STRUCTURAL CALCULATIONS
Pipe Supports and AST Anchorage

Riverside Transit Agency
1825 E. 3rd Street
Riverside, CA

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Prepared by: Paul Truong, P.E., Structural Engineer
Reviewed by: Daya Bettadapura, P.E., Principal Engineer

ABI Engineering Consultants, Inc.
1701 E. Edinger Ave., Ste A9
Santa Ana, CA 92705

Tel.: (888) 220-5596
Fax: (714) 866-4171
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TRAPEZE PIPE SUPPORT (Single Oil Line Per Note 17)
RTA IMPROVEMENT PROJECT

Seismic Loading Based on ASCE 7-05
Assume Site Classification: D
Acceleration values based on USGS Ground Motion Parameter Calculator

\[
\begin{align*}
S_s & = 1.5 \\
S_1 & = 0.6 \\
F_a & = 1 \\
F_v & = 1.5 \\
S_{ms} & = F_a S_s = 1.5 \\
S_{m1} & = F_v S_1 = 0.9 \\
S_{ds} & = 2/3 S_{ms} = 1 \\
S_{d1} & = 2/3 S_{m1} = 0.6 \\
\end{align*}
\]

**Supported Loading (Max.)**

- Pipe Size (Max.) = 1 inch diam. STL
- Pipe Unit Wt. (w/Contents) = 2.7 lb/ft
- Supported Length (Max.) = 10 ft
- Total Vertical Load, \( W \) = 27 lbs + 20 lbs (support)

**Seismic Design Force**

\[
\begin{align*}
ap & = 2.5 \\
R & = 2.5 \\
l_p & = 1.5 \\
z & = 0 \\
h & = 18 \\
F_p & = \frac{0.4 S_{ds} l_p}{1 + 2 z/h} (W) = 0.6 W \quad \text{GOVERNS} \\
F_p & \geq 1.6 S_{ds} l_p W = 2.4 W \\
F_p & \leq 0.3 S_{ds} l_p W = 0.45 W \\
\end{align*}
\]

- Vertical Load, \( W \) = 47.0 lbs
- Seismic Load, \( F_p \) (horiz) = 28.2 lbs \times 1.3 = 36.7 lbs
- Seismic Load, \( F_p \) (vert) = 1.3 \times 0.2 \times S_{ds} W = 7.0 lbs

**Trapeze Support Load Check**

\[
\begin{align*}
\text{Uplift, } F_u & = 0.9 D + 1.0 E = 0.9 W - 1.0 \times F_p(\text{vert}) = 17 \text{ lbs} \\
\text{Seismic Load, } F_p & = 36.7 \text{ lbs} \\
\end{align*}
\]

Applied Tension on Anchor = \( F_u \)
Applied Shear Load on Anchor = \( F_p \)

LOADS ARE VERY MINIMAL - 3/8" DIAM ROD AND UNISTRUT ARE STRUCTURALLY ADEQUATE
TRAPEZE PIPE SUPPORT (4 Lines Per Note 12)
RTA IMPROVEMENT PROJECT

Seismic Loading Based on ASCE 7-05
Assume Site Classification: D
Acceleration values based on USGS Ground Motion Parameter Calculator

\[
\begin{align*}
S_\text{s} &= 1.5 \\
S_1 &= 0.6 \\
F_a &= 1 \\
F_v &= 1.5 \\
S_{ms} &= F_a S_\text{s} = 1.5 \\
S_{m1} &= F_v S_1 = 0.9 \\
S_{ds} &= 2/3 S_{ms} = 1 \\
S_{d1} &= 2/3 S_{m1} = 0.6 \\
\end{align*}
\]

Supported Loading (Max.)

