**Title:** MISSISSIPPI RIVER: STUDY OF ALTERNATIVES FOR REHABILITATION OF LOCK AND DAM NO. 1, Minneapolis, Minnesota. Supporting data for Appendix C, structural investigations.

**Author(s):**

**Performing Organization Name and Address:**
Army Engineer District, St. Paul
1135 USPO & Custom House
St. Paul, MN 55101

**Report Date:**
April, 1976

**Number of Pages:**
14

**Distribution Statement (of this Report):**
Approved for public release; distribution unlimited.

**Keywords:**
- Locks (Waterways)
- Inland Waterways
- Mississippi River
- Structural Engineering

**Abstract:**
It is recommended that both the landward lock, the riverward lock and the dam at Lock & Dam no. 1, Minneapolis, Minnesota be completely rehabilitated. Based on studies completed to the date of this report, more detailed studies are required to firmly establish cost estimates, environmental effects, and the construction scheduling necessary to insure the work can be completed in the proposed two year construction period without delaying navigation.
MISSISSIPPI RIVER
STUDY OF ALTERNATIVES FOR REHABILITATION OF LOCK AND DAM NO. 1
MINNEAPOLIS, MINNESOTA

SUPPORTING DATA
FOR
APPENDIX C
STRUCTURAL INVESTIGATIONS
## Computation

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### Land Wall Monoliths

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<td>4</td>
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<td>55-57</td>
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<td>Construction</td>
<td>58-61</td>
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<td>124</td>
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<td>125</td>
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### Intermediate Wall Monolith Improved Normal Operating:

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### River Wall Monoliths: Improved Normal Operating:

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<td>Backfilled Riverside</td>
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<td>20</td>
<td>Interconnection of 20 &amp; 21</td>
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<td>Backfilled Riverside</td>
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**PILE BEARING CAPACITY**

**Buttress Dam:**

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<td>MONOLITH NOS</td>
<td>LOADING CONDITION</td>
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<td>--------------------</td>
</tr>
<tr>
<td>1-7</td>
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<tr>
<td>(L=14.0)</td>
<td></td>
</tr>
<tr>
<td>1-6</td>
<td>CONSTRUCTION</td>
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<tr>
<td>8-13</td>
<td>NORMAL OPERATING</td>
</tr>
<tr>
<td>(L=18.0)</td>
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</tbody>
</table>

**NOTES:**

1. SUMMATION OF HORIZONTAL FORCES ONE FOOT STRIP ACROSS EACH

2. FACTOR OF SAFETY AGAINST SLIDING TO COEFFICIENT OF FRICTION $f = 0.6$

3. NEGATIVE SIGN INDICATES LOCATION

4. ALL WATER SURFACE (W.S.) ELEVATION CONSTRUCTION CONDITION FOR MONOLITH

5. FOR 3-DIMENSIONAL ANALYSES
### Location of Resultant Foundation

<table>
<thead>
<tr>
<th>E, FT</th>
<th>±(½ - e)</th>
<th>PRESSURE, KSF</th>
<th>F.S.S.</th>
<th>+H</th>
<th>EV</th>
<th>SLIDING FACTOR, F.S.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.72</td>
<td>-1.39</td>
<td>7.46</td>
<td>0.00</td>
<td>143</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>4.22</td>
<td>-1.89</td>
<td>11.34</td>
<td>0.00</td>
<td>157</td>
<td>21</td>
<td>47</td>
</tr>
<tr>
<td>3.40</td>
<td>-0.40</td>
<td>4.13</td>
<td>0.00</td>
<td>2.06</td>
<td>11</td>
<td>35</td>
</tr>
</tbody>
</table>

- **Horizontal Forces (±H) and Vertical Forces (EV)** are for an average across each monolith.
- **Safety of Sliding (F.S.S.)** is based on $\phi = 32^\circ$ corresponding to $f = 0.625$ (for dam: $\phi = 33^\circ$, $f = 0.649$).

**Notes:**
- Location of resultant outside of middle third.
- Elevations for intermediate wall are interchangeable except for monoliths 4 & 5.
- Analyses E_x is across the wall and E_y along the wall.
<table>
<thead>
<tr>
<th>MONOLITH</th>
<th>LOADING CONDITION</th>
<th>ELEV. OF W.S. ELEV.</th>
<th>W.S. ELEV.</th>
<th>LOCATION OFF BACKFILL, AT LAND-FIT SIDE, FT SIDE, FT E, FT 1C LAND W</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>NORMAL OPERATING (PRESENT)</td>
<td>732.7</td>
<td>704.0</td>
<td>687.2</td>
</tr>
<tr>
<td>(L=32.6')</td>
<td>CONSTRUCTION - ALL REHABILITATION PLANS, CONDUIT LOWERED, NO CONC. FILL</td>
<td>724.7</td>
<td>704.0 (EMPTY)</td>
<td>7.47</td>
</tr>
<tr>
<td>3</td>
<td>NORMAL OPERATING - AFTER HYDRAULIC IMPROVEMENTS COMPLETED</td>
<td>732.7</td>
<td>704.0</td>
<td>687.2</td>
</tr>
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<td>IMPROVED NORMAL OPERATING - BACKFILL LOWERED BY 8'</td>
<td>724.7</td>
<td>704.0</td>
<td>687.2</td>
</tr>
<tr>
<td>4</td>
<td>CONSTRUCTION - ALL REHABILITATION PLANS, CONDUIT LOWERED, NO CONC. FILL</td>
<td>722.7</td>
<td>704.0 (EMPTY)</td>
<td>7.44</td>
</tr>
<tr>
<td>(L=32.0')</td>
<td>NORMAL OPERATING - AFTER HYDRAULIC IMPROVEMENTS COMPLETED</td>
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<td>704.0</td>
<td>687.2</td>
</tr>
<tr>
<td>4</td>
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<td>722.7</td>
<td>704.0</td>
<td>687.2</td>
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<td>Foundation</td>
<td>Pressure, l.s.f</td>
<td>R.S.O.</td>
<td>EH</td>
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<tr>
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<td>W.S. ELEV. AT RIVER SIDE, FT</td>
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<td>687.2</td>
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<td>704.0 (EMPTY)</td>
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<td>1-1 3/8&quot; BAR TENDONS PER ANCHOR SPACED 10 FT</td>
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<td>704.0</td>
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<tr>
<td>5-15</td>
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<td>704.0</td>
<td>687.2</td>
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<td>3-1 1/4&quot; BAR TENDONS PER ANCHOR SPACED 15 FT</td>
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<td>687.2</td>
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<td>BACKFILL LOWERED BY 10'</td>
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<td>704.0</td>
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## Summary of Structural Investigation

### Location of Resultant Eccentricity from Middle $\frac{1}{3}$

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<th>Ev</th>
<th>Eccentricity</th>
<th>Foundation Pressure, Ksf</th>
<th>F.S.O.T</th>
<th>EH</th>
<th>EV</th>
<th>Sliding Factor</th>
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<td>W.S. ELEV.</td>
<td>LOCATION OF BACKFILL, AT LAND-SIDE, FT</td>
<td>AT RIVER-SIDE, FT</td>
<td>E. E. FT</td>
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<tr>
<td>17 (L=20.0')</td>
<td>NORMAL OPERATING (GATE)</td>
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<td>700.0</td>
<td>687.2</td>
<td>9.70</td>
<td></td>
<td></td>
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<tr>
<td>17 (L=20.0')</td>
<td>IMPROVED NORMAL OPERATING BACKFILL LOWERED BY 10 FT</td>
<td>722.7</td>
<td>700.0</td>
<td>687.2</td>
<td>6.90</td>
<td></td>
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<tr>
<td>17 (L=20.0')</td>
<td>IMPROVED NORMAL OPERATING STABILIZED BY 1 3/8'' ANCHORS SPACED 10 FT.</td>
<td>732.7</td>
<td>700.0</td>
<td>687.2</td>
<td>6.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 (L=20.0')</td>
<td>IMPROVED NORMAL OPERATING STABILIZED BY 1 3/8'' ANCHORS SPACED 10 FT. BACKFILL LOWERED BY 10 FT.</td>
<td>722.7</td>
<td>700.0</td>
<td>687.2</td>
<td>3.20</td>
<td></td>
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**LAND WALL (CONT) LOWER G**

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<th>VARIES FROM 709.7 687.2 687.2 7.00 TO 732.7</th>
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<tbody>
<tr>
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<td>NORMAL OPERATING</td>
<td>697.6 687.2 687.2 2.70</td>
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<tr>
<td>6-12</td>
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<td>W.S. ELEVATIONS FT</td>
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<td>(L=400')</td>
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<td>6-16</td>
<td>CONSTRUCTION AND MAINTENANCE</td>
<td>(EMPTY)</td>
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<td>(GATE)</td>
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<td>(L=350)</td>
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<td>EX</td>
<td>EQ</td>
<td>PRESSURE, KSI</td>
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<tr>
<td>1 (OLD RIVER WALL) (L=25.0')</td>
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### Summary of Structural Investigations

#### River Wall (Cont'd)

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<tr>
<th>Depth (ft)</th>
<th>Water Surface (ft)</th>
<th>Water Level (ft)</th>
<th>Depth Below (ft)</th>
<th>Pile Load (kips/ft)</th>
<th>F.S.O.T.</th>
<th>ZH (Ev)</th>
<th>EV factor</th>
<th>F.S.S.</th>
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<td>1.95</td>
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<td>250</td>
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<td>234</td>
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<td>96</td>
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**Equation:**

\[ f_{eq} = \pm \left( \frac{t}{2} \cdot f_{k} \right) \]

**Foundation Pressure, Ksf:**

- \( f_{max} \)
- \( f_{min} \)

**Pile Load:**

- \( P_{max} \)
- \( P_{min} \)

**F.S.O.T. (Factor of Safety):**

- \( ZH \) (Ev)

**Ev Factor:**

- \( EV \)

**F.S.S. (Factor of Safety):**

- \( EH/EV \)
| MONOLITH NO'S | LOADING CONDITION | ELEV. OF BACKFILL FT | W.S. ELEV. W.S. ELEV. AT LAND- AT RIVER- | LOCATION OF RESIDUAL ECTRICITY FT | MY EY | 7 7.0 |
|---------------|--------------------|----------------------|-----------------------------------------|-----------------------------------|-------|------|------|
|               | IMPROVED NORMAL OPERATING |                      |                                         |                                   |       |      |      |
| 20            | BACKFILL LOCKSIDE MAXIMUM UPLIFT PRESSURE | 710.0 725.2 687.2 | 8.18 7.60 |                                         |       |      |      |
|               | SHEAR KEYS LOCKSIDE AVERAGE UPLIFT PRESSURE | 690.0 725.2 687.2 | 5.04 3.89 |                                         |       |      |      |
| 20            | SHEAR KEYS LOCKSIDE MAXIMUM UPLIFT PRESSURE | 690.0 725.2 687.2 | 5.60 5.10 |                                         |       |      |      |
| 20            | BACKFILL & SHEAR KEYS LOCKSIDE AVERAGE UPLIFT PRESSURE | 710.0 725.2 687.2 | 3.90 5.21 |                                         |       |      |      |
| 20            | BACKFILL & SHEAR KEYS LOCKSIDE MAXIMUM UPLIFT PRESSURE | 710.0 725.2 687.2 | 4.49 6.40 |                                         |       |      |      |

(2) MONOLITHS 18, 20 & 21 INTERCONNECT
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<th>13.80</th>
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<th>0.00</th>
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<th>Pmin = 23</th>
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**RIVER WALL (CONT'D)**

**FOUNDATION**

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<th>Ex.</th>
<th>E2</th>
<th>E4</th>
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<tr>
<td>Pile Load &amp; Sliding</td>
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<tr>
<td>14.88</td>
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</tr>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**48**

**SLIDING & FACTOR**

| 5240 | 14.15 | 5240 |
| 14.88 | 0.00 | - |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**E1**

**PRESSURE, KSF**

| 5240 | 14.15 | 5240 |
| 14.88 | 0.00 | - |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**E2**

**PRESSURE, KSF**

| 5240 | 14.15 | 5240 |
| 14.88 | 0.00 | - |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**E4**

**PRESSURE, KSF**

| 5240 | 14.15 | 5240 |
| 14.88 | 0.00 | - |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
### Loading Conditions

<table>
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<th></th>
<th>Upper Pool (ft)</th>
<th>Tail Water (ft)</th>
<th>Lower Pool (ft)</th>
<th>Eccentricity e (ft)</th>
<th>Location of Resultant Moment (ft)</th>
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<td>Normal Operating</td>
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<td>10 ksi/ft of Crest</td>
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<td>Ice Pressure</td>
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<td>1965 Flood</td>
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<td>713.0</td>
<td>719.0</td>
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<td>2.81</td>
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<td>Normal Operating with Earthquake but without Ice Pressure</td>
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<td>Additional Sand Fill Up to EL. 701.25 ft</td>
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© Internal Hydrostatic Pressure except normal operating.
## Buttress Dam

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<th>Resultant From Middle</th>
<th>φ H Kips</th>
<th>φ V Kips</th>
<th>Foundation Pressures</th>
<th>P&lt;sub&gt;T&lt;/sub&gt; Kips</th>
<th>P&lt;sub&gt;T&lt;/sub&gt; Kips</th>
<th>Factor</th>
<th>F.S.S.</th>
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<td>1726</td>
<td>2.53 1.02</td>
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<td>1903</td>
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<td>1.36 1.13</td>
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Static pressure (uplift) determined by flow net method operating conditions.
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<td>2</td>
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<td>14 SAND</td>
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<td>20 FINE SAND/B</td>
<td>46 SANDY GRAVEL</td>
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<tr>
<td>35</td>
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</tr>
</tbody>
</table>

**Note:** THE FILL BEHIND WALLS

**Number of Blows for 12" Penetration**
The land and guide wall monoliths have been considered to behave essentially as rigid structures. Therefore at-rest earth pressure coefficients have been utilized for calculating lateral forces, modified by reduction factors considering the deformation history of the monoliths and the nature of the granular backfill materials. For monoliths founded directly upon the sandstone (sand) a reduction factor of 0.95 was used. For monoliths bearing upon timber cribs a reduction factor of 0.85 was applied.

**LAND WALL, MONOLITHS 1-7 UPPER GUIDE WALL AND MONOLITHS 1-2 LOWER GUIDE WALL**

These monoliths are founded directly on sandstone

\[ \gamma_{\text{moist}} = 115 \text{pcf} \]
\[ \gamma_{\text{saturated}} = 130 \text{pcf} \]
\[ \gamma_{\text{submerged}} = 68 \text{pcf} \]

\[ \phi = 38^\circ \]

\[ K_0 = 1 - \sin \phi = 0.384 \]
\[ K = 0.95 \quad K_0 = 0.365 \]

\[ K \gamma_{\text{moist}} = 0.365 \times 115 = 42 \text{ psf} \]
\[ K \gamma_{\text{saturated}} = 0.365 \times 68 = 25 \text{ psf} \]
MONOLITHS 8-13 UPPER GUIDE WALL AND MONOLITHS 3-13 LOWER GUIDE WALL

These monoliths are bearing upon timber cribs

\[
\begin{align*}
\gamma_{\text{moist}} &= 115 \text{ psf} \\
\gamma_{\text{saturated}} &= 125 \text{ psf} \\
\gamma_{\text{submerged}} &= 63 \text{ psf}
\end{align*}
\]

\[
\phi = 35^\circ
\]

\[
K_0 = 1 - \sin \phi = 0.426
\]

\[
K = 0.85 \quad K_0 = 0.362
\]

\[
K_{\gamma_{\text{moist}}} = 0.362 \times 115 = 42 \text{ psf}
\]

\[
K_{\gamma_{\text{submerged}}} = 0.362 \times 63 = 23 \text{ psf}
\]

EQUIVALENT FLUID PRESSURES USED IN THE ANALYSES

Because of small variations in calculated values, the following equivalent fluid weight were used for calculating earth pressures acting on the land and guide wall monoliths

\[
K_{\gamma_{\text{moist}}} = 42 \text{ psf}
\]

\[
K_{\gamma_{\text{submerged}}} = 26 \text{ psf}
\]
\[ \Sigma V = 36.7 \text{ k} \quad \Sigma H = 12.76 \text{ k} \quad M_A = 120.3 \text{ k}\footnotemark[1] \quad \alpha = \frac{116.3}{36.7} = 3.28 \] 

1. \( C = 3.72 \quad R = 38.9 \text{ ksf} \) outside to 1/00 E by 1.39'

2. \( \frac{\Sigma H}{\Sigma V} = \frac{12.76}{36.7} = 0.348 \) \checkmark

3. \( f_{sw} = 7.46 \text{ ksf} \) (max.)

4. \( FSS = \frac{36.7 \times 0.625}{12.76} = 1.80 \) \checkmark

5. \( F_{cort} = \frac{36.7}{248.6} = 1.48 \) \checkmark
## Upper Lindo Guide Wall - Monoliths #1 - #7

### Water Level @ EL 7252

<table>
<thead>
<tr>
<th>Loads in Kips</th>
<th>Vert</th>
<th>Vert</th>
<th>Horiz</th>
<th>Horiz Arm</th>
<th>Moment 1</th>
<th>Moment 2</th>
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<tbody>
<tr>
<td>C1</td>
<td>8.0</td>
<td>5.0</td>
<td>15.0</td>
<td>2.5</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>5.0</td>
<td>8.0</td>
<td>15.0</td>
<td>4.0</td>
<td>141.1</td>
<td></td>
</tr>
<tr>
<td>C3</td>
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<td>15.0</td>
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<td>C4</td>
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<td></td>
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<tr>
<td>E1</td>
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<td>8.0</td>
<td>3.9</td>
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<td></td>
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<tr>
<td>E2</td>
<td>13.0</td>
<td>6.0</td>
<td>5.0</td>
<td>2.0</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>E3</td>
<td>13.0</td>
<td>3.0</td>
<td>5.0</td>
<td>2.0</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>20.1</td>
<td>0.625</td>
<td>14.7</td>
<td>7.0</td>
<td>123.1</td>
<td>36.7</td>
</tr>
<tr>
<td>Σ</td>
<td>54.3</td>
<td>17.6</td>
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<td></td>
<td>123.1</td>
<td>36.7</td>
</tr>
<tr>
<td>He1</td>
<td>0.42</td>
<td>7.5</td>
<td></td>
<td>12.76</td>
<td>36.7</td>
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</tr>
<tr>
<td>He2</td>
<td>0.42</td>
<td>7.5</td>
<td></td>
<td>12.76</td>
<td>36.7</td>
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</tr>
<tr>
<td>He3</td>
<td>0.28</td>
<td>20.1</td>
<td></td>
<td>12.76</td>
<td>36.7</td>
<td></td>
</tr>
</tbody>
</table>

ΣM = 120.3

248.8

[Note: The table contains calculations for various loads and moments, indicating the stability analysis for the upper Lindo guide wall.]
\[
H_{E1} = 0.042 \times 7.5^{1/2} = 1.18 \times 22.60
\]
\[
H_{E2} = 0.042 \times 7.5 \times 20.1 = 6.33 \times 10.05
\]
\[
H_{E3} = 0.026 \times 20.1^{1/2} = 5.25 \times 6.70
\]
\[
\Sigma H = 24.76 \text{ kN}
\]
\[
M_{E1} = 26.7 \text{ kN}\cdot m
\]
\[
M_{E2} = 63.6 \text{ kN}\cdot m
\]
\[
M_{E3} = \frac{35.2}{125.5} = 0.28 \text{ kN}\cdot m
\]
\[
\Sigma M = 368.9 - 105.5 - 123.1 = 120.3 \text{ kN}\cdot m
\]
\[
\alpha = \frac{120.3}{36.7} = 3.28 \text{ kN} \cdot m
\]
\[
\tau_{\text{ail}} = \frac{2}{3} \left( \frac{36.7}{3.28} \right) = 7.41 \text{ kN} \cdot m
\]
\[
G = 7.0 - 3.28 = 3.72
\]

Riverward side empty (Inside cofferdam end of wall)
Landward side W.S. EL. 719.7 (Ref. pgs 34-45)

\[ EL = 732.7 \]

1) \( R \) outside middle \( \frac{1}{3} \) by \( 1.89 \) ft
2) \( \frac{xH}{\text{ES}} = 0.44 \)
3) \( f_{soil} = 11.34 \) KSF
4) \( FSS = 1.41 \)
5) \( FSO1 = 1.57 \)
## CONSTRUCTION CONDITION (cont'd)

### FORCES

<table>
<thead>
<tr>
<th>Forces</th>
<th>$H$</th>
<th>$V$</th>
<th>ARM</th>
<th>$M_A$</th>
<th>$M_A$</th>
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<tbody>
<tr>
<td>C1</td>
<td>+ 6.0</td>
<td></td>
<td></td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>+ 6.0</td>
<td></td>
<td></td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>+ 8.3</td>
<td></td>
<td></td>
<td>45.6</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>+ 20.2</td>
<td></td>
<td></td>
<td>141.1</td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>+ 7.9</td>
<td>+ 3.3</td>
<td>11.0</td>
<td></td>
<td>75.2</td>
</tr>
<tr>
<td>E2</td>
<td>0.11 ( \times 6 \times 5.0 )</td>
<td></td>
<td></td>
<td>36.3</td>
<td></td>
</tr>
<tr>
<td>E3</td>
<td>+ 2.0</td>
<td></td>
<td></td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>- 6.4</td>
<td></td>
<td>9.3</td>
<td>59.5</td>
<td></td>
</tr>
<tr>
<td>HE1</td>
<td>0.042 ((13) \times \frac{1}{2} )</td>
<td>+ 3.5</td>
<td>18.9</td>
<td>66.2</td>
<td></td>
</tr>
<tr>
<td>HE2</td>
<td>0.042 ((13) \times 14.6 )</td>
<td>+ 8.0</td>
<td>7.3</td>
<td>58.4</td>
<td></td>
</tr>
<tr>
<td>HE3</td>
<td>0.026 ((14) \times \frac{1}{2} )</td>
<td>+ 2.8</td>
<td>4.9</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>HW</td>
<td>0.0625 ((4) \times \frac{1}{2} )</td>
<td>+ 6.7</td>
<td>4.9</td>
<td>32.8</td>
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</tbody>
</table>

\[ \bar{x} = \frac{131.6}{47.3}, \quad c = \gamma - \bar{x} = 4.22 \]

(1) Resultant outside middle \( \frac{1}{3} \), 1.89 ft

(2) \[ f_{\text{mil}} = \frac{2}{3} \frac{\bar{x} \cdot c}{6} = \frac{2}{3} \times \frac{47.3 \cdot 4.22}{2.78} = 11.3 \text{ KSF} \]

(3) \[ \frac{\bar{E}N}{\bar{E}V} = \frac{21.0}{47.3} = 0.44 \]

(4) \[ FSS = 1.4 \]

(5) \[ FS: T = \frac{362.2}{230.6} = 1.57 \]
\[ \Sigma V = 34.70 \text{k} \quad \Sigma H = 11.40 \text{k} \]
\[ M_a = 134.0 \text{k} \quad \alpha = \frac{134.0}{34.70} = 3.86 \quad \theta = 3.4^\circ \]
1. \( R = 37.78 \text{k} \) on tie side middle 3 by 0.4
2. \( \frac{\Sigma H}{\Sigma V} = 0.33 < 0.417 \text{ (ok)} \)
3. \( F_{SS} = \frac{24.75}{11.40} = 2.15 \)
4. \( F_{SOE} = 4.13 \text{ ksf} \)
5. \( F_{SOT} = 2.06 \)
### Upper Land Guide Wall - Monoliths #8 - 13

<table>
<thead>
<tr>
<th>Loads in Kips</th>
<th>Vert</th>
<th>Vert</th>
<th>Horiz</th>
<th>Horiz</th>
<th>Arm</th>
<th>Moment 1</th>
<th>Moment 2</th>
<th>Moment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>8.0</td>
<td>5.0</td>
<td>1.5</td>
<td>6.0</td>
<td>2.5</td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>8.0</td>
<td>3.0</td>
<td>1.5</td>
<td>3.6</td>
<td>4.0</td>
<td>14.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>18.0</td>
<td>4.0</td>
<td>1.5</td>
<td>10.8</td>
<td>9.0</td>
<td>97.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>18.0</td>
<td>11.0</td>
<td>(10.063)</td>
<td>7.4</td>
<td>9.0</td>
<td>66.6</td>
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<td></td>
</tr>
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<td>8.0</td>
<td>0.11</td>
<td>11.5</td>
<td>16.5</td>
<td>132.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6</td>
<td>3.0</td>
<td>19.0</td>
<td>0.13</td>
<td>2.9</td>
<td>13.0</td>
<td>50.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W1</td>
<td>7.5</td>
<td>0.625</td>
<td>18.0</td>
<td>8.5</td>
<td>3.0</td>
<td>76.5</td>
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</tr>
<tr>
<td>H1</td>
<td>315</td>
<td>3.75</td>
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<td>1.2</td>
<td>21.0</td>
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<tr>
<td>H2</td>
<td>315</td>
<td>18.5</td>
<td></td>
<td>5.8</td>
<td>9.25</td>
<td>53.6</td>
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<tr>
<td>H3</td>
<td>98</td>
<td>18.5</td>
<td>1/2</td>
<td>4.4</td>
<td>6.17</td>
<td>27.2</td>
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</tr>
</tbody>
</table>

\[ \sum V = 43.2 - 8.5 = 34.7 k \]

\[ \sum M = 376.5 - 182.6 = 194.0 k \]
UPPER LAND GUICE WALL-MUNROVILLS *8-24-13*

\[ \Sigma V = 34.70 \, k \]
\[ \Sigma H = 1140 \, k \]
\[ \Sigma M = 194.0 \, k \cdot \text{ft} \]
\[ a = \frac{194.0}{34.70} = 5.60 \]
\[ e = 9.0 - 5.6 = 3.4 \]
\[ M_e = 34.70 \times 3.4 = 118.0 \, k \cdot \text{ft} \]

1. RESULTANT OUTSIDE MIDDLE THIRD BY 0.4:

2. \[ \frac{\Sigma H}{\Sigma V} = \frac{1140}{34.70} = 33 \]

3. \[ F_{SS} = \frac{34.70 \times 625}{1140} = 1.90 \]

4. \[ f_{soil} = \frac{2}{3} \times 34.70/5.6 = 4.13 \, \text{kips} \]

5. \[ F_{SOI} = \frac{376.5}{182.6} = 2.06 \]
Landwall Monoliths #4-15 - Existing Condition

\[ \Sigma V = 202.0 k \quad \Sigma H = 85.0 k \quad \Sigma M_4 = 1647.0 kft \]

1. \( R = 218.0 k \) outside middle by 2.52
2. \( \frac{\Sigma H}{\Sigma V} = 0.422 \)
3. \( f_{soil} = 16.5 ksf \)
4. \( F_{SS} = \frac{2020 k}{85.0} = 1.49 \)
5. \( F_{SP} = 1.60 \)
LANDWALL MONOLITHS 5'-15
NORMAL OPERATING, EXISTING CONDITION

Added hor. force — friction from w.b. of submerged
\[ S_{ab, R} = 2 \times 56 \times 0.088 \times 0.55 = 5 \text{ k} \]

Compute difference in earth + hydrostatic pressures:

\[ \Delta H = 90 \text{ k} \]
\[ \Delta V = 45 - 41 = 4 \text{ k} \]
\[ \Delta M_A = 2487 - 2314 = 173 \text{ k} \]

Cont'd on pg 10 E
LANDWALL MONOLITHS 5-15
NORMAL OPERATING, EXISTING CONDITION (CONT'D)

From page 11,
\[ EH' = 85 \text{k} \]
\[ EV' = 202 \text{k} \]
\[ EM_a' = 1647 \text{k} \]
\[ \text{For W.S. EL 704, without Pr} \]

\[ EH = 85 + 0.7 = 85.7 \text{k} \]
\[ EV = 202 + (-4) = 198 \text{k} \]
\[ EM_a = -1647 + 173 = -1474 \text{k} \]

(1) \[ \alpha = \frac{1874}{198} = 9.44 \quad \varepsilon = \frac{1}{2} - \alpha = 8.5\% \quad -5.33 \quad 4\% \]

Location of Resultant 3.23' outside middle 3rd.

