PILE FOUNDATION

PILE FOUNDATION

The piles shall be 48" diameter, 5/8" wall steel pipes conforming to ASTM A53 Gr B and API 5L Gr B (Fy = 35 ksi, Fu = 60 ksi). The 5/8" wall thickness satisfies the AISC Specification Chapter B requirements for local buckling.

The pile lengths are based on a Factor of Safety equal to 2.0. Pile tests shall be performed. No group reduction factor is needed as long as a minimum spacing of 12' is maintained. Both the chamber module and gate bay module pile loads were checked considering five load cases. The maximum compressive load was dictated by the ship lock gatebay module experiencing the maximum operation condition with minimal uplift. The uniform pile reaction(transverse direction) was increased 125% beneath the lock walls, developing a maximum reaction of 840 kips. The 160' pile has a soil capacity of approx. 880 kip. The lighter barge lock required a 140' pile length. The shiplock gatebay was also analyzed as a rigid base acted upon by the eccentric gravity loads and lateral loads. The Program CPGA was used to determine the axial loads and combined stress created by axial compression and bending. The maximum reaction increased slightly to 851 kips and the maximum combined stress ratio is 0.49; both well within the permissible limit. The maximum required length pile was conservatively used throughout the foundation. The CPGA rigid base analysis was also used for the maintenance dewatering case to determine if any portion of the pile foundation went into tension. The results are no net tension. The same pile lengths were also adequate for the setting pads and tension piles. Tension piles were used solely to achieve the required Factor of Safety against flotation for the maintenance dewatering case.

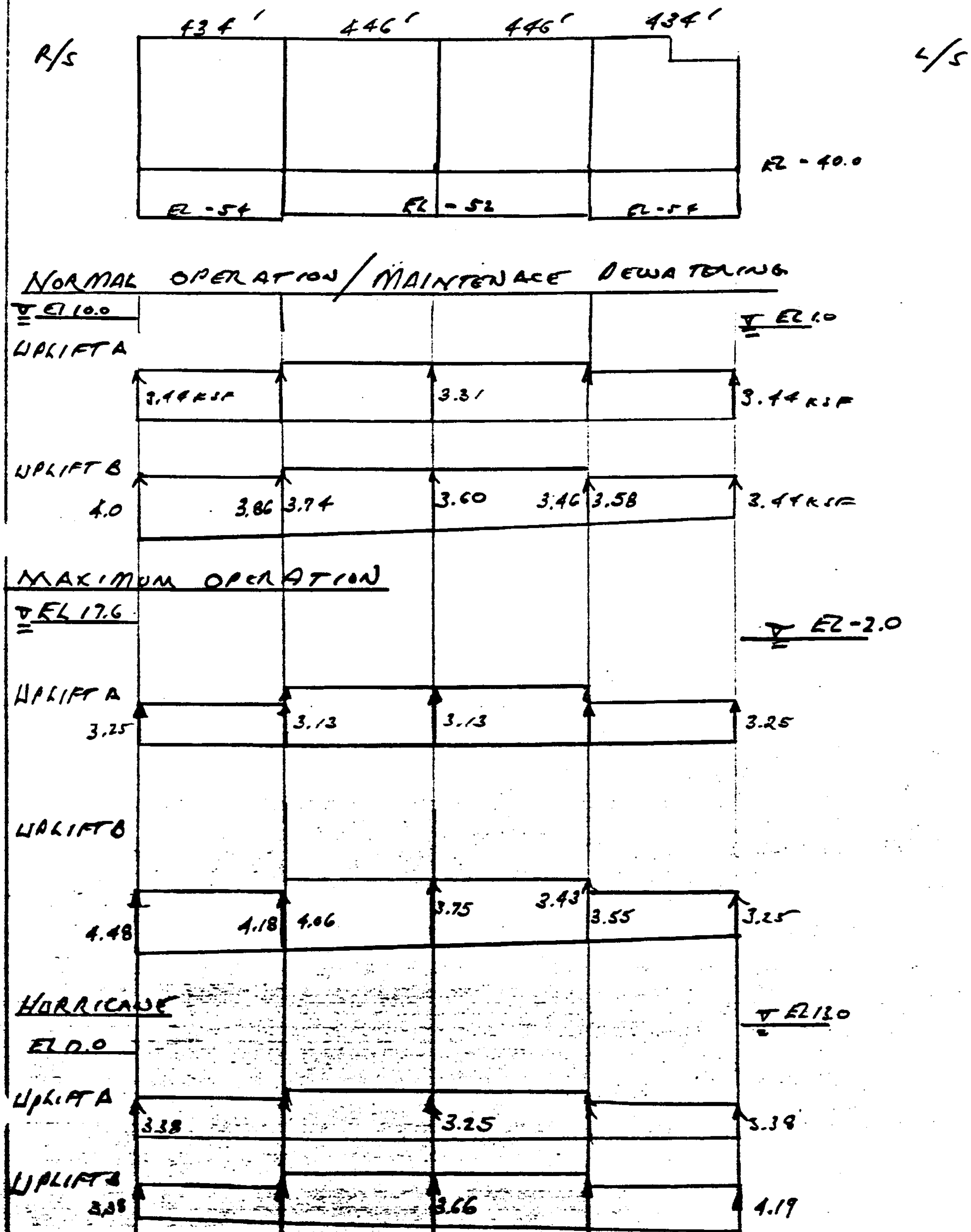
The included sample calculations are for the 1200 X 110 Ship Lock. Included are:

- Uplift Pressures
- Sliding Calculations
- Pile reactions for both the chamber and gatebay modules based on a simple P/A distribution with a 125% increase beneath the lock walls
- CPGA runs for the gatebay module incurring a moment created by eccentric gravity loads and lateral loads.
- Ultimate Pile Capacity curve

COMPUTATION SHEET

PROJECT 1200x110x36 FOUNDATION	PAGE 1 OF 20	COMPUTED BY MUG	DATE 6/96
SUBJECT UPLIFT PRESSURE ON BASE*		CHECKED BY	DATE

* Add 4' of head for pressure @ base of grout curt



SHIPLOCK GATEBAY   Z 20   MHG   9/95
SLIDING

Although Pile Founded, the majority of piles will make contact w/ the base through a tremied concrete pad.

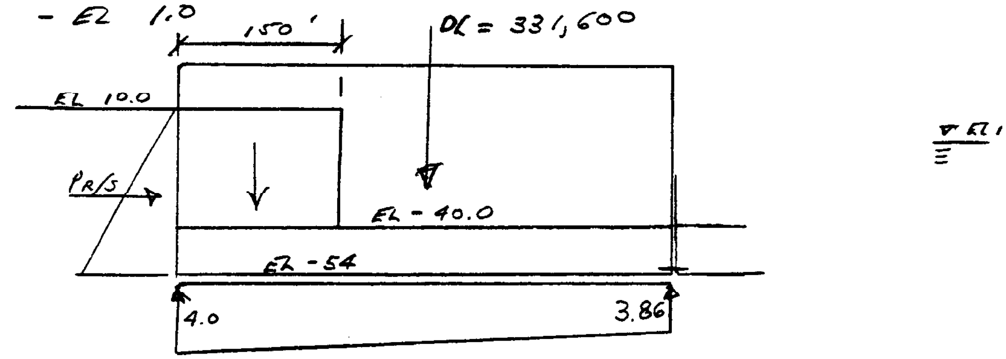
Conservatively assume sliding plane between base and 4' tremied pile cap. Resistance to sliding is developed from friction, neglect tension pile connections. Neglect drag.

