408 SW 11TH AV. DFS-01 C004-049778

14 24X

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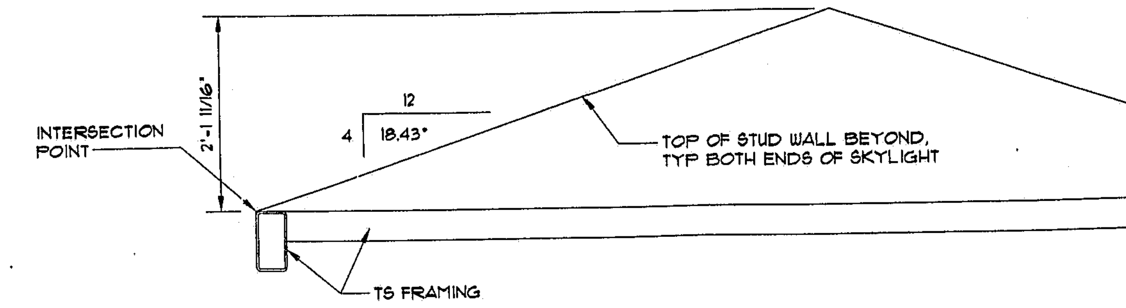
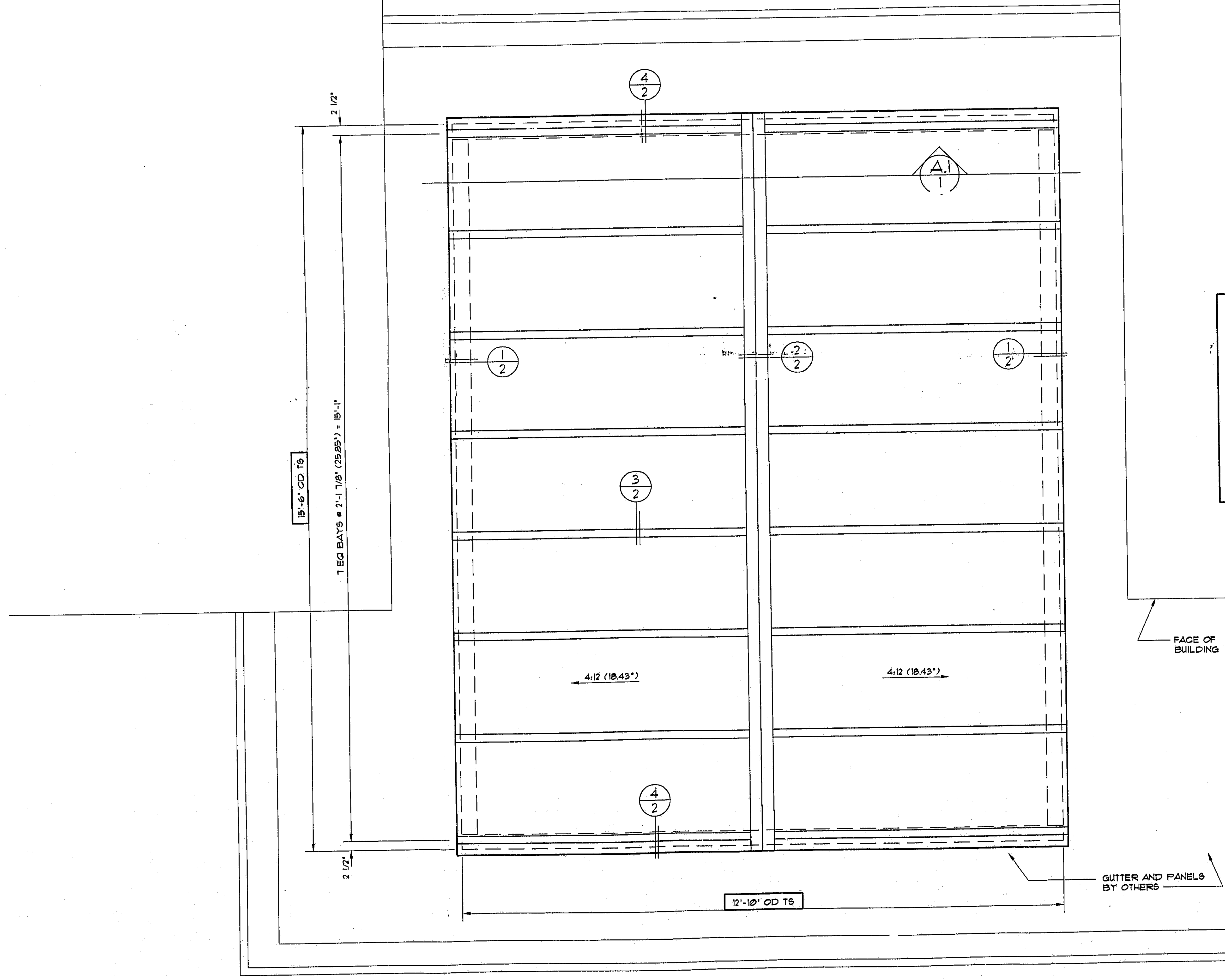
MAR 1 8 2005 MICROFILMED



A.1 FRAMING SECTION
3/4"=1'-0" ARCH. REF. =



A CANOPY PLAN VIEW - (1) THUS
3/4"=1'-0" ARCH. REF. = A12

NOTE!

All dimensions must be guaranteed by the general contractor or field measured by DeaMor prior to fabrication. Your signature on the guaranteed dimension line below states that the dimensions shown in block will be held, all custom materials will be fabricated to these same dimensions and cannot be field modified.

Guaranteed Dimensions By:

Bremick Construction, Inc. Date:

or; Field Dimensions By:

DeaMor Associates, Inc. Date:

City of Portland Bureau of Development Services By B.Curtis Date 1/28/05 Approved by Planning and Zoning Review

glass must be frosted per LUR 02-103:33 DZ

RECEIVED DEC 14 2004 DeaMor Associates

RECEIVED DEC - 7 2004 WATERLEAF ARCHITECTURE

RECEIVED DEC 13 2004 WATERLEAF ARCHITECTURE

GENERAL NOTES

Micro

1. The skylights will be manufactured by DeaMor Associates Inc. The framing is DeaMor Skylights standard fully gutted skylight system as shown in the details. Installation will be by DeaMor.
2. The skylights are designed to carry a live load of 25 psf plus a drifting load for a total of 69 psf.

   The deflection is limited to L/180. Wind load is based on 80 mph, exposure "B".

   Skylights are designed to withstand 120° F temperature swing without permanent deformation.

   Skylights are designed for Seismic Zone 3.

