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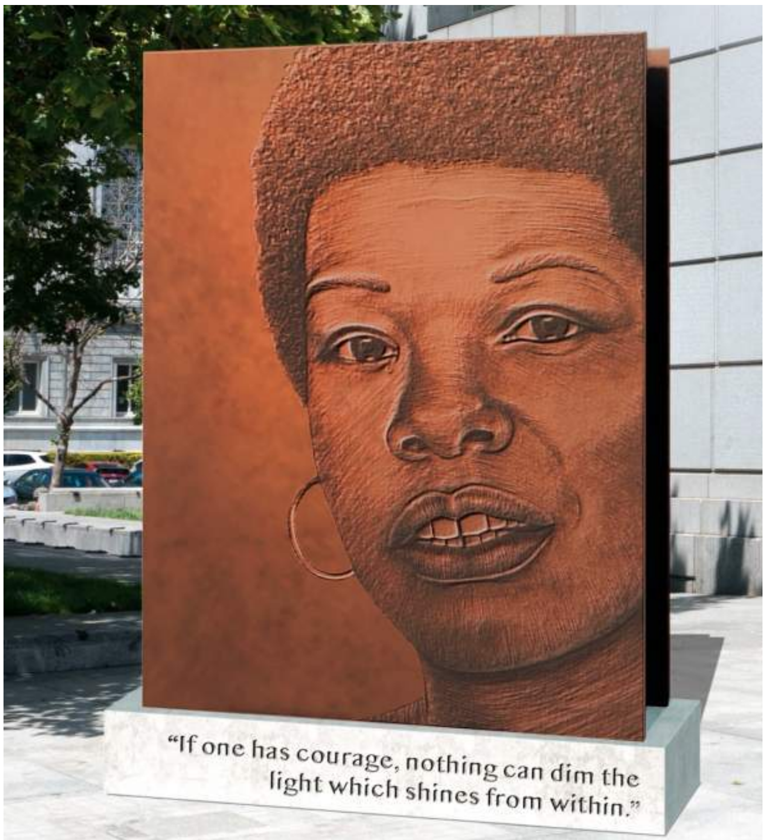
Structural Calculations

Dr. Maya Angelou Sculpture – SF Public Library



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TSE Job No. 2020.180
April 12, 2022

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2020,180 - Maya Angelou Sculpture - Book Check

Structure and Base Parameters

$B_{bronze}=72\ in$ | Length of bronze sculpture.

$w_{bronze}=24\ in$ | Width of bronze sculpture.

$H_{bronze}=96\ in$ | Height of bronze sculpture.

$B_{base}=80\ in$ | Length of stone base.

$w_{base}=30\ in$ | Width of stone base.

$H_{base}=12\ in$ | Height of stone base.

$s=H_{bronze} \rightarrow 96\ in$ | Elevation of sculpture above base.

$A_s=H_{bronze} \cdot B_{bronze} \rightarrow 48 ft^2$ | Total surface area of book.

$Elev=s \rightarrow 96\ in$ | Height of sculpture.

$d=w_{bronze}-2 \cdot 1.5\ in \rightarrow 21\ in$ | Assumed width of anchor points.

Self-weight

$W_{bronze}=8.6\ psf \cdot \left(\left(2 \cdot B_{bronze}+2 \cdot w_{bronze} \right) \cdot H_{bronze} \right) \rightarrow 1{,}101\ lbs$ | 3⁄16" thick bronze walls weight.

$W_{base}=170\ pcf \cdot \left(B_{base} \cdot w_{base} \cdot H_{base} \right) \rightarrow 2{,}833\ lbs$ | Granite base weight.

$W_p=W_{bronze}+W_{base} \rightarrow 3{,}934\ lbs$ | Total weight of sculpture.

Wind Check

Wind Loading Parameters: ASCE 7-16, Section 29.3 - Solid Freestanding Walls and Solid Signs

$V=86\ mph$ | (Fig 26.5-1B) Basic wind speed.

$K_d=0.85$ | (Tbl. 26.6-1) Wind directionality factor.

$ExpCat=B$ | (§ 26.7) Exposure Category.

$K_{zt}=1$ | (*§26.8.2*) Topographic factor.

$K_e=1$ | (§26.9) Ground elevation factor.

$G=0.85$ | (§26.11) Gust-effect factor.

Calculate Velocity Pressure

$\alpha=7$ | (Table 26.11-1) Gust-speed power law exponent.

$z_g=1{,}200\ ft$ | (Table 26.11-1) Nominal height of the atmospheric boundary layer.

$$K_z=\text{if } Elev<15\ ft \; \left| \begin{array}{l} 2.01 \cdot \left(\frac{15\ ft}{z_g} \right)^{\left(\frac{2}{\alpha}\right)} \\ 2.01 \cdot \left(\frac{Elev}{z_g} \right)^{\left(\frac{2}{\alpha}\right)} \end{array} \right| \rightarrow 0.57$$ | (Notes under Table 26.10-1) Velocity pressure exposure coefficient.

$q_z=0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot \left(\frac{V}{mph} \right)^2 \cdot psf \rightarrow 9.25\ psf$ | (Eqn. 26.10-1) Velocity pressure.

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Net Force Coefficients

$\frac{B_{bronze}}{s} \rightarrow 0.75 \quad \frac{s}{Elev} \rightarrow 1$

Case A $C_{f,A} = 1.55$ | (Fig. 29.3-1) Force coefficient, Case A (conservative).

Case B $C_{f,B} = 1.55$ | (Fig. 29.3-1) Force coefficient, Case B (conservative).

Case C $C_{f,C} = 2.25 \cdot (0.9) \left(1.8 - \frac{s}{Elev}\right) \rightarrow 1.62$ | (Fig. 29.3-1) Force coefficient with reduction factor, Case C.

$C_f = max(C_{f,A}, C_{f,B}, C_{f,C}) \rightarrow 1.62$

Forces

$F_w = q_z \cdot G \cdot C_f \cdot A_s \rightarrow 611\,lbs$ | (Eq. 29.3-1) Total wind force on surface for solid signs.

$F_{LL} = 200\,lbs \rightarrow 200\,lbs$ | Horizontal Live Load force.

$F = 0.5 \cdot (F_{LL}) + 1.0 \cdot (F_w) \rightarrow 711\,lbs$ | LRFD horizontal force (0.5L+1.0W) (reduced LL).

$M_{overturning,wind} = F \cdot (0.55 \cdot Elev) \rightarrow 3.13\,kip \cdot ft$ | Overturning moment about long axis (per Case C).

$M_{restoring,wind} = \frac{W_{bronze} \cdot w_{bronze}}{2} \rightarrow 1.1\,kip \cdot ft$ | Restoring moment about long axis.

$M_{wind} = max(0, M_{overturning,wind} - M_{restoring,wind}) \rightarrow 2.03\,kip \cdot ft$ | Net moment demand on book per wind force.

