CONNECTICUT RIVER FLOOD CONTROL PROJECT

HOLYOKE, MASS.

CONNECTICUT RIVER, MASSACHUSETTS

ANALYSIS OF DESIGN FOR LOCAL PROTECTION WORKS

FISCAL YEAR 1939 DIKE SECTION, ITEM Hi.2
INCLUDING PUMPING PLANTS – CONTRACT

APPENDIX A

APRIL, 1939

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

407-610A

HOLYOKE DIKE

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HOLYOKE DIKE

ANALYSIS OF DESIGN

APPENDIX

A. General Information.

1. Location design grade and loading. The reinforced concrete flood wall will extend from the end of the wall known as The Initial Fiscal Year 1939 Unit, Holyoke, Massachusetts, to 100± south of tailrace structure #10. Tailrace gate structures occur at the following stations: No. 1 at Sta. 16+75±, No. 4 at Sta. 25+90±, No. 6 at Sta. 35+60±, No. 7 at Sta. 40+83±, No. 8 at Sta. 44+30±, No. 9 at Sta. 50+10±, No. 10 at Sta. 52+90±, No. 11 at Sta. 55+90±, and No. 12 at Sta. 58+80±. Pumping stations will be incorporated as a part of Tailrace Gate Structures Nos. 1, 4, 7 and 10. The structures are designed to resist a principal load coming from the assumed head of water taken from 1.5 to 2.9 feet higher than the walls and therefore somewhat greater than the Comprehensive Plan flood stage. This design head is in accordance with instructions from the Office of the Chief of Engineers. The walls could be raised by temporary breast work at times of extreme flood. In general, the secondary loading is the ground fill on the landside of the walls. The walls vary in height from 8'6" to 37'0".

2. Type of wall. In general the "T" type cantilever wall was selected as being the most economical for the height of wall needed under the existing conditions. The sections of the flood wall adjacent to the tailrace structures were of a buttress type due to the necessary increased height. For some sections of the wall due to local conditions, such as a building obstruction, an "L" type cantilever was used as the most practicable type. Concrete facing walls were used at locations of existing dikes.

3. Tailrace gate structures. The concrete tailrace structures were designed to resist a load coming from a head of water, equivalent to that used in the design of the walls. The structures were investigated for stability for two conditions of loading; one with the river at flood stage and one with the river down. The conduit portions of the structures were designed as rigid boxes loaded with maximum pressures obtainable.

4. Pumping stations. In the following design analysis the pumping stations were considered an integral part of the tailrace gate structures.

B. General Design Data.

1. General. The structural design of the structures have been executed, in general, in accordance with standard practice. The specifications which follow cover the condition affecting the design for stability, reinforced concrete and structural steel.

2. Unit weights. The following unit weights for materials were assumed:

Water 62.5 pounds per cubic foot.

Dry earth 100 pounds per cubic foot.

Saturated earth 125 pounds per cubic foot.

Concrete 150 pounds per cubic foot.

Structural steel 489.6 pounds per cubic foot.

3. Earth pressures. In computing active earth pressures equivalent fluid pressures computed by the use of Rankine's formula were used. They are as follows:

Equivalent liquid pressure of dry earth = 35 pounds per cubic foot.

Equivalent liquid pressure for saturated earth = 80 pounds per cubic foot.

In computing passive resistances, Rankine's formula was used, with the coefficient of internal friction - 35 degrees.

4. Hydrostatic uplift.

a. River side of sheet piling, full head due to headwater.

b. Landside of sheet piling.

(1) At landward toe, full head due to tailwater.

(2) At sheet piling, full head due to tailwater plus one-half the difference between headwater and tailwater.

(3) At intermediate points, the uplift was assumed to vary uniformly with the distance from the toe.

5. Overturning. The resultant of all external loads, including hydrostatic uplift and excluding base pressure, does not fall within the middle third under every condition but under no condition is the allowable bearing value of the soil exceeded.

6. Sliding. The total horizontal forces due to external loads shall not exceed the resistance available from friction and passive resistance. The coefficient of friction used is 0.45.

7. Bearing. The total bearing pressure, equal to the sum of hydrostatic pressure plus the remaining effective base pressure, shall in no case exceed the maximum allowable soil pressure.

8. Frost cover. All footing bases shall lie at least 4 feet beneath the ground surface to avoid heaving by frost action.

9. Path of percolation. Except where steel sheet piling is driven to rock, the minimum path of percolation shall be determined as follows: Wall with sheet pile cut-off and with filter on landside five times the head of water for wall with stem up to 5'0" above the base and four times the head of water with stem greater than 5'0" above the base.

10. Reinforced Concrete. In general all reinforced concrete was designed in accordance with the "Joint Code of the American Concrete Institute and the Reinforcing Steel Institute for the Design of Concrete and Reinforced Concrete" issued in 1928 and the "Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete issued in January 1937."

(a) Allowable stresses. The allowable working stresses in concrete are based on an average ultimate compressive strength in 28 days of 3400 pounds per square inch for Class "A" concrete and 3000 pounds per square inch for Class "B" concrete.

	Lbs. per sq. in.
(b) Flexure (fc).	
Extreme fibre stress in compression	800
Extreme fibre stress in compression adjacent to supports of continuous or fixed beams or rigid frames	900
(c) Shear (v)	
Beams with no web reinforcement and without special anchorage	40
Beams with no web reinforcement but with special anchorage of longitudinal steel	60
Beams with properly designed web reinforcement and with special anchorage of longitudinal steel	180
Footings where longitudinal bars have no special anchorage	40
Footings where longitudinal bars have special anchorage	60
(d) Bond (u).	
In beams, slabs and one way footings	100
Where special anchorage is provided	200
The above stresses are for deformed bars.	
(e) Bearing (fc).	
Where a concrete member has an area at least twice the area in bearing	500
(f) Steel stresses	
Tension	18,000
Web reinforcement	16,000

(g) Protective concrete covering.

Type of members	Minimum cover in inches
Interior slabs	1-1/2
Interior beams	2
Members poured directly against the ground	4
Members exposed to earth or water but poured against forms	3

For secondary steel, such as temperature and spacer steel, the above minimum cover may be decreased by the diameter of the temperature or spacer steel rods.

C. Basic Assumption for Design.

1. Tailrace Gate Structures.

(a) Stability. The stability of the gate structures as a unit was investigated for the worst conditions of loading; namely, with the river at flood stage and also with the river at low stage. In all conditions of loading, the base pressures were held below the allowable.

(b) Roof slabs of pump houses. The roof slabs are of reinforced concrete. They were designed to carry the full dead load plus a live load of 40 pounds per square foot of roof surface.

(c) Machinery room floors. The machinery room floors were designed to carry all motors, etc. actually to be placed on that floor as well as a uniform load.

The following assumptions were made for design purposes:

(1) For the floor slab the design loads were the estimated dead load plus a uniform load of 350 pounds per square foot.

(2) For removable steel floor plates, the design loads were the estimated dead load plus a uniform load of 350 pounds per square foot.

(3) For the floor beams the design loads were the estimate dead loads on the unoccupied portion of the floor slabs which contribute loads to the beams under consideration. For the machinery loads an impact factor of 100 per cent has been added.

(d) Pump room side walls and floor slab.

In designing the pump room side walls and floor slabs, the assumption was made that the side walls, above the machinery floor are simply supported at the top edges and fixed at the base.

(e) Sumps. The pumping station sumps were designed as closed horizontal rectangular frames continuous at all four corners, except for the portions included in the depth of the sump sluice gate openings. These portions were designed as horizontal frames hinged on each side of the sluice gate openings. The sump floor slabs and the extensions of these slabs to the land side of the structures were designed for the net upward reactions against them as well as for the gravity loads which they are to support. The slabs were assumed as simply supported except where conditions justified assumptions of continuity.

(f) Conduits. The conduit portions of the tailrace structures were designed as rigid frames to carry the maximum possible loads from earth cover, horizontal earth thrust and maximum base pressure.

(g) Walls.

(1) The rear wall was designed to resist an earth load from the fill on the land side and also a water load from the river side.

(2) The front curtain wall was designed to resist an ice pressure of 1000 pounds per square foot assumed to act over two feet giving a loading of 500 pounds per foot.

(h) Buttresses. The buttresses were designed as cantilever beams carrying a load of one-half the span of the conduit.

2. Flood walls. The reinforced concrete flood walls were assumed to act as cantilever walls, resisting lateral forces in both directions. The restraint of the sheet piling was neglected.

(a) Wall Stem. The stem was designed as a cantilever beam fixed at the top of the base support to carry the differential load due to water pressure and earth pressure. The landside face of the stem was designed to carry the load from the backfill or railroad for those sections of the wall where these loads exist.

(b) Base Slab. Both riverside and landside footings were designed as cantilever beams fixed at the face of the stem.

3. Wing walls at gate structures. The reinforced concrete wing walls were assumed to act as buttress walls, resisting lateral forces in both directions. The restraint of the sheet piling is neglected.

(a) Wall Stem. The stem was designed to carry the differential load due to water pressure and earth pressure by beam action to the buttresses.

(b) Landside Base Slab. The landside footings were designed as beams simply supported at the buttresses, due to the "stepping up" of the bases adjacent to the structure.

(c) Riverside Base Slab. The riverside footings were designed as cantilever beams supported at the face of the stem.

(d) Buttresses. The buttresses were designed to resist the compressional tensional and shearing forces induced by the slabs.

HOLYOKE DIKE

ANALYSIS OF DESIGN

APPENDIX A

INTRODUCTION

Grades of concrete at top of walls were changed after computations were completed. This raise in grade is in favor of stability since the walls were computed originally for an extra 3 ft. head with less dead load in the stem.

Slight variations may be found between the computation dimensions and the dimensions of the final structure. In no case was this variation enough to warrant redesign.

WAR DEPARTMENT

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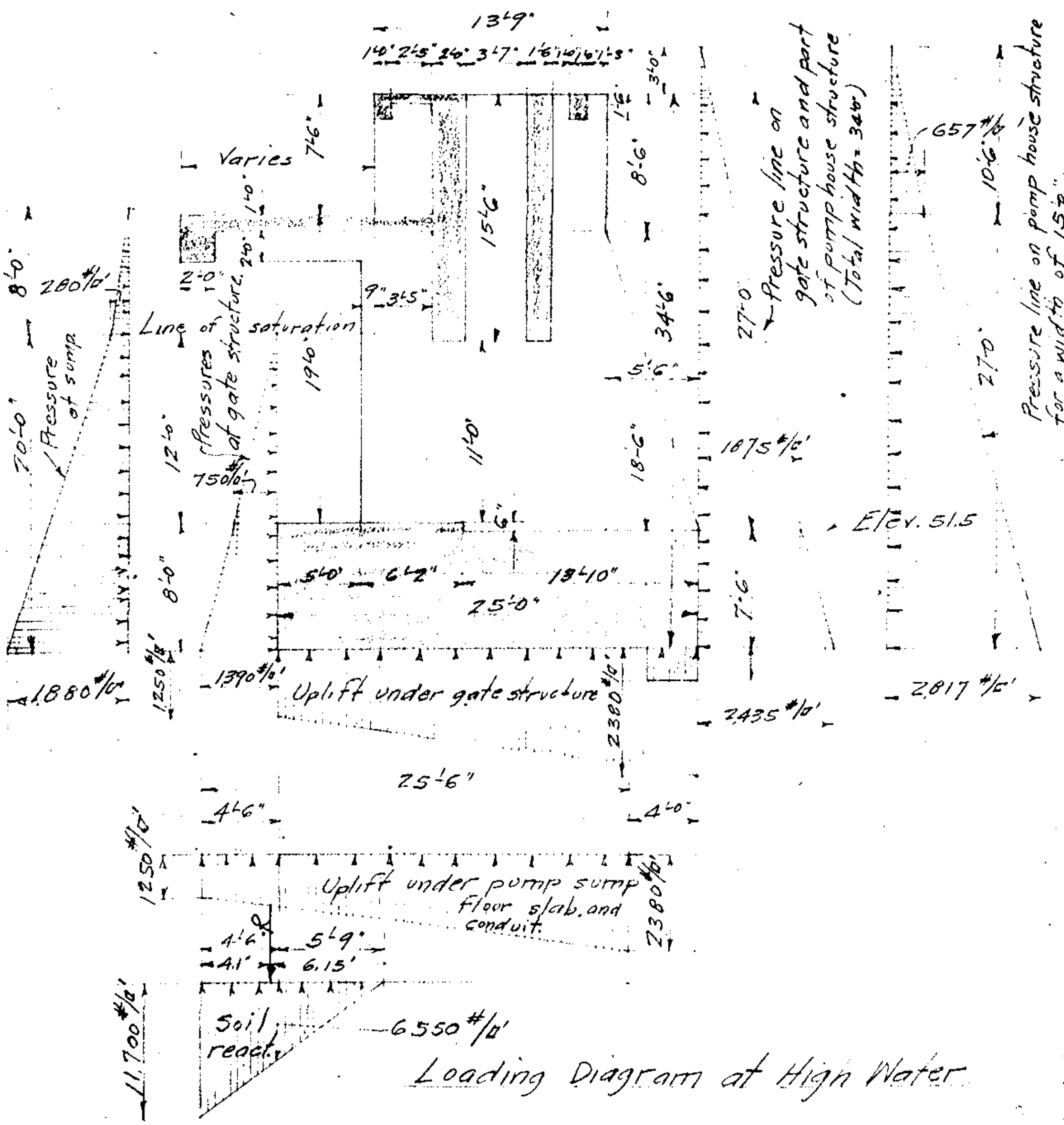
Subject Tailraces #1 & #2 - Holyoke, Mass.

Computation Stability of Structure - High Water

Computed by E.M.V. **Checked by** .... **Date** April 10, 1939



Loading Diagram at High Water

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WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailraces #1 & #2 - Holyoke Mass.
Computation Stability of Structure - High Water
Computed by E.M.V. **Checked by** **Date** April 10, 1939.

Forces Acting	↓	↓	→	←	Mom. Arm	Moments About Heel ↻	↺
4×1.5×1.0×10.0×150	9.0				12.0	108.	
2×2.4×0.5×10.0×150	3.6				8.0	29.	
2×2.0×15.5×10.0×150	93.0				10.2	950.	
2×1.5×15.5×10.0×150	69.7				14.8	1,020.	
2.7×2.0×5.0×150	4.0				0.0	0.	
1.0×14.0×11.0×150	23.1				2.2	51.	
5.2×8.5×13.8×150	91.4				12.6	1150.	
½×5.2×5.5×18.5×150	39.7				21.3	846.	
5.2×14.5×18.5×150	202.0				12.3	2480.	
2×0.5×11.2×10.0×150	16.8				5.6	94.	
25.0×7.5×27.7×150	778.0				12.5	9730.	
4.0×2.0×2.5×150	3.0				23.0	69.	
18.5×2.5×24.5×150	170.0				11.7	1990.	
18.5×2.0×24.5×150	135.7				11.7	1588.	
23.0×24.5×2.0×150	168.8				17.5	2955.	
3.0×9.0×20.5×150	83.0				17.0	1410.	
3.0×9.0×18.0×150	72.8				9.0	655.	
2.0×13.0×23.0×150	89.7				3.5	314.	
2.0×5.5×12.0×150	19.8				3.5	69.	
2.5×4.0×29.0×150	43.5				23.0	1000.	
	2116.6					26,508	

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Subject Tailraces #1 & #2 - Holyoke, Mass.

Computation Stability of Structure. - High Water

Computed by E.M.V. **Checked by** **Date** April 19, 1937.

	Forces Acting	↓	↑	→	←	Mom. Arm.	Moments About Heel ↻	↺
Concrete to here	15.5×3.0×14.5×150	101.0				11.5	1160.	
	7.0×1.5×20.0×150	31.5				8.3	261.	
	3.0×1.5×20.0×150	13.5				6.0	81.	
	14.5×18.5×1.0×150	40.2				11.8	475.	
	0.5×20.0×19.5×150	29.3				13.8	404.	
	2×1.0×17.7×21.5×150	114.2				13.8	1575.	
	2×1.0×17.7×18.5×150	98.2				13.8	1358	
	2.0×13.0×20.0×150	7.8				-0.5		4
	2×2.0×5×20.0×150	60.0				0.0	0	
Earth	7.0×8.0×20.0×125	140.0				-1.0		140
	Machinery 38,000#	38.0				12.0	457.	
	Sluice Gates 30,000#	30.0				12.0	360.	
Water	2×10.0×11.0×25.0×62.5	344.0				12.5	4300.	
"	2×10.0×18.5×8.8×62.5	203.0				20.6	4180.	
"	2×10.0×18.5×3.6×62.5	83.0				14.8	1228	
"	2.7×8.5×5.5×62.5	7.9				22.3	176.	
"	2.7×9.3×5.5×62.5	8.6				23.2	200.	
"	5.0×9.0×20.0×62.5	56.2				0.0	0.	
	18.5×13.0×11.0×62.5	165.2				12.5	2065	
Uplift	½(1250+2380)25×30.7		1392.0			13.8		19300
		1571.6	1392.0				18,280	19,444

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WAR DEPARTMENT

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Subject Tailraces #1 & #2 - Holyoke, Mass.
Computation Stability of Structure - High Water
Computed by E.M.V. **Checked by** ______ **Date** April 11, 1939

	Forces Acting	↓	↑	→	←	Mom. Arm	Moments About Heel ↻	↺
Uplift	½(844+1,935)25.5×17.5		620.0			9.9		6,135.
	½×1,875×30.0×34.0				955.0	17.5		16,700.
	½(1875+2,435)7.5×34.0				548.0	3.6		1,973.
Pressures	½(2817+657)27.0×15.0				704.0	10.7		7,540.
	½×657×10.5×15.0				51.7	30.5		1575.
	½×750×12.0×22.0			99.0		12.0	1,187.	
	½(750+1390)8.0×22.0			188.3		3.6	678	
Horiz.	½×280×8.0×26.0			29.1		22.7	660.	
	½(280+1880)20.0×26.0			561.		7.5	4200	
			620.0	877.4	2258.7		6725	33,923.
	Brought forward	2116.6					26,508.	
		1571.6	1392.0				18280.	19,444.
		ΣV=1676.2		ΣH=1381.3←			ΣM=1,854↺	
Added Conc. Under Sump.	22.5×6.5×17×150	372.0				6.8	2530.	
Added Uplift.	407×25.5×17.0		176.5			8.3.		1465.
		ΣV=1851.7					ΣM=789↺	

Subject Tailrace #1 & 2 - Holyoke, Mass.
Computation Stability of Structure - High Water
Computed by E.M.V. Checked by ______ Date April 11, 1939.

(Continued from sheet #4)

Position of resultant = $\frac{789}{1851.7}$ = 0.4' to left of rear edge of gate structure base slab = 4.10' inside rear edge of base slab under pump sump and conduit for tailrace #2.
Max. soil pressure = 11,700 #/□' for base slab under pump sump with river at max. stage.

Max. soil pressure under gate structure base slab = 6,550 #/□'.

(See sheet #1 for diagram)

Cantilever extension of sump floor slab -

Downward loads - base slab = 8 × 150 = 1,200 #/□'

Water in conduit = $\frac{5 \times 9 \times 62.5}{7.0}$ = 402

Conduit walls $\frac{16 \times 2 \times 150}{7.0}$ = 685

2,287 #/□'

$M = \frac{7}{2}(11,700 + 3,700)4.10 + \frac{7}{2}(1250 + 1560)3.8 - 2287 \times 7 \times 3.5$

$= 203,000'\#$. $A_s = \frac{203,000 \times 12}{\frac{7}{8} \times 84 \times 18,000} = 1.84^{\square''}$ - $1\frac{1}{8}''$□ 8" c.c. in bot. of slab.

Subject: Tailrace #1 & 2 - Holyoke, Mass.
Computation: Sump Floor Slab.
Computed by: E.M.V. Checked by: Date: April 11, 1939.

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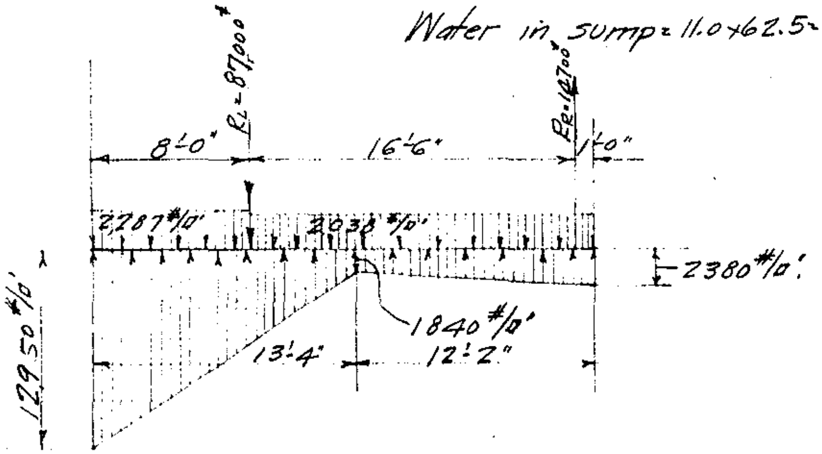
(Continued from sheet # 5)

Sump Floor slab -

Downward loads - base slab = 9 × 150 = 1,350 #/□'

Water in sump = 11.0 × 62.5 = 688

2,038 #/□'



R_L - 1840 × 25.5 × 10.75	=	508,000	
½ × 11,110 × 13.3 × 21.06	=	1,523,000	
½ × 540 × 12.2 × 4.06	=	13,400	
2,287 × 8.0 × 20.5	=		375,000
2,038 × 17.5 × 7.75	=		276,000
		1,393,400	

$R_L = \frac{1,393,400}{16.5} = 84,500\#$

$R_R = -4,500\#$

Max. mom. occurs at R_L and is same as shown on sheet # 5. Use 1⅛"□ bars 8" c.c. in bot. of slab. Use 1"φ bars 12" c.c. at rt. ∠s. to 1⅛"□ bars. Use 1"φ bars 12" c. both ways in top. Dowel base slab to sump walls with ¾"φ dowels, 12" c.c.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Gate Structure Base Slab

Computed by: E. M. V. Checked by: ________ Date: April 13, 1939.

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Gate structure base slab-

Downward loads - base slab = 8×150 = 1200 #/□'

water = 3.5×62.5 = 219

Total = 1419 #/□'

Upward force at rear edge of base slab

$= \frac{1}{2}(6550+5420) = 5,985$ #/□'

Net upward force = 5985 - 1419 = 4566 #/□'

$M = \frac{1}{10} \times 4,566 (12.6)^2 = 74,000$ '#

$A_s = \frac{74000 \times 12}{\frac{7}{8} \times 84 \times 18000} = 0.67$ □"

<u>Use 1"□ bars 12" c.c. both ways top & bot.</u>

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Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Stability of Structure - Low Water

Computed by: E.M.V. Checked by: Date: April 12, 1939.