   Supplemental engineering calculations accompany the drawings and are incorporated into the skylight design.
3. The skylights are free of uncontrolled leakage of water and air as determined by ASTM E-283 and ASTM E-331. Structural performance of the assembly is verified by ASTM E-330. Test reports are provided in the Supplemental Technical Data.
4. Aluminum components are of the following alloys and temper:

Rafters	6063-T6
All other extrusions	6063-T5
Flashings and Plates	5052-H32

5. Aluminum systems components will have a 0.7 mil Class I anodized finish. Color: to be selected
6. All fasteners will be non-magnetic 300 series stainless steel where indicated. Steel fasteners will have a corrosion resistant coating. Fasteners are designed for a safety factor of 4 to 1. All exposed fasteners will be finished to match the skylight framing.
7. All dissimilar metals will be separated by 3M Scotchrap 50, black vinyl All-Weather Corrosion Protection Tape, 10 mils thick.
8. Sealants between aluminum and glass will be one part neutral cure silicone, Dow Corning #791, black.
9. Backer rod behind sealants will be SOF Rod, as manufactured by Applied Extrusion Technologies, Inc. This is a reticulated, closed cell foam rod that does not absorb moisture and is non-gassing when punctured.
10. Baffles located over the 1/4"ø weeps along the eave angle are PVC-coated Reticulated Industrial Foam, manufactured by Scotfoam Corp. It is an 30 pore/inch open cell, flexible polyurethane foam with a PVC coating.
11. Norton Norseal V-740 expanded cellular foam glazing tape is used along the skylight perimeter for a seal against air infiltration.
12. Glazing gaskets are extruded 1/8"x1/2" 55-durometer Santoprene, mechanically interlocked into the skylight frame and caps.
13. Glass blocking is provided by 80-durometer silicone setting blocks interlocked or adhered to the skylight frame as shown in the details. Blocking is located at 1/4 points along the glass edges fully supporting the glass from sliding and lateral movement.
14. Edge clearance between glass and adjacent framing surfaces will be 1/4" minimum.
15. Glass: 7/16" thick laminated units consisting of (2) lites of 3/16" CLEAR Heat-Strengthened glass laminated with an .030" CLEAR PVB lamina interlayer. Includes standard pattern ceramic frit on the #3 surface.

(14)

Project Architect Review Stamp

W. Bailey 12/13/04

City of Portland APPROVED FEB 1 7 2005

Project Engineer Review Stamp | Skylight Engineer Stamp

Engineer Stamped Calculation

CONLEE ENGINEERS, INC. BY DL DATE 12-13-04

REVISIONS | BY

General Contractor: Bremick Construction, Inc.
OFFICE: Brent Parry 503-665-2086 Fax: 503-665-2836
FIELD: Mike Greenslade 503-...-8673

Architect: Waterleaf Architecture Interiors
CONTACT: Bill Bailey 503-228-...11

Mark Spencer Hotel - Entry Canopy
409 SW 11th Avenue Portland, OR 97202
Aluminum Framed Skylight

DeaMor Associates, Inc.
14010-A N.E. 3rd Ct., #102 Vancouver, WA. 98685
(503)284-6799 (360)574-3499
FAX: (360)574-3487

Date	11-29-04
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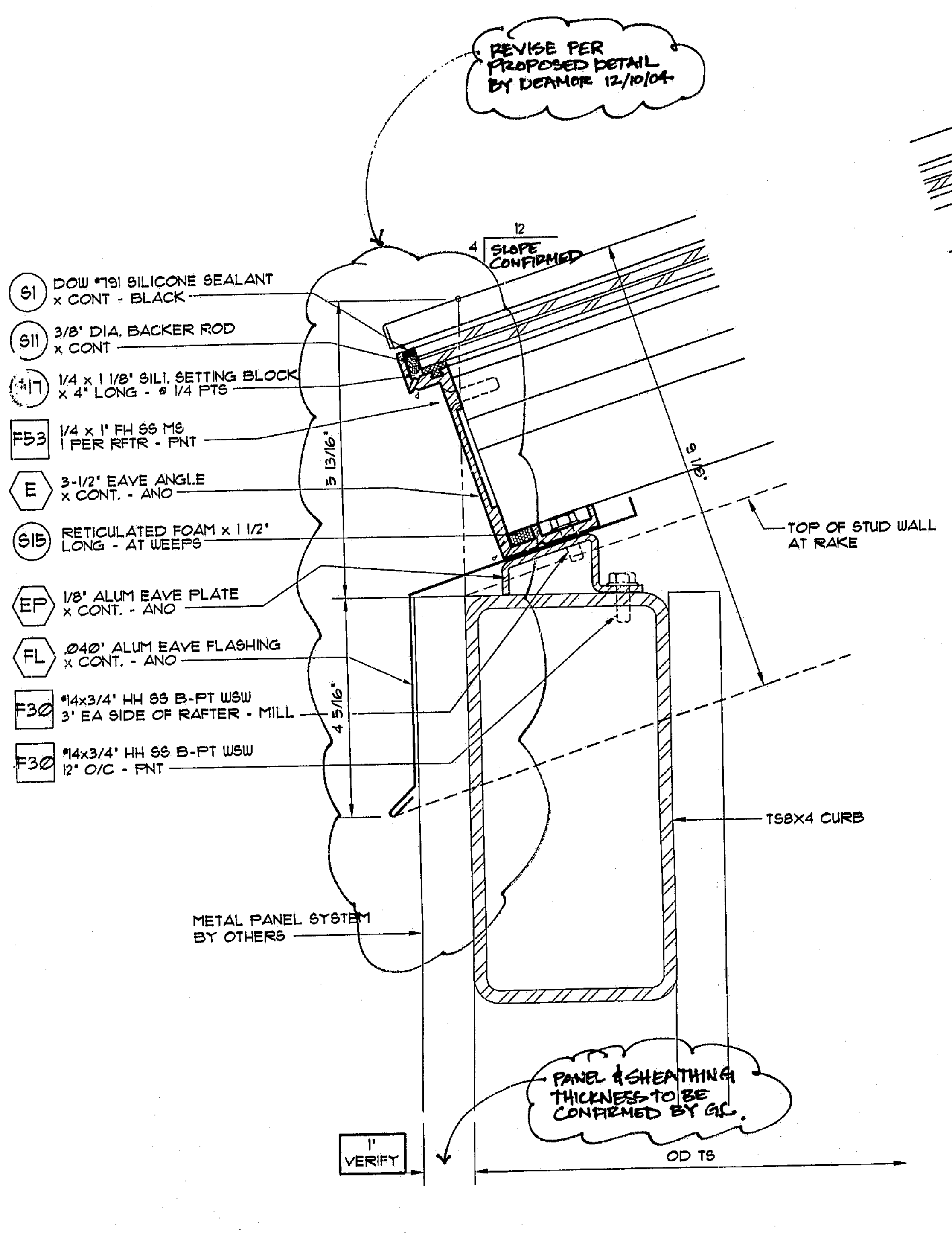
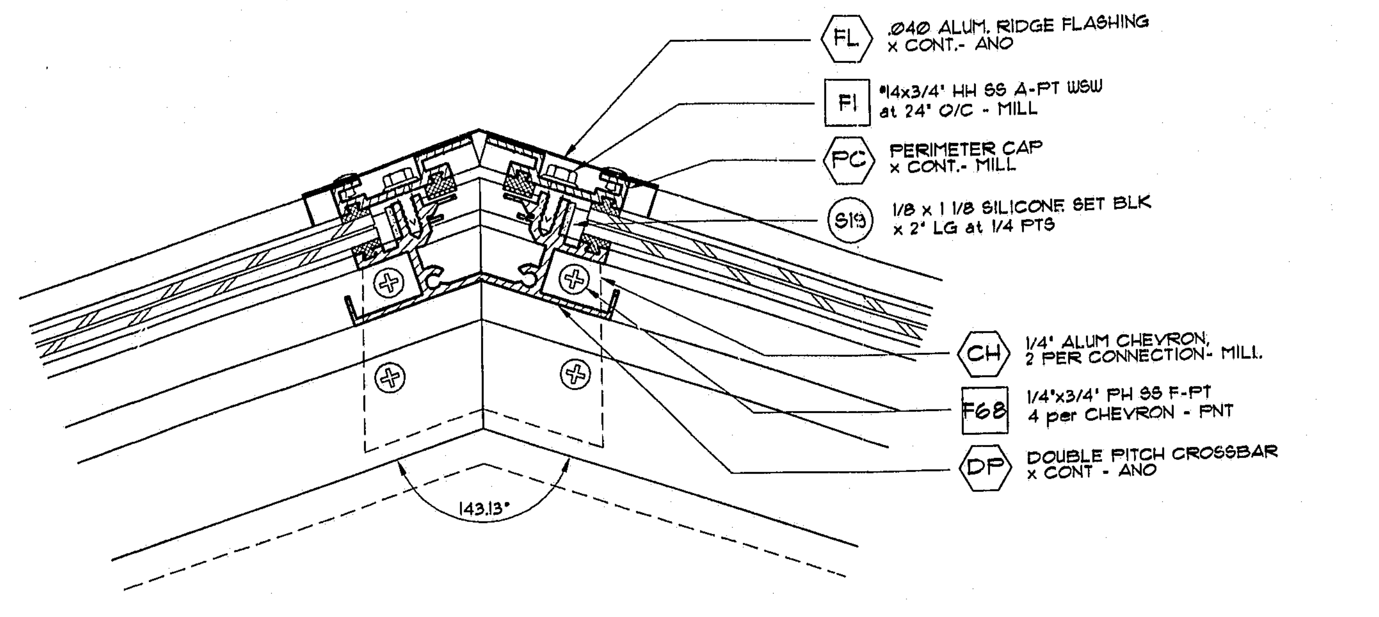
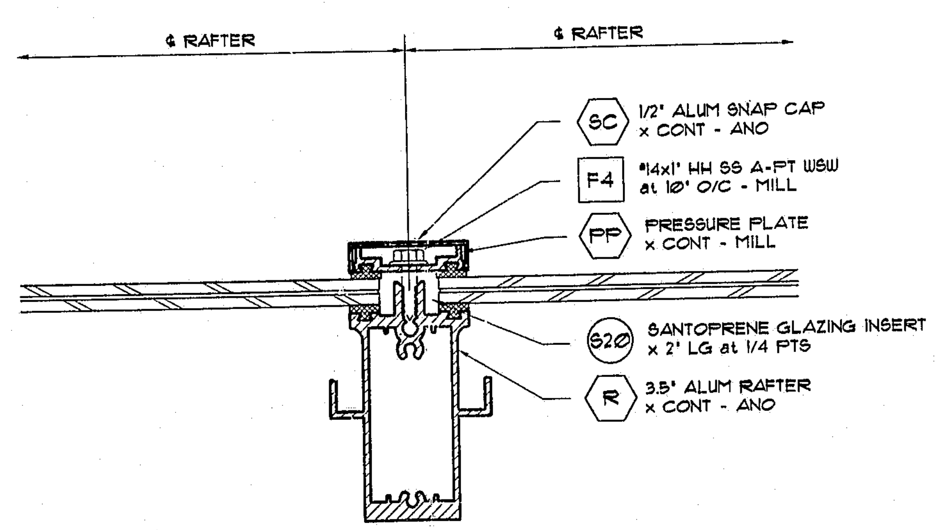