$\Sigma F_{RESIST} = \mu \cdot \Sigma$ GRAVITY LOADS   where μ = concrete to concrete friction coefficient = 0.65 *

Σ Dead Load STRUCTURE (FROM CASA INPUT PG 19) = 360,500 K − 1600 (BULK HEAD) − 27,300 (4' GROUT) = 331,600 K

MAINTENANCE DEWATERING   UPLIFT R

R/S STAGE − EL 10.0
L/S STAGE − EL 1.0   DL = 331,600



ΣP_Z = DL + CHAMBER H_2O − UPLIFT

$= 331{,}600 + (150 \times 110 \times 50 \times 0.0625) - \left(\frac{4.0 + 3.86}{2} \times 180 \times 434\right)$

$= 384{,}000 - 307{,}000$

$= 77{,}000$ K

$\Sigma P_Y = P_{R/S} - P_{L/S}$ Assume Construction outer waterstop is still intact ∴ $P_{L/S}$ is negligible

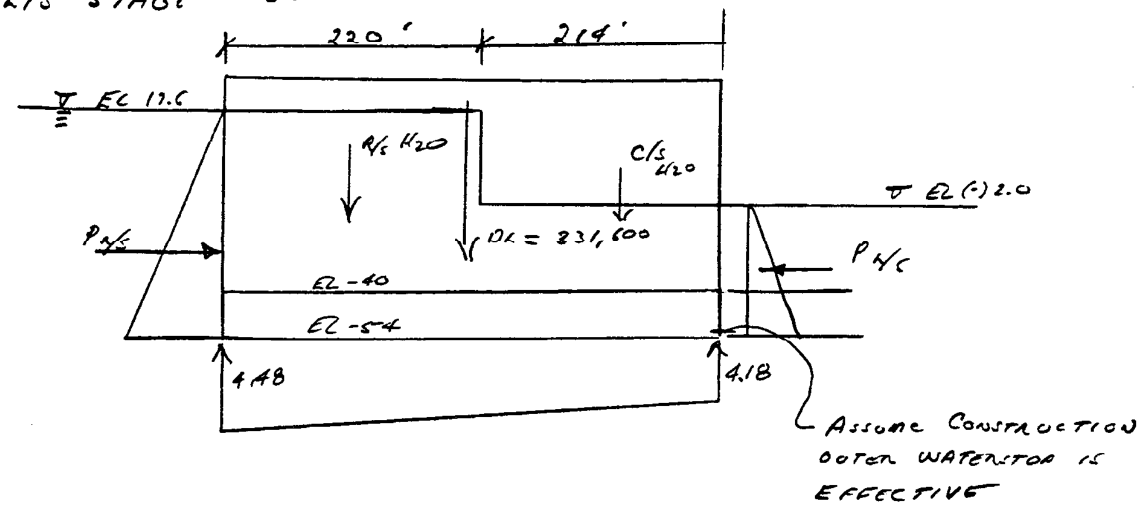
$= \frac{64^2}{2} \times 0.0625 \times 180 =$

$F.S. = \frac{(77{,}000 \times 0.65)}{23{,}040} = 2.17$

* PG 12, SMALL CONCRETE DAMS, PCA

MAXIMUM OPERATION UPLIFT B

R/S STAGE - EL 17.6
L/S STAGE - EL (-) 2.0



$\Sigma P_Z = \Sigma DL +$ CHAMBER H_2O @ EL 17.6 $+$ CHAMBER H_2O @ EL -2.0 $+$ H_2O Culvert $-$ Uplift

$= 331,600 + (110 \times 220 \times 57.6 \times 0.0625) + (110 \times 214 \times 38 \times 0.0625) + (2 \times 18.25 \times 20 \times 0.0625 \times 15 \times 39$

$- \left(\frac{4.48 + 4.18}{2} \times 180 \times 434\right)$

$= 487,970 - 338,260$
$= 149,700\ K$

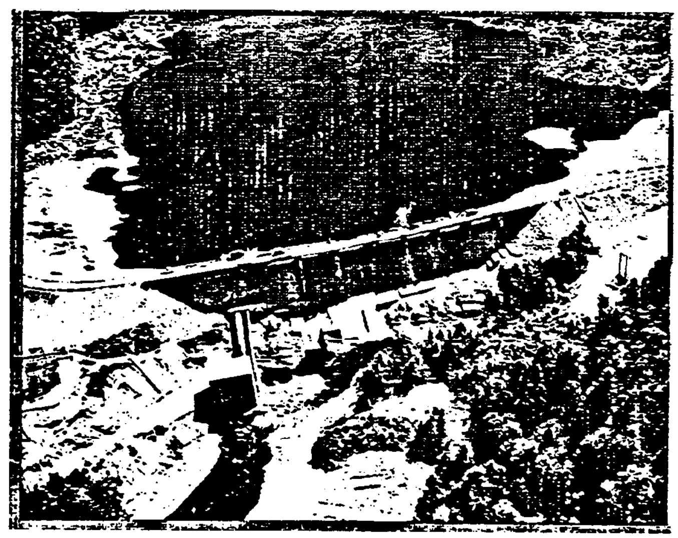
$\Sigma P_Y = \left(\frac{71.6^2}{2} \times 0.0625 \times 180\right) - \left(\frac{52^2}{2} \times 0.0625 \times 180\right)$

$= 13,630\ K$

$FS = \frac{149,700 \times 0.65}{13,630} = 7.1$

HYDRAULIC STRUCTURES REFERENCE SERIES

Small Concrete Dams



pca
PORTLAND CEMENT ASSOCIATION

Safety Factors

Safety factors should be considered in the light of economic conditions. Large safety factors result in a more costly structure; however, low safety factors may result in failure, which could also lead to high cost. Proper safety factors result only from an adequate determination of sliding, overturning, and overstressing forces within and acting on the dam.

Overturning

Ordinarily, the safety factor against overturning is between 2 and 3. In smaller dams it is often larger. If the computed safety factor falls below 2, the section of the dam should be modified to increase the safety margin. A gravity dam rarely fails from overturning since any tendency to overturn provides greater opportunity for a sliding force to create the failure. The safety factor against overturning is the ratio of the righting moment to the overturning moment about the toe of the dam. This can be expressed as:

$$FSo = \frac{W_c \times l_1 + W_w \times l_2}{P \times l_3 + U \times l_4} \qquad (1)$$

in which W_c = force due to weight of concrete
W_w = force due to weight of water on inclined surfaces
P = force of water acting to displace dam downstream
U = uplift force
l = length of moment arm for respective forces

All forces (except the resultant foundation force) should be considered in computing this safety factor. Other forces may be wave, ice, earthquake, and silt pressure.

Another method* of evaluating the safety factor against overturning relates to internal stresses. If the vertical stress at the upstream edge of any horizontal section computed without uplift exceeds the uplift pressure at that point, the section above that point is considered safe against overturning. This computation can be used for small dams, but is not recommended for dams of great height.

Also, if the uplift pressure at the upstream face exceeds the vertical stress at any horizontal section without uplift, the uplift forces greatly increase the tendency for overturning about the downstream toe at that assumed horizontal plane. The dam may still be considered safe if the tension stresses developed are less than the allowable stresses in the concrete and in the foundation material. This assumption is based on good workmanship and development of a tensile strength within the structure on all horizontal planes. A dam is usually designed so that there will be no tension (or a limited tensile force) in the upstream face under severe loading conditions.

Sliding

Three approaches are used by engineers in evaluating the safety of a dam from being displaced downstream. Each has merit and generally involves the same relationship of forces. Although the computed values are safe, they are considerably different. The three approaches are: (1) a safe sliding factor, (2) a safety factor, and (3) a shear-friction safety factor. Clear distinction must be made among these three approaches. The primary purpose of each is to obtain a safe coefficient that when exceeded would put the dam in jeopardy of being pushed downstream.

The sliding factor is the coefficient of friction required to prevent sliding of any horizontal plane in the dam or upon its foundation under loading conditions. For small dams the sliding factor normally determines safety against sliding. This approach does not employ shear forces; however, shear forces are assumed as added safety in design. Also, this approach penalizes

Table 1. Allowable Sliding Factors for Various Foundation Conditions

Material	Safe sliding factor, *f*	Suggested minimum factor of safety, *fs*	Shear sliding factor, *SSF*
Concrete on concrete	0.65-0.8	1-1.5	4
Concrete on sound rock, clean and irregular surface	0.8	1-1.5	4
Concrete on rock, some laminations	0.7	1-1.5	4
Concrete on gravel and coarse sands	0.4	2.5	—
Concrete on sand	0.3	2.5	—
Concrete on shale	0.3	2.5	—
Concrete on silt and clay	*	2.5*	—

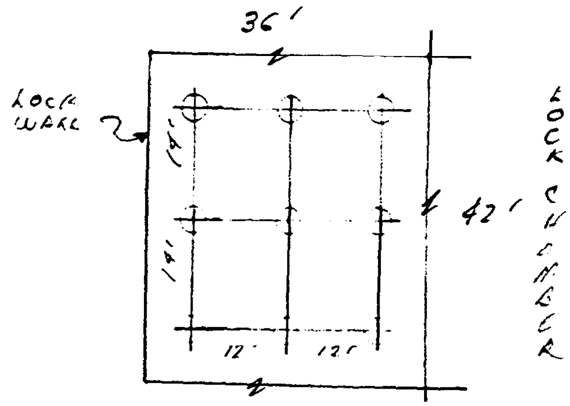
*Tests required to determine safety.