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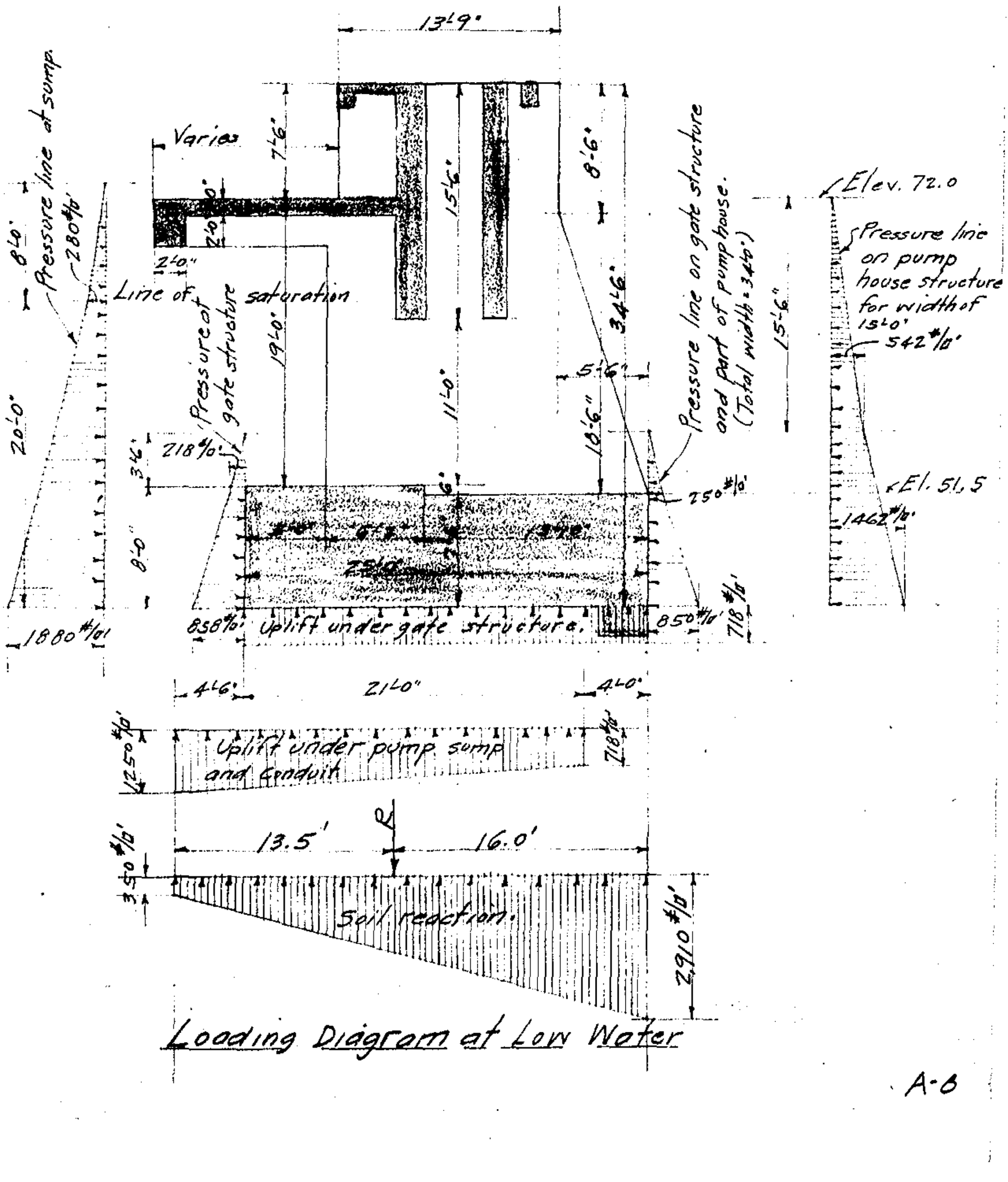

Loading Diagram at Low Water

WAR DEPARTMENT

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Subject Tailraces, #1 & #2 - Holyoke, Mass.

Computation Stability of Structure - Low Water

Computed by E.M.V. **Checked by** .... **Date** April 12, 1939.

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	Forces Acting	↓	↑	→	←	Mom. Arm.	Moment About Heel ↻	↺
	Concrete, earth and equipment	2820.3					32,639.	
Water	3.8 × 20.0 × 25 × 62.5	108.7				12.5	1,359.	
"	2.5 × 21.5 × 18.5 × 62.5	62.1				7.8	484.	
Horiz. Pressures.	½ × 280 × 8.0 × 23.0			25.8		22.7	585.	
	½(280+1880)20.0 × 23.0			496.0		7.5	3,720	
"	½ × 250 × 4.0 × 9.0				4.5	8.8		40.
"	½(250+850)7.5 × 9.0				37.1	3.1		115.
"	½ × 542 × 15.5 × 15.0				63.0	16.7		1051.
"	½(542+1462)11.5 × 15.0				173.0	4.9		848.
Uplift	718 × 25.0 × 25.2		453.0			12.5		5670.
"	½(1250+718)25.5 × 23.0		577.0			7.1		4095.
		2991.1	1010.0	521.8	277.6		38787	11,819.
		ΣV = 1981.1↓		ΣH = 244.2→			ΣM = 26,968 ↻	

Position of resultant $= \frac{26,968}{1,981.1} = 13.5'$ to right of rear edge of base slab under gate structure.

Eccentricity = 3.1'

Base pressure $= \frac{1,981,100}{25.5 \times 23 + 25 \times 25} \pm \frac{1,981,100 \times 3.1 \times 14.6}{69,645}$

(see sheet #8 for diagram) $= 1630 \pm 1280 =$ 2910 #/□' max. / 350 #/□' min.

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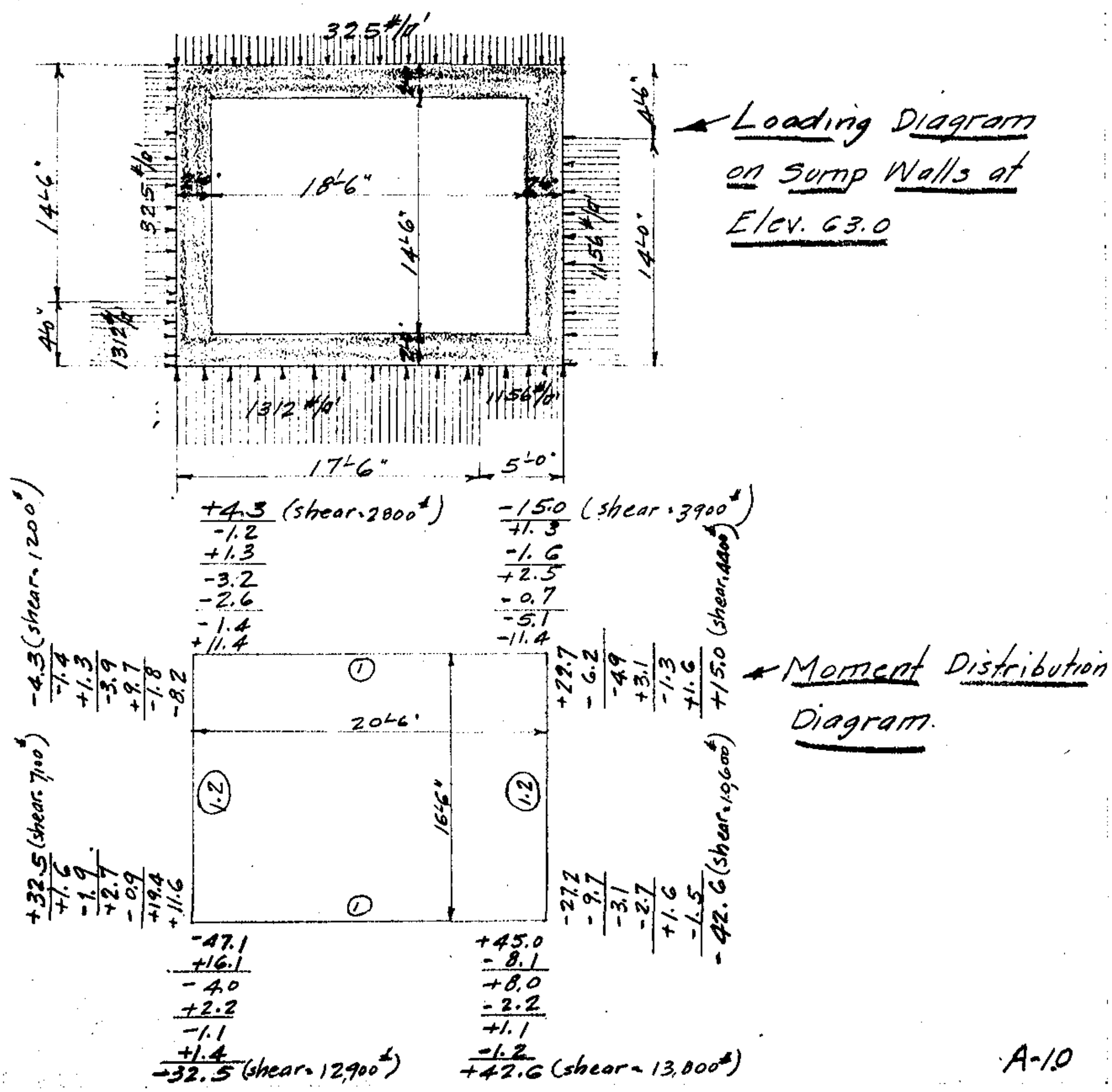
Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Sump Well - Section Above Sluice Gate.

Computed by: E.M.V. Checked by: ______ Date: April 13, 1939.

U. S. GOVERNMENT PRINTING OFFICE 9—10888



Subject Tailraces #1 & #2 - Holyoke, Mass.
Computation Sump Well - Section Above Sluice Gate.
Computed by E. M. V. **Checked by** **Date** April 13, 1939.

(Continued from sheet #10)

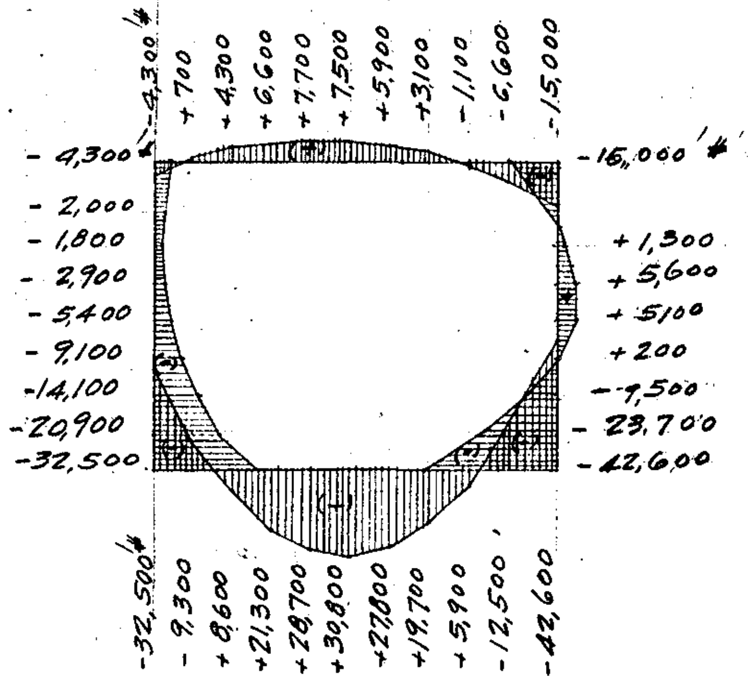


Diagram of Bending Moments.

Wall on river side -

Max. pos. mom. = 30,800'#.

Max. neg. " = 37,800 at right end.

" " " = 28,000 " left " .

$d = \sqrt{\frac{37800}{122.8}} = 17.5"$; $d = 20.5"$

Unit shear = $\frac{13,800 - 1156}{12 \times \frac{7}{8} \times 20.5}$ = 58.8#/□" O.K.

Subject Tailrace #1 & #2 - Holyoke, Mass.
Computation Sump Well - Section Above Sluice Gate.
Computed by E.M.Y. Checked by .... Date April 14, 1939.
U. S. GOVERNMENT PRINTING OFFICE 3—10836

(Continued from sheet #11)

A_s for pos. mom. = $\frac{30{,}800 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.14\square''$ = 1"φ, 8" c.c.

A_s for neg. moms. = $\frac{37800 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.41\square''$ = 1"φ, 6½" c.c.

$\frac{28{,}000 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.04\square''$ = 1"φ, 9" c.c.

Wall on land side -

Max. pos. mom. = 7,700'#.

Max. neg. " = 13,600'# at right end } See diagram on sheet #11.

" " " = 3,300'# " left "

A_s for pos. mom. = $\frac{7{,}700 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.29\square''$ Use ¾"φ, 12" c.c.

A_s for neg. moms. = $\frac{13600 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.50\square''$ = ¾"φ, 10½" c.c.

$\frac{3{,}300 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.12$ Use ¾"φ, 12" c.c.

Wall next to gate structure -

Max. pos. mom. = 5,600'#

" neg. " = 38,900'# at river end.

" " " = 13,500'# " land "

Subject Tailrace #1 & #2 - Holyoke, Mass.
Computation Sump Well - Section Above Sluice Gate.
Computed by E.M.V. Checked by ______ Date April 14, 1939.

(Continued from sheet #12)

A_s for pos. mom. = $\frac{5,600 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.21\square''$ Use $\frac{3}{4}''\phi$, 12" c.c.

A_s for neg. moms. = $\frac{38,900 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 1.44\square''$ = 1"ϕ, $6\frac{1}{2}$" c.c.

$\frac{13500 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.50\square''$ = $\frac{3}{4}''\phi$, 12" c.c.

Wall next to expansion joint -

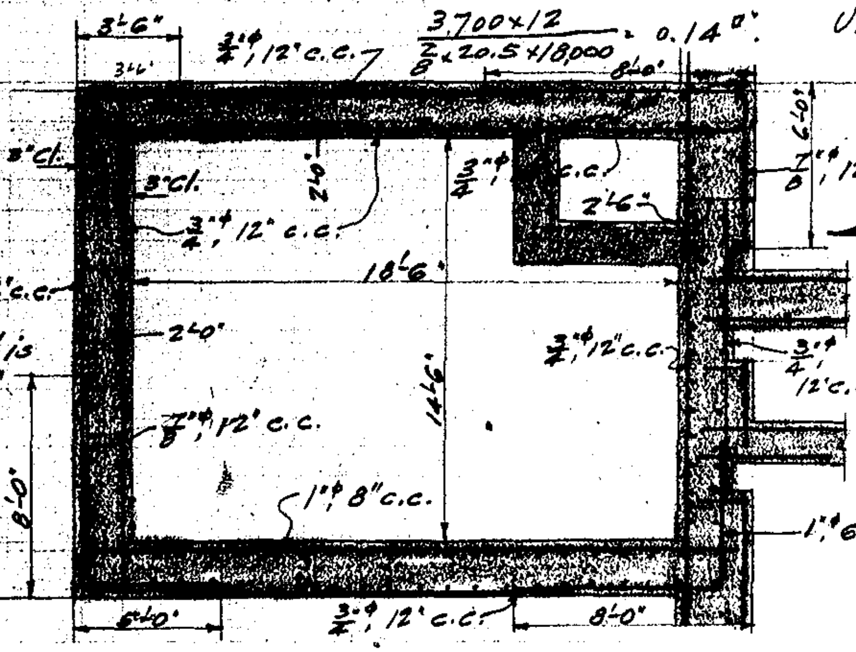
No positive moms.

Max. neg. mom. = 29,000'# at river end

" " " = 3,700'# at land "

A_s for neg. moms. = $\frac{29,000 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 1.08\square''$ = 1"ϕ, 9" c.c.

$\frac{3,700 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.14\square''$ Use $\frac{3}{4}''\phi$, 12" c.c.



Note: Wall is notched 4".

Section Thru Well Above Sluice Gate.

Subject Tailraces #1 & #2 - Holyoke, Mass.
Computation Sump Well - Section at Sluice Gate.
Computed by E.M.Y. **Checked by** .... **Date** April 14, 1939.

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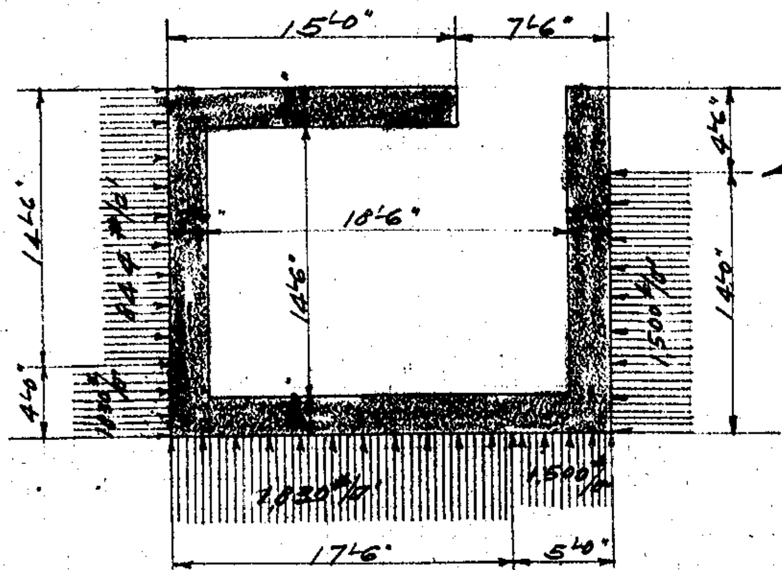
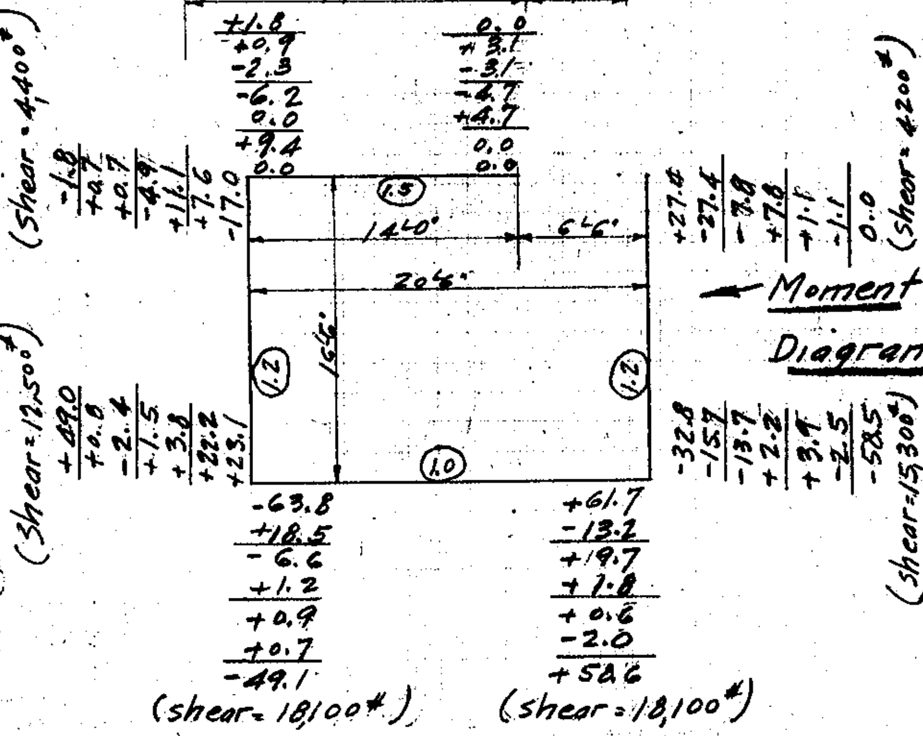


Loading Diagram on Sump Walls at Elev. 53.0

Water in sump to Elev. 57.5.



Moment Distribution Diagram.

Subject Tailraces #1 & #2 - Holyoke, Mass.
Computation Sump Well - Section at Sluice Gate.
Computed by E.M.Y. Checked by ______ Date April 15, 1939

(Continued from sheet #14)

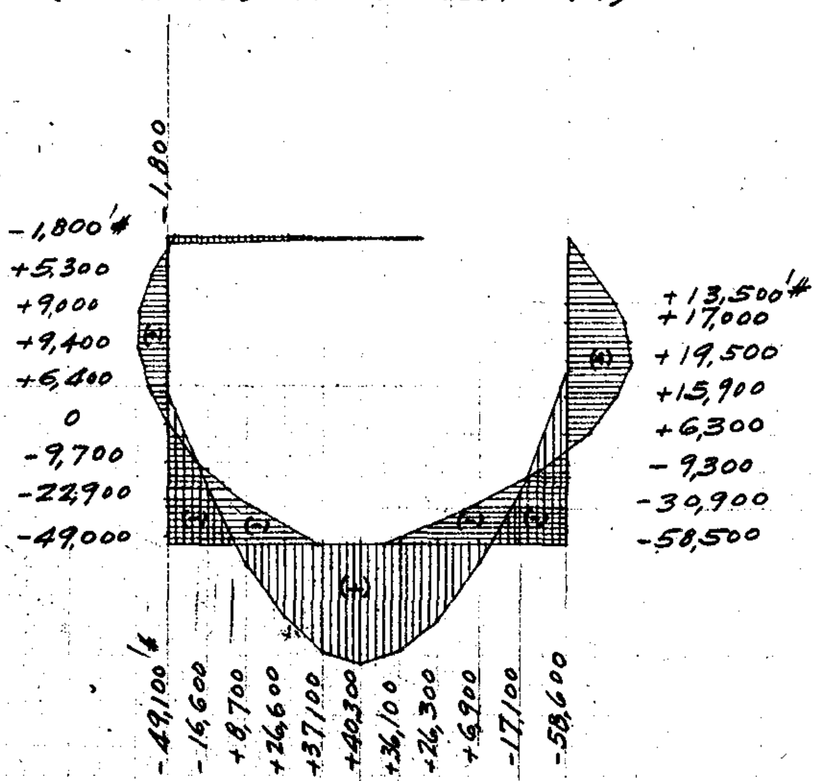


Diagram of Bending Moments.

Wall on river side -

Max. pos. mom. = 40,300'#

Max. neg. mom. = 42,800 at left end.

" " " = 52,300 " right " .

$d = \sqrt{\frac{52,300}{122.8}} = 20.6"$

Unit shear = $\frac{16,300}{12 \times \frac{7}{8} \times 20.6} = 75\#/\square"$ O.K. with special anchorage.

Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Sump Well - Section at Sluice Gate.
Computed by: E.M.Y. Checked by: ________ Date: April 17, 1939.

(Continued from sheet #15)

A_s for pos. mom. $= \frac{40{,}300 \times 12}{\frac{7}{8} \times 20.6 \times 18{,}000} = 1.49^{\square''} = 1''\phi,\ 6''$ c.c.

A_s for neg. mom. $= \frac{42{,}800 \times 12}{\frac{7}{8} \times 20.6 \times 18{,}000} = 1.58^{\square''} = 1''\phi,\ 6''$ c.c

$\frac{52{,}300 \times 12}{\frac{7}{8} \times 20.6 \times 18{,}000} = 1.93^{\square''} = 1''^{\square}\ 6''$ c.c.

Wall on land side -

Shears and bending moments negligible. Use $\frac{3}{4}''\phi$ bars 12" c.c. both faces.

Wall nex to gate structure -

Max. pos. mom. = 19,500'#

Max. neg. " = 53,200'#.

A_s for pos. mom. $= \frac{19500 \times 12}{\frac{7}{8} \times 20.6 \times 18{,}000} = 0.72^{\square''} = 1''\phi,\ 12''$ c.c.

" " neg. " $= \frac{53{,}200 \times 12}{\frac{7}{8} \times 20.6 \times 18{,}000} = 1.97^{\square''} = 1''^{\square}\ 6''$ c.c.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Sump Well - Section at Sluice Gate.