$T = \frac{M_{wind}}{d} \rightarrow 1{,}159\,lbs$ | Total tension on each anchor per wind force.

$n = 2 \cdot ceiling\left(\frac{B_{base}}{67\,in}\right) \rightarrow 4$ | Assumed number of anchors in total (2 rows).

$T_u = \frac{T}{\frac{n}{2}} \rightarrow 580\,lbs$ | Tension demand per anchor per wind force.

$V_u = \frac{F}{n} \rightarrow 178\,lbs$ | Shear demand per anchor per wind force.

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Seismic Check

F_p Seismic Calculation - ASCE 7-10 Ch. 13 Seismic Design Req. for Nonstructural Components

Table 13.5-1 Coefficients for Architectural Components: Appendages and ornamentations

$a_p = 2.5$ | Component amplification factor.

$R_p = 2.5$ | Component response modification factor.

$\Omega_0 = 2$ | Component overstrength factor.

Seismic parameters & Fp coefficients

$I_p = 1.0$ | (Sec. 13.1.3) Importance factor.

$S_{DS} = 1.2$ | Design Spectral Response at short period per Hazard Tool.

$z = 0\ in$ | Attachment height (above base).

$h = s \rightarrow 96\,in$ | Total height of sculpture.

$$F_{p,eqn} = \frac{0.4 \cdot a_p \cdot S_{DS}}{\frac{R_p}{I_p}} \cdot \left(1 + 2\left(\frac{z}{h}\right)\right) \rightarrow 0.48$$ | Eqn. 13.3-1 Horizontal force.

$F_{p,max} = 1.6 \cdot S_{DS} \cdot I_p \rightarrow 1.92$ | Eqn. 13.3-2 Max. horizontal force.

$F_{p,min} = 0.3 \cdot S_{DS} \cdot I_p \rightarrow 0.36$ | Eqn. 13.3-3 Min. horizontal force.

$F_{pvert,coeff} = 0.2 \cdot S_{DS} \rightarrow 0.24$ | Sec. 13.3.1 Vertical force.

$F_{p,coeff} = bounded\left(F_{p,eqn}, F_{p,min}, F_{p,max}\right) \rightarrow 0.48$

$F_p = F_{p,coeff} \cdot W_{bronze} \rightarrow 528\,lbs$ | Shear demand at the base of the book.

Force Analysis

$$M = \left(F_{p,coeff} \cdot \left(W_{bronze} \cdot \left(\frac{H_{bronze}}{2}\right)\right)\right) + 0.5 \cdot \left(\frac{F_{LL} \cdot H_{bronze}}{2}\right) \rightarrow 2.51\,kip \cdot ft$$ | Unfactored moment with reduced LL.

$$M_{restoring,seismic} = 0.9 \cdot \left(\frac{W_{bronze} \cdot w_{bronze}}{2}\right) \rightarrow 0.99\,kip \cdot ft$$ | Restoring moment from weight about long axis.

$M_{seismic} = max\left(0, M - M_{restoring,seismic}\right) \rightarrow 1.52\,kip \cdot ft$ | Net moment demand on book per seismic forces.

$$T_{seismic} = \frac{M_{seismic}}{d} \rightarrow 870\,lbs$$ | Total tension per seismic force.

$$T_{u,seismic} = \Omega_0 \cdot \left(\frac{T_{seismic}}{\frac{n}{2}}\right) \rightarrow 870\,lbs$$ | Tension demand per anchor. — Controlling tension demand

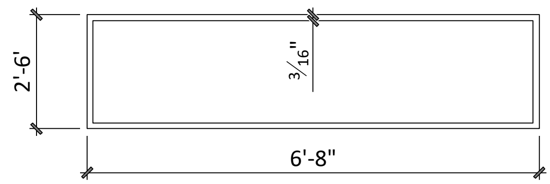
$$V_{u,seismic} = \frac{1.0 \cdot F_p + 1.0 \cdot F_{LL}}{n} \rightarrow 182\,lbs$$ | Shear demand per anchor. — Controlling shear demand.

2020,180 - Maya Angelou Sculpture - Book Check

Flexural Capacity Check

Overall section check: AISC, F7 - Rectangular HSS

Material Properties



Plan view

$F_{y,bronze} = 24.7\ ksi$ | Bronze yield strength.

$F_{u,bronze} = 55.1\ ksi$ | Bronze ultimate tensile strength.

$E_{bronze} = 15{,}200\ ksi$ | Bronze Young's Modulus.

Determining the type of flanges

$\lambda_r = 1.40 \cdot \sqrt{\frac{E_{bronze}}{F_{y,bronze}}} \rightarrow 34.7$ | (AISC, Tbl. B4.1a) Limiting width-to-thickness Ratio.

$\lambda = \frac{B_{bronze}}{t} \rightarrow 384$ | Width-to-thickness ratio of bronze box.

if $\lambda > \lambda_r$
- Box flanges are considered slender.
- Box flanges are NOT consider slender.

→ Box flanges are considered slender.

Box Parameters

$t = \frac{3\ in}{16}$ | Bronze walls thickness.

$b_e = 1.92 \cdot t \cdot \left(\sqrt{\frac{E_{bronze}}{F_{y,bronze}}}\right) \cdot \left(1 - \left(\frac{0.34}{\frac{B_{bronze}}{t}}\right) \cdot \left(\sqrt{\frac{E_{bronze}}{F_{y,bronze}}}\right)\right) \rightarrow 8.73\ in$ | (Eqn. F7-5) Effective width of box.

$S_e = \frac{\left(b_e \cdot w_{bronze}^{\ 3}\right) - \left(\left(b_e - 2 \cdot t\right) \cdot \left(w_{bronze} - 2 \cdot t\right)^3\right)}{6 \cdot w_{bronze}} \rightarrow 73 in^3$ | (AISC Tbl. 17-27) Properties of Geometric Sections.

Flange Local Buckling Check

$M_n = F_{y,bronze} \cdot S_e \rightarrow 150\ kip \cdot ft$ | Nominal Flexural Strength for slender flanges.

$dcr\left(\frac{M}{M_n}\right) \rightarrow$ OK (0.017)

2020,180 - Maya Angelou Sculpture - Book Check

Anchorage Demands

Check anchorage for Ω level seismic loading on epoxy threaded rod anchors. Anchorage will be concealed within sculpture, thus threaded rods will not be able to be rotated as they are lowered into epoxy grouted holes. For added level of safety, tension DCR for adhesive will be limited to 60%, while keeping all other failure modes at a DCR<100%.

Governing tension demand load combo: (0.9-0.2Sds)D+E

Seismic loading is checked for 100% loading in short direction of sculpture and 30% in long direction of sculpture per ASCE 7 Ch. 15.