(2) \[ \frac{EH}{EV} = \frac{85.7}{198} = 0.43 \]

(3) \[ FSS = \frac{198 \times 0.625}{85.7} = 1.44 \]

(4) \[ f_{\text{soil}} = \frac{2}{3} \times \frac{198}{7.44} = 17.74 \text{ ksf} \]

(5) \[ F_{\text{SS}} = \frac{405}{2404 + 173} = 1.57 \]
<table>
<thead>
<tr>
<th>Subject</th>
<th>Project #</th>
<th>File No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANDWALL MONOLITHS</td>
<td>LSD #1</td>
<td>600A</td>
</tr>
</tbody>
</table>

**FOR USE ON U.S. GOVERNMENT WORK ONLY**

**W.S. EL. '700' (LANDWARD)**

**LANDWALL MONOLITHS #5-15 - EXISTING CONDITION**

- \( E_4 = 24.0 \times 7.5 \times .13 = 23.40 \) k (Pen: Case for lowering backfill by 10.0')
- \( \Sigma E V = 202.0 \) k (222.8 - 44.6 + 23.4)
- \( \Sigma E H = 85.0 \)
- \( \Sigma M_A = 3583.5 - 808.0 + 2340 = 20.0 - 1596 = 4051 - 2404 \)
- \( \Sigma M_A = 1647.0 \) k

- \( q = \frac{1647.0}{202.0} = 8.15' \)
- \( c = 16.0 - 8.15 = 7.85' \)

1. Resultant \( R = 218.0 \) k outside middle by 2.52'
2. \( \frac{\Sigma H}{\Sigma V} = \frac{85.0}{202.0} = 0.422 \)
3. \( f_{soil} = \frac{3}{2} \times 2080/8.15 = 16.50 \) ksf
4. \( F_{55} = \frac{208.0 \times 6.25}{250} = 1.49 \)
5. \( F_{50} = \frac{4051}{4044} = 1.68 \)
LANDWALL MONOLITHS 5 - 15

MAINTENANCE LOADING
- LOCK EMPTY
- EXISTING BACKFILL @ EL 732.7
- (REFER TO NORMAL LOADING)
- FRICTION BETWEEN SLAB & ROCK

REFERENCE PAGES 10 & 10 a.

\[ E_H = 91 + 6.8 = 97.8 \text{ kips} \]
\[ E_V = 198 + 14 = 212.0 \text{ kips} \]
\[ E_M = (-1473 + (-150)) \left\{ \begin{array}{c}
-1590 \text{ kips - ft} \\
+33
\end{array} \right. \\
(1) \alpha = \frac{1590}{212} = 7.5' \quad \frac{1}{2} - \alpha = e = 8.5'

\text{ "R" OUTSIDE M} \quad 3.2 \text{ ft.}

(2) \frac{E_H}{E_V} = 97.8 = 0.46

(3) FSS = 1.35

(4) f_{soil} = \frac{2}{3} \times \frac{212}{7.5} = 18.84 \text{ ksf}

(5) FSOT = \frac{4051}{2578+150-33} = 1.5
MONOLITH NO. 3, NORMAL LOADING CASE (PRESENT)

Length of monolith, \( b = 24.3' \)

(1) Resultant 3.73 ft. outside middle \( \frac{1}{3} \)

(2) \( f_{soil} = 13.41 \text{ KSF} \)

(3) \( \frac{\Delta H}{EV} = 0.461 \)

(4) \( F:55 = 1.36 \)

(5) \( F.S.O.T = 1.54 \)
MONOLITH NO. 3, NORMAL LOADING CASE (CONT'D)

\[
\begin{array}{|c|c|c|c|c|}
\hline
& H - \Theta & V & \text{ARV} & M_{Y-R} \\
\hline
(1) & (28.7\%) & 0.42 \times (24.3) & 420 & 40.4 & +16187 \\
(2) & 28.7 \times 0.42 \times 30.8 \times 24.3 & 902 & 19.4 & +13922 \\
(3) & 14 \times 14 \times 24 \times (-0.15) & 570 & -706 & 2 & +1412 \\
(4) & 11.5 \times 11 \times 9 \times (-0.15) & 570 & -170 & 2 & -340 \\
(5) & \text{TO (14) FR. TEMP. CONST.} & & & +5641 \text{ (0.93)} & +5237 \\
(6) & \text{GY 28.7 \times 24.3 \times 0.11} & & & +460 & 13 & -5980 \\
(7) & \text{FROM TEMP. CONST.} & & & +261 & & -3463 \\
(8) & \text{FR. TEMP. CONST.} & & & +1019 & & +10496 \\
(9) & 2 \times 56 \times 0.088 \times 24.3 \times 24.3 & & & -132 & & \\
(10) & 1.92 \times 30 \times \frac{1}{2} \times 24.3 & & & -700 & 6 & +4200 \\
(11) & 0.88 \times 30 \times \frac{1}{2} \times 24.3 & & & -320 & 4 & -1280 \\
(12) & 14^2 \times \frac{1}{4} \times 0.0625 \times 24.3 & & & -150 & & \\
\hline
\end{array}
\]

\[\varepsilon_H = 2059\]

\[\varepsilon_V = \frac{4,466}{4,456} = 0.99\]

\[\varepsilon = \frac{4,456}{4,466} = 9.96\text{, }\frac{L}{c} = 5.38, \text{ }X = 0.64\]

(1) RESULTANT IS \(\varepsilon = 0.73\) OUTSIDE MIDDLE 3RD

(2) \[f \times \frac{2}{3} \varepsilon V = \frac{2}{3} \times \frac{4,466}{6.96 \times 32} = 1,344 \text{ ksf}\]

(3) \[\varepsilon H = 2059 \times 0.461 = 944.56 \quad \text{RESIST. } M = 4,0456 - 43570 - 3134 \]

(4) \[\text{FSS} = 625 \times 1.36\]

(5) \[\text{F.S.O.T.} = 1.54 \quad \text{RESIST. } M = 4,0456 - 2,930 + 320 \times 3\]

(6) \[\text{RESIST. } M = 4,0456 - 2,930 + 320 \times 3 = 4,046.1 (10.0)\]

\[\text{RESIST. } M = 4,0456 - 2,930 + 320 \times 3 = 4,046.1 (10.0)\]
LANDWALL MONOLITH NO. 3
REHABILITATION - ALL PLANS

RESULTS:
1) "R" outside mid ½ by 3.5' 1/8
2) $f_{soil} = \frac{12.5}{kF}$
3) $\frac{E}{kF} = 0.438$
4) $F_{ss} = 1.43$
5) $F_{sol} = 2.10$

* SEE RIVERWALL MONOLITH NO. 4 REHABILITATION PLAN 2 ANALYSIS.
<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>H</th>
<th>V</th>
<th>ARM</th>
<th>M&lt;sub&gt;ab&lt;/sub&gt;</th>
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<tr>
<td>10</td>
<td>See intermediate wall monolith No. 1, Rehabilitation Plan 2 Analysis</td>
<td></td>
<td></td>
<td>-1386</td>
<td>2.0</td>
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<tr>
<td>11</td>
<td>59.5 x 24 x 24.3 x 0.15</td>
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<td></td>
<td>5205</td>
<td>2.0</td>
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<tr>
<td>12</td>
<td>19.5 x 3 x 24.3 x 0.15</td>
<td></td>
<td></td>
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<td>159</td>
<td>14.5</td>
</tr>
<tr>
<td>14</td>
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<td></td>
<td></td>
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<td>13</td>
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<tr>
<td>16</td>
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<td>154</td>
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<td>17</td>
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<td>107</td>
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<tr>
<td>18</td>
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<td></td>
<td>102</td>
<td>25</td>
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<tr>
<td>21</td>
<td>30.8 x 4 x 0.062 x 24.3</td>
<td></td>
<td></td>
<td>719</td>
<td>10.3</td>
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<tr>
<td>22</td>
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<td></td>
<td>178</td>
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</tr>
<tr>
<td>23</td>
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<td></td>
<td></td>
<td>598</td>
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<tr>
<td>24</td>
<td>30.8 x 4 x 0.36 x 24.3</td>
<td></td>
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<td>25</td>
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<tr>
<td>26</td>
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<td>-224</td>
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<tr>
<td>27</td>
<td>20.92 x 30 x 1.5 x 24.3</td>
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<td></td>
<td>-700</td>
<td>6.0</td>
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<tr>
<td>28</td>
<td>1815</td>
<td></td>
<td></td>
<td>4164</td>
<td>-</td>
</tr>
</tbody>
</table>
LANDWALL MONOLITH NO. 3
REHABILITATION - ALL PLANS (CONT'D)

\[ EH = \frac{1815}{4164} \quad EV = 4164 \quad EM = \frac{31136}{4164} \]

1. \[ e = \frac{31136}{4164} = 7.47' \]
   \[ \frac{1}{6} = 5.33 \]
   Resultant, outside middle \( \frac{1}{3} \)

2. \[ X = \frac{L - e}{2} = \frac{8.53'}{2} \]
   \[ L = \frac{1}{3} \times \frac{4164}{24.3} = 13.39 \quad \text{KSP} \]

3. \[ \frac{EH}{EV} = 0.436 \]

4. \[ FSS = 1.43 \]

5. \[ (M_A \text{ Resisting}) = 4864 (114 + 16) = 83369 \quad \text{k} \]
   \[ (M_A \text{ Overturning}) = 24384 \quad 19 \times 1.1 + 2552 = 39784 \quad \text{k} \]
   \[ FSOI = \frac{83369}{39784} = 2.09 \]

\[ \frac{42336}{42336} \]
MONOLITH NO. 3
NORMAL LOADING
(WITHOUT STABILIZATION)

CONDUIT IS LOWERED AND 2 GATE SHAFTS ARE FILLED WITH CONCRETE
**MONOLITH NO. 3**

**NORMAL LOADING (CONT'D)**

This page is referred to: a) $P_{h, 10}$, for Hydrostatic and earth pressures  
(Analyzed per foot strip of wall)  
b) $P_{y, 3.5}$, for completed $8' \times 10'$ conduit geometry.  
c) $P_{z, 10}$, for Dead load

<table>
<thead>
<tr>
<th>Forces</th>
<th>$H$</th>
<th>$V$</th>
<th>$M_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net horizontal uplift</td>
<td>90.4 k</td>
<td>-29 k</td>
<td>$+\frac{2468}{k}$</td>
</tr>
</tbody>
</table>
| Water in lower conduit:  
$10' \times 6' \times 6' \times 0.625' \times \frac{243}{k}$ | -13 k | 12.0 k | 14.0' |
| 10' x 8' conduit space:  
Approx. length = 91'  
$80' \times 31' \times (0.15') = 44.4' \times \frac{243}{k}$ | 2 k | -28 k | |
| Dead load:  
\( P_{k} \) to 14 = $5641 + 261$ \( \frac{243}{k} \)  
15. 28.7 x 6 x 11 | -19 k | 14.0' | +266' k |
| \( P_{k} \)  
\( \frac{54}{k} \) \( \frac{85}{k} \) \( \frac{201}{k} \) \( \frac{4.28}{k} \) | -19 k | 15.7' | -3815' k |

\( M_{rev} = 4128' k \)  
\( M_{mv} = 2468' k \)  
\( E \gamma_{A} = -1660' k \)
MONOLITH NO 3
NORMAL LOADING (CONT'D)

\[ \frac{E_H}{E_V} = \frac{85}{201} \quad \frac{E_M}{E_V} = \frac{1660}{201} \]

\[ l = 32' \quad \frac{f}{\ell} = 5.33' \]

\[ \theta = \frac{E_M}{E_V} = \frac{8.30'}{8.3'}; \quad e = \frac{f}{\ell} - a = 7.70' \]

(1) Resultant is outside the middle \( \ell/3 \) by 2.40 feet

(2) \( f_{\text{soil}} = \frac{2}{3} \frac{E_V}{a} = \frac{2}{3} \frac{201}{8.3} = 16.10 \text{ ksf} \)

(3) \( \frac{E_H}{E_V} = \frac{85}{201} = 0.423 \)

(4) \( \text{SSF} = \frac{0.625}{E_H/E_V} = 1.48 \)

(5) \( F_S/\ell = \frac{M_{\text{soil}}}{M_{\text{soil}}} = \frac{4128}{2468} = 1.67 \)
LANDWALL MONOLITH NO. 4
REHABILITATION ALUM. PANS

Assumptions: Gravel removed for new tunnel while existing tunnel 11 still unplugged.

Results:
1) R' outside middle 3', 2.11'
2) f = 434 KSi
3) e1 = 0.41
4) F.S.S. = 1.52
5) F.S.O.T. = 1.79

EL 732.72

(3' SURCHARGE)
### LANDWALL MONOLITH NO. 4
#### REHABILITATION - ALL PLANS
**CONT'D**

<table>
<thead>
<tr>
<th>Concrete and soil</th>
<th>y</th>
<th>y</th>
<th>x</th>
<th>Mx</th>
<th>(My)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 x 9 x 35 (-0.15)</td>
<td>-530</td>
<td>0</td>
<td>+2.0</td>
<td>--</td>
<td>-1040</td>
</tr>
<tr>
<td>11 x 9 x 30 (-0.15)</td>
<td>-446</td>
<td>0</td>
<td>+2.0</td>
<td>+1650</td>
<td>-892</td>
</tr>
<tr>
<td>10 x 5 x 40 (-0.15)</td>
<td>-800</td>
<td>+5.5</td>
<td>+2.0</td>
<td>167</td>
<td>600</td>
</tr>
<tr>
<td>18 x 6.15 x 59.5 x 0.15</td>
<td>+942</td>
<td>+1.0</td>
<td>-1.0</td>
<td>--</td>
<td>-980</td>
</tr>
<tr>
<td>18 x 18 x 2 x 59.5 x 0.15</td>
<td>+1446</td>
<td>+2.85</td>
<td>+2.0</td>
<td>-4121</td>
<td>+2892</td>
</tr>
<tr>
<td>2 x 30 x 59.5 x 0.15</td>
<td>+1607</td>
<td>0</td>
<td>+11.0</td>
<td>0</td>
<td>+17677</td>
</tr>
<tr>
<td>3 x 3 x 49.5 x 0.15</td>
<td>+164</td>
<td>-11.3</td>
<td>+6.5</td>
<td>+1853</td>
<td>+1066</td>
</tr>
<tr>
<td>3 x 10.35 x 44.5 x 0.15</td>
<td>+207</td>
<td>-10.7</td>
<td>+3.5</td>
<td>+1925</td>
<td>725</td>
</tr>
<tr>
<td>9 x 16.35 x 39.5 x 0.15</td>
<td>+572</td>
<td>-2.5</td>
<td>-2.5</td>
<td>+6540</td>
<td>-2180</td>
</tr>
<tr>
<td>3 x 22.35 x 24.5 x 0.15</td>
<td>+246</td>
<td>-4.0</td>
<td>-8.5</td>
<td>984</td>
<td>-2091</td>
</tr>
<tr>
<td>3 x 30 x 19.5 x 0.15</td>
<td>+263</td>
<td>0</td>
<td>-11.5</td>
<td>--</td>
<td>-3025</td>
</tr>
<tr>
<td>3 x 30 x 14.5 x 0.15</td>
<td>+191</td>
<td>0</td>
<td>-14.5</td>
<td>--</td>
<td>-2842</td>
</tr>
<tr>
<td>2 x 3 x 30 x (0.089)</td>
<td>+16</td>
<td>0</td>
<td>+15.0</td>
<td>--</td>
<td>+240</td>
</tr>
<tr>
<td>6 x 3 x 30 x (0.089)</td>
<td>+64</td>
<td>0</td>
<td>-12.0</td>
<td>--</td>
<td>-768</td>
</tr>
<tr>
<td>3 x 5 x 10.35 x 0.11</td>
<td>+17</td>
<td>-10.0</td>
<td>+3.5</td>
<td>+167</td>
<td>60</td>
</tr>
<tr>
<td>9 x 10 x 16.35 x 0.11</td>
<td>+168</td>
<td>-7.5</td>
<td>-2.5</td>
<td>+1215</td>
<td>-405</td>
</tr>
<tr>
<td>3 x 25 x 22.35 x 0.11</td>
<td>+184</td>
<td>-4.0</td>
<td>-8.5</td>
<td>+736</td>
<td>-1564</td>
</tr>
<tr>
<td>6 x 30 x 18.7 x 0.11</td>
<td>+370</td>
<td>0</td>
<td>-13.0</td>
<td>--</td>
<td>-199</td>
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<tr>
<td>6 x 18.8 x 30 x 0.13</td>
<td>+328</td>
<td>0</td>
<td>-13.0</td>
<td>--</td>
<td>-166</td>
</tr>
<tr>
<td>3 x 6 x 60 x 30 x 0.11</td>
<td>+153</td>
<td>0</td>
<td>-13.0</td>
<td>--</td>
<td>-102</td>
</tr>
<tr>
<td>3 x 6 x 18 x 18 x 2</td>
<td>+517</td>
<td>-3.15</td>
<td>-4.5</td>
<td>+167</td>
<td>-212</td>
</tr>
<tr>
<td>3 x 6 x 24 x 11</td>
<td>+6017</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**Notes:**
- Units: y in feet, x in feet, Mx in kips, (My) in kips-ft.
- All calculations are subject to further review and verification.
- Final adjustments may be required based on additional data.

**Engineering Company:**
- Chicago Computer Co.
- Monolith No. 4

**Date:**
- 2/75

**Page No.:**
- 26

**Subject:**
- Landwall Stability - Temporary Construction

**Project:**
- Lock & Dam #1

**File No.:**
- 800A

**Page of Pages:**
- 10
**LANDWALL MONOLITH NO. 4**
**REHABILITATION - ALL PLANS (Contd)**

<table>
<thead>
<tr>
<th>Soil pressure, Hydrostatic Uplift and Surcharge</th>
<th>H</th>
<th>V</th>
<th>ARM</th>
<th>Mx</th>
<th>My</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carried fr. preceding pg.</td>
<td>+6617</td>
<td>-184</td>
<td>-3769</td>
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<td></td>
</tr>
<tr>
<td>(6) 719 x 30</td>
<td>10.3</td>
<td>-19.46</td>
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<td></td>
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</tr>
<tr>
<td>(7) 178 x 30</td>
<td>37.0</td>
<td>-8140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) 588 x 30</td>
<td>15.4</td>
<td>-11180</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) 300 x 30</td>
<td>10.3</td>
<td>-3811</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) 300 x 30</td>
<td>-864</td>
<td>6.0</td>
<td>+5184</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) 300 x 30</td>
<td>+130</td>
<td>29.9</td>
<td>+4662</td>
<td></td>
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<tr>
<td>(9) 300 x 30</td>
<td>-277</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \varepsilon_H = \frac{38354}{5153} = 7.44' \]
\[ \frac{5153 - 5.33}{5153} = 4.4' \]
\[ R = 2.11 \text{ ' outside the middle third} \]
\[ \varepsilon_y = \frac{-224}{5153} = -0.04' \]
\[ \varepsilon_y = \frac{25 \times 57.83}{30 \times 32} = 13.4 \text{ ksf} \]
\[ \sigma_y = 0.04' \]
\[ K = 2.5 \]
\[ \varepsilon_H = \frac{2115}{5153} = 0.41' \]
\[ \varepsilon_V = \frac{5153}{5153} = 0.41' \]
\[ \varepsilon_{M_B} = \left[ \frac{(6017 + 10)}{5573} \right] 56.17 = 100.04' \]
\[ \varepsilon_{M_{prel}} = 32.77 + 8.64 \times 2.2 + 4662 = 559.47' \]
\[ FSOT = 1.0 \]
LANDWALL MONOLITH NO. 4 - REHABILITATION, ALL PLANS (CONT'D)

FRICITION RESISTANCE FROM WEIGHT OF LANDLOCK SLAB

It is assumed that the 2' thick slab in landward lock is capable of supporting a transverse load, \( P_r \), equal to the force of friction between slab and foundation derived from its own weight.

\[
P_r = 2 \times 56 \times 0.15 \times 0.625 = 10.5 \text{ k per foot}
\]

\( P_r \) is resisted by uniformly distributed frictional force and becomes zero at end of 56' slab. Actually, buckling is not possible because any moment developed from eccentricity between \( P_r \) and friction is overcome by wt. of slab.

SSF FOR GROUND WATER BEHIND WALL @ EL 700.

\[
\begin{align*}
2165 & \quad 5153 \\
+91 & \quad +91 \\
-9 & \quad -9 \\
-121 & \quad -121
\end{align*}
\]

\[
\frac{\varepsilon_H}{\varepsilon_V} = 0.38
\]

\[
\text{SSF} = 1.64
\]

Factor of safety against sliding if

\[
4.0 \times (26.8 + 26.4) = 27
\]

\[
9 \times 30 = 270
\]
MONOLITH NO. 4
NORMAL LOADING
(WITHOUT STABILIZATION)

CONDUIT IS LOWERED
2 NEW GATE SHAFTS
FULL OR UNIFORM CONCRETE SECTION (24' TOP WIDTH)

This case is referred to monolith 3, lowered conduit existing, normal loading condition on pages 10k to 10m.
The same outside geometry and loading prevail except that now, conduit is shorter and that, 2 gate shafts are added. Another assumption is that the monolith is filled with concrete to the shape of monolith 3

Wt. of conduit space removed for monolith 3

\[
\text{Wt. of conduit space for monolith } 4
\]

\[
\text{Void} = -8 \times 4 \times 1 \times 0.15 \quad \text{---} \quad -12.\text{k}
\]

\[
\text{Water} = +8 \times 10 \times 1 \times 0.0625 \quad +3.0
\]

Service gate shaft:

\[
\frac{2 \times 9 \times 40 \times (-0.15)}{30} = \frac{-35}{30} \quad -12.6\text{k}
\]

Maintenance gate shaft:

\[
\frac{3 \times 9 \times 40 \times (-0.15)}{30} = \frac{-5.4}{30} \quad -5.4\text{k}
\]

\[
\begin{align*}
\Sigma H &= 8.6\text{ k} \quad \Delta V = -100 \quad 1 \\
\Sigma V &= 201 - 10 = 191.5 \text{k} \quad \times 14 \\
\Sigma M_A &= -1660 + 140 = 1520\text{(c)} \quad \Delta M_A = 140\text{k} \quad 2
\end{align*}
\]

\[
\begin{align*}
\alpha &= 1520 \div 7.96 \quad \epsilon = 16 \quad 2.96 = 8.84' \\
19.6 \quad (1) \text{resultant outside middle } \frac{3}{5}, \text{ by } 2.63 \\
(2) \frac{8}{3} \Sigma V &= 16.0\text{k} \quad (3) \frac{2}{5} \epsilon = 0.448 \\
(4) \frac{2}{3} \Sigma V &= 7.96 \quad (5) \Sigma V = (412.8 - 140) \div 24.8 \quad 1.63
\end{align*}
\]
LANDWALL GATE MONOLITH #17 - EXISTING CONDITION

1. \( R = \frac{6600}{40.5} \times \frac{5}{2} = 798 \)
2. \( \frac{H}{V} = \frac{2605}{550} = 4.75 \)
3. \( f_{soil} = 26.00 \text{kips} \)
4. \( F_{SS} = \frac{5910.425}{26.5} = 1.38 \)
5. \( F_{TOT} = \frac{100690}{76920} = 1.31 \)
## Landwall Gate Monolith #17 (continued)

<table>
<thead>
<tr>
<th>Loads in kips</th>
<th>V↓</th>
<th>V↑</th>
<th>H</th>
<th>H</th>
<th>ARM</th>
<th>MA♂</th>
<th>MA♀</th>
</tr>
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<tbody>
<tr>
<td>① 30x21.5x28.6x.15</td>
<td>8050</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td>120,750</td>
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</tr>
<tr>
<td>② 5x2x28.6x.087</td>
<td>25</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td>375</td>
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<tr>
<td>③ 227x6x28.6x.035</td>
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<td>270</td>
<td></td>
<td></td>
<td>5300</td>
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<tr>
<td>④ 5x3x28.6x.020</td>
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<td>295</td>
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<td>⑤ 80x28.6x.6x.088</td>
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<td>120</td>
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<td>1490</td>
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<tr>
<td>80x28.6x4x.150</td>
<td>137</td>
<td></td>
<td>120</td>
<td></td>
<td></td>
<td>1650</td>
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<td>⑥ 13x3x28.6x.15</td>
<td>168</td>
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<td>150</td>
<td></td>
<td></td>
<td>2530</td>
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<td>⑦ 45.5x15.5x4x.15</td>
<td>423</td>
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<td>200</td>
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<td>846</td>
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<tr>
<td>⑧ 11.5x15.5x4x087</td>
<td>62</td>
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<td>200</td>
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<td></td>
<td>124</td>
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<tr>
<td>⑨ 7.5x6.0x286x020</td>
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<td></td>
<td>270</td>
<td></td>
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<td>675</td>
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<td>Σ 8075</td>
<td>1140</td>
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<td>6935</td>
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<td>ΣV=6935'</td>
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\[ \Sigma M=6935' \]
<table>
<thead>
<tr>
<th>LOADS IN LBS</th>
<th>V</th>
<th>V</th>
<th>H</th>
<th>H</th>
<th>ARM</th>
<th>M_a</th>
<th>M_a</th>
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<tbody>
<tr>
<td>W_1 90.0 x 28.6 x 1.06</td>
<td>912</td>
<td></td>
<td>15.0</td>
<td>13,700</td>
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<tr>
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<td>344</td>
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<td>20.0</td>
<td>6,880</td>
<td></td>
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</tr>
<tr>
<td>GATE CLOSED, LOW WATER IN LOCK</td>
<td>230</td>
<td></td>
<td>12.5</td>
<td>2,880</td>
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<tr>
<td>H_1 1.37 x 14.35 x 28.6</td>
<td>643</td>
<td>49.7</td>
<td>26,200</td>
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<tr>
<td>H_2 1.37 x 19.8 x 28.6</td>
<td>1170</td>
<td>14.9</td>
<td>17,500</td>
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<tr>
<td>H_3 3.9 x 19.8 x 28.6</td>
<td>338</td>
<td>9.9</td>
<td>33,50</td>
<td>53,460</td>
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<tr>
<td>H_4 1.40 x 12.8 x 28.6</td>
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<tr>
<td>H_5 1.80 x 17.0 x 28.6</td>
<td>389</td>
<td>8.5</td>
<td>3310</td>
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<tr>
<td>Σ 230</td>
<td>1256</td>
<td>2685</td>
<td>76,920</td>
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</table>
Summary of Loads

\[ \Sigma V = 8075 + 1140 + 230 - 1256 = 5910 \, \text{k} \]

\[ \Sigma H = 2685 \, \text{k} \]

\[ R = 6500 \, \text{k} \]

\[ \Sigma M_a = 121.125 - 12321 - 76,920 = 31,384 \]

\[ \Sigma M_{ax} = 1550 \, \text{in} \]

\[ q_x = \frac{31384}{5910} = 5.30 \]

\[ e = 15.0 - 5.30 = 9.70 \]

\[ e_y = \frac{1550}{3910} = 0.26 \]

\[ A = 28.6 \times 30.0 = 858 \, \text{ft}^2 \]

Maximum Soil Pressure

\[ f = \frac{5910}{28.6 \times 5.50} = 26.00 \, \text{ksi} \]
LANDWALL GATE MONOLITH #17 (cont'd)

\[
\Sigma V = 6910 \text{k} \quad \Sigma H = 2685 \text{k}
\]

\[
\Sigma M_{yy} = 5910 \times 9.70 = 57,200 \text{ k}\text{ft}
\]

1. Soil Pressure, \( f = 26.00 \text{ksf} \)

\[
R = 6800, \text{ k outside middle} \quad \text{by 20'}
\]

2. \[
\frac{\Sigma H}{\Sigma V} = \frac{2685}{5910} = 0.455
\]

3. \[
F_{SS} = \frac{5910 \times 0.625}{2685} = 1.38
\]

4. \[
F_{SO7} = \frac{108,304}{76,920} = 1.41
\]
1. $R = 3560^2 \text{ kips/m}^2 \times 0.5' \times 8' = 135$

2. $\frac{S_H}{E} = \frac{1600}{3222} = 0.493$

3. $F_{SS} = \frac{3222 \times 625}{7490} = 1.35$

4. $F_{SO} = \frac{3107}{24816} = 1.26$

5. $\Sigma H = 33.6 \text{ ksf}$
### Lower Land Guide Wall Monolith #1 (continued)

<table>
<thead>
<tr>
<th>LOADS IN KIPS</th>
<th>V</th>
<th>V</th>
<th>H</th>
<th>H&lt;sub&gt;2&lt;/sub&gt;</th>
<th>A&lt;sub&gt;RM&lt;/a&gt;</th>
<th>M&lt;sub&gt;A&lt;/sub&gt;</th>
<th>M&lt;sub&gt;A&lt;/sub&gt;</th>
<th>M&lt;sub&gt;A&lt;/sub&gt;</th>
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<tbody>
<tr>
<td>C1</td>
<td>23.0 x 33 x 2.5 x 1.5</td>
<td>266</td>
<td></td>
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<td>667</td>
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<tr>
<td>C2</td>
<td>7.0 x 5 x 33 x 1.5</td>
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<td>2.5</td>
<td>435</td>
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<tr>
<td>C3</td>
<td>7.5 x 25 x 12 x 15</td>
<td>185</td>
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<td></td>
<td>3.75</td>
<td>697</td>
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<tr>
<td>C4</td>
<td>3.0 x 10 x 0.88</td>
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<td></td>
<td>15.0</td>
<td>390</td>
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<td>C5</td>
<td>23.5 x 33 x 1.5</td>
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<td></td>
<td></td>
<td>3.0</td>
<td>1800</td>
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<tr>
<td>C6</td>
<td>8.0 x 33 x 0.88</td>
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<td>113</td>
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<tr>
<td>C7</td>
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<tr>
<td>C9</td>
<td>13.0 x 30.7 x 11.5 x 11.5</td>
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<td>11.5</td>
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<tr>
<td>C10</td>
<td>13.7 x 33 x 1.15</td>
<td>345</td>
<td></td>
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<td>C11</td>
<td>10.5 x 5 x 33 x 11.5</td>
<td>200</td>
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<td>12.75</td>
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<tr>
<td>C12</td>
<td>10.4 x 3 x 35 x 11.5</td>
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<td>29.0</td>
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<tr>
<td>W1</td>
<td>81 x 18 x 33.0</td>
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<td></td>
<td></td>
<td>3.0</td>
<td>4350</td>
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</tr>
<tr>
<td>W2</td>
<td>81 x 3 x 10.4</td>
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<td></td>
<td></td>
<td>220</td>
<td>500</td>
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<tr>
<td>Σ</td>
<td>4051</td>
<td>829</td>
<td></td>
<td></td>
<td>38329</td>
<td>7276</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LOWER LAND GUIDE WALL MONOLITH #1 (CONT'D),

\[ H_{E1} = 4 \times 0.97 \times \frac{30.7}{2} \times \frac{23.0}{3} \times \frac{1}{2} = 114.0 \quad 43.17 \quad 4.950^{1/4} \]

\[ H_{E2} = 0.97 \times 22.5 \times 30.7 \times \frac{1}{2} = 335.0 \quad 24.25 \quad 8.120 \]

\[ H_{E3} = 0.95 \times \frac{1}{2} \times 22.5 \times 33.0 \]

\[ H_{E4} = \left\{ 0.95 \times 13.0 \times 33.0 \right\} \]

\[ H_{E5} = 0.94 \times 13.0 \times 33.0 \times \frac{1}{2} = 1490.0 \quad 4.33 \quad 316 \]

Resultant \( H = 1490.0 \text{ k} \)

\[ \frac{24.616}{1490.0} = 0.01650 \]

\[ \Sigma V = 4051 - 825 = 3222 \text{ k} \]

\[ \Sigma M_a = 38329 - 7276 - 24616 = -6487 \text{ k} \]

\[ \frac{6487}{3222} = 2.0' \]

1. \( R = 3560 \text{ k} \) outside middle

2. \( \frac{\Sigma H}{\Sigma V} = \frac{1490}{3222} = 0.468 \)

3. \( FSS = \frac{3222 \times 6.25}{1490.0} = 1.35 \)

4. \( FSO7 = \frac{31.053}{24616} = 1.26 \)
LOWER LAND GUIDE WALL MONOLITH #1 (CONT'D)

Soil Pressure Value

\[ V = 3222 \text{ k} \]
\[ h = 6 + 37.12 \quad \alpha = 20' \quad e = 70' \]
\[ f = \frac{2}{3} \times \frac{3222}{33 \times 2} = 58.6 \text{ ksf} \]
TYPICAL SECTION ALLER LAND GUIDE WALLS

I. CHECK STABILITY FOR BACKFILL AT TOP OF WALL

CONCRETE

| 1 | 5.0 x 7.0 x 15 = 5.3 k | 15.0 x 7.0 x 11 = 11.6 k |
| 2 | 7.5 x 5.0 x 15 = 5.6 k | 12.5 x 5.0 x 11 = 6.9 k |
| 3 | 10.0 x 5.0 x 15 = 7.5 k | 10.0 x 5.0 x 11 = 5.5 k |
| 4 | 12.5 x 3.0 x 15 = 5.6 k | 7.5 x 3.0 x 11 = 2.5 k |
| 5 | 10.0 x 4.0 x 15 = 12.0 k |                          |

TOTAL = 36.0 k
### Lower Land Guide Wall (Cont'd)

<table>
<thead>
<tr>
<th>Loads in Kips</th>
<th>VECT.</th>
<th>VERT.</th>
<th>HORIZ.</th>
<th>ARM</th>
<th>MUM 4</th>
<th>MUM 5</th>
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<tbody>
<tr>
<td>C₁</td>
<td>5.3</td>
<td></td>
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<td>13.2</td>
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<tr>
<td>C₂</td>
<td>5.6</td>
<td></td>
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<td>3.8</td>
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<tr>
<td>C₃</td>
<td>7.5</td>
<td></td>
<td></td>
<td>5.0</td>
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<tr>
<td>C₄</td>
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<tr>
<td>E₁</td>
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<td></td>
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<td>E₂</td>
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<td>13.75</td>
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<td>E₃</td>
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<td>15.00</td>
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</tr>
<tr>
<td>Wₜ</td>
<td>163 &amp; 083</td>
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<td></td>
<td>1000</td>
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<tr>
<td>Σ</td>
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<td>2.1</td>
<td>591.2</td>
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<td></td>
</tr>
</tbody>
</table>

**Hw**
- Hw₁ = 73 \times 1163/2 
- Hw₂ = 123 \times 22.3/2
- Hw₃ = 123 \times 11.63
- Hw₄ = 40 \times 11.63/2

**ΣH**
- 30.4
LOWE, LAND GUIDE WALL, (CONT'D)

CHECK STABILITY INCLUDING ROCK FILLED GRIB

\[ 10.0 \times 20.0 \times (10.0 - 0.063) = 7.3 \text{k} \]

\[ M_1 = 7.3 \times 10.0 = 73.0 \text{k}\text{ft} \]

\[ \Sigma V = 625 - 21.0 + 7.3 = 637 \text{k} \]

\[ \Sigma H_1 = 59.1 - 21.0 - 354.6 + 73.0 = 288.6 \text{k} \]

\[ a = \frac{288.6}{637} = 0.45' \]

1. RESULTANT OUTSIDE MIDDLE 2' BY 74'

2. \[ \frac{\Sigma H}{\Sigma V} = \frac{394}{637} = 0.45 \] (SEE BELOW)

MINIMUM SOIL PRESSURE

3. \[ f_{soil} = \frac{2 \times 637}{3 \times 2.5} = 10.6 \text{ ksf} \]

IF \[ \frac{\Sigma V}{\Sigma H} \leq 1.5 \], \[ \frac{\Sigma V}{\Sigma H} = 2.73 \] \text{ OR } \[ \frac{\Sigma H}{\Sigma V} = 0.417 \]

\[ F_{s; u} = \frac{637 \times 625}{30.4} = 1.39 \]
LOWET FLOOR GUIDE WALL (CON'T)

CHECK STABILITY AT TOP OF CRIB

\[ \sum V = 36.0 + 26.5 - 2.1 = 60.4 \text{ k} \]
\[ \sum H = 1.23 \times 22.37/2 + 1.23 \times 1.63 + 1.67 \times 0.03/2 \]
\[ \sum H = 13.70 + 2.06 + 0.65 = 16.41 \text{ k} \]
\[ \sum M = 591.2 \times 21.0 - 13.7 \times 9.1 - 200 \times 0.815 - 0.05 \times 1.57 \]
\[ \sum M = 591.2 - 148.0 = 443.2 \text{ ft}-\text{lb} \]

\[ q = \frac{443.2}{60.4} = 7.34 \]