Computed by: E.M.V. Checked by: Date: April 17, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10525

(Continued from sheet # 16)

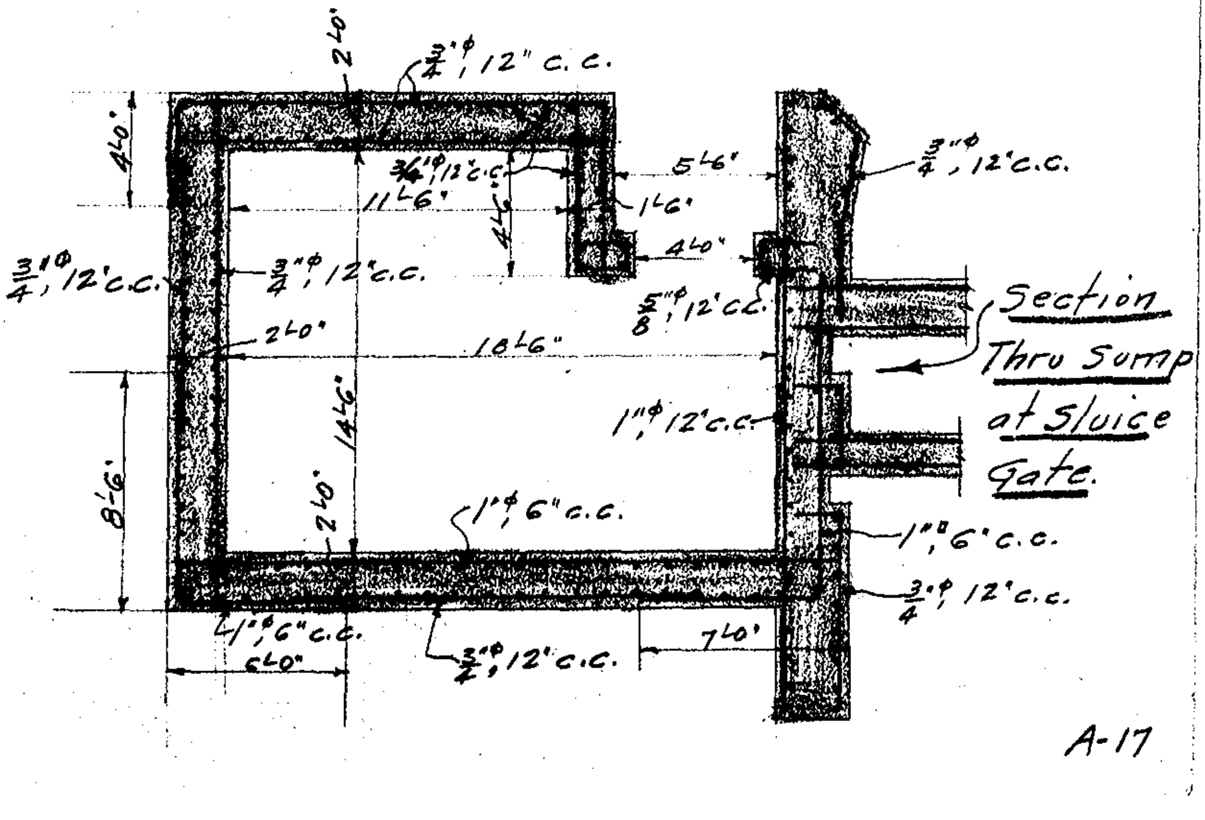
Wall next to expansion joint —

Max. pos. moment = 9,400'#.

" neg. " = 44,600'#.

A_s for pos. mom. = $\frac{9400 \times 12}{\frac{7}{8} \times 20.6 \times 18,000}$ = 0.35□" = $\frac{3}{4}$"φ, 12" c.c.

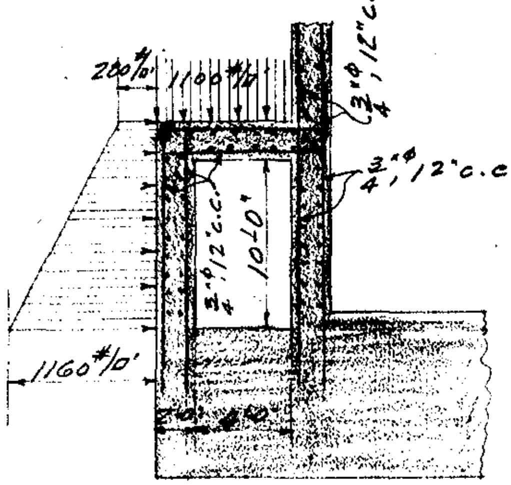
A_s for neg. mom. = $\frac{44,600 \times 12}{\frac{7}{8} \times 20.6 \times 18,000}$ = 1.65□" = 1"φ, 6" c.c.



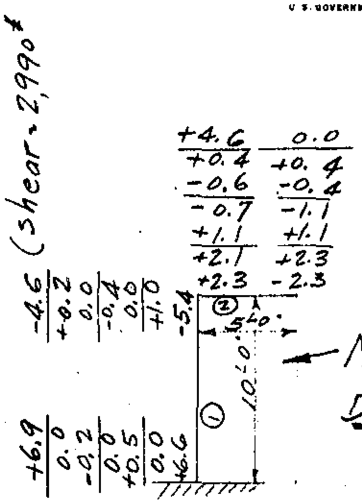
Section Thru Sump at Sluice Gate.

Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Conduit - Tailrace #2.
Computed by: E. M. Y. Checked by ...... Date: April 17, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Loading Diagram on Conduit.



Moment Dist. Diagram.

Bending mom. in horizontal plane in top slab

$= \frac{1}{8} \times 2900 \times \overline{20.5}^2 = 152,000'\#.$

$d = \sqrt{\frac{152000 \times 12}{122.8 \times 24}} = 24.8''. \quad d = 92.5''$

$A_s = \frac{152,000 \times 12}{\frac{7}{8} \times 92.5 \times 18,000} = 1.25^{\square''} = 3 - \frac{3}{4}''\phi$ bars.

WAR DEPARTMENT

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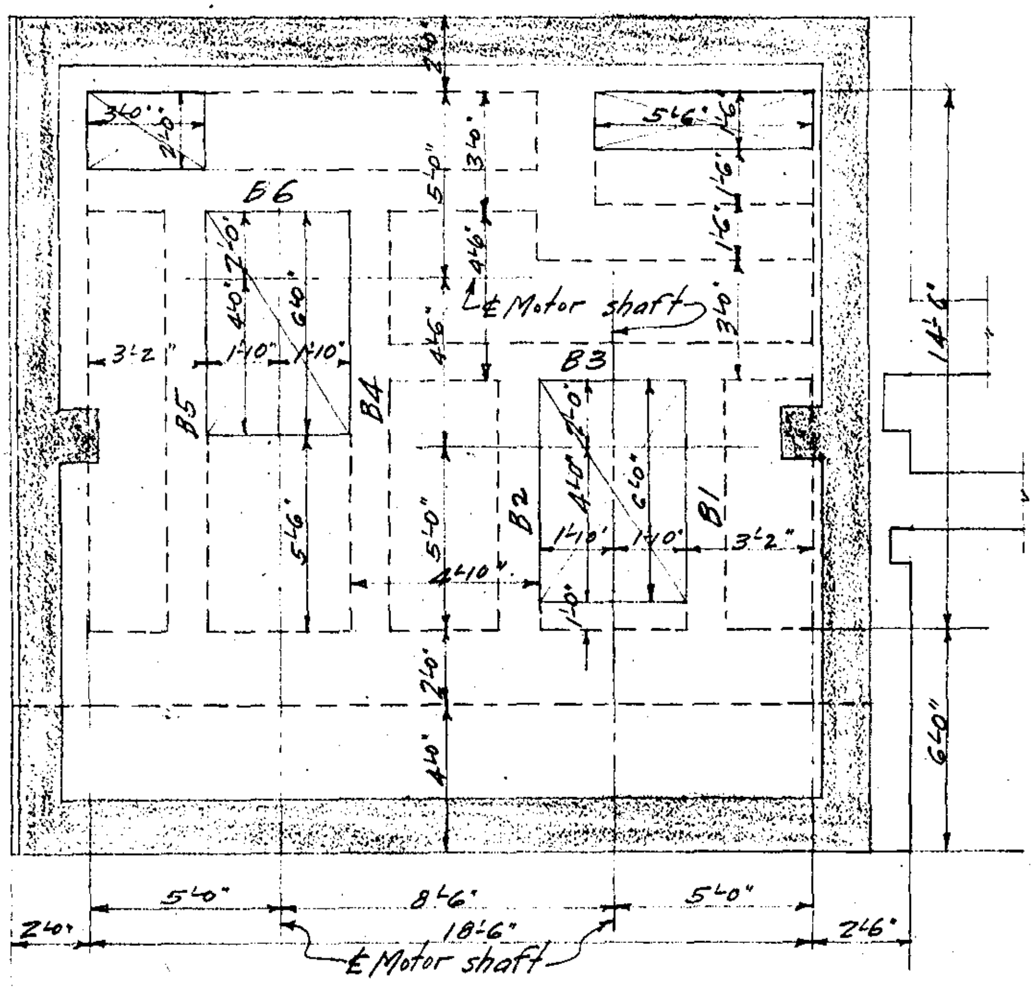
Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Pump Room Floor

Computed by: E. M. V. — Checked by: — Date: April 18, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10638



Plan of Pump Room Floor Framing

Assumed Live Load on floor slabs = 350#/□'

" " " " bms. = Machinery loads, impact at 100% for motor and pump loads, and 250# per sq. ft. of contributing floor area.

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WAR DEPARTMENT
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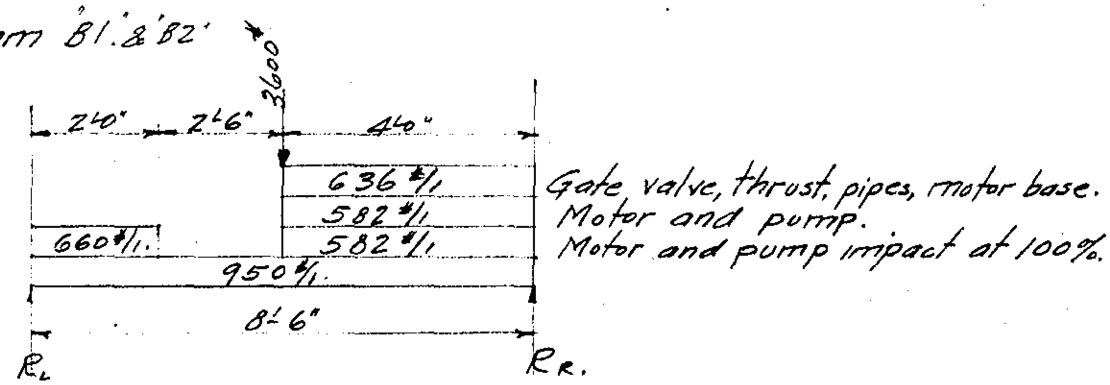
Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Pump Room Floor
Computed by: F.M.V. Checked by: Date: April 18, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10526

Beam "81" & "82"



R_L -	$1800 \times 4.0 \times 2.0$ =	14,400
	3600×4.0 =	14,400
	$950 \times 8.5 \times 4.25$ =	34,300
	$660 \times 2.0 \times 7.50$ =	9900
		73,000

$R_L = \frac{73{,}000}{8.50} = 8{,}600\#$

$R_R = 11{,}600\#$

Max. mom. $= 11{,}600 \times 4 - 2{,}750 \times 4.0 \times 2.0 = 24{,}400'\#$.

<u>Make beams same as Bm. "83", Tailrace #10, sheet #10.</u>

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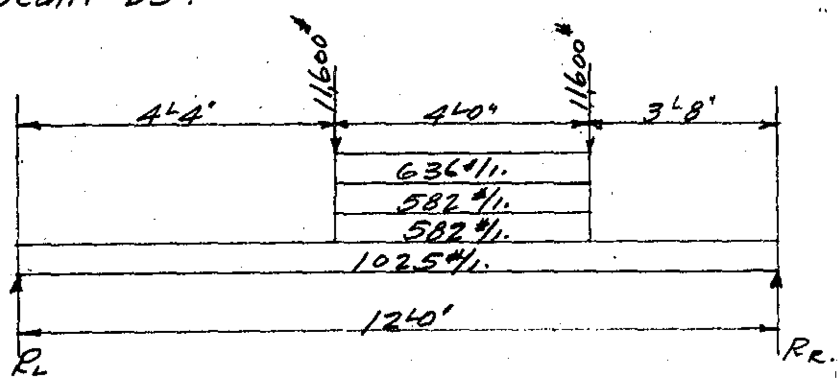
Subject Tailraces #1 & #2.
Computation Pump Room Floor
Computed by E.M.V. Checked by ______ Date April 18, 1939.

Beam "B3".



R_L = 1,800 × 4.0 × 5.67 = 40,800
23,200 × 5.67 = 131,400
1025 × 12.0 × 6.0 = 73,800
246,000

$R_L = \frac{246,000}{12.0} = 20,500\#$.

$R_R = 22,200\#$

$M = 29,500 \times 7.0 - 1,025\frac{(7.0)^2}{2} - 1800\frac{(2.67)^2}{2} - 11,600 \times 2.67 = 81,000'\#$.

Assuming beam stem 16" wide depth required by mom. $= \sqrt{\frac{81,000 \times 12}{122.8 \times 16}} = 22.2"$. Try bm. 25" deep. d = 22.5"

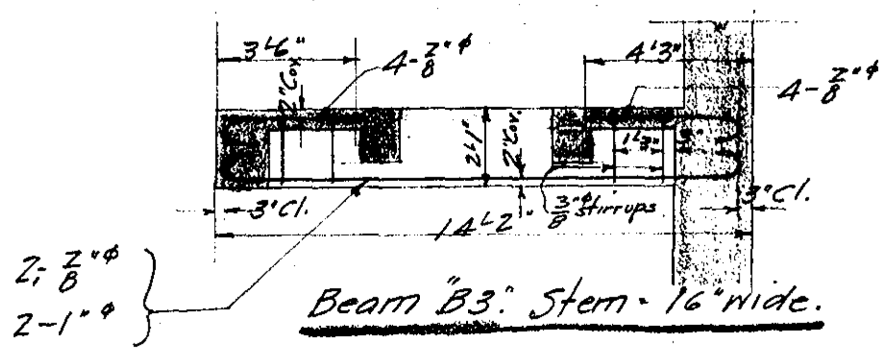
Unit shear $= \frac{22,200}{16 \times \frac{7}{8} \times 22.5} = 70.4\#/\square"$. No web reinforcement required. Use special anchorage.

$A_s = \frac{81000 \times 12}{\frac{7}{8} \times 22.5 \times 18,000} = 2.74\square"$. Try 2-⅞"ϕ @ 0.60 = 1.20□"
2-1"ϕ @ 0.78 = 1.56
2.76□"

Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Pump Room Floor
Computed by: E.M.V. Checked by: .... Date: April 18, 1939.

(Continued from sheet #21)

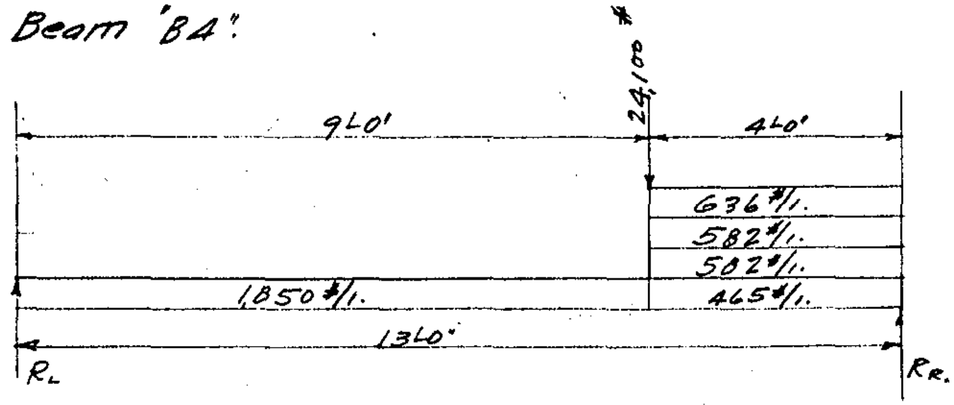
If all bars are run thru, then unit bond $= \dfrac{\frac{1.56}{2.76} \cdot 22{,}200}{2 \times 3.14 \times \frac{7}{8} \times 22.5} = 103$ #/□"



Beam "B3": Stem - 16" wide.

Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Pump Room Floor
Computed by: E.M.V. Checked by: Date: April 18, 1939.

Beam "B4".



R_L - 2,265 × 4.0 × 2.0 = 18,100
1,850 × 9.0 × 8.5 = 141,500
24,100 × 4.0 = 96,400
256,000

$R_L = \frac{256,000}{13.0} = 19,700\#$

$R_R = 30,100\#$

$M = 19,700 \times 9.0 - 1850 \frac{(9.0)^2}{2} = 102,200'\#$

Assuming bm. 16" wide, depth req'd by shear $= \frac{30,100}{16 \times \frac{7}{8} \times 60} = 36"$

If special anchorage is used, then depth required by shear $= \frac{30100}{16 \times \frac{7}{8} \times 90} = 23.9"$. Try total depth of 30".

"d" req'd by moment $= \sqrt{\frac{102,200 \times 12}{122.8 \times 16}} = 25"$

$A_s = \frac{102,200 \times 12}{\frac{7}{8} \times 27.5 \times 18,000} = 2.83\square"$. 4-1"$\phi$ @ 0.78$\square$" = 3.12$\square$"

WAR DEPARTMENT

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Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Pump Room Floor
Computed by: E.M.V. Checked by: Date: April 19, 1939

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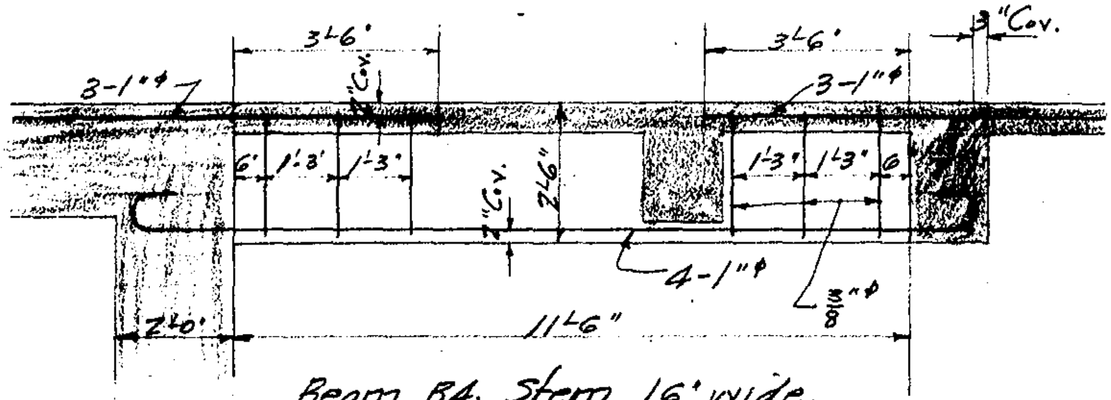
(Continued from sheet #23)

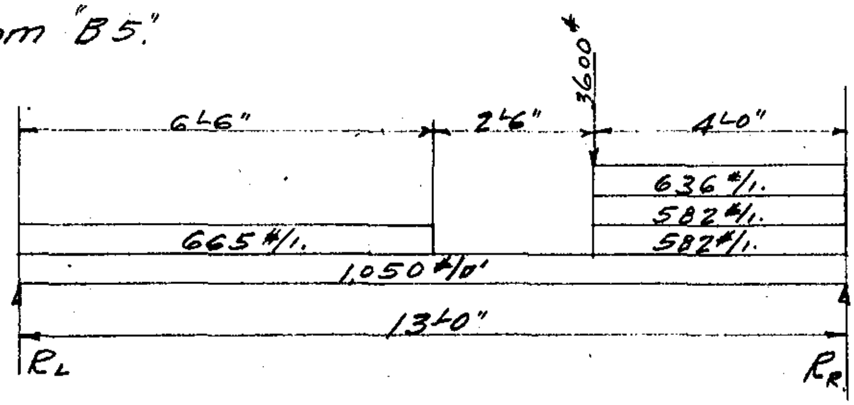
With all bars run thru full length, unit bond stress

$= \frac{30,100}{4 \times 3.14 \times \frac{7}{8} \times 27.5} = 100 \#/\square''$ **O.K.**



Beam B4. Stem 16" wide.

Beam "B5."



R_L - 1,800 × 4.0 × 2.0 = 14,400
3600 × 4.0 = 14,400
665 × 6.5 × 9.75 = 42,000
1050 × 13.0 × 6.50 = 88,700
159,500

$R_L = \frac{159,500}{13.0} = 12,300^{\#}$

$R_R = 16,500^{\#}$

$M = 12,300 \times 7.6 - 1715 \times 6.5 \times 4.35 - 1050 \times 1.1 \times 0.55 = 44,400'^{\#}$

Assuming a 16" stem, depth req'd by shear. $\frac{16,500}{\frac{7}{8} \times 16 \times 60} = 19.6"$

Depth req'd by bending = $\sqrt{\frac{44,400 \times 12}{122.8 \times 16}} = 16.5"$

Make beam 2'-0" deep. 'd' = 21.5"

$A_s = \frac{44,400 \times 12}{\frac{7}{8} \times 21.5 \times 18,000} = 1.57□"$ Use 4-$\frac{3}{4}$"φ bars @ 0.44□" = 1.76□"

With all bars run thru full length unit bond stress = $\frac{16,500}{4 \times 2.35 \times \frac{7}{8} \times 21.5} = 93^{\#}/□"$ O.K.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

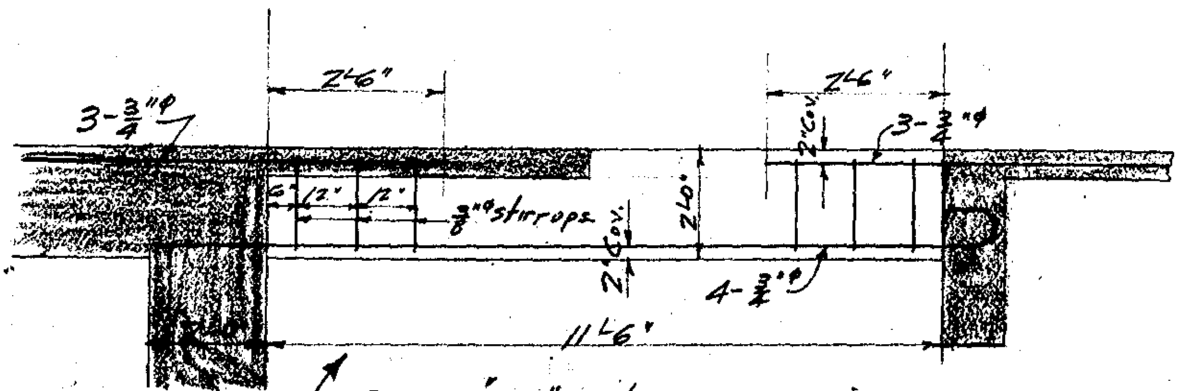
Subject Tailraces #1 & #2 - Holyoke, Mass.

Computation Pump Room Floor

Computed by E.M.V. **Checked by** **Date** April 19, 1939.

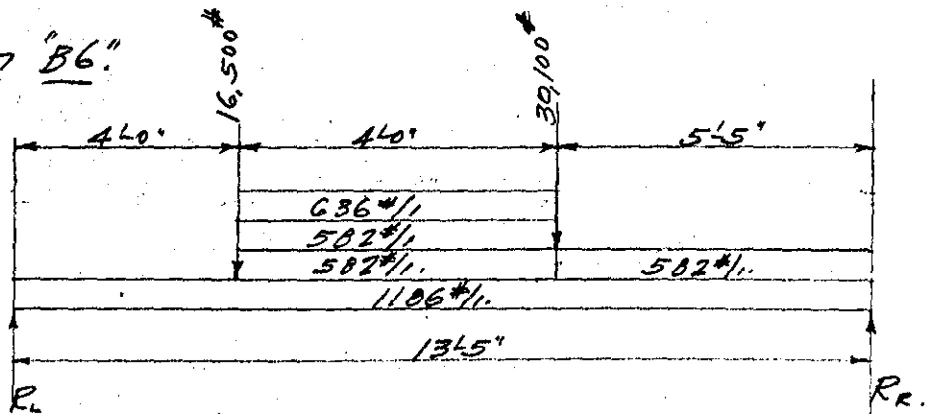
U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #25)



℄ Beam "B5." Stem 16" wide.

Beam "B6."



R_L - 30,100 × 5.42 = 163,500

16,500 × 9.42 = 155,300

582 × 5.42 × 2.76 = 8,700

1,800 × 4.00 × 7.42 = 53,400

1,186 × 13.42 × 6.71 = 106,800

487,700

$R_L = \frac{487,700}{13.42} = 36,300\#$

$R_R = 36,500\#$

Beam "B6" (Continued from sheet # 26).

Assuming beam 12" × 30" overall, unit shear $= \frac{36,500}{\frac{7}{8} \times 27.5 \times 12} = 127$ #/□".
Stirrups required if depth is O.K.

$M = 36,500 \times 5.42 - 1786 \times 5.42 \times 2.71$
$= 171,800$ '#.