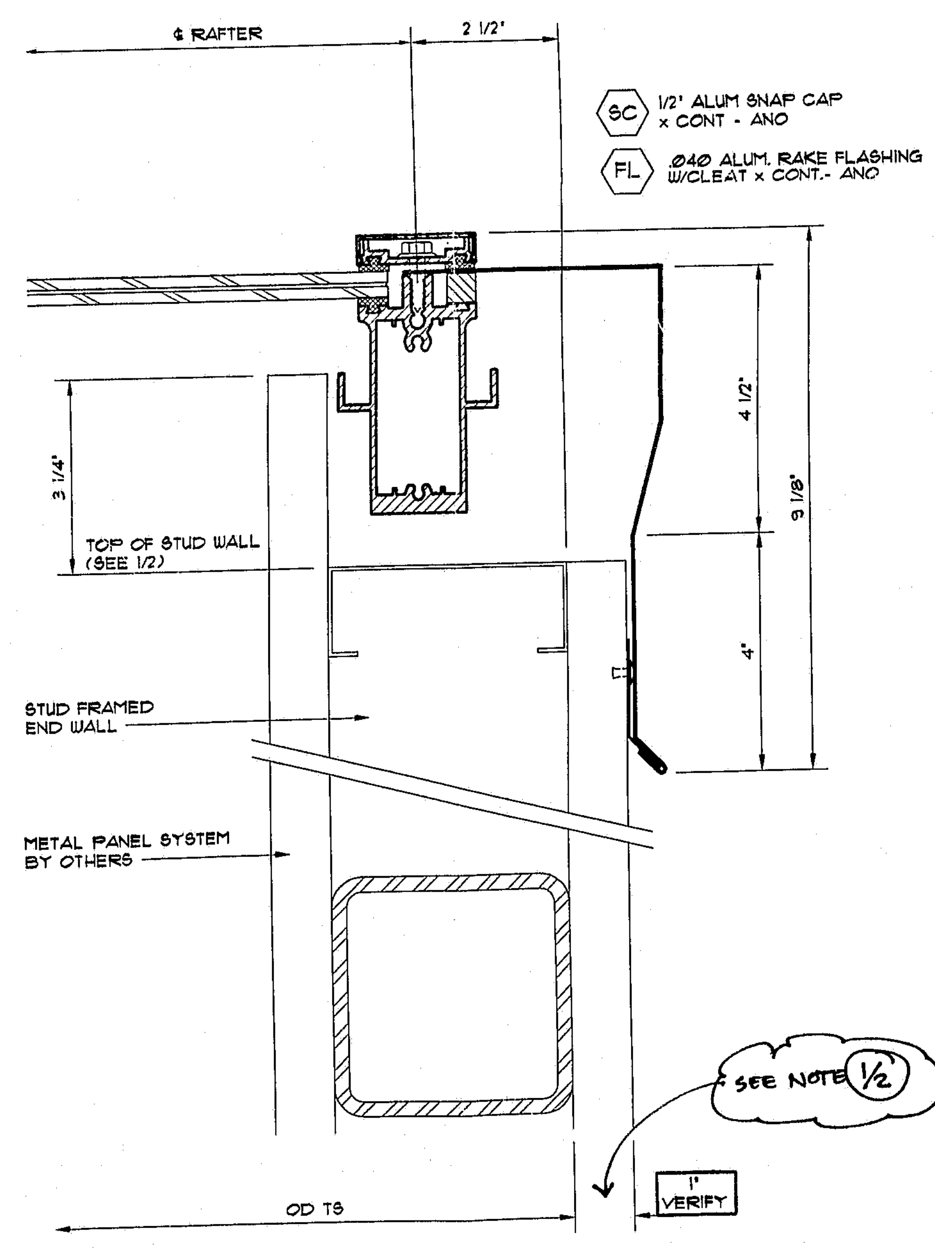
1/2 EAVE SECTION
HALF SCALE ARCH. REF. = 7/A12



2/2 RIDGE SECTION
HALF SCALE ARCH. REF. = NONE



3/2 RAFTER DETAIL
HALF SCALE ARCH. REF. = NONE



4/2 RAKE DETAIL
HALF SCALE ARCH. REF. = 4/A12

City of Portland
APPROVED
FEB 1 7 2005
Permit Number

REVISIONS	BY

General Contractor: Bremik Construction, Inc.
OFFICE: Brent Parry 503-665-2086 Fax: 503-665-2836
FIELD: Mike Greenslade 503-914-8613

Architect: Waterleaf Architecture & Interiors
CONTACT: Bill Bailey 503-228-7511

Mark Spencer Hotel - Entry Canopy

408 SW 11th Avenue
Portland, OR 97202

Aluminum Framed Skylights

DeaMor
Associates, Inc.
14010-A N.E. 3rd Ct., #102
Vancouver, WA. 98685
(503)284-6799 (360)574-3449
FAX: (360)574-3487

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Co. 04.049778 DFS.01.