SHIP LOCK PILE FOUNDATION 4 20 PJS 6/96

48"φ PILE GROUP EFFICIENCY FACTOR

Ref. EM 1110-2-2906

Consider Denser pile group beneath Gate Bay Middle Wall



$\eta = \dfrac{Q_{group}}{N\, Q_{ULT}}$

$N = \#$ Piles $= 9$

$B_g = 36'$

$L_g = 42'$

$D = 160'$

$Q_{ULT} = 850$ TONS $\times 2 = 1700$ KIPS From Pile Capacity Curves Dated May 96

$$Q_{group} = 2(B_g + L_g)D\bar{c} + \left[5\left(1 + \frac{D}{5B_g}\right)\left(1 + \frac{B_g}{5L_g}\right)\right] C_b L_g \cdot B_g$$

End Bearing $= 0$

$$C_{ave} = \frac{(800 \times 46') + (1200 \times 20) + (1500 \times 94)}{160} = 1260 \text{ psf} \quad \text{use } 1200$$

$\bar{c} = \alpha\, C_{ave}$ $\quad \alpha = 0.65$ ($C_{ave} = 0.6$ tsf) (Fig 4-5a EM 2906)

$\bar{c} = 0.65\,(1.20)$

$= 0.80$ KSF

$$Q_{group} = 2(B_g + L_g)D \cdot \bar{c} + 0$$

$= 2(36 + 42)\,160 \cdot 0.80$

$= 19{,}968$ K

$$\eta = \frac{19{,}968}{8 \times 1{,}700} = 1.47 > 1.0 \quad \therefore \underline{\underline{1.0}}$$

1200 x 110 x 36

IHNC Lock Replacement

Designed by: P.J.S.
Checked by:

Pile Determination - Normal Operations, Load Case 1

Chamber: EL. 10.00
Tailwater: EL. 1.00

Concrete Weight:							
Float-in segment:	1386.00 sf x (CADD)	14.00 ' strip x	0.15 =		2910.60 x 2 (other half) =		5821 kips
Grout:	4.00 ft x	14.00 ' strip x	172.00 ft x	0.1500 =		=	1445 kips
Walls:	786.12 sf x (CADD)	14.00 ' strip x	0.15 =		1650.85 x 2 (other half) =		3302 kips
Water:							
Chamber @ EL. 10.0:	50.00 ft x	14.00 ' strip x	110.00 ft x	0.0625 =		=	4813 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =		239.53 x 2 (other half) =		479 kips
Soil:							
Soil with water:	124.83 sf x (CADD)	14.00 ' strip x	0.12 =		209.71 x 2 (other half) =		419 kips
Drag:	295.43 kips (from C. Balint)				x 2 (other half) =		591 kips
Uplift:							
Tailwater @ El. 1.0:	57.00 ft x	14.00 ' strip x	172.00 ft x	-0.0625 =		=	-8579 kips
					Total weight:		8291 kips

Distribute 8291 kips over 172.0 ft: 8291 / 172 = 48.20 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

44.00 ft on each end, load is: 48.20 kips/ft x 1.25 = 60.25 kips/ft

so, for 88' of monolith, load is: 88.00 ft x 60.25 = 5302.42 kips

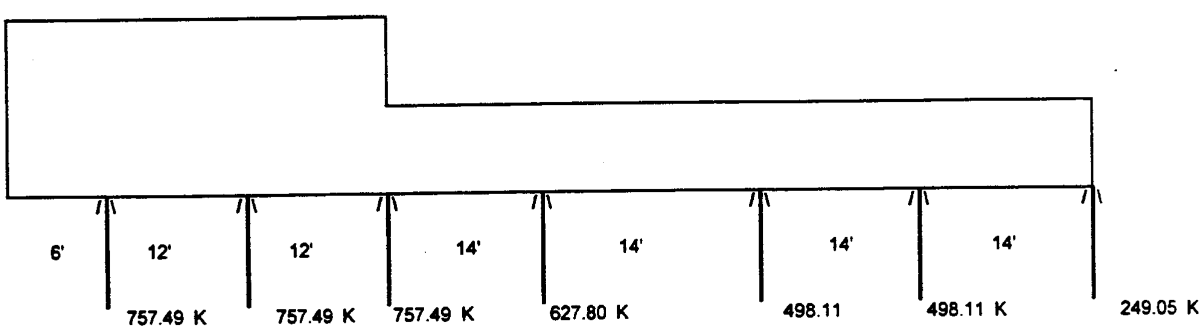
therefore, remaining 84' of monolith will have load of:[(48.20 x 172.00) 5302.42]/ 84 = 35.58 kips/ft

For 44.00 ft on each end: 88.00 ft x 60.25 / 7.0 piles = 757.49 kips/pile

Using a factor of safety = 2.0, this equates to **757.49 tons/pile**

For 84.00 ft in the middle: 84.00 ft x 35.58 / 6.0 piles = 498.11 kips/pile

Using a factor of safety = 2.0, this equates to **498.11 tons/pile**



1200 x 110 x 36
CHAMBER

IHNC Lock Replacement

Designed by: P.J.S.
Checked by:

Pile Determination - Maximum Operations, Load Case 2A * Governing Case *****
Chamber: EL. 17.60
Tailwater: EL. -2.00

Concrete Weight:							
Float-in segment:	1386.00 sf x (CADD)	14.00 ' strip x	0.15 =		2910.60 x 2 (other half) =		5821 kips
Grout:	4.00 ft x	14.00 ' strip x	172.00 ft x	0.1500 =		=	1445 kips
Walls:	786.12 sf x (CADD)	14.00 ' strip x	0.15 =		1650.85 x 2 (other half) =		3302 kips
Water:							
Chamber @ EL. 17.6:	57.60 ft x	14.00 ' strip x	110.00 ft x	0.0625 =		=	5544 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =		239.53 x 2 (other half) =		479 kips
Soil:							
Soil with water:	124.83 sf x (CADD)	14.00 ' strip x	0.12 =		209.71 x 2 (other half) =		419 kips
Drag:	295.43 kips (from C. Balint)				x 2 (other half) =		591 kips
Uplift:							
Tailwater @ EL.-2.0:	54.00 ft x	14.00 ' strip x	172.00 ft x	-0.0625 =		=	-8127 kips
					Total weight:		9474 kips

Distribute 9474 kips over 172.0 ft: 9474 / 172 = 55.08 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle.

42.00 ft on each end, load is: 55.08 kips/ft x 1.25 = 68.85 kips/ft

so, for 88' of monolith, load is: 84.00 ft x 68.85 = 5783.58 kips

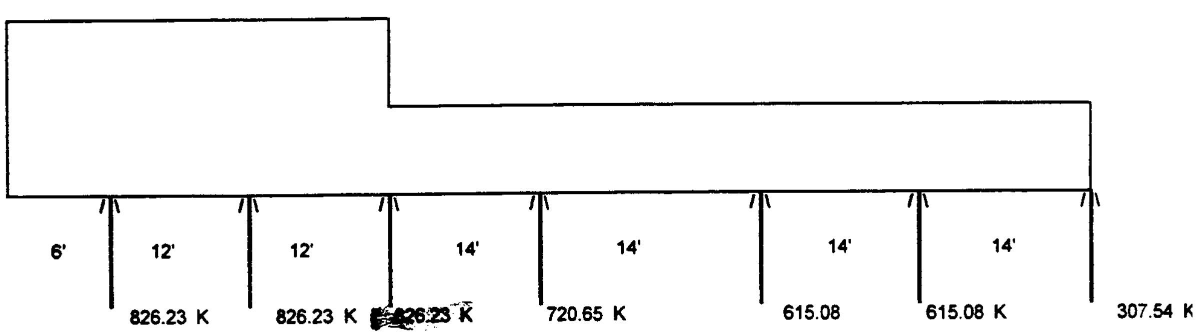
therefore, remaining 84' of monolith will have load of:[(55.08 x 172.00) 5783.58]/ 88 = 41.94 kips/ft

