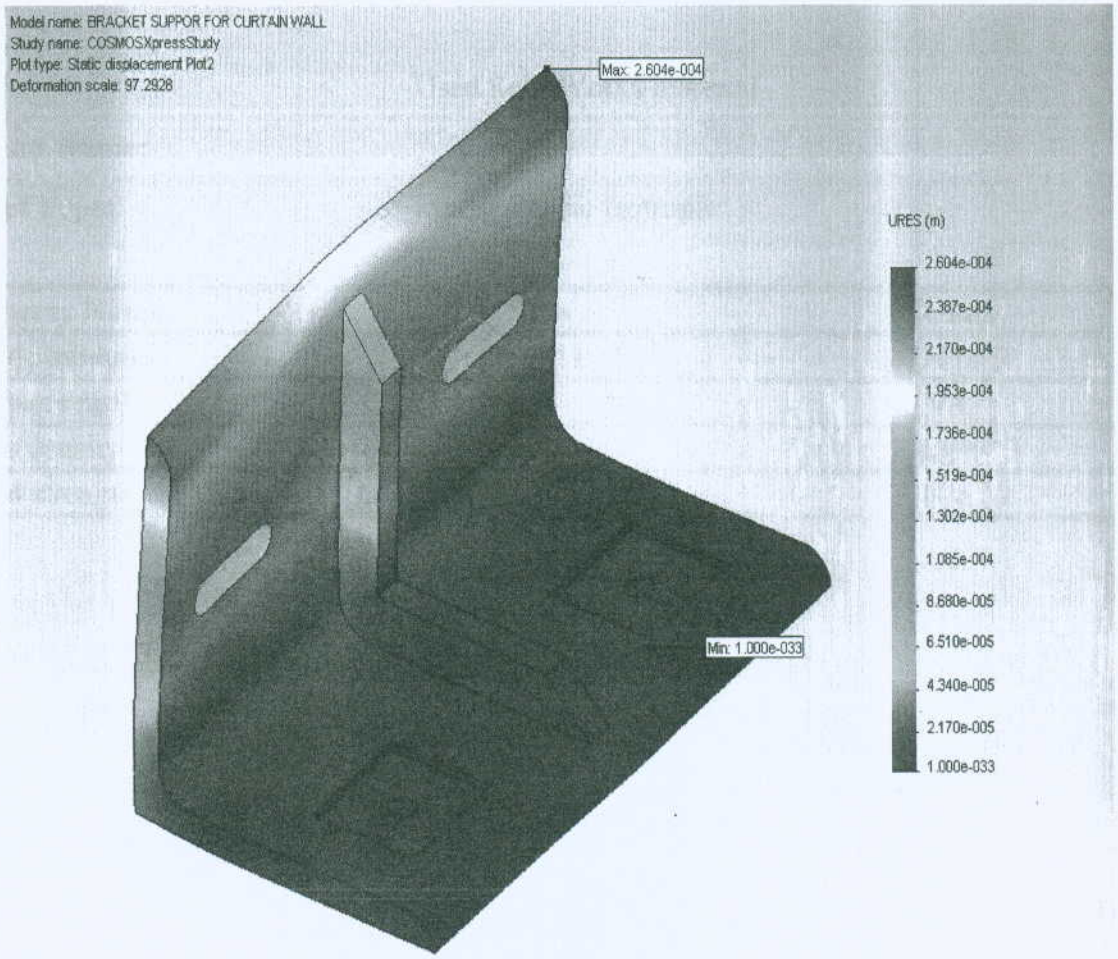


5b. Displacement

Name	Type	Min	Location	Max	Location
Plot2	URES: Resultant displacement	0 m	(200 mm, 0 mm, -89 mm)	0.000260407 m	(0 mm, 150 mm, 0 mm)

BRACKET SUPPOR FOR CURTAIN WALL-COSMOSXpressStudy-Displacement-Plot2

JPEG



6. Appendix

Material name: [SW]Galvanized Steel

Description:

Material Source: Used SolidWorks material

Material Library Name:

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	2e+011	N/m^2
Poisson's ratio	0.29	NA
Mass density	7870	kg/m^3
Yield strength	2.0394e+008	N/m^2

Note:

COSMOSXpress design analysis results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that: 1) the material behavior is linear complying with Hooke's law, 2) induced displacements are adequately small to ignore changes in stiffness due to loading, and 3) loads are applied slowly in order to ignore dynamic effects.

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSXpress helps you reduce your time-to-market by reducing but not eliminating field tests.

ตรวจสอบการรับแรงของ

PLATE FOR CURVE CURTAIN WALL

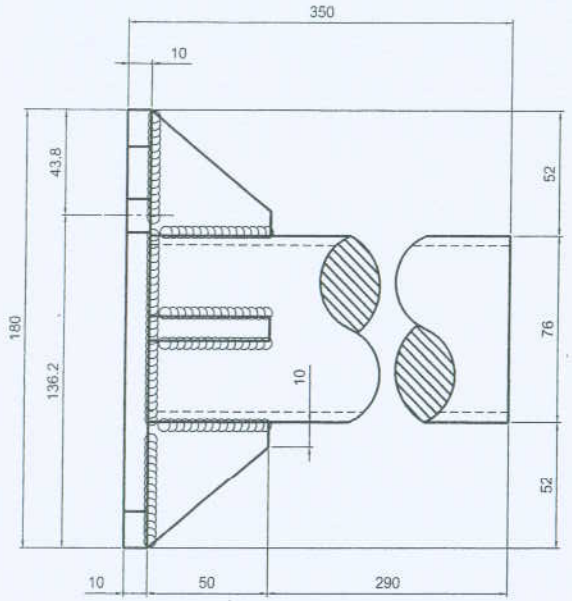
ตรวจสอบการรับแรงของ PLATE FOR CURVE CURTAIN WALL

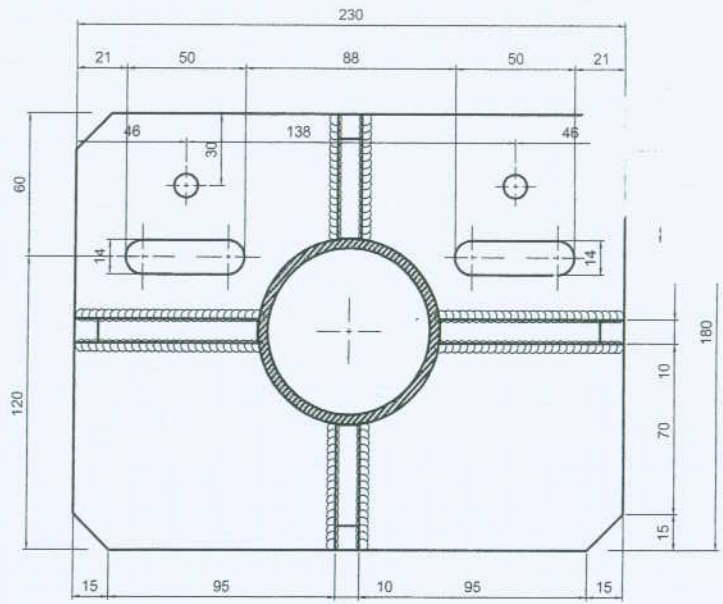
ตามข้อมูล Finite Element Method(FEM) ของ PLATE FOR CURVE CURTAIN WALL

การวิเคราะห์พิจารณาที่สภาวะประลัย (Ultimate Point, Ft = 0.50 x Fu)

Stress Max.	=	3.24E+07	N/m^2
Yield Stress(for Steel)	=	2.40E+08	N/m^2
$F_{t(steel)}$	=	0.6x2.40E+08	
	=	1.44E+08	N/m^2