$d_1 = 20\ in$ | Distance between anchors in short direction of sculpture per plan view below.

$d_2 = 67\ in$ | Distance between anchors in long direction of sculpture per plan view below.

Ω level seismic overturning moments (including vertical seismic load):

$M_1 = M + 0.2\, S_{DS} \cdot W_{bronze} \left(\frac{d_1}{2}\right) \rightarrow 2.73\ kip \cdot ft$ | Seismic moments for loading in short direction.

$M_2 = M + 0.2\, S_{DS} \cdot W_{bronze} \left(\frac{d_2}{2}\right) \rightarrow 3.25\ kip \cdot ft$ | Seismic moments for loading in long direction.

Dead load resisting moments:

$M_{DL,1} = W_{bronze} \left(\frac{d_1}{2}\right) \rightarrow 917\ lb \cdot ft$ | Resisting moment for loading in short direction.

$M_{DL,2} = W_{bronze} \left(\frac{d_2}{2}\right) \rightarrow 3{,}073\ lb \cdot ft$ | Resisting moment for loading in long direction.

Net tension on anchor:

$T_1 = \frac{M_1 - 0.9\, M_{DL,1}}{d_1} \rightarrow 1{,}145\ lbs$ | Tension load on single anchor for loading in short direction.

$T_2 = \frac{M_2 - 0.9\, M_{DL,2}}{d_2} \rightarrow 86.9\ lbs$ | Tension load on single anchor for loading in long direction.

$T_{design} = \left(T_1 + 0.3\, T_2\right) \cdot \Omega_0 \rightarrow 2{,}342\ lbs$ Design tension load on single anchor for 100% + 30% seismic loading

Shear demand on anchorage:

$V_{design} = \Omega_0 \cdot V_{u,seismic} \cdot 1.3 \rightarrow 473\ lbs$ | Shear demand for 100% + 30% seismic loading.

See anchorage report on following pages for justification of ½"ϕ SS threaded rod w/ 5" min. embed & Simpson SET-3G epoxy.

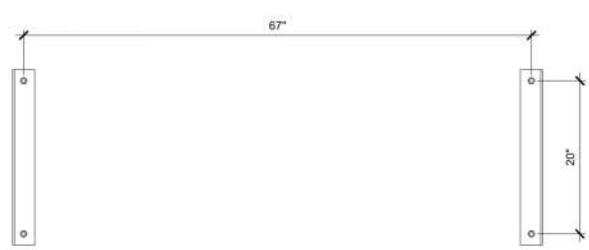
Clip Angle Demands

$A_{leg} = 0.25\ in \cdot 3\ in \rightarrow 0.75 in^2$

$\sigma_{lat} = \frac{T_{design} + V_{design}}{A_{leg}} \rightarrow 3.75\ ksi$ max. tension stress per leg

$F_{y,SS} = 31\ ksi$

∴ Stainless Steel angles OK by inspection.



Anchor Designer™
Software
Version 2.9.7376.0

Company:	Tipping Structural Engineers	Date:	12/2/2021
Engineer:		Page:	1/5
Project:			
Address:	1906 Shattuck Ave. Berkeley CA. 94704		
Phone:	510-549-1906		
E-mail:	f.last@tippingstructural.com		

1.Project information

Customer company:
Customer contact name:
Customer e-mail:
Comment:

Project description: Maya Angelou Sculpture in SFML
Location:
Fastening description:

2. Input Data & Anchor Parameters

General
Design method:ACI 318-14
Units: Imperial units

Anchor Information:
Anchor type: Bonded anchor
Material: A193 Grade B8/B8M (304/316SS)
Diameter (inch): 0.500
Effective Embedment depth, h_{ef} (inch): 5.000
Code report: ICC-ES ESR-4057
Anchor category: -
Anchor ductility: Yes
h_{min} (inch): 6.25
c_{ac} (inch): 8.60
C_{min} (inch): 1.75
S_{min} (inch): 2.50

Base Material
Concrete: Normal-weight
Concrete thickness, h (inch): 12.00
State: Cracked
Compressive strength, f'_c (psi): 3000
$\Psi_{c,V}$: 1.0
Reinforcement condition: B tension, B shear
Supplemental reinforcement: Not applicable
Reinforcement provided at corners: No
Ignore concrete breakout in tension: No
Ignore concrete breakout in shear: No
Hole condition: Dry concrete
Inspection: Continuous
Temperature range, Short/Long: 176/110°F
Ignore 6do requirement: Not applicable
Build-up grout pad: No

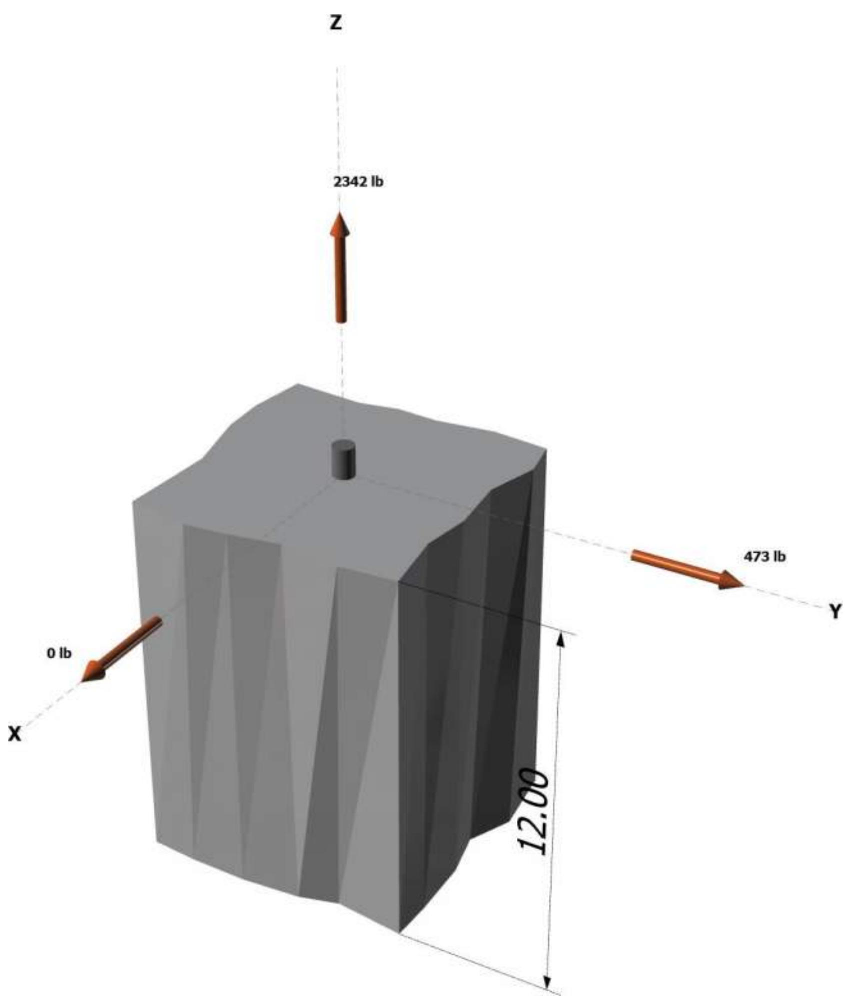
Recommended Anchor
Anchor Name: SET-3G - SET-3G w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS)
Code Report: ICC-ES ESR-4057

