AIOREMA

A SCULPTURAL MARQUEE FOR PORTLAND CENTER STAGE

CREATED BY
JAMES M HARRISON

-OWNER'S MANUAL-

SEPTEMBER 2006

Aiorema- a sculptural marquee for Portland Center Stage- created by James M Harrison

Background and Introduction

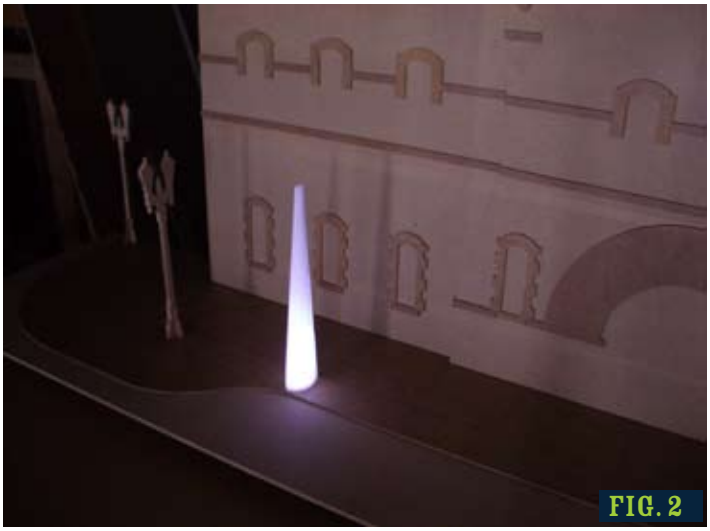
In June of 2006 I was asked to design a sculptural marquee for Portland Center Stage's new theater at the Armory. The opening date was set for the end of September, which meant three short months from start to finish. The brief was simple- produce something bold and iconic that would mark the front entrance of the building- a beacon of sorts.

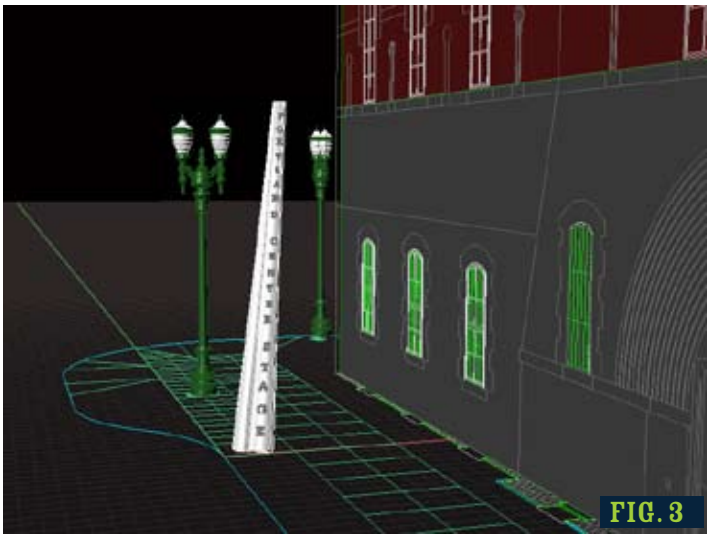
During my initial research I came across a beautiful word in a dictionary of theater terms. ***Aiorema*** was the name for a device used in Ancient Greek theater to transport the gods. This may have meant it was some sort of mobile crane.

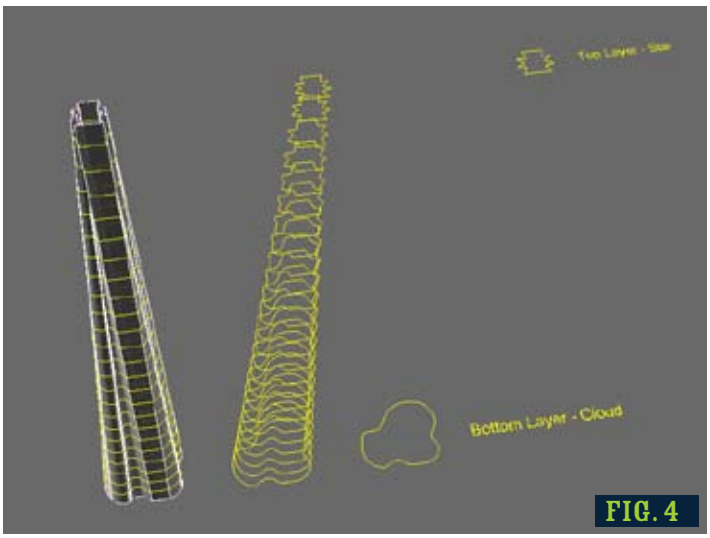
The sculpture is made out of a light diffusing acrylic- stacked for a total of 415 layers of 1/2" thick material. The piece measures 17' 3.5" in height.

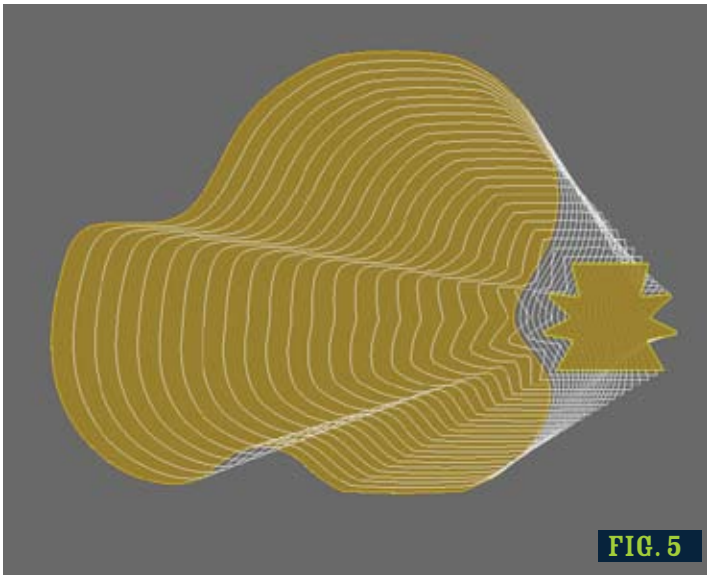
Aiorema is shaped like a cloud at the base, and shaped like a star against the sky. The layers gradually transition from the one shape to the other shape.

The sculpture is 'post-tensioned' on three stainless steel threaded rods, which connect it to the footing.









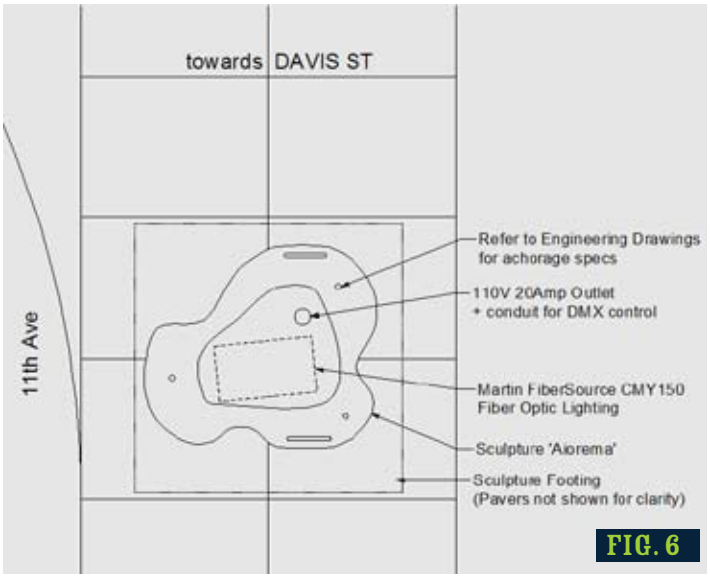


Figure 1- Photo of Armory Building site. Fig 2- Model showing 'light beacon' idea.
Fig 3- first computer rendering of concept. Fig 4- drawing showing how sculpture is built from stacked sections of material. Fig 5- Plan view depicting change from 'cloud' at base to 'star' at top.
Fig 6- Sculpture in relation to sidewalk.