แสดงว่าชิ้นงานสามารถรับแรงได้


350
10
43.8
136.2
180
52
76
52
10
10
50
290


230
21
50
88
50
21
46
30
138
46
60
14
14
120
180
10
70
15
15
95
10
95
15

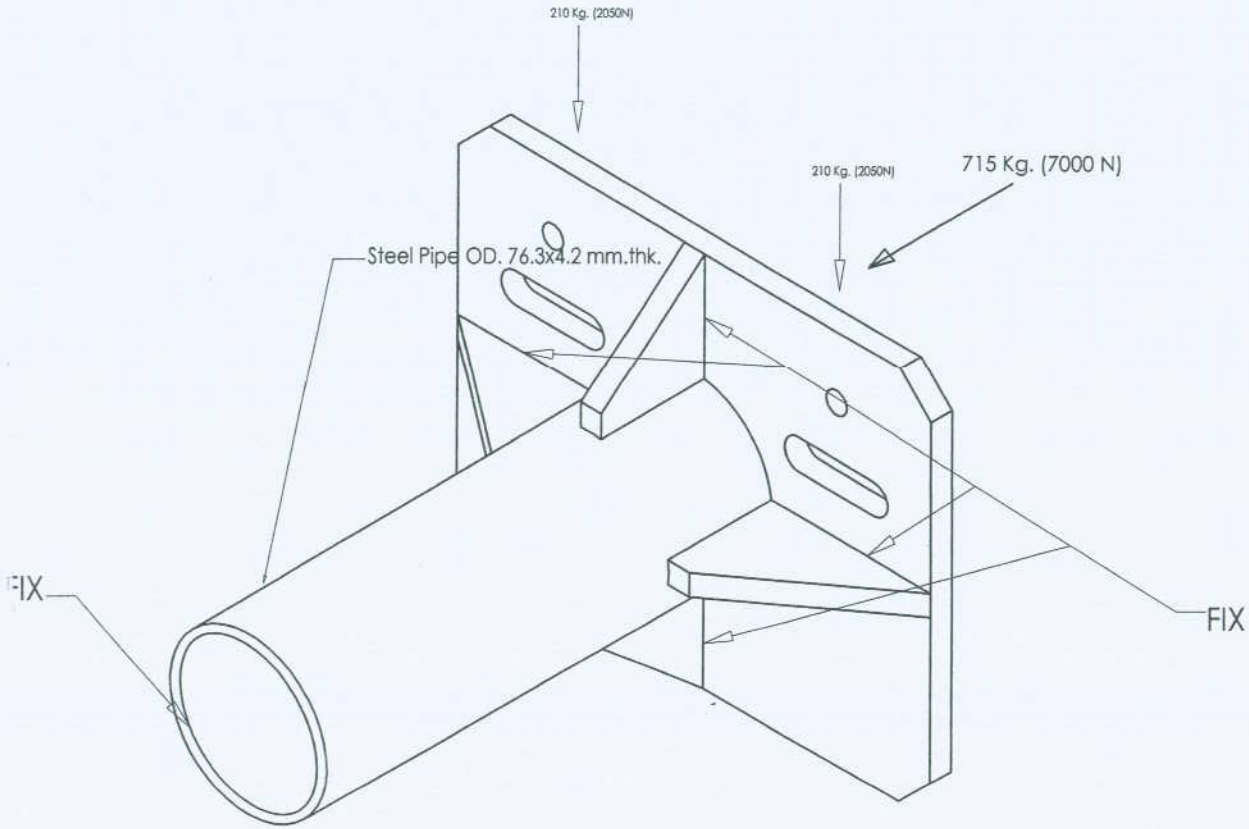

210 Kg. (2050N)
210 Kg. (2050N)
715 Kg. (7000 N)
Steel Pipe OD. 76.3x4.2 mm.thk.
FIX
FIX

PLATE FOR CURVE CURTAIN WALL

2. Materials

No.	Part Name	Material	Mass	Volume
1	PL FOR CURVE CW	[SW]Galvanized Steel	3.31094 kg	0.000420704 m^3

3. Load & Restraint Information

Restraint

Restraint1 <PL FOR CURVE CW>	on **13 Face(s)** immovable (no translation).
Description:	

Load

Load1 <PL FOR CURVE CW>	on **1 Face(s)** apply normal force **7000 N** using uniform distribution
Description:	
Load2 <PL FOR CURVE CW>	on **2 Face(s)** apply normal force **2050 N** using uniform distribution
Description:	

4. Study Property

Mesh Information

Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	5 mm
Tolerance:	0.25 mm
Quality:	High
Number of elements:	24446
Number of nodes:	40980
Time to complete mesh(hh;mm;ss):	00:00:27
Computer name:	DE01

Solver Information

Quality:	High
Solver Type:	Automatic

5a. Stress

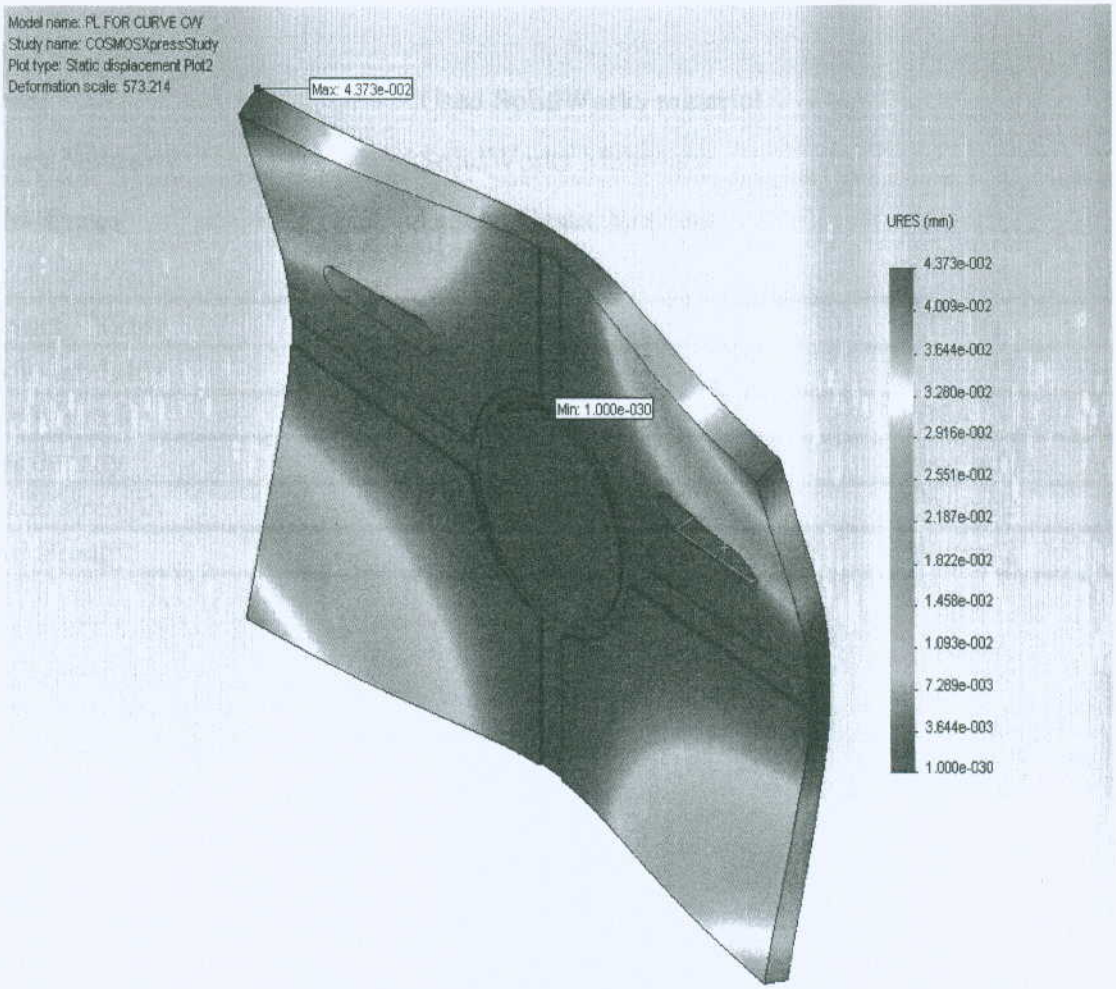
Name	Type	Min	Location	Max	Location
Plot1	VON: von Mises stress	82805.4 N/m^2	(89.9552 mm, 73.5325 mm, 5.04569 mm)	3.23622e+007 N/m^2	(-110.462 mm, -5 mm, 10 mm)

5b. Displacement

Name	Type	Min	Location	Max	Location
Plot2	URES: Resultant displacement	0 mm	(-17.05 mm, 29.5315 mm, 9 mm)	0.043733 mm	(-125 mm, 87.5 mm, 0 mm)

PL FOR CURVE CW-COSMOSXpressStudy-Displacement-Plot2

JPEG



6. Appendix

Material name: [SW]Galvanized Steel

Description:

Material Source: Used SolidWorks material

Material Library Name: SolidWorks Materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	2e+011	N/m^2
Poisson's ratio	0.29	NA
Mass density	7870	kg/m^3
Tensile strength	3.569e+008	N/m^2
Yield strength	2.0394e+008	N/m^2

Performance Test of Curtain Wall

TEST SPECIFICATIONS

Upon the request of the Client, the performance tests were conducted to the following specifications:

i) Air infiltration - ASTM E 283 - 04
Standard Test Method for Determining Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors under Specified Pressure Differences across the Specimen

ii) Structural Performance - ASTM E 330 - 02
Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference

iii) Water Penetration - ASTM E 331 - 00
Standard Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference

iv) Proof Load Test – 125% and 150% of the design pressure of the specimen as specified by client.