$d = \sqrt{\frac{171,800}{122.8}} = 37.4'$. Make beam 43" deep, $d = 39.5'$

Unit shear $= \frac{36,500}{\frac{7}{8} \times 39.5 \times 12} = 88$ #/□". No stirrups required.

$A_s = \frac{171,800 \times 12}{\frac{7}{8} \times 39.5 \times 18000} = 3.31$ □" Try 6-$\frac{7}{8}$"ϕ bars @ 0.60 = 3.60□" in 2-layers.

With all bars run thru unit bond stress $= \frac{36,500}{6 \times 2.74 \times \frac{7}{8} \times 39.5}$
$= 64$ #/□".

Therefore bend up upper 3-bars.
Point for bending up bars -

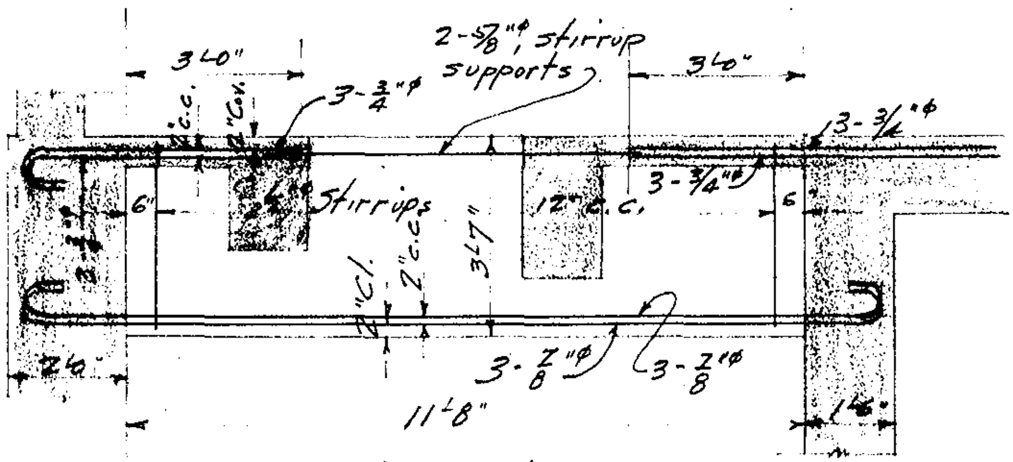
$36,300x - 1186\frac{x^2}{2} - 85900 = 0$, $x = 2.5$

Since the point to bend up steel is so close to the supports, bars are to be run thru without bending.

Because of the depth of the beam as compared to its width provide $\frac{1}{2}$"ϕ stirrups, 12" c.c. full length of beam.

Subject: Tailraces #1 & #2 - Holyoke, Mass.
Computation: Pump Room Floor
Computed by: E. M. V. Checked by Date: April 19, 1939.

Beam "B6" (Continued from sheet #27.



Beam "B6". Stem 12" wide.

Floor Slab. Max. span = 3'-8" clear.

Slab assumed 6" thk. = 75 #/□'

Granolithic fill 3" = 38

L.L. = 350

463 #/□'

$M = \frac{1}{12} \times 463 \times \overline{3.67}^2 \times 12 = 6,200''\#$.

$d = \sqrt{\frac{6200}{122.8 \times 12}} = 2.0''$. Make slab 6" thk. $d = 3.2''$

$A_s = \frac{6200}{\frac{7}{8} \times 3.2 \times 18,000} = 0.12 \square''$. Try $\frac{1}{2}''\phi$ bars 8" c.c.

Unit bond $= \frac{1.8 \times 463}{1.5 \times 1.57 \times \frac{7}{8} \times 3.2} = 126 \#/\square''$

Use $\frac{1}{2}''\phi$ bars 8" c.c. top and bot. in floor slabs.

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U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailraces #1 & #2 - Holyoke, Mass.

Computation: Pump Room Floor

Computed by: E.M.V. Checked by: Date: April 19, 1939.

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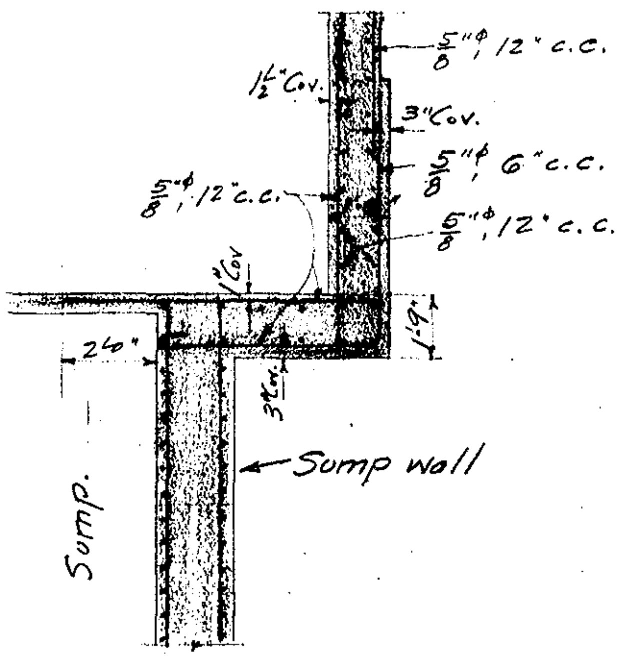
Cantilevered slab on river side —

This slab is 1'-9" thk. Reinforce as show in sketch.



For roof slab and roof beam use same sections as called for on sheets 17, 18 & 19, Tailrace #10.

WAR DEPARTMENT

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Page 1

Subject Tailrace #4. Holyoke, Mass.

Computation Stability of Structure - High Water.

Computed by E. M. V. Checked by ________ Date March 27, 1939.

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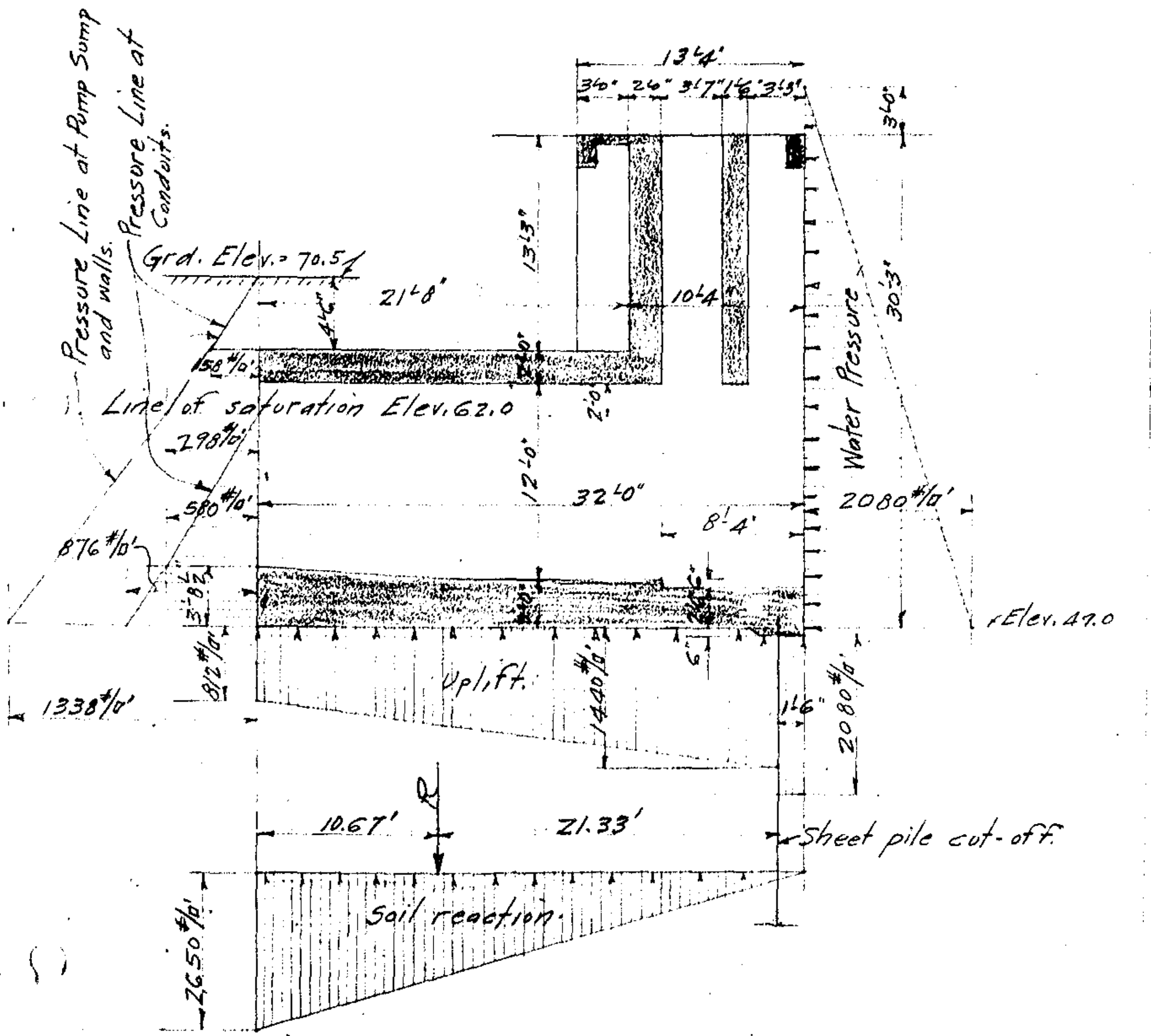
Note: Line of saturation at Elev. 62.0



Loading Diagram at High Water.

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WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 2

Subject: Tailrace #4 - Holyoke, Mass.

Computation: Stability of Structure, - High Water

Computed by: E.M.V. Checked by: Date: March 27, 1939.

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Forces Acting	↓	↑	→	←	Mom. Arm	Moments About Heel. ↷	↶
2×1.5×15.3×14.0×150	96.5				28.0	2,700.	
2×2.0×15.3×14.0×150	128.2				22.7	2,910.	
4×1.0×2.0×14.0×150	16.8				25.3	425.	
2×2.0×1.0×14.0×150	8.4				20.7	174.	
2×2.0×21.7×14.0×150	182.5				10.8	1,970.	
3.0×56.7×32.0×150	815.0				16.0	13,050.	
1.0×6.5×13.0×150	12.7				28.8	366.	
1.0×12.5×13.5×150	25.3				25.8	653.	
2.5×23.5×27.8×150	245.0				20.3	4,980.	
2.7×13.3×27.8×150	150.0				25.3	2,795.	
2.3×12.0×18.7×150	77.3				9.3	718.	
2.5×18.5×23.0×150	159.2				20.5	3,260.	
3.0×14.5×23.0×150	150.0				20.5	3075.	
1.5×17.5×7.0×150	27.5				14.5	398.	
1.5×3.0×17.5×150	11.8				17.3	204.	
0.83×17.0×19.0×150	40.5				20.5	830.	
2.0×5.0×23.0×150	34.5				20.5	707.	
2×1.4×7.0×23.0×150	67.5				20.5	1385.	
2×1.0×11.0×23.0×150	75.8				20.5	1554.	
	2,324.5					42,154	

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #4 - Holyoke, Mass.
Computation: Stability of structure - High water
Computed by: E.M.V. Checked by: Date: March 27, 1939.

(Continued from sheet #2)

	Forces Acting	↓	↑	→	←	Mom. Arm.	Moments About Heel ↷	↶
	2×2.0×18.5×17.0×150	188.5				20.5	3860.	
	1.8×7.0×17.0×150	32.1				31.1	1000.	
	1.3×9.0×17.0×150	29.8				22.3	664.	
	1.5×5.5×17.0×150	21.0				31.1	653.	
	1.0×5.5×17.0×150	14.1				31.5	444.	
	1.0×9.0×17.0×150	22.9				10.2	234.	
	20.3×17.8×0.4×150	21.7				20.5	445.	
	20.3×17.8×0.3×90	9.7				20.5	199.	
Conc. down to here	0.9×1.0×7.0×150	1.0				21.5	22.	
	0.9×1.0×8.0×150	1.1				18.0	20.	
	1.9×1.3×13.8×150	5.1				22.3	114.	
	1.3×1.9×12.0×150	4.4				24.0	106.	
	1.2×1.4×12.5×150	3.2				15.4	49.	
	2.0×13.5×9.0×150	36.4				4.5	164.	
Earth	4.5×21.7×30.7×100	300.0				10.8	3240.	
	9.0×22.5×17.5×100	354.0				4.5	1595.	
	Machinery 38,000#	38.0				21.5	818.	
	Sluice Gates 30,000#	30.0				24.0	720.	
	" " 5000#	5.0				13.8	69.	
		1118.0					14416	

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailrace #4 - Holyoke, Mass.

Computation Stability of Structure - High Water

Computed by E.M.V. Checked by .... Date March 28, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #3)

Forces Acting	↓	↑	→	←	Mom. Arm.	Moments About Heel ↘	↙
2×14.0×12.0×32×62.5	671.0				16.0	10,720.	
2×3.6×18.3×14.0×62.5	115.0				25.5	2,930.	
2×3.2×18.3×14.0×62.5	102.5				30.4	3,120.	
17.0×19.0×9.0×62.5	181.7				20.5	3725.	
56.7×16.6×2080.0				1956.0	11.1		21,700.
25.5×8.5×149.0			32.2		13.8	445	
25.5×13.0×818.0			271.5		5.1	1380	
32.0×4.5×79.0			11.4		18.5	210	
32.0×9.3×290.0			66.2		4.3	370	
32.0×3.7×728.0			86.0		1.7	146	
56.7×30.5×1126		1945.0			13.8		27,000.
56.7×1.5×2080		176.5			31.3		5,530.
	1,070.2	2,121.5	487.3	1956.0		23,046	54,230
Brought forward	2324.5					42,154	
" "	1118.0					14,416	
	ΣV = 2391.2 ↓		ΣH = 1468.7 ←			ΣM = 25,386.0 ↘	

(Left margin: Hydrostatic & Earth - Water Pressures.)

Subject Tailrace #4 - Holyoke, Mass.
Computation Stability of Structure - High Water
Computed by E.M.V. Checked by ______ Date March 28, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10523

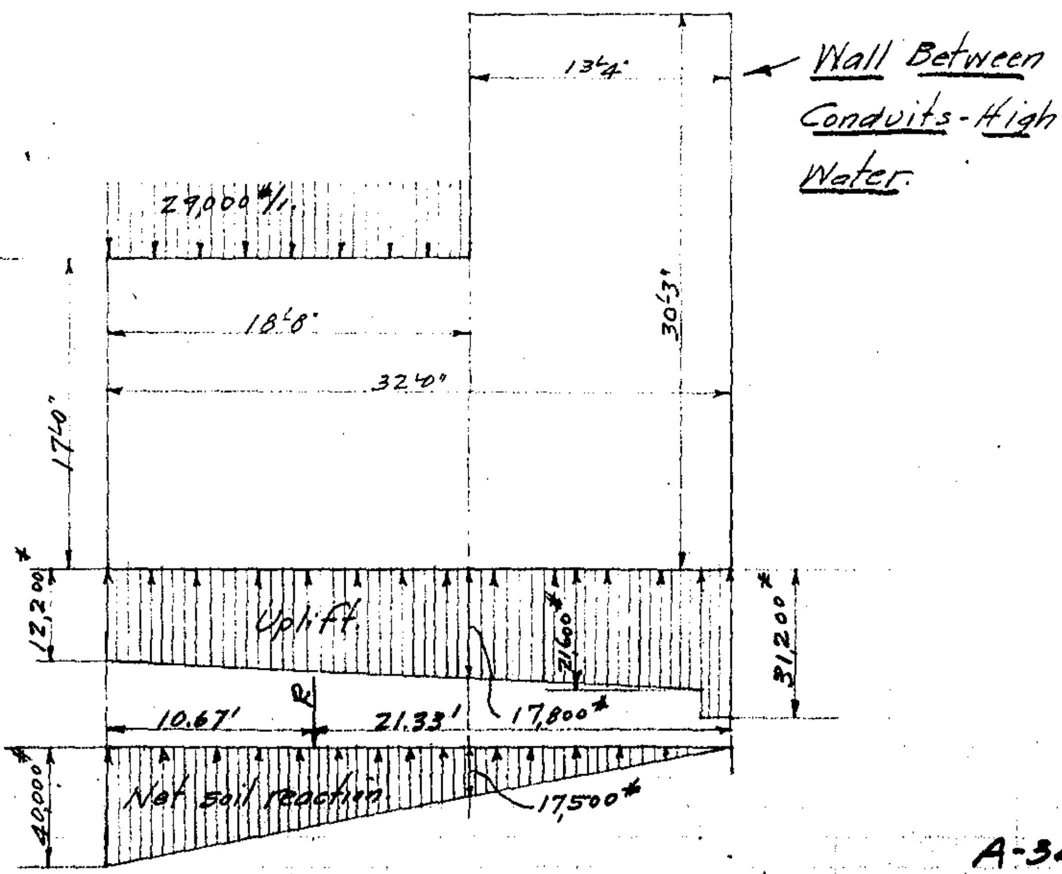
(Continued from sheet #4)

Position of resultant $= \frac{25386.0}{2391.2} = 10.6$ ft. to right of rear edge.

Eccentricity $= 16.0 - 10.6 = 5.4'$ = inner edge of middle third.

Max. soil press $= \frac{2,391,200}{56.7 \times 32} + \frac{2,391,200 \times 5.4 \times 6}{56.7 \times 32 \times 32} = 1317 + 1333 = 2650$ #/□'

Min. soil pressure = 0.



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. Page 6

Subject: Tailrace #4 - Holyoke, Mass.
Computation: Stresses in Wall Bet. Conduits - Max. High Water
Computed by: E.M.Y. Checked by: Date: March 28, 1939.

(Continued from sheet #5)

Max. mom. = $(17500+17,800-29,000)\overline{18.7}^2 \times \frac{1}{2}$ = 1,100,000'#

$\frac{1}{2}(40,000+12,200-35,300)\times\overline{18.7}^2\times\frac{2}{3}$ = 1,968,000'

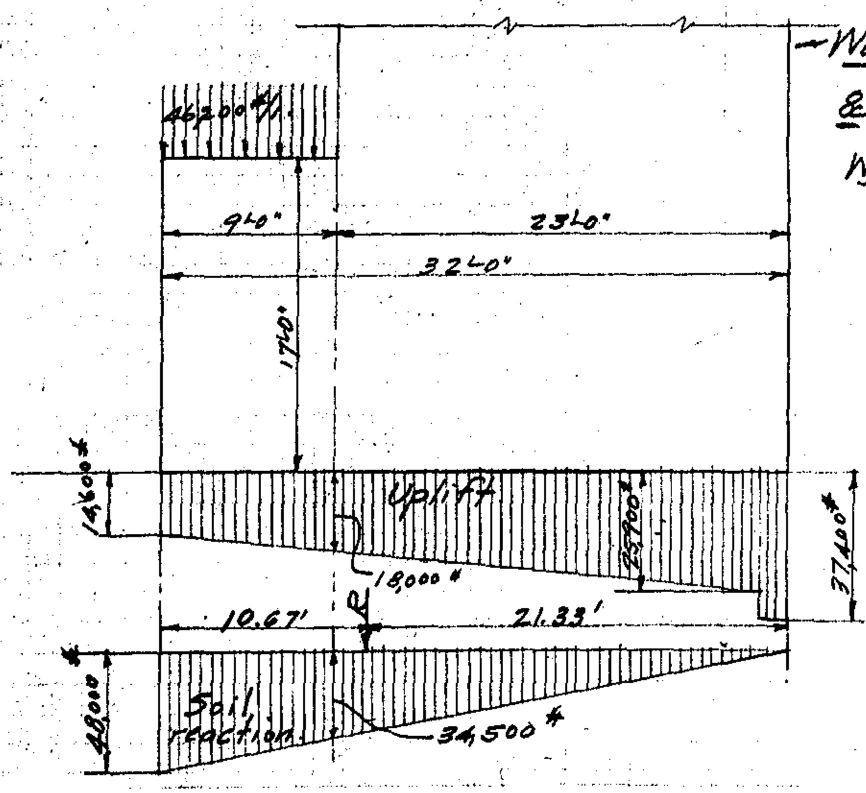
3,068,000'#

$d = \sqrt{\frac{3,068,000\times12}{122.8\times32}} = 97" = 8'-1"$

Unit shear = $\frac{6300\times18.7+\frac{1}{2}\times16,900\times18.7}{32\times\frac{7}{8}\times200} = \frac{275,000}{32\times\frac{7}{8}\times200} = 49\#/\square"$

$A_s = \frac{3,068,000\times12}{\frac{7}{8}\times200\times18,000} = 11.7\square"$ Use 9-1⅛"□ bars @ 1.265 = 11.4□" in bot. of wall.

Unit bond stress = $\frac{275,000}{9\times4.5\times\frac{7}{8}\times200} = 39\#/\square"$



Wall bet. conduit & Sump. - High Water.

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

Subject: Tailrace #4 - Holyoke, Mass.
Computation: Stresses in Walls.
Computed by: E.M.V. Checked by: Date: March 28, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10538

(Continued from sheet #6)

$$Max.\ mom. = 6300\frac{(9.0)^2}{2} + \frac{1}{2}\times 10{,}100 \times (9.0)^2 \times \frac{2}{3} = 528{,}000\ '\#.$$

$$A_s = \frac{528000 \times 12}{\frac{7}{8}\times 200 \times 18{,}000} = 2.0\ \square''$$

Use 5 - $\frac{3}{4}$"ϕ bars in bot. of wall

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

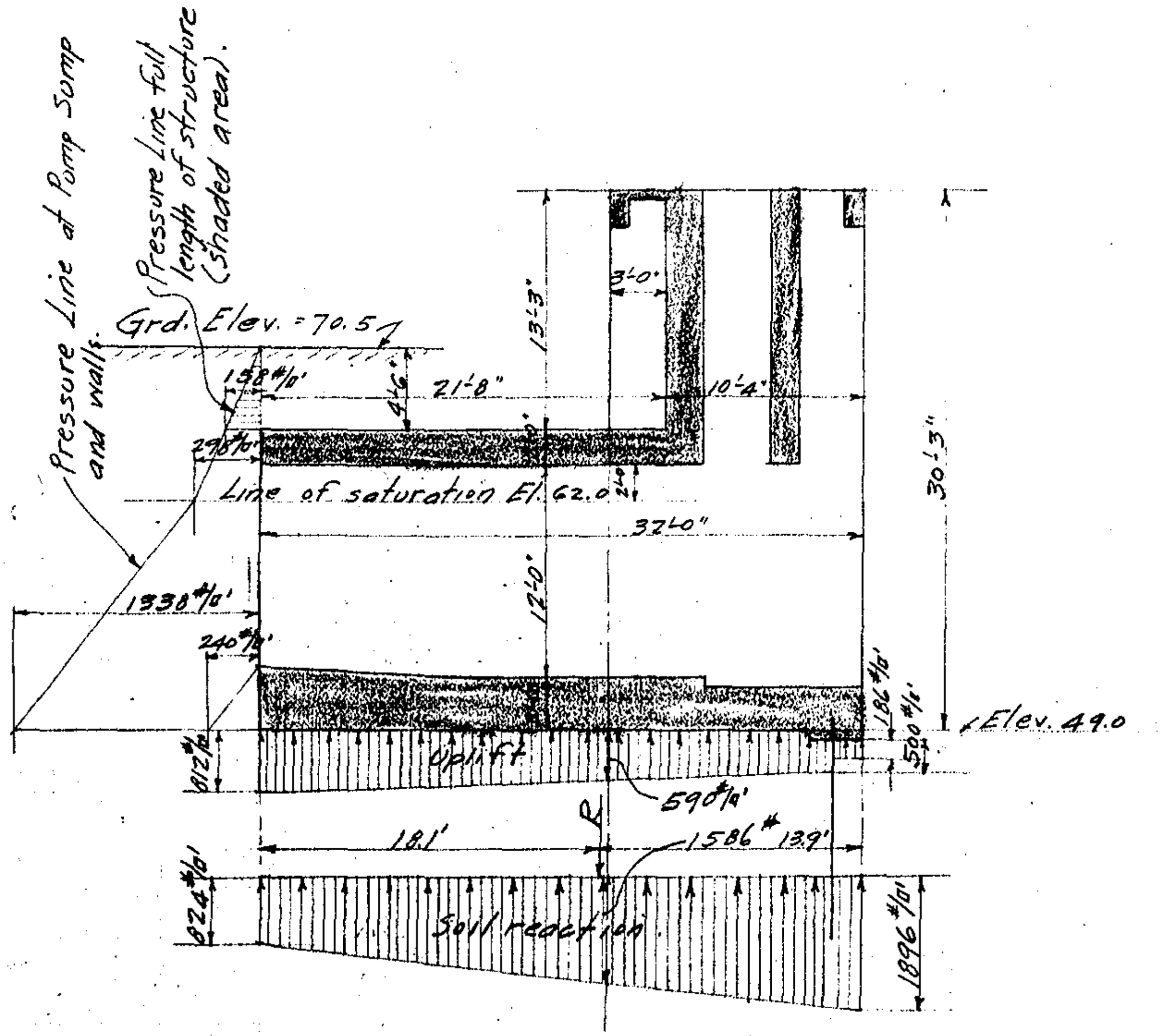
Page 8

Subject: Tailrace #4 - Holyoke, Mass.