FIG. 7


FIG. 8

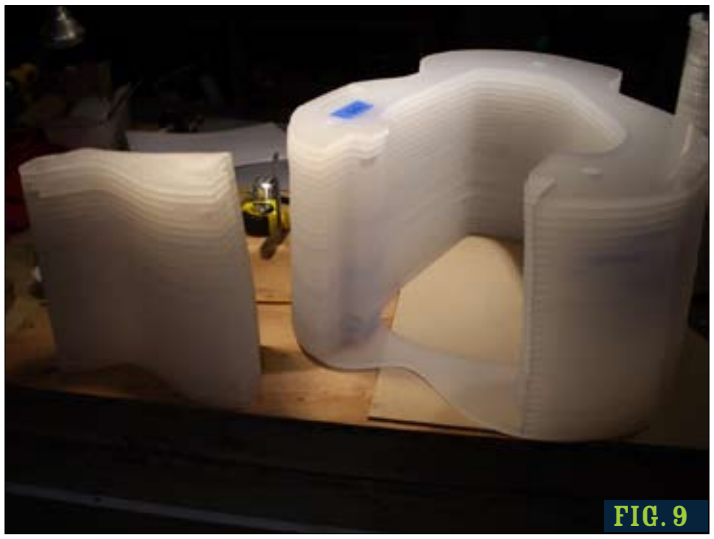


FIG. 9

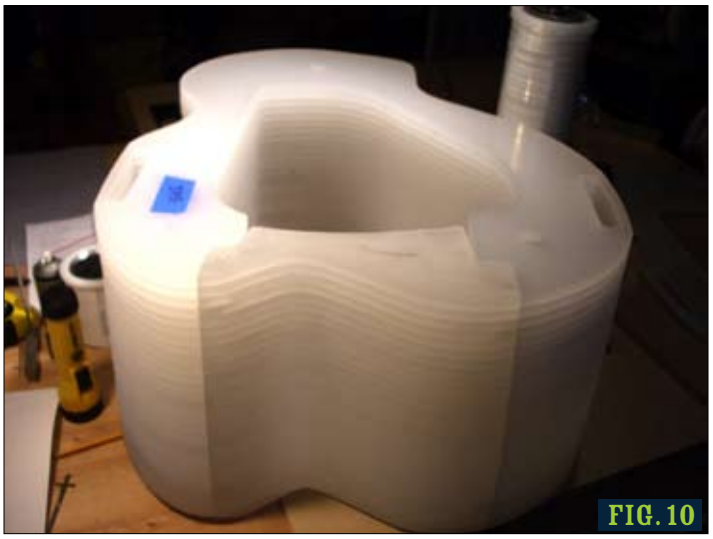


FIG. 10

FIG. 11


FIG. 12

Fabrication and Installation

Figure 7- Water Jet cutter in the process of cutting out layers. A total of 27 sheets of 1/2" thick 4' x 8' acrylic 'Satin Ice' were used- all the scrap was recycled. Fig 8- pieces arriving back at the shop.
Fig 9- Access door layers shown Fig 10- Access door shown in place Fig 11- Detail view of locking bolt for door. Fig 12- Inside face of door, showing location of screws- total of 4 with 1 at each corner.

FIG. 13

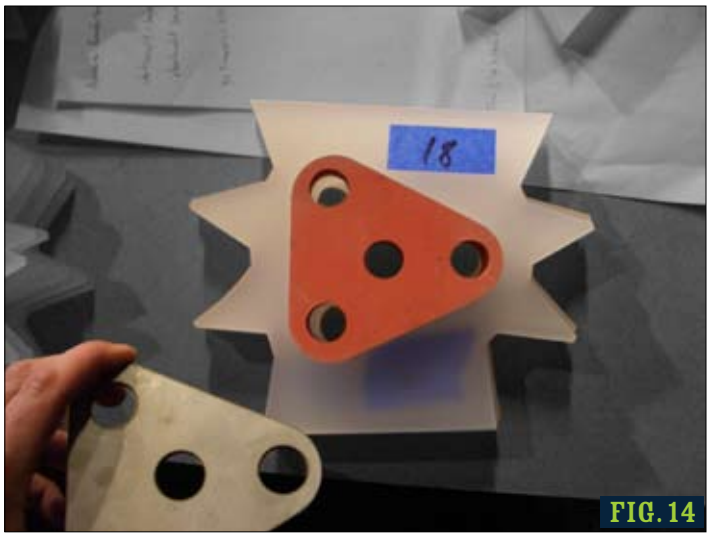


FIG. 14

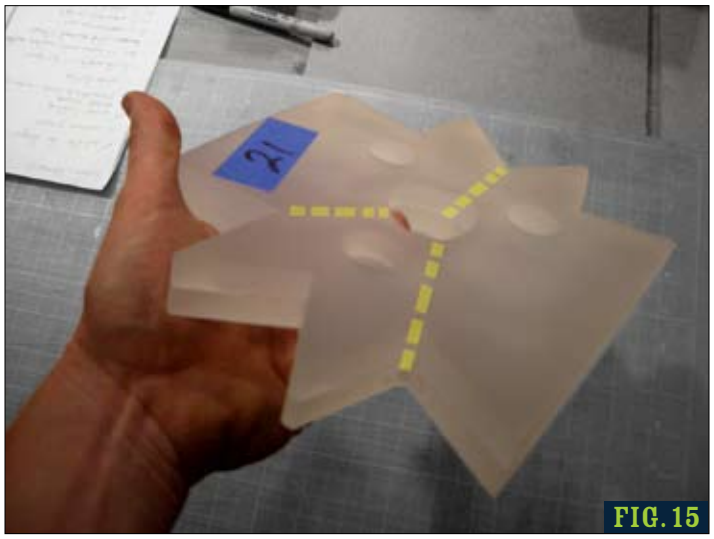


FIG. 15


FIG. 16


FIG. 17


FIG. 18

Fabrication and Installation

Figure 13- 'Readerboards' spelling PORTLAND CENTER STAGE- Waterjet cut ABS plastic glued to Acrylic backing with acrylic solvent cement. Fig 14- layer 18 showing red neoprene 'gasket' designed to take expansion and contraction of sculpture, stainless steel 'washer' also shown. Fig 15- 'Vent Holes' shown dotted at layer 21. Fig 16- First layer of sculpture being lowered into position Fig 17- overhead view showing layers, stainless steel threaded rod, and readerboards under assembly. Fig 18- 1st third of sculpture completed, showing assembly method.