CONTENTS

		Page
1.	General	3
2.	Test Parameters	6
	a. Air Infiltration b. Static Water Penetration c. Structural Performance d. Proof Load	
3.	Acceptable Performance Criteria	8
4.	Summary of Tests	9
5.	Test Results and Observations	10
6.	Conclusion	19

Test Instruments & Equipment

i. Airtight steel chamber (8.5 x 9 m) at maximum design pressure of ±7 kPa (approximately equivalent to 388.8 kph wind velocity)
ii. Air Compressor 1 at high speed, 10 HP
iii. Air Compressor 2 at high speed, 3 HP
iv. Manometer
v. Airflow meter
vi. Waterflow meter
vii. Digital Transducers (displacement)
viii. Hydraulic valve air control
ix. Sprinkler Tank

Note: Digital transducers were verified by TUV SUD PSB using calibrated gauge blocks to ensure accuracy and repeatability in measurements. Upon verification, all transducers were found to be within the tolerances specified (see photo 2 for method of verification).

Description of Test Specimen

The mock-up sample is according to the approved shop drawing details. The size of the specimen is 4.043 m (Width) x 8.330 m (Height) consisting of 6 panels (size 1333 x 4125 mm) vision glass fixed onto the steel chamber. The remainder area is covered using 20 mm thick plywood and sealant.

Aluminium:	Aluminium Alloy A6063-T5 Natural anodized (NA-1) finish
Glass:	13.52 mm thick laminated glass (6.0 mm thick Green Glass H.S. + NSS 208 on surface #2 + 1.52 mm Clear Dupont PVB + 6 mm thick Green Glass H.S. by PMK)
Sealant:	Dow Corning 795 Structural Silicone Sealant and/or GE 4000 Structural Silicone Sealant Sika Wacker Elastosil; Sika Polyuretane Sealant

The tests were conducted by [illegible]

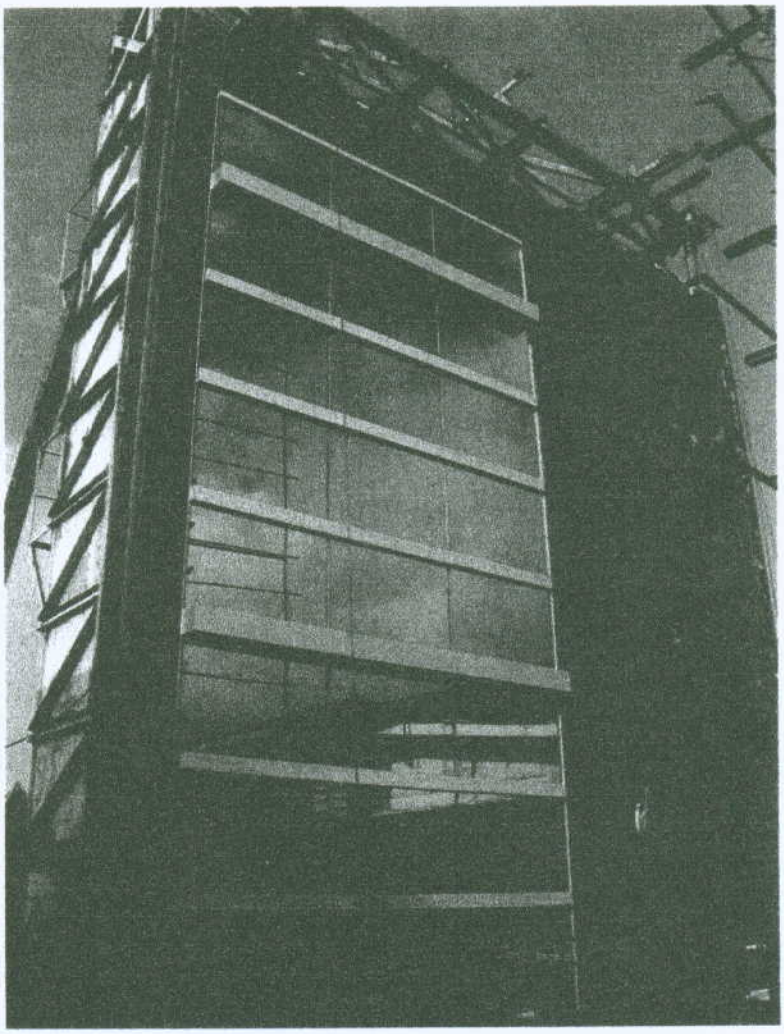


Photo 1. Overall view of mock-up sample

2. TEST PARAMETERS

Before the test proper was conducted, a preliminary load of 790 Pa (50% design pressure) was applied onto the mock-up sample.

a. Air Infiltration (ASTM E 283)

The mock-up specimen was covered with plastic sheet and subjected to a test pressure of 75 Pa. Pressure was maintained continuously for 10 seconds. Volume of air leakage through the chamber was measured and recorded. The plastic sheet was then removed and the volume of the gross leakage measured again and recorded. The difference in volume of leakage from the 2 measurements taken gives the air infiltration over the exterior surface area.

- Calculation for air infiltration

q_1 = air leakage through the chamber
q_2 = gross air leakage (leakage through chamber + specimen)

Actual air leakage through the specimen = $q_2 - q_1$

Air infiltration is calculated as the actual air leakage through the specimen divided by the total frontal area of the specimen (A, m^2).

i.e. Air infiltration = $(q_2 - q_1)/A$, $m^3/min/m^2$

b. Water Penetration by Static Pressure (ASTM E 331)

Static water penetration was conducted at a positive pressure of 137 Pa for 15 minutes; followed by 300 Pa for 15 minutes, with the water flow rate set at 3.4 $l/min/m^2$. Leakage was observed from inside the chamber and all leakage points were recorded.

c. Structural Performance (ASTM E 330)

The structural performance was conducted at the test pressures of 50%, 75% and 100% of design pressure for both positive and negative pressures.

A pre-load pressure was first applied at 790 Pa and residual readings were taken after the load was removed. Pressure was then gradually increased in steps at 790 Pa, 1180 Pa, and 1570 Pa. Deflection readings were taken after 10 seconds at each step

The same test procedure was then repeated for the negative pressure.

- Calculation of deflection

Calculation of deflection requirement was based on measured deflections. Where a structural member of the sample is rigidly supported at its ends only, its mid-span deflection and resultant span/deflection ratio under load was calculated as follows:

$$\text{Span/Deflection ratio} = S / (D_1 - D_2)$$

Where
- S : Span of loading
- D1 : Maximum deflection
- D2 : Average deflections at end supports.

d. Proof Load (ASTM E 330)

The proof load was conducted in a similar pressure scale as the structural performance. However, the pressure applied was applied in the following sequence up to a maximum of 2360 Pa.

Pressure was gradually increased in steps at 1970 Pa and 2360 Pa. Samples were then observed for any harmful deformation or falling materials.

The same test procedure was then repeated for the negative pressure.

3. ACCEPTABLE PERFORMANCE CRITERIA

a. Air Infiltration

Air Infiltration shall not exceed 0.06 cfm/ft² of exterior surface.

b. Static Water Penetration

No unacceptable water leakage shall be observed during and after application of the specified pressure and water spray.

Leakage is considered to have occurred when

i. Water appears on the inside face of the façade and is visible from an occupied space
ii. Uncontrolled water appears on the inside face of the façade. Unacceptable water is defined as any leakage that is not contained and drained away within the test duration.

c. Structural Performance

The maximum deflection of vertical frame and horizontal frame shall not exceed L/175 of span or 20 mm whichever is lesser between supports when subjected to the specified design pressure.

d. Proof Load

No harmful deformation or falling of materials shall be observed during and after pressure application.

4. SUMMARY OF TEST SEQUENCE AND PERFORMANCE CRITERIA

Items	ASTM Test Parameters	Evaluation
Pre-loading	Positive pressure of 790 Pa was applied on the test specimen.	-
Air Infiltration	a. Positive pressure of 75 Pa was applied. b. Reading is obtained for test specimen.	**ASTM E 283-04** Shall not exceed 0.0182 $m^3/min/m^2$ (0.06 $ft^3/min/ft^2$) of exterior surface.
Static Water Penetration	a. Water is sprayed onto the specimen for 5 minutes at 0 Pa (wet-down). b. Positive pressure is then applied in stages at 137 Pa for 15 minutes and 300 Pa for 15 minutes duration (see figure 1). c. Record all points of water penetration.	**ASTM E 331-00** No uncontrolled water leakage up to test pressure at a water spray of 3.4 $l/min/m^2$.
Structural Performance (Wind Loading)	a. Pre-load of 50% design pressure i.e. 790 Pa was applied and maintained for approximately 10 seconds. b. Take residual reading. c. Apply positive pressure in the following steps (see figure 2): - 790 Pa (50%) - 1180 Pa (75%) - 1570 Pa (100%) d. Maintain for 10 seconds and then take deflection reading at each step. e. Take residual deflection after load is removed. f. Repeat steps (a) – (e) for negative pressure.	**ASTM E 330-02** Net maximum deflection shall not exceed 1/175 times span or 20 mm whichever is lesser Mullion: Maximum allowable = 20.0 mm Transom: Maximum allowable = 7.4 mm
Proof load	a. Apply positive pressure in the following steps (see figure 2): - 1970 Pa (125%) - 2360 Pa (150%) b. Repeat for negative pressure.	No harmful deformation or falling of materials shall be observed.