Load and Geometry
Load factor source: ACI 318 Section 5.3
Load combination: not set
Seismic design: Yes
Anchors subjected to sustained tension: No
Ductility section for tension: 17.2.3.4.2 not applicable
Ductility section for shear: 17.2.3.5.2 not applicable
Ω_0 factor: not set
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: No

Strength level loads:

N_{ua} [lb]: 2342
V_{uax} [lb]: 0
V_{uay} [lb]: 473

<Figure 1>



3. Resulting Anchor Forces

Anchor	Tension load, N_{ua} (lb)	Shear load x, V_{uax} (lb)	Shear load y, V_{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2+(V_{uay})^2}$ (lb)
1	2342.0	0.0	473.0	473.0
Sum	2342.0	0.0	473.0	473.0

Maximum concrete compression strain (‰): 0.00
Maximum concrete compression stress (psi): 0
Resultant tension force (lb): 2342
Resultant compression force (lb): 0
Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.00
Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

4. Steel Strength of Anchor in Tension (Sec. 17.4.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
8095	0.75	6071

5. Concrete Breakout Strength of Anchor in Tension (Sec. 17.4.2)

$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5}$ (Eq. 17.4.2.2a)

k_c	λ_a	f'_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	3000	5.000	10410

$0.75\phi N_{cb} = 0.75\phi\,(A_{Nc}/A_{Nco})\,\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_b$ (Sec. 17.3.1 & Eq. 17.4.2.1a)

A_{Nc} (in^2)	A_{Nco} (in^2	$c_{a,min}$ (in)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	$0.75\phi N_{cb}$ (lb)
225.00	225.00	-	1.000	1.00	1.000	10410	0.65	5075

6. Adhesive Strength of Anchor in Tension (Sec. 17.4.5)

$\tau_{k,cr} = \tau_{k,cr} f_{short\text{-}term} K_{sat} (f'_c/2{,}500)^n \alpha_{N.seis}$

$\tau_{k,cr}$ (psi)	$f_{short\text{-}term}$	K_{sat}	$\alpha_{N.seis}$	f'_c (psi)	n	$\tau_{k,cr}$ (psi)
1163	1.00	1.00	0.90	3000	0.24	1094

$N_{ba} = \lambda_a \tau_{cr} \pi d_a h_{ef}$ (Eq. 17.4.5.2)

λ_a	τ_{cr} (psi)	d_a (in)	h_{ef} (in)	N_{ba} (lb)
1.00	1094	0.50	5.000	8588

$0.75\phi N_a = 0.75\phi\,(A_{Na}/A_{Na0})\,\Psi_{ed,Na}\Psi_{cp,Na}N_{ba}$ (Sec. 17.3.1 & Eq. 17.4.5.1a)

A_{Na} (in^2)	A_{Na0} (in^2)	c_{Na} (in)	$c_{a,min}$ (in)	$\Psi_{ed,Na}$	$\Psi_{p,Na}$	N_{a0} (lb)	ϕ	$0.75\phi N_a$ (lb)
170.55	170.55	6.53	-	1.000	1.000	8588	0.65	4187

8. Steel Strength of Anchor in Shear (Sec. 17.5.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\alpha_{V,seis}$	$\phi_{grout}\alpha_{V,seis}\phi V_{sa}$ (lb)
4855	1.0	0.65	0.80	2525

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.5.3)

$\phi V_{cp} = \phi \min|k_{cp}N_a\ ;\ k_{cp}N_{cb}| = \phi \min|k_{cp}(A_{Na}/A_{Na0})\Psi_{ed,Na}\Psi_{cp,Na}N_{ba}\ ;\ k_{cp}(A_{Nc}/A_{Nco})\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_b|$ (Sec. 17.3.1 & Eq. 17.5.3.1a)

k_{cp}	A_{Na} (in^2)	A_{Na0} (in^2)	$\Psi_{ed,Na}$	$\Psi_{cp,Na}$	N_{ba} (lb)	N_a (lb)
2.0	170.55	170.55	1.000	1.000	8588	8588

A_{Nc} (in^2)	A_{Nco} (in^2)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	N_{cb} (lb)	ϕ	ϕV_{cp} (lb)
225.00	225.00	1.000	1.000	1.000	10410	10410	0.70	12024

11. Results

Interaction of Tensile and Shear Forces (Sec. 17.6.)

Tension	Factored Load, N_{ua} (lb)	Design Strength, øN_n (lb)	Ratio	Status
Steel	2342	6071	0.39	Pass
Concrete breakout	2342	5075	0.46	Pass
Adhesive	**2342**	**4187**	**0.56**	**Pass (Governs)**

Shear	Factored Load, V_{ua} (lb)	Design Strength, øV_n (lb)	Ratio	Status
Steel	**473**	**2525**	**0.19**	**Pass (Governs)**
Pryout	473	12024	0.04	Pass

Interaction check	$N_{ua}/\phi N_n$	$V_{ua}/\phi V_n$	Combined Ratio	Permissible	Status
Sec. 17.6..1	0.56	0.00	55.9%	1.0	Pass

SET-3G w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS) with hef = 5.000 inch meets the selected design criteria.

12. Warnings

- Per designer input, the tensile component of the strength-level earthquake force applied to anchors does not exceed 20 percent of the total factored anchor tensile force associated with the same load combination. Therefore the ductility requirements of ACI 318 17.2.3.4.2 for tension need not be satisfied – designer to verify.

- Per designer input, the shear component of the strength-level earthquake force applied to anchors does not exceed 20 percent of the total factored anchor shear force associated with the same load combination. Therefore the ductility requirements of ACI 318 17.2.3.5.2 for shear need not be satisfied – designer to verify.

- Designer must exercise own judgement to determine if this design is suitable.

- Refer to manufacturer's product literature for hole cleaning and installation instructions.

2020,180 - Maya Angelou Sculpture - Base + Book Check

NOTE: Parameters not enlisted here have the same value that those found in "Book Check" section.

Structure and Base Parameters

$s = H_{bronze} + H_{base} \rightarrow 108\,in$ | Elevation of sculpture above ground.

$A_s = \left(H_{bronze} \cdot B_{bronze} \right) + \left(H_{base} \cdot B_{base} \right) \rightarrow 54.7\,ft^2$ | Total surface area of base + book.