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04-4978-DES-1-C2

STRUCTURAL CALCULATIONS

FOR

MARK SPENCER HOTEL
DOUBLE-PITCHED GLASS CANOPY

408 SW 11th Avenue
Portland, Oregon 97202

NO EXCEPTION TAKEN ☑ MAKE CORRECTIONS NOTED ☐
REJECTED ☐ REVIEW AND RESUBMIT ☐
SUBMIT SPECIFIED ITEM ☐

CHECKING IS ONLY FOR GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS. ANY ACTION SHOWN IS SUBJECT TO THE REQUIREMENTS OF THE PLANS AND SPECIFICATIONS. CONTRACTOR IS RESPONSIBLE FOR DIMENSIONS WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE, FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATION OF HIS WORK WITH THAT OF ALL OTHER TRADES AND THE SATISFACTORY PERFORMANCE OF HIS WORK.

BY Da DATE 1-17-05

CONLEE ENGINEERS, INC. 1300 S.W. BERTHA BLVD. PORTLAND, OREGON 97219 (503) 244-6379 FAX (503) 244-7023

REGISTERED PROFESSIONAL ENGINEER 10588PE OREGON MAY 6, 1980 V. ROBERT WELLS

12/30/16

Berry-Nordling Engineers, Inc.
HAS SUPERVISED THE DESIGN
OF ARCHITECTURAL METALS
IN REGARDS TO STRUCTURAL
ADEQUACY ONLY.
B.N.E.I. IS NOT RESPONSIBLE
FOR DIMENSIONAL ACCURACY
NOR THE WEATHERING ABILITY
AND/OR PERFORMANCE OF
ARCHITECTURAL METALS.

Contents

Contact Person: Shane A Empey

DESIGN CRITERI

BASED ON 2003 IBC

DEAD LOAD = 6.5 PSF

SNOW LOAD = 25 PSF
25 PSF

WIND LOAD : 85 MPH (3 second gust)

TRIB = 10 FT^2

hm = 30 ft

roof pitch = 1.5/12

a = 6 ft

$q_z = .00256 \times K_z \times K_{zt} \times K_d \times V^2 \times I_w$ (ASCE7 Eq. 6-15)

$K_{zt} = 1.0$

$-P = q_h(-GC_p) - q_h(+GC_{pi})$ (ASCE7 Eq. 6-22)

$+P = q_h(+GC_p) - q_z(-GC_{pi})$ (ASCE7 Eq. 6-23)

Components and Cladding Wind Loads
Using ASCE 7-02 Method 2 for h_m <or= 90 ft

K_d:	0.85
V (mph):	85
I_w:	1.2
Trib (ft^2):	16
pitch (#/12):	1.5

roof	"-" GC_p	"+" GC_p	"-/+" GC_{pi}
zone 1	-0.88	0.46	0.00
zone 2	-1.60	0.46	0.00
zone 3	-2.48	0.46	0.00

walls	"-" GC_p	"+" GC_p	"-/+" GC_{pi}
zone 4	-1.06	0.96	0.00
zone 5	-1.33	0.96	0.00

Open Building			ROOF						WALLS			
Exposure B			zone 1		zone 2		zone 3		zone 4		zone 5	
Height (ft)	K_z	q_z (psf)	"+P" (psf)	"-P" (psf)	"+P" (psf)	"-P" (psf)	"+P" (psf)	"-P" (psf)	"+P" (psf)	"-P" (psf)	"+P" (psf)	"-P" (psf)
0-15	0.70	12.7	5.8	-11.1	5.8	-20.2	5.8	-31.4	12.2	-13.5	12.2	-16.8
20	0.70	12.7	5.8	-11.1	5.8	-20.2	5.8	-31.4	12.2	-13.5	12.2	-16.8
25	0.70	12.7	5.8	-11.1	5.8	-20.2	5.8	-31.4	12.2	-13.5	12.2	-16.8
30	0.70	12.7	5.8	-11.1	5.8	-20.2	5.8	-31.4	12.2	-13.5	12.2	-16.8
35	0.73	13.2	6.1	-11.6	6.1	-21.1	6.1	-32.7	12.7	-14.0	12.7	-17.5
40	0.76	13.7	6.3	-12.1	6.3	-22.0	6.3	-34.0	13.2	-14.6	13.2	-18.2
50	0.81	14.6	6.7	-12.9	6.7	-23.4	6.7	-36.3	14.1	-15.6	14.1	-19.4
60	0.85	15.4	7.1	-13.5	7.1	-24.6	7.1	-38.1	14.8	-16.4	14.8	-20.4
70 *	0.89	16.1	7.4	-14.2	7.4	-25.7	7.4	-39.9	15.5	-17.1	15.5	-21.4
80 *	0.93	16.8	7.7	-14.8	7.7	-26.9	7.7	-41.7	16.2	-17.9	16.2	-22.3
90 *	0.96	17.4	8.0	-15.3	8.0	-27.7	8.0	-43.0	16.7	-18.5	16.7	-23.0

*h/w <or= 1.0 , and roof slope <or= 2:12

BERRY-NORDLING ENGINEERS, INC.
CIVIL-STRUCTURAL
3507 SW CORBETT AVE., PORTLAND OR, 97239, 503-227-7783, FAX 503-227-7781, bneng@e-z.net

Project: MARK SPENCER HOTEL

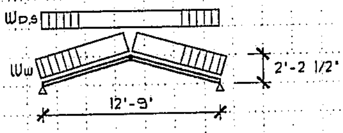
Client: DEA MOR Proj. No.: 04-770

Date: DECEMBER 04 By: SAE Sheet No.: 1

MODEL / MEMBER CHECKS

3-HINGE ARCH MODEL

RAFTERS ACT AS SIMPLE SUPPORT BEAM MEMBERS WITH A PIN SUPPORT AT THE PEAK. THE TRIBUTARY WIDTH REFERENCED BELOW IS THE WIDTH OF THE GLASS PANELS.



TRIB = 3.5 FT

$W_{DL} = 10 \cdot 2.0 = 20$ plf

$W_{SL} = 60 \cdot 2.0 = 120$ plf

$W_W = 31.0 \cdot 2.0 = 62$ plf (OUTWARD)

(SEE ATTACHED ANALYSIS.)

MEMBER CHECK (LCI: DL + SL)

(Conservative Loads)

V = 780 #

$A = 2.029\ IN^2$

$f_v = 1.17$ KSI

$F_v = 8.5$ KSI

∴ SHEAR OK

M = 1,311 lb-FT

$S_x = 3.531\ IN^3$

$f_b = 4.46$ KSI

$F_B = 15$ KSI

C = 2,606 lb.