5. TEST RESULTS AND OBSERVATIONS

Preliminary Loading

Date of Test: 20 June 2007

Pressure Applied (Pa)	Duration (sec)	Observation
790	10	No sample failure

a. Air Infiltration

Date of Test: 20 June 2007

Area of specimen, A: 33.67 m^2

Pressure (Pa)	Chamber Leakage, q_1 (cfm)	Gross Leakage, q_2 (cfm)	Net Leakage, ($q_2 - q_1$) (cfm)	Air Infiltration (cfm/ft^2)
75	29.5	37.0	7.5	0.02

b. Static Water Penetration

Date of Test: 20 June 2007

Pressure (Pa)	Duration (min)	Observation
0 (wet-down)	5	No leakage was observed on the mock-up sample.
137	15	No leakage was observed on the mock-up sample.
300	15	No leakage was observed on the mock-up sample.

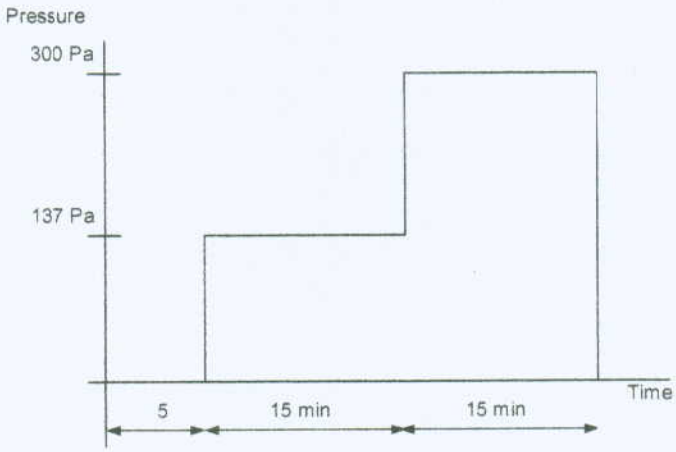


Figure 1. Pressure application diagram

c. Structural Performance

Date of Test: 20 June 2007

Figure 2. Pressure application diagram for structural performance and proof load

Results of Displacement Measurements

Positive Pressure (Measured displacements in mm. Refer to figure 3 for locations of displacement)

Transducer Points	0 Pa	790 Pa	1180 Pa	1570 Pa	0 Pa
1	0.00	0.28	0.45	-2.81*	-2.94*
2	0.03	4.79	6.96	15.22	2.55
3	0.00	0.14	0.28	1.06	0.39
4	0.02	3.60	5.28	10.09	1.30
5	0.00	3.76	5.38	9.21	0.89
6	0.00	3.33	4.69	7.38	0.43
7	0.00	1.74	2.51	2.69	-0.20
8	0.00	2.57	3.55	4.11	-0.12
9	0.00	2.33	3.17	3.80	-0.07
10	0.01	4.76	6.99	15.41	2.60
11	0.00	5.60	8.25	15.32	2.07
12	0.00	4.13	6.10	10.15	1.16
13	0.01	0.86	0.86	0.63	-0.26
14	0.00	0.74	0.89	1.14	0.13
15	0.02	0.12	0.13	0.23	0.09

Note: *Denotes the shifting of the brackets during the structural performance tests.

c. Structural Performance (Cont'd)

Date of Test: 20 June 20[illegible]

Results of Displacement Measurements

Negative Pressure (Measured displacements in mm)

Transducer Points	0 Pa	-790 Pa	-1180 Pa	-1570 Pa	0 Pa
1	0.00	-0.05	-0.11	-0.23	0.05
2	0.00	-7.12	-11.70	-16.22	-2.16
3	-0.03	-0.59	-1.28	-2.02	-0.59
4	0.00	-4.76	-8.28	-11.72	-1.73
5	0.00	-4.72	-8.00	-11.83	-1.86
6	0.00	-4.28	-7.09	-11.06	-1.95
7	0.00	-1.45	-1.91	-2.54	-0.39
8	0.00	-2.20	-3.10	-3.87	-0.35
9	0.00	-1.91	-2.66	-3.25	-0.33
10	0.00	-6.80	-11.22	-15.51	-2.11
11	-0.02	-6.95	-11.74	-16.83	-2.25
12	0.00	-4.70	-8.54	-12.88	-2.07
13	-0.01	-0.86	-1.61	-2.28	-0.41
14	-0.02	-0.49	-0.95	-1.52	-0.34
15	0.00	-0.09	-0.17	-0.49	-0.34

Calculation of Deflections for Typical Frame

Maximum pressure applied: +1570 Pa

Transducer Location	Item	Maximum Deflection (mm)	Criteria
			Maximum Deflection
1-2-3	Mullion	16.1	Shall not exceed 20.0 mm
4-5-6	Window Transom	0.5	Shall not exceed 7.4 mm
7-8-9	Transom	0.9	Shall not exceed 7.4 mm
10-11-12	Glass	7.5	-
13-14-15	Stack Joint Transom	0.7	Shall not exceed 7.4mm

Maximum pressure applied: -1570 Pa

Transducer Location	Item	Maximum Deflection (mm)	Criteria
			Maximum Deflection
1-2-3	Mullion	-15.1	Shall not exceed 20.0 mm
4-5-6	Window Transom	-0.4	Shall not exceed 7.4 mm
7-8-9	Transom	-1.0	Shall not exceed 7.4 mm
10-11-12	Glass	-2.6	-
13-14-15	Stack Joint Transom	-0.1	Shall not exceed 7.4mm

d. Proof Load Test

Date of Test: 20 June 2007

Pressure (Pa)	Observation
+2360	No damage, failure or harmful deformation of materials.
-2360	No damage, failure or harmful deformation of materials.

Remark: Additional negative pressure of -3200 Pa was applied on the mock-up sample. No failure was observed.

6. CONCLUSION

i. Air Infiltration

Air infiltration calculated on the mock-up sample was: 0.02 cfm/ft².

This result calculated was less than the maximum allowable criteria of 0.06 cfm/ft² specified by the specifying authority. Hence, result of this test complied with the given criteria.

ii. Static Water Penetration

No water leakage was observed on the mock-up sample throughout the test. Result of this test complied with the given criteria as specified.

iii. Structural Performance

Mullion

Maximum deflection of mullion at positive pressure of 1570 Pa was at location nos. 1-2-3. Reading measured was 16.1 mm.

Maximum deflection of mullion at negative pressure of 1570 Pa was at location nos. 1-2-3. Reading measured was 15.1 mm.

Results for maximum deflection measurements complied with the given criteria as specified for both positive and negative pressure.

Transom

Maximum deflection of transom at positive pressure of 1570 Pa was at location nos. 7-8-9. Reading measured was 0.9 mm.

Maximum deflection of transom at negative pressure of 1570 Pa was at location nos. 7-8-9. Reading measured was 1.0 mm.

Results for maximum deflection measurements complied with the given criteria as specified for both positive and negative pressure.

Glass

Maximum deflection of glass at positive pressure of 1570 Pa at location nos. 10-11-12 was measured to be 7.5 mm.

Maximum deflection of glass at negative pressure of 1570 Pa at location no. 10-11-12 was measured to be 2.6 mm.

No criteria was specified for this parameter.

iv. Proof Load

No damage or harmful deformation was observed during the application of both the positive and negative proof load of ± 2360 Pa. In addition, no failure was observed when subjected to a negative pressure of -3200 Pa.

Result of this test complied with the given criteria as specified.