1. \( q = 2.66' \) within Middle
2. \( \frac{\sum H}{\sum V} = \frac{15.41}{60.4} = 0.263 < 0.367 \text{ OK} \)
3. \[ h_{\text{avg}} = \frac{60.4}{20.0} \pm \frac{60.4 \times 2.66}{66.7} = 3.02 \pm 2.90 \text{ kF} \]

\[ S = \frac{20.0^2}{6} = 66.7 \]
LOWER LAND GUIDE WALL (CONT'D)

CHECK STABILITY ASSUMING CRIBS FILLED IN WITH CONCRETE

CRIB WT \(10 \times 20 \times (15 - 0.063) = 174.4 \text{ kips}\)

\(M_a = 174.4 \times 10 = 1740 \text{ kip-ft}\)

\(174.4 - 73 = 101 \text{ kip-ft}\)

\(\Sigma M_a = 2880 + 101 = 3881 \text{ kip-ft}\)

\(\Sigma V = 677 + (174 - 73) = 778 \text{ kips}\)

\(\alpha = \frac{3881}{778} = 5.0'\)

1. RESULTANT AT MIDDLE 1/2 (BY 0.0')

2. \(\frac{\Sigma H}{\Sigma V} = \frac{304}{778} = 0.391 \text{ kips/kip-ft} \text{ for } f_{s,FL} = 0.625 \text{ and } f_{s,SL} = 0.15\)

3. \(f_{s,FL} = \frac{2}{\alpha} \frac{778}{5.0} = 104 \text{ ksf}\)
LOWER LAND GUIDE WALLS - CRIBS FILLED WITH GROUT

$K = 0.50$ (SOIL PRESSURE AT REST CONDITION)

$\Sigma V = 59.3k$

$\Sigma H = 12.1k$

$\Sigma H_A = 90.6k$

$\alpha = \frac{409.6}{59.3} = 6.9'$$e = 3.10' < \frac{200}{G} = 3.33$

$R = 61.2k$ INSIDE MIDDLE 3

$\frac{\Sigma H}{\Sigma V} = 0.205 < 4.17 (f_r = 0.625, f_{s5} = 1.15')$

$f_{s5} = \frac{53.5}{12.1} = 3.06$

$f_{sw} = 2.65, 5.73 ksf, min .21kF$
<table>
<thead>
<tr>
<th>LOADS IN KIPS</th>
<th>VERT.</th>
<th>VERT.</th>
<th>HORIZ.</th>
<th>HORIZ.</th>
<th>ARM</th>
<th>MA 2</th>
<th>MA 5</th>
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</thead>
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<tr>
<td>C1</td>
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<td>12.1</td>
<td>524.2</td>
<td>114.8</td>
<td></td>
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</tr>
</tbody>
</table>
Lower Land Guide Wall with Backfill Removed (Cont'd)

\[ \Sigma V = 61.9 - 2.1 = 59.3 \text{kN} \]

\[ \Sigma H = 12.1 \text{kN} \]

\[ \Sigma H_4 = \frac{524.2 - 114.8}{2} = \frac{409.4}{2} \text{kN} \]

\[ \alpha = \frac{409.4}{59.3} = 6.9 \]

1. \( c = 10.0 - 6.9 = 3.1 \text{ kN/m} \) Resultant within Middle’s

\[ M = 59.3 \times 3.1 = 183.8 \text{kNm} \]

2. \[ \frac{\Sigma V}{\Sigma V} = \frac{12.1}{59.3} = 0.205 \]

3. \[ f_{su} = \frac{59.3}{200} \times \frac{183.8}{66.7} = 2.97 \pm 2.76 \text{ ksi} \]

\[ \text{Max} \ 5.73 \text{ ksf} \]

\[ \text{Min} \ 0.21 \text{ ksf} \]
LOWER, LAND GUIDE WALLS - BACKFILL REMOVED (CON'T)

(SOIL PRESS. 42PSF & 26PSF)

\[ H_{E1} = 0.42 \times 10.37^{2} / 2 = 2.25 \text{k} \times 15.10 = 34.00 \text{kf} \]

\[ H_{E2} = 1.935 \times 11.63 \times 5.07 \text{k} \times 5.80 = 22.40 \text{ k} \]

\[ H_{E3} = 1.304 \times 11.63 / 2 = 1.77 \text{k} \times 3.90 = 6.92 \text{kf} \]

\[ \Sigma H = 9.09 \text{kf} \]

\[ \Sigma M_A = 524.2 \times 210 = 70.3 = 482.9 \text{kft}^2 \]

\[ \Sigma V = 619 - 3.1 = 59.3 \text{k} \]

\[ \Sigma H = 9.1 \text{k} \]

\[ \alpha = 432.9 / 59.3 = 7.3' \]

\[ \theta = 2.7' < 3.33' \text{ (used)} \]

1. \( L = 59.3 \text{k ft inside middle by 0.63' \)

2. \[ \frac{\Sigma H}{\Sigma V} = \frac{9.10}{59.3} = 0.15 \]

3. \[ f_{SOIL} = \frac{5.93}{20.0} \times \frac{5.9 \times 27}{66.70} \]

\[ S = \frac{200}{6} = 66.70 \text{ ft}^3 \]

\[ f_{SOIL} = 2.97 \times 2.42 \]

\[ f_{MAX} = 5.89 \text{kfe} \]

\[ f_{MIN} = 5.57 \text{kfe} \]

4. \[ FSS = \frac{59.3 \times 625}{9.10} \leq 4.07 \]

5. \[ FSOI = 5.75 \]
LOWER LAND GUIDE WALLS - BACKFILL REMOVED

1. $R = 59.3^\circ$ inside middle by 0.63
2. $\frac{EH}{EV} = \frac{9.10}{59.3} = 0.153$
3. $f_{vol} = \text{max } 5.39 \text{ ksf }$  
   $f_{vol} = \text{min } 0.55 \text{ ksf }$
4. $FSS = \frac{59.3 \times 62.5}{9.10} = 4.07$
5. $FSC = 5.75$
16b. STABILITY OF LOWER GUIDE WALL MONOLITHS G-12 DURING CONSTRUCTION PERIOD (Backfill removed) Ref. page 27

According to water level readings in borehole No. 74-80 and downstream of the lock chamber, the difference in hydraulic grade line was about 7' on Sept. 10, 1974. Using the same difference, assume that the hydraulic grade line behind the lower guide wall monoliths is approximately, 674 + 7 = 681' when the construction area is dewatered. Assume 3' of surcharge.

(1) \( R'' \) inside middle \( \frac{1}{3} \) by 0.11'

(2) \( \frac{\Delta H}{V} = 0.22 \)

(3) \( F_{SS} = 2.84 \)

(4) \( f_{SS,1} = 6.95 \text{ KSF min} \quad 0.12 \text{ KSF max} \)

(5) \( F_{SO} = 3.78 \)
### Construction Condition

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th>V</th>
<th>ARM</th>
<th>( \Phi )</th>
<th>Q</th>
</tr>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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<td>10.9</td>
<td>63</td>
<td>172</td>
<td>65.1</td>
</tr>
<tr>
<td>4</td>
<td>3.8</td>
<td>2.7</td>
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<tr>
<td>5</td>
<td>0.4</td>
<td>1.8</td>
<td>1</td>
<td>172</td>
<td>65.1</td>
</tr>
</tbody>
</table>

\[ \begin{align*}
\text{EH} &= 15.5 \times 10^3 \\
\text{EV} &= 70.6 \times 10^3
\end{align*} \]

1. \( \bar{x} = 479 = 6.78' \quad e = 3.22' \quad 70.6 \)
   Resultant inside: middle \( \frac{1}{3} \), \( 0.11 \) ft

2. \( \frac{EH}{EV} = 0.22 \)  
3. \( FSS = 2.84 \)

4. \( f_{soil} = \frac{70.6}{20} \left(1 + \frac{6 \times 3.22}{20}\right) = 6.95 \text{ KSF max.} \)
5. \( F_{out} = \frac{651}{172} = 3.78 \)

\( \frac{\text{EH}}{\text{EV}} = 0.22 \)
INTERMEDIATE WALL MONOLITHS #4-16

NORMAL OPERATING CONDITION

1. Resultant Oults. 5' by 0.59
2. \( \frac{E H}{v} = \frac{1031}{5844} = 0.178 \)
3. \( f_{son} = 10.90 \text{ ksf} \)
4. \( FSS = 1.80 \)
5. \( FSOT = 1.94 \)

CONSTRUCTION CONDITION (ONE LOCK EMPTY)

1. Resultant Oults. 5' by 0.56
2. \( \frac{E H}{v} = 0.354 \)
3. \( f_{son} = 11.32 \text{ ksf} \)
4. \( FSS = 1.77 \)
5. \( FSOT = 2.02 \)
### Intermediate Wall Monoliths 4-16

<table>
<thead>
<tr>
<th></th>
<th>(V_{k} )</th>
<th>(V_{h} )</th>
<th>(H )</th>
<th>(M_{k} )</th>
<th>(M_{h} )</th>
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<tbody>
<tr>
<td>C1</td>
<td>350x570x28x15</td>
<td>8380</td>
<td>0</td>
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<tr>
<td>C2</td>
<td>(10x23+170)x28x0.35</td>
<td>392</td>
<td>0</td>
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<td></td>
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<tr>
<td>C3</td>
<td>(\bar{V}_{1} \times 1.8 \times 28 \times 0.88 )</td>
<td>178</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>(\bar{V}_{2} \times 1.8 \times 28 \times 0.88 )</td>
<td>178</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>2x2.5x4.0x28x0.88</td>
<td>49</td>
<td>0</td>
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<tr>
<td>C6</td>
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<td>16.0</td>
<td>660</td>
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<tr>
<td>( \sum )</td>
<td></td>
<td>8470</td>
<td>748</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| HW1 | 310x29.75x28 | 2148 | 16.5 | 35500 | |
| HW2 | .73x11.5x28 | 117 | 284 | 450 | |
| W1 | 3.10x17.5x28 | 1520 | 583 | 8860 | |
| W2 | .73x17.5x28 | 358 | 583 | 2090 | |
| \( \sum \) | 117 | 2148 | 8470 | 45020 |
**Intermediate Wall Monoliths #4-16 (Cont'd)**

**Normal Operating Condition** (W. L C 725.2' f 687.2')

\[
\Sigma V = 8470 - 748 - 1520 - 358 = 5844 \text{ k}
\]

\[
\Sigma H = 2198 - 117 = 2081 \text{ k}
\]

\[
\Sigma M_E = 45020 - 2540 = 42480 \text{ k}
\]

\[
c = \frac{42480}{5844} \times 7.26' \quad \frac{490}{6} = 6.67' \quad \alpha = 12.74'
\]

1. **Resultant outside middle 3/4 by 0.59'**

2. \[
\frac{\Sigma H}{\Sigma V} = \frac{2081}{5844} = 0.358
\]

3. \[
\frac{f_{sox} = \frac{2}{3} \times \frac{5844}{25 \times 12.74} = 1090 \text{ ksf}}{5844 \times 6.25}{2081} = 1.80
\]

4. \[
FSS = \frac{5844 \times 6.25}{2081} = 1.80
\]

5. \[
F \dot{S} = \frac{7722 \times 20}{79550} = 1.94
\]

6. \[
M_4 = \frac{35500 + 1.73 \times 35.0 \times 280 \times 20 + 2.37 \times 35.0 \times 28 \times 15.84}{2} - 450 = 35500 + 14300 + 30200 - 450 = 79550
\]

\[ 8470 - 748 = 7722 \text{ k} \]
INTERMEDIATE WALL MONOLITHS 4-16

REHABILITATION CONDITION - ONE LOCK EMPTY
(CONSTRUCTION)

$$\Sigma V = 8470 - 748 - 1520 - 126 = 6076 \text{ in}$$

$$\Sigma H = 2148 \text{ in}$$

$$C_3 = 17 \times 4.8^2 \times 28 \times 15 = 304 \text{ in}$$

$$\Sigma M_y = 45020 - 126 \times 8.7 = 43920 \text{ in}^2$$

$$c = \frac{43920}{6076} = 7.23'$$

$$a = 12.77$$

1. Resistant outside middle \( y \) by 0.56'

2. \( \frac{\Sigma H}{\Sigma V} = \frac{2148}{6076} = 0.354 \)

3. \( f_{sox} = \frac{3 \times 6076}{28 \times 12.77} = 11.32 \text{ ksf} \)

4. \( F_{SS} = \frac{6076 \times 605}{2148} = 1.77 \)

5. \( F_{SO} = \frac{2772 \times 3.0}{76450} = 2.02 \)

$$M_a = 35500 + \frac{3.10 \times 350 \times 28.0 \times 25.84 + 126 \times 12.3}{2}$$

$$= 35500 + 39400 + 1550 = 76450 \text{ in}^2$$
REHABILITATION PLAN 2 - MONOLITH NO. 4
INTERMEDIATE WALL, LANDWARD LOCK REBUILT
RIVERLOCK — NO CHANGE

1) Resultant in side middle \( y \) by .57
2) Factor of sliding = .39
3) Sliding safety factor = 1.61
4) Bearing pressure = 9.66 ksf
5) F.S.O.T. = 1.89

\[ E_\Delta = 1858 \ k \]  
\[ E_V = 4789 \ k \]  
\[ E_{Mx} = 4789 \ k \]  
\[ E_{My} = 923 \ k \]  
\[ E_{Mz} = -923 \ k \]  
\[ E_{Mz} = -29343 \ k \]  
\[ E_{Hx} = \frac{1858}{4789} = .39 \]  
\[ E_Y = 0.15 \]  
\[ E_Y = 0.01 \]  
\[ F_s = \frac{6.96 \times 4789}{5.66 \ ksf} = 8862-816+936-8162 \]  
\[ F_s = 8862-1386+938 \]  
\[ F_s = 702 \]  
\[ F.S.O.T. = \frac{1502 (17.5+1.47)}{1893 \times 9.33 + 8085} = 1.89 \]  
\[ \frac{818}{612} = 1.34 \]
<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>Y</th>
<th>X</th>
<th>Mx</th>
<th>My</th>
</tr>
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<tr>
<td>1</td>
<td>14x14x24 (0.15)</td>
<td>706</td>
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<td>-7.61</td>
<td>+2083</td>
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<tr>
<td>2</td>
<td>6.4x8.0x7.0x9 (15)</td>
<td>108</td>
<td>10</td>
<td>-8.0</td>
<td>-7.61</td>
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<tr>
<td>3</td>
<td>15.5+21 (7.8)(9x0.15)</td>
<td>192</td>
<td>8.5</td>
<td>-7.67</td>
<td>+1632</td>
</tr>
<tr>
<td>4</td>
<td>21+17 (4.35)(3)(-0.15)</td>
<td>110</td>
<td>2.2</td>
<td>-7.67</td>
<td>+242</td>
</tr>
<tr>
<td>5</td>
<td>17+12 (7.2)(-0.15)(9)</td>
<td>141</td>
<td>-3.6</td>
<td>-7.67</td>
<td>-5.08</td>
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<tr>
<td>6</td>
<td>12+11 (5)(9)(-0.15)</td>
<td>78</td>
<td>-9.65</td>
<td>-7.61</td>
<td>-753</td>
</tr>
<tr>
<td>7</td>
<td>24.3x11x9 (-0.15)</td>
<td>-361</td>
<td>0</td>
<td>+7.61</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3.5x11x9 (-0.15)</td>
<td>52</td>
<td>10.5</td>
<td>-7.67</td>
<td>+546</td>
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<td>2.0x11x9 (-0.15)</td>
<td>30</td>
<td>-6.1</td>
<td>-7.67</td>
<td>-183</td>
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<tr>
<td></td>
<td>3.5x3.0x2.0x9 (-1.5)</td>
<td>7</td>
<td>4.98</td>
<td>-7.67</td>
<td>+67</td>
</tr>
</tbody>
</table>

\[ V_1 = 1386 \text{ kN} \]
\[ M = 928 \text{ kN m} \]

**Gross Conc.**

\[ \begin{align*}
    57 \times 24.3 \times 35 \times 0.15 & = -7272 \\
    3 \times 8 \times 24.3 \times 0.088 & = +51 \\
    4 \times 5 \times 24.3 \times 0.088 & = +43 \\
    \text{Water:} 8 \times 10 \times 24.3 \times 0.0625 & = +122 \\
    l = 49.5 \times 0.0625 \times 24.3 & = 1856 \text{ kN} \\
    \Sigma H = \frac{49.5}{2} \times 0.0625 \times 24.3 & = 1856 \text{ kN} \\
    \Sigma V = 4789 & \\
    \Sigma M_x = +923 \text{ kN m} \\
    \Sigma M_y = -393 \text{ kN m} \\
\end{align*} \]
REHABILITATION PLAN 2 - MONOLITH #4 (CONT'D)
**HARZA ENGINEERING COMPANY CHICAGO**

**SUBJECT: INTERMEDIATE WALL STABILITY - TEMPORARY CONSTRUCTION**

**PROJECT: LOCK & DAM NO. 1**

**FILE NO.: B004 A**

**DATE: 2/175**

---

**REHABILITATION PLAN 2 - MONOLITH NO. 5**

**INTERMEDIATE WALL LANDWARD LOCK CULVERT REBUILT**

**NO CHANGE IN RIVER LOCK**

---

1. Resultant outside middle 1/2 by 0.9'
2. Factor of sliding = 0.41
3. Factor of safety against sliding = 1.54
4. Bearing pressure = 11.30 Ksf
5. F.S.O.T. = 1.90

---

**New vertical & hor. opening cut, concrete removed, existing opening not plugged. L = 40'**

---

**W.S. EL 1725.2**

**Water in existing tunnel**

---

**Z-AXIS**

---

**F.732.7**

---

**X-AXIS**

---

**F.675.7**

---
### Rehabilitation Plan 2 - Monolith #5 (Cont'd)

#### Concrete

<table>
<thead>
<tr>
<th>No.</th>
<th>Dimensions</th>
<th>Y</th>
<th>X</th>
<th>MY (k-ft)</th>
<th>Mx (k-ft)</th>
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<tr>
<td>1</td>
<td>7 x 13.5 x 9 x (-0.15)</td>
<td>-128</td>
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<td>+6.5</td>
<td>-7.67</td>
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<tr>
<td>2</td>
<td>15 x 13 x 4.8 x 8 (-0.15) x 2</td>
<td>-161</td>
<td>-12.5</td>
<td>0.0</td>
<td>-2013</td>
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<td>3</td>
<td>13 x 12 x 5.1 x 8 (-0.15) x 2</td>
<td>-153</td>
<td>-7.5</td>
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<td>10 x 15.1 x 8 (-0.15) x 2</td>
<td>-362</td>
<td>+7.5</td>
<td>0.0</td>
<td>+2715</td>
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<td>6</td>
<td>10 x 7 x (9-8) x (-0.15)</td>
<td>-11</td>
<td>+6.0</td>
<td>-7.67</td>
<td>+66</td>
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<tr>
<td>7</td>
<td>8 x 12.5 x 9 (-0.15)</td>
<td>-135</td>
<td>+6.5</td>
<td>-7.67</td>
<td>+878</td>
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<tr>
<td>8</td>
<td>5.5 x 5 x 9 (-0.15)</td>
<td>-37</td>
<td>+6.5</td>
<td>-7.67</td>
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<tr>
<td>9</td>
<td>30 x 9 x 11 (-0.15)</td>
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<td>10</td>
<td>10 x 2 (-0.15) x 13</td>
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<td>11</td>
<td>3 x 9 x 13 (-0.15)</td>
<td>-53</td>
<td>-1.5</td>
<td>+7.67</td>
<td>-80</td>
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</table>

- \( M_y = \frac{26,990}{7273} \) k-ft
- \( M_y = 3.7 \) k-ft
- \( M_y = 12.8 \) k-ft

\[ Y_1 = \text{Maximum} \]
Rehabilitation Plan 2 - Monolith #5 (cont'd)
REHABILITATION PLAN 2 - MONOLITH NO. 5 (CONT'D)

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th>V</th>
<th>Y</th>
<th>X</th>
<th>M_x</th>
<th>M_y</th>
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<tbody>
<tr>
<td>2</td>
<td>80 x 0.0625/0.15</td>
<td>+1.33</td>
<td>-12.5</td>
<td>+1467</td>
<td>+413</td>
<td>+253</td>
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<tr>
<td>3</td>
<td>77 x 0.0625/0.15</td>
<td>+1.32</td>
<td>-17.5</td>
<td>+1467</td>
<td>+240</td>
<td>+245</td>
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<tr>
<td>4</td>
<td>70 x 0.0625/0.15</td>
<td>+1.29</td>
<td>-25.0</td>
<td>+1467</td>
<td>+73</td>
<td>+222</td>
</tr>
<tr>
<td>5</td>
<td>181 x 0.0625/0.15</td>
<td>+1.75</td>
<td>+17.5</td>
<td>+1467</td>
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<td>+579</td>
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<tr>
<td>H_y</td>
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<tr>
<td>U</td>
<td>49.5 x 0.0624 x 35 x 30</td>
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</table>

\[ \begin{align*}
E_x &= \frac{4334}{5651} = 0.76 \\
E_y &= \frac{2861}{5651} = 0.51 \\
E_z &= \frac{2861}{5651} = 0.02 \\

k &= 2.4 \\
\frac{f}{1200} &= 11.30 \text{ KSF} \\
\frac{E}{H} &= \frac{-3393}{5651} = \frac{-406}{SSF} = 4.54 \\
F_{\text{L.D.F.}} &= \frac{7273 \times 20.24 + 169 \times 21}{37950 + 1628 \times 27} = \frac{151700}{37950} = 1.90 \\
\end{align*} \]
Intermediate Wall Monolith #18 (cont'd)

Hydrostatic Load

\[
\begin{align*}
0.15 \times 9.0 &= 1.35 \times 6.0 = 8.12 \\
0.10 \times 9.0 &= 0.90 \times 4.5 = 37.00 \\
1.03 \times 17.0 &= 17.50 \times 17.5 = 307.00 \\
1.79 \times 9.0 &= 16.10 \times 30.5 = 492.00 \\
0.15 \times 9.0 &= 1.35 \times 32.0 = 43.30 \\
0.29 \times 170 &= \frac{4.92 \times 20.3}{49.42} = \frac{100.00}{987.42} \\
49.42 \times 28.0 &= 1,380.0 \\
49.42 \times 20.0 &= 987.42 = 20.0 \\
\end{align*}
\]
**Intermediate Wall Monolith #18 (60750)**

**Dimensions:**
- PL: 30.8'
- 12.0'
- 32.75'
- H: 11.2'

**Calculations:**
- \( PL = (2.37 \times 38.0^\circ + 2.37 \times 11.1) \) 32.75 = 2850 k
- \( V = 2850 \times 990 \times 2210^\circ = Y \)
- \( 2850 - 16.37 + 11.2^2 \times 4 = 2210 \times 30.8^\circ \)
- \( 38500 - 68200 = -11.2^\circ \)
- \( H = Y = 2650 k \)

**Additional Calculations:**
- \( 45.2 \times 23.7 = 1072.0 \)
- \( 26.4 \times 5.5 = 145.0 \)
- \( \frac{121.5}{71.6} = 17.0 \) (above EL 676.10)
## Intermediate Wall Downstream Gate Mono. #18

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<thead>
<tr>
<th></th>
<th>Vert H</th>
<th>Vert L</th>
<th>Horiz L</th>
<th>Horiz R</th>
<th>Arm</th>
<th>Max</th>
<th>Myy</th>
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<td>Gates LL</td>
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<td>Gates RL</td>
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<td>&quot; &quot; Y1</td>
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</table>
HYDROSTATIC LOAD ON LANDLOCK SIDE

\[ 2.37 \times 38.0/2 + 2.37 \times 11.1 = 71.6 \]

\[ 71.6 \times 14.0 = 1000 \text{ k c @ 17.0' above sub el 676.1} \]

\[ M_{yy} = 1000 \times (17.0 + (676.1 - 672.6))] = 20,500 \text{ kft} \]

SOIL PRESSURE AND LOCATION OF RESULTANT

\[ \Sigma V = 60.9 \text{ k} \]

\[ \Sigma M_{xx} = 37.626 \text{ k} \]

\[ \alpha_{yy} = 6.10' \]

\[ \Sigma M_{yy} = 181,105 \text{ kft} \]

\[ \alpha_{xx} = 29.90' \]

\[ C_{yy} = 14.0 - 6.10 = 7.90' \quad \text{outside mld. F} \text{ by 0.90'} \]

\[ C_{xx} = 29.9 - 17.5 = 12.4' \quad \text{outside mld. F} \text{ by 3.65'} \]

\[ A = 2.37 \times 4.5 = 9.80 \text{ ft}^2 \]
INTERMEDIATE WALL MONOLITH #18 (GNT'60)

SOIL PRESSURE AT FOOT:

\[
\frac{c}{d} = \frac{1340}{350} = 3.856
\]

\[
\frac{c_{yy}}{b} = \frac{790}{280} = 0.282
\]

\[
c = 12.0
\]

\[
f = 12 \cdot \frac{60810}{980} = 79.5 \text{ ksf}
\]

\[
F_{s07} = \frac{6081 \times 17.5}{2650 \times 20.5 + 1000 \times 26.5 + 1380 \times 220} = \frac{106,000}{107,600} = 1.03
\]

\[
\Sigma H = 2650 + 1000 = 3650 \text{ k}
\]

\[
\Sigma V = 6081 \text{ k}
\]

\[
F_{ss} = \frac{6081 \times 0.625}{3650} = 1.04
\]

*Actual sliding will be resisted by sill seam*
STABILITY OF MONOLITH #1 DURING CONSTRUCTION

(OLD RIVER WALL)

\[
\begin{align*}
\frac{(25 \times 36 - 3.5 \times 18)}{15} &= 125 \text{k} \\
-13.3 \times 0.0625 \times 25 &= -21 \\
\Sigma Y &= 104 \text{k} \\
\end{align*}
\]

\[
\begin{align*}
1.92 \times 15/2 &= 17.8 \text{k} \\
Hw_1 &= 1.67 \times 26.7/2 = 22.6 \text{k} \\
&= 18.20 = 403 \text{k} \\
Hw_2 &= 1.67 \times 9 = 15.6 \text{k} \\
&= 4.05 = 73 \\
\Sigma H &= 37.8 \text{k} \\
\Sigma M_z &= 479 \times 17.8 \times 4.17 = 5540 \text{k-ft} \\
M_{overt} &= 1040 \text{k-ft}
\end{align*}
\]
STABILITY OF MONOLITH #1 DURING CONSTRUCTION (CON'T)

\[ \Sigma V = 125.0 - 21.0 - 17.8 = 86.2 \text{k} \]

\[ \Sigma M = 554.0 \text{ k} \quad \Sigma H = 37.8 \text{k} \]

\[ e = \frac{554}{86.2} = 6.42' \quad a = 6.08' \quad \theta \]

\[ \left( \frac{b}{b} \right) = 4.16 - 6.42 = -2.26' \]

1. \[ R = 95.0 \text{ OUTSIDE MIDDLE } \frac{1}{3} \text{ BY } 2.4' \]

2. \[ \frac{\Sigma H}{\Sigma V} = \frac{37.8}{86.2} = 0.439 \]

3. \[ f_{sec} = \frac{24 \times 86.2}{3 \times 6.08} = 9.50 \text{ ksf} \]

4. \[ F_{SS} = \frac{86.2 \times 55}{37.8} = 125 \ast \]

\[ M_a = 473 + 17.5 \times 16.67 = 776 \text{ k} \cdot \text{ft} \]

5. \[ F_{SUT} = \frac{1453 + 12.5}{776} = 1.67 = \frac{1453}{1040} = 1.40 \]

* A. + C. SLIDING WILL BE IMPROVED, IF EXISTING PART OF MONOLITH #1 UNDER CONSTRUCTION WOULD BE CONTROLLED.
FOR FOUNDATION PRESSURES SEE .50 g

FOR PILE LOADS SEE p: .50 a and p .50 b
### Typical River Wall Monolith

<table>
<thead>
<tr>
<th>Loads in Kips</th>
<th>V</th>
<th>V</th>
<th>H</th>
<th>H</th>
<th>Arm</th>
<th>Max</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>6.0 x 10 x 15</td>
<td>9.0</td>
<td></td>
<td></td>
<td>5.0</td>
<td>45.0</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>5.0 x 20 x 15</td>
<td>6.8</td>
<td></td>
<td></td>
<td>6.5</td>
<td>44.2</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>5.0 x 12.0 x 15</td>
<td>9.0</td>
<td></td>
<td></td>
<td>8.0</td>
<td>72.0</td>
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<tr>
<td>C4</td>
<td>5.0 x 15.0 x 15</td>
<td>11.3</td>
<td></td>
<td></td>
<td>9.5</td>
<td>107.3</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>32.0 x 24.0 x 15</td>
<td>115.0</td>
<td></td>
<td></td>
<td>160.0</td>
<td>1615.0</td>
<td></td>
</tr>
<tr>
<td>C6</td>
<td>2.0 x 40 x 15</td>
<td>1.2</td>
<td></td>
<td></td>
<td>1.0</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>C7</td>
<td>17 x 4.8 x 15</td>
<td>10.8</td>
<td></td>
<td></td>
<td>14.0</td>
<td>151.5</td>
<td></td>
</tr>
<tr>
<td>C8</td>
<td>4.0 x 3.0 x 15</td>
<td>1.8</td>
<td></td>
<td></td>
<td>24.5</td>
<td>45.2</td>
<td></td>
</tr>
<tr>
<td>E5</td>
<td>10.0 x 18.0 x 15</td>
<td>20.8</td>
<td></td>
<td></td>
<td>17.0</td>
<td>354.0</td>
<td></td>
</tr>
<tr>
<td>E6</td>
<td>5.0 x 15.0 x 15</td>
<td>8.6</td>
<td></td>
<td></td>
<td>18.5</td>
<td>159.0</td>
<td></td>
</tr>
<tr>
<td>E7</td>
<td>5.0 x 12.0 x 15</td>
<td>6.9</td>
<td></td>
<td></td>
<td>20.0</td>
<td>138.0</td>
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</tr>
<tr>
<td>E8</td>
<td>5.0 x 9.0 x 15</td>
<td>5.2</td>
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<td></td>
<td>21.5</td>
<td>111.5</td>
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</tr>
<tr>
<td>∑</td>
<td>193.8</td>
<td>12.6</td>
<td></td>
<td></td>
<td>2647.2</td>
<td>196.7''</td>
<td></td>
</tr>
<tr>
<td>∑ V = 181.2 k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24505'' A''2</td>
<td></td>
</tr>
</tbody>
</table>
### Typical River Wall Monolith (Cont'd)

<table>
<thead>
<tr>
<th>Load in Kips</th>
<th>$V_1$</th>
<th>$V_2$</th>
<th>$H_1$</th>
<th>$H_2$</th>
<th>ARM</th>
<th>$M_{b1}$</th>
<th>$M_{b2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C13 8.0 x 19.0 x 15</td>
<td>22.8</td>
<td></td>
<td></td>
<td></td>
<td>4.0</td>
<td>91.4</td>
<td></td>
</tr>
<tr>
<td>C14 6.6 x 6.5 x 15</td>
<td></td>
<td>6.4</td>
<td></td>
<td></td>
<td>10.2</td>
<td>65.3</td>
<td></td>
</tr>
<tr>
<td>C15 15.0 x 29.25 x 15</td>
<td></td>
<td>66.0</td>
<td></td>
<td></td>
<td>7.5</td>
<td>496.0</td>
<td></td>
</tr>
<tr>
<td>C16 12.0 x 11.0 x 15</td>
<td></td>
<td>19.8</td>
<td></td>
<td></td>
<td>19.0</td>
<td>377.0</td>
<td></td>
</tr>
<tr>
<td>C17 12.5 x 7.25 x 15</td>
<td>13.6</td>
<td></td>
<td></td>
<td></td>
<td>21.25</td>
<td>290.0</td>
<td>1319.7</td>
</tr>
<tr>
<td>$\Sigma$ 128.6 $k$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_{w1}$ 3.10 x 49.5 x 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77.0</td>
<td>16.5</td>
<td>$M_{b2}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1270.0</td>
</tr>
</tbody>
</table>
TYPICAL RIVER WALL MONOLITH (CONT'D)