FIG. 19


FIG. 20


FIG. 21

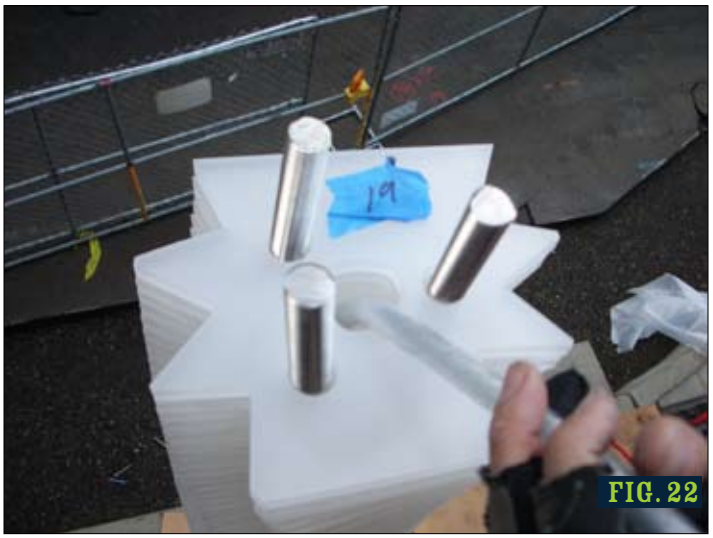


FIG. 22


FIG. 23

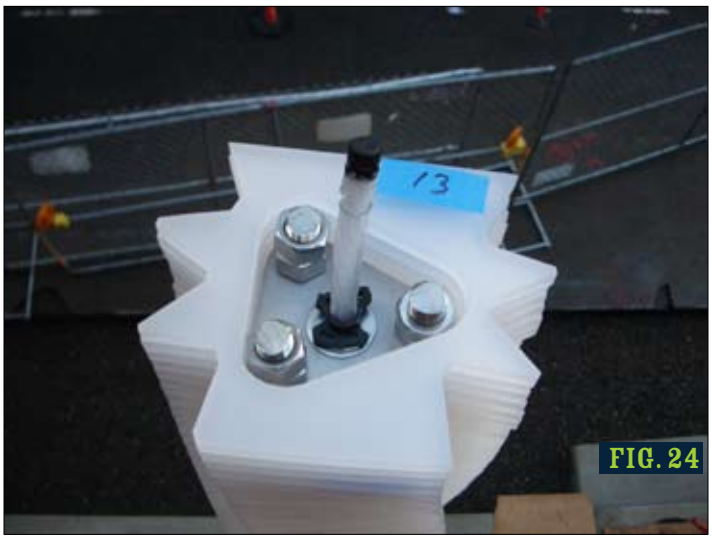


FIG. 24

Fabrication and Installation

Figure 19- view looking down into sculpture 'cavity'- prior to installation of fiber optic rope lighting and light fixture Fig 20- construction just past the half way point. Fig 21- sculpture nearing completion.
Fig 22-layer 19, showing termination of threqaded rods and rope lighting. Fig 23- layer 19 with neoprene gasket, stainless steel washer, double nuts, and single strand of rope lighting passing thru. Fig 24- layer 13 showing 'pocket' for structure and termination of rope lighting with black mirror end cap. The final 12 layers mark the uppper terminus of the sculpture and enclose all internal structure.

Lighting- Martin Fibersource CMY150

General Product description from the manufacturer's website:
(For further information contact www.martin.com)

"The FiberSource CMY150 is an automated 150-watt color-changing luminaire for illuminating fiber optic cables in permanent installations. It features seamless CMY color mixing and full-range continuous dimming.

The new Martin FiberSource CMY 150 is a professional fiber illuminator for permanent outdoor and indoor installations. Full CMY color mixing and unprecedented brightness combine to create new design possibilities for fiber applications. Intended for permanent installations, the FiberSource CMY 150 is designed around a robust IP44 rated housing. It is based on a very efficient 150 W lamp giving 6000 hours of lamp life.

The FiberSource CMY 150 features an extremely broad color spectrum achievable from a full CMY color mixing system. Additionally, a full range dimmer gives the user an added effect dimension.

The large fiber port accepts up to 800 pieces of 1mm fiber optic cable. The fixture features DMX control and a very comprehensive stand-alone operation including real-time clock activation."

MARTIN FIBERSOURCE CMY150

FOR WARRANTY AND MAINTENANCE ISSUES, CONTACT CASCADE LIGHTING:

Cascade Lighting Representatives

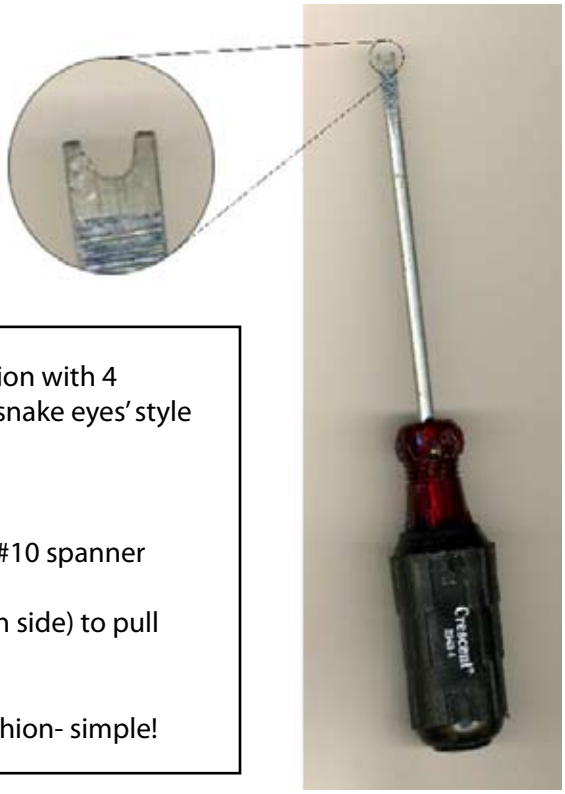
Mike Moyer

400 NE 11th Avenue
Portland OR 97232
503-242-2522x6208

vo: 503-445-6208
fx: 503-274-5407
cell: 503-969-3449

mmoyer@cascadelight.com

How to Access Lighting- via removeable door



The access door is held in position with 4 machine screws - #10 spanner 'snake eyes' style security head.

To remove door:
-first remove each screw using #10 spanner screwdriver
-use 2 dental picks (one on each side) to pull out door at bottom

Reinstall the door in reverse fashion- simple!

Primary Material- Cyro Acrylite Satin Ice

‘‘ACRYLITE® Satin Ice acrylic sheet has a frosted appearance throughout the entire sheet straight to the edge that offers excellent light diffusion for indoor or outdoor lit displays, panels and store fixtures. Its surface hides fingerprints and scratches for enhanced service life.” From the manufacturer’s website. For further information visit www.cyro.com

Precedent: At the Georgia World Congress Center in Atlanta,Georgia, thirteen 28 ft high custom pylons made from ACRYLITE Satin Ice sheet run the length of the building, illuminating the front walkway. I spoke with the facilities supervisor before specifying this material for Aiorema. He informed me they have had no issues with the material in the ten years it has been in place.

