kpff Consulting Engineers

December 5, 2013

Via Email

Mr. Tim Eddy
Hennebery Eddy Architects Inc.
921 SW Washington Street, Suite 250
Portland, Oregon 97205

RE: Ash + Ash
Portland, Oregon

Dear Tim:

As requested please find attached analysis and sketches, sheets 1 through 16 dated June to December, 2013 for the deferred submittal of the ¾ inch laminated glass roof top guard rail and connections as well as the glass rail on the main stair.

If you have any questions or need further information, please call me.

Sincerely,

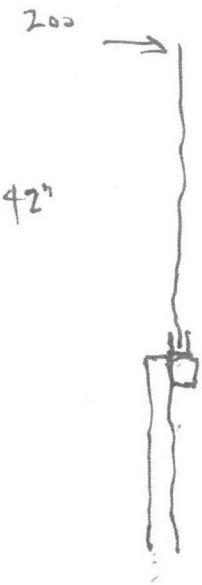
Ronald G. Kernan, P.E., S.E.
Associate

RGK/jkd
212271/glass railing calcs 12-05-2013

REGISTERED PROFESSIONAL ENGINEER
9053
OREGON
DEC. 17, 1979
RONALD G. KERNAN
EXPIRES: 12-31-15

111 SW Fifth Avenue, Suite 2500 Portland, Oregon 97204-3628 (503) 227-3251 Fax (503) 227-7980
Seattle Everett Tacoma Lacey Portland Eugene Sacramento Grass Valley San Francisco Walnut Creek Los Angeles Long Beach Pasadena Irvine San Diego Boise Phoenix St. Louis Chicago New York

kpff Consulting Engineers, Portland, Oregon	Project ASH-YASN	By RGK	Sheet No. 5
	Location	Date 6-13	
	Client HEA	Revised	Job No. 212271
	ROOF TOP RAILING	Date	

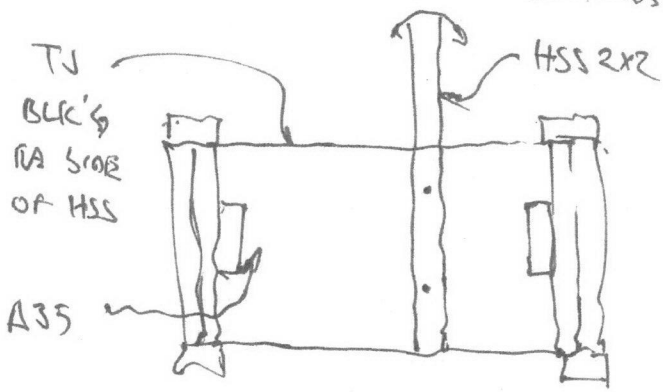


$M_{WIND} = \frac{30(4)(3.5^2)}{2} = 735$ #·FT

$= 8820$ #·IN

$(12)\frac{25(4)(3.5)^2}{2} = 7350$ #·IN

$\therefore$ 200 # @ TOP CONTROLS



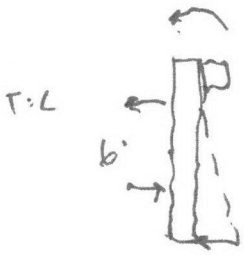
$M = 200(42) = 8400$ #·IN

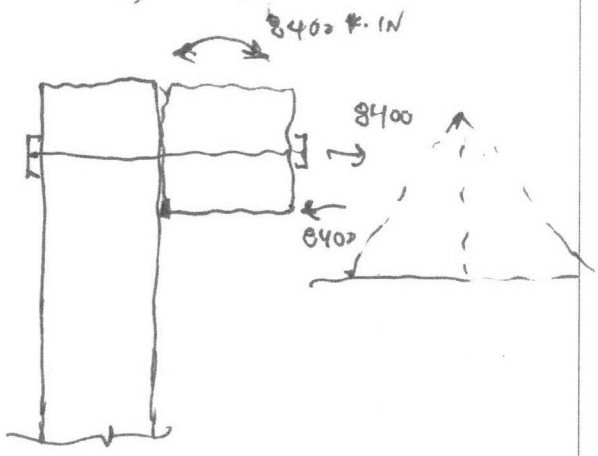
$S_{REQ'D} = \frac{8400}{0.6(46000)} = 0.3\ IN^3$

HSS 2x2x1/8 $S = 0.76\ IN^3$

$R = \frac{8400}{24} = 350$ #

A35 ~ 500# $\therefore$ OK





$T:C = \frac{8400}{6} = 433$

BOLT SHEAR $= \frac{8400}{6} = 1400$#

3/4" BOLT IN LSL BLK'G

$f_p = \frac{1400}{1.5(0.75)} = \frac{1244\ PSI}{1.6} = 778$

$F_p \sim 435$ PSI $\therefore$ USE DOUBLE BLK'G

Project: Ash&Ash
Project No.: 212271
Client: Hennebery Eddy
Subject: Roof Top Railings

Engineer: RGK
File: 212271 roof railing.MCD
Date: 12-13
Rev.:

Given: Drawing A202 dated 9-30-2013 & glass submittal

Required: Check glass railing, shoe, and attachments to structure

Solution:

From Attached DuPont analysis for effective thickness of laminated glass;

$t_e := 14.31 \cdot mm = 0.563 \cdot in$ $\quad F_b := 7400 \cdot psi$ for laminated glass

For 50 plf load, consider 1' section of glass: $M := 50 \cdot plf \cdot 1 \cdot ft \cdot 36 \cdot in = 150\, ft \cdot lb$

$$s := \frac{12 \cdot in \cdot t_e^2}{6} = 0.635 \cdot in^3$$

$$f_b := \frac{M}{s} = 2835.507 \cdot psi \quad < \quad F_b$$ Therefore OK

For 200 lb concentrated load, assume load is distrubuted to base shoe @ 45 degrees

$$s := \frac{36 \cdot in \cdot t_e^2}{6} = 1.904 \cdot in^3$$

$$f_b := \frac{200 \cdot lb \cdot 36 \cdot in}{s} = 3780.676 \cdot psi \quad < \quad F_b$$ Therefore OK

Reference attached hand calculations for HSS 2 x 2 x 1/4 post, connections, and wood members.