MONOLITH I (SH. #5)

\[ \Sigma V = 181.2 \text{k} \] (WITHOUT UPLIFT)

\[ \Sigma M_A = 2450.5 \]

LOCATION OF RESULTANT/VERT.

\[ \frac{2450.5}{181.2} = 13.50' \] (DISTANCE FROM "A")

HYDRAULIC UPLIFT

\[
\begin{array}{c|c|c|c|c}
\text{3.10 ksf} & 1.75 & 1.75 \text{ ksf} & 0.562 \times 24 = 13.5 \\
1.35 & 42.0 & 16.2 & 0.562 \text{ ksf/f} \\
\end{array}
\]

\[
1.75 \times 24.0 = 42.0 \text{k}
\]

\[
1.35 \times 24.0/2 = 16.2 \text{k}
\]

MONOLITH II (SH. #5)

\[ \Sigma V = 128.6 \text{k} \] (WITHOUT UPLIFT)

\[ \Sigma M_B = 1319.7 \text{k} \]

LOCATION OF RESULTANT

\[ \frac{1319.7}{128.6} = 10.3' \] (DIST. FROM "B")

HYDROSTATIC UPLIFT

\[
\begin{array}{c|c|c|c|c}
\text{120 ksf} & 1.8 \text{ ksf} & 28.0 & 102 \times 14 = 14.3 \text{k} - 19.3 \text{k} \\
\end{array}
\]
W.S. EL. @ "B" = 675.7 + \frac{1}{.0625} \left[ \frac{(3.10 - .18) 28 + .18}{52} \right] = 703.7'}
**TYPICAL RIVER WALL MONOLITH (UNITED)**

**MONOLITH (I) FOUNDATION PROPERTIES**

Piles C 3.0' SPACING 7 ROWS C 3' = 21.0'

For 30' WIDE MONOLITH X 24' DEEP

\[ I_{yy} = 20 \times 10.5^2 + 20 \times 7.5^2 + 20 \times 4.5^2 + 20 \times 1.5^2 = 3793 \]

\[ S_{yy} = \frac{3793}{10.5} = 362 \] FOR 1'0 WIDTH \( S = 12.0 \)

**MONOLITH (II) FOUNDATION PROPERTIES**

For 30' WIDE X 28.0' DEEP MONO.

\[ I_{yy} = 20 \times 12.0^2 + 20 \times 9.0^2 + 20 \times 6.0^2 + 20 \times 3.0^2 = 5400 \]

\[ S_{yy} = \frac{5400}{12} = 450 \] FOR 1'0 WIDTH \( S = 15.0 \)

**MONO'S (I) & (II) COMBINED**

\[ I_{yy} = 20 \times 3.0^2 + 20 \times 6.0^2 + 20 \times 3.0^2 + 20 \times 12.0^2 + 20 \times 15.0^2 + 20 \times 18.0^2 \]
\[ + 20 \times 21.0^2 + 20 \times 24.0^2 = 36670 \]

\[ S_{yy} = \frac{36670}{24} = 1550 \] FOR 1'0 WIDTH \( S = 51.7 \)
**TYPICAL RIVER WALL MONOLITH (CONTD)**

**MONOLITH FOUNDATION LOADING**

\[
\begin{align*}
181.2 & \times 11.5 = 2084 \\
-16.2 & \times 8.0 = -130 \\
-42.0 & \times 12.0 = -504 \\
\hline
\text{Total} & = \frac{1450}{1230} = 11.80' \quad (13.7' \text{ FROM 'A'})
\end{align*}
\]

\[
M_2 = 77.0 \times 16.5 - 123.0 \times 0.2 - 12.9 \times 4.0 = 1194.4''
\]

\[
\theta = \frac{1194.4}{1230} = 2.30' \quad \gamma = \frac{1}{2} - \theta = 5.7''
\]

**AERIAL LOADING,**

\[
A = 24.0 \text{ ft}^2
\]

**SOIL PRESSURE**

\[
f = \frac{123}{2.30} = \frac{35.6}{37 + ksf}
\]

**PILE LOADING,**

\[
P = \frac{123.0}{80/30} + \frac{1194.4}{12} = 46.0 \pm 99.0
\]

\[
P_{\text{MAX}} = 1450 k
\]

\[
P_{\text{MIN}} = -530 k
\]

*For combined pile loading, sf of sh = 2*
TYPICAL RIVER WALL MONOLITH (CONT'D)

MONOLITH (3), FOUNDATION LOADING

\[ 128.6 \times 10.30 = 1325.0 \text{ k} \]

\[ -14.3 \times 9.33 = -134.0 \]

\[ -5.1 \times 14.00 = -71.3 \]

\[ \frac{109.2^2}{1120.0} (M_b) \]

\[ X = \frac{1120.0}{109.2} \times 10.25 = 10.25 \times 3.75 \]

\[ M_b = 109.2 \times 3.75 + 1.75 \times \frac{3.75^2}{2} + 1.44 \times \frac{5.55^2}{2} = 415.0 \text{ k} \]

\[ \frac{1}{e} = 3.80 \text{ \& } S = \frac{10 \times 280^2}{6} = 1300 \]

\[ \frac{1}{e} - e = 0.8' \]

AREA LOADING

\[ f = \frac{109.2 + 415.0}{2} = 3.92 \pm 3.20 \]

\[ \frac{0.175 \times 2.8}{2} = 0.74 \]

\[ \frac{0.144 \times 5.5}{2} = 0.40 \]

\[ P_{max} = 7.12 \text{ k} \text{ \& } P_{min} = 0.72 \text{ k} \]

PILE LOADING

\[ P = \frac{109.20 + 415}{80/30} = 41.2 \pm 27.7 \]

\[ P_{max} = 68.9 \text{ k} \]

\[ P_{min} = 13.5 \text{ k} \]

FOR COMBINED PILE LOADING, SEE SHEET 3.
TYPICAL RIVER WALL MONOLITH (CONT'D)

COMBINED PILE LOADING FOR MONO'S 1 & 2

\[ M_{20} = 415.0 \text{kN} \]

\[
\begin{align*}
77.0 \times 16.5 & = 1270 \text{kNm} \\
-12.9 \times 4.0 & = -51.6 \\
\text{total} & = 1218.4 \text{kNm}
\end{align*}
\]

\[ y = \frac{1218.4}{64.1} = 19.1 \text{ in} \]

MOMENT C.E.L 684.45

\[ 64.1 \times (19.0 - 8.75) - 415.0 = 243.3 \text{kNm} \]

\[ \text{EH} = 64.1 \]

PILE LOADING

\[ P = \frac{1270}{8/3} - \frac{243.3}{51.7} = 480 - 4.7 \]

\[ P_{\text{max}} = 43.30 \text{k/side} \]

\[ P = \frac{1071}{9/3} + 4.7 \]

\[ P_{\text{min}} = 357 + 4.7 = 40.4 \text{k/side} \]

FOR PILE LOADS WHERE STEEL SHEET PILING IS NOT CONSIDERED, SEE P.50A
TYPICAL RIVERWALL MONOLITH
EXISTING CONDITION
NORMAL LOADING

ANALYSIS @ ELEVATION 675.7'

WALL JOINT

& PILES

FORCES PER 3' STRIP:

\( V = \) GRAVITY LOAD = 978 k

\( H = \) LAT'L HYDROSTATIC FORCE = 210 k

\( U = \) UPLIFT = 253 k

- Elevation 687.2'
- Elevation 690
- 12 k
- 8 k
- 26 psf
- 62.5 psf
- Timber pilers
- 0.53 ksf
- 0.19 ksf
- 0.72 ksf

1) MAX BEARING ON PILES = 50 k (PILE #16)

2) HORIZONTAL PILE LOAD = 13 k
TYPICAL RIVERWALL
EXISTING CONDITION
NORMAL LOADING

PILE FOUNDATION PROPERTIES

\[ I = 2(24)^2 + 2(21)^2 + 2(18)^2 + 15^2 + 2(12)^2 + 2(9)^2 + 2(4)^2 + 3^2 + 2^2 \]

\[ I_{Y-Y} = 3442 \text{ ft}^4 \]

\[ S = 3442 \text{ ft}^3 \text{ per 3 ft} \cdot \text{ft longitudinal} \]

Number of piles = 16

HORIZONTAL LOAD PER PILE

\[ P_H = \frac{230 - 30}{16} = 13.5 \text{ kips (Approx)} \]

Original and new river walls
**TYP. RIVERWALL MONOLITH, EXISTING CONDITION, NORMAL LOADING**

**GRAVITY LOAD**

<table>
<thead>
<tr>
<th>Fig.</th>
<th>GRAVITY LOAD</th>
<th>H</th>
<th>A</th>
<th>ARM A</th>
<th>ARM Y-Y</th>
<th>M_A</th>
<th>M_Y-Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6 x 10 x .15</td>
<td></td>
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<td>9.0</td>
<td>5.0</td>
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<tr>
<td>2</td>
<td>5 x 5 x .15</td>
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<td>6.8</td>
<td>6.5</td>
<td>44.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5 x 12 x .15</td>
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<td>8.0</td>
<td>72.0</td>
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</tr>
<tr>
<td>4</td>
<td>5 x 15 x .15</td>
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<td>11.3</td>
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<td>8.6</td>
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<td>5 x 12 x .15</td>
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<tr>
<td>9</td>
<td>32 x 24 x .15</td>
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<td>115.2</td>
<td>14.0</td>
<td>161.3</td>
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<tr>
<td>10</td>
<td>24 x 8.75 x (-.063)</td>
<td>-1.3</td>
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<tr>
<td>11</td>
<td>Π (4.8)^2 x (6.15)</td>
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<td>14.0</td>
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<td>151</td>
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<tr>
<td>12</td>
<td>4 x 3 x (-15)</td>
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<td>-1.8</td>
<td>24.5</td>
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<td>13</td>
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<td>47.3</td>
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<td>643</td>
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</tr>
</tbody>
</table>

**TOTAL**

\[
\text{ARMS Y-Y} = \text{ARMS} - 28',
\]

\[
295.8 \times 3 \text{ ft. strip of wall} = 887k
\]

\[
\Delta V = 24 \times 8.45 \times 3 \times .15
\]

\[
978.3 \times 14' = 13400k
\]

\[
\varepsilon V < \text{GRAVITY} = 978k
\]

\[
\varepsilon M_{Y-Y} < \text{GRAVITY} = 5298k
\]

**REFERENCE** Pg. 42

**TAKEN AT ELEVATION 684.45'**
Typical River Wall Monoliths
Existing, Normal Loading Condition

Max. Load on Piles @ EL. 675.7

Lateral Pressures:
\[ M_{\text{Gravity}} = 5298" \]
\[ (725.2 - 675.7)^2 \times 0.0625 \times 3 = +230^k \times 16.5 = 3795'k^2 \]
\[ (687.2 - 675.7)^2 \times 0.0625 \times 3 = -12^k \times 3.8 = -46'7 \]
\[ (650 - 651.7)^2 \times 0.026 \times 3 = -8^k \times 4.9 = -38'7 \]
\[ \Sigma H = 210^k \quad M_{\Sigma H} = 3711'k^2 \]

Uplift:
\[ 3.10 \times 52 \times 3 = +242^k ; \quad x 8.7 = +2105'2 \]
\[ 0.72 \times 52 \times 3 = +56 , \quad x 8.7 = -487'1 \]
\[ 0.53 \times 28 \times 3 = -45 \quad x 12 = -540'2 \]
\[ U = 253'k \]
\[ M_u = 2158'k \]

Pile Load:
\[ \Sigma V = 978 - 253 = 725^k \quad \Sigma M = +571'k^2 \]
\[ \frac{725}{16} - \frac{571}{143} = 41.3 \quad 42^k \text{ - P Vert. on Pile #1} \]
\[ \frac{725 + 571}{16} = 49.3 \quad 50^k \text{ - P Vert. on Pile #16} \]
FOR USE ON US. GOVERNMENT

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WORK ONLY

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\[ e = \frac{54.4}{2} - 27.8' = -2.58' \]

\[ \frac{1}{2} - e = 4.42' \]

\[ p = \frac{232.3}{54.0} (1 + \frac{6 \times 2.58}{54.0}) = \begin{cases} 
5.54 \text{ ksf max} \\
3.07 \text{ ksf min} 
\end{cases} \]

\[ \varepsilon_H = 63.5 \quad \varepsilon_H = 0.273 \\
\varepsilon_V = 232.3 \quad \varepsilon_V = 2.01 \]

\[ \psi = \text{P.S.S.} = 2.01 \]
Riverwall TYP. MONOLITH
CONSTRUCTION/Maintenance

Maximum bearing load on extreme "locksde" pile.

Assume complete transfer of vert.
load between original and new riverwall.

\[ \Delta V = 24 \times 8.45 \times 3 \times 0.15 = 91.3^k \times (-14) = -1278^k \]
\[ \Delta V_1 = 887.0^k \times (-4.53) = -4020^k \]
\[ U_1 = 14.8^k \times (-10) = 148^k \]
\[ U_2 = 11.3^k \times (+19) = 215^k \]

\[ \Xi V = \frac{952.2^k}{27.2^k} = \frac{14.3^k}{3} = -130^k \]

\[ \Xi H = \frac{952.2^k}{27.2^k} = \frac{5495^k}{143} \]

Force per pile, \( P = \frac{\Xi V \pm \Xi M}{S} \)

\[ P_1 = 98^k \text{ Pile #1} \]
\[ P_2 = 21^k \text{ Pile #2} \]

\[ P_H = \frac{27.2^k}{16} = 2^k \]
River Wall Monolith #19 (Cont'd)

Hydrostatic Pressure at Bottom

1). Lockside Average

\[
\frac{3.10 + 1.73}{2} = 1.92 \text{ ksf}
\]

\[
32 \times 28 \times 1.73 = 655 \text{ k}
\]

\[
32 \times 14 \times 1.19 = 534 \text{ k}
\]

\[
M_4 = 655 \times 16 + 534 \times 21.33 = 10450 + 11390 = 21840 \text{ k}\]

\[
\sum M_4 = 66,360 - 21840 = 44,520 \text{ k}
\]

2). Lockside Maximum

\[
M_4 = 10,450 + 1.185 \times 28 \times 1.19 = 10,450 + 22,700
\]

\[
M_4 = 33,150 \text{ k}\]
### River Wall Monolith #1 (Contd)

**Pile Loading for Average Hydrostatic Load**

\[ V = 6248 - 1189 = 5059 \text{ k} \]

\[ M_a = 73,260 - 21,940 = 51,420 \text{ k ft} \]

\[ a = \frac{51420}{5059} = 10.16 \quad \theta = \frac{320}{2} = 10.16 \quad \theta = 16.4' \]

\[ M_e = 5059 \times 5.84 = 29,500 \text{ k ft} \]

**Sheet Pile Loading**

\[ P_{SR} = \frac{5059 \times 99}{3 \times 600} = 1203 \pm 16.4 \text{ k ft} \]

For 15" SHT PILES, \( P_{max} = 91.8 \text{ k} \) \( P_{min} = 0.8 \text{ k} \)

**Max Load on Timber Piles**

\[ I_0 = 8690 \]

\[ S = \frac{8690}{6.0} = 725 \]

\[ P = \frac{5059 \times 29,500}{99 \times 725} = 51.10 \pm 40.7 \]

\[ P_{max} = 91.8 \text{ k} \quad P_{min} = 104 \text{ k} \]

\[ H = 2150 - 383 \times 1767 \text{ k} \text{ or } 17.8 \text{ EA. PILE} \]
River wall monolith #19 (lockside average), cont'd

Check area loading, assuming area between sheet piles:

\[ A = 29.0 \times 28.0 = 812 \text{ ft}^2 \]

\[ q = \frac{A}{l \times b} = \frac{812}{10.16 \times 5.84} = 13.6 \text{ ksf} \]

1. Resultant outside middle 3/4 by 400':

\[ A = 29.0 \times 28.0 = 812 \text{ ft}^2 \]

\[ q = \frac{A}{l \times b} = \frac{812}{10.16 \times 5.84} = 13.6 \text{ ksf} \]

2. \[ f_{swl} = 3 \times \frac{5059}{28 \times 0.66} = 11.8 \text{ ksf} \]

3. \[ \frac{\Sigma H}{\Sigma V} = \frac{1767}{5059} = 0.350 \]

4. \[ F_{55} = \frac{5059 \times 0.55}{1767} = 1.57 \]

5. \[ F_{SOT} = \frac{112,860}{61,440} = 1.84 \]
RIVER WALL MONOLITH NO. 19

EXISTING NORMAL LOADING CONDITION

PILE LOADING, ASSUMING THAT THE TIMBER PILES SUPPORT ALL THE LOAD

(BEARING CAPACITY OF STEEL SHEET PILING NOT CONSIDERED)

ASSUME 6 PILES COINCIDES WITH BASE

TIMBER PILES @ 3' O.C.

SPC. EACH WAY

"LOCK SIDE AVERAGE"

\[ \Sigma V = 5059 \times \frac{3}{8} = 540 \text{ k} \]

\[ \Sigma M_x = 29,500 \times \frac{3}{28} = 3160 \text{ k'} \]

\[ \Sigma H = 1767 \times \frac{3}{28} = 189 \text{ k'} \]

MAXIMUM LOAD ON TIMBER PILES:

\[ P = \frac{540}{9} + \frac{3160}{45} = 60 + 70 = \frac{130}{9} \text{ (MAX) /PILE} \]

MINIMUM LOAD ON TIMBER PILES = 60 - 70 = \frac{-10}{9} \text{ (MIN) /PILE}

HORIZONTAL LOAD PER PILE = \frac{189}{9} = \frac{21}{9} \text{ k' /PILE}
Riverwall Monolith No. 19 (Center)

Maximum Loading on Piles (Lockside Maximum)

\[ \Sigma V = 6268 - 1717 = 4551 k \]
\[ M_x = 73260 - 33150 = 40110 k \]
\[ \alpha = \frac{40110}{4551} = 8.85 \quad \epsilon = \frac{320}{2} - 8.85 = 7.14' \]
\[ M_d = 7.14 \times 4551 = 32350 k \]

\[
\begin{align*}
I_{xx} &= 18 \times 14.5^2 + 18 \times 12.0^2 + 18 \times 9.0^2 + 18 \times 6.0^2 + 18 \times 3.0^2 \\
&= 8690 ft^4
\end{align*}
\]

\[ S_{xx} = \frac{8690}{16.50} = 5200 ft^3 \]

Max Load on Sheet Piling

\[ P = \frac{4551}{99} \times \frac{32350}{500} = 45.60 \times 54.00 \left( \frac{99.60}{k} \right) \]

For 15' Sht. Piles \( P_{max} = 41.6 k/pile \quad P_{min} = 3.5 k/pile \quad \text{(Tens.)} \)

Max Load on Timber Piles

\[ I_{xx} = 8690 ft^2 \quad S_{xx} = \frac{8690}{12} = 725 ft^2 \]
RIVER WALL MONOLITH NO. 19

EXISTING, NORMAL LOADING CONDITION

PILE LOADING

ASSUMPTION THAT PILES SUPPORT ALL LOAD

"LOCK SIDE MAXIMUM." - Reference pgs 56 & 55

\[ \epsilon_V = 4531 \times \frac{3}{28} = 486 \text{k} \quad \text{SECT. MOD., } S = 45 \text{ ft}^3 \]

\[ \epsilon M_e = 32,350 \times \frac{3}{28} = 3466 \text{k} \]

\[ P_{\text{max}} = \frac{486 + 3466}{45} = 54 + 77 = \frac{131}{45} \text{k} \]

\[ P_{\text{min}} = 54 - 77 = - \frac{23}{45} \text{k} \]

\[ P_H = 21 \text{k} \]
Riverwall Monolith #19 (Silty Sand)

Max Load on Timber Piles (Locked Maximum) (Cont'd)

\[ P = \frac{45.6 \times 22350}{725} = 45.6 \times 31 = 800 \text{kN} \]

\[ P_{\text{max}} = 90.2 \text{kN}, \quad P_{\text{min}} = -10.4 \text{kN} \]

\[ N/\text{pile} = 17.8 \text{kN} \]

Check Foundation Loading, Assuming Area (Between Sheet Piling) Supporting All Loads (Aber Loading)

\[ A = 230 \times 28 = 810 \text{ ft}^2 \]

\[ e = 7.14', \quad \alpha = 7.45 - 7.14 = 0.36' \]

1. Resultant outside middle \( \frac{\alpha}{2} = 7.14' \)

\[ \frac{32}{6} = 1.80 \]

2. \( f_{\text{soil}} = \frac{2 \times 4531}{3 \times 28 \times 7.14 \times 0.36} = 12.17 \text{kN} \)

3. \( F_{\text{S.F.}} = \frac{4531 \times 0.55}{1767} = 1.41 \text{kN} \)

4. \[ \frac{E}{V} = \frac{1767}{4531} = 0.39 \quad (\text{for } f=5.5 \text{ ksi, } \frac{F_{\text{S.F.}}}{F_{\text{soil}}} = 0.56) \]

5. \( F_{\text{soil}} = \frac{112.860}{39600 \times 33/50} = 1.55 \text{kN} \)
### Riverwall Gate Monolith #20 Cont'd

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>C1</td>
<td>746</td>
<td></td>
<td></td>
<td></td>
<td>4.0</td>
<td>22,984</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>958</td>
<td></td>
<td></td>
<td></td>
<td>10.7</td>
<td>10,220</td>
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</tr>
<tr>
<td>C3</td>
<td>9 x 28 x 0.087</td>
<td>88</td>
<td></td>
<td></td>
<td>11.5</td>
<td>1,000</td>
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<tr>
<td>C4</td>
<td></td>
<td>196</td>
<td></td>
<td></td>
<td>4.0</td>
<td>784</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td></td>
<td>260</td>
<td></td>
<td></td>
<td>14.0</td>
<td>3,560</td>
<td></td>
</tr>
<tr>
<td>Gate</td>
<td>230</td>
<td></td>
<td>28.5</td>
<td></td>
<td>14,654</td>
<td>30,544</td>
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</tr>
<tr>
<td></td>
<td>(\sum 7022 + 456)</td>
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<tr>
<td>Load in kips</td>
<td>V</td>
<td>V</td>
<td>Arm</td>
<td>Moment</td>
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<tr>
<td>C₄ + C₂ + C₃</td>
<td>6792</td>
<td>0</td>
<td>0</td>
<td>1820</td>
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<tr>
<td>C₄</td>
<td>196</td>
<td>0</td>
<td>5.56</td>
<td>1280</td>
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<td>C₅</td>
<td>260</td>
<td>7.0</td>
<td>1870</td>
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<tr>
<td>Gate</td>
<td>280</td>
<td>452</td>
<td>18.4 %</td>
<td>5980 ³/²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W₁</td>
<td>73 x 320 x 14.0</td>
<td>327</td>
<td>7.0</td>
<td>2290</td>
<td></td>
<td></td>
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<tr>
<td>W₂</td>
<td>119 x 32 x 14.0²</td>
<td>267</td>
<td>7.0</td>
<td>3570 ³/²</td>
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<tr>
<td>W₃</td>
<td>327</td>
<td>7.0</td>
<td>3730</td>
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<tr>
<td>Lockside Average</td>
<td>327</td>
<td>7.0</td>
<td>3570 ³/²</td>
<td></td>
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</tbody>
</table>

Lockside Maximum: 3270² x 1642 x 3570⁴/² = 7840 k²
RIVERWALL GATE MONOLITH #20 (CONT'D)

HYDROSTATIC LOAD ON GATES

\[ \frac{2.37 \times 320}{2} = 45.10 \, k \]
\[ \frac{2.37 \times 9.1}{66.7} = 21.60 \, k \]
\[ 45.1 \times 21.77 = 980.0 \, k \]

\[ y = \frac{1078.3}{66.7} = 16.2' \]
\[ \frac{21.6 \times 4.55}{66.7} = \frac{98.3}{1078.3} \, k \]

TOTAL GATE THRUST

\[ 66.7 \times 32.75 = 2180 \, k \]

\[ T = \frac{PL}{2 \sin \phi} \]
\[ S = T \cos 2\alpha \]
\[ X = T \sin 2\alpha \]
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RIVERWALL GATE MONOLITH 420 (REVIEWED)

\[ \Sigma M_{xx} = \Sigma (5980 - 3570 + 2050 \times (16.2 + 2.5)) = 40,820 \text{ k} \]

\[ \Sigma M_{yy} = 30,544 - 14,654 - 2470 \times 18.7 - 32 \times 28.9 \times 1.19 \times 160 - 105 \]

\[ = 31,525 - 47,774 = -16,250 \text{ k} \]

\[ \Sigma H_{yy} = 30,544 - 14,654 - 46200 - 1420 - 17800 + 650 \]

\[ + 221 = 31,525 - 47,774 = -16,250 \text{ k} \]

\[ \epsilon_x = \frac{7.25}{16,320} \]

\[ \epsilon_y = \frac{8.62}{16,320} \]

\[ \Sigma V = 7022 - 456 \times 3.27 - 267 = 5645 \text{ k} \]

\[ \Sigma H_x = 3260 \text{ k} \]

\[ \Sigma H_y = 2050 \text{ k} \]

\[ \Sigma H_R = 3850 \text{ k} \]

(CONT'D ON PAGE 65)
Riverwall Gate Monolith #20 (Cont'd)

Pile Loading for Lockside Average Uplift Pressure

\[
\begin{align*}
I_{yy} &= 8690 \\
S_{yy} &= 6090
\end{align*}
\]

Another computation for pile loads is on page 64 b, where sheet piling is not included.

\[
I_{xx} = 22 \times 3.0^2 = 198 \\
22 \times 6.0^2 = 792 \\
22 \times 9.0^2 = 1783 \\
22 \times 12.0^2 = \frac{3170}{5943}
\]

\[
S_{xx} = \frac{5943}{12} = 495
\]

\[
P = \frac{5645}{99} \pm \frac{40820}{495} \pm \frac{48550}{600} = 57.0 \pm 82.5 \pm 81.0
\]

\[
\text{MAX } P = 57.0 + 82.5 + 81.0 = 220.5 \text{ k}
\]

\[
\text{MIN } P = 106.5 \text{ k (Uplift)}
\]

Total \( H_x = 3260 \text{ k} \) or \( \frac{3260}{99} = 33.0 \text{ k/PILE} \)
River wall gate monolith #20 (cont'd)

Existing conditions - area loading (clockwise maximum)

\[ \Sigma V = 5380 \, \text{kN} \]

\[ \Sigma M_x = 40,820 + 1870 = 42690 \, \text{kN}\cdot\text{m} \]

\[ \Sigma M_y = 48,850 + 1420 = 49970 \, \text{kN}\cdot\text{m} \]

\[ \Sigma H_x = 3260 \, \text{kN} \]

\[ \Sigma H_y = 2050 \, \text{kN} \]

\[ A = 912 \, \text{ft}^2 \]

\[ c_y = \frac{42690}{5380} = 7.95 \]

\[ c_x = \frac{49970}{5380} = 9.29 \]

\[ c_{y/c} = 1.95/29.5 = 0.284 \]

\[ c_{y/c} = 3.29/29.5 = 0.113 \]

\[ k = 9.7 \]

1. \[ f_{sy} = 9.7 \times \frac{5380}{912} = 64.2 \, \text{kN/ft}^2 \]

2. \[ \text{3. Outside Kern} \]

3. \[ \frac{\Sigma H}{\Sigma V} = \frac{3260}{5380} = 0.61 \]

4. \[ S = \frac{5380 \times 0.55}{14.72} = 190 \]

\[ F_{ss} = \frac{5380 \times 0.55}{3851} = 0.77 \]
RIVER WALL GATE MONOLITH NO. 20
EXISTING, NORMAL LOADING CONDITION

ASSUME PILE FOUNDATION SUPPORTING ALL LOAD

"LOCK SIDE AVERAGE" Page 64

\[ \varepsilon_v = 5645 \]  
\[ \varepsilon_f = 4860 \]  
\[ \varepsilon_m = 3260 \]

\[ \varepsilon_x = 5645 \]  
\[ \varepsilon_y = 4860 \]  
\[ \varepsilon_m = 48550 \]

\[ P_{\text{max}} = \frac{5645 + \frac{48550 \times 12}{4860}}{81} \]

\[ + \frac{40820 \times 12}{4860} \]

\[ = 69.7 + 119.9 + 108.9 = 250.5 \]

\[ P_{\text{min}} = 69.7 - 119.9 - 100.8 = -151 \]

\[ P_{\text{h}} = \frac{3260}{81} = 40 \]
**River Wall Gate Monolith #20**  

Face 1/1.3, Normal Loading Conditions:

"Locally: Maximum" (Ref. p. 64)

\[
\begin{align*}
\Sigma V &= 5380k \\
\Sigma M_x &= 42691k \text{ in} \\
\Sigma M_y &= 49970k \text{ in} \\
\Sigma H_x &= 2260k \\
\Sigma H_y &= 2052k \\
\Sigma H_z &= 3851k \\
\end{align*}
\]

\[
\begin{align*}
R &= \frac{5380}{81} \pm \frac{42691 \times 12.0}{4862} \pm \frac{49970 \times 12.0}{4850} = \\
&= 66 \pm 165 = 131k \\
&= \begin{cases} 
5.14k \text{ max} \\
-162k \text{ min}
\end{cases}
\end{align*}
\]

\[
R_{Hx} = \frac{2260}{81} = 27.6k \text{ in} \\
R_{Hy} = \frac{3851}{81} = 48k \text{ in}
\]
RIVERWALL GATE MONOPOLE #20 (CONT'D)

CHECK SOIL PRESSURE, ASSUMING AREA LOADING

(LOCKSIDE AVERAGE)

\[ A = 29' \times 28' = 812 \text{ ft}^2 \]

\[ c_y = \frac{40820}{5645} = 7.25' \]

\[ c_x = \frac{48550}{5645} = 8.62' \]

\[ \frac{c_y}{b} = \frac{7.25}{28.0} = 0.26 \]

\[ \frac{c_x}{b} = \frac{8.62}{28.0} = 0.30 \]

\[ K = 7.70 \]

SUMMARY OF RESULTS

1. \[ f = 7.70 \times \frac{5645}{812} = 53.5 \text{ ksf} \]

2. RESULTANT OUTSIDE KERN

3. \[ \frac{\Sigma H}{\Sigma V} = \frac{3260}{5645} = 0.58 \]

4. \[ F_{SS1} = \frac{5645 \times 55}{3260} = 0.95 \quad F_{SS2} = \frac{5645 \times 55}{3850} = 0.81 \]

(FROM PAGE 63)
Sliding Stability

Top of imperious layer (unit B) EL 660.00

H.WL EL 725.2' \times 0.625 \times 65.2 = 4.08 klf

H_w = 0.625 \times 65.2^{3/2} = 133.0 k

H_{w2} = 0.625 \times 70.2^{3/2} = 154.0 k (top of imperious layer)

Total Vertical Load

ΣV = 6948 - 200 - 1190 = 5059 k

5059/28 = 180 k/ft or width

Weight of Soil

4 \times 28 \times 0.065 = 6.3 

11.6 \times 32.0 \times 0.068 = 25.7

9.5 \times 32.0 \times 0.115 = 35.0

ΣV = 180.0 + 31.5 + 35.0 = 246.5 k

ϕ = 22° \tan ϕ = .404

246.5 \times .404 = 100.5 k

ϕ = 23° \tan ϕ = .424

246.5 \times .424 = 104.5 k

ϕ = 18° \tan ϕ = .325 \times 246.5 = 80.5 k
SLIDING STABILITY (CONT'D)

\[ K_p = 1.5 \]

\[ 1.5 \times 1.3 = 1.95 \text{ ksf} \]
\[ 1.5 \times 0.68 = 1.02 \text{ ksf} \]
\[ 1.5 \times 1.15 = 1.73 \text{ ksf} \]

\[ 0.85 \times 27.2 = 23.1 \text{ k} \]

\[ 0.5 \times 1.73 \times 4.8^2 = 2.0 \text{ k} \]

\[ 0.83 \times 27.2 + 1.90 \times 27.2 = 60.8 \text{ k} \]

\[ 9.5 \times 3.63 + 1.93 \times 9.5 = 43.1 \text{ k} \]

\[ \Sigma H = 2.0 + 23.1 + 60.8 + 43.1 = 129.0 \text{ k} \]

\[ 5.49 \times 5.0 + 2.5 \times 9.8 = 29.9 \text{ k} \]

\[ \Sigma H = 129 + 30 = 159 \text{ k} \]
SLIDING STABILITY (CONT'D)