$A_x = 2.029\ IN^2$

$f_c = 1.29$ KSI

$kl/r = 1 \cdot 81 / 1.319 = 61.4$

$F_B = 14.2 - 0.074 \cdot (61.4) = 9.6$ KSI

$$\frac{4.46}{15} + \frac{1.29}{9.6} = 0.43$$

$\boxed{\therefore \text{STANDARD 3.5" RAFTER OK}}$

MEMBER CHECK (LCI: DL + WL)

(Conservative Loads)

V = 255 #

$A = 2.029\ IN^2$

$f_v = 0.38$ KSI

$F_v = 8.5 \cdot 4/3 = 11.3$ KSI

∴ SHEAR OK

M = 428 lb-FT

$S_x = 3.531\ IN^3$

$f_b = 1.53$ KSI

$F_B = 15 \cdot 4/3 = 20$ KSI

C = 764 lb

$A_x = 2.029\ IN^2$

$f_c = 0.38$ KSI

$kl/r = 1 \cdot 81 / 2.84 = 61.4$

$F_B = 14.2 - 0.074 \cdot (61.4) = 9.6$ KSI

$$\frac{1.53}{20} + \frac{0.38}{9.6} = 0.12$$

$\boxed{\therefore \text{STANDARD 3.5" RAFTER OK}}$

3607 SW CORBETT AVE., PORTLAND OR, 97239, 503-227-7783, FAX 503-227-7784, bneng@e-z.net

CONNECTION CHECKS

(1) ¼" shear/pry screw @ eave angle to eave plate

V = 1,637 #/rafter (lc1: dl+sl)

Vcap = 364 #/screw

$\frac{1,637}{364}$ = 4.50 screws/rafter(24")

V = 391 #/rafter (lc2: dl+wl)

Vcap = 364·4/3 = 484 #/screw

T = 145 #/rafter

Tcap = 630(.125/.203)·4/3 = 517 #/screw

$\frac{391}{484} + \frac{145}{517}$ = 1.09 screws/rafter(24")

∴ use 1/4" @ 4' o/c

(2) ¼" shear/pry screw @ eave angle to eave plate

V = 1,412 #/rafter (lc1: dl+sl)

Vcap = 364 #/screw

$\frac{1,412}{364}$ = 3.88 screws/rafter(24")

V = 325 #/rafter (lc2: dl+wl)

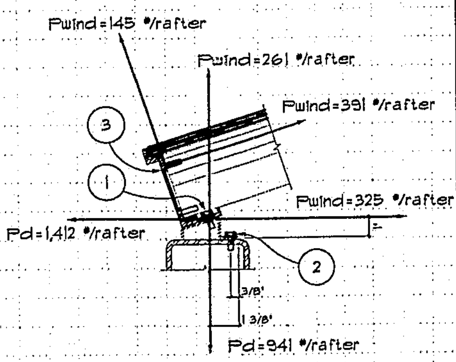
Vcap = 364·4/3 = 484 #/screw

T = 261(1.375/.375) = 957 #/rafter

Tcap = 630·4/3 = 840 #/screw

$\frac{325}{484} + \frac{957}{840}$ = 1.81 screws/rafter(24")

∴ use 1/4" @ 6" o/c



(3) ¼" shear/tension screw @ rafter to eave angle (lc2: dl+wl)

V = Pw = 145 #/rafter

Vcap = 364·4/3 = 484 #/screw

T = 391 #/rafter

Tcap = 630·4/3 = 840 #/screw

$\frac{145}{484} + \frac{391}{840}$ = 0.77 screws/rafter(24")

∴ use (1) 1/4" @ ea rafter

(4) 1/8" bent ridge PL (lc1: dl+sl)

M = 1,412·.75 = 1,059 lb-in/rafter

Sx = 24·.1875²/6 = .141 in³

fb = 7.53 ksi

Fb = 13 ksi

∴ 3/16" EAVE PL OK

BERRY-NORDLING ENGINEERS, INC.
CIVIL-STRUCTURAL
3607 SW CORBETT AVE., PORTLAND OR. 97239, 503-227-7783, FAX 503-227-7784, bneng@e-z.net

Project: MARK SPENCER HOTEL

Client: DEA MOR — Proj. No.: 04-770

Date: DECEMBER 04 — By: SAE — Sheet No.: 3

GLAS PANEL CHECK USING "JPL METHOD
SUPPORTS: 4 SIDES DEAD+SNOW, 2 SIDES WIND+DEAD

pitch = 4 : 12

LC1: DEAD LOAD + SNOW LOAD

DETERMINING ALLOWABLE STRESSES

σ_B (ksi) = $f_A * f_\tau * \sigma_{11}$

Length "a" (ft): 6.5
Width "b" (ft): 2

f_A = 0.97
f_τ = 0.74
σ_{11} = 8.2

σ_B (ksi) = 5.88

DETERMINE APPLIED STRESSES

t (inches): 0.19
Panes: 2

Uniform Normal Pressures
DEAD LOAD (psf): 4.88
SNOW LOAD (psf): 69 73.875

LIF = 75 b/a = 3.25

SIF = 200

σ_b (ksi) = 0.51 OK

LC2: DEAD LOAD + WIND LOAD

DETERMINING ALLOWABLE STRESSES

σ_B (ksi) = $f_A * f_\tau * \sigma_{11}$

Length "a" (ft): 6.5
Width "b" (ft): 2

f_A = 0.97
f_τ = 0.88
σ_{11} = 8.2

σ_B (ksi) = 6.99

DETERMINE APPLIED STRESSES

L (ft) = 2
t (inches): 0.188
Panes: 2

Uniform Normal Pressures
WIND LOAD (psf): 31
DEAD LOAD (psf): 4.88 26.125

Mmax (ft-#): 13.06

Sx (in^3): 0.140625

σ_b (ksi) = 1.11 OK

3607 SW CORBETT AVE., PORTLAND OR. 97239, 503-227-7783, FAX 503-227-7784, bneng@e-z.net

Snow Drift Analysis

Snow Load Design Data

Pf	25.0	psf
Pg	25.0	psf

Drift Type	Lower Structure
Upper Roof Pitch	0/12

- Pg - Basic Snow Load
- Wb - Upper Roof Dimension
- Wd - Surcharge Dimension
- S - Horizontal Spacing Between Roofs
- hr - Vertical Spacing Between Roofs

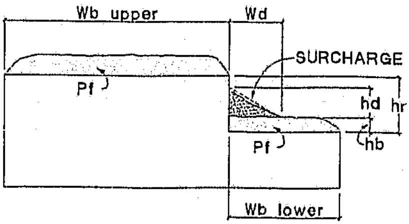
Input Data

Wb upper	50.0	ft.
Wb lower	12.00	ft.
S	0.0	ft
hr	10.00	ft.
Wd	9.41	ft.

Drift Surcharge Only Considered When	Drift Surcharge Applies ?	
(hr-hb) / hb > 0.2	5.90	Yes
hd = (0.43 (Wb^(1/3)) ((Pg + 10)^(¼)) - 1.5)	2.35	ft.
hb = Pf / D	1.45	ft.
D = 0.13Pg + 14.0 <= 35 pcf	17.25	pcf

SUMMARY

Drift Surcharge		
No Sliding Snow		
Pm = D (hd + hb) <= D hr	65.6	psf
- Base (Pf)	25.0	psf
Drift = Pm - Base	40.6	psf
Drift at Lower Roof Edge	0.0	psf
Avg Drift Load over Roof	20.3	psf
Avg Total Snow Load over Roof	45.3	psf



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CIVIL-STRUCTURAL
3607 SW CORBETT AVE., PORTLAND OR. 97239, 503-227-7783, FAX 503-227-7784, bneng@e-z.net

Project: MARK SPENCER HOTEL
Client: DEA MOR Proj. No.: 04-770
Date: DECEMBER 04 By: SAE Sheet No.: 5