Project: Ash&Ash
Project No.: 212271
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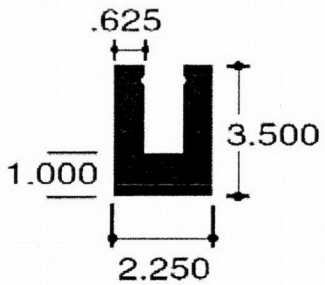
Page --
Engineer: RGK
File: 212271 roof railing.MCD
Date: 12-13
Rev.:

Check Aluminum shoe & connection to HSS 2 x 2: Shoe is 6063-T6 Aluminum

From 2010 Aluminum Design Manual, Table 2-21: $F_b := 19.7 \cdot ksi$



For 12" section of shoe, section modulus of side in bending: $s := \frac{12 \cdot in \cdot (0.625 \cdot in)^2}{6} = 0.781\ in^3$

$M := 200 \cdot lb \cdot 36 \cdot in = 600\ ft \cdot lb$

$f_b := \frac{M}{s} = 9.216\ ksi$ < F_b Therefore OK

With 1/2" ϕ bolts holding shoe to HSS, check tension in bolt:

$t_{bolt} := \frac{M}{\left(\frac{3.5 \cdot in}{2}\right)} = 4114.286\ lb$ ~ $T_{allow} := 0.142 \cdot in^2 \cdot 0.6 \cdot 36 \cdot ksi \cdot 1.33 = 4079.376\ lb$

within 1%, Therefore OK

DuPont Glass Laminating Solutions: Beam Calculator - Mozilla Firefox

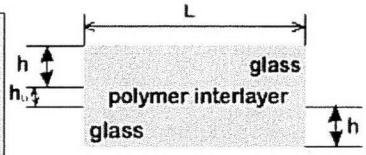
www2.dupont.com/SafetyGlass/en_US/tech_info/beamCalculator.html

DuPont Glass Laminating Solutions — STRENGTH OF GLASS CALCULATOR

Close window

SELECT LAMINATE PROPERTIES, BEAM GEOMETRY, AND LOADING CONDITIONS

Laminate: Symmetric
Temperature: 50C
Time: 3s
Length, L (0.3-4m): 1.07 m
Glass Thickness,h: 10 mm
Interlayer Thickness,: 1.52 mm
Edge Finish: Polished
Glass Type: Tempered
Line Load (0.5-5 kN/m): .73 kN/m



Calculate stress, deflection

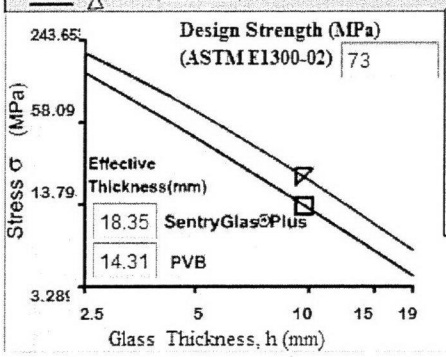
Glass Stress (MPa)

SentryGlas®Plus 13.9123 laminate meets ASTM strength recommendation

PVB 22.8820 laminate meets ASTM strength recommendation

Laminate Thickness (h+h+hv) 21.52 mm

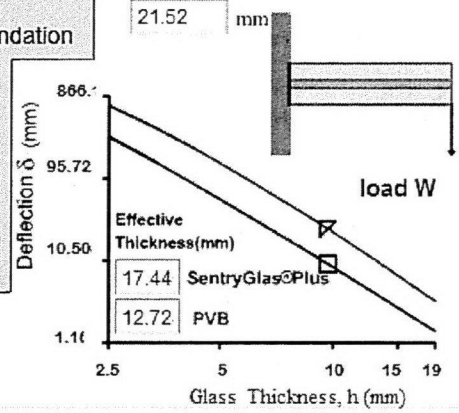
Case 1



Laminate Deflection (mm)

SentryGlas®Plus 9.63313

PVB 24.8038



Back

2.5 3.0 4.0 5.0 6.0 8.0 10.0 12.0 16.0 19.0

10 mm

Glass Thickness, h(mm)

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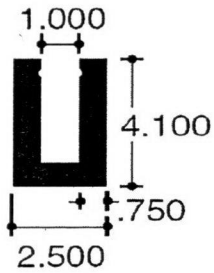
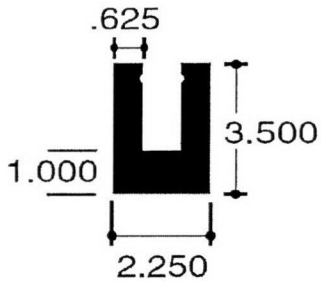
DUPONT The miracles of science™

Glass Handrail System

Base Shoe

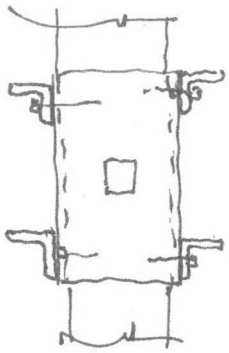


Part Number	Description	Alloy	Dimension	Weight Per Foot (Estimated)	Weight Per Piece (Estimated)
SHOE63	Handrail Shoe	6063-T52	20 Feet	7.970	159.400