SLIDING STABILITY C CLAY SEAM - SUMMARY

Assume no cohesion in clay seam

\[ H_w = 4.08 \times 65.2/2 = 133.0 \text{ kN} (154^2) \]
\[ H_3 = 246.5 \times 4.04 = 100.0 \text{ kN} (104.5^2) \]
\[ H_0 = 129.0 \text{ kN} \]

\[ F_{SS} = \frac{100.0 + 129}{188.0} = 1.72 \quad \phi = 22^\circ \]
\[ F_{SS} = \frac{104.5 + 129}{183} = 1.75 \quad \phi = 23^\circ \]
\[ F_{SS} = \frac{80.5 + 129}{183} = 1.58 \quad \phi = 18^\circ \]
LANDWALL MONOLITHS #15 - STABILIZING BY ANCHORS

1. \( R = 219.0 \) k INSIDE MIDDLE
2. \( \frac{E + 4}{2V} = \frac{71.0}{207.8} = 0.343 \)
3. \( f_s = 6.5 \pm 5.2 \sqrt{\text{MAX} 11.7 \text{ ksf} \text{ MIN} 1.3 \text{ ksf}} \)
4. \( F_S = \frac{207x.625}{70.0} = 1.85 \)
5. \( F_S = \frac{68.31}{2404} = 2.0 \)

ANCHOR PLATE NUT

DRIVE POINT WITH CASING
(CASING WITHDRAWN H2)
63.5 k
62.5 k
10'-15' LG (CURRENT)
PRESTRESSING 187 k
3 ANCHORS FOR MONOLITH

HIGH PRESSURE GROUP
128 k
512 k
125
180 k
120 k
7'-140'
15'

LOW PRESSURE GROUP
405 k
345 k
615 k
420 k
10'-15' LG (CURRENT)

EL 700.0 WL

EL 673.2/4

C88KSE

EL 687.2

140'

30.0'

C88KSE
LANDWALL MONOLITHS 4-15 STABILIZING BY ANCHORS ONLY

\[ H_1 = 1.37 \times 32.7/2 = 22.40 \text{kN} \]
\[ H_2 = 1.37 \times 26.8 = 36.92 \text{kN} \]
\[ H_3 = 0.70 \times 26.8/2 = 9.36 \text{kN} \]
\[ H_4 = 0.80 \times 12.8/2 = 5.12 \text{kN} \]
\[ H_5 = 0.80 \times 14.0 = 11.20 \text{kN} \]
\[ \Sigma H = 85.0 \text{kN} \]
LANDWALL MONOLITHS *5-15 STABILIZING BY ANCHORS

(Cont'd)

MAXIMUM LOAD ON ANCHORS (ACTIVE PRESS. CONDITION)

\[
\begin{align*}
22.40 \times 37.7 &= 846.0 \\
36.92 \times 13.4 &= 495.0 \\
9.36 \times 8.93 &= 83.6 \\
5.12 \times 18.27 &= 93.4 \\
11.20 \times 7.00 &= 78.4
\end{align*}
\]

\[\Sigma 85.0 k\]
\[\Sigma 1596.4 k^1 / (m)\]

\[H = \frac{1596.4}{55.50} = 28.7 k / \text{ft. of wall}\]

\[\frac{T}{H} = \sqrt{3} \]

\[T = \frac{28.7}{3} \times 3.10 = 30.0 k, \quad V = 9.5 k\]

TOTAL SECTION 30' MONOLITH = 9000 k

USE 1/2" RYERSON "DYWIDAG" BILLS, WITH PRESTRESSING.

\[B0T_n = 187.2 k\]

CHECK STABILITY CONDITIONS USING 3 ANCHORS FOR EACH MONOLITH, SEE NEXT SHEET. \[3 \times 187.2 < 9000, \text{OK}\]
<table>
<thead>
<tr>
<th>Subject</th>
<th>LANDWALL MONOLITHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>FS 0 #1</td>
</tr>
</tbody>
</table>

**LANDWALL MONOLITHS 3'-15' STABILIZING BY ANCHORS (CONT'D)**

$130$ bars; $80.7^0 = 187.2^0$ (Ryerson Catalog 40-1 P. 35)

Loss of Prestress assumed 25ksi (ACI 318-71 Commentary)

Usable Tension $187.2 - .76 = 250 = 1482 k/lbar$

$$
\frac{3 \times 148.2 \times 3.0}{30} \times \frac{3.16}{3} = 14.04 \text{ k/ft} (= H) \quad \frac{3.16}{4} = \frac{1}{3}
$$

**EXISTING CONDITIONS**

$\Sigma V = 202.0 k \quad \Sigma H = 85.0 k \quad \Sigma M_a = 1647.0 k$

**IMPROVED CONDITIONS**

$\Sigma V = 202.0 + 50.0 = 207.0 k$

$\Sigma H = 85.0 - 14.0 = 71.0 k$

$\Sigma M_a = 1647.0 + 14.0 \times 55.5 = 2425 k$

$\Sigma R = 2190 k$

$$
\alpha = \frac{2425}{207} = 11.7'
$$

$$
e = 16.0 - 11.7 = 4.3'
$$

$M_{yy} = 4.3 \times 207 = 890.0 k$

$$
\sigma_{yy} = \frac{320}{6} = 1700 \text{ psi}
$$

$4051 + 14 \times 55.5 = 4231 k$

**FOR RESULTS OF IMPROVED CONDITIONS SEE SHEET #1**
LANDWALLS 5-15

ANALYSIS OF UPPER LANDWALL MONOLITHS FOR ASSUMED
WATER SURFACE ON LANDWARD SIDE AT ELEVATION 704

Ref.: pages 69-72, and 75a

\( P_n \) = Friction resistance due to weight of submerged slab = 5 k

<table>
<thead>
<tr>
<th>Forces for W.S.</th>
<th>Change in hydro-</th>
<th>Forces for W.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>@ E1. 700</td>
<td>Static and earth</td>
<td></td>
</tr>
<tr>
<td>(From p. 72)</td>
<td>pressures, (Pg 75c)</td>
<td>@ E1 704</td>
</tr>
</tbody>
</table>

\( \Sigma H \rightarrow E \) = 71k - \( P_n \) 6 k 77 - 5 = 72 k

\( \Sigma V \downarrow \Theta \) = 201 k - 4 k 203 k

\( \Sigma M_a \downarrow \Theta \) = -2425 k 163 k 2262 \text{ k}

\( \alpha = \frac{2262}{203} = 11.14^\circ \quad e = 4.86' < 5.33 \)

(1) Resultant, \( R = 203 \) inside middle \( \frac{1}{3} \) by \( 0.47' \)

(2) \( f_{soil} = \frac{208}{32} (1 + \frac{6 \times 4.86}{32}) = 6.34 (1 \pm 0.91) \)

\( f_{max} = 12.1 \text{ KSF} \)

\( f_{min} = 0.6 \text{ KSF} \)

(3) Factor of sliding = \( \frac{72}{203} = 0.35 \) \( \frac{EH}{EV} \)

(4) Factor of safety against sliding, \( F_S = 1.76 \)

(5) Factor of safety against overturning

\( F.S.O.T. = \frac{14051}{2447 - 14.0 \times 533} = 2.37 \)
**LANDWALL MONOLITHS 5-15' IMPROVEMENT & STABILITY, USING LARGER ANCHORS**

**ITEM 19 OF GENERAL COMMENTS RECEIVED 2/21/75**

Determination of maximum size of rock anchors in Landwall, utilizing only active soil pressure in backfill during prestressing.

```
| 1  | 22.5 k   | 37.8' | 851 |
| 2  | 37.0 k   | 13.5' | 500 |
| 3  | 9.5 k    | 9.0'  | 86  |
| 4  | 5.0 k    | 18.4' | 92  |
| 5  | 11.0 k   | 4.1'  | 52  |

Rb = 285 k
RC = 56.5 k

T = 28.5 k x 3.16 / 3.0 = .30 k per foot of wall

T = 30.0 x 15 = 450 k max for rock anchors SP0D 15', O.C.

# ASSUMED W.S. ELEV. DURING PRESTRESSING
```
LANDWALL MONOLITHS #5-15

IMPROVEMENT OF STABILITY BY LARGER ANCHORS (CONT'D)

ASSUME 2-1/4" RODS/ANCH. SEE SKETCH ATTACHED.

PRESTRESSING FORCE, 0.80 f_pu = 150 k = 2 x \frac{2}{300}

LOSTS 1.25 x 2 x 25 kpsi = -63 k

DESIGN CAPACITY PER ANCHOR = 237 k

ASSUME 3-1/4" RODS PER ANCHOR. 150 x 3 = 450 k

DESIGN CAPACITY/ANCHOR = 237 x \frac{3}{2} = 356 k

2-1/4" (DOUBLE ROD) CAPACITY = 237 = 15.8 \text{k/ft.} < 30 k

3-1/4" (TRIPLE ROD) CAPACITY = 356 = 23.7 \text{k/ft.} < 30 k

DOUBLE ROD ANCHOR:

15.8 x \frac{3.0}{3.16} = 15 k

23.7 x \frac{3.0}{3.16} = 22.5 k

TRIPLE ROD ANCHOR:

15.8 \times \frac{1}{3.16} = 5.0 k

23.7 \times \frac{1}{3.16} = 7.5 k

* TENSION DUE TO MAXIMUM ACTIVE SOIL PRESSURE
LANDWALL STABILIZATION IMPROVEMENT OF STABILITY USING LARGER ANCHORS

A. 2-1/4\" Ø STRAND PER ANCHOR, 2 ANCHORS PER MONOLITH

\[ \Sigma H = 85 - 15 - 15 = 55 \text{ k} \]

\[ \Sigma V = 207 + 5 + 5 = 212 \leq \]

\[ \Sigma M = 1647 + 55.5 \times 15.0 = 2480' \text{ k} \]

\[ L = 32' \]

\[ \frac{L}{2} = 5.3' \]

\[ \frac{L}{4} = 8.0' \]

RESULTANT INSIDE MIDDLE 1/2, 1.0

(1) \[ X = \frac{2480}{212} = 11.7' \]

\[ e = 4.3 \]

\[ f = \frac{212}{32} (1 + 6 \times 4.3) = \sqrt{12.0 \text{ KSF MAX.}} \]

\[ f = \frac{212}{32} = 3.27 \text{ KSF MIN.} \]

(3) \[ \frac{\Sigma H}{\Sigma V} = 0.33 \]

(4) FSS = 1.89

(5) \[ K.S.T. = \frac{4051}{2487 - 15.0 \times 55.5} = 2.45 \]

B. 3-1/4\" Ø STRANDS PER ANCHOR, 2 ANCHORS PER MONOLITH

\[ \Sigma H = 85 - 22.5 = 62.5' \]

\[ \Sigma V = 207 + 7.5 = 214.5' \]

\[ \Sigma M = 1647 + 55.5 (22.5) = 2896' \]

(1) \[ X = 13.5' \]

RESULTANT INSIDE MIDDLE 1/2 BY 2.83

(2) \[ f = \frac{2145}{32} (1 + 6 \times 2.5) = \sqrt{9.80 \text{ KSF MAX.}} \]

(3) \[ \frac{\Sigma H}{\Sigma V} = 0.29 \]

(4) FSS = 2.16

(5) \[ K.S.T. = \frac{4051}{2487 - 22.5 \times 55.5} = 3.27 \]
DRILL 1 HOLE THROUGH 5/8".
DRILL COUNTERSINK TWO HOLES AS DIMENSIONED.

MATERIAL
1R 1/2 x 7/8 x 8 A36
OR Fy Min = 33000, Carbon.

FOR REFERENCE ONLY.
For Reference Only.

MATERIAL

1/2 1 1/2 x 8 x 8 A36

OR MIN F'Y = 33000, MIN CARBON = .15
LANDSLIDE MONOPLANTS 2'-15' LONGERING BAKINGLY BY 10'-0"

1. $R = 180.0' - OUTSIDE $ by 0.5'
2. $\frac{\Sigma H}{V} = \frac{62.10}{178.2} = .343$
3. $F_{SS} = \frac{178.2 \times 62.6}{63.10} = 1.79$
4. $F_{SOT} = \frac{36/20}{1812.0} = 2.0$
### Landwall Monoliths #5

#### Stabilization of Land

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>40.0</td>
<td>72.0</td>
<td>16.0</td>
<td>1150.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>12.0</td>
<td>54.0</td>
<td>17.0</td>
<td>918.0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C3</td>
<td>8.0</td>
<td>2.1</td>
<td>28.0</td>
<td>588.0</td>
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<tr>
<td>C4</td>
<td>2.0</td>
<td>0.7</td>
<td>5.0</td>
<td>0.7</td>
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<tr>
<td>C5</td>
<td>47.5</td>
<td>42.8</td>
<td>15.0</td>
<td>94.0</td>
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<td></td>
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</tr>
<tr>
<td>E1</td>
<td>22.6</td>
<td>22.4</td>
<td>27.5</td>
<td>617.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>16.0</td>
<td>20.0</td>
<td>18.5</td>
<td>570.0</td>
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<td></td>
</tr>
<tr>
<td>E3</td>
<td>9.0</td>
<td>8.8</td>
<td>29.0</td>
<td>255.0</td>
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<td></td>
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</tr>
<tr>
<td>W1</td>
<td>88.0</td>
<td>26.4</td>
<td>17.0</td>
<td>450.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td>140.0</td>
<td>12.0</td>
<td>22.0</td>
<td>264.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>0.95</td>
<td>10.7</td>
<td>34.4</td>
<td>370.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>H2</td>
<td>0.95</td>
<td>25.6</td>
<td>13.5</td>
<td>345.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>H3</td>
<td>0.35</td>
<td>9.4</td>
<td>9.0</td>
<td>94.0</td>
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<tr>
<td>Hw1</td>
<td>0.84</td>
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<td>9.0</td>
<td>204.0</td>
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<tr>
<td>Hw2</td>
<td>0.44</td>
<td>6.2</td>
<td>4.7</td>
<td>29.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Moment = 83583.5

### Notes
- For use on U.S. Government work only
- Subject: Stability of Land
- Wall Monoliths
- Project: 450 #1
- File No.: B004A
- Date: 5/74, Page: 74 of 16
LANDOALL MONOLITHS 4&-15 - LOWERING BACKFILL BY 10' (CONT'D)

\[ \sum V = 222.8 - 44.60 = 178.2 \text{kF} \]

\[ \sum M = 3613 - 1812.0 = 1801 \text{kF'fe} \]

\[ \sum H = 62.1 \text{k} \quad R = 189.0 \text{fe} \]

\[ \alpha = \frac{1801}{1812} = 10.10 \]

\[ e = 32.0/3 - 10.10 = 0.57 \]

1. RESULTANT OUTSIDE MIDDLE 5 BY 0.57'

2. \[ \frac{\sum H}{\sum V} = \frac{6210}{178.2} = 0.343 \]

3. F.S.S. = \[ \frac{178.2 + 1625}{62.1} = 1.79 \]

4. \[ f_{w-x} = \frac{2}{3} \times 1812/10.10 = 12.0 \text{ ksf} \]

5. F.S.O.T. = \[ \frac{3613.0}{1812} = 2.0 \]
ANALYSIS OF UPPER LANDWALL MONOLITHS FOR ASSUMED WATER SURFACE ON LANDWARD SIDE AT ELEVATION 704

Reference: Pages 73-75 of this computation.

\[ H = 68 - 62 = 6 \]  
\[ V = 45 - 41 = 4 \]  
\[ M_A = 1047 + 110 - 969 - 725 = 163 \]
**Upper Landwall Monoliths, (cont'd)**

<table>
<thead>
<tr>
<th>Forces for W.S. @ El. 700</th>
<th>Change in Hydrostatic and Earth Forces</th>
<th>Forces for W.S. @ El. 704</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mathbf{E H} \rightarrow \mathbf{D} )</td>
<td>( +62^k - \mathbf{P}_r^* )</td>
<td>(+ 6^k)</td>
</tr>
<tr>
<td>( \mathbf{E V} \downarrow \mathbf{D} )</td>
<td>( +178^k )</td>
<td>(+ 174^k)</td>
</tr>
<tr>
<td>( \mathbf{EM}_A \mathbf{G} \mathbf{D} )</td>
<td>(-1801^k)</td>
<td>(+163^k)</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\mathbf{d} &= \frac{1638}{174} = 9.41^k \\
\mathbf{e} &= 16 - 9.41 = 6.59^k \\
\text{Resultant} \quad \mathbf{R} &= 174^k, \text{ outside max. } \frac{1}{3} \text{, } 1.26^k \\
\mathbf{f}_{\text{soil}} &= \frac{2}{3} \times \frac{114}{941} = 12.33 \text{ KSF} \\
\text{Factor of slippage} &= \frac{\mathbf{d}}{\mathbf{e}} = 0.35 \\
\text{Factor of safety against slippage} &= \frac{625}{1.36} = 1.74 \\
\text{F.S.O.T.} &= \frac{3519}{1718 + 163} = 1.87
\end{align*}
\]

*Friction resistance due to weight of submerged slab: \( \mathbf{P}_r = 56 \times 2 \times 0.002 \times 0.55 = 6^k \).
**Monolith No. 3**

**Normal Loading**
**Improved (or stabilized) Condition**

Backfill is lowered by 8', gate shafts are filled.

The only differences in load between this condition and that of existing (lowered conduit, shafts filled) condition are the following decreases: both in horizontal earth pressure and weight of backfill.

\[
\frac{20.7(0.042)}{2} = 9.0 k
\]

\[
20.7(0.042)(30.8) = 26.8 k
\]

\[
\Delta H = (17.3 - 9) + (37.3 - 26.8) = 8.3 + 10.5 = 18.8 k
\]

\[
\Delta M_a = (17.3)(40.4) + 9(37.7) + (10.5)(15.4) - 5(29) = (699 + 339) - 162 + 145 = -377 k
\]

\[
\Delta V = 8 \times 6 \times 0.11 = \frac{5 k}{29} \times \frac{29}{145} = 3.5 k
\]

\[
\Delta H_s = 8.5 - 18.8 = 66.2 k \\ \Delta V = 201.5 - 19.5 = 182 k \\ \Delta M_a = 1660 - 377 = 203 k
\]

\[
\text{Resultant outside middle} \frac{1}{3} \text{ by } 0.28' \\
\text{FS07 not necessary, resultant is almost at middle} \frac{2}{3} \text{ by } 2.05
\]

\[
\text{(1) Resultant outside middle } \frac{1}{3} \text{ by } 0.28' \\
\text{(2) } f_{w1} = \frac{2}{3} (19.5) = 12.6 \text{ ksf} \\
\text{(3) } E4/EV = 66.2/196 = 0.338 \text{ (4) SSF = 1.85} \\
\text{(4) FS07 not necessary, resultant is almost at middle } \frac{2}{3} \text{ by } 2.05
\]
MONUMENT NO 4
NORMAL LOADING
IMPROVED (OR STABILIZED) CONDITION

BACKFILL IS LOWERED BY 10 FEET - The only differences in load between this condition and that of existing (lowered conduit, 2 gate shafts full conc. sect.) condition are the following:

Decreases (ΔH, ΔV + ΔM) both in horizontal earth pressure and weight of backfill.

\[ 18.7^2 \left( \frac{1}{2} \right) (0.042) = 7.3 \text{ kips/ft of wall} \]
\[ 18.7 (0.042)(30.3) = 24.2 \]

However,

\[ \Delta H = 10.0k + 13.0k = 23.0k \]
\[ \Delta V = 10 \times 6 \times 11 = -6.6k \]
\[ -17.3 \times 40.4 + 7.3(37.3) = -429k \]
\[ -13.0 \times 1.5 \times 4 = -200k \]
\[ 6.6 \times 29.0 = 191k \]

\[ \Delta M_A = -438k3 \]

\[ \varepsilon_H = 85.0 - 23.0 = 62.0k \]
\[ \varepsilon_V = 191.0 - 6.6 = 184.4k \]
\[ \varepsilon M_A = -438 - 1958 = -438k3 \]

\[ a = 10.62' \]
\[ e = 5.38' \]
\[ e M_A = -438 \]

(i) Resultant outside middle \[ \frac{1}{3} \] by \[ \frac{0.05 + 0.01}{2} \]

(ii) \[ f_{w,1} = (2/3)(184.4)(\sqrt{19.6}) = 11.58 \text{ kips} \]

(iii) \[ (\varepsilon_H/\varepsilon_V) = 2.3 \text{ ksi} \]

(iv) S.S.F. = 1.86

(v) \[ q_{1/2} = 144.191 = 1797 = 2.06 = F.S.O.T. \]
LANDWALL GATE MONOLITH #7 - 10:0 BACKFILL REMOVAL

\[ H_1 = 0.95 \times 22.70/2 \times 28.6 = 309.0 \text{ k} 37.37 \text{ k} 11.500 \]

\[ H_2 = 0.95 \times 23.80 \times 28.6 = 810.0 \text{ k} 14.90 \text{ k} 12.030 \]

\[ H_3 = 339.0 \text{ k} 9.93 \text{ k} 3.950 \]

\[ H_4 = 145.0 \text{ k} 21.27 \text{ k} 3.100 \]

\[ H_5 = \frac{339.0}{1991.0 \text{ k}} 8.50 \text{ k} 3.310 \]

\[ V_3' = 6.0 \times 28.6 \times 10.0 \times 0.115 = 197.0 \text{ k} \]

\[ \Sigma V = 5910 - 197 = 5713 \text{ k} \]

\[ \Sigma H_x = 1991.0 \text{ k} \]

\[ \Sigma M_A = 108.30^4 - 197.0^2 \times 270 - 33.290 - 23460 = 46.234 \text{ k} \]

\[ \Sigma M_{xx} = 1550 \text{ k} \]

\[ \Sigma M_{yy} = 5289 \times 6.90 = 33120 \text{ k} \]

\[ \alpha = \frac{46.234}{5713} = 8.10 \]

\[ \epsilon = 15.0 - 8.10 = 6.90 > 5.00 \text{ OUTSIDE MIDDLE } \frac{1}{3} \text{ BY } 1.90 \]

MAX SOIL PRESSURE

\[ f = \frac{3}{2} \times \frac{5713}{206 \times 3.10} = 1644 \text{ ksf} \]
**LANDWALL GATE MONOLITH #17-10'0 BACKFILL REMOVAL**

\[ \Sigma V = 5713.0 \text{k} \]
\[ \Sigma H_{x} = 1991.0 \text{k} \]
\[ \Sigma H_{y} = 39.400 \text{ k} \]

1. \[ f_{so} = 16.44 \text{kse} \]
2. \[ R = 6050 \text{ k} \]
3. \[ \frac{\Sigma H}{\Sigma V} = \frac{1991}{5713} = .350 \]
4. \[ FSS = \frac{5713 \times 625}{19910} = 1.79 \]
5. \[ F_{sot} = \frac{102964}{56750} = 1.81 \]
LANDWALL GATE MONOLITH #17 - STABILIZING BY ANCHORS

1. \( f_{so/d} = 18.70 \text{ ksf} \)
2. \( R = 6440 \text{ kips} \)
3. \( \frac{\sum H}{\sum V} = \frac{2260}{5051} = 0.44 \)
4. \( F_{SS} = \frac{6054 \times 625}{7260} = 1.67 \)
5. \( F_{SOT} = \frac{13.504}{76920} = 1.71 \)
LAND WALL GATE MONOLITH #17 - STABILIZING BY ANCHORS

(Cont'd)

EXISTING CONDITIONS

\[ \Sigma H = 2685' \]
\[ \Sigma V = 5910' \]
\[ \Sigma M_a = 31,384'k \]
\[ \Sigma M_x = 1550'k \]

IMPROVED CONDITIONS USING 3 ANCHORS

3 - 1/8" ANCHORS, SEE CALCS FOR MONO'S #4 - 15

USEFUL TENSION 140.2'k/ton

\[ T = \frac{3.16}{3} \]
\[ T = 1422 \times 3 = 4266'k \]
\[ H = 425.0'k \]
\[ V = 1410'k \]

\[ \Sigma V = 5910' + 41 = 6051'k \]
\[ \Sigma H_{ton} = 2685 - 425 = 2260'k \]
\[ \Sigma M_a = 31384 + 425 \times 54.50 = 31384 + 23200 = 54584'k \]
\[ a = \frac{54584}{6051} = 9.00' \]
\[ r = 6.00' \]
\[ M_{yy} = 6051 \times 6.00 = 36,300'k \]
\[ f_{sm} = \frac{3}{900 \times 28.5} = 18.70'k/ft \]
LANDWALL GATE MONOLITH #17 - STABILIZING BY ANCHORS (CONT'D)

IMPROVED CONDITIONS OF STABILITY BY 3 ANCHORS (CONT'D)

\[
\frac{\Sigma H}{\Sigma V} = \frac{2260}{6057} = 0.37
\]

\[
f_{soil} = 18.70 \text{ ksf}
\]

\[
F_{SS} = \frac{6051 \times 625}{2260} = 167
\]

\[
M_4 = 108,304 + 23,200 = 131,504 \text{ k}
\]

\[
M_A^2 = 76,920 \text{ k}
\]

\[
f_{soil} = 131,504 \div 76,920 = 1.71
\]

\[
R = 6440 \text{ k}
\]

4 - \( \frac{1}{3} \) ROCK ANCHORS \( F_{SS} = 1.88 \)
LANDWALL GATE MONOLITH #17 - STABILIZING BY BACKFILL

REMOVAL (10 DEEP) AND ANCHORS (3 1/8" ANCHORS)

\[ \Sigma V = 571.3 + 141 = 5854 \text{ k} \]
\[ \Sigma H = 1991 - 425 = 1566 \text{ k} \]
\[ \Sigma M_A = 4623 + 425 \times 54.50 = 69484 \text{ k} \]
\[ a = \frac{69484}{5854} = 11.80 \]

1). E = 3.20
\[ M_{yy} = 5854 \times 3.20 = 18700 \text{ k} \]
\[ S_{yy} = 6 \times 320^2 \times 29.0 = 4290 \text{ ft}^3 \]
\[ A = 29.0 \times 320 = 9.55 \text{ ft}^2 \]
\[ \frac{\Sigma H}{\Sigma V} = \frac{1566}{5854} = 0.268 \]
\[ F_{SS} = \frac{5854 \times 625}{1566} = 2.34 \]
\[ M_A = 109,304 - 5340 + 2320 = 126,164 \]
\[ M_A^2 = 33,290 + 2,3460 = 35,636 \text{ k} \]
\[ F_{SOT} = \frac{126,164}{56,750} = 2.23 \]
Summary

Landwall Gate Mono #17 - Stabilizing by 10'-0" Backfill Removal

1. $R = 6050$ kips, middle 3' by 1.90'
2. $\frac{\Sigma H}{\Sigma V} = \frac{1981}{5713} = 0.35$
3. $f_{soil} = 16.44 ksf$
4. $FSS = \frac{5713 	imes 25}{1981} = 1.79$
5. $F_{SOT} = \frac{10296}{56750} = 0.18$

Landwall Gate Mono #17 - Stabilizing by 10'-0" Backfill -

- Removal and 2-1/2" Anchors

1. $R_{inside} middle 3' by 1.80'$
2. $\frac{\Sigma H}{\Sigma V} = 0.27$
3. $f_{soil} = 11.10 ksf$
4. $FSS = 2.34$
5. $F_{SOT} = 2.23$
Intermediate Wall Gate Monolith No. 18
Improvement of stability by vertical rock anchors
Normal loading condition

Assume 3-1/4" bore-tendons per anchor, design capacity = 356 k per anchor.

Approximate arrangement of 5" boreholes was estimated from drawings available with the indication that there is only very limited space for rock anchors.