IPS Weld-On #16 Acrylic Solvent Cement was used to bond each layer together. For technical data go to www.ipscorp.com

LOCAL SUPPLIER:

GE Polymershapes

Susan Ainsworth Smith
Inside Sales

West Region
6212 N.E. 78th Ct., Ste. C, Portland, OR 97218
503 255-5288, 866 437-7427, Fax: 503 255-5256
susan.ainsworth@gep.ge.com
www.gepolymershapes.com

catena consulting engineers

July 24, 2006 ⚠ August 8, 2006

James Harrison
3155 NE 73rd Avenue
Portland, OR 97213

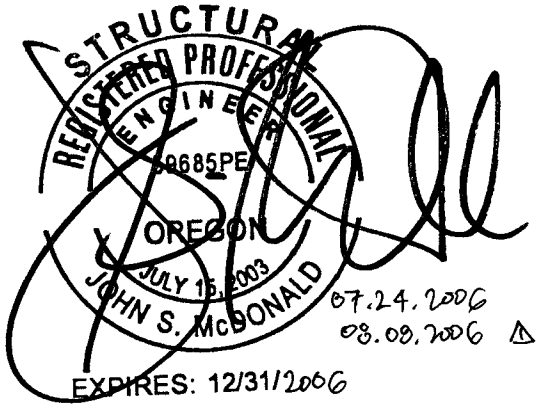
RE: Aiorema – Portland Center Stage: Portland, OR
Project Number: 2006081.00

James:

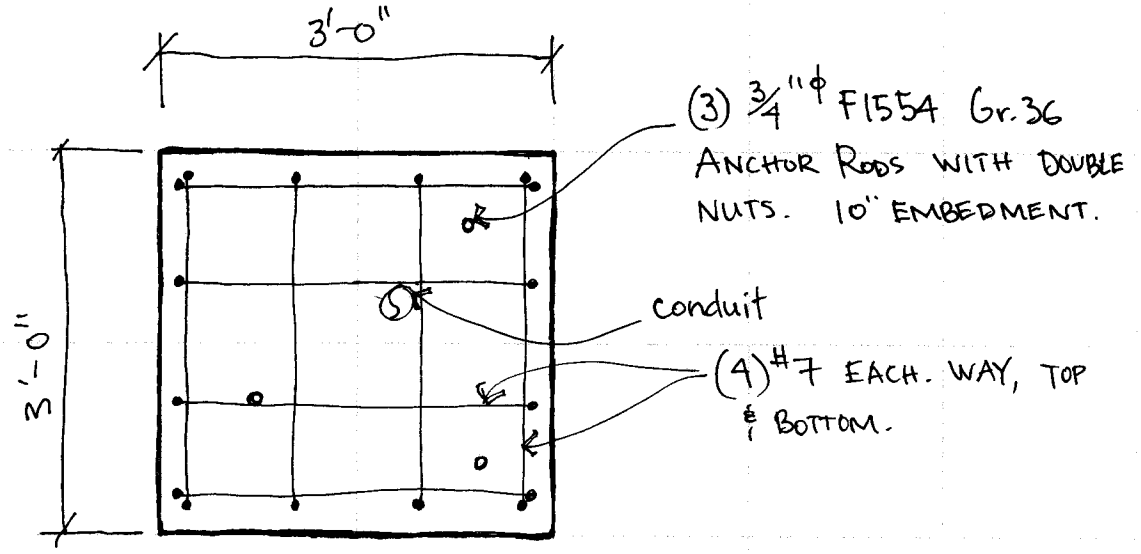
The attached calculations, pages 1-4, verify the adequacy of the footing for the Aiorema sculpture located in Portland, OR in meeting the requirements of the 2004 Oregon Structural Specialty Code. The scope of work is shown on the attached detail sheet dated ~~July 24~~, 2006 (S1). August 2, ⚠

Respectfully,

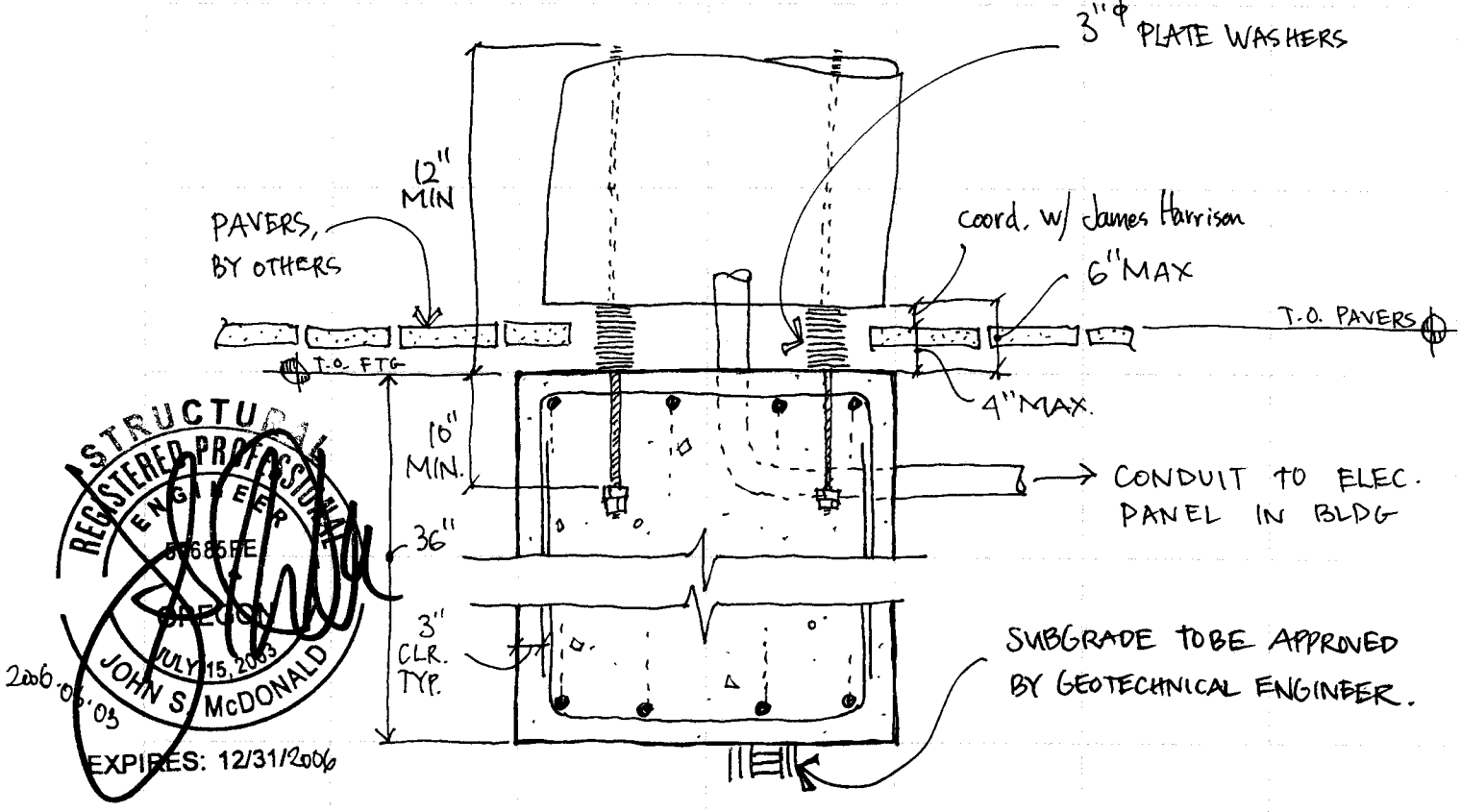
catena consulting engineers



John S. McDonald, S.E.