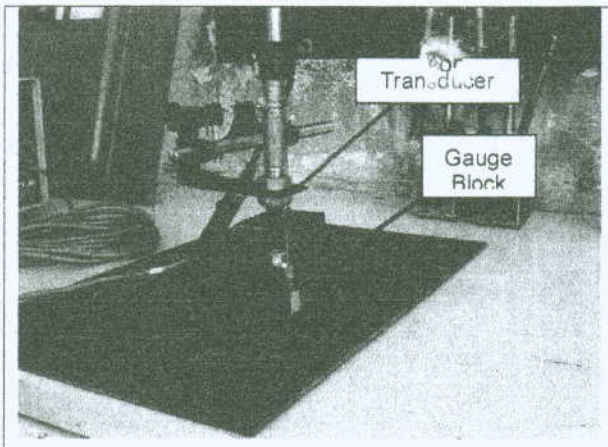


Photo 2. Verification of displacement transducer

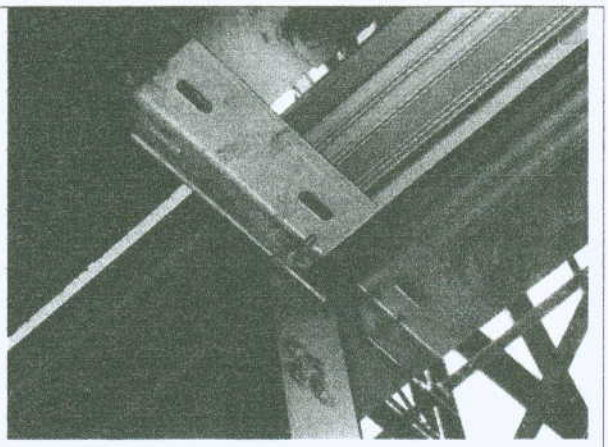


Photo 3. Anchorage point of the sample

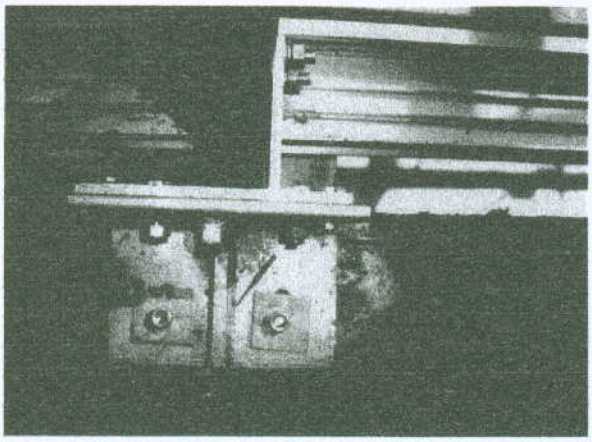


Photo 4. Anchorage point at another location

Photo 5. Another view of anchorage point

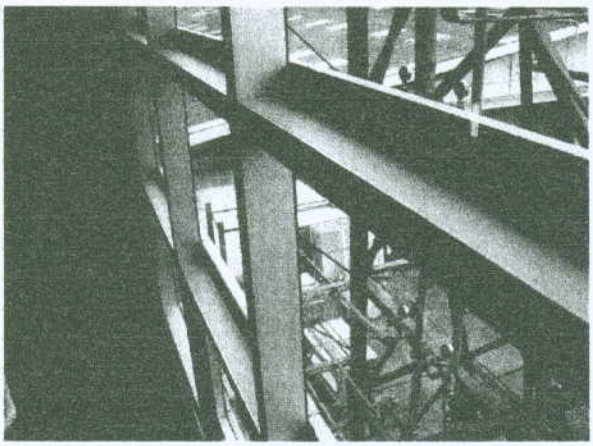


Photo 6. Sample viewed from inside chamber

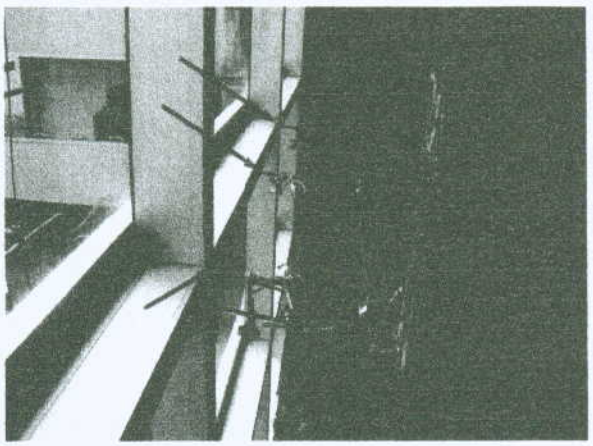


Photo 7. Location of some transducer points (arrowed in red)