For 42.00 ft on each end: 84.00 ft x 68.85 / 7.0 piles = 826.23 kips/pile

Using a factor of safety = 2.0, this equates to **826.23 tons/pile**

For 88.00 ft in the middle: 88.00 ft x 41.94 / 6.0 piles = 615.08 kips/pile

Using a factor of safety = 2.0, this equates to **615.08 tons/pile**



IHNC Lock Replacement

Designed by: P.J.S.
Checked by:

Pile Determination - Maximum Operations, Load Case 2B
Chamber: EL. -2.00
Tailwater: EL. -2.00

Concrete Weight:					
Float-in segment:	1386.00 sf x (CADD)	14.00 ' strip x	0.15 =	2910.60 x 2 (other half) =	5821 kips
Grout:	4.00 ft x	14.00 ' strip x	172.00 ft x 0.1500 =	=	1445 kips
Walls:	786.12 sf x (CADD)	14.00 ' strip x	0.15 =	1650.85 x 2 (other half) =	3302 kips
Water:					
Chamber @ EL.-2.0:	38.00 ft x	14.00 ' strip x	110.00 ft x 0.0625 =	=	3658 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =	239.53 x 2 (other half) =	479 kips
Soil:					
Soil with water:	124.83 sf x (CADD)	14.00 ' strip x	0.12 =	209.71 x 2 (other half) =	419 kips
Drag:	295.43 kips (from C. Balint)			x 2 (other half) =	591 kips
Uplift:					
Tailwater @ EL.-2.0:	54.00 ft x	14.00 ' strip x	172.00 ft x -0.0625 =	=	-8127 kips
				Total weight:	7588 kips

Distribute 7588 kips over 172.0 ft: 7588 / 172 = 44.11 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

44.00 ft on each end, load is: 44.11 kips/ft x 1.25 = 55.14 kips/ft

so, for 88' of monolith, load is: 88.00 ft x 55.14 = 4852.51 kips

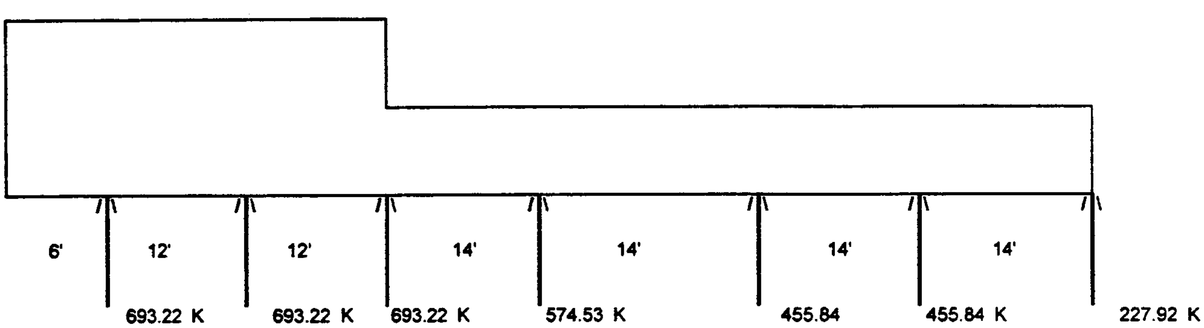
therefore, remaining 84' of monolith will have load of:[(44.11 x 172.00) 4852.51] / 84 = 32.56 kips/ft

For 44.00 ft on each end: 88.00 ft x 55.14 / 7.0 piles = 693.22 kips/pile

Using a factor of safety = 2.0, this equates to **693.22 tons/pile**

For 84.00 ft in the middle: 84.00 ft x 32.56 / 6.0 piles = 455.84 kips/pile

Using a factor of safety = 2.0, this equates to **455.84 tons/pile**



IHNC Lock Replacement

Designed by: P.J.S.
Checked by:

Pile Determination - Maintenance Dewatering, Load Case 3
Chamber: No Water
Tailwater: EL. 1.00

Concrete Weight:						
Float-in segment:	1386.00 sf x (CADD)	14.00 ' strip x	0.15 =		2910.60 x 2 (other half) =	5821 kips
Grout	4.00 ft x	14.00 ' strip x	172.00 ft x	0.1500 =	=	1445 kips
Walls:	786.12 sf x (CADD)	14.00 ' strip x	0.15 =		1650.85 x 2 (other half) =	3302 kips
Water:						
	0.00 ft x	14.00 ' strip x	110.00 ft x	0.0625 =	=	0 kips
	0.00 sf x	14.00 ' strip x	0.0625 =		0.00 x 2 (other half) =	0 kips
Soil:						
Soil with water:	124.83 sf x (CADD)	14.00 ' strip x	0.12 =		209.71 x 2 (other half) =	419 kips
Uplift:						
Tailwater @ El. 1.0:	3.92 ks x	14.00 ' strip x	172.00 ft	=	=	-9427 kips
Headwater @ EL. 10.0	(.5(3.84+3.99))				Total weight:	1560 kips

Distribute 1560 kips over 172.0 ft: 1560 / 172 = 9.07 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

44.00 ft on each end, load is: 9.07 kips/ft x 1.25 = 11.34 kips/ft

so, for 88' of monolith, load is: 88.00 ft x 11.34 = 997.55 kips

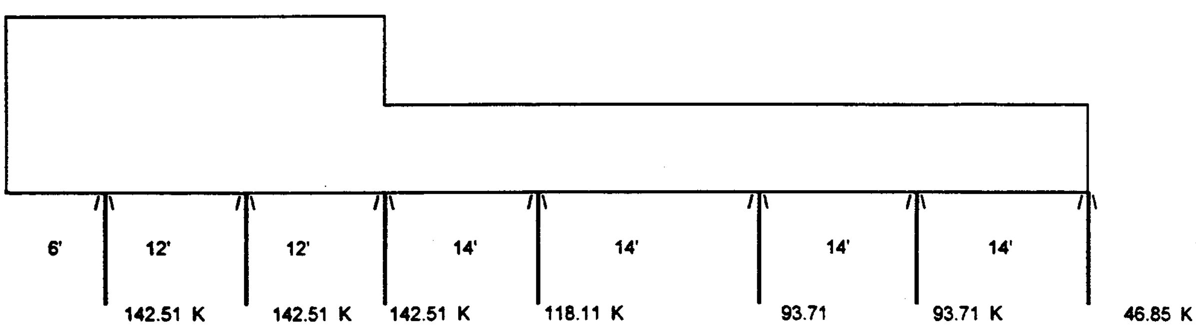
therefore, remaining 84' of monolith will have load of:[(9.07 x 172.00) 997.55]/ 84 = 6.69 kips/ft

For 44.00 ft on each end: 88.00 ft x 11.34 / 7.0 piles = 142.51 kips/pile

Using a factor of safety = 2.0, this equates to **142.51 tons/pile**

For 84.00 ft in the middle: 84.00 ft x 6.69 / 6.0 piles = 93.71 kips/pile

Using a factor of safety = 2.0, this equates to **93.71 tons/pile**



1200 x 110 x 36

CHAMBER

IHNC Lock Replacement

Designed by: P.J.S.
Checked by:

Pile Determination - Hurricane, Load Case 4B
Chamber: EL. 0.00
Tailwater: EL. 13.00

Concrete Weight:					
Float-in segment:	1386.00 sf x (CADD)	14.00 ' strip x	0.15 =	2910.60 x 2 (other half) =	5821 kips
Grout:	4.00 ft x	14.00 ' strip x	172.00 ft x	0.1500 = =	1445 kips
Walls:	786.12 sf x (CADD)	14.00 ' strip x	0.15 =	1650.85 x 2 (other half) =	3302 kips
Water:					
Chamber @ EL. 0.0:	40.00 ft x	14.00 ' strip x	110.00 ft x	0.0625 = =	3850 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =	239.53 x 2 (other half) =	479 kips
Soil:					
Soil with water:	124.83 sf x (CADD)	14.00 ' strip x	0.12 =	209.71 x 2 (other half) =	419 kips
Drag:	295.43 kips (from C. Balint)			x 2 (other half) =	591 kips
Uplift:					
Tailwater @ EL. 13.0:	69.00 ft x	14.00 ' strip x	172.00 ft x	-0.0625 = =	-10385 kips
				Total weight:	5523 kips

Distribute 5523 kips over 172.0 ft: 5523 / 172 = 32.11 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