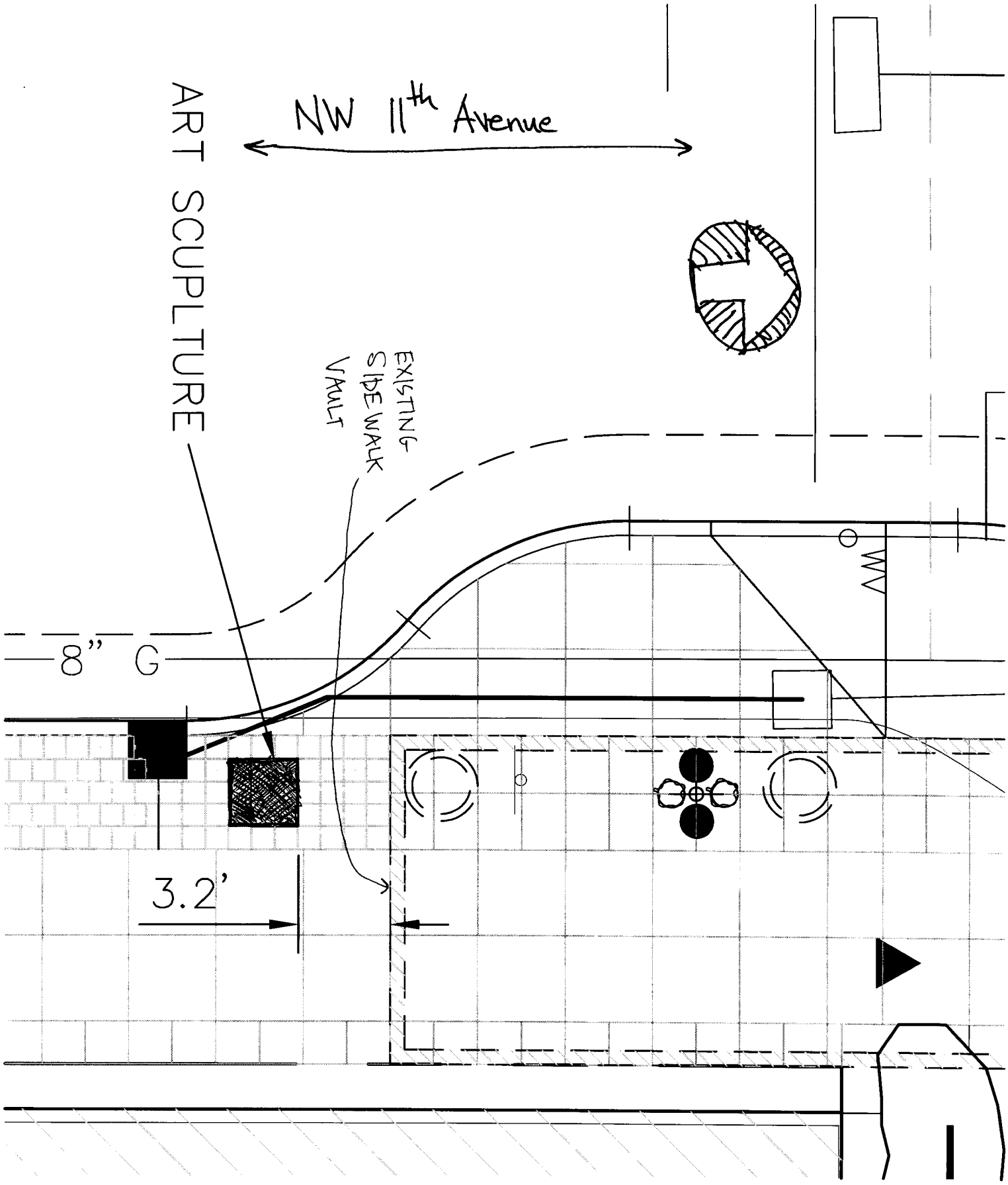


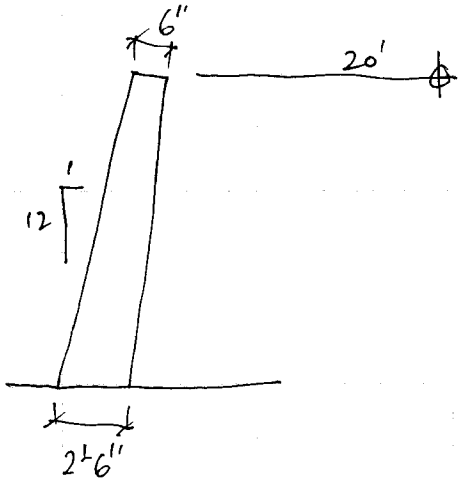
FOOTING: PLAN VIEW

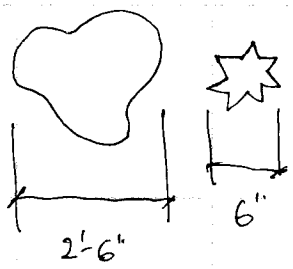


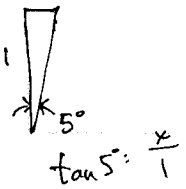
STRUCTURAL REGISTERED PROFESSIONAL ENGINEER 17685PE OREGON JULY 15, 2003 JOHN S. McDONALD 2006.08.03 EXPIRES: 12/31/2006

SECTION THRU FOOTING

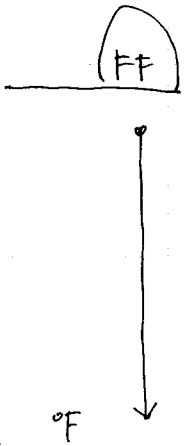

NW 11th Avenue
ART SCUPLTURE
EXISTING SIDEWALK VAULT
8"
G
W
3.2'







Acrylite GP



Density:	74.25 #/FT³
$F_{u\,tension}$	10,000 psi
E:	409,000 psi
$F_{y\,compress}$	18,000 psi
F_v:	9,000 psi
α:	0.00004 in/in °F

EARTHQUAKE

W_T: $\left(\frac{2.5+.5}{2}\right)^2 \frac{\pi}{4} (20') \, 74.25 \#/FT^3$

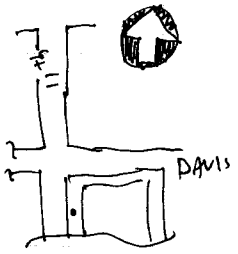
: 2,600 #

Lat: 45° 31' 29.11" N

Long: 122° 40' 55.5" W

45.5242

122.6821



S_s = 0.984 g

S_1 = 0.345 g

WIND DESIGN

2004 OSSC

§ 1609.1.1

Exception 6.

$P = C_e C_q q_s I_w$ – 80 mph Exp. B

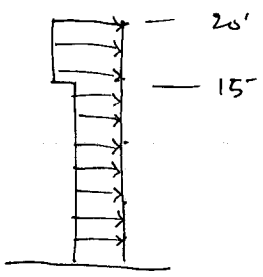
= 0.67(1.4)16.4

: 15.4 psf

= 0.62(1.4)16.4

: 14.2 psf

2/3 of this for cylindrical



Wind Base Shear:

: 15.4 psf $\left(\frac{25+5}{2}\right)$ 20'

: 462 #

V = 0.29W

= 900 #

catena consulting engineers

Project Number:	**2006081**	**Page/of:**	2
Project:	**Aiorema**	**By:**	JSM
Subject:	**Portland Center Stage Sculpture**	**Date:**	Friday, July 21, 2006

2003 IBC Equivalent Lateral Force Procedure Base Shear & Vertical Force Distribution

Per ASCE 7-02 as ammended by 2003 IBC

Occupancy Category (Table 1604.5) = I. Low Hazard to Human Life if Fail → Seismic Importance Factor, I_E = 1; Seismic Use Group = I

Site Class (Table 1615.1.1) = D → Stiff soil profile = D

from ICC provided CD: S_S = 98.4 g% → Site Coefficient for S_s, F_a = 1.11

(MCE Spectral Response Acceleration @ 0.2-second Period)

Site Coefficient for S_1, F_v = 1.71

from ICC provided CD: S_1 = 34.5 g%

(MCE Spectral Response Acceleration @ 1.0-second Period)