Computation: Stability of Structure - Low Water.

Computed by: E.M.V. Checked by: Date: March 29, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Loading Diagram at Low Water (Elev. 52.0).

Forces Acting	↓	↑	→	←	Mom. Arm.	Mom. About Heel ↻	Mom. About Heel ↺
Concrete, earth and equipment	3442.5					56,570.	
158×2.25×56.7			19.9		18.5	368.	
228×4.0×25.5			23.3		14.8	345.	
818×13.0×25.5			271.0		5.1	1380.	
120×3.7×56.7			25.2		1.2	30.	
656×30.5×56.7		961.0			14.0		13,450.
186×1.5×56.7		15.8			31.3		494
	3442.5	976.8	339.4			58,693	13,944
	ΣV=2465.7		ΣH=339.4 →			ΣM=44,749 ↻	

Position of resultant $= \frac{44749}{2465.7} = 18.1$ ft. to right of rear edge.

Eccentricity. $18.1 - 16.0 = 2.1'$ toward river edge.

Soil pressure $= \frac{2,465,700}{56.7 \times 32} \pm \frac{2,465,700 \times 2.1 \times 6}{56.7 \times 32 \times 32} = 1360 \pm 536$

$= 1896$ #/□' max.

824 #/□' min.

(See sheet # 8 for loading diagram.)

Subject Tailrace # 4- Holyoke, Mass.
Computation Conduit.
Computed by E.M.V. Checked by .... Date March 29, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10886

(See sheet #11 following for sketch)

I for roof slab $= \frac{1}{12} \times 12 (24.0)^3 = 13,800''^4$
l " " " $= 18.25 \times 12 = 219$
$\frac{I}{l} = 63.0$

I " outside walls $= \frac{1}{12} \times 12 (30.0)^3 = 27,000''^4$
l " " " $= 14.25 \times 12 = 171$
$\frac{I}{l} = 157.6$

I " bot. slab $= \frac{1}{12} \times 12 (42.0)^3 = 74,000''^4$
l " " " $= 18.25 \times 12 = 219$
$\frac{I}{l} = 338$

I " center wall $= \frac{1}{12} \times 12 (24.0)^3 = 13,800''^4$
l " " " $= 14.25 \times 12 = 171$
$\frac{I}{l} = 80.8$

WAR DEPARTMENT

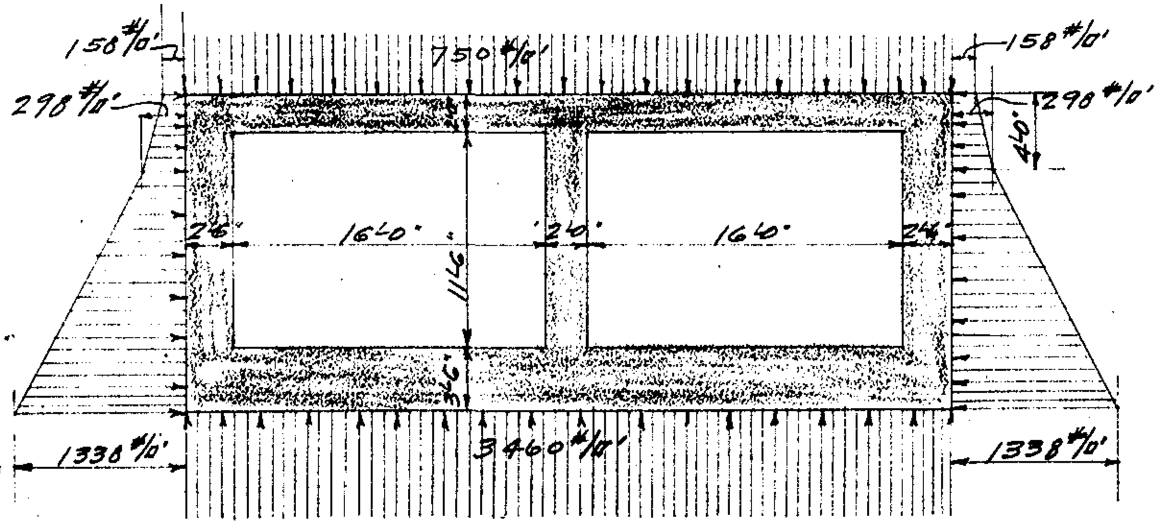
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — Page 11

Subject: Tailrace #4 - Holyoke, Mass.

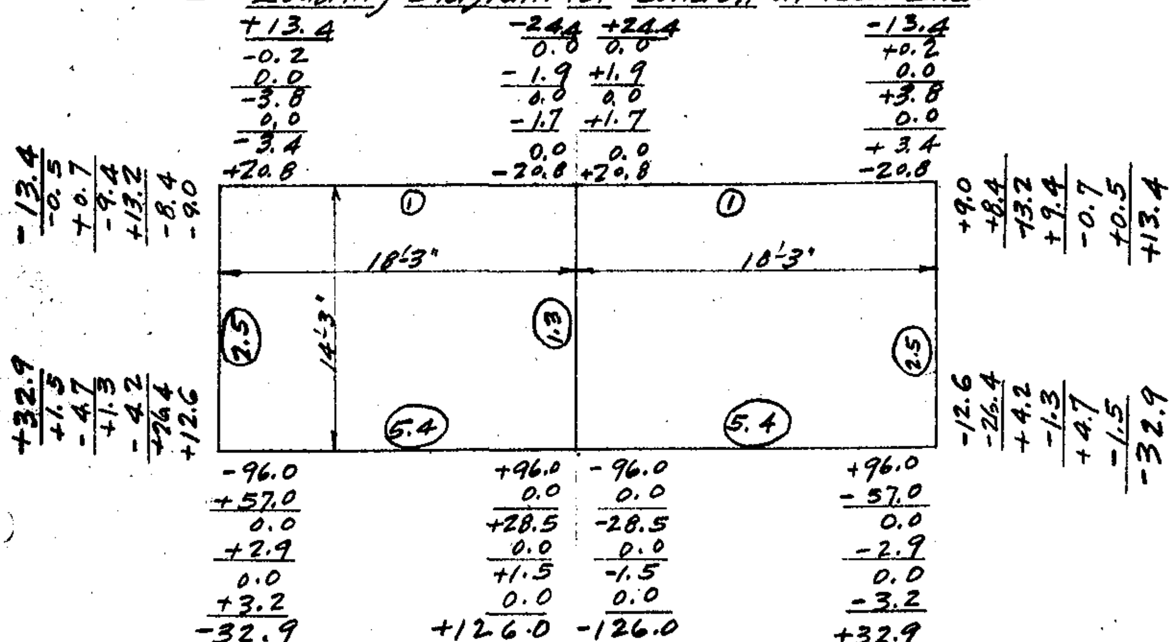
Computation: Conduits.

Computed by: E. M. V. Checked by: ________ Date: March 29, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10590



℄ Loading Diagram for Conduit at Rear End.



Moment Distribution Diagram

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — Page 12

Subject: Tailrace #4 - Holyoke, Mass.

Computation: Conduits.

Computed by: E.M.Y. — Checked by: — Date: March 30, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10639

(Continued from sheet #10).

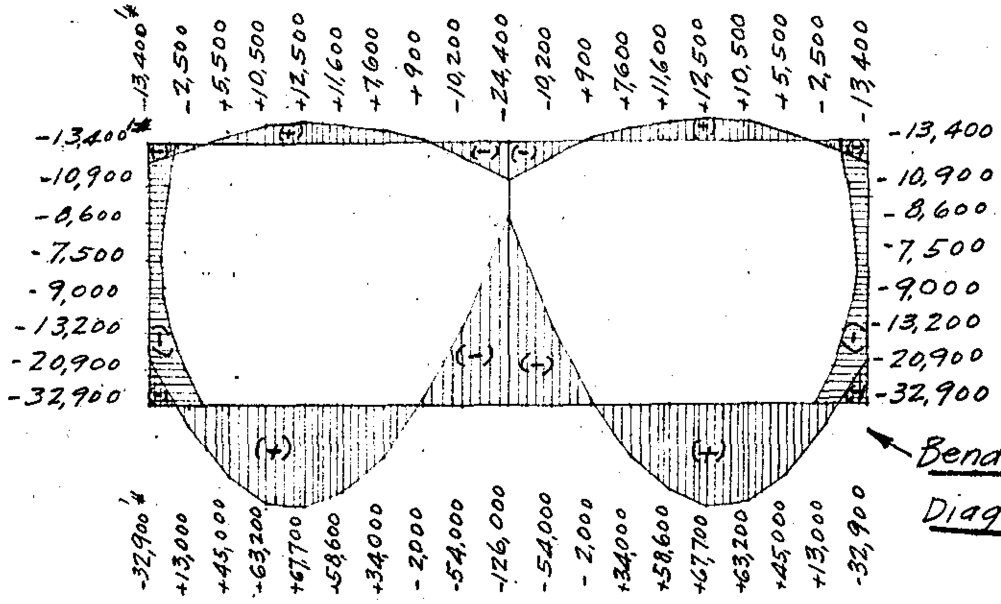
Shears -

1. Top slab, left end $= \frac{13{,}400 + 750 \times \overline{18.25}^2 \times \frac{1}{2} - 24{,}400}{18.25} = 6200.^{\#}$
2. " " right " $= 24{,}400 + 750 \times \overline{18.25}^2 \times \frac{1}{2} - 13400 = 7{,}400^{\#}$
3. Bot. " left " $= 3460 \times 9.12 - (126000 - 32{,}900)\frac{1}{18.25} = 26{,}400^{\#}$
4. " " right $= 3460 \times 9.12 + (126{,}000 - 32{,}900)\frac{1}{18.25} = 36{,}600^{\#}$
5. Left wall, top

$193 \times 3 \times 12.75$	=	7,400
$53 \times 3 \times 12.25$	=	1,900
$298 \times 11.25 \times 5.63$	=	18,800
$450 \times 11.25 \times 3.75$	=	18,900
End mom.	=	13,400
		60400
Deduct, mom.		32900
Net.	=	27,500

Shear $= \frac{27500}{14.25} = 1{,}900^{\#}$

6. Left wall, bot. $= [\frac{1}{2}(193+298)3 + \frac{1}{2}(298+1198)11.25] - 1900 = 7{,}100^{\#}$



Bending Mom. Diagram.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #4 - Holyoke, Mass.
Computation: Conduits.
Computed by: E. M. V. Checked by: Date: March 30, 1939

Design of Sections -

Top slab. - Max. pos. mom. = 12,500'#

" neg. " = 20,700'#

Max. shear = 7400#.

$d = \sqrt{\frac{20700}{122.8}} = 13.0"$ "d" as used = 20.5"

As for pos. mom. = $\frac{12,500 \times 12}{\frac{7}{8} \times 20.5 \times 18,000}$ = 0.46□" - 3/4"φ, 12" c.c.

As for neg. mom. = $\frac{20,700 \times 12}{\frac{7}{8} \times 20.5 \times 18,000}$ = 0.77□" = 3/4"φ 7" c.c. over middle support. Lap bars 10'-6" ove middle support. Bend down into sidewalls.

Unit bond stress = $\frac{6,600}{1.6 \times 2.35 \times \frac{7}{8} \times 20.5}$ = 98#/□"

Unit shear = $\frac{6600}{12 \times \frac{7}{8} \times 20.5}$ = 30.6#/□"

Bot. slab. - Max. pos. moment = 67,700'#

" neg. " = 109,500'#

" shear = 33,100#

$d = \sqrt{\frac{109,500}{122.7}} = 29.8"$ 'd' as ued = 37.5"

Unit shear = $\frac{33100}{12 \times \frac{7}{8} \times 37.5}$ = 84#/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Tailrace #4 - Holyoke, Mass.

Computation: Conduits

Computed by: E.M.V. Checked by: Date: March 30, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10888

(Continued from sheet #13)

A_s for pos. mom. $= \frac{67,700 \times 12}{\frac{7}{8} \times 37.5 \times 18,000} = 1.37 \square''$: 1"φ, 7" c.c.

A_s for neg. mom. $= \frac{109,500 \times 12}{\frac{7}{8} \times 37.5 \times 18,000} = 2.22 \square''$: 1"φ, 4½" c.c. over middle support. Lap bars 12'6" over middle support. Bend up into side walls.

Unit bond $= \frac{33,100}{2.7 \times 3.14 \times \frac{7}{8} \times 37.5} = 119$ #/□" O.K. at center support.

" " $= \frac{22000}{1.33 \times 3.14 \times \frac{7}{8} \times 37.5} = 160$ #/□" at end supports. Special anchorage.

Sidewalls -

No positive moment. Use ¾"φ, 12" c.c.

A_s for neg. mom. $= \frac{27,900 \times 12}{\frac{7}{8} \times 26.5 \times 18,000} = 0.79 \square''$ = 1"φ, 12" c.c.

Subject: Tailrace #4 - Holyoke, Mass.
Computation: Sump Floor Slab and Apron Slabs for Conduits.
Computed by: E. M. V. Checked by: ______ Date: March 30, 1939

Average soil reaction = 1745 #/□'
" hydrostatic pressure = 612
Total average " = 2357 #/□'
Deduct wt. of slab = 450
Net = 1907 #/□'

$M = \frac{1}{10} \times 1907 \times (18.0)^2 = 62{,}000'\#$ for pump well floor slab.

$M = \frac{1}{10} \times 1907 \times (15.3)^2 = 44{,}600'\#$ " end apron slab.

$M = \frac{1}{12} \times 1907 \times (14.0)^2 = 30{,}900'\#$ " interior apron slab.

End shear for pump well floor at outside wall

$= 1907 \times 9 - \frac{62000}{18} = 13{,}800\#$

End shear for pump well floor slab at interior wall

$= 1907 \times 18 - 13800 = 20{,}500\#$

Unit shear $= \frac{20{,}500}{\frac{7}{8} \times 30.5 \times 12} = 64 \#/\square''$

"d" for pump well slab $= \sqrt{\frac{62000}{122.8}} = 22.4''$ "d" = 30.5"

$A_s = \frac{62000 \times 12}{\frac{7}{8} \times 30.5 \times 18{,}000} = 1.55\square''$ - 1"φ bars 6" c.c. for pump well.

$A_s = \frac{30{,}900 \times 12}{\frac{7}{8} \times 25.5 \times 18{,}000} = 0.93\square''$ = 7/8"φ bars 7½" c.c. for interior apron slab

$A_s = \frac{44{,}600 \times 12}{\frac{7}{8} \times 25.5 \times 18{,}000} = 1.33\square''$ - 1"φ bars 7" c.c. for end apron slab.

Provide special anchorage for all bars.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject Tailrace #4- Holyoke, Mass.

Computation Sump Floor Slab & Apron Slabs for Conduits.

Computed by E. M. V. **Checked by** .... **Date** March 31, 1939

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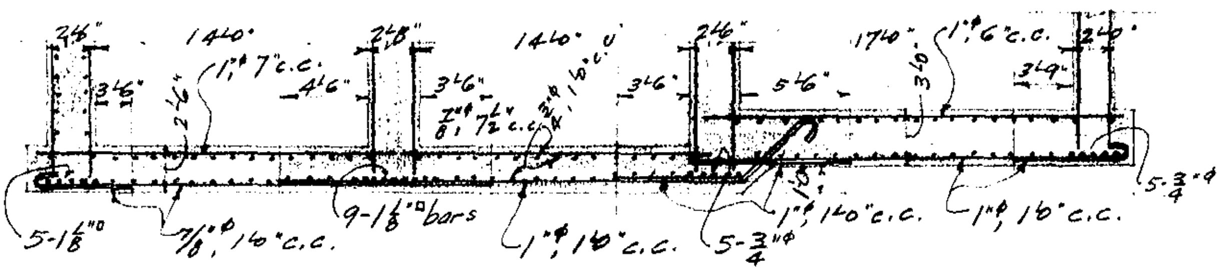
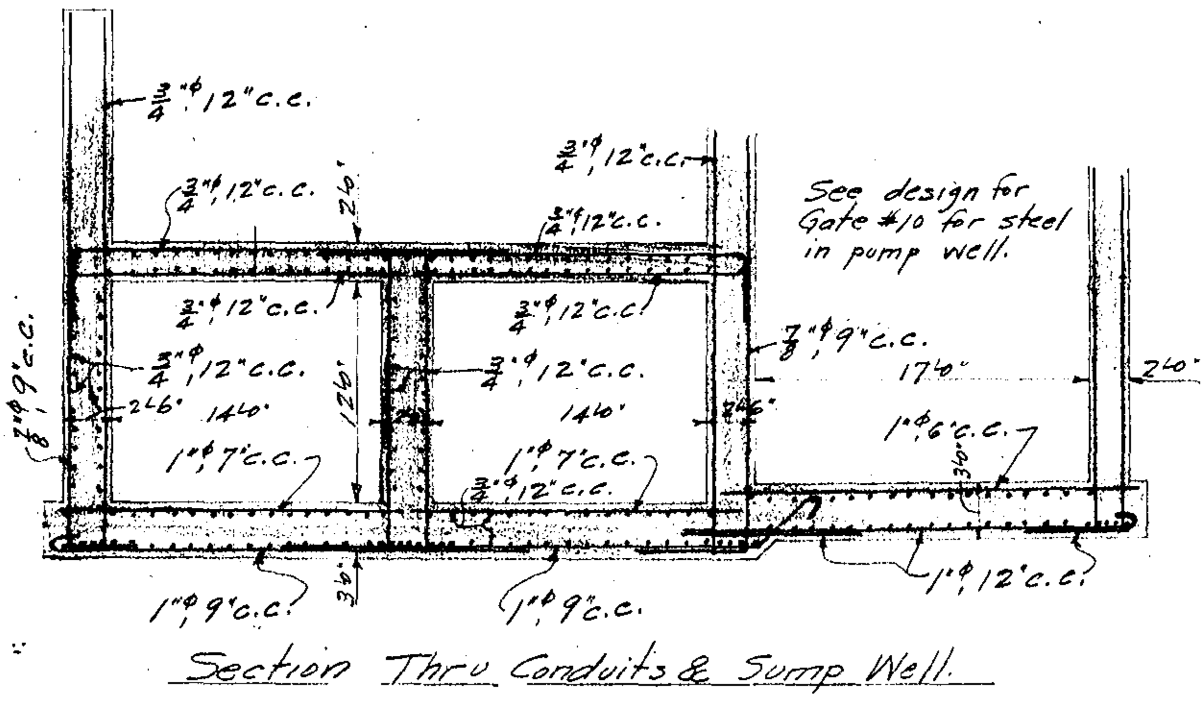


Section Thru Conduit Aprons & Sump Well.



Section Thru Conduits & Sump Well.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailrace #7 - Holyoke, Mass.

Computation Stability of Structure - High Water

Computed by E.M.V. **Checked by** **Date** April 1, 1939.

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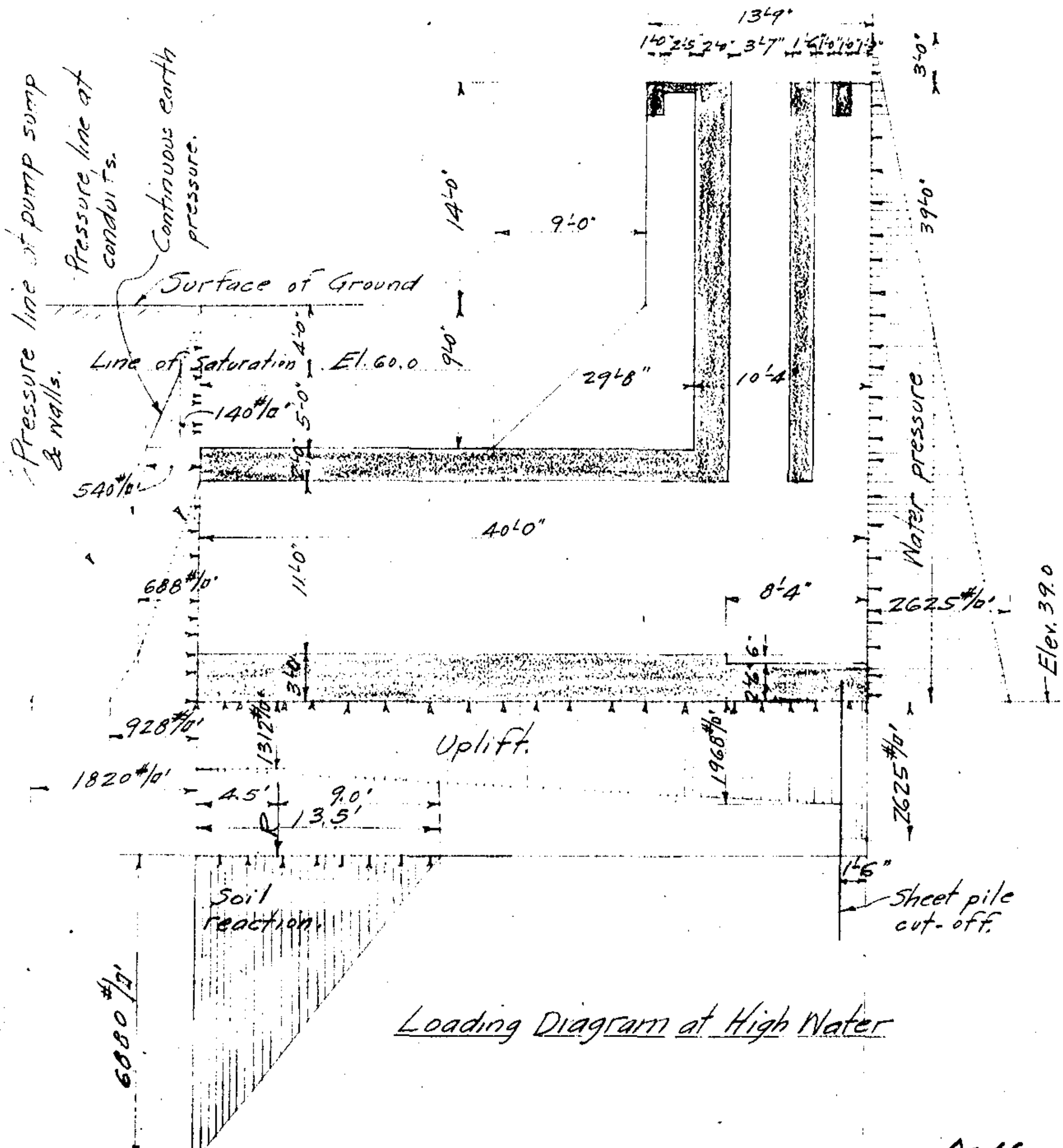


Loading Diagram at High Water

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: ________ Date: April 1, 1939.