Pipe Size (Max.) = 3/4 inch diam. STL (4 total)
Pipe Unit Wt. (w/Contents) = 1.8 lb/ft
Supported Length (Max.) = 10 ft
Total Vertical Load, W = 72 lbs + 20 lbs (support)

Seismic Design Force

\[
\begin{align*}
ap &= 2.5 \\
R &= 2.5 \\
l_p &= 1.5 \\
z &= 0 \\
h &= 18 \\
F_p &= 0.4 ap S_{ds} lp (1+2 z/h) (W) = 0.6 W \text{ GOVERNS} \\
F_p \geq 1.6 S_{ds} lp W &= 2.4 W \\
F_p \leq 0.3 S_{ds} lp W &= 0.45 W \\
\end{align*}
\]

Vertical Load, W = 92.0 lbs
Seismic Load, Fp (horiz) = 55.2 lbsx1.3 = 71.8 lbs
Seismic Load, Fp (vert) = 1.3x0.2*Sds*W = 18.7 lbs

Trapeze Support Load Check

Uplift, \( F_u = 0.9D + 1.0E = 0.9*W - 1.0*Fp(\text{vert}) \) = 46 lbs
Seismic Load, \( F_p = 71.8 \text{ lbs} \)

Applied Tension on Rod = \( F_u \)
Applied Shear Load on Ros = \( F_p \)

LOADS ARE VERY MINIMAL - 3/8" DIAM ROD AND UNISTRUT ARE STRUCTURALLY ADEQUATE
STRUT SUPPORT ANCHORAGE DESIGN
RTA IMPROVEMENT PROJECT

Seismic Loading Based on ASCE 7-05
Assume Site Classification: D
Acceleration values based on USGS Ground Motion Parameter Calculator

\[ S_s = 1.5 \]
\[ S_1 = 0.6 \]
\[ F_a = 1 \]
\[ F_v = 1.5 \]
\[ S_{ms} = F_a \times S_s = 1.5 \]
\[ S_{m1} = F_v \times S_1 = 0.9 \]
\[ S_{ds} = 2/3 \times S_{ms} = 1 \]
\[ S_{d1} = 2/3 \times S_{m1} = 0.6 \]

**Supported Loading (Max.)**

<table>
<thead>
<tr>
<th>Pipe Sizes (Max.)</th>
<th>1 inch diam. STL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes Unit Wt. (w/Contents)</td>
<td>2.7 lb/ft</td>
</tr>
<tr>
<td>Supported Length (Max.)</td>
<td>10 ft</td>
</tr>
<tr>
<td>Total Vertical Load, W</td>
<td>27 lbs</td>
</tr>
</tbody>
</table>

**Seismic Design Force**

\[ ap = 2.5 \]
\[ R = 2.5 \]
\[ ip = 1.5 \]
\[ z = 0 \]
\[ h = 95 \]

\[ F_p = \frac{0.4 \times ap \times Sds \times Ip}{1 + 2 \times z/h} \times W = 0.6 \text{ W} \]
\[ F_p \geq 1.6 \times Sds \times Ip \times W = 2.4 \text{ W} \]
\[ F_p \leq 0.3 \times Sds \times Ip \times W = 0.45 \text{ W} \]

<table>
<thead>
<tr>
<th>Vertical Load, W</th>
<th>27.0 lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Load, Fp (horiz)</td>
<td>16.2 lbsx1.3 = 21.1 lbs</td>
</tr>
<tr>
<td>Seismic Load, Fp(vert)</td>
<td>1.3\times0.2\times Sds\times W = 7.0 lbs</td>
</tr>
</tbody>
</table>

**Concrete Anchorage Design**

Uplift, Fu:
\[ Fu = 0.9D + 1.0E = 0.9W - 1.0Fp(vert) = 17 \text{ lbs} \]
\[ OR \]
\[ Fu = 1.2D + 1.0E = 1.2W - 1.0Fp(vert) = 25 \text{ lbs} \]

Shear Load in Y-direction = Fu
Shear Load in X-direction = Fp(horiz)

LOADS ARE MINIMAL - 3/8" DIAM HILTI KWIK BOLT or SIMPSON TITEN HD BOLT ARE STRUCTURALLY ADEQUATE
Seismic Loading Based on ASCE 7-05
Assume Site Classification: D
Acceleration values based on USGS Ground Motion Parameter Calculator

\[
\begin{align*}
S_s &= 1.5 \\
S_1 &= 0.6 \\
F_a &= 1 \\
F_v &= 1.5 \\
S_{ms} &= F_a \cdot S_s = 1.5 \\
S_{m1} &= F_v \cdot S_1 = 0.9 \\
S_{ds} &= \frac{2}{3} \cdot S_{ms} = 1 \\
S_{d1} &= \frac{2}{3} \cdot S_{m1} = 0.6
\end{align*}
\]