Photo 8. Inspection of mock-up sample

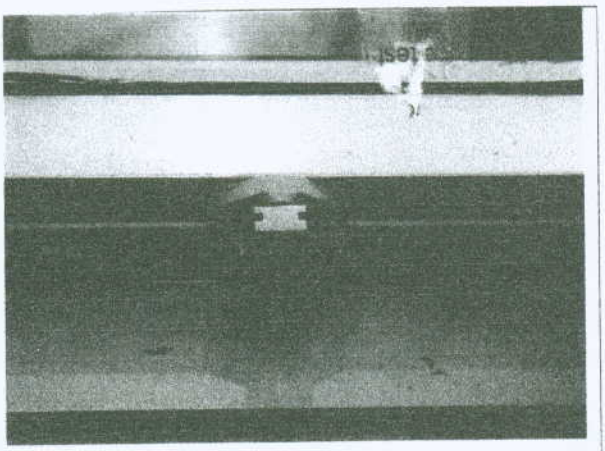


Photo 9. Lockset used for openable window

Photo 10. Polythene sheet for Air Infiltration test

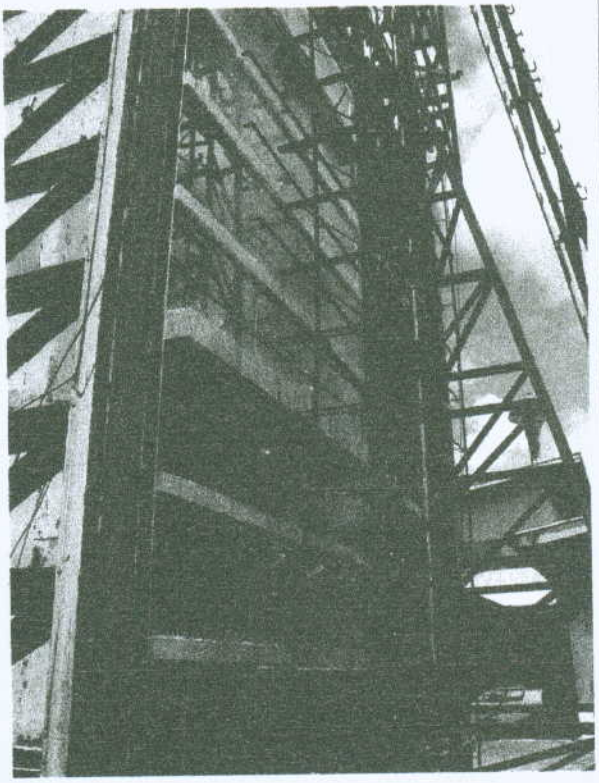


Photo 11. Water Penetration test in progress

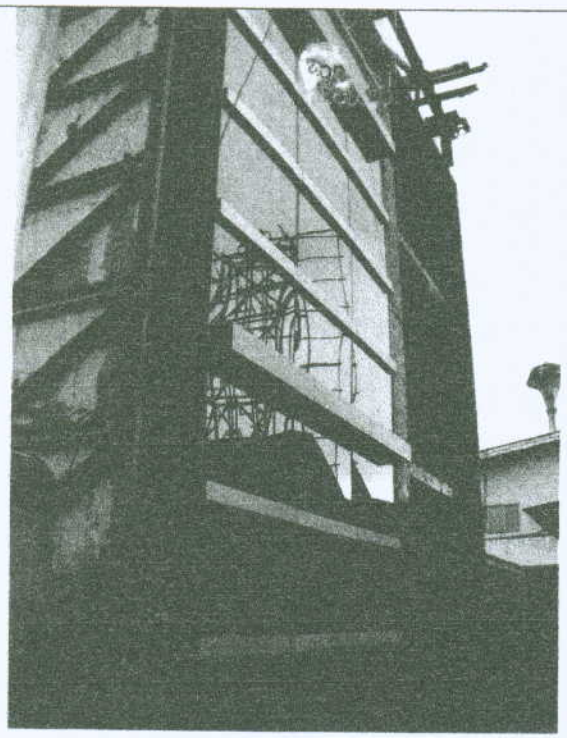


Photo 12. View of sample during proof load test

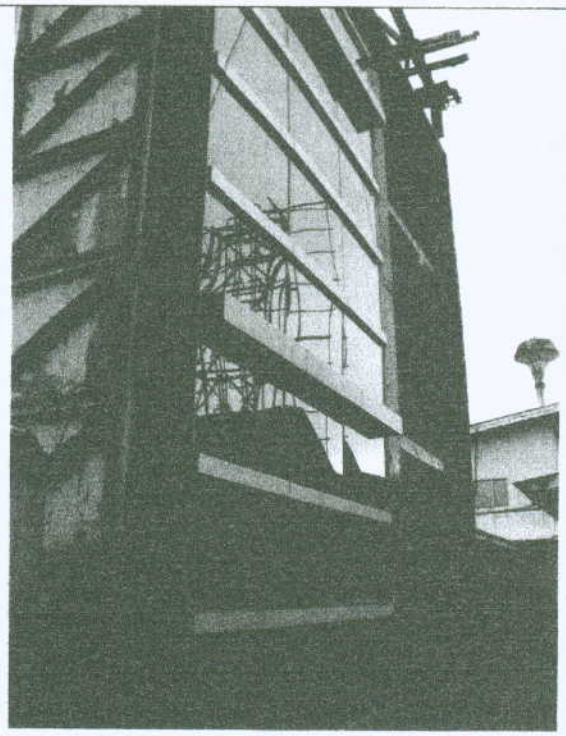


Photo 13. View of sample during proof load test

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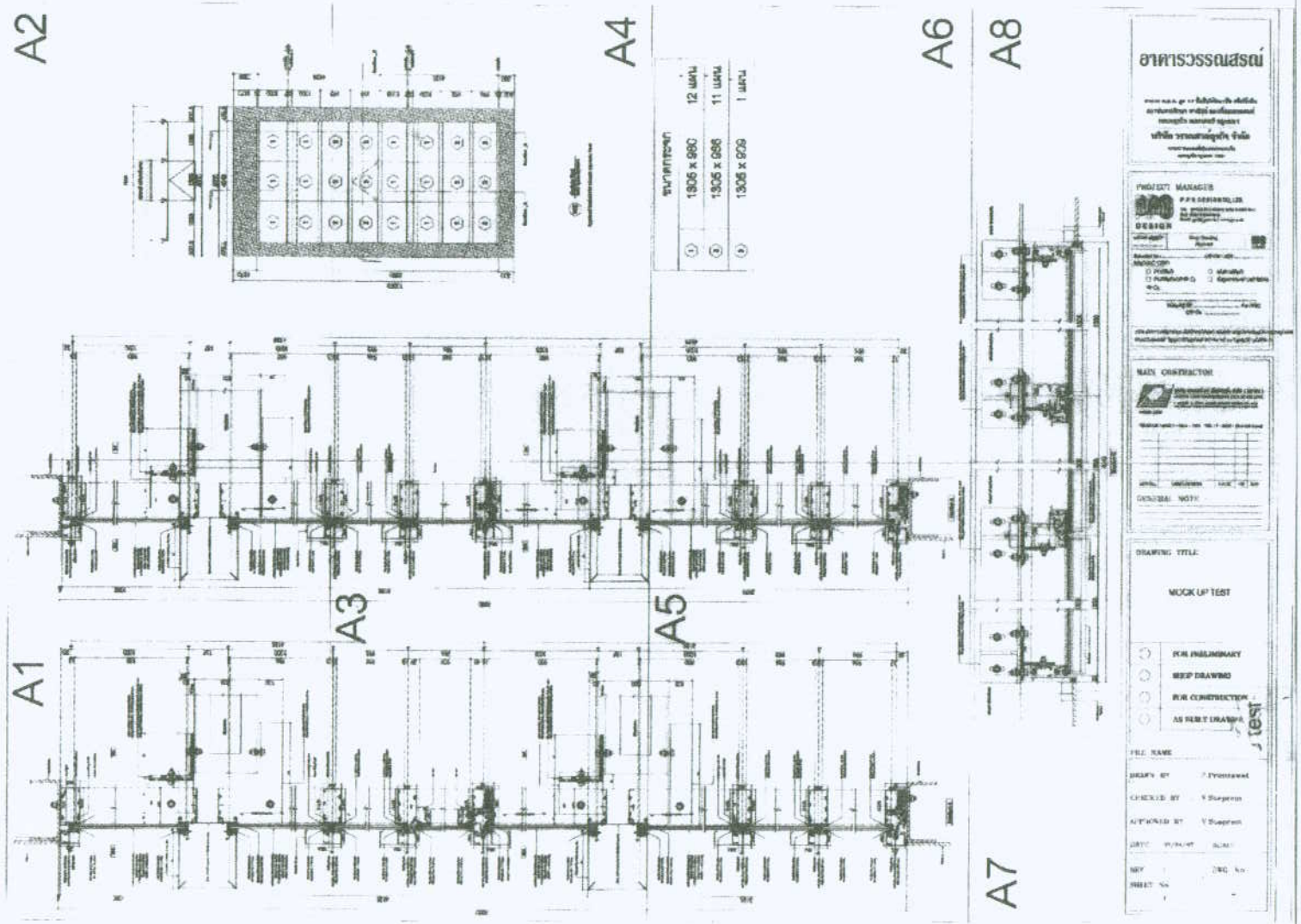
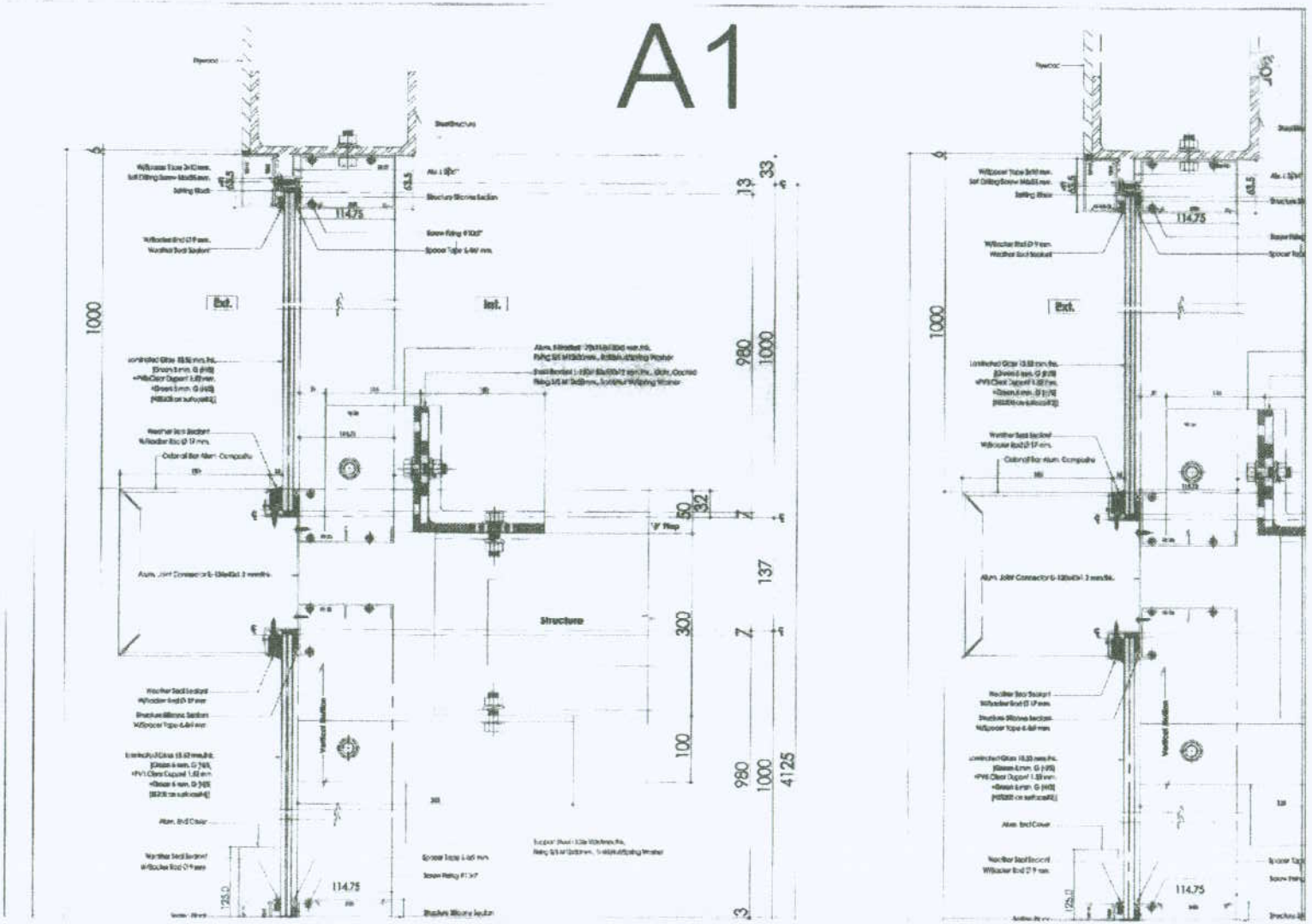