.19. FASTENER LOAD TABLES

D. Spaced Threads

TABLE 25

STAINLESS STEEL - Alloy Groups 1, 2 and 3, Condition AF

Nominal Thread Diameter & Thread/Inch	D Nominal Thread Diameter (Inch)	K Basic Minor Diameter (Inch)	A(R) Thread Root Area (Sq. In.)	Allowable Tension (Pounds)	Allowable Shear		Bearing (Pounds)			Minimum Material Thickness to Equal Tensile Capacity of Fastener (In.)		
					Single (Pounds)	Double (Pounds)	1/8" St. A36	1/8" Al. 6063-T5	1/8" Al. 6063-T6	A36	6063-T5	6063-T6
#6-20	0.1380	0.0997	0.0078	265	153	306	1201	278	414	0.100	0.208	0.152
#8-18	0.1640	0.1257	0.0124	422	243	487	1427	328	492	0.130	0.265	0.205
#10-16	0.1900	0.1389	0.0152	517	298	597	1653	380	570	0.136	0.285	0.208
#12-14	0.2160	0.1649	0.0214	728	420	840	1879	432	648	0.161	0.349	0.252
1/4-14	0.2500	0.1887	0.0280	952	550	1099	2175	500	750	0.182	0.389	0.282
5/16-12	0.3125	0.2443	0.0469	1595	921	1841	2719	625	938	0.230	0.541	0.362
3/8-12	0.3750	0.2983	0.0699	2377	1372	2744	3262	750	1125	0.276	0.658	0.438

F_u (Minimum Ultimate Tensile Strength) 85,000 psi
F_y (Minimum Tensile Yield Strength) 50,000 psi

$A(R) = 7854K^2$

Where: $A(R)$ = Thread Root Area, sq. in.
K = Basic Minor Diameter, in.

$F_t = 0.40F_u$

Allowable tension $= 0.40F_u\,[A(R)]$

$F_v = \frac{0.40}{\sqrt{3}}F_u$

Allowable shear (Single) $= \frac{0.40}{\sqrt{3}}F_u[A(R)]$

TABLE 26

STAINLESS STEEL - Alloy Group 1, 2 and 3, Condition A

Nominal Thread Diameter & Thread/Inch	D Nominal Thread Diameter (Inch)	K Basic Minor Diameter (Inch)	A(R) Thread Root Area (Sq. In.)	Allowable Tension (Pounds)	Allowable Shear		Bearing (Pounds)			Minimum Material Thickness to Equal Tensile Capacity of Fastener (In.)		
					Single (Pounds)	Double (Pounds)	1/8" St. A36	1/8" Al. 6063-T5	1/8" Al. 6063-T6	A36	6063-T5	6063-T6
#6-20	0.1380	0.0997	0.0078	175	101	203	1201	278	414	0.077	0.148	0.111
#8-18	0.1640	0.1257	0.0124	279	161	322	1427	328	492	0.096	0.199	0.146
#10-16	0.1900	0.1389	0.0152	342	197	395	1653	380	570	0.104	0.203	0.152
#12-14	0.2160	0.1649	0.0214	481	278	556	1879	432	648	0.121	0.245	0.181
1/4-14	0.2500	0.1887	0.0280	630	364	727	2175	500	750	0.137	0.274	0.203
5/16-12	0.3125	0.2443	0.0469	1055	609	1218	2719	625	938	0.171	0.352	0.259
3/8-12	0.3750	0.2983	0.0699	1573	908	1816	3262	750	1125	0.204	0.428	0.311

F_u (Minimum Ultimate Tensile Strength) 75,000 psi
F_y (Minimum Tensile Yield Strength) 30,000 psi

$A(R) = 7854K^2$

Where: $A(R)$ = Thread Root Area, sq. in.
K = Basic Minor Diameter, in.

$F_t = 0.75F_y$

Allowable tension $= 0.75F_y\,[A(R)]$

$F_v = \frac{0.75}{\sqrt{3}}F_y$

Allowable shear (Single) $= \frac{0.75}{\sqrt{3}}F_y[A(R)]$

TABLE 27

STAINLESS STEEL - Alloy Groups 1, 2 and 3, Condition CW

Nominal Thread Diameter & Thread/Inch	D Nominal Thread Diameter (Inch)	K Basic Minor Diameter (Inch)	A(R) Thread Root Area (Sq. In.)	Allowable Tension (Pounds)	Allowable Shear		Bearing (Pounds)			Minimum Material Thickness to Equal Tensile Capacity of Fastener (In.)		
					Single (Pounds)	Double (Pounds)	1/8" St. A36	1/8" Al. 6063-T5	1/8" Al. 6063-T6	A36	6063-T5	6063-T6
#6-20	0.1380	0.0997	0.0078	312	180	360	1201	278	414	0.112	0.240	0.174
#8-18	0.1640	0.1257	0.0124	496	286	573	1427	328	492	0.147	0.329	0.235
#10-16	0.1900	0.1389	0.0152	608	351	702	1653	380	570	0.153	0.328	0.238
#12-14	0.2160	0.1649	0.0214	856	494	988	1879	432	648	0.182	0.403	0.289
1/4-14	0.2500	0.1887	0.0280	1120	647	1293	2175	500	750	0.205	0.449	0.323
5/16-12	0.3125	0.2443	0.0469	1876	1083	2166	2719	625	938	0.260	0.627	0.416
3/8-12	0.3750	0.2983	0.0699	2796	1614	3229	3262	750	1125	0.313	0.763	0.505

F_u (Minimum Ultimate Tensile Strength) 100,000 psi
F_y (Minimum Tensile Yield Strength) 65,000 psi

$A(R) = 7854K^2$

Where: $A(R)$ = Thread Root Area, sq. in.
K = Basic Minor Diameter, in.

$F_t = 0.40F_u$

Allowable tension $= 0.40F_u\,[A(R)]$

$F_v = \frac{0.40}{\sqrt{3}}F_u$

Allowable shear (Single) $= \frac{0.40}{\sqrt{3}}F_u[A(R)]$

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RAM Advanse

Analysis Results

Reactions

	Forces [Lb]			Moments [Lb*ft]		
Node	FX	FY	FZ	MX	MY	
Condition lc1=dl+sl						
1	1412.20100	940.77760	0.00000	0.00000	0.00000	0.0
2	-1412.20100	940.77760	0.00000	0.00000	0.00000	0.0
SUM	0.00000	1881.55520	0.00000	0.00000	0.00000	0.0
Condition lc2=dl+wl						
1	-325.32526	-260.85320	0.00000	0.00000	0.00000	0.0
2	325.32526	-260.85320	0.00000	0.00000	0.00000	0.0
SUM	0.00000	-521.70640	0.00000	0.00000	0.00000	0.0

Points of interest and inflection points in members

CONDITION : lc1=dl+sl

			Plane 1-2		Plane 1-3		
Station	Dist to J [ft]	Axial [Lb]	Shear V2 [Lb]	M33 [Lb*ft]	Shear V3 [Lb]	M22 [Lb*ft]	Torsion [Lb*ft]
MEMBER 1							
0%	0.000	-1637.231	-445.923	0.000	0.000	0.000	0.000
50%	3.360	-1488.481	0.327	749.682	0.000	0.000	0.000
100%	6.720	-1339.731	446.577	0.000	0.000	0.000	0.000
MEMBER 2							
0%	0.000	-1637.231	-445.923	0.000	0.000	0.000	0.000
50%	3.360	-1488.481	0.327	749.682	0.000	0.000	0.000
100%	6.720	-1339.731	446.577	0.000	0.000	0.000	0.000