Modified Short Period Acceleration, $S_{MS} = F_a * S_s$ = 1.089

Modified 1 sec. Period Acceleration, $S_{M1} = F_v * S_1$ = 0.590

$2/3 * S_{MS} = S_{DS}$ = 0.726 g

Seismic Design Category per S_{DS} = D

$2/3 * S_{M1} = S_{D1}$ = 0.393 g

Seismic Design Category per S_{D1} = D

Seismic Design Category per S_{DS} & S_{D1} = D

(Table 9.5.5.3.1) Coefficient, C_U = 1.40

Basic Resisting System = Inverted Pendulum System → Response Modification Coefficient = 2 1/2 ..... R

System Overstrength Factor = 2 ..... Ωo

Lateral Resisting Elements (Table 1617.6.2) = Cantilever column systems

Deflection Amplification Factor = 2 1/2 ..... Cd

Numerical Coefficient, C_T = 0.02

Numerical Coefficient, x = 0.75

Structure Height, h_n (ft) = 20

Structure Height Limit (ft) = [redacted]

Approximate Fundamental Period, Ta = 0.19 Second(s)

Period per Substantiated Analysis, T ≤ 0.26 Second(s)

Design Period, T = 0.19 Second(s)

Formula (9.5.5.2.1-1) = $S_{DS} / (R/I)\ W$ = 0.290 W

... but not greater than:

Formula (9.5.5.2.1-2) = $S_{D1} / T / (R/I)\ W$ = 0.832 W

... and of course, not less than:

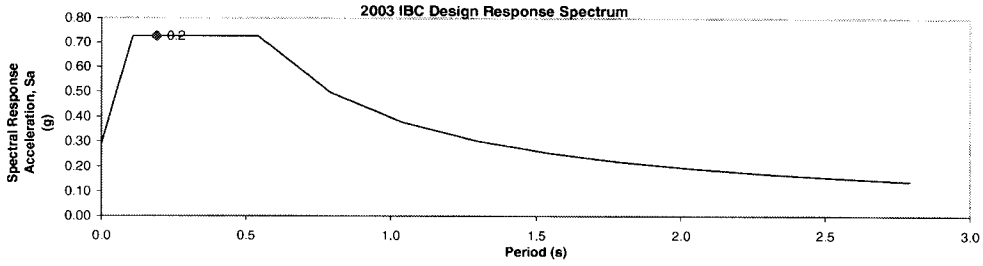
Formula (9.5.5.2.1-3) = $0.044\ S_{DS}\ I\ W$ = 0.032 W

(9.5.5.2.1-1) need not exceed (9.5.5.2.1-2) and shall not be less than (9.5.5.2.1-3) → ***DESIGN BASE SHEAR*** = **0.290 W** (E_h)

... using allowable stress design:

Section 1605.3.2 → ***TOTAL DESIGN BASE SHEAR*** = **0.207 W** ($E_h/1.4$)

Structure Weight, W (kips) = 3 → ***DESIGN BASE SHEAR*** = **0.9 kips**



Geotechnical Info

2a

John McDonald

From: Dan Trisler [dtrisler@geodesigninc.com]
Sent: Friday, July 21, 2006 12:08 PM
To: John McDonald
Cc: James Harrison
Subject: RE: Foundation Design Information

John -

The information looks correct, though you can use a passive resistance of 250 pcf.

- Dan

From: John McDonald [mailto:john@catenaengineers.com]
Sent: Friday, July 21, 2006 12:03 PM
To: Dan Trisler
Cc: 'James Harrison'
Subject: Foundation Design Information

Dan:

This is to summarize and formalize our phone conversation yesterday regarding the foundation design criteria for the sculpture on the sidewalk outside of the Portland Center Stage project.

Dead + Live load allowable bearing pressure: 2,500 psf
Increase for wind and earthquake (*1.33): 3,333psf
Coefficient of friction to resist sliding: 0.35
Active pressure: 45 pcf
Passive pressure: 200 pcf

The bottom of the sculpture footing should be located 3 feet below top of finished sidewalk.

Please confirm/comment/correct at your earliest convenience.
Thanks Dan, feel free to call me with any questions.

John S. McDonald

catena consulting engineers
1111 ne flanders street
suite 206
portland, or 97232

503.467.4980 voice
503.467.4797 fax
503.984.8573 mobile

a connected series of related elements

GEODESIGN INC

Memorandum

To:	Mr. Doug Nelson	From:	Daniel J. Trisler, P.E.
Company:	Portland Family of Funds	Date:	July 25, 2006
Address:	c/o Vickers/Nelson and Associates 1420 NW Lovejoy Street, Suite 416 Portland, Oregon 97209		

REGISTERED PROFESSIONAL ENGINEER 69398 OREGON MARCH 12, 2002 DANIEL J. TRISLER

RENEWAL DATE: 6/30/06

cc:	Mr. John McDonald, Catena Consulting Engineers (via email only) Mr. Dick Kirschbaum, GBD Architects (via email only) Mr. Michael Dutton, KPFF Consulting Engineers (via email only)

GDI Project:	PortFamFun-1-01
RE:	Armory – Portland Center Stage Sculpture Foundation Design Parameters

☐ Urgent ☒ For Review ☐ Please Comment ☐ Please Reply

GeoDesign, Inc. prepared this memorandum to document the design parameters that we verbally provided to Mr. John McDonald for the design of the proposed sculpture foundation. The proposed sculpture will be located off the northwest corner of the building, immediately south of the new stormwater detention tank.

The sculpture may be supported by a spread footing foundation system. The bottom of the footing should be embedded at least 3 feet below the adjacent sidewalk grade. The footing may be sized based on an allowable bearing pressure of 2,500 pounds per square foot. The value applies to the total of dead plus long-term live loads and may be increased by 1/3 for short-term loads, such as those resulting from wind or seismic forces.

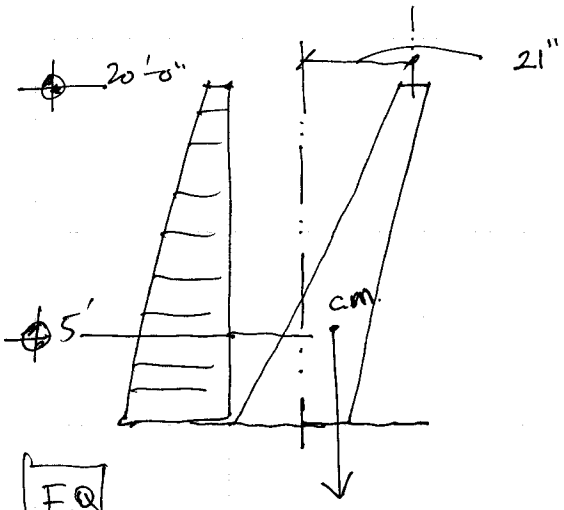
Lateral loads on the footing can be resisted by passive earth pressure of 250 pounds per cubic foot (pcf) acting on the sides of the footing. The upper 12 inch depth of adjacent soil/sidewalk should not be considered when calculating passive resistance. A coefficient of friction equal to 0.35 may also be used when calculating resistance to sliding. If needed, an active earth pressure of 45 pcf should be used for design of unbalanced soil forces.

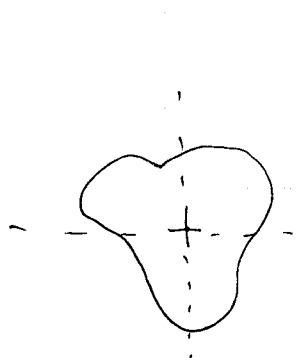
Should you have questions, please feel free to contact us.