Forces Acting	↓	↑	→	←	Mom. Arm.	Mom. About Heel ↘	↙
8.3×2.5×48.3×150	150.0				35.8	5,370.	
31.7×3.0×48.3×150	688.0				15.8	10,870.	
20.0×3.0×40.0×150	360.0				20.0	7,200.	
2.0×27.7×47.6×150	395.0				13.8	5,450.	
2×2.7×11.0×24.0×150	214.0				28.0	5,990.	
2×2.3×11.0×16.0×150	121.2				8.0	970.	
2×2.5×11.0×24.0×150	198.0				28.0	5,540.	
2×2.8×11.0×16.0×150	147.8				8.0	1,181.	
½×7.8×9.0×9.0×150	47.3				23.3	1,100	
7.8×23.0×13.8×150	371.0				33.1	12,280	
2.5×23.0×10.0×150	86.2				28.5	2,450.	
3.0×4.0×40.0×150	72.0				20.0	1,440.	
2.0×17.0×23.0×150	117.2				28.5	3,340.	
1.5×7.0×21.0×150	33.2				22.5	725.	
2×2.0×17.0×21.0×150	214.0				28.5	6,100.	
3.0×1.5×21.0×150	14.2				25.3	359.	
2×1.0×18.0×23.0×150	124.2				28.5	3,535.	
2×1.0×18.0×17.0×150	91.8				28.5	2,615.	
0.83×17.0×19.0×150	40.2				28.5	1,144	
	3485.3					77,659	

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 3

Subject: Tailrace #7 - Holyoke, Mass.

Computation: Stability of Structure — High Water

Computed by: E.M.V. Checked by: Date: April 1, 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10030

Forces Acting	↓	↑	→	←	Mom. Arm	Mom. About Heel ↷	↶
0.9 × 1.0 × 7.0 × 150	0.9				29.5	27.	
0.9 × 1.0 × 8.0 × 150	1.1				26.0	29.	
1.9 × 1.3 × 13.8 × 150	5.1				30.3	154.	
1.3 × 1.9 × 12.0 × 150	4.4				32.0	141.	
1.2 × 1.4 × 12.5 × 150	3.2				23.4	75.	
20.3 × 17.8 × 0.5 × 150	27.1				28.5	772.	
3 × 2.0 × 13.0 × 23.0 × 150	26.9				30.7	825.	
3 × 1.5 × 13.0 × 23.0 × 150	202.0				36.0	7,272.	
6 × 1.0 × 2.0 × 13.0 × 150	23.4				33.3	779.	
0.9 × 1.0 × 17.0 × 150	2.3				28.5	65.	
2 × 1.5 × 1.0 × 12.0 × 150	5.4				28.5	154.	
2.5 × 2.0 × 17.0 × 150	12.8				8.5	109.	
½ × 10.5 × 10.5 × 2 × 150	16.6				13.5	224.	
4.0 × 29.7 × 48.3 × 100	573.5				14.9	8,550.	
5.0 × 29.7 × 48.3 × 125	897.0				14.9	13,350.	
4.0 × 17.0 × 20.0 × 100	136.0				8.5	1,155	
16 × 17.0 × 20.0 × 125	680.0				8.5	5,780	
Machinery 38,000#	38.0				29.5	1,120	
Sluice Gates 30,000	30.0				32.0	960	
	2685.7					41,541.	

I — Concrete to here

Earth

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: ______ Date: April 1, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10536

	Forces Acting	↓	↑	→	←	Mom. Arm.	Mom. About Heel ↘	Mom. About Heel ↖
	Sluice Gate 5,000#	5.0				21.8	109.	
Hydrostatic & Earth Pressures - Water	3×13.0×31.7×11.0×62.5	850.0				15.8	13,400.	
	3×13.0×8.3×11.5×62.5	232.0				35.8	8,310.	
	3×3.6×28.0×13.0×62.5	245.0				33.5	8,200.	
	3×3.5×28.0×13.0×62.5	238.2				38.4	9,540.	
	70×4.0×68.3			19.1		23.0	439.	
	340×5.0×68.3			116.0		18.6	2,155.	
	1180×16.0×29.3			553.0		6.0	3,318.	
	344×11.0×13.0×3			147.8		6.7	990.	
	808×3.0×39.0			94.5		1.4	132.	
	1,313×42.0×68.3				3760.0	14.0		52,700.
	1,640×38.5×68.3		4305.0			20.5		88,300.
	2,625×1.5×68.3		268.0			39.3		10,520.
		1,570.2	4,573.0	930.4	3760.0		46,593.	151,520.
	Brought forward	3,485.3					77,659.	
	" "	2,685.7					41,541.	
		ΣV = 3,178.2↓		ΣH = 2829.6←			ΣM = 14,273.0↻	

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: Date: April 3, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10638

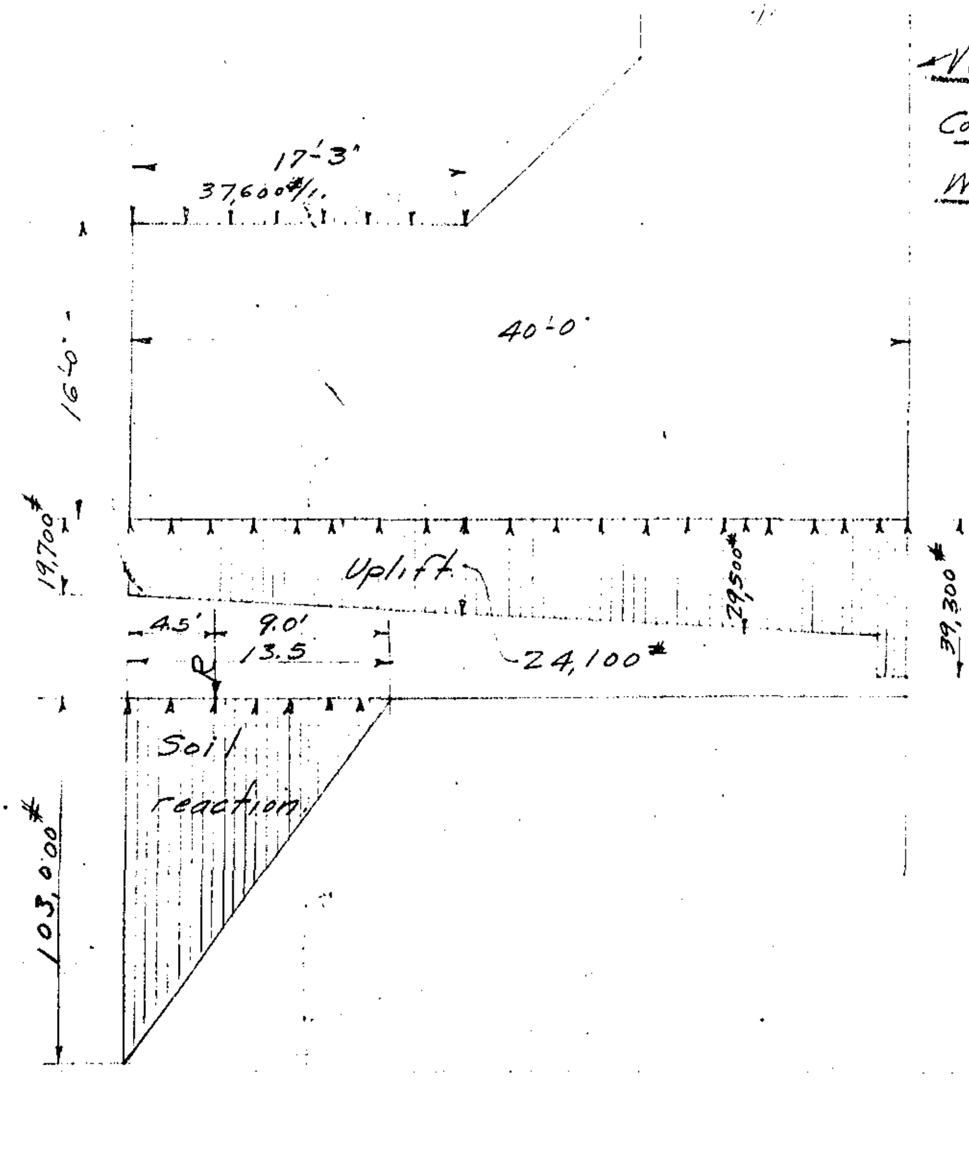
(Continued from sheet #4)

Position of resultant = $\frac{14273.0}{3178.2}$ = 4.5' to right of rear edge.

Eccentricity = 20.0 - 4.5 = 13.5'

Max. soil pressure = $\frac{3,178,200 \times 2}{3 \times 4.5 \times 68.3}$ = 6,880 #/□'

Wall Between Conduits - High Water



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #7 - Holyoke, Mass.

Computation: Wall Between Conduits - High Water

Computed by: E.M.Y. Checked by: ______ Date: April 3, 1939

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Max. mom. = 19,700 × 17.25 × 8.63 = 2,930,000'#

$\frac{1}{2}$ × 4,400 × 17.25 × 5.75 = 218,000

$\frac{1}{2}$ × 103,000 × 13.5 × 12.75 = 8,850,000

12,018,000

Deduct 37,600 × 17.25 × 8.63 = 5600,000

Net = 6,418,000'#

$d = \sqrt{\frac{6,418,000 \times 12}{122.7 \times 32}} = 140" = 11'-8"$ $d = 187"$

Unit shear $= \frac{\frac{1}{2}(19700 + 24100)17.25 + \frac{1}{2} \times 93500 \times 15.9 - 37600 \times 17.25}{32 \times \frac{7}{8} \times 187}$

$= \frac{478000}{32 \times \frac{7}{8} \times 187} = 91.\#/\square"$

$A_s = \frac{6,498,000 \times 12}{\frac{7}{8} \times 187 \times 18,000} = 26.1\square"$ Try 16-1¼"□ bars @1.5625□" = 25.00□"

Unit bond stress $= \frac{478000}{16 \times 5 \times \frac{7}{8} \times 187} = 36.4\#/\square"$

Use 16-1¼"□ bars in each interior counterfort wall

Use-12-1¼"□ bars in each exterior wall.

Bars to be placed in 2-layers at bot. of wall.

WAR DEPARTMENT

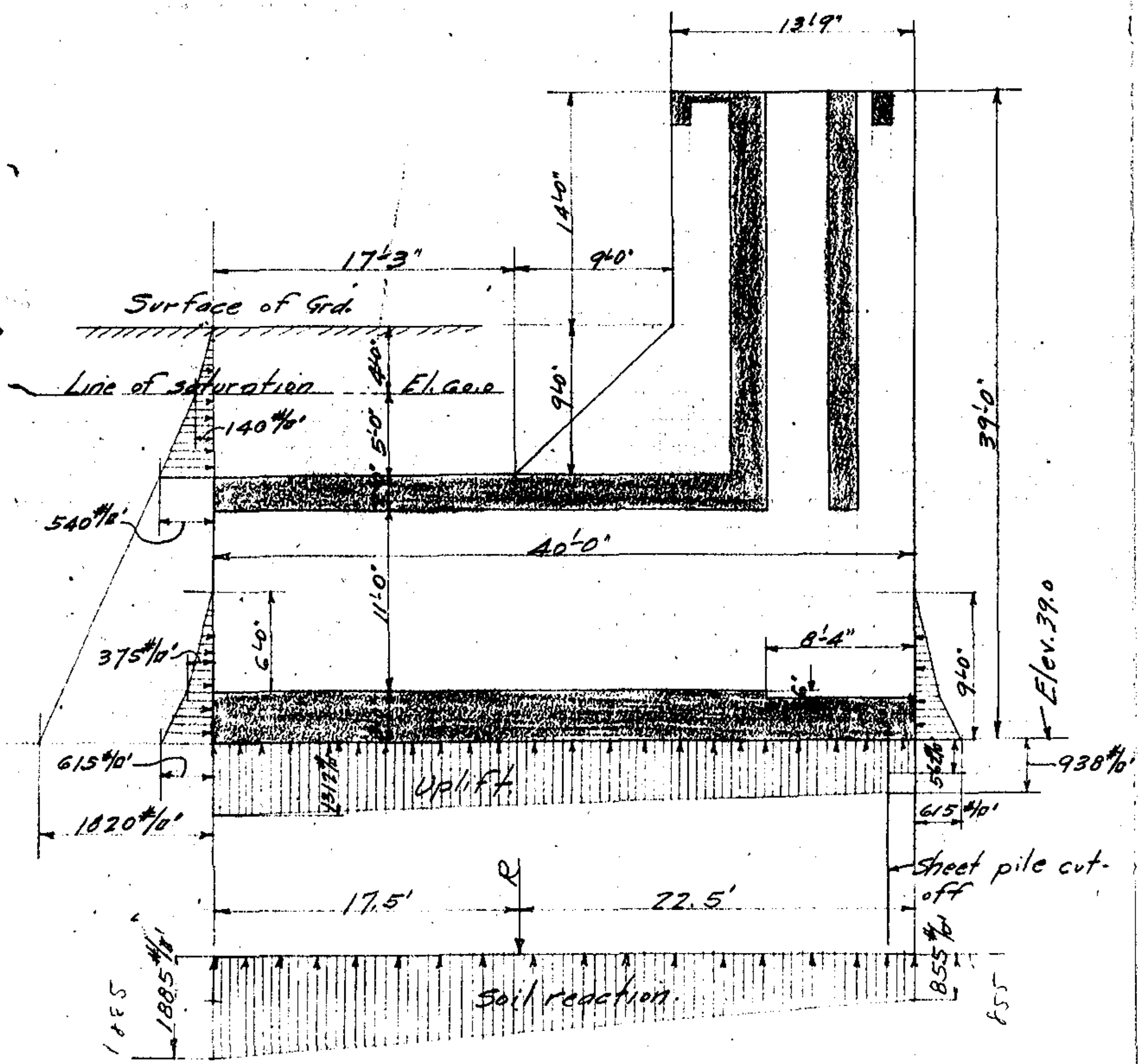
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

Subject: Tailrace #7 - Holyoke, Mass.

Computation: Stability of Structure - Low Water

Computed by: E.M.V. Checked by: ________ Date: April 3, 1939.



Loading Diagram at Low Water (Elev. 48.0)

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. Page 8

Subject Tailrace #7 - Holyoke, Mass.

Computation Stability of Structure - Low Water

Computed by E.M.V. Checked by .... Date April 4, 1939

Forces Acting.	↓	↑	→	←	Mom. Arm.	Mom. About Heel ↻	Mom. About Heel ↺
Concrete, earth and equipment	6176.0					119,309.	
Water 6.0×3×13.0×40×62.5	585.0				20.0		
Earth pressure			688.1			5,912.	
Uplift 1125×38.5×68.3		2955.0			19.3		57,000.
do. 562×1.5×68.3		57.6			39.3		2,260.
	6,761.0	3,012.6	688.1			125,221.	59,260.
	ΣV=3,748.4↓		ΣH=688.1			ΣM=65,961.↻	

Position of resultant $= \frac{65,961}{3,748.4} = 17.5'$ to right of rear edge.

Eccentricity $= 20.0 - 17.5 = 2.5'$ toward rear.

Soil pressure $= \frac{3,748,400}{68.3 \times 40} \pm \frac{3,748,400 \times 2.5 \times 6}{68.3 \times 40 \times 40} = 1370 \pm 515$

$= 1,885$ #/□' max.

$= 855$ #/□' min.

(See sheet #7 for loading diagram).

Provide 4-¾"φ bars in top of each wall

WAR DEPARTMENT

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Page 9

Subject: Tailrace, #7- Holyoke, Mass.

Computation: Conduits.

Computed by: E.M.V. Checked by: Date: April 4, 1939.

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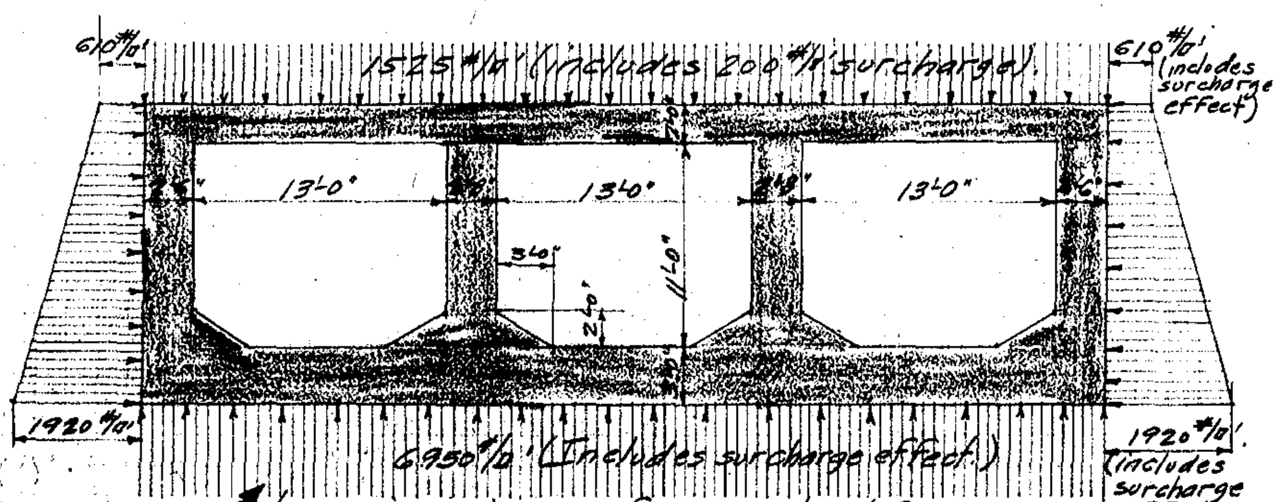
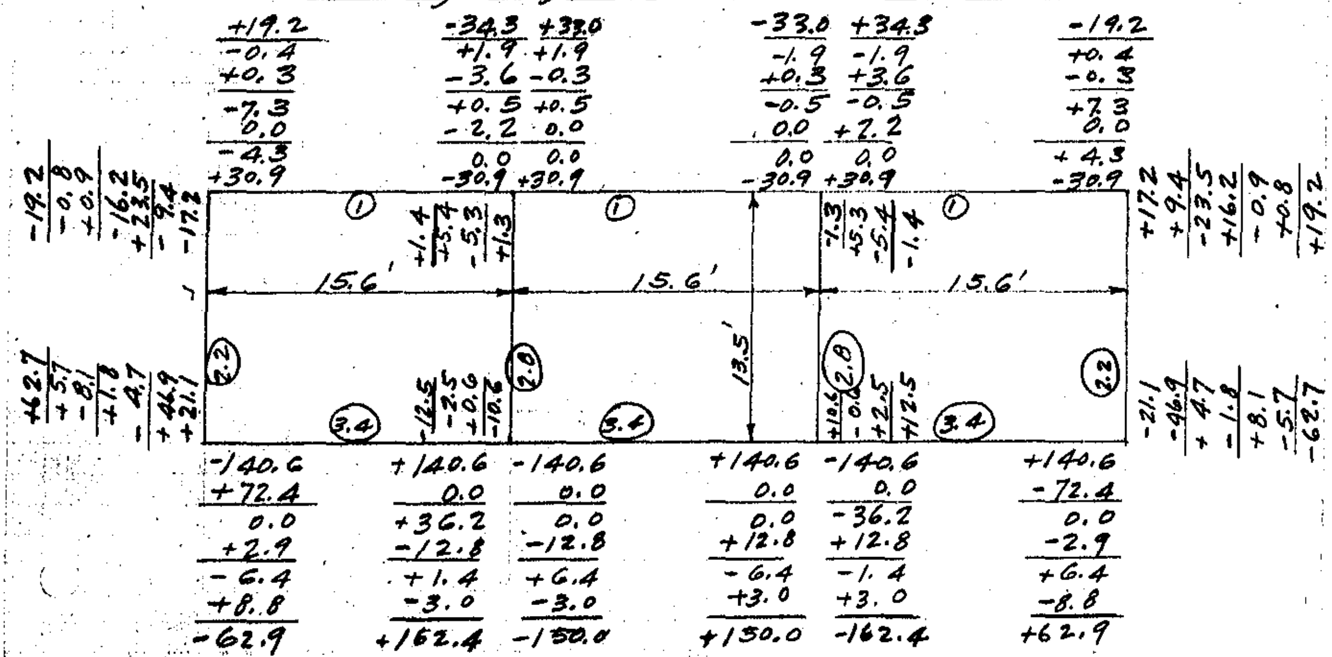


Loading Diagram for Conduits at Rear End



Moment Distribution Diagram.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Conduits.
Computed by: E.M.V. Checked by: ______ Date: April 4, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10656

(Continued from sheet #9)

Shears -

Top slab, left end $= (19{,}200 + 1525(15.6)^2 \times \frac{1}{2} - 34{,}300)\frac{1}{15.6} = 10{,}900^{\#}$

" " right end $= (-19200 + 1525(15.6)^2 \times \frac{1}{2} + 34{,}300)\frac{1}{15.6} = 12{,}800^{\#}$

Center top slab $= 1525 \times 7.8 = 11{,}900^{\#}$

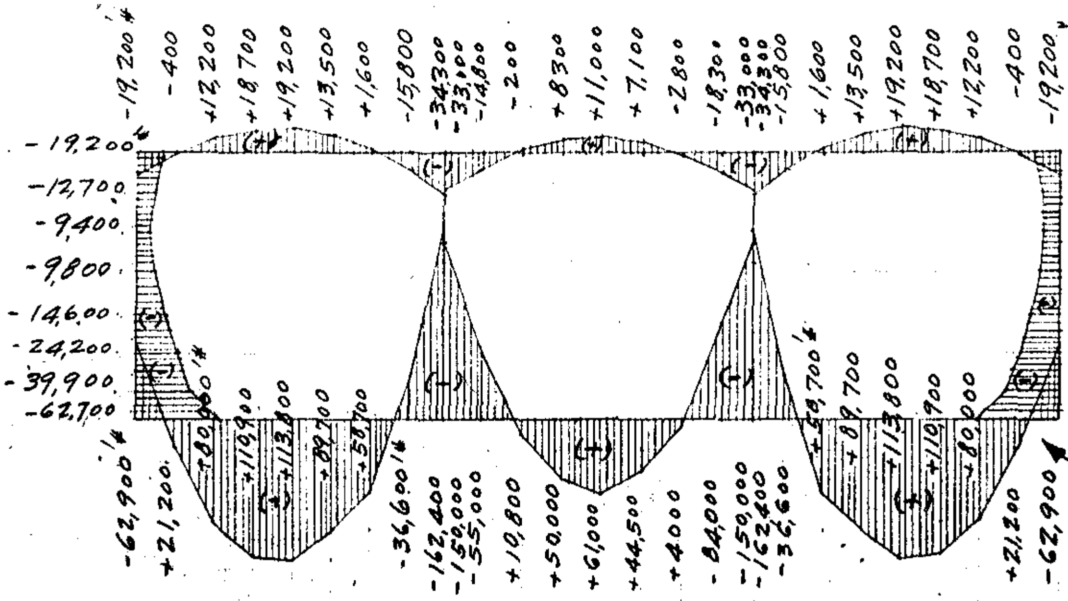
Bot. slab, left end $= (62{,}900 + 6950(15.6)^2 \times \frac{1}{2} - 162{,}400)\frac{1}{15.6} = 47{,}800^{\#}$

" " , right $= (-62{,}900 + 6950(15.6)^2 \times \frac{1}{2} + 162{,}400)\frac{1}{15.6} = 60{,}500^{\#}$

Center bot. slab $= 6950 \times 7.8 = 54{,}200^{\#}$

End walls, top $= (19{,}200 + 692(13.5)^2\frac{1}{2} + \frac{1}{2} \times 1105 \times \frac{\overline{13.5}^2}{3} - 62{,}700)\frac{1}{13.5}$
$= 3{,}900^{\#}$

" " , bot. $= (-19{,}200 + 692(13.5)^2\frac{1}{2} + \frac{1}{2} \times 1105\frac{(13.5)^2 2}{3} + 62{,}700)\frac{1}{13.5}$
$= 12{,}800^{\#}$



Moment Diagram.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Conduits.
Computed by: E. M. V. Checked by: Date: April 5, 1939.