$Elev = s \rightarrow 108\,in$ | Height of sculpture.

$d = w_{base} - 2 \cdot 1.5\ in \rightarrow 27\,in$ | Assumed width of anchor points.

Wind Check

Forces

$F_w = q_z \cdot G \cdot C_f \cdot A_s \rightarrow 696\,lbs$ | (Eq. 29.3-1) Total wind force on surface for solid signs.

$F_{LL} = 200\ lbs \rightarrow 200\,lbs$ | Horizontal Live Load force.

$F = 0.5 \cdot \left(F_{LL} \right) + 1.0 \cdot \left(F_w \right) \rightarrow 796\,lbs$ | LRFD horizontal force (0.5L+1.0W) (reduced LL).

$M_{overturning,wind} = F \cdot \left(0.55 \cdot Elev \right) \rightarrow 3.94\,kip \cdot ft$ | Overturning moment about long axis (per Case C).

$M_{restoring,wind} = \left(\frac{W_{bronze} \cdot w_{bronze}}{2} \right) + \left(\frac{W_{base} \cdot w_{base}}{2} \right) \rightarrow 4.64\,kip \cdot ft$ | Restoring moment about long axis.

$M_{wind} = max\left(0\ ,\ M_{overturning,wind} - M_{restoring,wind} \right) \rightarrow 0\,kip \cdot ft$ | Net moment demand on book per wind force.

$T = \frac{M_{wind}}{d} \rightarrow 0$ | Total tension on each anchor per wind force.

$n = 2 \cdot ceiling\left(\frac{B_{base}}{67\ in} \right) \rightarrow 4$ | Assumed number of anchors in total (2 rows).

$T_u = \frac{T}{\frac{n}{2}} \rightarrow 0$ | Tension demand per anchor per wind force.

$V_u = \frac{F}{n} \rightarrow 199\,lbs$ | Shear demand per anchor per wind force.

2020,180 - Maya Angelou Sculpture - Base + Book Check

NOTE: Parameters not enlisted here have the same value that those found in "Book Check" section.

Seismic Check

Seismic parameters & Fp coefficients

$h = s \rightarrow 108\,in$ | Total height of base + book.

$F_{p,eqn} = \dfrac{0.4 \cdot a_p \cdot S_{DS}}{\dfrac{R_p}{I_p}} \cdot \left(1 + 2\left(\dfrac{z}{h}\right)\right) \rightarrow 0.48$ | Eqn. 13.3-1 Horizontal force.

$F_{p,max} = 1.6 \cdot S_{DS} \cdot I_p \rightarrow 1.92$ | Eqn. 13.3-2 Max. horizontal force.

$F_{p,min} = 0.3 \cdot S_{DS} \cdot I_p \rightarrow 0.36$ | Eqn. 13.3-3 Min. horizontal force.

$F_{pvert,coeff} = 0.2 \cdot S_{DS} \rightarrow 0.24$ | Sec. 13.3.1 Vertical force.

$F_{p,coeff} = bounded\left(F_{p,eqn}, F_{p,min}, F_{p,max}\right) \rightarrow 0.48$

$F_p = F_{p,coeff} \cdot W_p \rightarrow 1{,}888\,lbs$ | Shear demand at the base.

Force Analysis

$M = \left(F_{p,coeff} \cdot \left(W_{bronze} \cdot \left(\dfrac{H_{bronze}}{2}\right) + W_{base} \cdot \left(\dfrac{H_{base}}{2}\right)\right)\right) + 0.5 \cdot \left(\dfrac{F_{LL} \cdot H_{bronze}}{2}\right) \rightarrow 3.19\,kip \cdot ft$ | Unfactored moment with red. LL.

$M_{restoring,seismic} = 0.9 \cdot \left(\left(\dfrac{W_{bronze} \cdot w_{bronze}}{2}\right) + \left(\dfrac{W_{base} \cdot w_{base}}{2}\right)\right) \rightarrow 4.18\,kip \cdot ft$ | Restoring moment from weight about long axis.

$M_{seismic} = max\left(0, M - M_{restoring,seismic}\right) \rightarrow 0\,kip \cdot ft$ | Net moment demand on book per seismic forces.

$T_{seismic} = \dfrac{M_{seismic}}{d} \rightarrow 0$ | Total tension per seismic force.

$T_{u,seismic} = \Omega_0 \cdot \left(\dfrac{T_{seismic}}{\dfrac{n}{2}}\right) \rightarrow 0$ | Tension demand per anchor.

$V_{u,seismic} = \dfrac{1.0 \cdot F_p + 1.0 \cdot F_{LL}}{n} \rightarrow 522\,lbs$ | Shear demand per anchor.

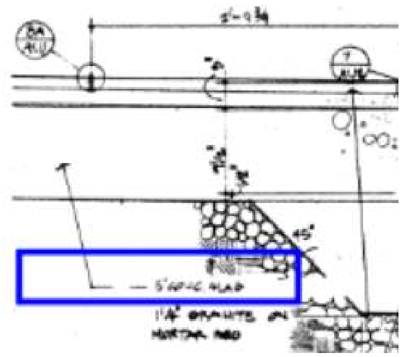
Even though the tension demands are zero, please provide (4) ½" SS threaded rod w/3" min. embed & Simpson SET-3G epoxy.

2020,180 - Maya Angelou Sculpture - Base + Book Check

Checking Bearing stresses per CBC Ch. 18

PRESUMPTIVE LOAD-BEARING VALUES

CLASS OF MATERIALS	VERTICAL FOUNDATION PRESSURE (psf)	LATERAL BEARING PRESSURE (psf/ft below natural grade)	LATERAL SLIDING RESISTANCE	
			Coefficient of friction[a]	Cohesion (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500	100	—	130



(E) dwgs.

CBC Ch. 18.

VERTICAL PRESSURE

$P_{CBC,Vert} = 1{,}500\,psf \cdot \left(\frac{4}{3}\right) \rightarrow 2{,}000\,psf$ | Max. vertical pressure (conservative) + ⅓ per Section 1806.1 on CBC Ch. 18.

Sculpture contribution

$W_p \rightarrow 3{,}934\,lbs$ | Total weight of sculpture.

$Area_{base} = B_{base} \cdot w_{base} \rightarrow 16.7\,ft^2$ | Total base area.

$P_{sculp} = \frac{W_p}{Area_{base}} \rightarrow 236\,psf$ | Sculpture pressure.

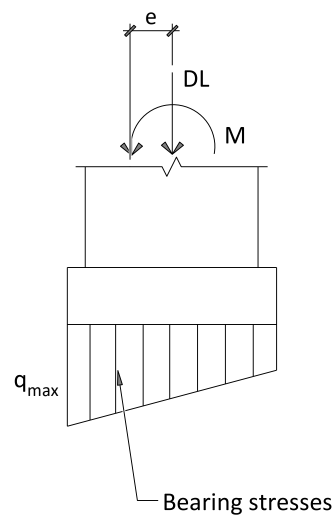
Existent layers contribution

$P_{granite} = 20\,psf$ | 1 ¼" granite layer. See (e) dwgs.