44.00 ft on each end, load is: 32.11 kips/ft x 1.25 = 40.13 kips/ft

so, for 88' of monolith, load is: 88.00 ft x 40.13 = 3531.87 kips

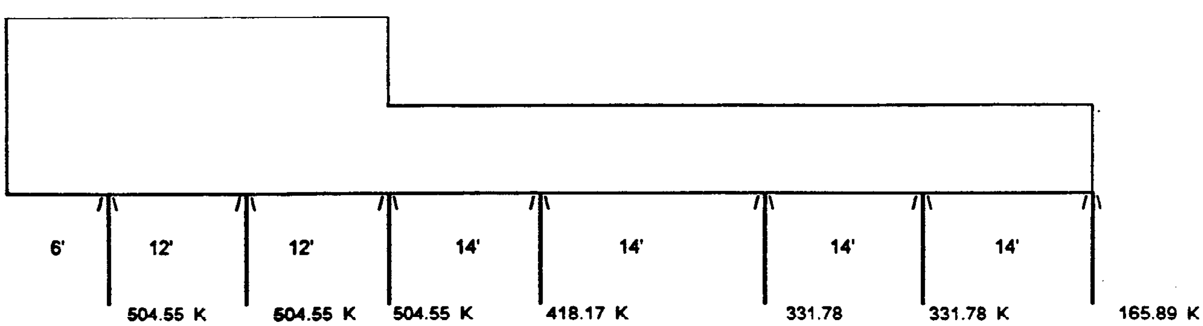
therefore, remaining 84' of monolith will have load of:[(32.11 x 172.00) 3531.87]/ 84 = 23.70 kips/ft

For **44.00 ft on each end:** 88.00 ft x 40.13 / 7.0 piles = 504.55 kips/pile

Using a factor of safety = 2.0, this equates to: **504.55 tons/pile**

For **84.00 ft in the middle:** 84.00 ft x 23.70 / 6.0 piles = 331.78 kips/pile

Using a factor of safety = 2.0, this equates to: **331.78 tons/pile**



IHNC Lock Replacement **"Gate Bay"**

Designed by: P.J.S.
Checked by:

Pile Determination - Normal Operations, Load Case 1
Chamber: EL. 10.00
Tailwater: EL. 1.00

Concrete Weight:						
Float-in segment:	1695.00 sf x (CADD)	14.00 ' strip x	0.15 =	3559.50 x	2 (other half) =	7119 kips
Grout:	4.00 ft x	14.00 ' strip x	180.00 ft x	0.1500 =	=	1512 kips
Walls:	860.31 sf x (CADD)	14.00 ' strip x	0.15 =	1806.65 x	2 (other half) =	3613 kips
Water:						
Chamber @ EL. 10.0:	50.00 ft x	14.00 ' strip x	110.00 ft x	0.0625 =	=	4813 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =	239.53 x	2 (other half) =	479 kips
Drag:	295.43 kips (from C. Balint)			x	2 (other half) =	591 kips
Uplift:						
Tailwater @ El. 1.0:	59.00 ft x	14.00 ' strip x	180.00 ft x	-0.0625 =	=	-9293 kips
Additional Weight:						
(from gates & water elevatio differentials on each side of gates)	3.22 k/ft (from P. Schaefer) x	14.00 ' strip		=	=	45 kips
					Total weight:	8879 kips

Distribute 8879 kips over 180.0 ft: 8879 / 180 = 49.33 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 49.33 kips/ft x 1.25 = 61.66 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 61.66 = 5179.59 kips

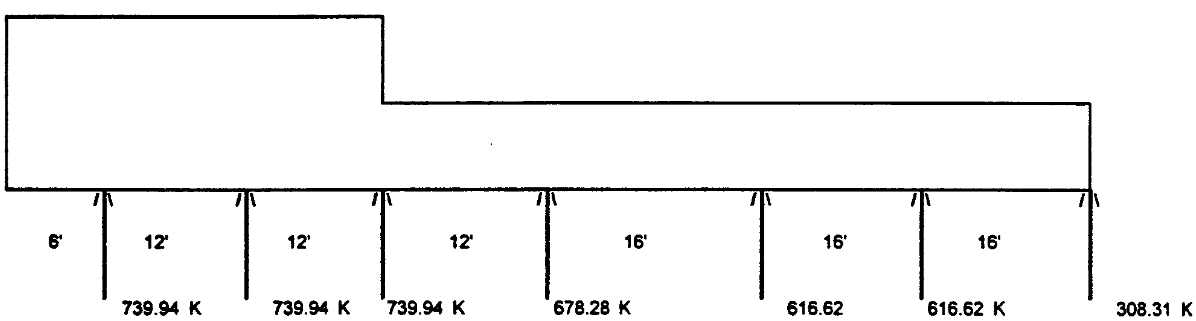
therefore, remaining 96' of monolith will have load of:[(49.33 x 180.00) - 5179.59] / 96 = 38.54 kips/ft

For 42.00 ft on each end: 84.00 ft x 61.66 / 7.0 piles = 739.94 kips/pile

Using a factor of safety = 2.0, this equates to: 739.94 tons/pile

For 96.00 ft in the middle: 96.00 ft x 38.54 / 6.0 piles = 616.62 kips/pile

Using a factor of safety = 2.0, this equates to: **616.62 tons/pile**



IHNC Lock Replacement **"Gate Bay"** Designed by: P.J.S.
Checked by:

Pile Determination - Maximum Operations, Load Case 2A * Governing Case *****
Chamber: **EL. 17.60**
Tailwater: **EL. -2.00**

Concrete Weight:						
Float-in segment:	1695.00 sf x (CADD)	14.00 ' strip x	0.15 =	3559.50 x 2 (other half) =		7119 kips
Grout:	4.00 ft x	14.00 ' strip x	180.00 ft x	0.1500 =	=	1512 kips
Walls:	860.31 sf x (CADD)	14.00 ' strip x	0.15 =	1806.65 x 2 (other half) =		3613 kips
Water:						
Chamber @ EL. 17.6:	57.60 ft x	14.00 ' strip x	110.00 ft x	0.0625 =	=	5544 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =	239.53 x 2 (other half) =		479 kips
Drag:	295.43 kips (from C. Balint)			x 2 (other half) =		591 kips
Uplift:						
Tailwater @ EL.-2.0:	56.00 ft x	14.00 ' strip x	180.00 ft x	-0.0625 =	=	-8820 kips
Additional Weight: (from gates & water elevation differentials on each side of gates)	3.81 k/ft (from P. Schaefer) x	14.00 ' strip		=	=	53 kips
				Total weight:		10092 kips

Distribute 10092 kips over 180.0 ft: 10092 / 180 = 56.06 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 56.06 kips/ft x 1.25 = 70.08 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 70.08 = 5886.75 kips

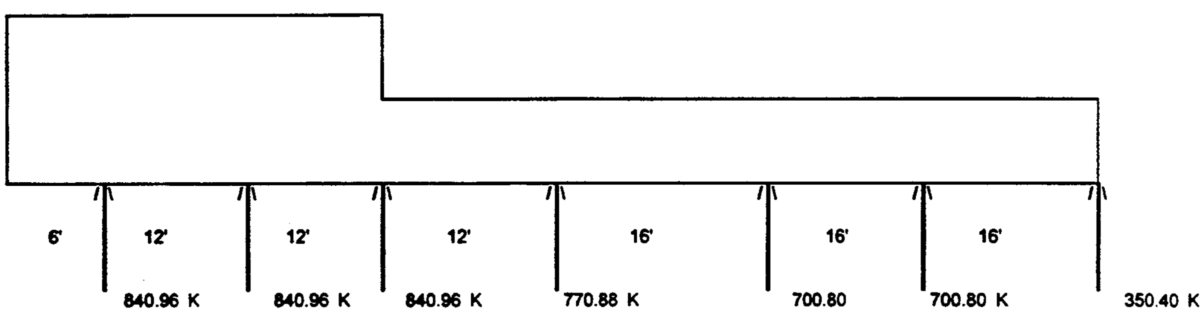
therefore, remaining 96' of monolith will have load of:[(56.06 x 180.00) 5886.75]/ 96 = 43.80 kips/ft

For **42.00 ft on each end:** 84.00 ft x 70.08 / 7.0 piles = 840.96 kips/pile

Using a factor of safety = 2.0, this equates to: **840.96 tons/pile**

For **96.00 ft in the middle:** 96.00 ft x 43.80 / 6.0 piles = 700.80 kips/pile

Using a factor of safety = 2.0, this equates to: **700.80 tons/pile**



IHNC Lock Replacement **"Gate Bay"** Designed by: P.J.S.
Checked by:

Pile Determination - Maximum Operations, Load Case 2B
Chamber: EL. -2.00
Tailwater: EL. -2.00

Concrete Weight:					
Float-in segment:	1695.00 sf x (CADD)	14.00 ' strip x	0.15 =	3559.50 x 2 (other half) =	7119 kips
Grout:	4.00 ft x	14.00 ' strip x	180.00 ft x	0.1500 = =	1512 kips
Walls:	860.31 sf x (CADD)	14.00 ' strip x	0.15 =	1806.65 x 2 (other half) =	3613 kips
Water:					
Chamber @ EL.-2.0:	38.00 ft x	14.00 ' strip x	110.00 ft x	0.0625 = =	3658 kips
Water in culvert:	273.75 sf x	14.00 ' strip x	0.0625 =	239.53 x 2 (other half) =	479 kips
Drag:	295.43 kips (from C. Balint)			x 2 (other half) =	591 kips
Uplift:					
Tailwater @ EL.-2.0:	56.00 ft x	14.00 ' strip x	180.00 ft x	-0.0625 = =	-8820 kips
Additional Weight: (from gates & water elevatio differentials on each side of gates)	3.08 k/ft (from P. Schaefer) x	14.00 ' strip		= =	43 kips
				Total weight:	8195 kips

Distribute 8195 kips over 180.0 ft: 8195 / 180 = 45.53 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 45.53 kips/ft x 1.25 = 56.91 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 56.91 = 4780.33 kips

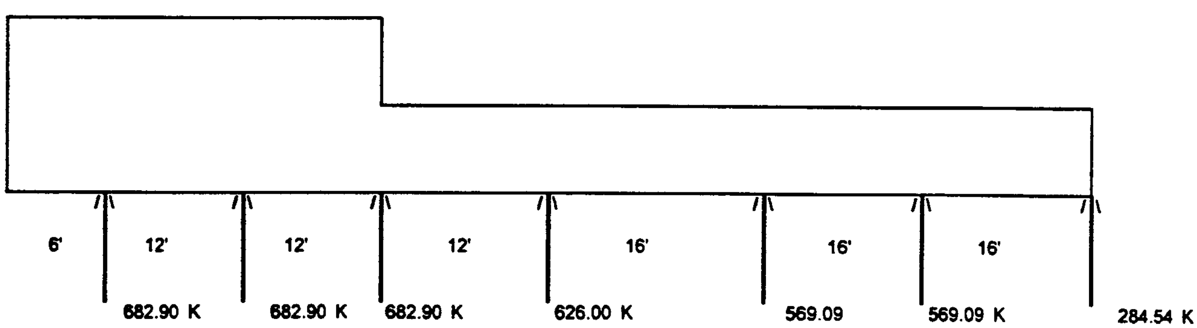
therefore, remaining 96' of monolith will have load of:[(45.53 x 180.00) 4780.33]/ 96 = 35.57 kips/ft

For 42.00 ft on each end: 84.00 ft x 56.91 / 7.0 piles = 682.90 kips/pile

Using a factor of safety = 2.0, this equates to: **682.90 tons/pile**

For 96.00 ft in the middle: 96.00 ft x 35.57 / 6.0 piles = 569.09 kips/pile

Using a factor of safety = 2.0, this equates to: **569.09 tons/pile**



IHNC Lock Replacement	****Gate Bay****	Designed by: P.J.S. Checked by:

Pile Determination - Maintenance Dewatering, Load Case 3
Chamber: No Water
Tailwater: EL. 1.00

Concrete Weight:								
Float-in segment:	1695.00 sf x (CADD)	14.00 ' strip	x	0.15 =		3559.50 x 2 (other half) =		7119 kips
Grout:	4.00 ft x	14.00 ' strip	x	180.00 ft x	0.1500 =		=	1512 kips
Walls:	860.31 sf x (CADD)	14.00 ' strip	x	0.15 =		1806.65 x 2 (other half) =		3613 kips
Water:								
	0.00 ft x	14.00 ' strip	x	110.00 ft x	0.0625 =		=	0 kips
	0.00 sf x	14.00 ' strip	x	0.0625 =		0.00 x 2 (other half) =		0 kips
Uplift:								
Tailwater @ El. 1.0: Headwater @ EL. 10.0	4.18 ks x (.5(4.11+4.25))	14.00 ' strip	x	180.00 ft		=	=	-10534 kips
Additional Weight: (from gates & water elevatio differentials on each side of gates)	4.07 k/ft (from P. Schaefer) x			14.00 ' strip		=	=	57 kips
						Total weight:		1768 kips

Distribute 1768 kips over 180.0 ft: 1768 / 180 = 9.82 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 9.82 kips/ft x 1.25 = 12.28 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 12.28 = 1031.15 kips

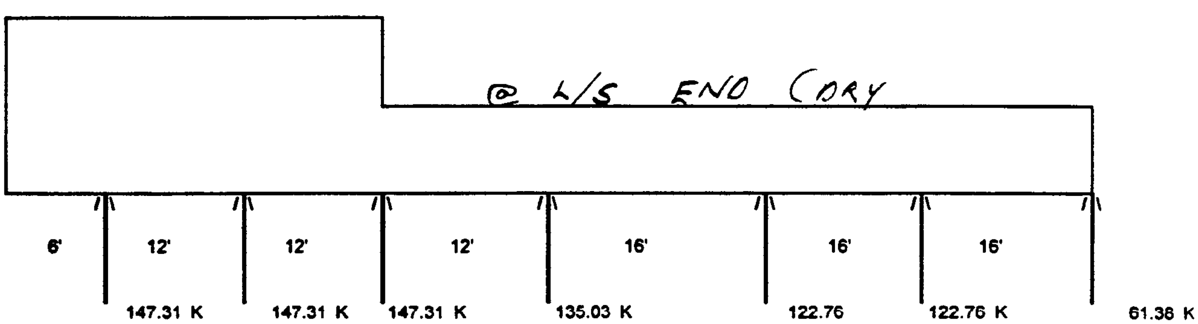
therefore, remaining 96' of monolith will have load of:[(9.82 x 180.00) 1031.15]/ 96 = 7.67 kips/ft

For 42.00 ft on each end: 84.00 ft x 12.28 / 7.0 piles = 147.31 kips/pile

Using a factor of safety = 2.0, this equates to: **147.31 tons/pile**

For 96.00 ft in the middle: 96.00 ft x 7.67 / 6.0 piles = 122.76 kips/pile

Using a factor of safety = 2.0, this equates to: **122.76 tons/pile**



IHNC Lock Replacement ****Gate Bay**** Designed by: P.J.S.
Checked by:

Pile Determination - Maintenance Dewatering, Load Case 3
Chamber: R/S OF BULKHEAD AT EL. 10.0
Tailwater: EL. 1.00

Concrete Weight:

Float-in segment: 1695.00 sf x 14.00 ' strip x 0.15 = 3559.50 x 2 (other half) = 7119 kips
(CADD)

Walls: 860.31 sf x 14.00 ' strip x 0.15 = 1806.65 x 2 (other half) = 3613 kips
(CADD)

Water:

50.00 ft x 14.00 ' strip x 110.00 ft x 0.0625 = = 4813 kips

0.00 sf x 14.00 ' strip x 0.0625 = 0.00 x 2 (other half) = 0 kips

Uplift:

Tailwater @ El. 1.0: 4.18 ksf x 14.00 ' strip x 180.00 ft = = -10534 kips
Headwater @ EL. 10.0 (.5(4.11+4.25))

Additional Weight:

(from gates & water elevatio 4.07 k/ft (from P. Schaefer) x 14.00 ' strip = = 57 kips
differentials on each side of gates)

Total weight: 5068 kips

Distribute 5068 kips over 180.0 ft: 5068 / 180 = 28.16 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 28.16 kips/ft x 1.25 = 35.20 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 35.20 = 2956.44 kips