(Continued from sheet #10)

Design of top slab - Max. pos. mom. = 19,200'#.
" " shear = 10,600#

$d = \sqrt{\frac{19,200}{122.8}} = 12.5"$ $d = 20.5"$

Unit shear = $\frac{10,600}{12 \times \frac{7}{8} \times 20.5} = 49\#/\square" \; O.K.$

$A_s = \frac{19200 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.72\square" = \frac{3}{4}"\phi, 7" c.c.$

Bond stress = $\frac{10600}{1.7 \times 2.35 \times \frac{7}{8} \times 20.5} = 148\#/\square"$. Special anchorage.

Max. neg. mom. = 25,800'#. at interior supports
" " " = 13,700'# " outer supports.

A_s for interior neg. mom. = $\frac{25,800 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.96\square"$.

A_s " end " " $= \frac{13,700 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.51\square"$.

Use $\frac{7}{8}"\phi$ bars 12" c.c. top all three spans.
Stagger top bars over interior supports with top bars from side spans to provide 6" spacing.

Use $\frac{3}{4}"\phi$ bars 7" c.c. for bot. bars in end spans.
" $\frac{3}{4}"\phi$ " 12" " " " " " center span.

(Continued from sheet #11)

Design of bottom slab—

Max. pos. mom. in side spans = 113,800'#.

Max. " " " center span = 61,000'#.

Neg. mom. in end spans, interior end = 122,600'#

" " " " " , exterior " = 39,000'#

" " " center span = 114,200'#.

Effective depth req'd by mom. = $\sqrt{\frac{113,800}{122.8}}$ = 30.4".

Depth req'd by shear = $\frac{60,500 - 6950 \times 1.33}{\frac{7}{8} \times 12 \times 90}$ = 54". Provide haunches.

As for pos. mom.; side spans, = $\frac{113800 \times 12}{\frac{7}{8} \times 31.5 \times 18,000}$ = 2.75 □"

" " " " center span = $\frac{61.0}{113.8} \times 2.75$ = 1.48 □".

" " neg. mom. interior end = $\frac{122.6}{113.8} \times 2.75$ = 2.96 □"

" " " " exterior " = $\frac{39.0}{113.8} \times 2.75$ = 0.94 □"

" " " " center span = $\frac{114.2}{113.8} \times 2.75$ = 2.76 □".

For pos. mom. side spans, use 1"□, 4" c.c.

" " " , center span, " 1"□, 8" c.c.

" neg. " , interior " 1"□, 4" c.c.

" " " , exterior end " 1"□, 12" c.c.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #7- Holyoke, Mass.

Computation: Conduits.

Computed by: E. M. V. Checked by: Date: April 5, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10688

(Continued from sheet #12)

Design of sidewalls—

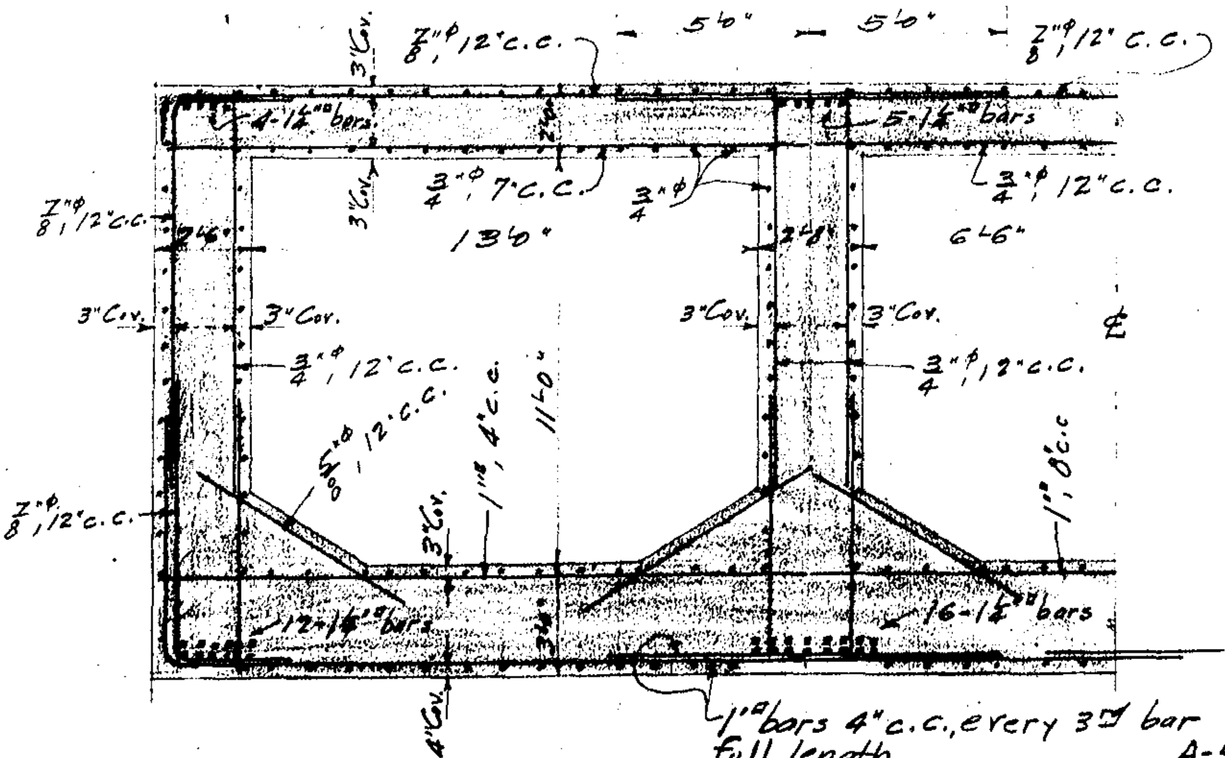
Max. neg. mom. at top = 17,600'#

" " " " bot. = 55,000'#

No positive mom.

A_s at top = $\frac{17600 \times 12}{\frac{7}{8} \times 26.5 \times 18{,}000}$ = 0.51☐" = $\frac{7}{8}$"φ, 12" c.c.

A_s at bot. = $\frac{55{,}000 \times 12}{\frac{7}{8} \times 26.5 \times 18{,}000}$ = 1.58☐" Bend up 1"φ bars from bot slab and stagger with $\frac{7}{8}$"φ bars.



Subject: Tailrace #7- Holyoke, Mass.
Computation: Apron in Front of Conduits.
Computed by .... Checked by .... Date: April 7, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10686

River up. { Downward pressure on apron slab = 39.5×62.5 + 2.5×150 = 2845#/□'
{ Hydrostatic pressure upward = 1968

Net downward pressure = 877#/□'

River down to Elev. 48.0 -

Downward pressure on apron slab = 6.5×62.5 + 2.5×150 = 782#/□'
Hydrostatic upward pressure plus soil reaction = 2785#/□'
Net upward reaction = 2003#/□'

For downward reaction - "M" in end spans = $\frac{1}{10}$ × 877 (14.25)² = 17,800'#.
"M" in center span = $\frac{1}{12}$ × 877 (13.0)² = 12,400'#.

For upward reaction - "M" in end spans = $\frac{1}{10}$ × 2007 (14.25)² = 40,800'#
"M" " center span = $\frac{1}{12}$ × 2007 (13.0)² = 28,400'#.

Required "d" = $\sqrt{\frac{40,800}{122.8}}$ = 18.2". "d" as furnished = 25.5"

$A_s = \frac{17800 \times 12}{\frac{7}{8} \times 25.5 \times 18,000} = 0.53$□"
$A_s = \frac{12,400 \times 12}{\frac{7}{8} \times 25.5 \times 18,000} = 0.37$□"
} For downward pressures.

$A_s = \frac{40,800 \times 12}{\frac{7}{8} \times 25.5 \times 18,000} = 1.22$□"
$A_s = \frac{28,400 \times 12}{\frac{7}{8} \times 25.5 \times 18,000} = 0.85$□"
} For upward pressures.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #7 - Holyoke, Mass.

Computation: Apron Slab in Front of Conduits.

Computed by: E.M.V. Checked by .... Date: April 7, 1939.

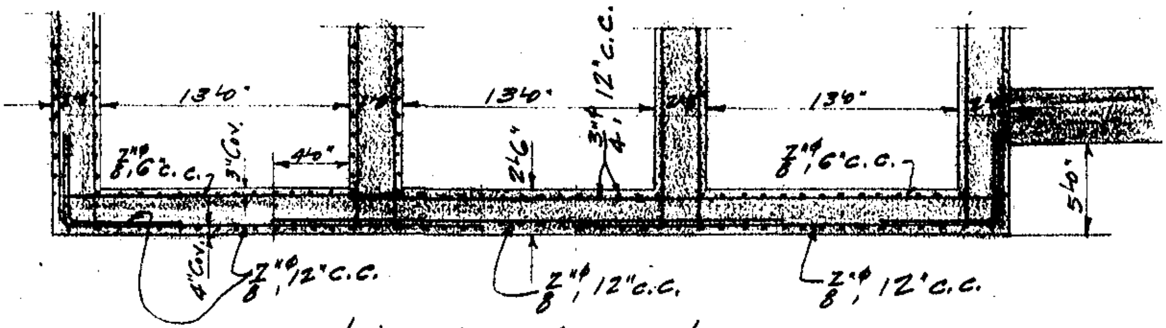
U. S. GOVERNMENT PRINTING OFFICE 3—10688

(Continued from sheet #14)

Max. end shear for end spans $= \frac{\frac{5}{8} \times 2007 \times 14.25}{12 \times \frac{7}{8} \times 25.5} = 66.7\#/\square''$ O.K.

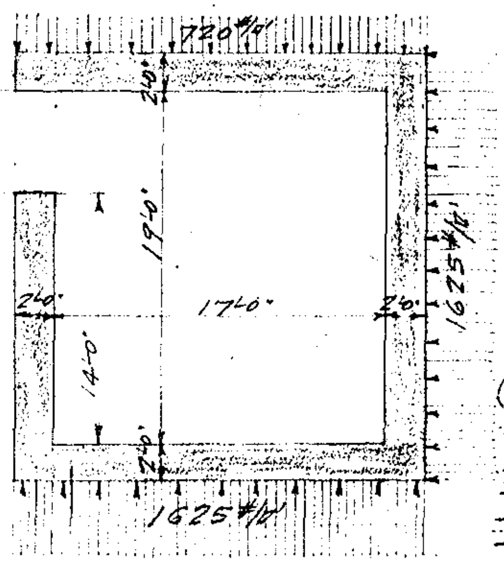
Use $\frac{7}{8}$"ϕ bars 12" c.c. in bot. of slab. Lap over supports to provide 6" spacing.

Use $\frac{7}{8}$"ϕ bars 6" c.c. in top of slabs. in all spans. Lap bars and stagger laps.

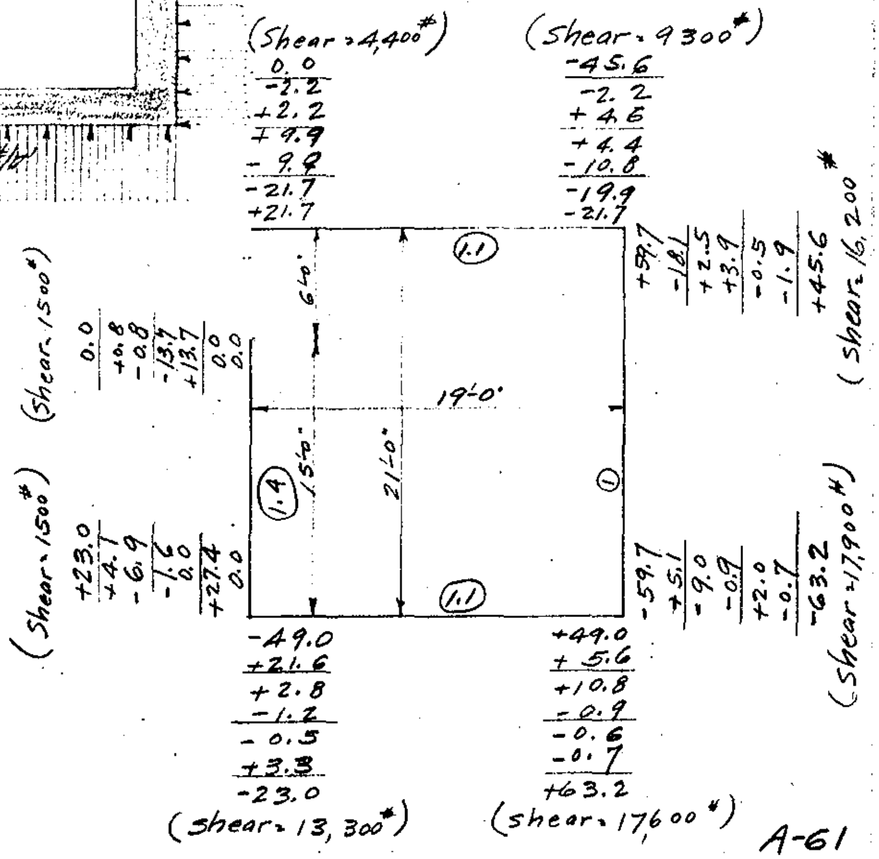


Section Thru Apron Slabs.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Pump Sump at Sluice Gate Opening.
Computed by: E. M. V. Checked by: .... Date: April 6, 1939.



Loading Diagram on Sump at Sluice Gate.



Subject: Tailrace #7 - Holyoke, Mass.
Computation: Pump Sump at Sluice Gate Opening
Computed by: E.M.Y. Checked by: Date: April 7, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10638

(Continued from sheet #)

A_s for neg. moms. $= \dfrac{17{,}700 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.66^{\square''} = \frac{3}{4}''\phi,\ 8''$ c.c.

$\dfrac{56{,}200 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 2.09^{\square''} = 1''\phi,\ 4''$ c.c.

Wall on sluice gate side —

Max. neg. mom. = 22,400'#. $A_s = \dfrac{22{,}400 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.83^{\square''}$

Pos. mom. = 0. $= \frac{3}{4}''\phi,\ 6''$ c.c.

Wall opposite sluice gate —

Max. pos. mom. = 35,000'#.

Max. neg. mom. = 56,200'# and 39,600'#.

A_s for pos. mom. $= \dfrac{35000 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.30^{\square''} = 1''\phi,\ 7''$ c.c.

A_s for neg. mom. $= 2.09^{\square''}$ and $\dfrac{39.6}{35.0} \times 1.30 = 1.47^{\square''}$

$= 1''\phi,\ 4''$ c.c. and $6''$ c.c.

Wall on land side —

Max. pos. mom. = 13,500'#.

Max. neg. " = 42,100'#.

A_s for pos. mom. $= \dfrac{13{,}500 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 0.50^{\square''} = \frac{5}{8}''\phi,\ 7''$ c.c.

A_s for neg. mom. $= \dfrac{42{,}100 \times 12}{\frac{7}{8} \times 20.5 \times 18{,}000} = 1.56^{\square''} = 1''\phi,\ 6''$ c.c.

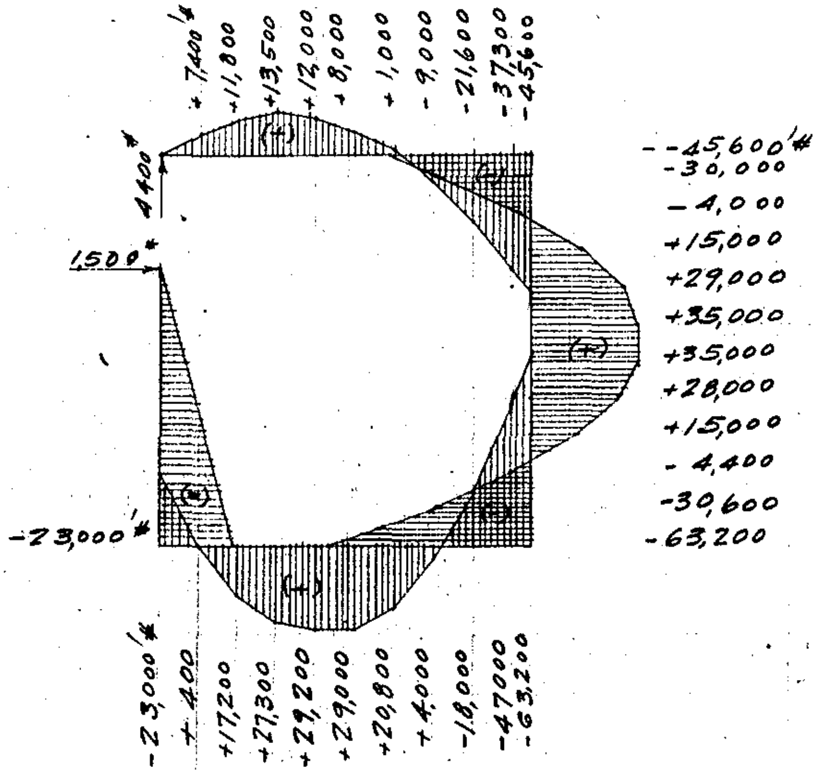
WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Pump Sump at Sluice Gate Opening.
Computed by: E. M. V. Checked by: Date: April 6, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10836

(Continued from sheet #)



Bending Moment Diagram.

Wall on river side —

Max. pos. mom. = 29,200'#.

Neg. mom. = 17,700'# and 56,200'#.

Max. shear = 16,000#

Unit shear = $\frac{16,000}{\frac{7}{8}\times 20.5\times 12}$ = 74#/□" O.K.

As for pos. mom. = $\frac{29200\times 12}{\frac{7}{8}\times 20.5\times 18,000}$ = 1.08□" = 7/8"φ, 7" c.c.

WAR DEPARTMENT

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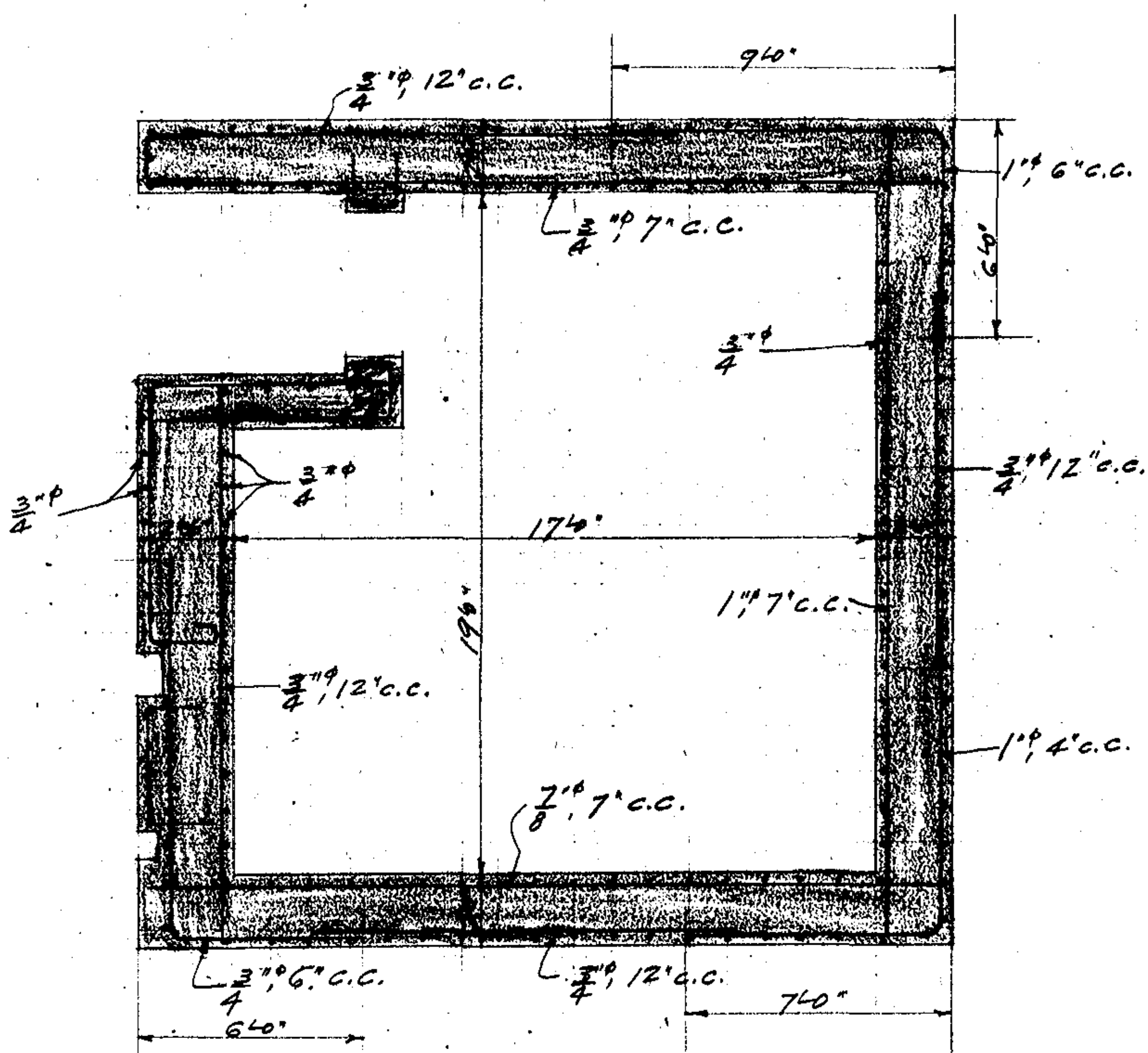
Subject: Tailrace #7 - Holyoke, Mass.

Computation: Pump Sump at Sluice Gate Opening.

Computed by: E.M.V. Checked by: ______ Date: April 7, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10553

(Continued from sheet #)

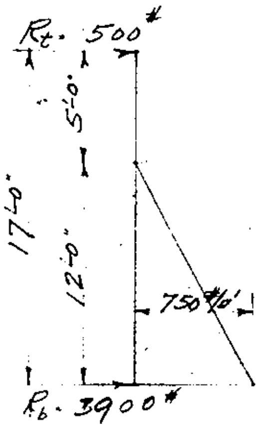


Section Thru Pump Sump at Sluice Gate Opening.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Pump House Wall - River Side
Computed by: E.M.Y. Checked by: Date: April 7, 1939.

U.S. GOVERNMENT PRINTING OFFICE 9—10686

North wall of operating house—
Assume that wall is simply supported at the top and fixed at the base.



Max. pos. mom. = $500(5.0+4.0) - \frac{1}{2} \times 250 \times 4 \times \frac{4}{3}$
$= 3900'\#$

$d = \sqrt{\frac{3900}{122.8}} = 5.6"$.

"d", as furnished = 13.5"

Unit shear = $\frac{3900}{12 \times \frac{7}{8} \times 13.5} = 27\#/\square"$ O.K.

$A_s = \frac{3900 \times 12}{\frac{7}{8} \times 13.5 \times 18{,}000} = 0.22\square" = \frac{5}{8}"\phi, 12"$ c.c.
for inside face.

Max. neg. mom. = $500 \times 17.0 - \frac{1}{2} \times 750 \times 12.0 \times 4.0 = 9500'\#$

$A_s = \frac{9500 \times 12}{\frac{7}{8} \times 13.5 \times 18{,}000} = 0.53\square" = \frac{5}{8}"\phi$ 6" c.c.
for outside face.

WAR DEPARTMENT

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Subject: Tailrace #7- Holyoke, Mass.

Computation: Sump Floor Slab & Sump Floor Slab Extension.

Computed by: E.M.V. Checked by: Date: April 8, 1939.

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1. Sump Floor Slab.-

*Max. upward pressure on slab = 2770 #/□'

Deduct wt. of slab = 450

Net = 2320 #/□'.

$M = \frac{1}{8} \times 2320 (19.0)^2 = 104{,}500'\#.$

$d = \sqrt{\frac{104500}{122.8}} = 29.1$" required; 31.5" furnished.

Unit shear $= \frac{8.5 \times 2320}{\frac{7}{8} \times 12 \times 31.5} = 59\#/□"$ O.K.

$A_s = \frac{104{,}500 \times 12}{\frac{7}{8} \times 31.5 \times 18{,}000} = 2.53□"$ Use 1"□, 5" c. to c.

Unit bond stress $= \frac{8.5 \times 2320}{2.4 \times 4 \times \frac{7}{8} \times 31.5} = 75\#/□"$.