$\gamma_{conc} = 150\,pcf$ | Density of SOG.

$P_{conc} = \gamma_{conc} \cdot 5\,in \rightarrow 62.5\,psf$ | 5" Concrete slab. See (e) dwgs.

$P_T = P_{sculp} + P_{granite} + P_{conc} \rightarrow 319\,psf$ | Total pressure on soil (DL).



DL + Wind Moment

$$q_{max} = \text{if } e < \frac{B_{base}}{6} \;\; P_T + \left(\frac{6 \cdot (P_T \cdot Area_{base}) \cdot e}{w_{base\_} \cdot B_{base\_}^{\,2}}\right) \;\; \text{else} \;\; \frac{2 \cdot P_T \cdot Area_{base}}{3 \cdot w_{base\_} \cdot \left(\frac{B_{base\_}}{2} - e\right)} \rightarrow 531\,psf$$

where

$e = \frac{M_{overturning,wind}}{P_T \cdot Area_{base}} \rightarrow 0.74\,ft$ | Eccentricity.

2020,180 - Maya Angelou Sculpture - Base + Book Check

$P_{check} = if\ P_{CBC,Vert} > P_T + q_{max}$
Vertical Pressure is OK
Vertical pressure exceeds maximum
→ Vertical Pressure is OK

LATERAL BEARING PRESSURE

There is not Lateral Bearing Pressure since the sculpture is sitting on top of the SOG and Granite layer.

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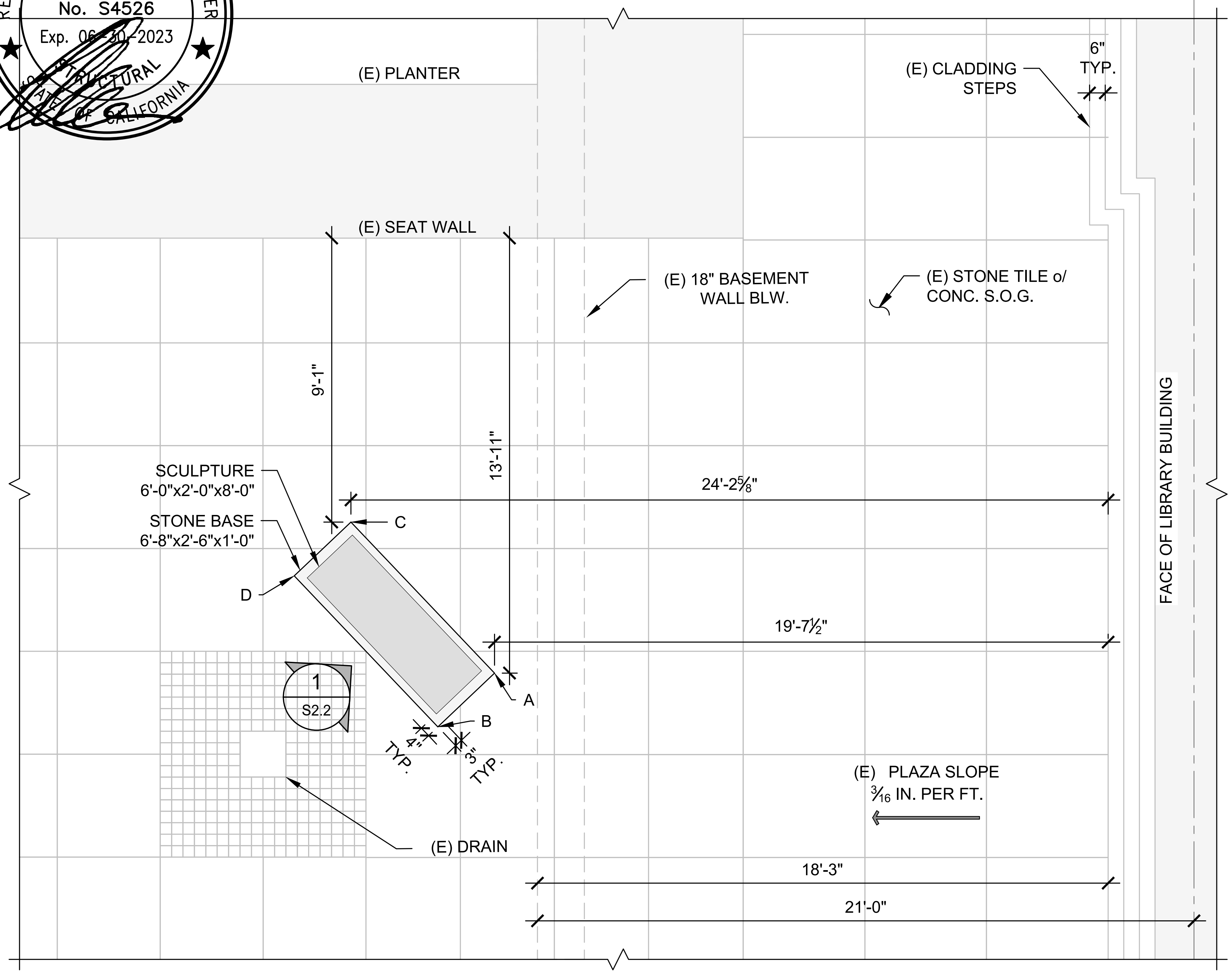


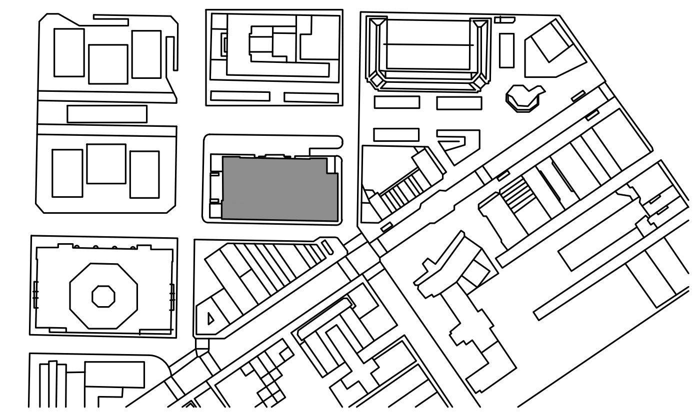
2 S2.1 SCULPTURE ENLARGED PLAN VIEW

1/4" = 1'-0"