CONDITION : lc2=dl+wl

			Plane 1-2		Plane 1-3		
Station	Dist to J [ft]	Axial [Lb]	Shear V2 [Lb]	M33 [Lb*ft]	Shear V3 [Lb]	M22 [Lb*ft]	Torsion [Lb*ft]
MEMBER 1							
0%	0.000	391.120	144.590	0.000	0.000	0.000	0.000
50%	3.360	412.370	0.025	-242.863	0.000	0.000	0.000
100%	6.720	433.620	-144.540	0.000	0.000	0.000	0.000
MEMBER 2							
0%	0.000	391.120	144.590	0.000	0.000	0.000	0.000
50%	3.360	412.370	0.025	-242.863	0.000	0.000	0.000
100%	6.720	433.620	-144.540	0.000	0.000	0.000	0.000

Maximum relative deflections

CONDITION lc1=dl+sl

Member	Defl. (2) [in]	@(%)	Defl. (3) [in]	@(%)
1	0.17355 (L/465)	50.00000	0.00000 (< L/10000)	0.00000
2	0.17355 (L/465)	50.00000	0.00000 (< L/10000)	0.00000

CONDITION lc2=dl+wl

Member	Defl. (2) [in]	@(%)	Defl. (3) [in]	@(%)
1	0.05622 (L/1434)	50.00000	0.00000 (< L/10000)	0.00000
2	0.05622 (L/1434)	50.00000	0.00000 (< L/10000)	0.00000

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Project: MARK SPENCER HOTEL
Client: DEA MOR
Proj. No.: 04-770
Date: DECEMBER 04 By: SAE
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Low-Cost
Solar Array Project

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Proposed Method for Determining the Thickness of Glass in Solar Collector Panels

Donald M. Moore

March 1, 1980

Prepared for
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by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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DETERMINE ALLOWABLE STRESS

Determine the breaking stress, σ_B, corresponding to each of the loading conditions identified in step A1. The breaking stress is a function of acceptable failure rate, surface area of the plate, load duration, and degree of temper of the glass (i.e., annealed, semi-tempered, tempered). The breaking stress, σ_B, is obtained from Equation 11.

$$\sigma_B = (f_A)(f_T)\sigma_{11} \tag{11}$$

where

σ_{11} = breaking strength of glass for 1-square-meter samples subjected to a load of 1 minute total duration. This strength is a function of the failure rate and glass type and is obtained from Figure 12.

f_A = fraction of σ_{11} for a plate area other than 1 square meter (obtained from Equation 7 or Figure 10).

f_T = fraction of σ_{11} for a load duration other than 1 minute for various glass tempers (obtained from Figure 9).

These quantities are determined as follows:

(1) The designer must specify the acceptable failure rate. This should be based on economic considerations; that is, the failure rate which produces the minimum life-cycle cost for a given application should be used.

(2) From Figure 12 obtain σ_{11}, the breaking strength for the specified glass type for a 1-square-meter sample subjected to a load of 1-minute total duration corresponding to the failure rate chosen in step (1) above.

(3) The fraction of σ_{11} for a plate area other than 1 square meter may be taken from Figure 10 or Equation 7, which may be rewritten as follows:

$$f_A = \left(\frac{1}{a \times b}\right)^{1/6} \qquad = \left(\frac{1550}{A \times B}\right)^{1/6} \quad \text{... } A \,\&\, B \text{ in inches}$$

where

a = length of plate in meters

b = width of plate in meters

(4) Next, the designer must estimate the total duration of the loading conditions delineated in step A1. Assume that the design life of a photovoltaic solar panel installation is usually 20 years, and with the exception of deadweight and thermal loads, the loading conditions specified in step A1 are expected to occur only once during that period. For these assumptions the following ranges of total load duration may be recommended for the various types of loads.

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Load	Total Load Duration for 20-Year Period	
Wind	1 min - 15 min	1.00 - 0.94
Earthquake	15 sec - 5 min	[illegible]
Snow	12 hr - 3 days	[illegible]
Deadweight	20 yr	[illegible]
Thermal	2 yr - 7 yr	[illegible]

(5) Using Figure 9 and the above load durations, determine the fraction of σ_{11} for total load durations other than 1 minute, depending on whether annealed, semi-tempered (i.e., heat strengthened) or tempered glass is being specified for the installation being analyzed. As previously mentioned, this analysis assumes that the glass surfaces are in good condition and have not been subjected to damage or "bruising" such as would be caused by mishandling, hail, impact by rocks, or sandstorms. The designer may interject a degree of conservatism here to cover these possibilities by using load durations as long as or longer than the higher end of the recommended range. Construct a table of load type versus fraction of 1-minute breaking strength as shown:

Load	f_T
Wind	f_W
Earthquake	f_E
Snow	f_S
Deadweight	f_D
Thermal	f_T

(6) Using Equation 11 and the values of σ_{11}, f_A and f_T obtained from steps C2, C3, and C5, respectively, the following table of load type versus breakage stress may be constructed:

Load	Breakage Stress	
Wind	σ_{BW}	[illegible] 15.45 [illegible]
Earthquake	σ_{BE}	
Snow	σ_{BS}	[illegible]
Deadweight	σ_{BD}	15.94 [illegible]
Thermal	σ_{BT}	

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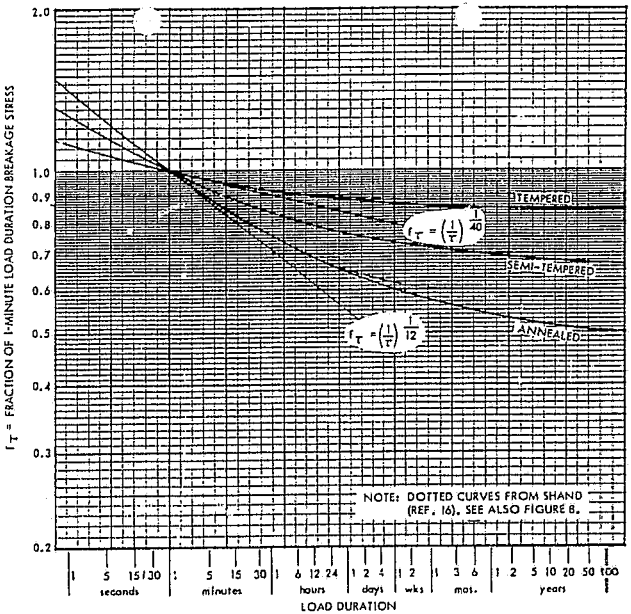

Figure 9. Fraction of 1-Minute Load Duration Glass Breakage Stress versus Load Duration

For the purpose of the design method presented herein, it is expedient to define the fraction, f_A, which is the fraction of the breaking stress of a 1-square-meter plate which will be attained by a plate of area A if both plates break 1 minute after the sudden application of the full load. From Equation 5 the fraction f_A may be expressed mathematically as

$$f_A = \left(\frac{1}{A}\right)^{\frac{1}{6}} \tag{7}$$

where

f_A = fraction of the breaking stress of a 1 square meter plate which will be attained by a plate of area A

A = area of plate for which breaking stress is unknown (expressed in square meters)

Equation 7 is plotted on Figure 10.