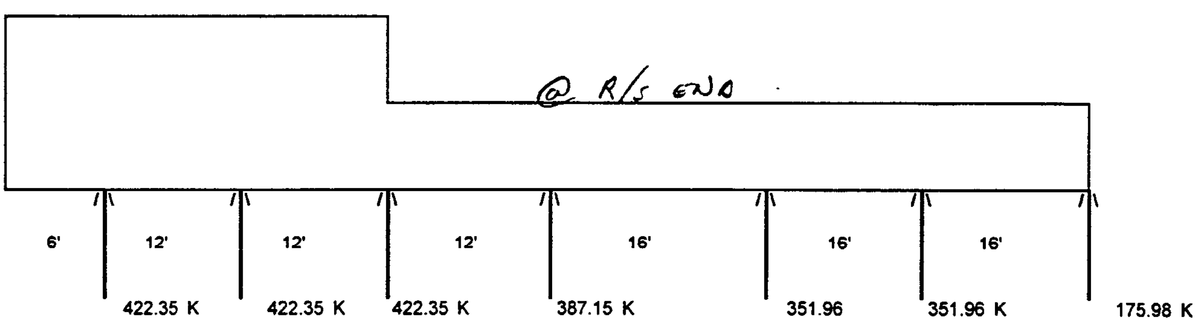
therefore, remaining 96' of monolith will have load of:[(28.16 x 180.00) 2956.44]/ 96 = 22.00 kips/ft

For 42.00 ft on each end: 84.00 ft x 35.20 / 7.0 piles = 422.35 kips/pile

Using a factor of safety = 2.0, this equates to **422.35 tons/pile**

For 96.00 ft in the middle: 96.00 ft x 22.00 / 6.0 piles = 351.96 kips/pile

Using a factor of safety = 2.0, this equates to **351.96 tons/pile**



IHNC Lock Replacement	**"Gate Bay"**	Designed by: P.J.S. Checked by:

Pile Determination - Hurricane, Load Case 4B
Chamber: EL. 0.00
Tailwater: EL. 13.00

Concrete Weight:

Float-in segment:	1695.00 sf (CADD)	x	14.00 ' strip	x	0.15 =	3559.50	x 2 (other half) =	7119 kips
Grout	4.00 ft	x	14.00 ' strip	x	180.00 ft x	0.1500 =	=	1512 kips
Walls:	860.31 sf (CADD)	x	14.00 ' strip	x	0.15 =	1806.65	x 2 (other half) =	3613 kips
Water:								
Chamber @ EL. 0.0:	40.00 ft	x	14.00 ' strip	x	110.00 ft x	0.0625 =	=	3850 kips
Water in culvert:	273.75 sf	x	14.00 ' strip	x	0.0625 =	239.53	x 2 (other half) =	479 kips
Drag:	295.43 kips (from C. Balint)						x 2 (other half) =	591 kips
Uplift:								
Tailwater @ EL. 13.0:	71.00 ft	x	14.00 ' strip	x	180.00 ft x	-0.0625 =	=	-11183 kips
Additional Weight: (from gates & water elevatio differentials on each side of gates)	3.40 k/ft (from P. Schaefer)	x	14.00 ' strip			=	=	48 kips
							Total weight:	6029 kips

Distribute 6029 kips over 180.0 ft: 6029 / 180 = 33.50 kips/ft for a 14' strip

Distribute 125% of load at both ends of monolith and rest of load in middle:

42.00 ft on each end, load is: 33.50 kips/ft x 1.25 = 41.87 kips/ft

so, for 84' of monolith, load is: 84.00 ft x 41.87 = 3517.11 kips

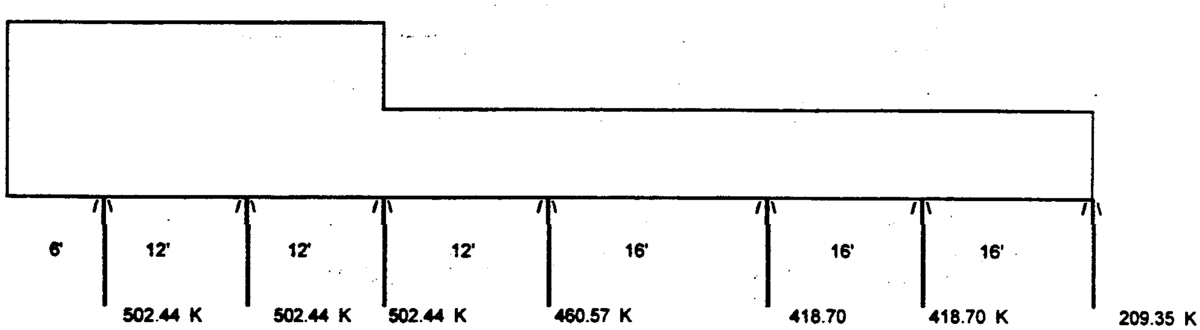
therefore, remaining 96' of monolith will have load of:[(33.50 x 180.00) 3517.11]/ 96 = 26.17 kips/ft

For 42.00 ft on each end: 84.00 ft x 41.87 / 7.0 piles = 502.44 kips/pile

Using a factor of safety = 2.0, this equates to: **502.44 tons/pile**

For 96.00 ft in the middle: 96.00 ft x 26.17 / 6.0 piles = 418.70 kips/pile

Using a factor of safety = 2.0, this equates to: **418.70 tons/pile**



The following CPGA run checks reactions and stresses in the Gate Bay Module pile foundation for load cases with significant lateral loads. Since the piles are "grouted to" and not "embedded in" the same cases were analyzed with the overturning loads resisted axially. ($\sigma = \frac{P}{A} \pm \frac{Mc}{I}$).

The load cases considered were the Maintenance Dewatering and Maximum Operation; Of the two the Maximum Operation governed.