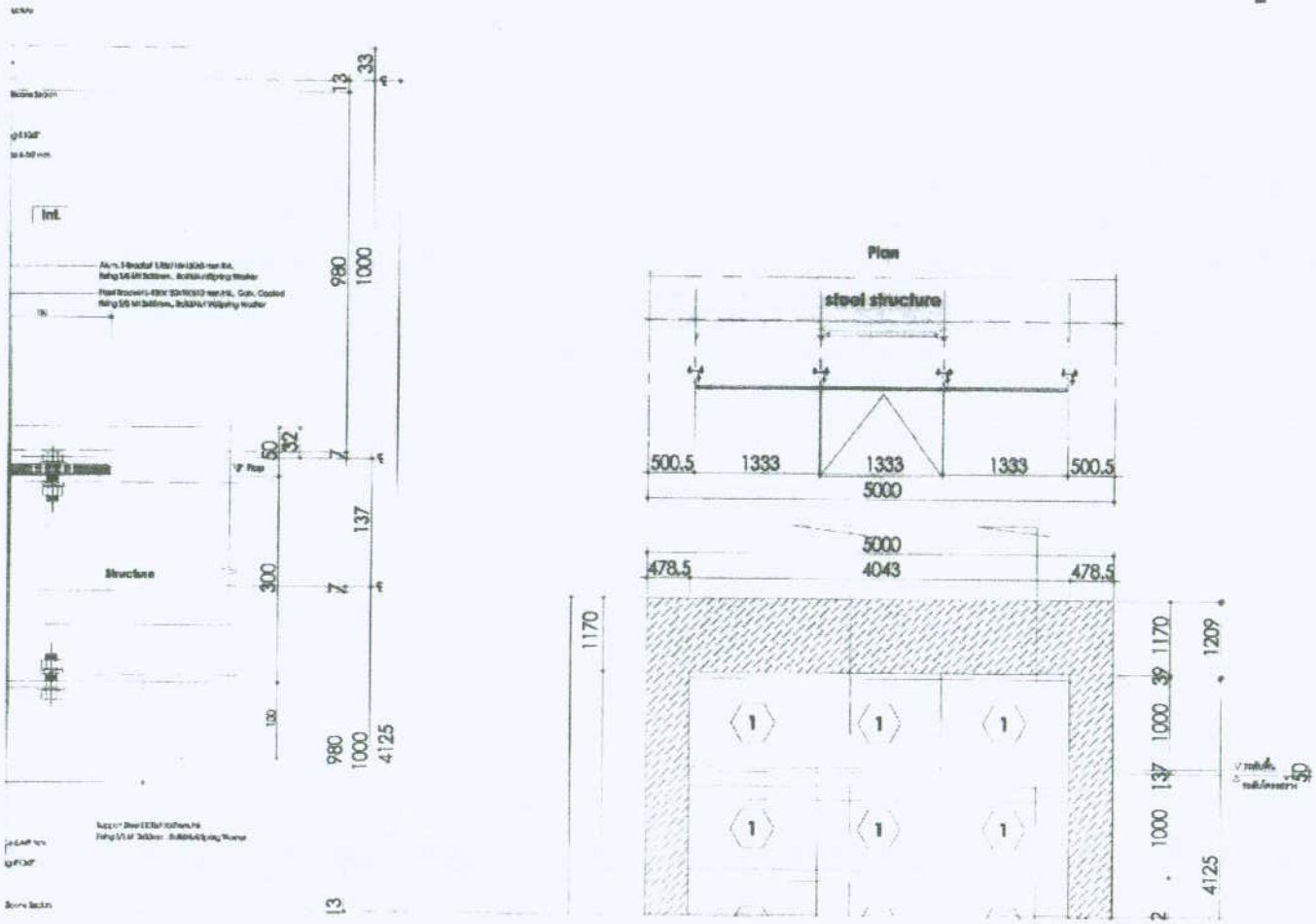
Test Report No. 54S073616/1/RT
dated 02 JUL 2007

A1



Test Report No. 54S073616/1/RT
dated 02 JUL 2007

A2



Test Report No. 54S073616/1/RT
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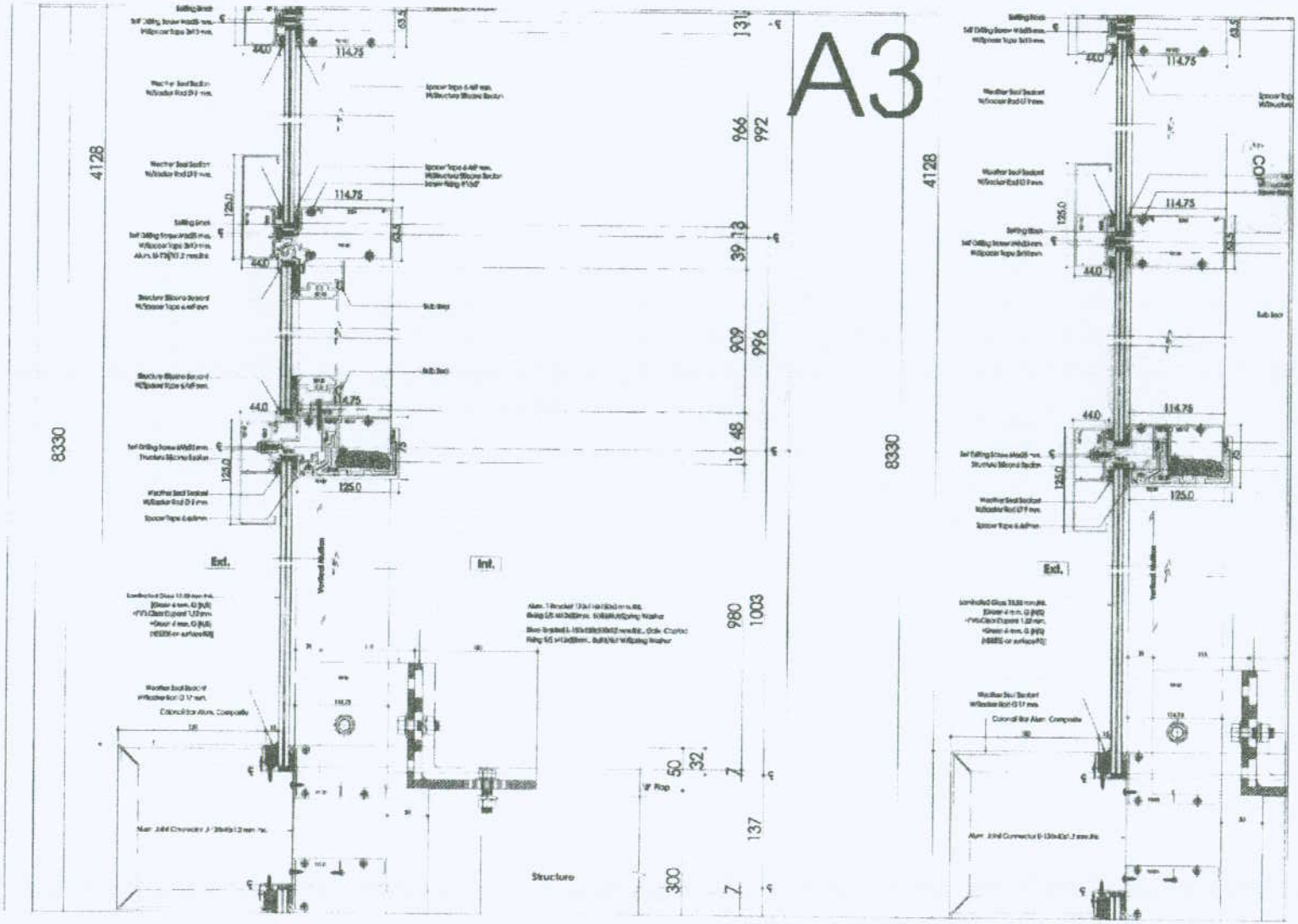

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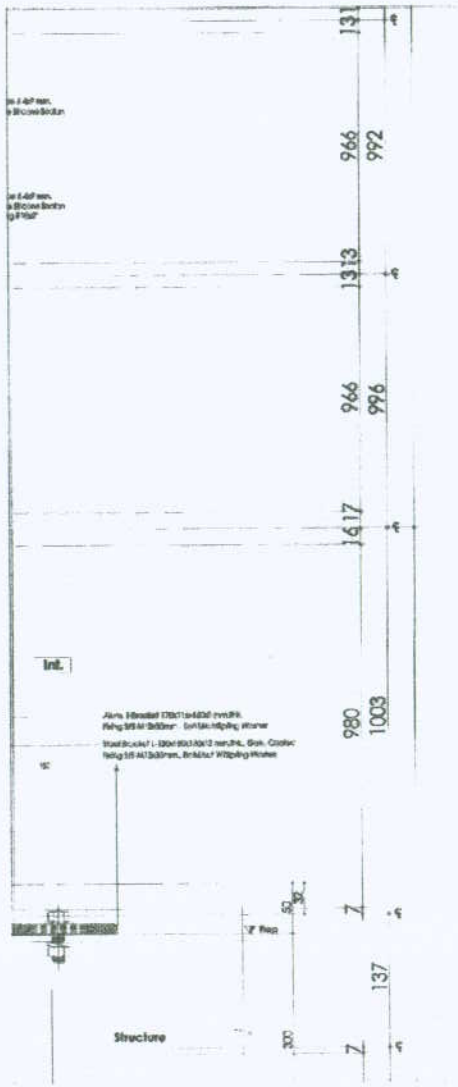
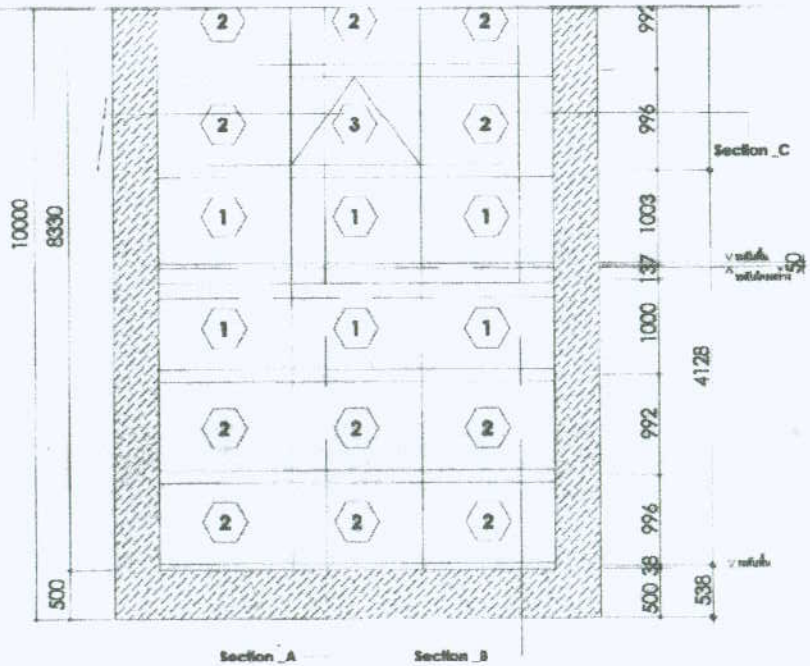
dated 02 JUL 2007