DJT:SVM:sms

One copy submitted

Document ID: PortFamFun-1-01-072506-geom-sculpture.doc





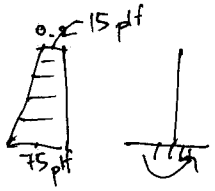
$\tan 5° = \frac{x}{20'}$

$x = 240 \tan 5°$

$= 20.99$ inches.

EQ

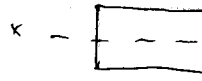
M_{OT}: @ C.M. = $900^{\#} \cdot 5' = 4{,}500$ ft#

distributed: 

M = Same.

SELF

M_{OT}: $3000^{\#}(60" \tan 5°) = 1{,}312$ ft#



$S_x = \frac{3(2'-1")^2}{6} = 2.17$ ft^3

Dead: 3000#

LOAD COMBOS

Footing Allowable: 1605.3.1

$D + 0.7E \rightarrow 3000 + [0.7(4500) + 1312]$

$0.6D \pm 0.7E. \rightarrow 0.6(3000) - [4462]$ (4462 = 4500 + 1312)

$\frac{P}{A} + \frac{M}{S}$:

Assume 3'x3' ftg: $A = 9$ ft^2, $S = 4.5$ ft^2

$\frac{3000}{9} + \frac{4462}{4.5}$: 1,325 psf

$\frac{0.6(3000)}{9}$ ↓ : −791 psf ∴ uplift...

consider ftg weight.

~~3x3x3~~ @ 150 #/ft^3 = 4050#

~~$0.6(3000 + 4050) - 992$~~

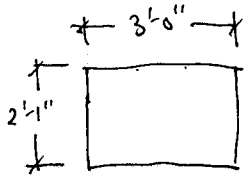
~~$4230 - 992 = 3238$~~ ✓ ok.

2'-1" x 3'-0" x 3'-0" @ 150 pcf : 2812#

$0.6(3 + 2.8) - 0.99 = 2{,}495$ ok

$\frac{3000}{9} + \frac{4462}{2.17}$: 2500 psf

$\frac{0.6(3000 + 2812)}{6} - \frac{4462}{2.17}$: −1475 psf

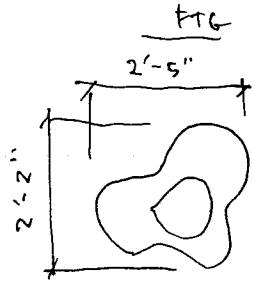


thickness = 36"

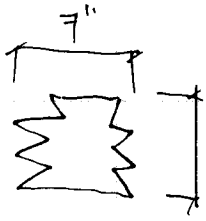
$A = 6.25\ ft^2$

$S_{weak} = \frac{3(2)^2}{6} = 4.5\ ft^3$

self wt ftg: $3 \cdot 3 \cdot \frac{3}{2}(150) = 4050\ \#$



$A \simeq 4.12\ ft^2 - 1.67\ ft^2 = 2.45\ ft^2$ at base



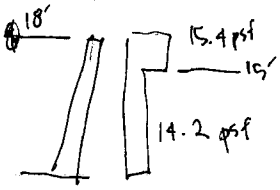
$A \simeq 42\ in^2 = 0.29\ ft^2$

BASE TOP

height = 18' → $\left(\frac{2.45 + 0.29}{2}\right) 18 \left(74.25\ \#/FT^3\right)$: 1835 # ← self weight

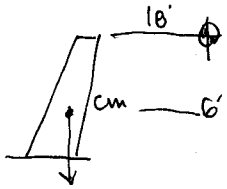
V = 0.29W : 532 # ← EQ

Wind:



$15.4\ psf \left(\frac{2.5' + 7/12}{2}\right) 18 = 427\ \#$ Wind governs

FOOTING DESIGN



M_{ot} (eq)

$= 532^{\#}(6') = 3192\ ft\#$

M_{ot} (self)

$: 1835 \left(\frac{6(12)\tan 5^\circ}{12}\right) = 964\ ft\#$ ← SELF INDUCED "LEANING MOMENT"

$D + 0.7E : 1835 + \underbrace{0.7(3192) + 964}_{3198} :$

$0.6D \pm 0.7E : 0.6(1835 + 2812^{ftg}) - 0.7(3192)$

$\frac{P}{A} \pm \frac{M}{S} : \frac{1835}{6.25} + \frac{3198}{2.17} = 1768\ psf : \frac{.06(1835 + 4050)}{9} - \frac{0.7(3192)}{4.5} : -104 psf$

$2788/6.25 + 3198/2.17$

OK

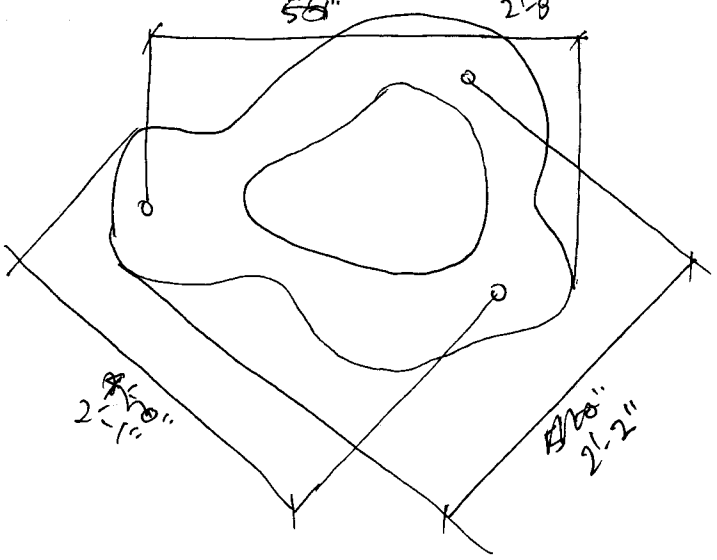
Base Shear: ~~900~~ 532 # ÷ 3 anchors → 300# per Anchor bolt.

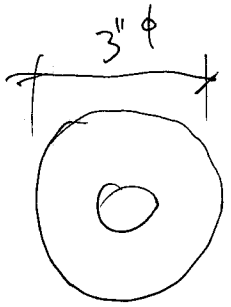
$M_u = 1.2D + 1.0E$

built lean of 5° slf wt ↑ ; Eq ↑

$= 1.2(\text{~~1,312~~ } 964 \text{ ft-#}) + 1.0(\text{~~3500~~ } 3192) = \text{~~6075~~ } 4349 \text{ ft-#s}$

$= \text{~~72.9~~ } 52.2 \text{ in-kips}$





Area = 7.1 in²

Using (3) 3/4" ϕ A36 threaded rods,

limit tension to $0.5F_y = 18$ ksi → 18ksi(0.441in²) = 7.9 kips → limit to 6 kips → 13.58 ksi

$\phi M_n = \phi T_{all}\left(d - \frac{a}{2}\right)$

$a = \frac{T_{all}}{C_{all}\, b} = \frac{\text{~~18~~ } 13.58(0.44)}{0.75(18)} = \text{~~1.33~~ } 0.\text{~~88~~}$ in ; $a = \frac{A_s f_y}{0.85 f'_c b}$; $a = \frac{6^k}{}$

↑ compressive strength of acrylic.