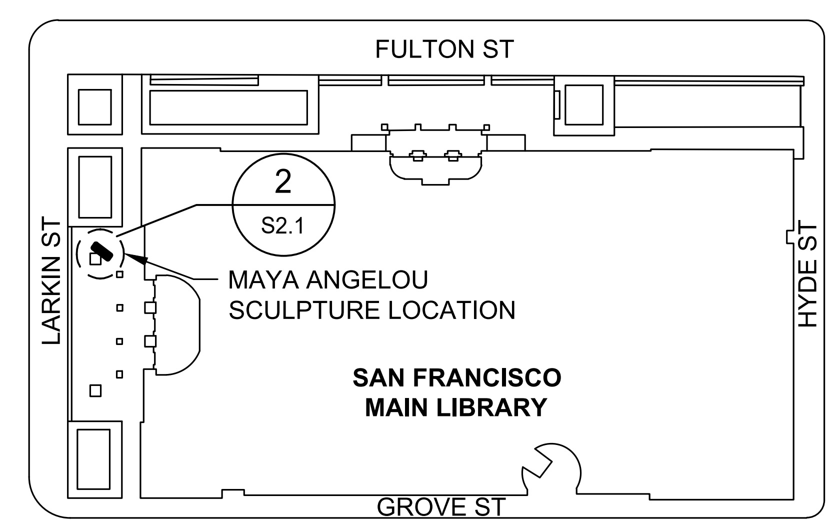
POINT	DISTANCE WEST OF LIBRARY FACADE	ELEVATION DROP FROM POINT A	STONE THICKNESS
A	19'-7 1/2"	0.00"	12.00"
B	21'-5 1/4"	0.34"	12.34"
C	24'-2 5/8"	0.86"	12.86"
D	26'-0 3/8"	1.20"	13.20"

NOTE: TOP OF STONE BASE SHALL BE FLAT AND LEVEL. BOTTOM OF BASE SHALL BE MILLED AS A FLAT PLANE TO PROVIDE CORNER THICKNESSES AS NOTED.

3 S2.1 STONE BASE THICKNESS



KEY PLAN



1 S2.1 S.F. LIBRARY PLAN VIEW

NTS

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MAYA ANGELOU SCULPTURE SUPPORT
SAN FRANCISCO, CA

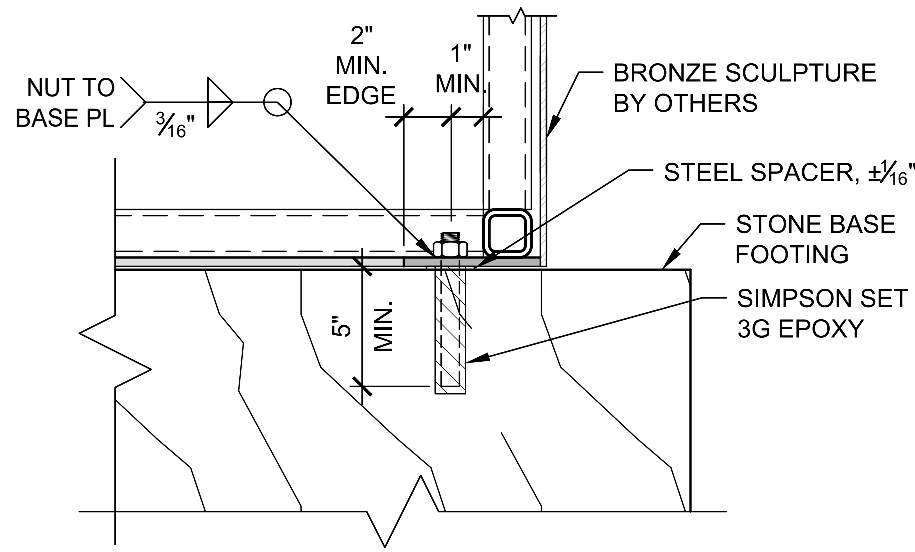
SCULPTURE LOCATION
100% CONSTRUCTION DOCUMENTS

DATE	04-12-22
SCALE	AS NOTED
DRAWN	MH
JOB	2020.180.00

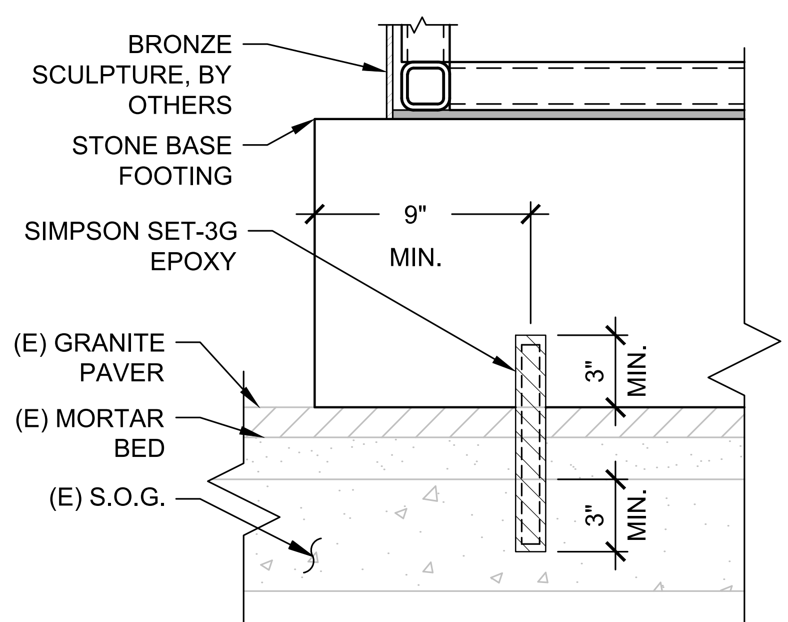
SHEET
S2.1
OF SHEETS

INSTALLATION NOTES:
1) SCULPTURE SHALL BE INSTALLED PLUMB IN FIELD VERIFIED ANCHOR LOCATIONS.
2) BOTTOM OF STONE BASE SHALL BE SLOPED TO MATCH (E) PLAZA GRADE, SEE PLAN.
3) PLACE A THIN LAYER OF GROUT BETWEEN THE STONE BASE AND PAVERS TO ENSURE UNIFORM BEARING.
3) ROTATION OF ANCHOR BOLTS INTO PROPERLY CLEANED AND PREPARED EPOXY FILLED HOLES IN CONC. SLAB OR STONE BASE IS NOT REQUIRED.