Resultant of 12 Anchors:

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>6</td>
<td>7</td>
<td>42</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>134</td>
</tr>
</tbody>
</table>

\[ h = 11.2 \quad \text{ft} \]
\[ y = -2.8 \text{ ft} \]
\[ 12 \times 356 = 4272 \quad \text{lb} \]

From existing condition, pg 40

\[ \theta = 36.50° \quad V = 608.1 \quad x = 12.4' \quad y = -7.9' \]
I-WALL GATE MONOLITH 18
IMPROVEMENT OF STABILITY BY VERTICAL ANCHORS
NORMAL LOADING CONDITION (Cont'd)

Location of Resultant:

\[
EV = 427.4 \times 28 = 11962.8 \\
6081 \times 7.9 = 48040
\]

\[
EV = 427.4 \times 5.8 = 60400 \times (60400/60400) = EM_x
\]

\[
6081 \times 12.4 = 75400 \times EM_y
\]

\[
EM_x = 7.3, EM_y = 75400
\]

Bearing pressures: ("Foundation Design")

\[
E_x = 0.20, E_y = 0.20, K = 4.5
\]

(1) \[
F_{max} = K \times EV = 4.5 \times 10^{3.353} = 47.54 \text{ ksf}
\]

(2) Resultant is outside "KERN"

(3) Sliding factor (along x-axis) = 3650 = 0.353

(4) Sliding factor of safety = 0.625 = 1.77

Conclusion: Referring to results on page 4, bearing pressure decreased by 36%, but it is still too high. Stabilizing by interconnection of 3 monolithe is recommended.
STABILIZATION OF INTERMEDIATE WALL GATE MONO #18

12 ANCHORS WITH 500 KIPS CAPACITY EACH

\[ M_u = 37,606 \text{ k}\text{f}, \quad y = 6.1' \]
\[ M_{u2} = 181,105 \text{ k}\text{f}, \quad x = 29.9' \]

\[ \Sigma V = 6081 + 3600 = 9681 \text{ k}\text{f} \]

\[ x = \frac{6081 \times 17.4}{9681} = 7.8' \]
\[ y = \frac{6081 \times 7.9}{9681} = 4.96' \]

\[ c_x = \frac{7.8}{35.0} = .22 \quad c_y = \frac{4.96}{280} = .018 \]

\[ C = 4.2 \quad f_{sec} = 4.2 \times \frac{9681}{980} = 41.5 \text{ k}\text{f} \]

\[ F_{SOT} = \frac{9681 \times 17.5}{102.600} = 1.65 \]

\[ F_{S5} = \frac{9681 \times 1.625}{3850} = 1.66 \]
INTERMEDIATE WALL GATE MONOLITH #18

MONO'S #17, 18, 19 INTERCONNECTED

MONOLITH #19
### Intermediate Wall Gate Monolith #18 (Continued)

### Monoliths #18 & #19 Interconnected (Continued)

#### Monolith #19

<table>
<thead>
<tr>
<th>Load (kip)</th>
<th>$V_1$</th>
<th>$V_2$</th>
<th>Arm</th>
<th>$M_{max}$</th>
<th>$M_{max}^2$</th>
<th>$M_{yy}$</th>
<th>$M_{yy}^2$</th>
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<tbody>
<tr>
<td>1</td>
<td>35 x 23 x 57 x 15</td>
<td>6883</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5.5 x 3 x 23 x 0.087</td>
<td>38</td>
<td>14.75</td>
<td></td>
<td></td>
<td>487</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2 x 80 x 23 x 15</td>
<td>552</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2 x 6 x 8 x 23 x 0.063</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.5 x 3.08 x 0.5</td>
<td>693</td>
<td>8.5</td>
<td></td>
<td></td>
<td>5890</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4 x 8 x 53.5 x 15</td>
<td>257</td>
<td>10.5</td>
<td>2698</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4 x 9 x 12.3 x 0.063</td>
<td>25</td>
<td>10.5</td>
<td></td>
<td></td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>$\left(4 \cdot 2.5 \right)^2 \times 53 \times 15$</td>
<td>1533</td>
<td>6.5</td>
<td></td>
<td></td>
<td>9364</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>$\left(4 - 2.5 \right)^2 \times 74 \times 0.63$</td>
<td>95</td>
<td>6.5</td>
<td></td>
<td></td>
<td>553</td>
<td></td>
</tr>
</tbody>
</table>

$W_t = 115 \times 0.063 \times 2 \times 35$

$\Sigma 7/66 = 3618$

$\Sigma V = 3548$

$\Sigma T = 34552$

$\Sigma B = 99242$
**MONOLITH #18**

\[ M_y = 6081 \times 12.4 = 75500 \text{ kN-m} \]
\[ M_x = 6081 \times 7.90 = 48100 \text{ kN-m} \]
\[ V = 6081 \text{ kN} \quad \text{AREA} \quad 35 \times 18 = 980 \text{ ft}^2 \]

**MONOLITH #19**

\[ M_y = 3548 \times 2.51 = 8920 \text{ kN-m} \]
\[ M_x = 3548 \times 0.97 = 3450 \text{ kN-m} \]
\[ V = 3548 \text{ kN} \quad \text{AREA} \quad 23 \times 35 = 805 \text{ ft}^2 \]

\[ 6081 = 12.57 \]
\[ 3548 \times \frac{12.47 + 6.1}{9629} = 66000 \]
\[ y = \frac{66000}{9629} = 6.85 \text{'} \]
\[ 6081 \times 12.4 = 75400 \]
\[ 3548 \times 2.51 = \frac{8910}{84.310} \text{ kN-m} \]
\[ x = \frac{8910}{9629} = 0.975 \text{'} \]
INTERMEDIATE WALL GATE MONOLITH #18, INTERCONNECTED

WITH MONOLITH #19 (ON TIE ROD)

MONOLITH #19 \[ \Sigma V = 3548 k \]

\[ \Sigma M_x = 3455 k \text{ in} \]

\[ \Sigma M_y = 8924 k \text{ in} \]

\[ e_y = \frac{3455}{3548} = 0.97' \]

\[ e_x = \frac{8924}{3548} = 2.51' \]
**E**NGINEERING

**INTERMEDIATE WALL GATE MONO #18 & MONO #19**

INTERCONNECTED (UNITED)

(By shear keys)

\[ H_x = 3650 k \rightarrow \]

\[ H_y = 2210 k \downarrow \]

Resultant \( H = 9280 k \)

\[ M_{xx} = 9629 \times 3.25 = 31400 k' \]

\[ M_{yy} = 9629 \times 8.75 = 84200 k' \]

1). \( b = 7.175 \) & MIDDLE \( k \)

2). \( \frac{54}{25} = \frac{9629}{9629} = .445 \)

3). \( FSS = \frac{9629 \times 8.75}{4285} = 1.41 \) (Min. very resist. by floor)

4). \( f_{inl} = 3.25 \times \frac{6081}{28.35} = 2010k \times \)

\[ c = 3.25 \]

\[ \frac{975}{35.5} = 0.15 \quad \frac{c}{b} = \frac{3.25}{51.0} = 0.064 \]

5). \( FSO \times \frac{134}{170} \times \frac{170}{102400} = 1.75 \)

\[ 1.31 \]
INTERMEDIATE WALL GATE MONO #18 & MONO #19 INERTION

OVERTURNING STABILITY

MONOLITH WT. 6634 kN Myy = 116.900 kN-m α = 75°

\[ M = 1380 \times 20.0 + 563 \times 20.0 + 20.500 = 102.400 \text{kN-m} \]

\[ M_I = (6634 + 470) \times 17.5 + 490 \times 17.5 + 2470 \times 139.170 \times \text{kN-m} \]

WATER IN CULVERTS AND GATE SLOTS

8x10 x 28 x 0.063 = 141 k 141 + 85 = 226 k
8x6 x 28 x 0.063 = 85 k 141 - 85 = 56 k

GATE SLOTS 13.5 x 4.0 + (2x4-2) = 59.0 + 6 = 64.0 ft²
60 x 8.5 x 0.063 = 37 k 176 - 37 = 139 k
60 x 46.5 x 0.063 = 176 k 176 - 37 = 139 k

\[ M_y = 56 x 5.5 + 139 x 15.5 + 308 + 2100 = 2470 \text{kN-m} \]

\[ FS_{OT} = \frac{134.170}{102.400} = 1.31 \]

\[ 112.400 \]
FORCES IN MONOLITH #17

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>x</th>
<th>y</th>
<th>M&lt;sub&gt;x&lt;/sub&gt;</th>
<th>M&lt;sub&gt;y&lt;/sub&gt;</th>
</tr>
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<td>1</td>
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<td>+8394</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>9 x 3 x 2 x 29 x 0.15</td>
<td>+227</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>8 x 2 x 28 x 0.08</td>
<td>-358</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>54.6 x 4 x 2 x 19.5 x 0.15</td>
<td>-1278</td>
<td>0</td>
<td>4.25</td>
<td>-5432</td>
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<tr>
<td>5</td>
<td>47.1 x 4 x 19.5 x 0.63</td>
<td>+231</td>
<td>15.5</td>
<td>4.25</td>
<td>+915</td>
</tr>
<tr>
<td>6</td>
<td>12.1 x 4 x 19.5 x 0.63</td>
<td>+59</td>
<td>15.5</td>
<td>4.25</td>
<td>+251</td>
</tr>
<tr>
<td>7</td>
<td>4.7 x 4 x 2 x 2 x 0.15</td>
<td>-153</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SUB TOTAL</td>
<td>+711.6</td>
<td>-3450</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

UPLIFT

\[ H = \left( \frac{2.37 \times 1.3}{2} \right) + 2.37 \times 11.5 = 71.6 \]

\[ H = 71.6 \times 28 = 2000 \text{ K} \]

\[ \varepsilon = \frac{41784}{5737} = 7.28 \% \]

\[ \varepsilon = \frac{41784}{5737} = 7.28 \% \]

\[ \varepsilon_M = +41784 \text{ K} \]

\[ \varepsilon_M = -41993 \text{ K} \]
INTERMEDIATE WALL GATE MONOLITH #18 - IMPROVED CONDITIONS

OF STABILITY BY INTERCONNECTING MONO'S #17, 18 & 19

---

\[ \text{EV} = 15366 \text{k} \]

\[ \text{Hy} = 7210 \text{k} \]

\[ \text{Hx} = 2650 \text{k} \]

---

\[ \text{Y} \]

\[ \text{X} \]

\[ 28.99', 24.23' \]

\[ 35.0' \]

\[ 12.52' \]

\[ 13.5' \]

\[ 6081 \text{k} \]

---

\[ 5.1' \]

\[ 0.97 \]

---

\[ 0.76 \]

\[ \frac{0.76}{0.76} \text{ Hx = 2650k} \]

---

\[ 7.3\% \]

\[ 57.37 \text{k} \]

---

\[ 0.23' \]
INTERMEDIATE WALL GATE MONO *18 & MONO'S *17819

INTERCONNECTED BY SHANK KEYS.

OVERTURNING STABILITY

\[ M = 102,200 + 1260 \times 27.27 + 960 \times 7.3 + 1380 \times 2.5 = 147,380 \]  
\[ H = (2.37 \times 38.92 + 2.37 \times 14.5) \times 28 = 1260 + 960 = 2220 \]  
\[ F_{307} = \frac{6960 \times 17.5 + 134170}{147380} = \frac{319340}{147380} = 2.17 \]
INTERMEDIATE WALL GATE MONO #18 & MONO'S #17 & #19

INTERCONNECTION BY SHEAR KEYS (CONT'D)

\[ M_{yy} = 5580 \times 7.4 + 6081 \times 12.4 + 3548 \times 2.5 = 125590 \text{ kN-m} \]

\[ E_x = \frac{125590}{15210} = 8.3' \]

\[ \Sigma V = 5580 + 6081 + 3548 = 15210 \text{ kN} \]

1. RESULTANT INSIDE MIDDLE BY ORI

2. \[ \frac{\Sigma H}{\Sigma V} = \frac{5650}{15210} = 0.37 \]

3. \[ F_{ss} = \frac{15210 \times 625}{5000} = 1.68 \]

4. \[ f_{so} = 2.60 \times \frac{6081}{35 \times 2.5} = 16.1 \text{kN/m} \text{ OK} \]

\[ \frac{c}{b} = \frac{8.3}{35} = 0.238 \quad c = 2.60 \quad a = 17.5 - 3.3 = 9.2 \]

5. \[ F_{soT} = \frac{256170}{147380} = 1.74 \]

\[ f_{soT} = \frac{2.5 \times 15201}{35 \times 2.5} = 13.4 \quad k = 2.5 \]

\[ \frac{e_x}{b} = \frac{8.3}{35} = 0.238 \quad \frac{e_x}{h} = \frac{1.24}{7.0} = 0.18 \]
River Wall Monolith #18

Backfilling Riverside up to EL 7100'

\[ \begin{align*}
  & \text{SHEAR} \quad \text{ARM} \quad \text{MOMENT ft-lb} \\
  H_{W2} &= 0.73 \times 11.4 \times 28 = 180 \text{ k} \\
  H_{E1} &= 0.96 \times 11.4 \times 28 = 307 \text{ k} \\
  H_{E2} &= 0.96 \times 11.6 \times 28 = 312 \text{ k} \\
  H_{E3} &= 1.15 \times 11.6 \times 28 = 488 \text{ k} \\
  \Sigma H &= 785.8 \text{ k} \\
  \Sigma M &= 8359.0 \text{ ft-lb} \\
  \end{align*} \]
**FOR USE ON U.S. GOVERNMENT WORK ONLY**

<table>
<thead>
<tr>
<th>HARZA ENGINEERING COMPANY</th>
<th>SUBJECT</th>
<th>IMPROVING CONDITIONS OF STABILITY OF RIVER WALL</th>
<th>PROJECT</th>
</tr>
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<td>STUDY 5</td>
<td>LD H</td>
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<td>S00A</td>
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<td>IMPROVING CONDITIONS OF STABILITY OF RIVER WALL</td>
<td>DATE: 10.74</td>
<td>PAGE: 96</td>
</tr>
</tbody>
</table>

**RIVER WALL MONOLITH #19 (UNITED)**

**BACKFILLING RIVERSIDE UP TO EL 7100' (UNITED)**

- \( \Sigma H = 2150 - 786 = 1364' \)
- \( \Sigma M_a = 110,200 - 39,600 + 3360 - 21,840 = 57,200' \)
- \( \Sigma V = 5059' \)

**Load on Timber Piles from Average Hydrostatic**

**Lockside Load**

\[
P = \frac{51,10 \times 23,800}{725} = 51,1 \pm 32.8'
\]

\[
\alpha = \frac{57,200}{5059} = 11.3\;
\gamma = 4.7\;
\]

\[M_d = 23,800'k
\]

\[H = 1364'k
\]

\[P_{\text{MAX}} = 88.9'k
\]

\[P_{\text{MIN}} = 18.3'k
\]

**Area Loading for the Same Condition**

1. Resultant inside middle \( \frac{0.63}{10.61} = 0.06 \)
2. \( f_{soil} = 72.20k_SF_{(MAX)} \)
3. \( \frac{1364}{5059} = 0.270 \)
4. \( f_{soil} = 5059kSF_{(MIN)} \)
5. \( f_{soil} = 1186\times 2.04 = 1.93 \)

**See Load on Timber Piles on Page 96**

Where steel sheet piling is neglected.
**River Wall Monolith #19 (Cont'd)**

**Backfilling Riverside up to El 7100 (Cont'd)**

**Load on Timber Piles from Max. Hydrost. Lockside Load**

\[ \Sigma H = 2150 - 786 = 1364 \text{kN} \]
\[ \Sigma V = 4530 \text{kN} \]
\[ M_A = 110280 - 39600 + 8360 - 33150 = 45900 \text{kNm} \]
\[ \alpha = \frac{45900}{4530} = 10.13 \quad \theta = 5.87' \]
\[ M_e = 26600 \text{kNm} \]

**Pile Load**

\[ P = 45.6 \pm \frac{26600}{725} = 45.6 \pm 36.7 \]
\[ P_{\text{Max}} = 82.3 \text{kN} \quad P_{\text{Min}} = 8.9 \text{kN} \]

**Area Loading**

1. **Resultant Outside Middle's by 7.86**
2. \[ f_{50\%} = 3 \times \frac{4531}{10.13} = 1280 \text{kN/m} \]
3. \[ \frac{\Sigma H}{2V} = \frac{1364}{4531} = 0.302 (\leq 0.367) \]
4. \[ F_s = \frac{4531 \times 55}{1364} = 1.83 \]
5. \[ F_{50T} = \frac{118640}{72750} = 1.63 \]

SEE PAGE 96C FOR TIMBER PILE LOADS WHERE STEEL SHEET PILING IS NEGLECTED
River Wall Monolith No. 19

Improve Normal Loading Conditions for Pile Loading
Backfill Riverside up to EL 710'

"Lockside Average" Reference page 86
For 3' Wall:

\[ \Sigma V = 5059 \times \frac{3}{2} = 542 \text{k} \]
\[ \Sigma M = 23,800 \times \frac{3}{2} = 2550 \text{k}\text{ft} \]
\[ \Sigma H = 1364 \times \frac{3}{2} = 146 \text{k} \rightarrow P_H = 16 \text{k} \]
\[ P_{\text{max}} = \frac{542}{9} + \frac{2550}{45} = 60 + 57 = 117 \text{k} \]
\[ P_{\text{min}} = 60 - 57 = 3 \text{k} \]

"Lockside Maximum" Reference page 97
3' strip of Wall:

\[ \Sigma V = 4530 \times \frac{3}{2} = 486 \text{k} \]
\[ \Sigma M = 26,600 \times \frac{3}{2} = 2850 \text{k} \]
\[ \Sigma H = 1364 \times \frac{3}{2} = 146 \text{k} \rightarrow P_H = 16 \text{k} \]
\[ P_{\text{max}} = \frac{486}{9} + \frac{2850}{45} = 54 + 63 = 117 \text{k} \]
\[ P_{\text{min}} = 54 - 63 = -9 \text{k} \]
River Wall Gate Monolith #20

Assume Monoliths #20 & #21 interconnected

Weight of Monolith #21

1. \(24.0 \times 57.0 \times 23.0 \times 0.15 = 4750\) k
2. \(4.0 \times 57.0 \times 23.0 \times 0.15 = 788\) k
3. \(9.0 \times 4.0 \times 23.0 \times 0.087 = 72\) k
4. \(-80.0 \times 23.0 \times 0.15 = -276\) k

Assumed piling: \(9 \times 8 = 72 + 2 \times 8 = 88\) k

Pile loading - Monolith #21 - existing condition

Uplift load: \(32 \times 23.0 \times 0.73 = 538\) k

\((538 - 538) / 88 = 54.5\) k/pile
**River Wall Gate Monolith #20 (Cont'd)**

**Assume Monoliths #20 & #21 Interconnected**

\[ I_{xx} = 22 \times 3.0^2 = 198 \]
\[ 22 \times 6.0^2 = 792 \]
\[ 22 \times 9.0^2 = 1780 \]
\[ 22 \times 12.0^2 = 3180 \]
\[ 22 \times 15.0^2 = 4960 \]
\[ 22 \times 18.0^2 = 7130 \]
\[ 22 \times 21.0^2 = 9100 \]
\[ 22 \times 24.0^2 = 12700 \]
\[ \frac{40440}{22} = 1880 \text{ ft}^4 \]

\[ S_{xx} = \frac{40440}{24} = 1680 \text{ ft}^3 \]

\[ I_{yy} = 2 \times 17 \times 3.0^2 = 306 \]
\[ 2 \times 17 \times 6.0^2 = 1220 \]
\[ 2 \times 17 \times 9.0^2 = 2750 \]
\[ 2 \times 17 \times 12.0^2 = 4900 \]
\[ 2 \times 17 \times 14.5^2 = 7150 \]
\[ 16326 \]

\[ S_{yy} = \frac{16326}{14.5} = 1133 \text{ CSHEET PILES} \]

\[ S_{yy} = \frac{16326}{12} = 1360 \text{ CTIMBER PILES} \]
River Wall Gate Monolith #20 (Cont'd)

Assume Monoliths #20 & 21 interconnected (Cont'd)

Center Gravity of Loads

\[ \begin{align*}
    5645 \times 0 &= 0 \\
    4736 \times 18.25 &= 88,700 \\
\end{align*} \]

\[ \frac{10441}{88,700} \]

\[ y = \frac{87,500}{10441} = 8.39' \]

\[ M_{xx} = 10441 \times 4.13 = 43,300 \text{ k} \]

\[ P = \frac{10441 \times 43300}{187} + \frac{43550}{1360} = 55.83 \pm 25.80 \pm 11.94 \]

Max Pile Load \( P = 17.3 \text{ k/PILE} \)

Min Pile Load \( P = -57 \text{ k/PILE} \)
Riverwall Gate Monolith #20 (Note:)

Backfilling Riverside up to EL 110.0'

\[
\begin{align*}
H_{W1} & = 118.0' \\
H_{E1} & = 307.0' \\
H_{E2} & = 312.0' \\
H_{E3} & = 48.8' \\
E1 & = 4.6 \times 30.4'' \times 28 \times 116 = 225 \times 14.47 = 3300''^3 \\
\sum M_y & = 8353.0 - 3300 = 5060''^3
\end{align*}
\]
RIVER WALL GATE MONOJ1TH #20 (LOADED)

BACKFILLING RIVERSIDE UPTO FL 7'0" (Lockside Average)

\[ \Sigma M_y = 5080 - .73 \times 5.8 \times 28 \times 3.87 - 117 \times 1.4 \times 28 \times 12.5 - 117 \times 11.6 \times 28 \times 5.8 \]
\[ \Sigma M_y = 40550 - 4130 = 44120 \text{ k} \]
\[ \Sigma M_x = 40,820 \text{ k} \]
\[ \Sigma V = 5645 + 128 = 5873 \text{ k} \]
\[ \Sigma H = 2684 \text{ k} \]
\[ \Sigma H = \frac{1}{2} (2684^2 + 1050^2) = 3380 \text{ k} \]

PILE LOADING

\[ P = \frac{5873}{99} + \frac{40820}{23.5} + \frac{44420}{600} = 59.4 + 62.4 = 73.8 \text{ k} \]
\[ \text{MAX} P = 215.6 \text{ k} \]
\[ \text{MIN} P = .96.8 \text{ k} \]

AREO CODING FOR THE SAME CONDITIONS

\[ c_y = \frac{40,820}{5873} = 6.95 \quad c_x = \frac{44,420}{5873} = 7.55 \]
\[ \frac{6.95}{25.0} = .25 \quad \frac{7.55}{25.0} = .30 \quad A = 23 \times 28 \times 812 \text{ ft}^2 \]
\[ L = 6.3 \]
\[ f_{50L} = 6.30 \times \frac{5873}{812} = 45.50 \text{ ksf} \]
River Wall Gate Model: #20
Hawker Side Latch Fitted Up to E1.710 k.

"Lock-side Analysis" (KFF, p. 103)

\[ \sum V = 5872 \text{k} \]
\[ \sum H_k = 4080 \text{k} \quad \sum M_y = 4440 \text{k} \]
\[ \sum H_x = 2634 \text{k} \quad \sum U_y = 2655 \text{k} \quad \sum U_x = 3282 \text{k} \]

\[ P_V = \frac{5872}{4860} \times \frac{3328}{4860} \times \frac{12}{4} = \]

\[ = 12 \pm 10 \pm 10 = \begin{cases} 12 \text{ k} \text{ max} \\ -12 \text{ k} \text{ min} \end{cases} \]

\[ \Delta = \frac{6.67}{23.1} = P_{wK} \quad \frac{23.1}{k} \]
River wall gate monolith #20 (cont'd)

Backfilling riverside up to EL 710.0'

Summary of results for area loading

1. \( f = 45.50 \text{kpsi} \)
2. \( R = 6500 \text{k} \)
3. \( \frac{\Delta M}{E V} = \frac{2684}{5873} = 0.45 \)
4. \( F_{55} = \frac{5873 \times 1.55}{2684} = 1.20 \quad F_{55R} = \frac{5873 \times 1.55}{3380} = 0.96 \)
RIVER WALL GATE MONOLITH #20
RIVER SIDE BACK FILLED UP TO EL 710.5

"LOCKSIDE MAXIMUM" (REF. P. 106)

\[ \Sigma V = 5610 \text{ k} \]
\[ \Sigma M_x = 42690 \text{ k"} \]
\[ \Sigma M_y = 45840 \text{ k"} \]
\[ \Sigma H_x = 2684 \text{ k} \]
\[ \Sigma H_y = 2050 \text{ k} \]
\[ \Sigma H_a = 3380 \text{ k} \]

\[ P = \frac{5610}{81} + \frac{42690 \times 10.5}{4860} = \frac{45840 \times 12.0}{4860} \]
\[ P = 69 + 105 + 113 = \begin{cases} 287 \text{ k max} \\ -149 \text{ k min} \end{cases} \]

\[ P_{H_x} = \frac{2684}{81} = 22 \text{ k} \text{ max} \]
\[ P_{H_y} = \frac{2050}{81} = 42 \text{ k} \text{ max} \]
River wall gate monolith #20 (lined)

Backfilling Riverside up to El 710.0 (Lockside maximum)

\[ \Sigma V = 5380 + 228 = 5610 \text{k} \]

\[ \Sigma H_x = 2684 \text{k} \quad \Sigma H_y = 2050 \text{k} \quad \Sigma H = 3380 \text{k} \]

\[ \Sigma M_{xx} = 42,690 \text{ in} \]

\[ \Sigma M_{yy} = 49,970 - 4130 = 45,840 \text{ in} \]

\[ F_{ssx} = \frac{5610 \times 0.55}{2684} = 1.15 \quad F_{ssy} = \frac{5610 \times 0.55}{3380} = 0.92 \]

\[ \theta_y = \frac{42690}{5610} = 7.6' \]

\[ \theta_x = \frac{45840}{5610} = 8.18' \]

\[ \frac{c_y}{d} = 7.6/2.0 = .372 \quad K = 7.6 \]

\[ \frac{c_x}{d} = 8.18/2.0 = .822 \]

\[ f_{soil} = 7.6 \frac{5610}{812} = 52.4 \text{k} \]
INTERCONNECTION OF RIVERWALL MONOLITHS 20, 19 & 21

"LOCKSIDE AVERAGE" UPLIFT

AREA:

19 = 896 ft^2
20 = 896 ft^2
21 = 736 ft^2

\[ I_y = \frac{79(32)^3}{12} = 215,700 \]

\[ I_x = \frac{32(79)^3}{12} = 1,315,000 \]

\[ V = \begin{bmatrix} 5059 & 5645 & 4796 \end{bmatrix} \]

\[ \begin{align*}
  M_x & = \begin{bmatrix} 29500 \end{bmatrix} \\
  M_y & = \begin{bmatrix} -25.5 \\ +9.75 \\ +28.0 \end{bmatrix} \\
  M_z & = \begin{bmatrix} -123,000 \end{bmatrix} \\
  M_r & = \begin{bmatrix} +55,000 \end{bmatrix} \\
  +134,300 \end{align*} \]

\[ R = \frac{15500}{\frac{5.04}{78200}} \]

\[ e_x = 3.89' \]

COMPUTE FOUNDATION PRESSURE AT POINTS 1, 2, 3, 4, 5 AND 6, ASSUMING NO TRANSFER OF VERTICAL LOAD BETWEEN MONOLITHS:
INTERCONNECTION OF 20, 19 & 21 (CONT'D) — NO BACKFILLING.

"LOCKSIDE AVERAGE:" \[ f_{11} = \frac{5059 + 60,300 (39.5) - 78,200 (16.0)}{896} = 5.65 - 1.81 \times 5.82 = 1.98 \text{ KSF} \]

\[ f_{12} = \frac{5059 + 60,300 (-11.5) + 5.82}{896} = 5.65 - 0.53 + 5.82 = 10.94 \text{ KSF} \]

\[ f_{13} = \frac{5059 + 60,300 (16.5)}{896} = 5.65 + 0.2 \times 5.82 = 12.86 \text{ KSF} \]

\[ f_{14} = \frac{4794 + 1.81 + 5.82}{736} = 4.79 + 0.2 \times 5.82 = 14.15 \text{ KSF} \]

\[ f_{15} = 6.52 + 0.76 - 5.82 = 1.46 \text{ KSF} \]

\[ f_{16} = 6.30 - 0.53 - 5.82 = -0.05 \text{ KSF} \]

**THE TENSION PRESSURES ARE NOT CRITICAL & THEREFORE FURTHER REFINEMENT IS NOT REQUIRED**

<table>
<thead>
<tr>
<th>MON. # 19</th>
<th>f_{max}</th>
<th>f_{min} *</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.94</td>
<td>-1.98</td>
<td></td>
</tr>
</tbody>
</table>

| MON. # 20 | 12.88 | -0.05* |

| MON. # 21 | 14.15 | 1.46    |

RESULTANT IS OUTSIDE OF KERN.
INTER CONNECTION OF RIVER WALL MONOCLYTHS 202 & 21

'LOCKSIDE MAXIMUM' UPLIFT

NO BACKFILLING

\[ I_x = 1,315,000 \\
I_y = 215,700 \\
4531 \times 7.14 = 32351 \\
5380 \times 9.29 = 49980 \\
4796 \times 0 = 0 \\
\left( 1.4707 \times 5.10 \right) \times 82331 = 82331 \]

\[ 4531 \times -25.5 = -115540 \\
5380 \times 10.45 = +56221 \\
4796 \times 28.0 = +134288 \\
\left( 1.4707 \times 5.10 \right) \times 74969 = 74969 \]

\[ M_x = 74969 = 0.0570; \quad M_y = 82331 + 0.384 \]

\[ I_x = \frac{1315000}{4531} = 289.6 \]

\[ f_1 = 5.06 + 0.0570(-39.5) + 0.381(16) = -3.30 \text{ KSF} \]

\[ f_2 = 5.06 + 0.0570(-11.5) + 0.381(16) = -10.51 \text{ KSF} \]

\[ f_3 = 6.00 + 0.0570(16.5) + 0.381(16) = 13.05 \text{ KSF} \]

\[ f_4 = 6.00 + 0.0570(11.5) + 0.381(-16) = -0.77 \text{ KSF} \]

\[ f_5 = 6.52 + 0.0570(36.5) + 0.381(16) = 14.88 \text{ KSF} \]

\[ f_6 = 6.52 + 0.0570(16.5) + 0.381(-16) = 1.35 \text{ KSF} \]
INTERCONNECTION OF 20, 19 & 21 - NO BACKFILL (CONT'D)

"LOCKSIDE MAX" UPLIFT

<table>
<thead>
<tr>
<th>MONOLITH</th>
<th>MAX</th>
<th>MIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>#19</td>
<td>10.51</td>
<td>-3.30</td>
</tr>
<tr>
<td>#20</td>
<td>13.05</td>
<td>-7.77</td>
</tr>
<tr>
<td>#21</td>
<td>14.98</td>
<td>1.35</td>
</tr>
</tbody>
</table>

SLIDING FOR MONOLITHS 20 & 21

"LOCKSIDE AVERAGE" UPLIFT

\[
\begin{align*}
\epsilon V_{20+21} &= 5645 + 4796 = 10441 \\
\epsilon H_x &= 1000 + 2470 = 3470 \\
\epsilon H_y &= -1895 \\
\epsilon H_R &= \frac{4030}{10441} \text{ (HORIZONTAL RESULTANT)} \\
\text{SLIDING FACTOR} &= \frac{4030}{10441} = 0.386 \quad \text{FSS} = 1.42, <1.5
\end{align*}
\]

"LOCKSIDE MAX" UPLIFT

\[
\begin{align*}
\epsilon V_{20+21} &= 5380 + 4796 = 10176 \\
\epsilon H_R &= \frac{4030}{10176} \\
\text{SLIDING FACTOR} &= \frac{4030}{10176} = 0.396 \quad \text{FSS} = 1.39, <1.5
\end{align*}
\]

THE TENSION PRESSURES ARE NOT CRITICAL.

FURTHER REFINEMENT IS NOT REQUIRED.
INTERCONNECTION OF RIVERWALL MONOLITHS 20, 19 & 21

"LOCKSIDE MAX." & "LOCKSIDE AVE" UPLIFTS

\[
\begin{align*}
2032 \times 24.5 &= 49784 \\
1000 \times 3.5 &= 3500 \\
&= \frac{53284}{217} \\
2470 \times (-3.5) &= -8645 \\
2050 \times (-16) &= -32800 \\
&= \frac{41445}{217}
\end{align*}
\]

\[
\begin{align*}
\varepsilon_M &= 118.39 \text{k in} \\
\varepsilon_H &= 5502 \text{ in} \\
\varepsilon_H &= 2050 \text{ in}
\end{align*}
\]

\[
J = I_x + I_y = 118,900
\]

\[
H &= 37.95 \text{ ft}
\]

\[
H_r = \frac{\varepsilon_M (r)}{H} = \frac{118.39 (37.95)}{118.600} = 3.78
\]

\[
H_r (X \text{ COMPONENT}) = 3.78 \times \frac{3}{37.9} = 3.59
\]

\[
H_r (Y \text{ COMPONENT}) = 3.78 \times \frac{12}{37.9} = 1.76
\]

\[
3.59 + 24.45 = 28.04 \approx 28 \text{ k (P = 30 k)}
\]

\[
1.20 + 9.11 = 10.31 \approx 10 \text{ k (MAX)}
\]

\[
\frac{49.5^2}{2} 0.0625 \times 28 = 2150 \text{ ft}
\]

\[
\frac{11.6^2}{2} 0.0625 \times 28 = \frac{118}{2032} \text{ ft} \Rightarrow \frac{1}{2} = 1016 \approx 1000 \text{ ft}
\]
INTERCONNECTION OF MONOLITHS 19, 20 121 — NO BACKFILL

"LOCKSIDE AVERAGE" UPLIFT

ASSUME NO TRANSFER OF VERTICAL LOAD BETWEEN MONOLITHS

\[ \Sigma M_y = 78,200' \text{ k}\] (Fr. Foundation pressure)

\[
\begin{align*}
5059 \times 24.5 &= 123945 \\
5645 \times -10.75 &= -60684 \\
4796 \times -240 &= -115084 \\
15500 &= 75823 \\
X &= 78200 = 5.05'
\end{align*}
\]

\[ EV = \frac{I_y}{I_x} \]

\[
\begin{align*}
I_x &= 105,000 \\
I_y &= 13,500 \\
M_x &= 0.72 \\
M_y &= 5.79
\end{align*}
\]

\[
P = 62 + 1.78(-34) + 5.79(-12)
\]

\[
P_1 = 62 - 27 - 69 = -34\text{ k}
\]

\[
P_2 = 62 + 1.72(-12) + 69 = 122\text{ k}
\]

\[
P_3 = 70 + 1.72(-9) - 69 = -6\text{ k}
\]

\[
P_4 = 70 + 1.72(-15) + 69 = 150\text{ k}
\]

\[
P_5 = 76 + 1.72(-18) - 69 = 20\text{ k}
\]

\[
P_6 = 76 + 1.72(32) + 69 = 172\text{ k}
\]

\[
\text{MONOLITH #} \quad 19 \quad \begin{array}{c} 122\text{ k} \\ 20 \quad 150\text{ k} \\ 21 \quad 172\text{ k} \end{array}
\]

\[ P_{\text{MAX}} \quad M_{\text{MIN}} \]

\[
\begin{align*}
\text{MONOLITH #} & \quad 19 \quad 122\text{ k} \\
20 & \quad 150\text{ k} \\
21 & \quad 172\text{ k}
\end{align*}
\]
INTERCONNECTION OF MONOLITHS 19, 20, 21 - NO BACKFILL

"LOCKSIDE MAXIMUM UPLIFT"

NO TRANSFER OF VERTICAL LOAD BETWEEN MONOLITHS

\[
\begin{align*}
\text{MY} & = \frac{82,331}{15,500} = 5.31' \\
\text{MX} & = 0.85 \\
\text{MY} & = 6.10
\end{align*}
\]

\[
N_y = \frac{4531 \cdot 56^k}{81} = 81 \cdot 5380 \cdot 66^k = 4796 \cdot 76^k
\]

MONOLITH # 19

\[
\begin{align*}
P_{\text{MIN}} & = P_1 = 56 + (0.85 \cdot 36) + 6.10(12) \\
& = 56 - 30 - 73 = -47^k \\
P_{\text{MAX}} & = P_2 = 56 + (0.85 \cdot 17) + 73 = 119^k
\end{align*}
\]

MONOLITH # 20

\[
\begin{align*}
P_{\text{MIN}} & = P_3 = 66 + (0.85 \cdot 9) - 73 = -14^k \\
P_{\text{MAX}} & = P_4 = 66 + (0.85 \cdot 15) + 73 = 151^k
\end{align*}
\]

MONOLITH # 21

\[
\begin{align*}
P_{\text{MIN}} & = P_5 = 76 + (0.85 \cdot 18) - 73 = 18^k \\
P_{\text{MAX}} & = P_6 = 76 + 30 + 73 = 179^k
\end{align*}
\]
RIVER WALL GATE MONOLITH #20 (CONT'D)

INTERCONNECTION OF MONOLITHS #19, 20 & 21 & BACKFILLING

\[
egin{align*}
\text{(4.20)} & \quad (4\text{.87}) \\
1364 & \quad 23.800" \\
28' & \quad .5059^l \\
& \quad (4.530) \\
& \quad (5.610) \\
& \quad (7.60) \\
& \quad (4.736^k)
\end{align*}
\]
River wall gate monolith #20 (continued)
Interconnection of monc's #19, 70, 21 & backfilling

**Lockside Average**

\[
\begin{align*}
5059 & \quad 23,800 \\
5873 & \quad 44,420 \\
4796 & \quad 0.0 \\
\frac{5059 + 5873 + 4796}{15.728k} & \quad \frac{68,220}{15.728} = 4.33 = \epsilon_x
\end{align*}
\]

\[
F_{55} = \frac{5059 + 4796}{3380} \times 55 = 1.7k
\]

\[
S_{soil} = \frac{5059 + 5873 + 4796}{3940} = 7.2 \pm 6.5
\]

Max 13.7 ksf

Min 0.7 ksf

**Lockside Maximum**

\[
\begin{align*}
4530 & \quad 26,600k \\
5610 & \quad 15,840k \\
4796 & \quad 0.0 \\
\frac{4530 + 5610 + 4796}{14936} & \quad \frac{72,840}{14936} = 4.84 = \epsilon_x
\end{align*}
\]

\[
F_{55} = \frac{5610 + 4796}{3380} \times 55 = 1.70
\]

\[
S_{soil} = \frac{5610 + 5610 \times 1.84}{3940} = 6.9 \pm 6.9
\]

Max 13.2 ksf

Min 0.0 ksf

(Next pp 107a to 108 e)
For use on U.S. government work only

Harza Engineering Company
Chicago

Subject: Pile Wall Stability
Pile Load
Computed: J.J
Checked: R.N.M.