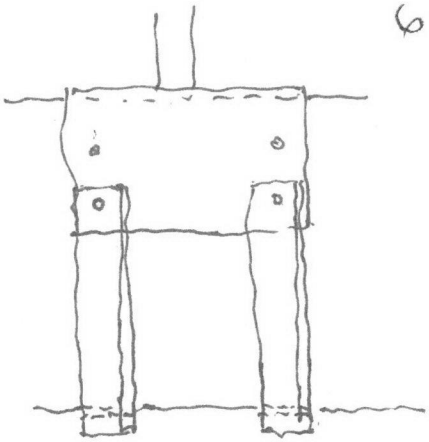


Part Number	Description	Alloy	Dimension	Weight Per Foot (Estimated)	Weight Per Piece (Estimated)
SMSHOE63	Glass Base Shoe	6063-T6	10 Feet	6.349	63.490
SMSHOE63D*	Glass Base Shoe	6063-T6	10 Feet	6.349	63.490

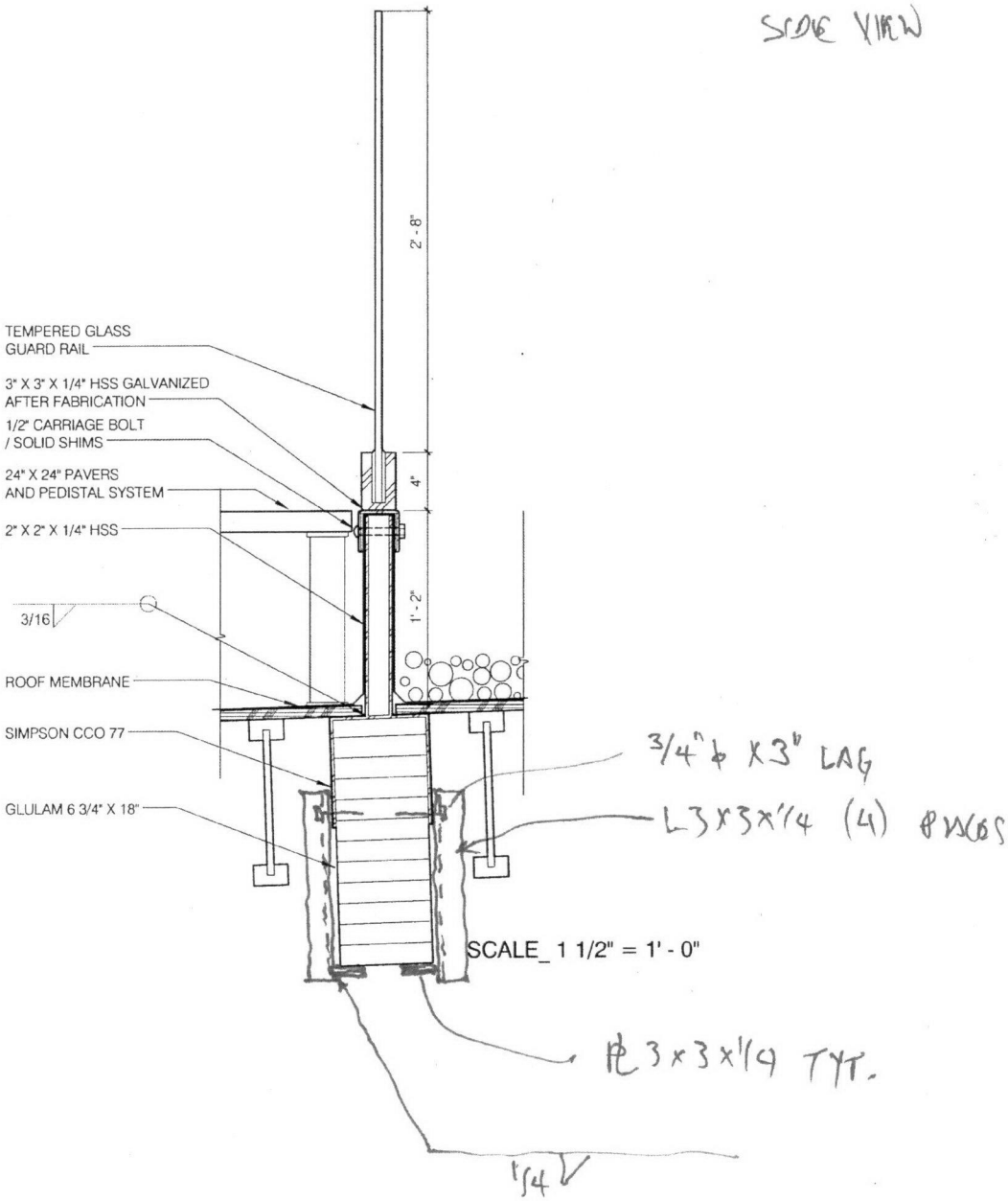
*Pre-drilled .563" holes on 12 inch centers beginning 6 inches from the end