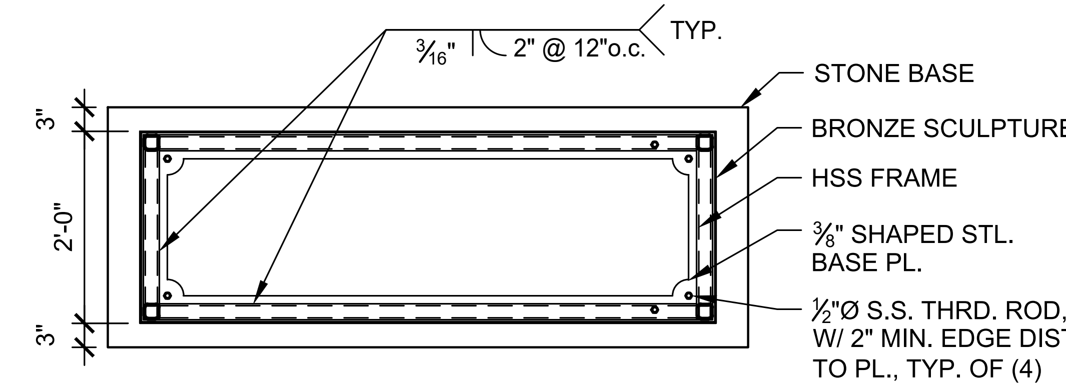
MATERIAL NOTES:
1) BRONZE MATERIAL SHALL BE BY EVERDUR, OR EQUAL, WITH MINIMUMYIELD STRENGTH, Fy = 24 KSI.
2) STAINLESS STEEL TUBE SHALL BE ASTM A500 Gr. B WITH MINIMUM YIELD STRENGTH, Fy=46 KSI.
3) STAINLESS STEEL THREADED ROD SHALL BE ASTM A193 GR. B8/B8M
4) EPOXY SHALL BE SIMPSON SET-3G, OR APPROVED EQUAL.



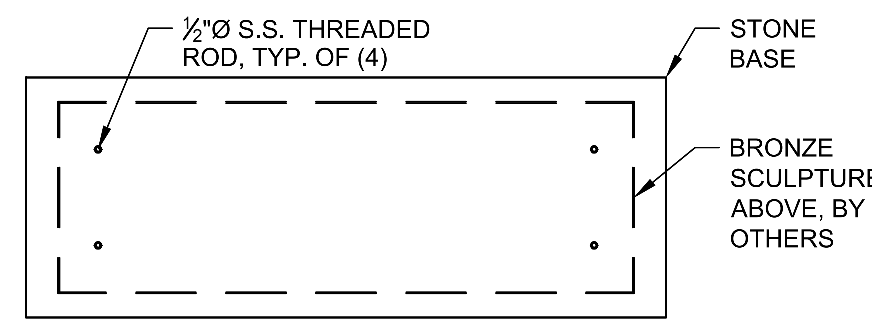
3 S2.2 ANCHOR AT SHAPED BASE PL & HSS FRAME
1 1/2" = 1'-0"



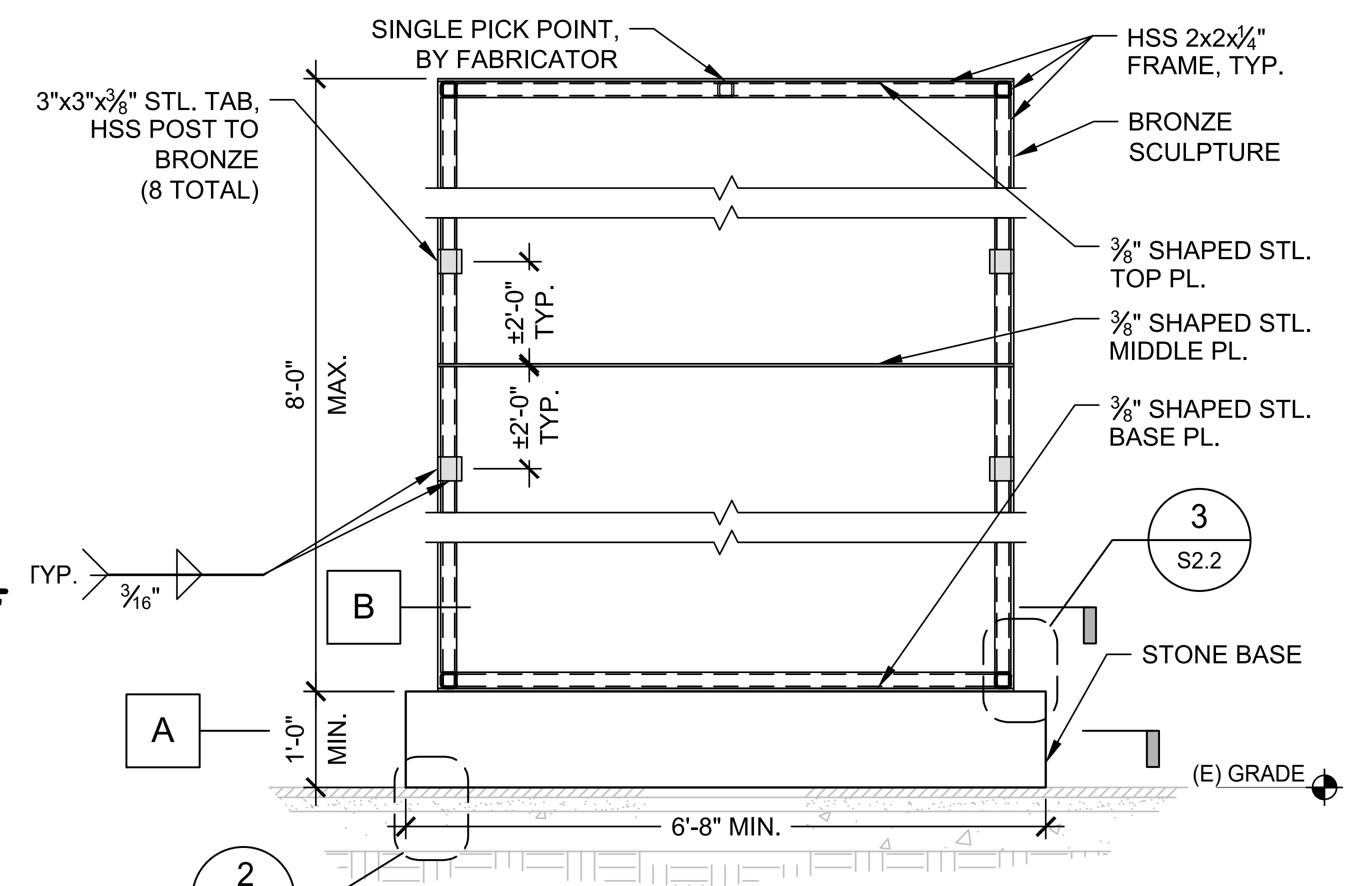
2 S2.2 ANCHORAGE TO (E) GRADE
1 1/2" = 1'-0"



B SCULPT. ANCHOR BOLTS INTO STONE - PLAN VIEW



A STONE ANCHOR BOLTS INTO (E) S.O.G. - PLAN VIEW



1 S2.2 SCULPTURE ELEVATION
1/2" = 1'-0"

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OF	SHEETS