$\phi M_n = \phi\, 18(0.44)\left(\frac{25"}{\text{~~48~~}\ 11"} - \frac{0.587}{2}\right)$

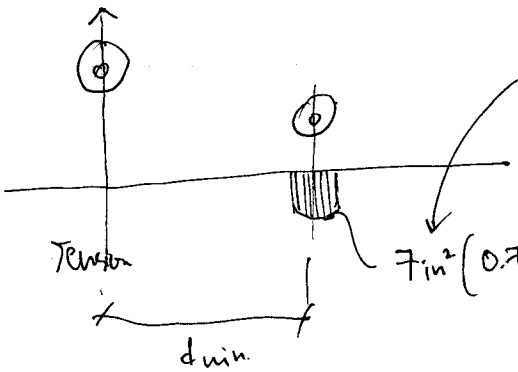
$= \phi\ \text{~~8880~~ } 195 \text{ in-kips} \gg M_u = 72.9 \text{ in-kips}$

$T_{all} = 18(0.44) = \underline{7.92} \text{ kips}$

↓

and is T_{ult} since this is the ~~total~~ demand on anchor.

3"ϕ plate washers, Area = 7 in²



ONE anchor, not 2

f'_c for acrylic

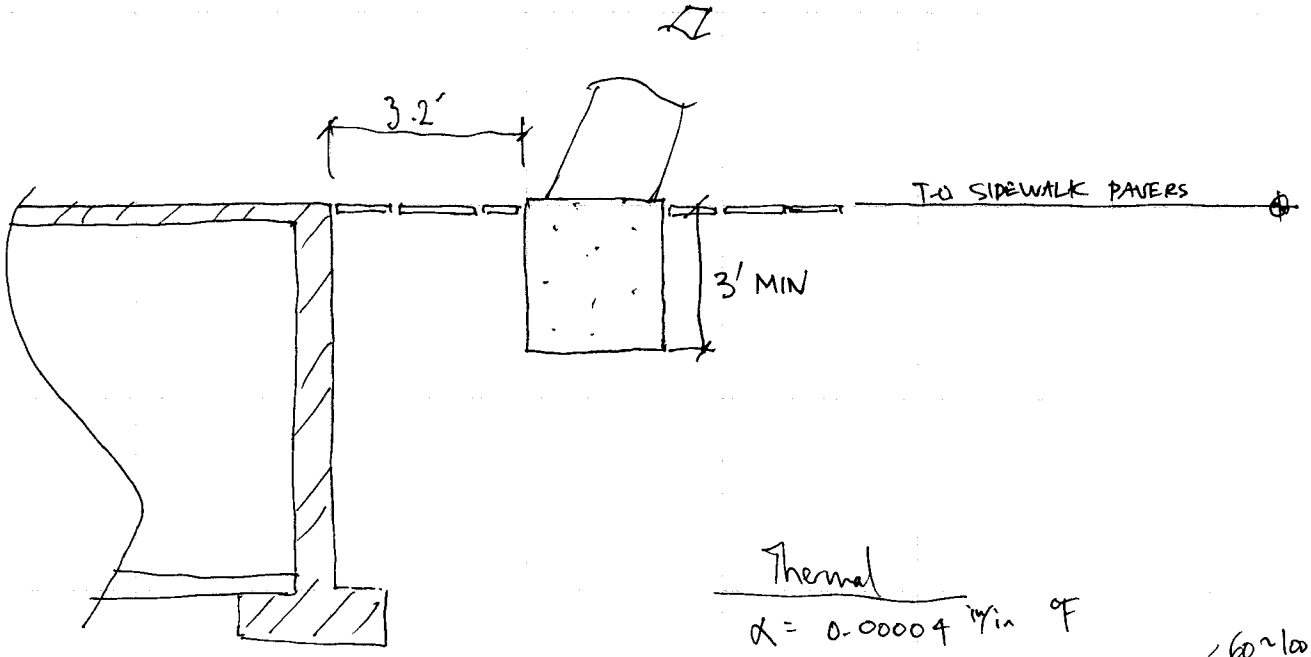
$7\,in^2(0.75)18\,ksi = 94.5\,kips$. use limited T = 6kips

$d_{min} = 17"$

$M_n = Td = 6(17) = 102$ inkips

$\phi M_n = 0.9(102) = 92$ inkips $> M_u = 52.2$ inkips

OK ✓



Thermal

$\alpha = 0.00004$ in/in °F

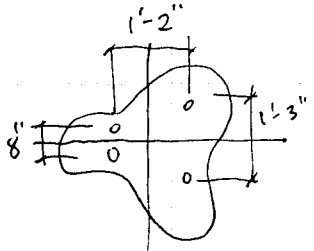
60~100°F

$\Delta L = L\alpha\Delta T$

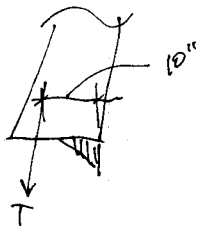
$= 240" (0.00004) 40$

$= 0.384"$

About 4X "expansive" as aluminum.



A.B.: F1554 - Gr.36



0.75 acrylic → ~~0.15~~ 0.165

$\phi M_n = \phi A_s f_y (d - \frac{a}{2})$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{36(0.31)2(\quad)}{0.85(18)\,10"} = 0.14$

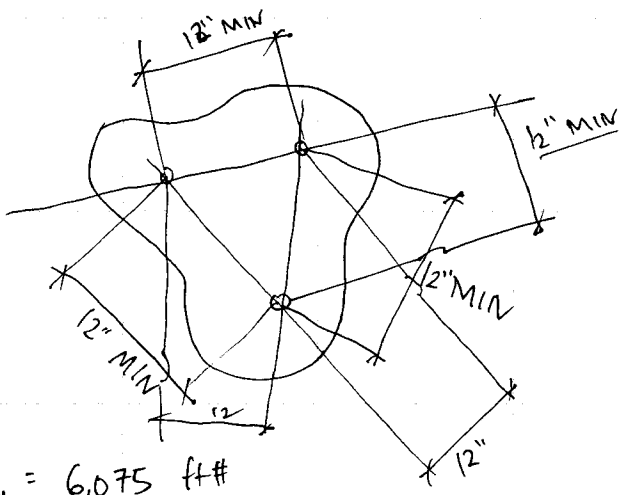
$= \phi 2(36)0.31\left(10 - \frac{0.165}{2}\right) = \phi 221$ inkips.

$F_{y\,\text{compression}} = 18{,}000$ psi

$M_u = 1.2D + 1.0E = 1.2(1312) + 1.0(4500) = 6{,}075$ ft#

$M_u = 72.9$ inkips $< \phi M_n = \phi 221$ inkips

$\phi = 0.7 \rightarrow \phi M_n = 154$ inkips ok.



$M_u = 6{,}075$ ft#

$= 72.9$ inkips

$\phi M_n = \phi A_s f_y \left(d - \frac{a}{2}\right)$

3/4" ϕ Anchor Rod

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(36)\ 0.44\ in^2}{0.85\ (18)\ 10"} = 0.1173"$

$\phi M_n = 0.9(0.44)36\left(12" - \frac{0.1173}{2}\right)$ (0.75)

$= 170$ inkips $>$ 72.9 inkips

Primary Maintenance Instructions

For routine cleaning, gently wash sculpture with Simple Green diluted with water using a rag and bucket.

To remove graffitti or more stubborn dirt- contact the conservator!

Conservator for Aiorema

J. Claire Dean
Dean & Associates Conservation Services
503-331-1972
Fax: 503-331-0762
clairedean@aol.com

Under NO circumstances shoule the sculpture be pressure washed!

In the event I, the artist, am unreachable, I fully trust Claire Dean to make desicions that would affect the aesthetics of the sculpture.

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www.jamesmharrison.com

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