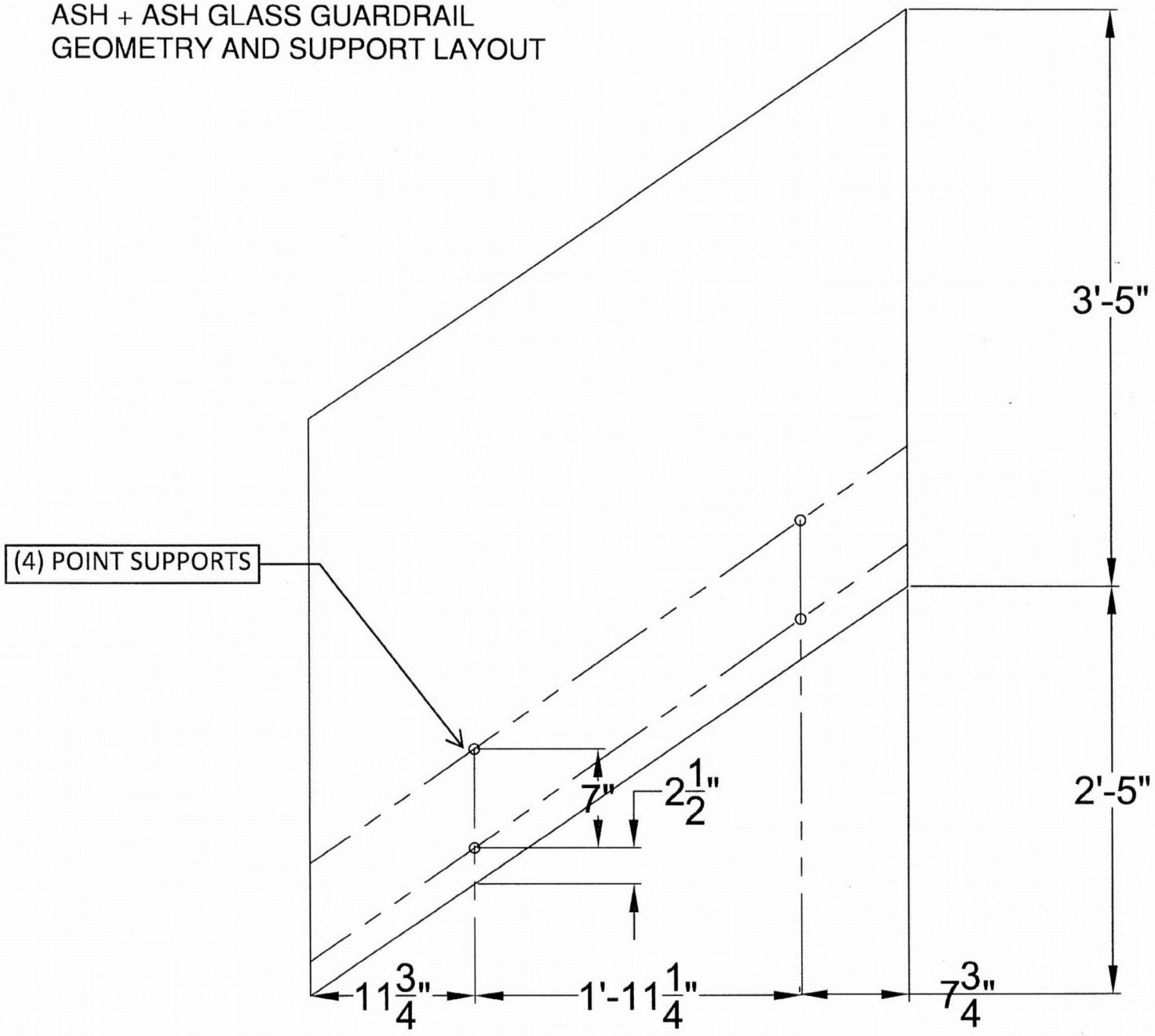
PLAN



SIDE VIEW



ASH + ASH GLASS GUARDRAIL
GEOMETRY AND SUPPORT LAYOUT



Use SJ MEPLA for analysis of laminated glass guardrail support.

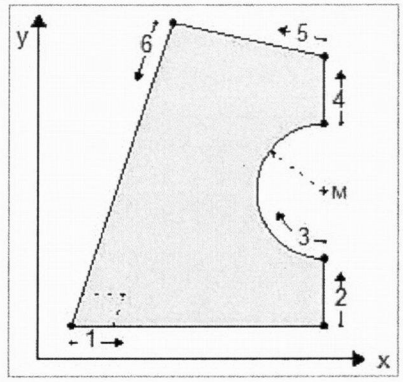
MEPLA input is as follows:

Geometry-

Project: Ash + Ash - 4 Button - Rev: Workspace geometry

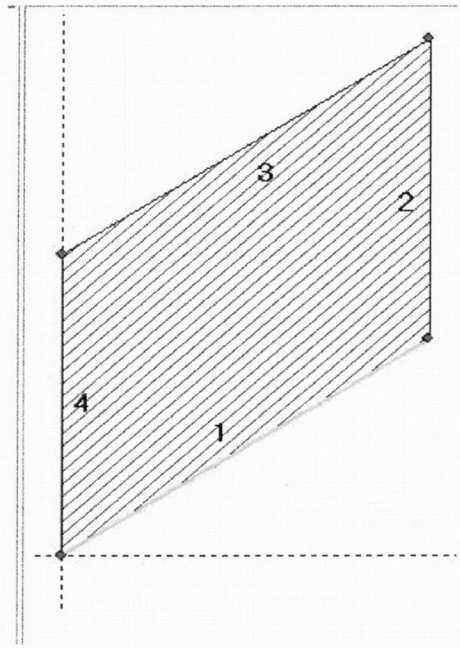
New item | Delete item | Delete all items

Edge	X [mm]	Y [mm]	X_m	Y_m	Rotation
	0	0	0	0	0
1	0	0	0	0	0
2	1083	749	0	0	0
3	1083	1790	0	0	0
4	0	1041	0	0	0



40 mm element size

Correction



Glass build-up- 10mm Fully Tempered/1.52mm PVB Interlayer/10mm Fully Tempered

For design, use PVB properties at 50 degrees C, 3 sec loading

Project: Ash + Ash - 4 Button - Rev: Workspace layers

Package: 1 from 1 New item | Delete item

Layer	Material	E	ν	t	ρ	α_T	ΔT
	Glass, heat strengthened	70000.	0.23	9.02	2.55e-9	1.e-5	0
3	Glass, heat strengthened	70000.	0.23	9.02	2.55e-9	1.e-5	0
2	PVB 50 C 3s loading	1.32	.4999	1.52	1.07e-9	8.e-5	0
1	Glass, heat strengthened	70000.	0.23	9.02	2.55e-9	1.e-5	0

Intermediate space

Package (from-to)	Gas	t	γ	ΔT	p_i
1 - 2					
2 - 3					
3 - 4					

External pressure

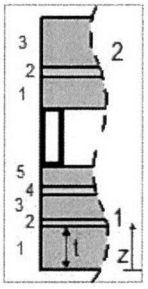
N/mm² Difference of height m

Climatic load case

Note: 1 bar = 1000 mbar = 0.1 N/mm²

with contact of glass packages

Tolerance 0.1 mm



Supports-

Define glass disk fixings and apply at the (4) locations noted.