Summary

$P_{COMP\ max} = 851\ K$

$P_{TEN\ max} = N/A$

48" ⌀ pile   Len = 160' w/ Tip @ EL -215

$P_{ULT\ COMP} = 860$ TONS

$P_{ULT\ TENSION} = 720$ TONS

Wall THICKNESS - COMPLY WITH AISC TABLE B5.1 REQUIREMENTS FOR LOCAL BUCKLING

$D/t_w < 3300/F_y$ USE ASTM A53 Gr B
API 5L Gr B Pipe

$t_{w\ min} = \frac{48 \times 35}{3300} = 0.51"$ $F_y = 35$ KSI

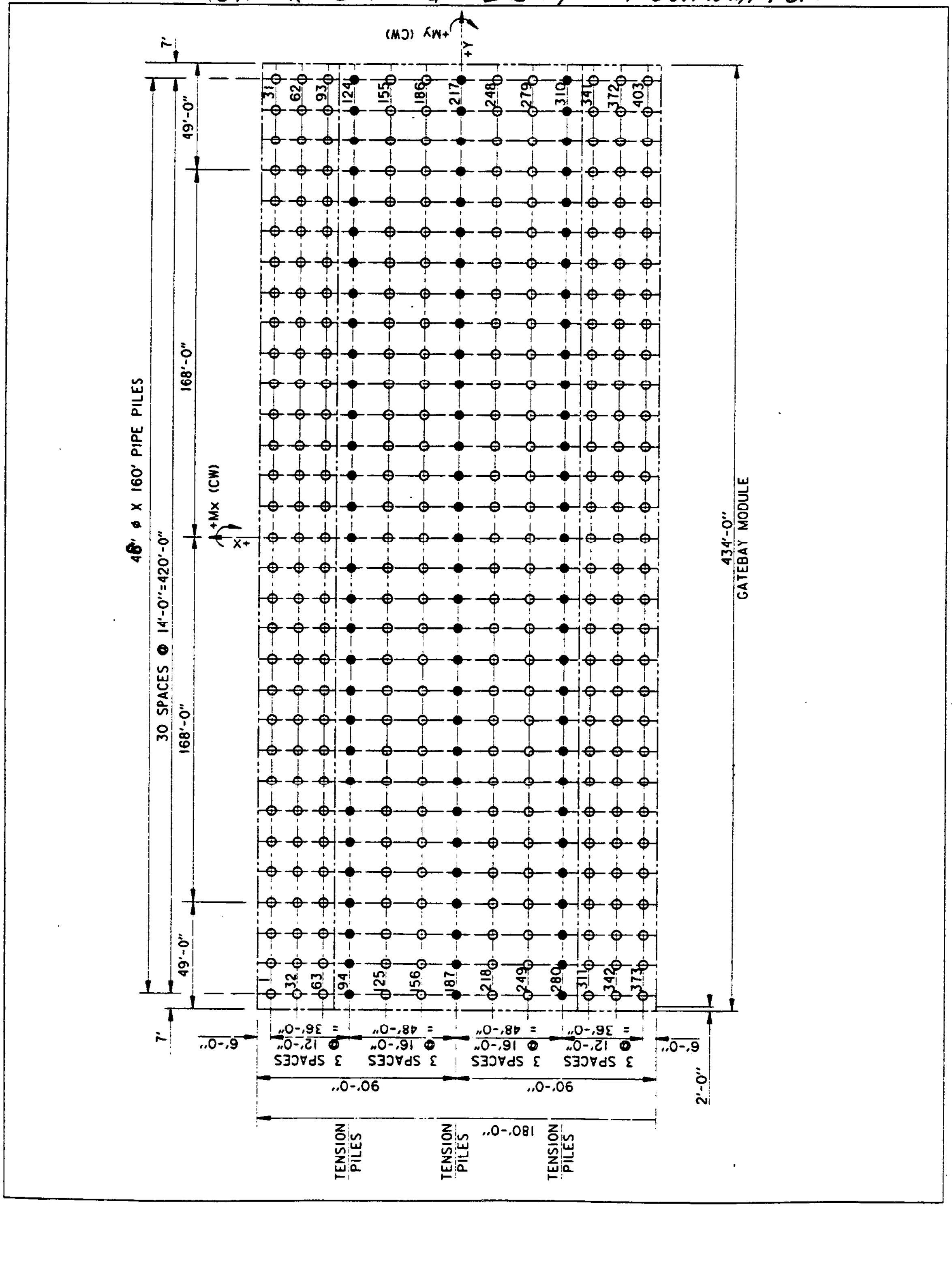
USE 5/8" WALL PIPE

$A = 93"^2$

$f_{a\ max} = \frac{851\ K}{93} = 9.15$ KSI

$F_a = 35 \times 5/6 \times 1/3 = 10.$ KSI $> f_a$

SHIPLOCK GATEBAY FOUNDATION



COMPUTATION SHEET

PROJECT	PAGE 17 OF 20	COMPUTED BY COB	DATE 9/96
SUBJECT		CHECKED BY	DATE

PROPERTIES OF PILE 48"Ø, 5/8" WALL, 35 KSI

$E = 29{,}000$ KSI

$I_1 = I_2 = 0.049087 (48^4 - 46.75^4)$

$= 26{,}100 \, in^4$

$S_1 = S_2 = 26{,}100 \, in^4 / (48"/2)$

$= 1087.5 \, in^3$

$A = 0.785398 (48^2 - 46.75^2)$

$\cong 93.02 \, in^2$

$C_{33} = 2.0$ (FULL SKIN FRICTION)

$B_{66} = 0$ (NO TORSIONAL EFFECTS CONSIDERED)

ALLOWABLES

$AC = 880 K$ } PILE CAPACITY

$AT = 760 K$ } CURVES ← CONTROLS

$A_{CC} = A_{TT} = (F_A)(A)$

$F_A = 5/6 \times 3/5 \times F_Y$

$= 0.50 \, (35 ksi)$

$= 17.5 \, ksi$

$A_{CC} = (17.5)(93.02 \, in^2)$

$= 1627 \, K$

$\frac{D}{t} = \frac{48}{0.625} = 76.8 < \frac{3300}{F_Y} = 94$

$A_{m1} = A_{m2} = F_b S$ ∴ Compact

$F_b = 0.55 \, F_Y$ FOR COMPACT PIPE

$= 19 \, KSI$

$A_m \, (19.0 \, ksi)(1087.5 \, in^3)$

$= 20{,}940$

SOIL

$ES < 0.355$ KSI FROM PILE CURVES

LENGTH = 160'

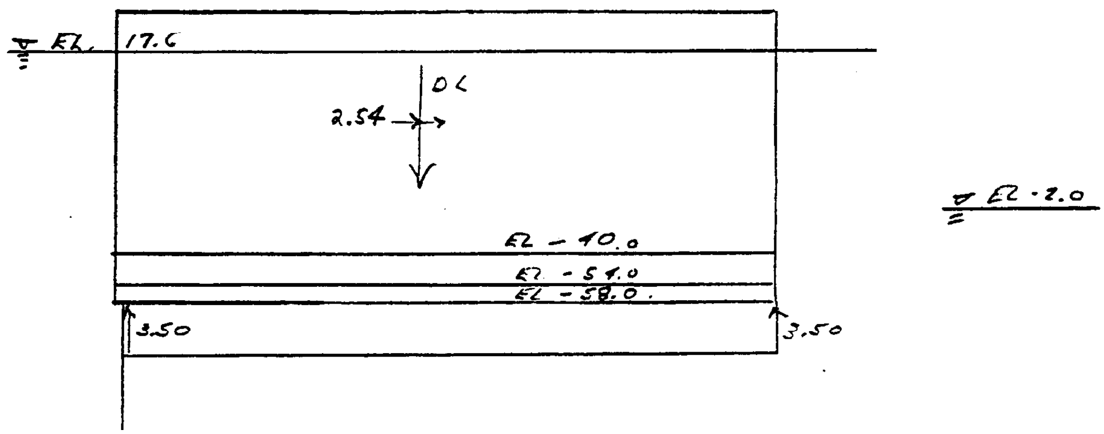
$LU = 0$

COMPUTATION SHEET

PROJECT SHIP LOCK FOUNDATION	PAGE 18 OF 20	COMPUTED BY MM	DATE 9/96
SUBJECT RIGID BASE ANALYSIS		CHECKED BY	DATE

MAX. OPERATION UPLIFT A

CHAMBER FULL



$\Sigma P_x = 0 \quad \Sigma P_y = 0$

$\Sigma P_z =$ Gate DL + Chamber$_{H_2O}$ + Culvert H_2O + Grout − Uplift

$= 331,600 + (110 \times 434 \times 57.6 \times 0.0625) + (2 \times 15 \times 18.25 \times 0.0625 \times 393')$
$+ (4' \times 180 \times 434 \times 0.15) - (3.50 \times 180 \times 434)$

$= 331,600 + 171,800 + 13,450 + 46,890 - 273,420$
$= 290,360\ K$

INCLUDE DRAG FORCE = 18,230 K

$\Sigma P_z = 308,600\ K$

$\Sigma M_x = (331,600 \times -2.54) + (0) + (13,450 \times 20.5) + 0 - 0 + 0_{DRAG}$
$= -567,600'\ K$

```
010 IHNC LOCK R/S GATEBAY-MAXIMUM OPERATION 2A/FULL CHAMBER-
015 DRAG FORCE INCLUDED//FILE:GATE2A17
020 PROP 29000 26100 26100 93.0 2.0 0 ALL
030 SOIL ES 0.355 LEN 160.0 0 ALL
040 TENSION 0.8 ALL
050 ALLOW R 880.0 760.0 1627.0 1627.0 20940.0 20940.0 ALL
070 PILE 1 84 -210 0
080 ROW Y 31 1 30 AT 14
090 REPEAT 13 3 AT -12 6 AT -16 3 AT -12
100 LOAD 1 0 0 308600 -567600 0 0
120 FOUT 2 4 5 6
130 PFO ALL
```

R/S GATEBAY

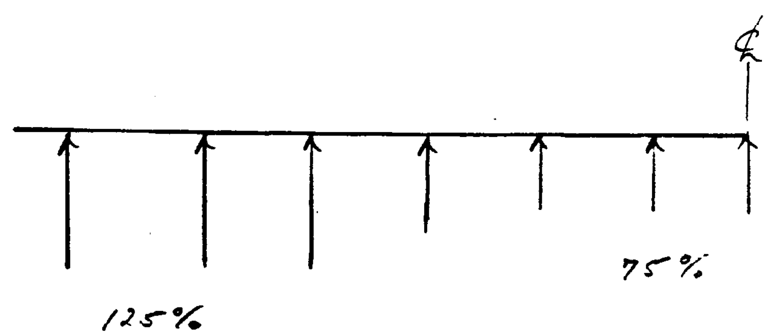
UPLIFT A

CHAMBER @ EL 17.6 W/DRAG

MAX. OPERATION

P_{max} = 785 K < 880 capacity

CBF_{max} = 0.49



$W_{125\%}$ => 785 x 13 piles / 180' = 56.7 K/LF for 14' pile spacing

42' x 56.7 x 1.25 / 3.5 piles = 851 kips < 880 capacity