Project: LD #1
File No.: 800A
Date: 3/75
Page 1 of 10 Pages

Laval W. A., Missouri, #19-30 & #21 Inter, Minnesota.
River side backfilled up to 61.76.

I = 2.9 * 36.3^2
23.2^2
23.2^2
24.5^2
21.5^2
18.3^2
14.5^2
11.5^2
7.7^2

10530000 Lb-ft

A

B

Y

X
LIVEFALL MONOLITHS #14, #20 & #21 INTERCONNECTION

'Locally Average' (cont'd)

\[ \Sigma V = 15956 \text{ kN} \]
\[ \Sigma M_x = 83124 \text{ kNm} \]
\[ \Sigma M_y = 63496 \text{ kNm} \]
\[ \Sigma H_z = 3386 \text{ kN} \]
\[ \Sigma H_y = 2050 \text{ kN} \]
\[ \Sigma M_H = 10596 \text{ kNm} \]

\[ A_P = \frac{5024 + \frac{83124 \times 36.3}{105300} + \frac{63496 \times 12.0}{13500}}{80 + 28 + 56} = 164 \text{ kN} \]
\[ B_P = \frac{5024 - \frac{83124 \times 36.3}{105300} - \frac{63496 \times 12.0}{13500}}{62 - 28 - 56} = -22 \text{ kN} \]

Assuming that all horizontal loads are taken by piles
(NO PASSIVE SOIL PRESSURE)

\[ y = r \cdot \sqrt{12.3^2 + 26.3^2} = 37.95 \]

\[ I_P = I_v + I_y = 105.3 + 12.6 = 117.9 \text{ m}^4 \]

\[ P_{Hx} = \frac{3617}{117.9} = 16.07 \text{ kN} \]
\[ P_{Hy} = \frac{9250}{117.9} = 78.0 \text{ kN} \]
\[ P_V = 13732 < 37.95 = 4.38 \text{ kN} \]
\[ P_{Fx} = 4.38 \cdot \frac{12.3}{117.9} = \frac{4.9}{2.7} = 1.78 \text{ kN} \]
\[ P_{Fy} = 4.38 \cdot \frac{26.3}{117.9} = 0.95 \text{ kN} \]

\[ \max P_H = \sqrt{(P_{Hx} + P_{Fy})^2 + (P_{Hy} + P_{Fy})^2} = \sqrt{(16.07 + 4.15)^2 + (78.0 + 0.95)^2} = 14.2 \text{ kN} \]
\[ \min P_H = 14.2 \text{ kN} \]
\[ A_V, P_H = 18.5 \text{ kN} \]

\[ r = 2.278 \]
RIVER WALL MONOLITHS #19, #20 & #21 INTERCONNECTED.
RIVERSIDE FACE FILLED UP TO EL. 710.0

"LOOK SIDE MAXIMUM" (REF. p. 97, 106 & 107)

**Vertical:**

\[
\begin{align*}
Y & = 1564.4 + 4530.2 - 5.87 \\
   & = 549.2 \text{(net)}
\end{align*}
\]

**Horizontal:**

\[
\begin{align*}
X & = 4520 \times 5.87 = 96.8 \\
   & = 5610 \times 8.15 \times 0.1 - 0.78 \\
   & = 5024 \times (-0.72) + 4622 \\
   & = 15164 \times 0.7854
\end{align*}
\]

\[
\begin{align*}
Y & = \frac{-78.14}{15164} = 0.00513 \\
X & = \frac{15164}{15164} = 1.00 \\
Y & = \frac{-96.8}{15164} = 0.00639
\end{align*}
\]

**Moment:**

\[
\begin{align*}
\text{Moment} & = 549.2 \text{(net)} \\
   & = 549.2 \text{(net)}
\end{align*}
\]
RAVIER WALL MONUMENTS #19, #20 & #21 INTERCONNECTED
RAVIER SIDE BACKFILLED UP TO FL 7/10, 0'  

"LOCKSIDE MAXIMUM" cont'd

\[ \Sigma V = 15164 \text{kL} \]

\[ \Sigma M_x = 169188 \text{kl} \]
\[ \Sigma M_y = 67859 \text{kl} \]

\[ \Sigma H = \text{same as "Lockside Average"} \]

\[ A'V = \frac{5024}{9 \times 7} + \frac{96982 \times 36.0}{105300} + \frac{67859 \times 16.0}{13500} = 80 + 33 + 60 = 173 \text{k} \]

\[ B'V = \frac{4530}{9 \times 9} - \frac{96982 \times 36.0}{105300} - \frac{67859 \times 16.0}{13500} = 56 - 33 - 60 = -27 \text{k} \]

\[ P = \begin{cases} \frac{1}{2} \times 22.78 \text{ max.} & \text{max. } \text{same as "Lockside Average"} \\ \frac{1}{2} \times 18.50 \text{ avg.} & \text{same as "Lockside Average"} \\ \frac{1}{2} \times 14.21 \text{ min.} & \end{cases} \]
## Pile Bearing Capacity

**Ultimate Bearing Capacity (From 1110-2-2906)**

\[ Q_u = A_z \frac{1}{15} D_z N_q + \frac{2}{3} A_f K D_z^2 \frac{1}{3} \tan \delta \]

- \( A_z = 0.755 \times 0.83^2 = 0.558 \text{ ft}^2 \)
- \( D_z = 13' \); \( N_q = 20 \)
- \( A_f = \pi \times 0.83 = 2.54 \text{ ft}^2 \)
- \( K = 1.50 \)
- \( \tan \delta = \tan 33^\circ = 0.65 \)

\[ Q_u = 0.558 \times 0.034 \times 13 \times 20 + 13 \times 1.50 \times 163 \times 0.034 \times 0.65 \]

\[ Q_u = 4.9 + 7.3 = 12.2 \text{ ton/pile} \]

Assuming \( F_s = 3 \)

\[ Q = 12.2/3 = 4.0 \text{ ton/pile} \]

**Pile Bearing Capacity** \( Q = 8.0 \text{kips/pile} \)
LOADING CONDITIONS — THE FOLLOWING ARE ASSUMPTIONS

AND OTHER GIVEN DATA USED IN THE ANALYSES OF

VARIOUS LOADING CONDITIONS. IN ALL CASES, THE HORIZON-

TAL PILE LOAD OF 45 PER PILE AND FRICTIONAL RESISTANCE

OF 40% APRON DUE TO ITS SUBMERGED WEIGHT ARE ASSUMED.

I NORMAL OPERATING CONDITION TO RESIST HORIZONTAL FORCES

1. UPSTREAM WATER SURFACE EL. 723.2
2. EXISTING SAND FILL IN DAM
3. UPSTREAM SEDIMENT EL 710.2
4. TAILWATER ELEVATION 690.6'
5. ICE PRESSURE 10 KIPS PER FOOT OF CREST HORIZONTAL
   AT ELEVATION 723.2'
6. TENDENCY OF MOUTH TO SLIDE TAKEN ALONG
   CRITICAL PLANE FROM BOTTOM OF Cutoff
   WALL, EL 684.6 TO EL 690.6 AT THE TOE.
   (FOR ALL LOADING CONDITIONS)

II FLOOD DISCHARGE CONDITION

A. 1965 FLOOD EXISTING CONDITION

1. MAX. UPSTREAM W.S. EL 734.7
   TAILWATER AND LOWER POOL EL 719.
2. SPACE INSIDE OF DAM FILLED WITH WATER
3. UPLIFT DETERMINED BY FLOW NET METHOD.

B. 1951 FLOOD EXISTING CONDITION

1. MAX. UPSTREAM W.S. EL 731
   TAILWATER EL 695.5 (BEFORE HYDRAULIC JUMP)
   LOWER POOL EL 709.0
2. UPLIFT DETERMINED BY FLOW NET METHOD.
3. WATER INSIDE DAM SAME LEVEL AS
   RELIEF HOLE OUTLETS (EL 697.4)
III EARTHQUAKE CONDITION

1. EARTHQUAKE INERTIA FORCES AND HYDRO-DYNAMIC FORCES ADDED TO AND ICE PRESSURE REMOVED FROM NORMAL OPERATING CONDITION.

2. EARTHQUAKE ACCELERATION ASSUMED TOWARD UPSTREAM DIRECTION E.G., FORCES ARE OPPOSITE (TOWARD DOWNSTREAM DIRECTION).

\[ \frac{2g}{g} = 0.1 \]
### Loading Condition

**1951 Flood Improved Condition**

1. **Maximum Upstream W.S. El 731**
   - Tailwater El. 695.5
   - Lower Pool El. 709.

2. **Uplift Determined by Flow Net Method**

3. **Water in Cavity of Dam Same Level as Relief Hole Outlets (El. 697.4 ft)**

4. **For Stabilization by Increasing the Height of Existing Sand Fill,** a sliding safety factor of 1.5 was set for the force of friction to equalize the combined tangential components of 4.9 ft H forces on an inclined sliding plane, and the required height of additional sand fill determined.
## NORMAL OPERATING CONDITION (EXISTING)

1. Bearing pressures
   - \( f_A = \frac{253}{244} \text{ KSF} \)
   - \( f_B = 1.08 \text{ KSF} \)

2. Resultant within middle \( \frac{1}{3} \), \( e = 4.32' \)

3. Sliding factor, \( \frac{R_T}{R_N} = 0.279 \)

4. "Sliding Safety Factor", \( SSF = 2.33 \) 
   \( (f = 0.649) \)
II  FLOOD DISCHARGE CONDITION

A. 1965 FLOOD EXISTING CONDITION

734.7

1. BEARING PRESSURES:
   \[ f_a = 1.36 \text{ ksf} \]
   \[ f_c = 0.85 \text{ ksf} \]

2. RESULTANT WITHIN MIDDLE 1/3; \( e = 0.32 \)

3. SLIDING FACTOR, \( \frac{R_T}{R_h} = 0.217 \)

4. SLIDING SAFETY FACTOR, \( SSF = 2.98 \)
   \( (f = 0.649) \)
II FLOOD DISCHARGE CONDITION

B. 1951 FLOOD EXISTING CONDITION

1. BEARING PRESSURES:
   \[ f_A = \frac{1.47}{120} \text{ KSF} \]
   \[ f_B = \frac{1.27}{120} \text{ KSF} \]

2. RESULTANT WITHIN MIDDLE \( \frac{1}{3} \)
   \[ e = \frac{0.72}{120} \]

3. SLIDING FACTOR \( \frac{R_T}{R_N} = 0.439 \)

4. SLIDING SAFETY FACTOR, \( SSF = 1.48 \)
III EARTHQUAKE CONDITION

(EXISTING)

1. BEARING PRESSURES
   \[ f_a = \frac{2.27}{2.81} \text{ KSF} \]
   \[ f_b = 1.28 \text{ KSF} \]

2. RESULTANT WITHIN MIDDLE \( \frac{1}{3} \), \( e = \frac{2.81}{2.81} \)

3. SLIDING FACTOR, \( \frac{R_I}{R_N} = 0.319 \)

4. SLIDING SAFETY FACTOR, \( SSF = 2.03 \)  
   \( (f = 0.649) \)
FLOOD DISCHARGE

1951 FLOOD - IMPROVED CONDITION

\[
\begin{align*}
(87 + \varepsilon V \cos 0.05^\circ) \cdot \frac{649}{1.5} &= 821 - \varepsilon V \sin 0.05^\circ \\
\varepsilon V &= 1463^k \quad \text{IMPROVED} \\
\varepsilon V' &= -1446 \quad \text{WITHOUT IMPROVEMENT} \\
\Delta V &= 17^k \quad \text{REQUIRED WEIGHT OF ADDITIONAL} \\
&\quad \text{SANDFILL FOR SSF OF 1.5} \\
1. \text{BEARING PRESSURES:} & \\
2. \text{RESULTANT HAVING MIDDLE THREE} & \\
3. \text{SLIDING FACTOR} &= 0.4 \\
4. \text{SSF} &= 1.5 \\
&= 1.48 \text{ ksf} \\
&= 1.30 \text{ ksf}
\end{align*}
\]
NORMAL
OPERATING CONDITION

ASSUMPTIONS:

1. UPSTREAM WATER SURFACE
   ELEV. 723.2
   \[ -56.6 \]

2. EXISTING SAND FILL '7' HIGH

3. UPSTREAM SEDIMENT HEIGHT 15'

4. TAILWATER ELEV. 690.6'

5. 8" TO 12" CONCRETE RESURFACING @
   DOWNSTREAM FACE.

6. 2' OF ICE = 10 ksi PER FOOT OF CREST

(PAGE 5 OF FM 110-2-5200)
<table>
<thead>
<tr>
<th>(FEET)</th>
<th>(FT-KIPS)</th>
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<tbody>
<tr>
<td>$2.75 \times 3.12 \times 16 \times 0.15$</td>
<td>57.95</td>
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<tr>
<td>$2.5 \times 12.5 \times 16 \times 0.15$</td>
<td>75.48</td>
</tr>
<tr>
<td>$2.75 \times 3.12 \times 16 \times 0.15$</td>
<td>69.42</td>
</tr>
<tr>
<td>$3.5 \times 0.37 \times 16 \times 0.15$</td>
<td>3.24</td>
</tr>
<tr>
<td>$4 \times 12.5 \times 16 \times 0.15$</td>
<td>20.51</td>
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<tr>
<td>$5.9 \times 4.2 \times 16 \times 0.15$</td>
<td>58.32</td>
</tr>
<tr>
<td>$3 \times 0.37 \times 16 \times 0.15$</td>
<td>30.32</td>
</tr>
<tr>
<td>$4.3 \times 9 \times 16 \times 0.15$</td>
<td>53.31</td>
</tr>
<tr>
<td>$10 \times 4.2 \times 16 \times 0.15$</td>
<td>33.00</td>
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<tr>
<td>$10 \times 1.5 \times (16 - 2) \times 0.15$</td>
<td>5.15</td>
</tr>
<tr>
<td>$0.4 \times 10 \times 0.33 \times 0.15$</td>
<td>0.30</td>
</tr>
<tr>
<td>$5 \times 0.33 \times 0.15$</td>
<td>0.25</td>
</tr>
<tr>
<td>$5 \times 0.42 \times 0.15$</td>
<td>56.32</td>
</tr>
<tr>
<td>$2 \times 3 \times 0.15$</td>
<td>1.57</td>
</tr>
<tr>
<td>$2.75 \times 3.12 \times 16 \times 0.15$</td>
<td>50.31</td>
</tr>
<tr>
<td>$1.0 \times 0.1 \times (16 - 2) \times 0.15$</td>
<td>3.11</td>
</tr>
<tr>
<td>$1.0 \times 0.1 \times 0.15$</td>
<td>3.11</td>
</tr>
<tr>
<td>$0.5 \times 4.2 \times 0.15$</td>
<td>2.09</td>
</tr>
<tr>
<td>$1.25 \times 4.7 \times 16 \times 0.15$</td>
<td>4.65</td>
</tr>
<tr>
<td>$2.7 \times 4.7 \times 16 \times 0.15$</td>
<td>52.27</td>
</tr>
<tr>
<td>$10 \times 0.5 \times (16 - 2) \times 0.15$</td>
<td>3.15</td>
</tr>
<tr>
<td>$1 \times 0.1 \times 0.15$</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Sub-total: $\frac{1154.27}{0.85} = 1354.32$
NORMAL CONDITION (CONT'D)

Areas:

\[ 4 \times 4 = 8.00 \]
\[ 4 + 2.2 = 3.10 \]
\[ \frac{4 + 1.5}{2} = 5.25 \]

\[ A_1 = 9.4 \]

\[ A_2 = \frac{2 + 2}{2} \]

\[ 4 \times 1.75 = 7.00 \]
\[ 4 \times 1.1 = 4.4 \]

\[ A_3 = 7.15 \]

\[ 4 \times 1.5 = 6 \]
\[ \frac{2.14 + 4.11}{2} = 2.84 \]

\[ A_{14} = 8.84 \]
NORMAL CONDITION (CONT'D)

BEARING PRESSURES:

\[ \gamma = \frac{37885}{36400} + 4.13 = 2.08 \]

\[ e = 30.4 - \bar{y} = 4.32 \]

\[ f_A = \frac{1724}{9278} \left( 1 + \frac{6 \times 4.32}{60.8} \right) = 2.53 \]

\[ f_B = 1.677 \left( 1 - 0.42 \right) = 1.02 \]

Ice 10x CONC:

\[ 40 \times 6.0 \times 16 \times 0.088 = 34 \times 54.6 = 1900 \]

\[ 20 \times 10 \times 16 \times 0.088 = 38 \times 87 = 3300 \]

\[ 3.3 \times 4.13 \times 16 \times 15 = 33 \times 2 = 66 \]

W leftovers of conv. below \[ E1 = 90.6 = 95 \times -1803 \]
<table>
<thead>
<tr>
<th>Layer</th>
<th>Size</th>
<th>Weight</th>
<th>Resurfacing</th>
<th>Stair Fill</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>15.8 x 10 x 16 x 0.15</td>
<td>37.92</td>
<td>7.8</td>
<td>296</td>
</tr>
<tr>
<td>43</td>
<td>5.5 x 10 x 16 x 0.15</td>
<td>13.20</td>
<td>2.2</td>
<td>29</td>
</tr>
<tr>
<td>44</td>
<td>3.0 x 0.83 x 16 x 0.15</td>
<td>17.93</td>
<td>14.6</td>
<td>262</td>
</tr>
<tr>
<td>45</td>
<td>6.0 x 0.67 x 16 x 0.15</td>
<td>9.65</td>
<td>19.8</td>
<td>191</td>
</tr>
<tr>
<td><strong>Total 3</strong></td>
<td><strong>78.70</strong></td>
<td></td>
<td></td>
<td><strong>778</strong></td>
</tr>
</tbody>
</table>

**Concrete Fill:**
- 4 1/4 x 14 x 0.12 cement-sand fill: 526.4 tons
- 71/2

**Water:**
- H: $0.625 \times 32.5^3 \times \frac{1}{16} \times \frac{1}{2} + 528.13$ tons
- W: $22.23 \times 28.33 \times 16 \times 0.0254$ tons
- V: $32.5 \times 0.0625 \times 4 \times 16$ tons
- L: $32.5 \times 0.0625 \times 52.65 \times \frac{1}{16}$ tons

**Earth and Sediment Forces:**
- $H_{550}$: 0.20 x 5 x 15 x 16 x 0.5 + 37 tons
- $W_{550}$: 9.0 x 6.0 x 0.5 x 0.0675 x 16 tons

**Ice Pressure:**
- 10 x 16
- Sub-total 4 = \( \frac{160}{725.1} \times 93.4 \times 55.73 \times 32.5 \times 5200 \times 33225 \times 34225 \times 1803 \)
- Conc. below el 69.6 = 9.5

**Stability of Dam:**
- $A^1 = \frac{2.53}{102}$ KSF
- $A^1 = \frac{100}{102}$ KSF
NORMAL OPERATING CONDITION (CONT'D)

SLIDING SAFETY FACTOR (SSF)

ASSUME APRON SLAB & PILE RESISTANCE AS IN Pgs. 125

\[ R = \sqrt{728^2 + 1837^2} = 1976 \]

\[ \theta = \tan^{-1} \frac{728}{1837} = 21.62^\circ \]

\[ R_T = R \sin 15.57^\circ = 590 \]

\[ R_U = R \cos 15.57^\circ = 1903 \]

\[ SSF = \frac{0.649}{590/1903} = 2.33 \]
Above elev. 690.6 \(-725\) \(1631\)
Below 690.6:

\[ H_a = \frac{2.03 \times 6 \times 16}{2} \]
\[ E_a = 0.31 \times 6 \times 16 \]
\[ E_b = \frac{0.12 \times 6 \times 16}{2} \]
\[ S_a = \frac{52.6 \times 6 \times 16 \times 0.068}{2} \]
\[ C_a = 6 \times 4 \times 16 \times 0.088 \]

\[ \Delta H = 23 \]
\[ \Delta V = 200 \]

PILE RESISTANCE - 160
APRON SUBMERGED WT.
FRICITION RESISTANCE - 68
WITH 1.5 SAFETY FACTOR
\(C_f = 0.99\)

\[ 728^\circ \]
\[ 1837 \]

LOCK AND DAM #1
STABILITY OF DAM

Pd 1254
Py 135
FLOOD DISCHARGE CONDITION

APRIL 1951 FLOOD FORCES

APRIL 1965 FLOOD FORCES

W, 22.23\times 6
W_c 22.23\times 6
W_s (1965) 11.5
W_s (1951) 7.8

H, 0.0625\times 5
H_s (1965) = 7.8\times 5
H_s (1951) = 11.5\times 5

H_s (1965) = 0.06
H_s (1951) = 0.06

U_1 5.56 \times 3.3
U_2 4.5 \times 5.5
U_3 1.0 \times 4.4
U_4 3.06 \times 15
U_2 3.06 \times 6.6
U_3 25 \times 122
U_4 25 \times 3.6
U_5 10 \times 40.6

HS15 0.0205 \times 11
WS15 7 \times 6 \times \frac{1}{2} \times 1
F_1 (1951) 44 \times 3
F_2 (1965) 44 \times 3
F_2 47 \times 3.7
### R.N.M. 1/75

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>$W_1$</td>
<td>$22.23 \times 29.33 \times 1.0/2$</td>
<td>$326$</td>
<td>$44.5$</td>
</tr>
<tr>
<td>$W_2$</td>
<td>$22.23 \times 2.34 \times 1.0$</td>
<td>$52$</td>
<td>$55.5$</td>
</tr>
<tr>
<td>$W_3 (1965)$</td>
<td>$11.5 \times 31.7 \times 1.0$</td>
<td>$365$</td>
<td>$40.7$</td>
</tr>
<tr>
<td>$W_3 (1951)$</td>
<td>$7.8 \times 31.7 \times 1.0$</td>
<td>$247$</td>
<td>$40.7$</td>
</tr>
</tbody>
</table>

### $H_1$ (1951) $0.0625 \times 32.5 \times 16 \times \frac{1}{2}$ $1.6$ $528$ $1951$ Flood

### $H_2 (1965) = 11.5 \times 0.0625 \times 32.5 \times 16 + 2.54$ $16.3$ $4140$ $1965$ Flood

### $H_3 (1951) = 0.0625 \times 4.9 \times 16 \times 1/2 - 12$ $10.8$ $5720$

### $H_3 (1965) = 0.0625 \times 28.4 \times 16/2 - 403$

| $U_1$ | $55.6 \times 33.5 \times 1.0$ | $1863$ | $27.8$ | $51731$ |
| $U_2$ | $4.5 \times 55.6 \times 1.0/2 (1965)$ | $125$ | $37.0$ | $4625$ |
| $U_3$ | $1.0 \times 44.0 \times 1.0$ | $44$ | $56.1$ | $2468$ |
| $U_4$ | $30.6 \times 15.5 \times 1.0$ | $474$ | $15.3$ | $7252$ |
| $U_5$ | $30.6 \times 6.5 \times \frac{1}{2} \times 1.0$ | $99$ | $20.4$ | $2020$ |
| $U_6$ | $25 \times 22 \times 1.0$ | $550$ | $43.1$ | $23705$ |
| $U_7$ | $25 \times 3.6 \times \frac{1}{2} \times 1.0$ | $45$ | $41.3$ | $2129$ |
| $U_8$ | $1.0 \times 40.0 \times 1.0$ | $40$ | $56.1$ | $2244$ |

### $V_{S15} 0.0205 \times 15.2 \times 16 \times \frac{1}{2}$ $1556$ $1965$ Flood

### $V_{S15} 7 \times 6 \times \frac{1}{2} \times 0.675 \times 16$ $29$ $53.7$ $1556$

### $F_1 (1951) 44 \times 3.3 \times 14 \times 0.12$ $244$ $29.0$ $7076$

### $F_2 (1965) 44 \times 3.3 \times 14 \times 0.13$ $264$ $29$ $7651$

### $F_2 49 \times 3.7 \times 13 \times 0.13$ $294$ $29$ $8526$

### Lock and Dam No. 1

Stability of Dam

---

### Uplift

- **1965 Flood**
- **1951 Flood**
- **Uplift diagram**
- **Sediment**
  - $U = 130, k = 0.3$
  - $ Existing Sand fill $7076$ $7651$ $8526$
FLOOD DISCHARGE CONDITION

1965 FLOOD

Purpose

Determination of water using weighted mean theory for comparison with flow net method for design of small dams.
\[ H = 734.7 - 718 = 15.7' \]
\[ \frac{L}{H} = \frac{92}{H} = 5.95 \]

<table>
<thead>
<tr>
<th>Point</th>
<th>Creep length, x</th>
<th>Uplift, ((L-x)^\frac{1}{2} + 28.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>44.1</td>
</tr>
<tr>
<td>b</td>
<td>21</td>
<td>40.5</td>
</tr>
<tr>
<td>c</td>
<td>42</td>
<td>36.9</td>
</tr>
<tr>
<td>d</td>
<td>58.9</td>
<td>34.0</td>
</tr>
<tr>
<td>e</td>
<td>60.9</td>
<td>33.7</td>
</tr>
<tr>
<td>f</td>
<td>64.2</td>
<td>33.2</td>
</tr>
<tr>
<td>g</td>
<td>66.2</td>
<td>32.8</td>
</tr>
<tr>
<td>h</td>
<td>79.0</td>
<td>30.6</td>
</tr>
<tr>
<td>i</td>
<td>86.0</td>
<td>29.4</td>
</tr>
<tr>
<td>J</td>
<td>92.0</td>
<td>28.4</td>
</tr>
</tbody>
</table>

\[ u_1 = 37 \times 4 \]
\[ u_2 = 3 \times 52.6 / 2 \]
\[ u_3 = 34 \times 52.6 \]
\[ u_4 = 7.1 \times 4 / 2 \]

\[ u = 202 \text{ kips} \quad \text{creep theory} \]
\[ u_d = 2032 \text{ kips} \quad \text{Flow net method} \]

\[ \boxed{\text{USE FLOWNET}} \]

LOCK AND DAM NO. 1
STABILITY AT DAM
FLOOD DISCHARGE CONDITION

1965 FLOOD

Assumptions:
1. Max. flood el. 734.7 \{ April 1965 \\
T.W. el. 719.0 \} \\
2. Water inside Dam as high as T.W.

BEARING PRESSURES @ PTS. A' & B

\[ X = \frac{30757 \times 29.44}{1215} = 8.4 \quad e = 30.4 - 29.44 = 0.96 \]

\[ f(A') = \frac{1215}{972.8} \left( 1 + 6 \times 0.96 \right) = 1.36 \]

\[ f(B) = \frac{1215}{972.8} \left( 1 - 0.95 \right) = 1.13 \]
<p>| | | | | | |</p>
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<tbody>
<tr>
<td>H515</td>
<td>W515</td>
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<tr>
<td>Additional submerged concrete</td>
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<tr>
<td>below el. C90.6</td>
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</tbody>
</table>

**Concrete Resurfacing**

**R. M. W.**

11/13/75

0.96

189
FLOOD DISCHARGE

1965 FLOOD - EXISTING CONDITION

"SLIDING SAFETY FACTOR" AT PLANE AC

UPLIFT BY FLOW NET METHOD

ADDITIONAL FORCES BELOW EL. 690.6:

\[ \begin{align*}
\Sigma V' &= 1120 \text{k} + 131 \text{k} (\text{generated}) \\
\Sigma V_T &= 1326 \text{k} \\
\Sigma V &= 1120 + 206 = 1326 \text{k}
\end{align*} \]

\[ \begin{align*}
\Sigma H &= 536 + 131 - 228 = 439 \text{k} \\
\Sigma V &= 1120 + 206 = 1326 \text{k}
\end{align*} \]

\[ \begin{align*}
\Sigma H &= 439 \sin \theta = 46 \text{k} \\
\Sigma V &= 1326 \cos \theta = 1319 \text{k} \\
\Sigma H + \Sigma V &= 1365 \text{k}
\end{align*} \]

\[ \begin{align*}
\Sigma H_T &= 439 \cos \theta = 437 \text{k} \\
\Sigma V_T &= 1326 \sin \theta = -140 \text{k} \\
\Sigma H_T - \Sigma V_T &= 297 \text{k}
\end{align*} \]

\[ \text{SSF} = \frac{(\Sigma H_N + \Sigma V_N)(0.649)}{(\Sigma H_T - \Sigma V_T)} = \frac{1365 \times 0.649}{297} = 2.98 \]

CHECK:

\[ \begin{align*}
\theta &= \tan^{-1} \frac{43}{132} = 18.32^\circ \\
R &= R \sin \theta = 297 + 217 \\
R &= R \cos \theta = 1366 \\
\angle w &= 12.27^\circ \\
\text{SSF} &= \frac{55}{29/136} = 2.98
\end{align*} \]

(NEXT SHEET IS P. 125 a)
A. Frictional resistance of submerged concrete downstream, 44.13 ft. from pt. "A".

B. Critical shear section of apron checked for allowable force reaction assuming that the cut-off-wall, apron (2) & piles act as a solid support.

A. Submerged concrete wt. downstream of point "A":

- 2 x 10 x 16 x 0.088 = 28
- 3 x 4.13 x 16 x 0.088 = 17
- 40 x 3 x 16 x 0.088 = 141
- 3 x 4 x 16 = 192
- 2 x x x 12 = -24
- 3.5 x 4 x 2 = 28
- \( F = 203 \times 0.999 = 101 \) k

B. Shearing capacity of slab at section A-A:

\[ t = \frac{2}{L} \]

\[ L = 16' \]

\[ t \times L = A = 2 \times 16 \times 144 = 4608 \text{ in}^2 \]

\[ V = \frac{60 \times 4608}{276} = 276 \text{ k} \]

276 k shall be governed by pile resistance.

Assume 4' spacing e.w., 40 piles per 16' monolith.