W3 Curtain Wall
Unit Type System

Typical Detail for Mock Up Lab Test

A4

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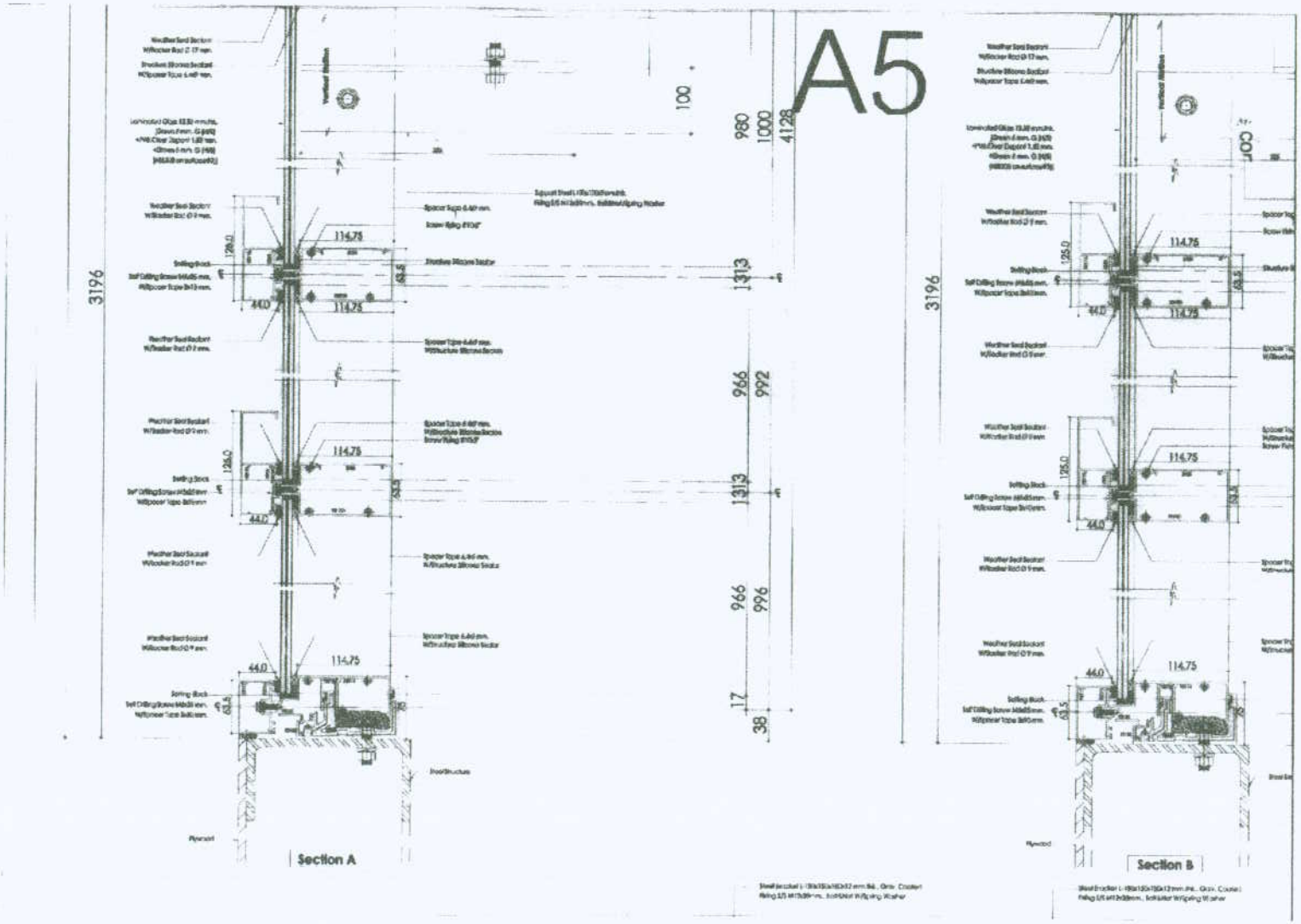
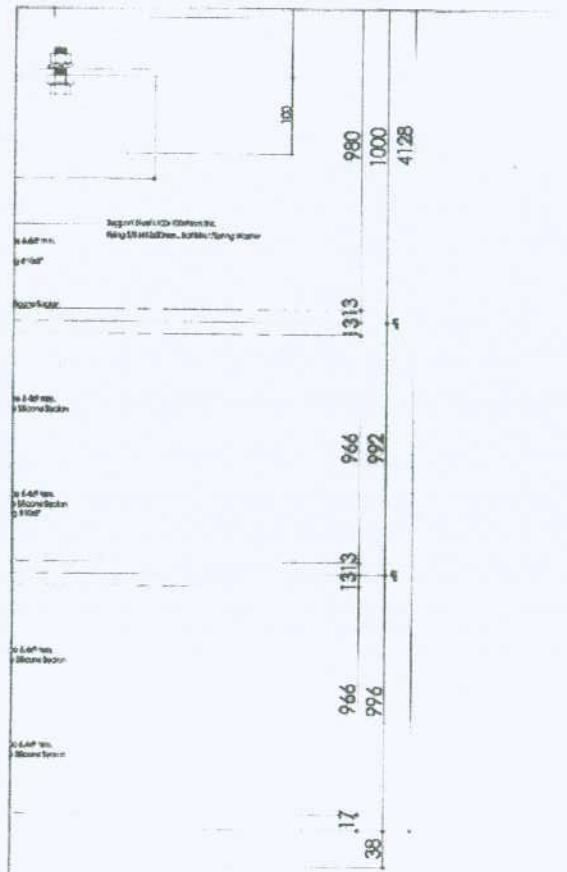
dated 02 JUL 2007

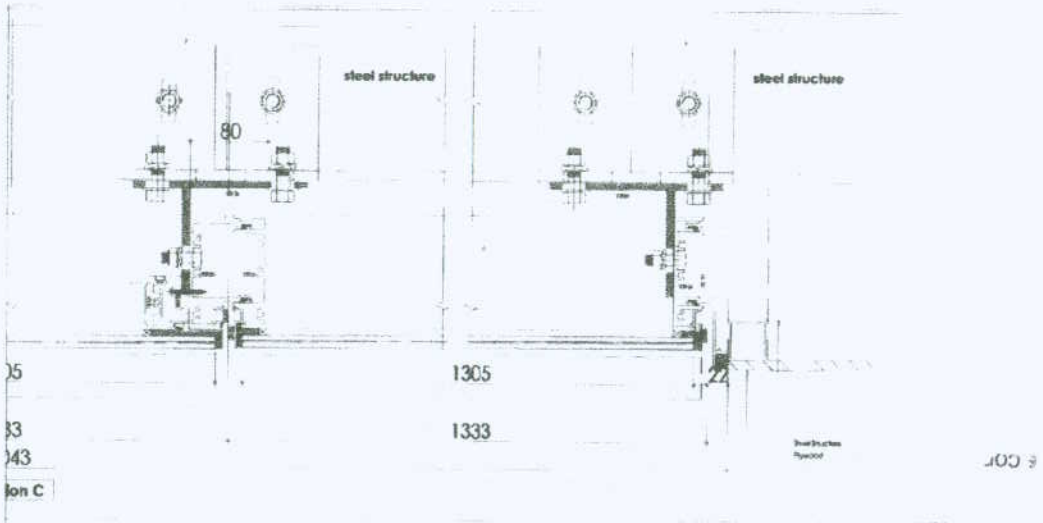


Test Report No. 54S073616/1/RT
dated 02 JUL 2007



ขนาดกระจก		
1	1305 x 980	12 แผน
2	1305 x 966	11 แผน
3	1305 x 909	1 แผน

A6



A8