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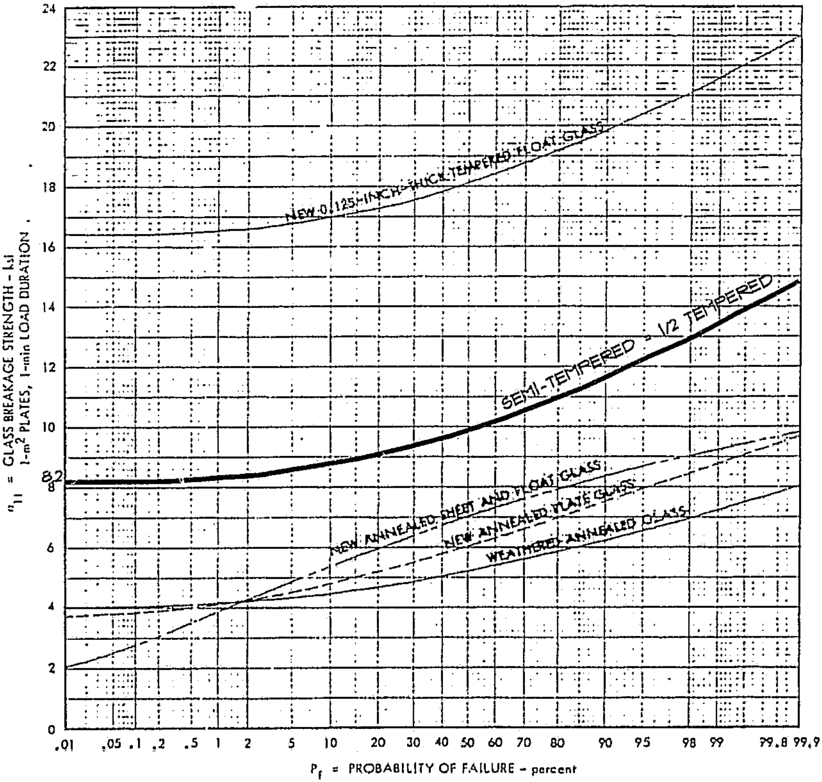

Figure 12. Recommended Design Values for Breakage Strength versus Probability of Failure for 1 m^2, Simply Supported, Glass Plates Subjected to a Uniform Normal Pressure Load of 1-Minute Duration

DETERMIN[illegible] MAXIMUM APP[illegible]IED STRESS

Modify the table of loads from step A1 to obtain the pressures borne by the glass layer being analyzed:

Load Description	Pressure
Wind	p'_W
Earthquake	p'_E
Snow	p'_S
Deadweight	p'_D
Thermal	(Tensile stress in glass obtained from other analysis)

B. ESTIMATE THE STRESSES

Now determine the stress levels corresponding to each of the above loading conditions.

(1) Assume a glass thickness, t.

(2) Calculate the "Load Intensity Factor" (LIF) corresponding to each of the above loading conditions. The dimensionless LIF is a function of the loading, and the geometry and material properties of the plate as follows:

$$LIF = \frac{pb^4}{Dt} \qquad [illegible] \qquad (2)$$

where

p = uniform normal pressure psi

b = width of plate

t = thickness of plate

D = flexural rigidity of plate

$$= \frac{Et^3}{12(1-\nu^2)} \qquad = [illegible]$$

E = Young's modulus of plate (use 10,000,000 lb/in^2 for glass)

ν = Poisson's ratio of plate (use 0.22 for glass)

(3) From Figure 7 determine the "Stress Intensity Factor" (SIF) corresponding to the Load Intensity Factor (LIF) for each of the loading conditions of step A1. Note that the SIF is a dimensionless quantity related to the maximum positive princi[illegible] in the plate

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The *maximum value may* occur in either the center of the plate or the corner of the plate depending on the intensity of the loading.

(4) The maximum positive principal stress corresponding to each of the loading conditions is now calculated from the equation

$$\sigma = SIF \frac{D}{b^2 t} \qquad (3)$$

(5) Now construct a table of stresses corresponding to the various loading conditions

Loading	Stress
Wind	σ_W
Earthquake	σ_E
Snow	σ_S
Deadweight	σ_D
Thermal*	σ_T

C: DETERMINE THE ALLOWABLE STRESS FOR GLASS

The allowable stress for a given loading condition is the breakage stress from Figure 12 taken at an acceptable failure rate and corrected for the surface area of the glass plate being considered and an estimated total load duration for the given loading condition. The allowable stress for a given combined loading condition is the same, except that the allowable stress corresponding to the shortest load duration of the loads being considered is taken as the allowable stress for all loads in the combination. For example, when the combination of wind load (short duration) and deadweight load (long duration) is considered, the breakage load associated with the wind load is applied to the combined loading condition.

*The thermal stress (if any) must be determined from a different analysis than that described in this paper. Thermal stresses will exist in the glass if: 1) The glass panel is rigidly mounted to a material with a different thermal expansion coefficient, 2) the glass panels are subjected to local heating, such as will result when part of the panel is shadowed from the sun, and 3) local heating results from damaged solar cells attaining a back-biased condition. During the summer of 1979 Dave Goodwin of JPL studied the stresses due to local heating effects. A general conclusion of his work is that for the third type of local heating effect, one should expect a stress in the glass of 40 lb/in^2 to 80 lb/in^2 per degr centigrade local temperature gradients in the glass. At this writing, however, no recommendations as to the temperature gradients to be expected are available.

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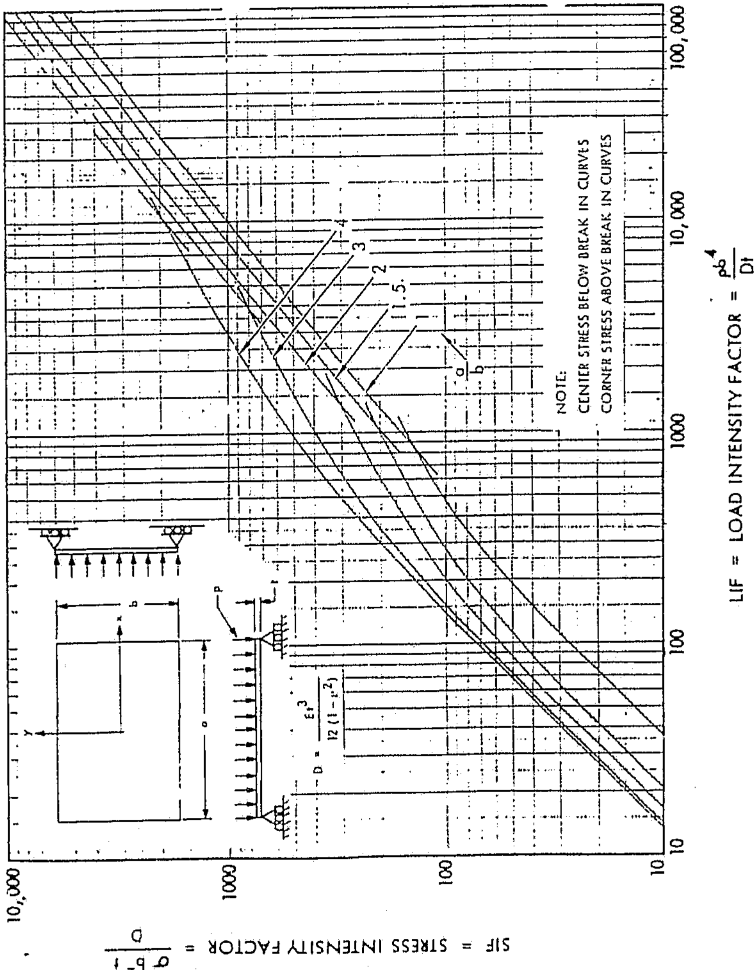

Figure 7. SIF versus LIF Showing Composite Curves of the Larger of the Maximum Positive Principal Stresses on Plate (Center Bottom or Top Surface Near Corner)

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