40 x 4 k per pile = 160 kips.

\[ q = 160 \text{ k} \]

(Previous sheet is p. 125)
LOCK AND DAM NO. 1
UPLIFT UNDERNEATH THE DAM

DEC. 9, 1979
PROJECT 800 A
FLOOD DISCHARGE CONDITION

1951 FLOOD

Purpose: Determination of uplift using weighted creep theory for comparison with flow net method.
Ref.: DESIGN OF SMALL DAMS

\[ L = (6 + 1) \]

(For other information, see page 9)

\begin{align*}
U_1 &= 5.8 \times 90 \times 16 \\
U_2 &= 5.8 \times 1.3 \times \frac{3}{2} \\
U_3 &= 46.8 \times 1.2 \times \frac{3}{2} \\
U_4 &= 46.8 \times 7.1 \times \frac{3}{2} \\
U_5 &= 3.0 \times 1.3 \times \frac{3}{2} \\
U_6 &= 40 \times 1.0 \times \frac{3}{2}
\end{align*}
\[ L = \frac{(6 + 17.5 + 2) \times 2 + 80.75}{3} = 77.9 \text{'} \]

\[ H = 131 - 69.5 = 35.5 \text{'} \]

\[ r = \frac{1}{H} = 0.02843 \]

\[ U = \frac{L - x}{r} + 4.8 \]

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<tr>
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<tbody>
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<tr>
<td>e</td>
<td>-</td>
<td>-</td>
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<td>i</td>
<td>80.0</td>
<td>6.7</td>
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\[ \Sigma U = 850 \]

Creep theory: 1208
Flow net method: 1208

USE FLOW NET

LOCK AND DAM NO. 1
STABILITY OF DAM

[Signature]
**Flood Discharge**

**1951 Flood - Existing Condition**

**Assumptions:**

1. Max. flood el. 731'
   T.W. el. 695.5 (lower pool el. 709)
2. Water inside dam same level as relief hole outlets (697.4 ft)
3. Uplift by flow net method

**BEARING PRESSURES @ POINTS "A" AN "B"**

\[ \Delta H = 807 \text{ ft} \]
\[ \Delta V = 1335 \text{ ft} \]
\[ \gamma A = 4.13 \text{ ft} \]
\[ \gamma B = 34113 \text{ ft} \]
\[ L = 56.65 \text{ ft} \]
\[ L' = 60.6 \text{ ft} \]

\[ \overline{X} = \frac{34113}{1335} + 4.13 = 29.68 \text{ ft} \]
\[ \bar{e} = 30.4 \text{ ft} \]
\[ 0.72 \text{ ft} \]

\[ \begin{align*}
  f_A &= 9728 \left( 1 + \frac{0.72}{60.8} \right) = 1.47 \text{ KSF} \\
  f_B &= 1.370 \left( 1 - 0.071 \right) = 1.27 \text{ KSF}
\end{align*} \]

[Diagram of dam with points A and B, and calculations for uplift and bearing pressures]
Concrete D.L. Resurfacing

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<tr>
<td>W₂</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>W₃</td>
<td>247</td>
<td></td>
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|   |   |   |   |   |
|---|---|---|---|
| U₁ | 474 | 7252 |   |
| U₂ | 99  | 2020 |   |
| U₃ | 550 | 23705|  |
| U₄ | 45  | 2129 |   |
| U₅ | 40  | 2244 |   |

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<td>5720</td>
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<tr>
<td>H₂</td>
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<td>4140</td>
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<tr>
<td>H₃</td>
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</tr>
<tr>
<td>W₅15</td>
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<td>1556</td>
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</table>

Submerged conc. below Elev. 690.6

95

1803

807 2543 1208 1335 147395 81508 34113

A¹ = 1.41 ksf
B  1.27 ksf

29.68 ft

LOCK AND DAM NO. 1
STABILITY OF DAM
1951 Flood - Existing Condition

Sliding Safety Factor at Plane AC

Additional Forces Below El. 690.6:

\[ \varepsilon V' = 1240 \quad \text{(Carried from page 128)} \]

\[ \varepsilon H = 807 \quad \text{(Carried)} \]

\[ \varepsilon H = 1054 \quad \text{---} \]

\[ \varepsilon V' = 1240k \]

\[ S_a = 172 \]

\[ C_a = 34 \]

\[ \varepsilon V = 1446k \]

(Next sheet is p. 129a)
BUTTRESS DAM
1951 FLOOD — EXISTING CONDITION

DETERMINATION OF FACTOR OF SAFETY AGAINST SLIDING

\[
\frac{(\varepsilon H_n + \varepsilon V_n) \cdot 649}{\text{B.F.}} = \frac{\varepsilon H - \varepsilon V}{\text{B.F.}}
\]

\[\varepsilon H = 1054 \quad \varepsilon H = 1054 - 228 = 826^k \quad \varepsilon V = 1446^k\]

\[\varepsilon H_n = 826 \sin 6.05^\circ = 87 \quad \varepsilon V_n = 1446 \cos 6.05^\circ = 1438 \]

\[\varepsilon H = 826 \cos 6.05^\circ = 821 \quad \varepsilon V = 1446 \sin 6.05^\circ = -152\]

\[\text{SSF} = \frac{1524 \times 649}{66} = 1.48^k < 1.5\]

CHECK:

\[R = \sqrt{826^2 + 1446^2} = 1665\]

\[\Theta = \tan^{-1} \frac{826}{1446} = 29.74^\circ \quad \omega = -6.05^\circ \quad \omega = 23.69^\circ \]

\[\frac{R_T}{R_n} = \frac{R \sin \omega}{R \cos \omega} = \frac{669^k}{1525^k} = 0.439\]

\[\text{SSF} = 1.48\]

PREVIOUS SHEET IS P. 129
EARTHQUAKE CONDITION
(NORMAL CONDITION WITH EARTHQUAKE)

ASSUMPTIONS:

EARTHQUAKE INERTIA AND HYDRODYNAMIC
FORCES ADDED TO AND ICE PRESSURE
REMOVED FROM NORMAL OPERATING
CONDITION.
ACCELERATION IN UPSTREAM DIRECTION.

\[ y = \frac{h}{2} \times \sin \theta \]

\[ \text{EL 723.2} \]

\[ \text{EL 690.6} \]

\[ 13' \]

\[ 56.6' \]

\[ 57.6k \]

\[ 6.325 \]

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

59 x
75 x
69 x
9 x
221 x
58 x
28 x
54 x
337 x
96 x
3 x
0.3
0.2
56
4
6
3

Less Ice
Pe. Hydro
Inertia
Normal condition -- +725 1631

Less Ice pressure -- -160

$P_e$ Hydrodynamic 3.6x10 + 5%/6

Inertial forces:

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</tr>
<tr>
<td>2</td>
<td>75 x 0.1</td>
<td>+7.5</td>
</tr>
<tr>
<td>3</td>
<td>67 x 0.1</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
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<td>6</td>
<td>58 x 0.1</td>
<td>+5.8</td>
</tr>
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<td>7</td>
<td>28 x 0.1</td>
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<td>8</td>
<td>54 x 0.1</td>
<td>+5.4</td>
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<td>337 x 0.1</td>
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<td>12</td>
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<tr>
<td>13</td>
<td>0.25 x 0.1</td>
<td>--</td>
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<tr>
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<td>+5.6</td>
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<td>4 x 0.1</td>
<td>0.4</td>
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<tr>
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</tr>
<tr>
<td>17</td>
<td>3 x 0.1</td>
<td>0.3</td>
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EARTHQUAKE CONDITION (CONT'D)

**Corps of Engineers' Formula**

\[ Pe_x = \frac{2}{3} C_e \times y \sqrt{h_y} \]

\[ C_e = \frac{51}{\sqrt{1 - 0.72 \left( \frac{h}{1000} \right)^2}} \]

- \( h = \text{total height of dam} = 32.5' \)
- \( y = \text{depth of water} = y \)
- \( Pe_x = \frac{2}{3} \times 51 \times 0.1 \times 32.5 \sqrt{325} = 3.6 \text{kips/ft} \)
<table>
<thead>
<tr>
<th>R.N.M.</th>
<th>8/74</th>
<th>J1</th>
<th>3/26/75</th>
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<td>+ 5.2</td>
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<td>+ 0.3</td>
<td>180</td>
<td>5</td>
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<td>$0.3 \times 0.1$</td>
<td></td>
<td>180</td>
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<td>+ 0.7</td>
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<td>+ 0.4</td>
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LOCK & DAM #1
STABILITY OF DA
NORMAL OPERATING CONDITION

WITH EARTHQUAKE (CONT'D)

BEARING Pressures:

\[ \Sigma V = 1726 \text{ in} \quad \Sigma M_A = 4049 \text{ lb-ft} \]

\[ X_{A'} = \frac{4049 \text{ lb}}{1726} + 4.13 = 27.59 \text{ in} \]

\[ f_{(1)} = \frac{1726 \text{ in} \left( 1 + 6 \times 2.61 \right)}{922.8 \text{ in} \times 60.8} = 2.27 \]

\[ f_{(2)} = 1.77 \left( 1 - (\text{C} / 6.8) \right) = 1.28 \]
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<th>RN/M</th>
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<th>690.6</th>
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<td>12.4</td>
<td>35</td>
</tr>
</tbody>
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Submerged concrete below el. 690.6

95

1803

804

1726

2958

43454

40496

\( + 4.13 = 27.59' \)

\( \bar{e}' = 2.81' \)

LOCK & DAM #1

STABILITY OF DAM

(1) = 2.27 ksf

(2) = 1.28 ksf
Earthquake Condition

Sliding Safety Factor @ Plane AC

\[ R = \sqrt{807 + 1837} = 2036 \text{kN} \]

\[ \tan^{-1} \theta = \tan^{-1} \left( \frac{807}{1837} \right) = 23.72^\circ \]

\[ \theta = 6.05^\circ \]

\[ \sin \theta = 0.1167 \]

\[ R_f = R \sin \theta = 609 \text{kN} \]

\[ R_N = R \cos \theta = 1311 \text{kN} \]

Sliding factor = \[ \frac{609}{1311} = 0.469 \]

\[ SSF = \frac{6.49}{0.469} = 13.8 \]

40 piles @ 4'

\[ 2036 \times 0.53 \]

\[ 1.5 \]
Below el. 640.6:

\[
\begin{align*}
E_b' & = 204 \\
E_b & = 1631 \\
H_a & = \text{From normal condition}
\end{align*}
\]

40 piles @ 4\(^{\circ}\) per pile = \(-160\)\(^{\circ}\)

\[
\frac{203^\circ \times 0.675}{1.5} = -68
\]

\[
807 \text{ k}
\]

1837

LOCK AND DAM NO.1
STABILITY OF DAM
Flood Discharge

1951 Flood - Improved Condition

Max. Flood El. 731. -
Lower Pool El. 709. -
Tailwater Elevation @ Apron 695.5'

$\Delta V = 1335^k$ (Page 128)
$\Delta V = 1352^k$ (Additional Fill - Page 135)
$\Delta H = 807^k$ (Above Elevation 690.6)

$\Delta M_a = 34113 + 476 = 34589^k$

For bearing pressures, $L' = 60.8$, from $A' + B$

$X_a = X_a + 4.13$, Area $A = 972.8$

$X_{b'} = \frac{34589^k}{1352^k} + 4.13 = 29.71'$

$e_{ab} = 30.4 - 29.71 = 0.69$ ft.

$F_a = \frac{1352}{972.8} \left( 1 + \frac{(610.69)}{60.8} \right) = 1.48$ ksf

$F_b = \frac{1352}{972.8} \left( 1 - \frac{(610.69)}{60.8} \right) = 1.30$ ksf

$F_a = \frac{1352}{807} = 1.352$

$X_a = X_a$

$B = 1.352 X_a$

$L' = 60.78 \approx 60.8$
BUTTRESS DAM
1951 FLOOD - IMPROVED CONDITION

DETERMINATION OF REQUIRED HEIGHT OF ADDITIONAL SAND FILL FOR A FACTOR OF SAFETY AGAINST SLIDING OF 1.5 (For other assumptions see page 128)

\[ \Sigma H' = 1054 \text{k} \]

\[ \Sigma V = 1446 \text{k} \]

\[ \Sigma H = 826 \text{k} \]

\[ \Sigma T = 203 \text{k} \]

\[ \Sigma T = 40 \text{ PILES} \times 4 \text{k} \]

\[ \Sigma V = 499 \text{k} \]

\[ \Sigma H_T = 1054 \text{k} \]

\[ \Sigma H_V = 6.05 \text{k} \]

\[ \Sigma V = 1446 \text{k} \]

\[ \Sigma W = 1.5 \]

\[ \Sigma W = 1463 \text{k} \]

\[ \Sigma V \text{ FOR EXISTING CONDITION} = 1446 \text{k} \]

\[ \text{REQUIRED WEIGHT OF ADDITIONAL FILL} = 17 \text{k} \]

\[ \text{REQUIRED HEIGHT OF ADDITIONAL FILL} = 0.25 \text{'} + \]
STABILITY ANALYSIS
LOCK & DAM NO. 1
SECTION thru BUTTRESS DAM

SCALE: 1" = 5' - 0"
46.75
L = 56.6 ft
L1 = 60.8'
UPSTREAM & DOWNSTREAM COFFERDAMS

UPSTREAM  \( H = 733 - 708 = 25 \text{ FT} \)

DOWNSTREAM  \( H = 705 - 674 = 31 \text{ FT} \)

STABILITY OF DOWNSTREAM COFFERDAM

1. OVERTURNING  \( w = 130 \text{ PCF} \)

   \[ EM_c = 0, \quad \text{wh} \quad B_c = M \]
   \[ B = \sqrt{\frac{6M}{wH}} = \sqrt{\frac{6 \times 230}{13 \times 31}} = 18.5' \]
   \[ B_{nc} \text{ (USED)} = A_1 + A_2 \]
   \[ = \frac{646.9 + 210.4}{33.87} = 25.31' \quad \text{OK} \]

2. VERTICAL SHEAR @ Q

   \( Q = \text{VERTICAL SHEAR PER FT STRIP} \)
   \[ = \frac{3}{2} \frac{M}{B} - 1.5 \times 230 = 13.63 \]
   \( \phi = 33^\circ \)
   \[ R = \text{SHEARING RESISTANCE} \]
   \[ = \frac{\kappa w h}{2} (1.5 + 30 \times 0.9) \]
   \[ = \frac{29.5 \times 1.3 \times 31}{2} \times 0.9 = 16.95 \]
   \[ F.S. = \frac{R}{Q} = \frac{16.95}{13.63} = 1.24 \]

\[ A = A \]
DOWNSTREAM COFFERDAM (CONT'D)

3. INTERLOCK TENSION

UNIT PRESSURE @ BOTTOM

\[ K\text{wh} = 0.295 \times 0.13 \times 31 = 1.19 \text{ ksf} \]

\[ P = K\text{wh}(D) = 1.19 \times 28 = 33.32 \frac{k}{\text{ft}} \]

\[ T = \frac{P}{2} = 16.66 \frac{k}{\text{lin. ft.}} \]

\[ = 1.4 \frac{k}{\text{lin. inch}} < 8 \frac{k}{\text{lin. inch}} \]

RECOMMENDED DESIGN STRESS IN INTERLOCKS OF SECTION MP-101 = 8 \frac{k}{\text{lin. inch}}.

UPSTREAM COFFERDAM WILL BE THE SAME AS DOWNSTREAM COFFERDAM.
CONSTRUCTION ENCLOSURE STRUCTURE

DL 5" LL 30PSF

Assume spacing of supports 10'0 on CTS

Load on TUTSS 10 x 30 = 300 \text{ k/ft}

\(0.30 \times 64 + 0.03 \times 64 = 19.20 + 1.92 = 21.12 \text{ k}\)

Use 44 LR 12, allowable load 23.10 k

Spacing of BMS 7'4

Load on BMS 7.33 \times 0.3 = 2.22 k/ft

Total load /bm 2.2 \times 10.0 = 22.4 k/bm

Use M6x4.4, allowable load 3.8 k/bm

Use 2x6 timber C 2-0CTRS for roof covering

BEAM C I-WALL

Load \times 35 k/ft

Total load on bm 35 \times 79 = 108 k

Use W16 \times 26
ESTIMATE OF MATERIALS FOR CONSTRUCTION SHELTER

ROOF TRUSSES (25 JOISTS)

64.0 x 30 = 1.92 k/Truss

2 x 54 = 1.92

= 208 k

SECONDARY TRUSSES & BRIDGING = 116 k SEE NEXT SHEET.

TRUSS STEEL TOTAL = 324.0 k

BEAMS

19 LINES x 532'6" CABS 7' CIRS

M10 x 9.4

19 x 532 x 0.044 = 4.5 k

W8 x 17

4 x 532 x 0.170 = 36.2

W16 x 26

29 x 0.026 x 54 = 40.8

TOTAL = 122.0 k

COLUMNS

12 x 4 x 0.017 x 54 = 44.0 k

BASE LS

4 x 54 x 0.25 = 6.0 k

TOTAL = 50.0 k
Estimate of Materials for Construction Shelter

Roof Trusses (continued)

Bridging for Trusses

Blinds of Bridging: 532' LG

8 x 532 x 2 x 1.06 x .005 = 45.2 k

Trusses @ bottom of joists, ~ 100' spacing, creed

6 x 2 x 640 x .09 = 70.0 k

Bridging and Secondary Trusses Total: 116.0 k

Bracing for Cul's

2 x 18.8 x .010 x 54 = 21.0 k Center Bay

4 x 17 x 255 x .005 = 9.0 At 4 rows of Cul's

Bracing Total: 30.0 k
ESTIMATE OF STEEL FOR CONSTRUCTION SHELTER

Roof trusses 324 k say 164 ton
Beams 172 k 86 "
Bracing L3 100 k 50 "

Total steel Req'd 300 ton
REHABILITATION OF BOTH LOCKS

LUMBER: 
1 x 6 \(160 \times 535 = 86,000\) BOARD FT
2 x 8 \(160 \times 266 \times 1.33 = 57,000\) ''
TOTAL = 143,000 ''

TAR PAPER: \((86,000)1.1 = 95,000\) FT²

CANVASS:
12' HIGH ALL AROUND
\((157 + 532)2 \times 12 = 17,000\)

LOCK OPENINGS \(56(28 + 57)2 = 10,000\)
TOTAL 27,000 FT²
STEEL

1. ROOF TRUSS (LJ BAR JOISTS)
   \[1.92 \text{ k/Truss} \times 54 \times 1.92 = 104 \text{k}\]

2. BRIDGING
   \[4 \text{ Sejs/Bay} \times 53 \text{ Bays} \times 22' \text{ Long/Sej} \times 5' / \text{FT} = 23 \text{k}\]

3. SECONDARY TRUSSES @ BOTTOM OF JOISTS SPACED 100' (6 REG'D/LOK)
   \[6 \times 64 \times 0.09 = 35 \text{k}\]

4. M6 x 4.4 BEAMS (SPACED 7'-4'"")
   \[\left(\frac{64}{7.33} + 1\right) \times 530 \times 4.4 = 23 \text{k}\]

5. W9 x 17 COLUMNS
   \[12 \times 3 \times 0.017 \times 54 = 33 \text{k}\]

6. W16 x 26 - 29 \times 0.026 \times 54 = 41 \text{k}\]

7. W8 x 17 - 3 \times 10 \times 54 \times 17 = 28 \text{k}\]

8. BASE TR 3 \times 54 \times 0.025 = 4 \text{k}\]

9. COL. BRACE, CENTER BAY - 2 \times 18.5 \times 0.010 \times 54 = 21 \text{k}\]

10. BROWS COL. - 3 \times 17 \times 25.5 \times 0.005 = 7 \text{k}\]

TOTAL FOR STEEL = $\frac{319 \text{ (114)} \times 180}{2} \text{k}\]
<table>
<thead>
<tr>
<th>LUMBER</th>
<th>TAR PAPER</th>
<th>CANVAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; x 6&quot; 94 x 535 = 51,000</td>
<td>51,000 + (10%)(51,000) = 56,000 FT²</td>
<td></td>
</tr>
<tr>
<td>2&quot; x 8&quot; 94 x 266 x 1.33 = 34,000</td>
<td></td>
<td>12' HIGH ENCLOSURE</td>
</tr>
<tr>
<td>TOTAL = 85,000 BOARD FEET</td>
<td></td>
<td>(53 + 532) 2 x 12 = 15,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOCK OPENING:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56 x (28 + 57) = 4,760</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOTAL FOR CANVAS = 20,000 FT²</td>
</tr>
</tbody>
</table>
## SUMMARY

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>REHABILITATION OF BOTH LOCKS</th>
<th>REHABILITATION OF LAND LOCK ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURAL STEEL, TONS</td>
<td>300</td>
<td>180</td>
</tr>
<tr>
<td>LUMBER, BF/1000</td>
<td>143</td>
<td>85</td>
</tr>
<tr>
<td>TAR PAPER, SQ.FT.</td>
<td>95,000</td>
<td>56,000</td>
</tr>
<tr>
<td>CANVAS, SQ.FT.</td>
<td>27,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>
ASSUME THAT CRIBS IN MONOLITH 6-13 NEED REMEDIAL GRouting.

LENGTH OF CRIBS \( \Sigma L = 190 \text{ FT} \)
WIDTH OF CRIBS = 18 FT
HEIGHT OF ROCK FILL = 11 FT

ASSUME THAT HOLES WILL BE DRILLED AT 6 FT SPACING IN 3 RANS.

\[ n = \frac{190}{6} \times 3 = 95 \text{ holes} \]

DEPTH OF DRILL HOLE = 732.7 - 706.7 = 26 FT

TOTAL LENGTH OF DRILLING

\[ \Sigma C = 95 \times 26 = 2470 \text{ LIN FT} \]

DEPTH OF GROUTING = 11 FT EACH HOLE
ASSUME THAT GROUT TAKES 1.5 CU FT/LIN FT

TOTAL VOLUME OF GROUT

\[ 11 \times 2 \times 95 = 1970 \approx 2000 \text{ CY} \]

COST

SET-UPS \[ 96 \times \$50 = \$4800 \]

DRILLING \[ 2470 \times \$10 = \$24700 \]

GROUTING \[ 80 \times \$160 = \$12800 \]

TOTAL \( \$42300 \)
<table>
<thead>
<tr>
<th>LENGTH (FT)</th>
<th>WIDTH (FT)</th>
<th>AREA (FT²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>30</td>
<td>2,700</td>
</tr>
<tr>
<td>325</td>
<td>50</td>
<td>16,250</td>
</tr>
<tr>
<td>100</td>
<td>40</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>22,950</strong></td>
</tr>
</tbody>
</table>

**DEPT**TH = 10 FT

**VOLUME** = \(22,950 \times \frac{10}{27} = 8,500\) 

**SAY** 9,000 CUBIC YARDS

**UNIT COST** = $3.00

**COST** = 9,000 \times 3 - $27,000
**ALT: 1 1\(\frac{3}{8}\)\(^{\circ}\) SINGLE ANCHORS**

Use 1\(\frac{3}{8}\)\(^{\circ}\) single anchors - 3 per monolith

<table>
<thead>
<tr>
<th>Total number of anchors</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of anchor</td>
<td>90 ft</td>
</tr>
<tr>
<td>Diameter of bore hole</td>
<td>3 in</td>
</tr>
</tbody>
</table>

**SET-UP**

48 holes @ $400.00 = $19,200

**DRILLING**

- Total length = 48 x 90 = 4,320 in = 350 ft
- Unit cost of 3" hole = $10.00 per lin ft
- Cost of drilling = 4320 x 10.00 = $43,200

**PLACE, GROUT AND TENSION ANCHOR BARS**

**Anchor Bars**

1\(\frac{3}{8}\)" bars: \(W = 5.05 \text{ lb./ft}\)

| Total length = 48 x 90 = 4,320 in = 350 ft |
| Total weight = 4320 x 5.05 = 21,800 lb |

**GROUT**

\[D = \frac{3}{8} = 0.375 \text{ ft} = 4.5\]

- Volume of one hole: \(V = \frac{4}{3} \times 0.25 \times 4.5 = 4.11 \text{ cu. ft}\)
- Total volume: \(2V_{vol} = 48 \times 4.11 = 194 \text{ cu. ft}\)

**Cost**

\[4320 \times $11.00 = 47,520\]

**TOTAL**

109,920
## Alt. 2 1/4" Double Anchors

Use 1/4" double anchors - 2 per monolith
Total number of anchors = 32
Length of anchor = 95 feet
Diameter of bore hole = 4 in

### Set-Up

<table>
<thead>
<tr>
<th>Holes</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>$ 400.00</td>
</tr>
</tbody>
</table>

### Drilling

- Total length = 32 x 95 = 3,040 ft
- Unit cost of 4" bore = $ 12.00 per lin. ft
- Cost of drilling = 3,040 x 12.00 = $ 36,480

### Place, Grout, and Tension Anchor Bars

**Anchor Bars**

1/4" bars: w = 4.172 lb./ft
- Total weight = 32 x 4.172 = 133.50 lb.
- Total weight = 6080 x 4.172 = 25,400 lb.

**Grout**

- D = 4" = 0.33 ft, L = 95 ft
- Volume per hole: \( V = \frac{\pi}{4} \times 0.33 \times 95 = 8.3 \text{ cu. ft.} \)
- Total volume: \( V_{\text{net}} = 32 \times 8.3 = 265 \text{ cu. ft.} \)

### Cost

- $ 3040 x $ 15.00 = $ 45,600
- $ 94,880
ALT. 3 1 1/4" TRIPLE ANCHORS

Use 1 1/4" triple anchors - 2 per monolith
Total number of anchors = 32
Length of anchor = 100 feet
Diameter of bore hole = 5 in

SET-UP
32 holes @ $ 400.00 = $ 12,800

DRILLING
Total length = 32 x 100 = 3,200 ft
Unit cost of 5" bore = $ 16.00 per ft
Cost of drilling = 3200 x 16.00 = $ 51,200

PLACE, GROUT AND TENSION ANCHOR BARS

Anchor Bars
1 1/4" bars, W = 4,172 lb/ft
Total length = 32 x 10 x 100 = 32,000 ft
Total no. = 9,600 x 4,172 = 40,251

Grout
D = 5" = 0.417 ft; L = 100 ft
Volume of one mo. = V = \(\frac{\pi \times 0.417^2 \times 100}{4} = 13.66 \text{ cu-ft}\)
Total volume \(\Sigma V_{gr} = 32 \times 13.66 = 437 \text{ cu-ft}\)

Cost
\[\frac{3200 \times 20.00}{\$} = \frac{64,000}{\$ 128,000}\]
**VERTICAL KEYS (2.0')**

**SET-UP**

$$4 \times 250, - = 1,000$$

**DRILLING**

$$L = 4 \times 10.0' = 160.0'$$

$$160.0' \times \frac{4}{10} = 22,400$$

**CONCRETE**

$$V = \frac{3.14 \times 2.0^2}{4} \times 150.0' \times \frac{1}{27} = 190.0'$$

$$190.0' \times 120, - = 22,800$$

**TOTAL**

$$25,680$$

---

**HORIZONTAL KEYS (2.0') n = 8**

**SET-UP AND DRILLING**

$$8 \times 1,200, - = 9,600$$

**CONCRETE**

$$V = \frac{3.14 \times 2.0^2}{4} \times 8.0' \times \frac{1}{27} = 60.0'$$

$$60.0' \times 120, - = 7,200$$

**TOTAL**

$$10,320$$

**TOTAL AL**

$$25,680 + 10,320 = \boxed{36,000}$$
### FOR COMPUTATION PURPOSES

**FOR COMputation PURPOSES: Assume 3 different ground elevations.**

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>80</td>
</tr>
<tr>
<td>690</td>
<td>40</td>
</tr>
<tr>
<td>680</td>
<td>30</td>
</tr>
</tbody>
</table>

### EXCAVATION

**Assume a depth of 3.185 ft.**

Area = 80 x 160

\[ V = 80 \times 160 \times 3.185 = 1420 \text{ cy} \]

\[ V = 1500 \text{ cy} \]

### IMPERVIOUS BLANKET

- **MIN**
- **MAX**

\[ V = 1500 \text{ cy} \]
CROSS-SECTION: GROUND ELEV. 680

SCALE 0 10 20 FEET

Excavation: 105 x 3 = 315 ft²
Imperial blanket: 65 x 3 = 195 ft²
Random fill: 50 x 24 = 1200 ft³
Gravel: 10 x 15 = 150 ft²
Random: 110 x 2 = 220 ft²
Selected large rocks: 115 x 2.5 = 288 ft²
<table>
<thead>
<tr>
<th>GROUND ELEV.</th>
<th>690</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>86 \times 3 = 240 \text{ ft}^3</td>
</tr>
<tr>
<td>Impervious blanket</td>
<td>60 \times 3 = 180 \text{ ft}^3</td>
</tr>
<tr>
<td>Random fill</td>
<td>38 \times 14 = 532 \text{ ft}^3</td>
</tr>
<tr>
<td>Gravel fill</td>
<td>78 \times 1.5 = 117 \text{ ft}^3</td>
</tr>
<tr>
<td>Random rock fill</td>
<td>83 \times 2 = 166 \text{ ft}^3</td>
</tr>
<tr>
<td>Selected large rocks</td>
<td>90 \times 2.5 = 225 \text{ ft}^3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GROUND ELEV.</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>60 \times 3 = 180</td>
</tr>
<tr>
<td>Impervious blanket</td>
<td>40 \times 3 = 120</td>
</tr>
<tr>
<td>Random fill</td>
<td>26 \times 6 = 156</td>
</tr>
<tr>
<td>Gravel fill</td>
<td>52 \times 15 = 780</td>
</tr>
<tr>
<td>Random rock fill</td>
<td>57 \times 2 = 114</td>
</tr>
<tr>
<td>Selected large rocks</td>
<td>62 \times 2.5 = 155</td>
</tr>
</tbody>
</table>
EXCAVATION

\[ 3 \times 15 \times 30 = 9450 \text{ ft}^3 \]
\[ 240 \times 40 = 9600 \]
\[ 180 \times 80 = 14400 \]

\[ 33450 \text{ ft}^3 = 1230 \text{ cy} \]

USE \[ 1.15 \times 1230 = 1424 \text{ cy} \rightarrow 1500 \text{ cy} \]

GRAVEL FILTER

\[ 2.55 \times 30 = 7650 \text{ ft}^3 \]
\[ 180 \times 40 = 7200 \]
\[ 120 \times 80 = 9600 \]

\[ 24,450 \text{ ft}^3 \]

USE \[ 24,450 \times \frac{1}{1.15} \times \frac{1}{27} = 1041 \text{ cy} \rightarrow 1100 \text{ cy} \]

RANDOM FILL

\[ 1200 \times 30 = 36,000 \text{ ft}^3 \]
\[ 532 \times 40 = 21,280 \]
\[ 104 \times 80 = 8,320 \]

\[ 65,600 \text{ ft}^3 \]

USE \[ 65,600 \times \frac{1}{1.15} \times \frac{1}{27} = 2794 \text{ cy} \rightarrow 3200 \text{ cy} \]
<table>
<thead>
<tr>
<th>GRAVEL FILTER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>167 x 20 = 3340</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>117 x 30 = 3510</td>
<td></td>
</tr>
<tr>
<td>115 x 20 = 2300</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong> = 15780</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>U.S.L. <strong>15780 x 1/15 = 1038 cu yd → 700 cu yd</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANDOM ROCK FILL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>220 x 30 = 6600</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>166 x 30 = 5080</td>
<td></td>
</tr>
<tr>
<td>114 x 20 = 2280</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong> = 22360</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>U.S.E. <strong>22360 x 1/15 = 952 cu yd → 1000 cu yd</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SELECTED RIVER MATERIAL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>28 x 30 = 840</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>225 x 30 = 6750</td>
<td></td>
</tr>
<tr>
<td>175 x 30 = 5250</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong> = 29250</td>
<td>ft$^3$</td>
</tr>
<tr>
<td>U.S.E. <strong>29250 x 1/15 = 1275 cu yd → 1700 cu yd</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Cost Estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Unit</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>1500</td>
<td>3.00</td>
<td>4,500</td>
</tr>
<tr>
<td>Gravel filter</td>
<td>1100</td>
<td>10.50</td>
<td>11,550</td>
</tr>
<tr>
<td>Random fill</td>
<td>3000</td>
<td>6.00</td>
<td>18,000</td>
</tr>
<tr>
<td>Gravel filter</td>
<td>700</td>
<td>10.50</td>
<td>7,350</td>
</tr>
<tr>
<td>Random fill</td>
<td>1000</td>
<td>16.00</td>
<td>16,000</td>
</tr>
<tr>
<td>Selected local rocks</td>
<td>1800</td>
<td>7.00</td>
<td>32,500</td>
</tr>
</tbody>
</table>

**Total** 59,900