**Tank Specs**

Model: DOUBLE WALL HOOVER AST (5,000 gal CAPACITY)
Tank Wt. = 12000 lbs
Fuel Wt. = 36500 lbs
Width = 95 in
Length = 190 in
Height = 83 in

**Seismic Design Base Shear, V (ASCE 7-05 Section 15.4.2)**

Importance Factor, I = 1.5
Total Weight, W = 48500 lbs

\[
V = 0.3 \cdot S_{ds} \cdot W \cdot I = 21825 \text{ lbs}
\]

**Concrete Anchorage Design* (Worst Case)**

Centroid Height, \(C_y = \frac{H}{2} = 41.5 \text{ in}\)

\[
\begin{align*}
\text{Uplift Due to Moment} &= 2 \cdot (C_y \cdot V) \div \text{Width} = 19068.2 \text{ lbs} + 12 \text{ bolts (18" o.c. Along One Side)} = 1589 \text{ lbs} \\
\text{Applied Shear Load to Each Anchor} &= V = 21825.0 \text{ lbs} + 32 \text{ bolts (Total Along Perimeter)} = 682 \text{ lbs}
\end{align*}
\]

*USE 1/2" DIAM HILTI KB-TZ SS316 BOLTS w/MIN 3-1/4" EMBED INTO 2500 PSI (MIN) CONCRETE @ 24" O.C. (ALLOWABLE SHEAR = 2.6 kips; ALLOWABLE PULLOUT = 1.9 kips)*
Conterminous 48 States
Latitude = 33.983
Longitude = -117.352
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - \( F_a = 1.0 \), \( F_v = 1.0 \)
Data are based on a 0.01 deg grid spacing

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1.500 (Ss, Site Class B)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.600 (S1, Site Class B)</td>
</tr>
</tbody>
</table>

Conterminous 48 States
Latitude = 33.983
Longitude = -117.352
Spectral Response Accelerations SMs and SM1
SMs = \( F_a \times Ss \) and SM1 = \( F_v \times S1 \)
Site Class D - \( F_a = 1.0 \), \( F_v = 1.5 \)

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1.500 (SMs, Site Class D)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.900 (SM1, Site Class D)</td>
</tr>
</tbody>
</table>

Conterminous 48 States
Latitude = 33.983
Longitude = -117.352
Design Spectral Response Accelerations SDs and SD1
SDs = \( \frac{2}{3} \times SMs \) and SD1 = \( \frac{2}{3} \times SM1 \)
Site Class D - \( F_a = 1.0 \), \( F_v = 1.5 \)

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Sa (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1.000 (SDs, Site Class D)</td>
</tr>
<tr>
<td>1.0</td>
<td>0.600 (SD1, Site Class D)</td>
</tr>
</tbody>
</table>

Conterminous 48 States
Latitude = 33.983
Longitude = -117.352
MCE Response Spectrum for Site Class B
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - \( F_a = 1.0 \), \( F_v = 1.0 \)

<table>
<thead>
<tr>
<th>Period (sec)</th>
<th>Sa (g)</th>
<th>Sd (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.600</td>
<td>0.000</td>
</tr>
<tr>
<td>0.080</td>
<td>1.500</td>
<td>0.094</td>
</tr>
<tr>
<td>0.200</td>
<td>1.500</td>
<td>0.586</td>
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<tr>
<td>0.400</td>
<td>1.500</td>
<td>2.345</td>
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<td>0.500</td>
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<tr>
<td>0.600</td>
<td>1.000</td>
<td>3.517</td>
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<tr>
<td>0.700</td>
<td>0.857</td>
<td>4.103</td>
</tr>
<tr>
<td>0.800</td>
<td>0.750</td>
<td>4.690</td>
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</table>