Project: Ash + Ash - 4 Button - Rev: Workspace supports

Spring support | Edge support | Glass fixing | Spacer | Edge beam | Elast. edge support | Elast. base | Elast. line support | Bonded edges

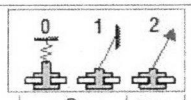
Kind of fixing:

New item | Delete item | Show picture...

Manufacturer - product*	Type	r_i	r_a	E_s	E_h	t_s	t_h	h_k	r_k
DiskFixing	2	9.5	22	60.	500.	3.	2.		
DiskFixing	2	9.5	22	60.	500.	3.	2.		

Position of fixing:

New item | Delete item



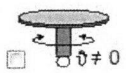
*Reference	X [mm]	Y [mm]	Z_h	C_x	C_y	C_z	C_φ	C_θ	Type
DiskFixing	888	858	10	10000	10000	10000	10000	10000	0
DiskFixing	888	858	10	10000	10000	10000	10000	10000	0
DiskFixing	888	680	10	10000	10000	10000	10000	10000	0
DiskFixing	296	446	10	10000	10000	10000	10000	10000	0
DiskFixing	296	268	10	10000	10000	10000	10000	10000	0

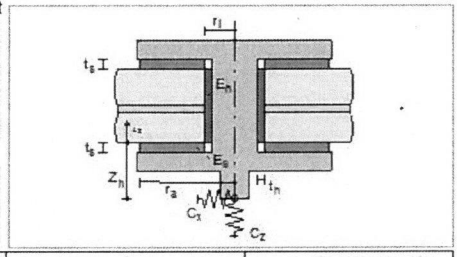
Contact approaches (tolerance value):

☐ for the bush 0.001 mm

☐ for the disk layer 0.001 mm

Degree of freedom for rotat

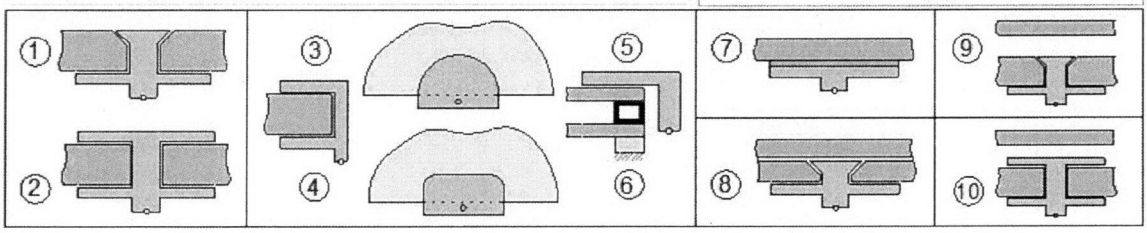


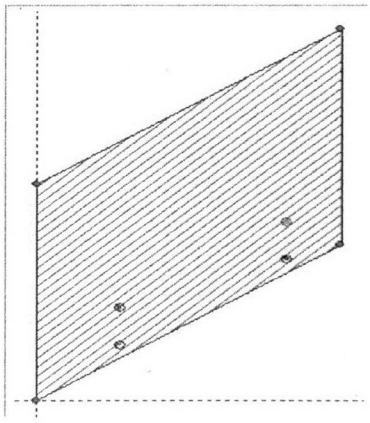


Load transmission at the borehole rim:

☑ only the countersunk head touches the glass chamfer (type 1, 8, 9)

☐ only glass layer touches the bush (type 2, 10)





Loading-

50 plf uniform load at top of barrier or 200 lb concentrated point load

Point load:

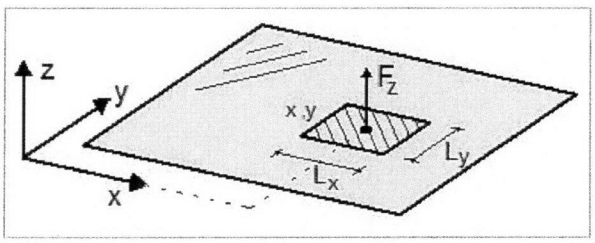
Project: Ash + Ash - 4 Button - Rev: Workspace loads

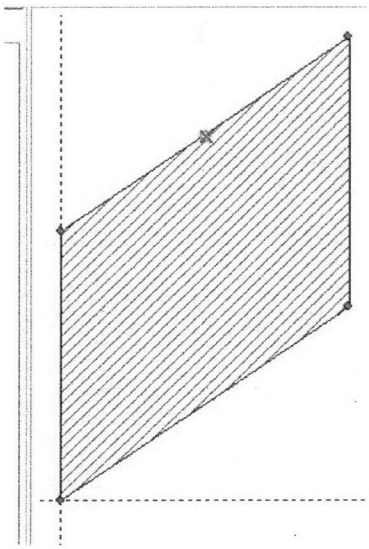
Face load | Concentrated load | Line load | Load cases | Border loads

Package: 1 from 1

New item | Delete item

X [mm]	Y [mm]	F_x [N]	F_y [N]	F_z [N]	L_x [mm]	L_y [mm]
541.5	1405			590	10	10
541.5	1405			590	10	10





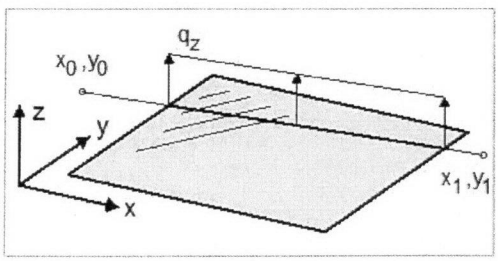
Project: Ash + Ash - 4 Button - Rev: Workspace loads

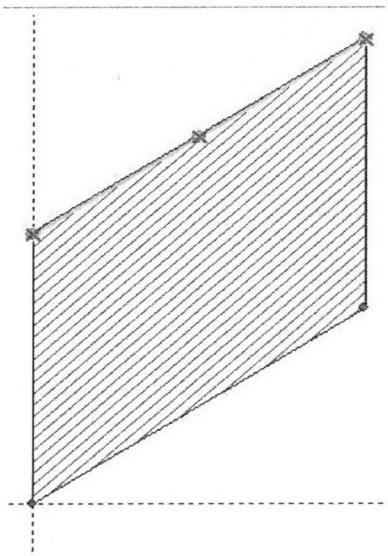
Face load | Concentrated load | Line load | Load cases | Border loads

Package: 1 from 1

New item | Delete item

X_1	Y_1	X_2	Y_2	q_x	q_y	q_z
0	1030	1083	1780	0	0	.73
0	1030	1083	1780	0	0	.73





Load cases consist of gravity loads (w/ 1.5 factor per ASTM E1300 to account for long-term loading) plus live load.

Project: Ash + Ash - 4 Button - Rev: Workspace loads

Face load | Concentrated load | Line load | Load cases | Border loads

☑ Use load cases

New item | Delete item | Delete all items | Open file... | Save file...

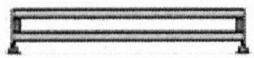
LC	DW	Wind	Snow	Line	Point	Climate Δp ΔT	Climate ΔH	Shear	Comment
	1.5	0	0	0	1	0	0	1	
1	1.5	0	0	0	1	0	0	1	
2	1.5	0	0	1	0	0	0	1	
3	1	0	0	0	0	0	0	1	

Wind

Pressure 0

Suction 0

without



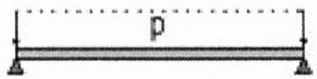
Suction 0

Pressure 0

without

Snow

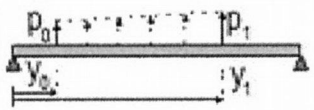
☑ P: 0



☐

P_0: 0 P_1: 0

Y_0: 0 Y_1: 0



Climate

Winter (default)

Summer (default)

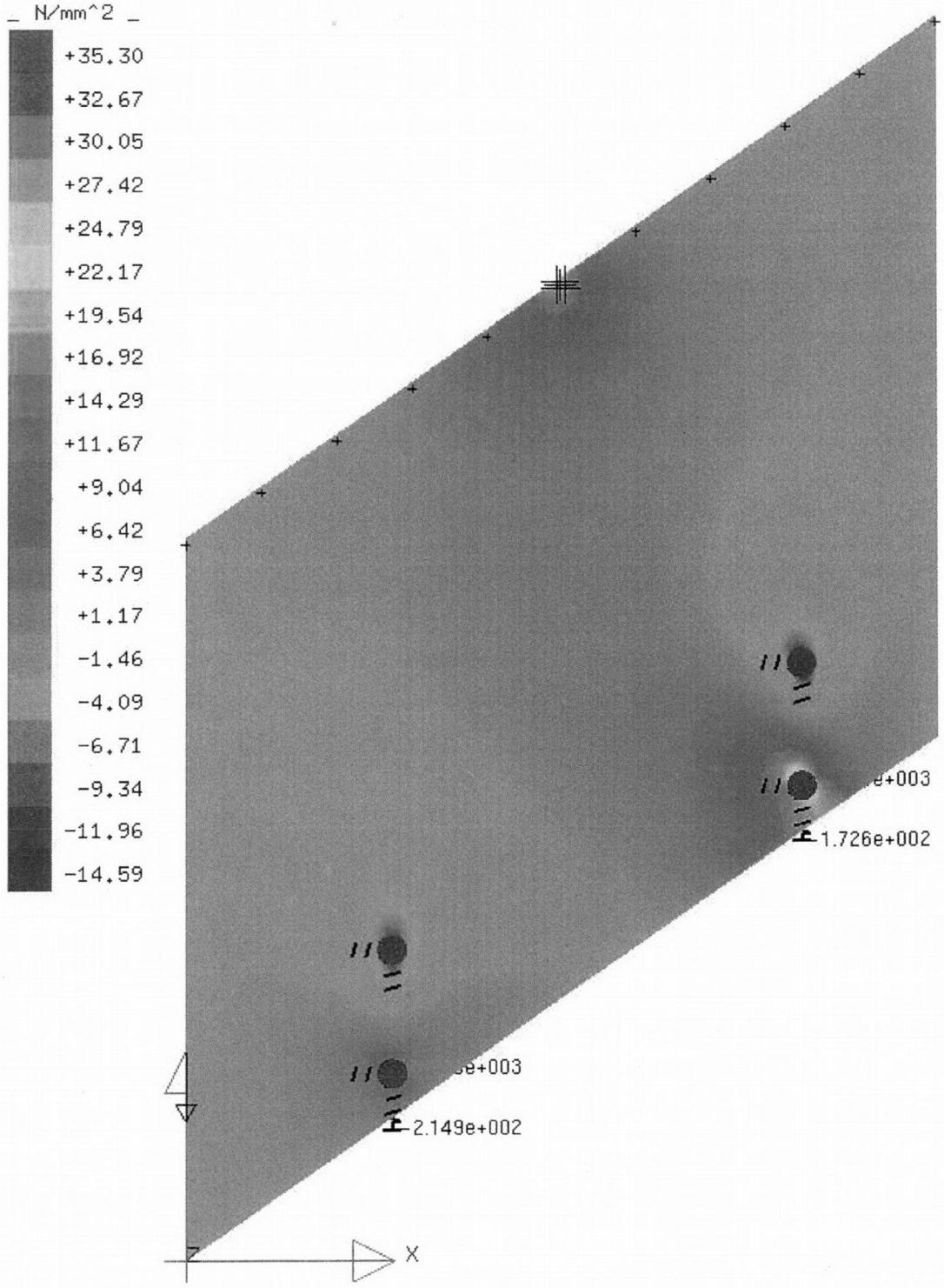
self-defined

without

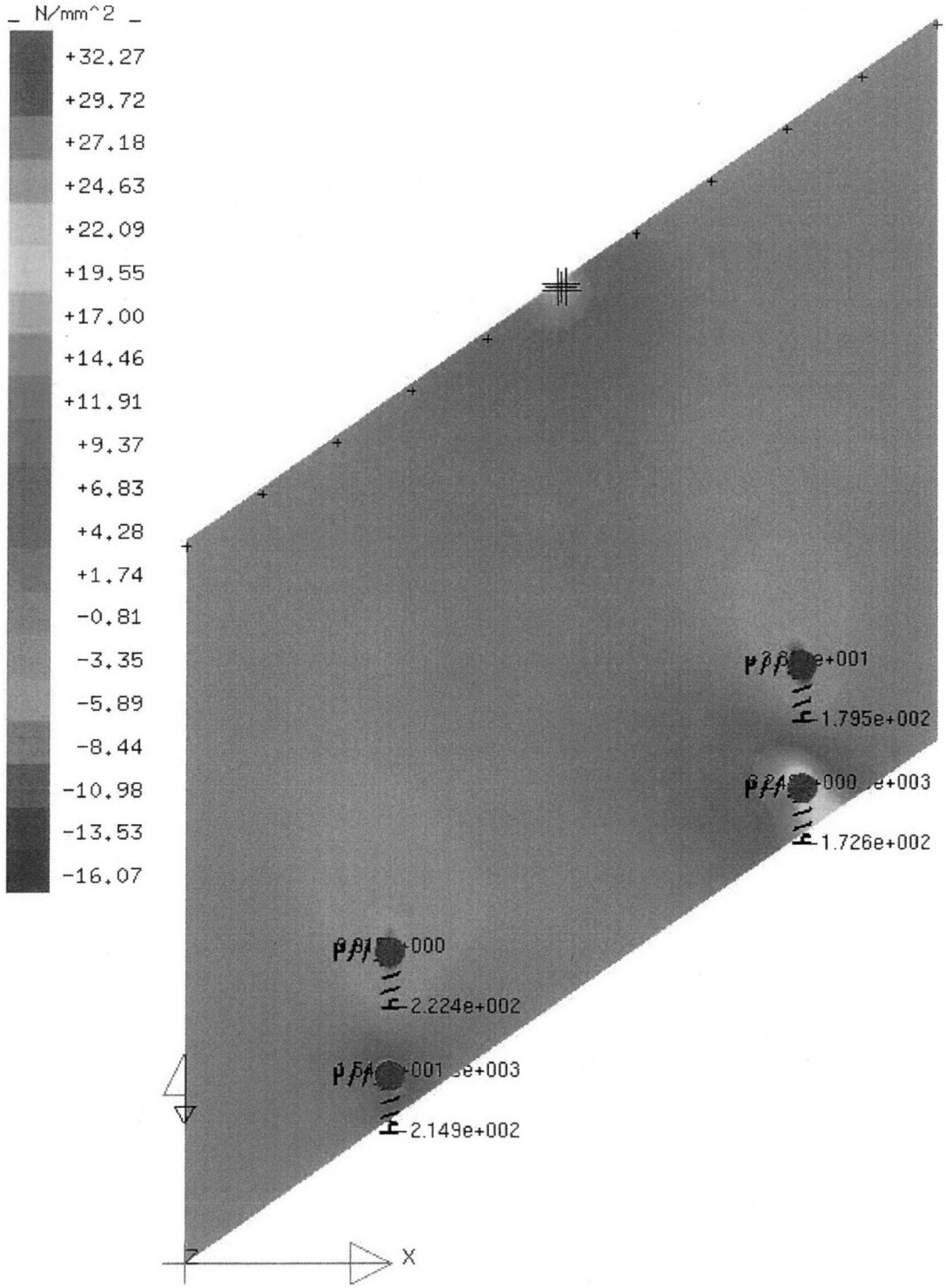
Winter Summer None

Results:

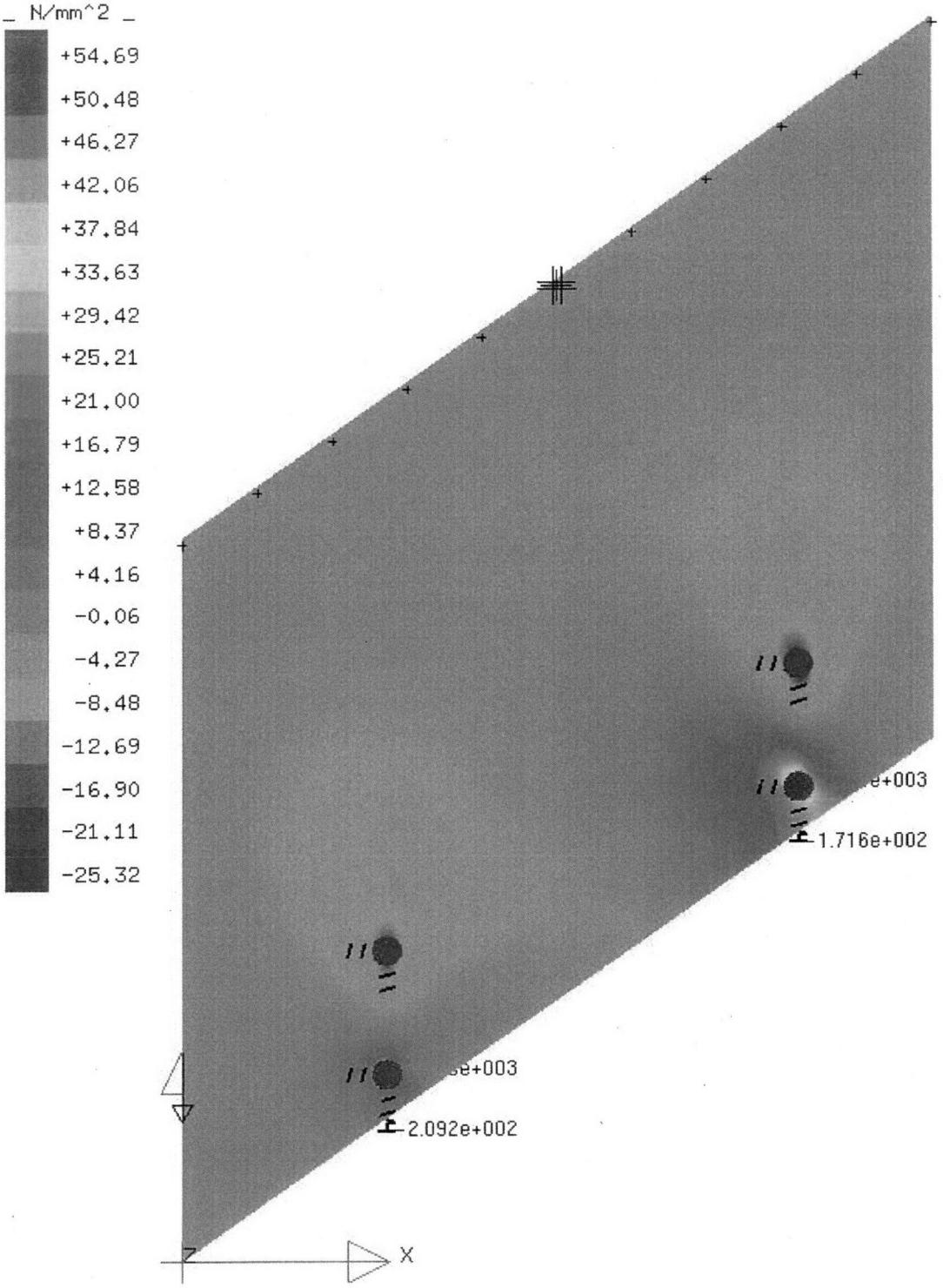
Load Case 1, outer lite:



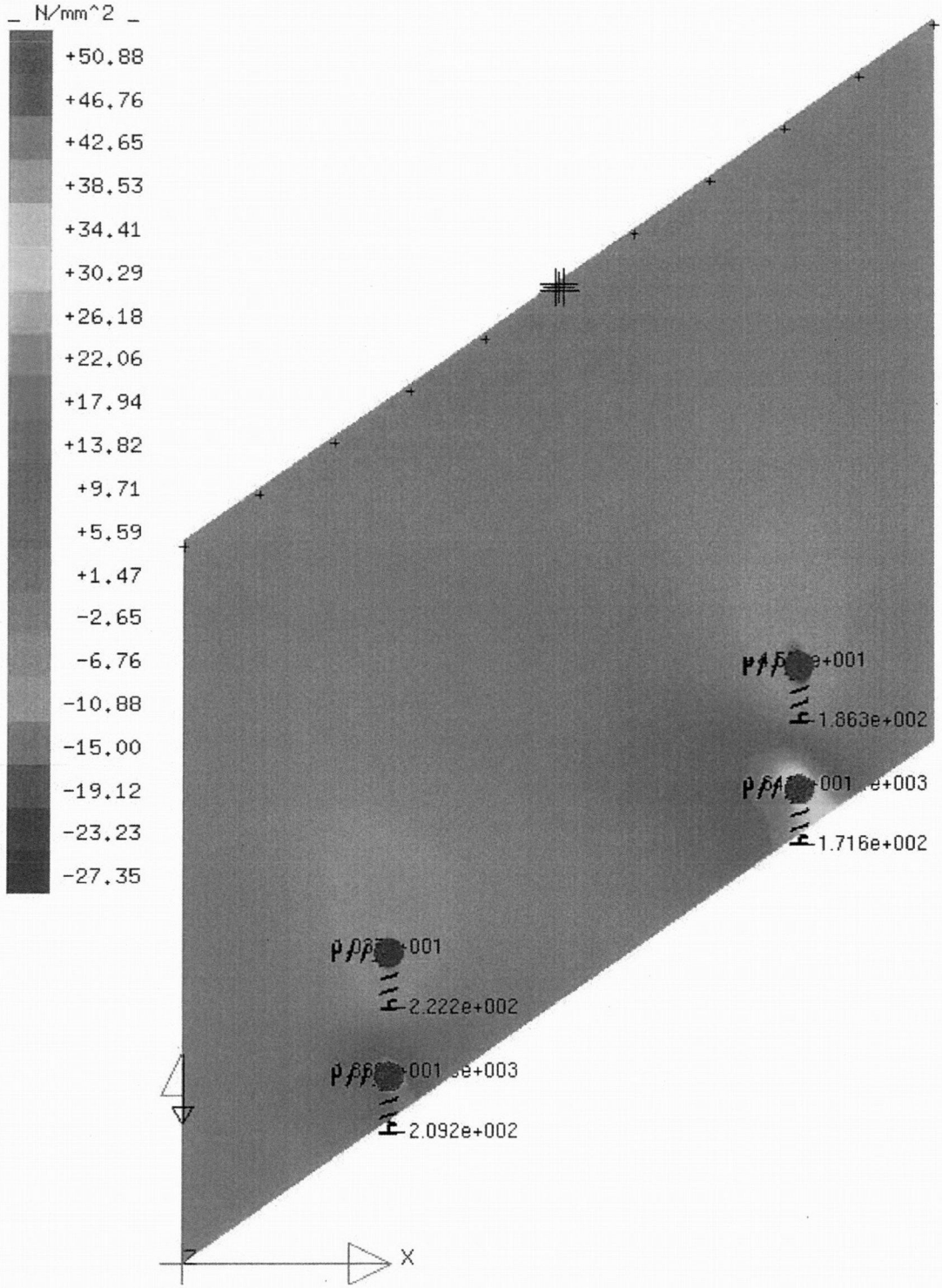
Load Case 1, inner lite:



Load Case 2, outer lite:



Load Case 2, inner lite:



Maximum stress = 54.69 MPa.

Maximum allowable stress = 54.3 MPa (for 1 in 1000 probability of breakage, tempered glass)

D/C = 1.01, OK