2. Sump Floor Slab Extension -

Downward loads - Wt. of dry earth = 4 × 100 = 400 #/□'.

" " sat. " = 13 × 125 = 1625

" " slab = 3 × 150 = 450

Total = 2,475 #/□'.

Upward reaction, high water = 8192 #/□' max.

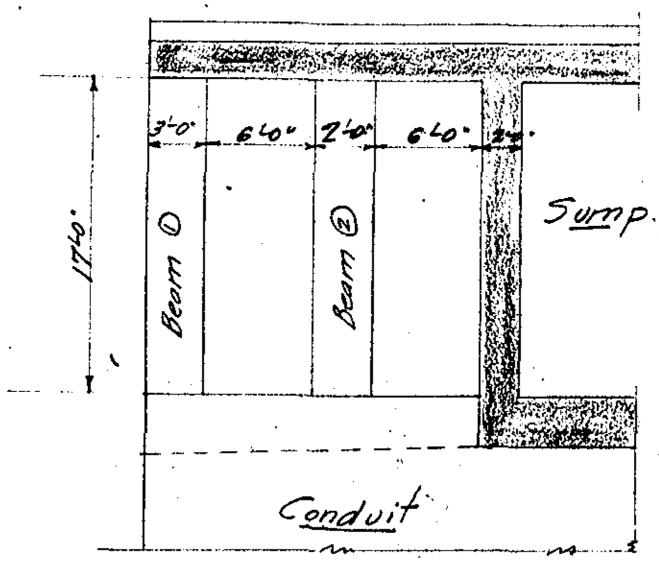
" " , " " = 1542 #/□' min.

" " , low " = 2440 #/□' max.

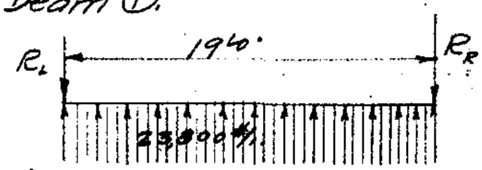
Subject: Tailrace #7 - Holyoke, Mass.
Computation: Sump Floor Slab & Sump Floor Slab Extension
Computed by: E.M.V. Checked by: ______ Date: April 8, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10636

(Continued from sheet #21)



Beam ①.



$R_L = R_R = 227,000^{\#}$

Depth of bm. = 73.5" effective.

$M = \frac{1}{8} \times 23,800 (19.0)^2 = 1,075,000'^{\#}$

"d" req'd $= \sqrt{\frac{1,075,0000 \times 12}{122.8 \times 36}} = 54"$

Unit shear $= \frac{203,000}{36 \times \frac{7}{8} \times 73.5} = 87.5^{\#}/\square" $ O.K.

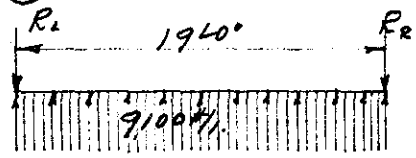
$A_s = \frac{1,075,000 \times 12}{\frac{7}{8} \times 73.5 \times 18,000} = 11.2\square"$. Use 12-1"□ bars in 2-layers.

Bond stress $= \frac{203,000}{12 \times 4 \times \frac{7}{8} \times 73.0} = 66^{\#}/\square"$ O.K.

Subject: Tailrace #7 - Holyoke, Mass.
Computation: Sump Floor Slab & Sump Floor Slab Extension.
Computed by: E.M.V. Checked by: Date: April 8, 1939.

(Continued from sheet #22.)

Beam ②.



$R_L = R_R = 86,500$#

Depth of bm. = 73.5" effective.

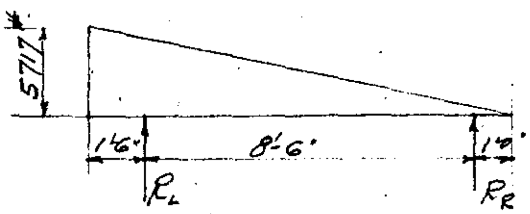
$M = \frac{1}{8} \times 9100 (19.0)^2 = 410,000$ '#.

Assuming bm. to be 2'-0" wide, unit shear $= \frac{77400}{24 \times \frac{7}{8} \times 73.5} = 50$#/□" O.K.

$A_s = \frac{410,000 \times 12}{\frac{7}{8} \times 73.5 \times 18,000} = 4.25$□" Use 6-1"□ bars.

Unit bond stress $= \frac{77400}{6 \times 3.14 \times \frac{7}{8} \times 73.5} = 64$#/□" O.K.

Floor slab -



$R_L = \frac{5717 \times \frac{1}{2} + 11.0 \times 6.3}{8.5} = 23,300$#

$R_L = 8,100$#

$M = 8100 \times 5.6 - 8100 \times \frac{5.6}{3} = 30,300$ '#.

Since the slab is continuous, the mom. may be taken as $\frac{8}{10} \times 30,300 = 24,200$ '#.

$A_s = \frac{24200 \times 12}{\frac{7}{8} \times 31.5 \times 18,000} = 0.59$□" Use $\frac{7}{8}$"□ bars 12" c.c. top & bot.

Bond stress $= \frac{23300 - \frac{1}{2}(5717 + 4157) \times 3}{2.75 \times \frac{7}{8} \times 31.5} = 108$#/□" O.K.

WAR DEPARTMENT

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Subject Tailrace #7 - Holyoke, Mass.

Computation Sump Floor Extension.

Computed by E.M.V. Checked by ______ Date April 8, 1939.

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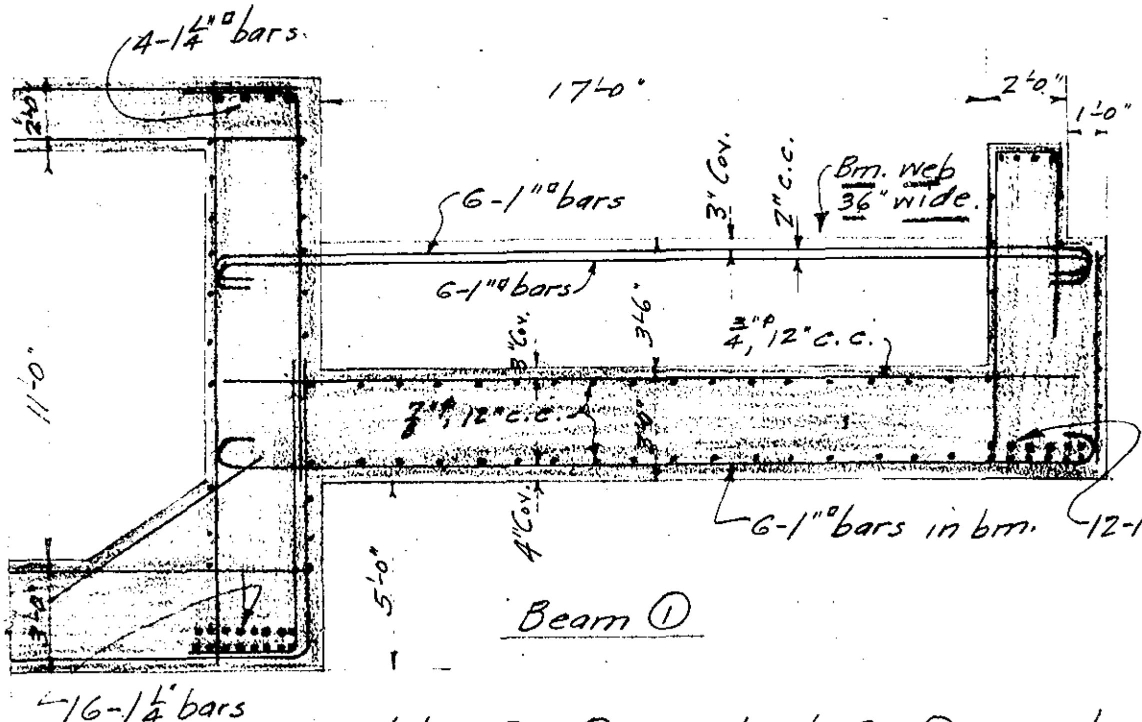


Beam ①

Note: Bm. ② similar to Bm. ① except top steel consists of 6-1"ø bars and bot. steel 3-1"ø bars. Also, web is 24" wide.
(See sheet #22 for location.)

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

Subject: Pumping Stations - Tailraces 4-7-10

Computation: Design Data

Computed by: E.M.Y. Checked by ______ Date: March 13, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10828

Size of motor bases	4'-2" x 4'-6"
Wt. of each motor	4100#
Wt. of each pump	5200
Pump thrust	7800
Wt. of each gate valve	2400
Wt. of 4-unit switchboard	9600
Loaded switchboard area	26 Sq. Ft.
Crane capacity	4 Tons.
Wt. of sluice gate in sump, including friction and appurtenances	12,000
Wt. of sluice gates in flood wall, each, net	9,000
" " " " " " ", including mechanism and friction	20,000
Hydrostatic pressure against sluice gate in sump	30,000
Hydrostatic pressure against sluice gates in flood wall, each	244,500

Size of each sluice gate in flood wall - 11'-0" wide x 11'-10" high

Sluice gate wall opening 10'-0" wide x 11'-0" high.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

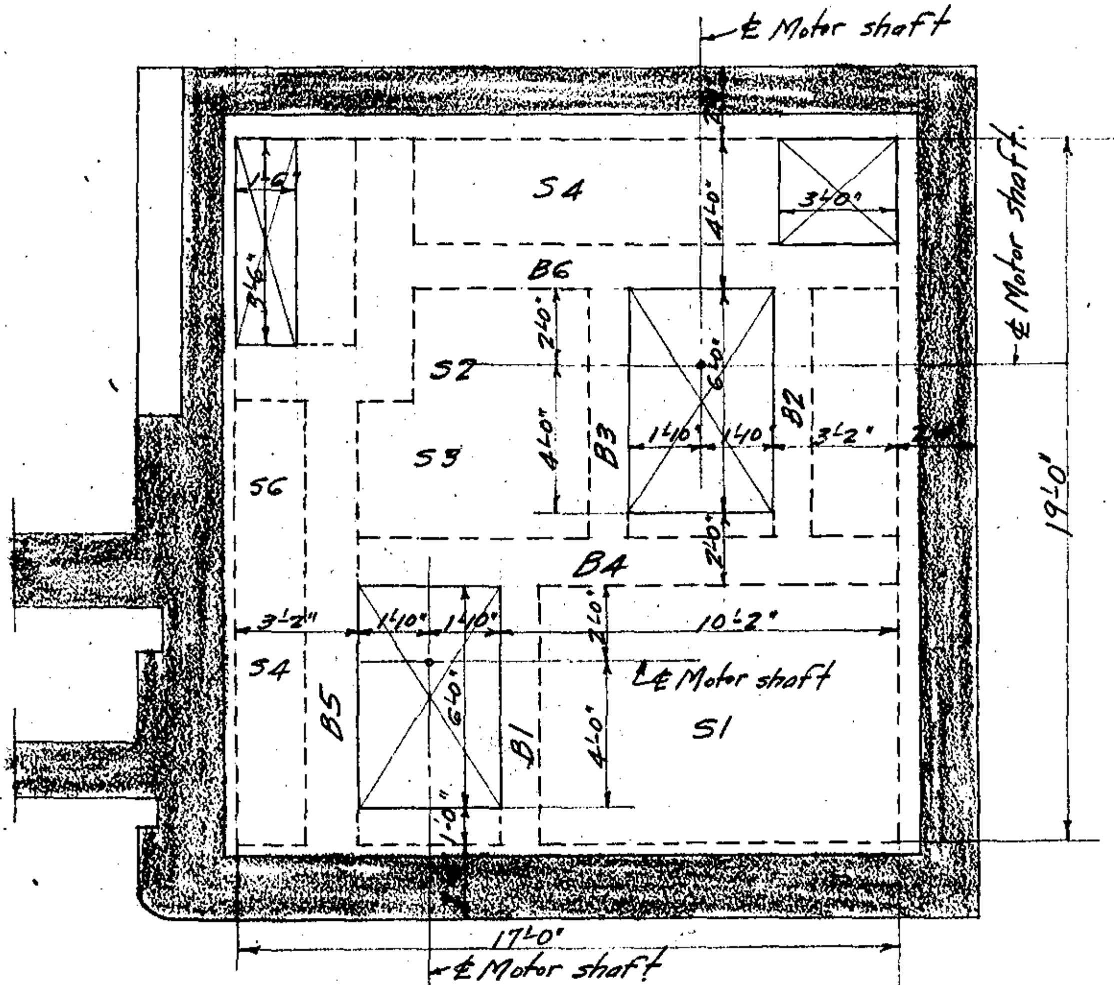
Page 2

Subject: Pumping Stations - Tailraces 4-7 & 10 - Holyoke, Mass.

Computation: Pump Room Floor

Computed by: E.M.V. Checked by: Date: March 6, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10588



Plan of Pump Room Floor Framing

Assumed Live Load on slabs = 350# per sq. ft.

Assumed Live Load on bms. = Machinery loads, impact at 100% for motor and pump loads, and 250# per sq. ft. of contributing floor area.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Pumping Stations - Tailraces 4-7-10

Computation: Pump Room Floor Slabs.

Computed by: E.M.V. Checked by: Date: March 13, 1939

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Assume floor slab 7" thk = 88# per sq. ft.

" " fill 3" " = 37 " " "

D. L. Total = 125# " " "

L.L. = 350

Total = 475# " " "

Slab "51": Assume slab partly restrained.

Span = 8'-0".

$M = \frac{1}{10} \times 475 \times 64 \times 12 = 36,400$ "#.

$d = \sqrt{\frac{36,400}{122.8 \times 12}} = 4.96"$. Make slab 7" thk.

$A_s = \frac{36,400}{\frac{7}{8} \times 5.25 \times 18000} = 0.44\square"$ $\frac{1}{2}$"ϕ bars 5" c.c.

Unit shear = $\frac{4.0 \times 475}{\frac{7}{8} \times 5.75 \times 12} = 31.5$ #/□".

Unit bond stress = $\frac{4.0 \times 475}{2.4 \times 1.57 \times \frac{7}{8} \times 5.75} = 100$ #/□".

Make slab 7" thk.

Bars $\frac{1}{2}$"ϕ, 5" c.c.

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation: Pump Room Floor slabs.
Computed by: E.M.V. Checked by: Date: March 7, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10585

Slab "S2". Span = say 6'-0"

$M = \frac{1}{8} \times 488 \times 36 \times 12 = 26{,}200$ "#. Make slab 7" thk., $d = 5.25$".

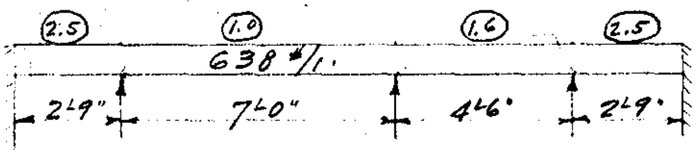
$A_s = \frac{26{,}200}{\frac{7}{8} \times 5.25 \times 18000} = 0.32$ □". Try $\frac{1}{2}$"φ, 6" c.c.

Unit bond stress $= \frac{3.0 \times 488}{2 \times 1.57 \times \frac{7}{8} \times 5.25} = 102$ #/□". special anchorage.

<u>Make slab "S2" 7" thk.</u>

<u>Use $\frac{1}{2}$"φ bars 6" c.c.</u>

Slab "S3". <u>Note</u>:- The uniform load of 638# is to be reduced to 488#.



+0.4	-0.4	+2.6	-2.6	+1.1	-1.1	+0.4	-0.4
0	-1.6	+0.6	+0.6	+0.9	+0.3	+0.4	0.0
-0.8	0	+0.3	+0.3	+0.2	+0.5	0	+0.2
0	-0.2	-0.1	+0.0	+0.1	-0.2	-0.3	0
-0.4	-2.2	+2.2	-2.3	+2.3	-0.5	+0.5	-0.2
R_1	R_2		R_3		R_4		R_5

$2.75 R_1 + 400 - 638 \frac{(2.75)^2}{2} + 2200 = 0$, <u>$R_1 = -69$#</u>

$7.00 R_2 - 69 \times 9.75 + 400 - 638 \frac{(9.75)^2}{2} + 2300 = 0$, <u>$R_2 = +4040$#</u>

$4.50 R_3 - 69 \times 14.25 + 400 - 638 \frac{(14.25)^2}{2} + 500 + 4040 \times 11.50 = 0$,

<u>$R_3 = 4040$#</u>

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation: Pump Room Floor Slabs.
Computed by: E.M.V. Checked by: Date: March 7, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10588

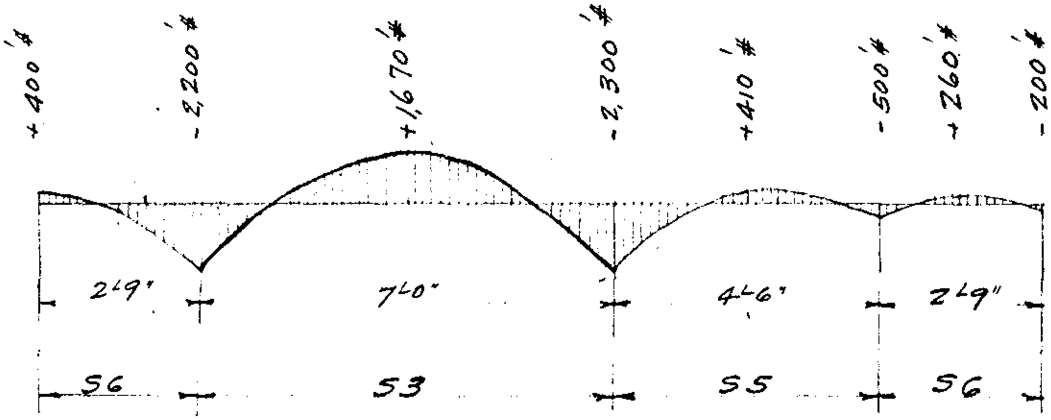
Slab "S3" (continued from sheet #4).

$2.75R_4 + 400 - 69 \times 17.0 - \frac{638(17.0)^2}{2} + 4040 \times 2 \times 10.75 + 200 = 0$

$\underline{R_4 = +2{,}100}$

$2.75R_5 - 200 - 638\frac{(2.75)^2}{2} + 500 = 0,$

$\underline{R_5 = +770^{\#}}$



Mom. Diagram - Slabs S3, S5, S6.

Max. pos. mom. for slab "S3" = $1{,}670 \times 12 \times \frac{488}{638} = 15{,}300''\#$

" neg. " " " 'S3' = $2{,}300 \times 12 \times \frac{488}{638} = 21{,}100''\#$

A_s for pos. mom. = $\frac{15{,}300}{\frac{7}{8} \times 5.25 \times 18{,}000} = 0.19^{\square''}$

A_s for neg. mom. = $\frac{21{,}100}{\frac{7}{8} \times 5.25 \times 18{,}000} = 0.26^{\square''}$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 6

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.

Computation: Pump Room Floor Slab.

Computed by: E.M.V. Checked by: ______ Date: March 7, 1939.

Slab "53" (Continued from sheet #5).

For pos. mom. try $\frac{1}{2}$"ϕ, 12" c. to c.

" neg. " " $\frac{1}{2}$"ϕ, 8" c. to c.

Unit bond stress at supports $= \frac{(4040-1820)\frac{488}{638}}{1.5 \times 1.57 \times \frac{7}{8} \times 5.25} = 157$ #/□"

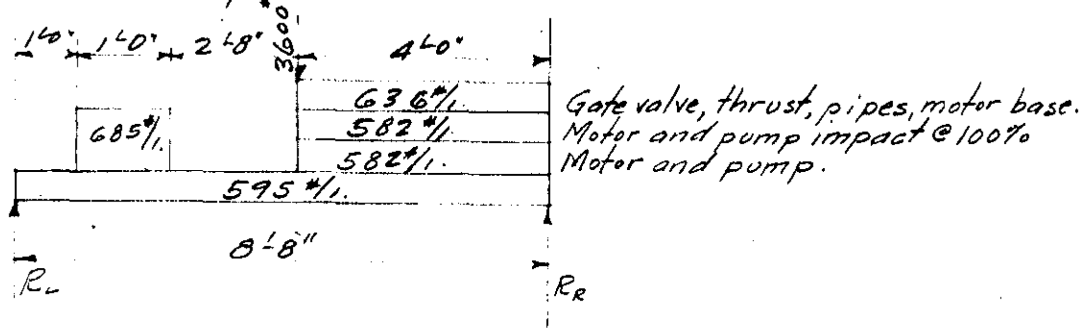
Use $\frac{1}{2}$"ϕ rods 8" c. to c. for both pos. and neg. moms.
Run all positive steel thru to provide continuous positive reinforcement for slabs 53, 55 & 56.
Provide separate straight bars for neg. reinforcement.

Slab "54." $M = \frac{1}{8} \times 488 \times 9 \times 12 = 6{,}600$ "#

Make slab 7" thk.

Use $\frac{1}{2}$"ϕ bars 10" c. to c.

Beam "B1". Span = 8'-6".



Assuming bm. to be 12" wide and 20" deep, effective flge wide = 12" + 1/12 × 8.5 = say 20".

Wt. of bm = 283 # per lin. ft.

" " floor fill = 62 " " "

L.L. froom floor = 250

Total = 595 # " " "

R_L - 1800 × 4.0 × 2.00 = 14,400

900 × 1.00 × 7.17 = 6,500

595 × 8.67 × 4.33 = 22,300

3600 × 4.00 = 14400

Total = 57,600

$R_L = \frac{57,600}{8.67} = 6,700$ #

$R_R =$ 10,200 #

Max. mom. = 6700 × 4.7 - $595\frac{(4.7)^2}{2}$ - 685 × 3.17 = 22,600 '#

Depth req'd by shear = $\frac{10,200}{7/8 \times 120 \times 12}$ = 8.1

WAR DEPARTMENT

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Page 8.

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.

Computation: Floorbeam Design

Computed by: E.M.V. Checked by: Date: March 8, 1939.

Beam "B1" (Continued from sheet #7).

Effective flge width = 20"; $d = \sqrt{\frac{22{,}600 \times 12}{122.8 \times 20}} = 10.5"$

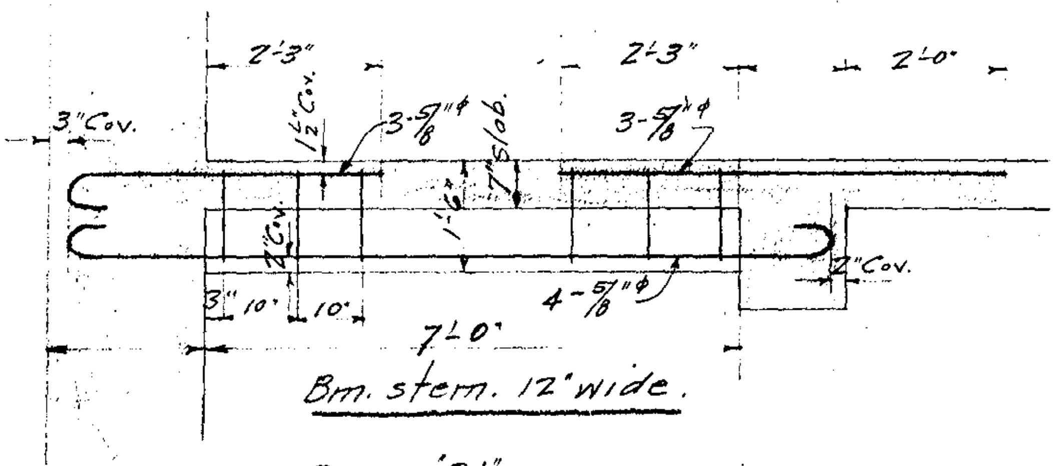
Make total depth of bm. 18"; d = 15.5"

$A_s = \frac{22{,}600 \times 12}{\frac{7}{8} \times 15.5 \times 18{,}000} = 1.11 \square"$. 4-5/8"φ bars @ 0.30□" = 1.20□"

Unit bond stress = $\frac{10{,}200}{4 \times 1.96 \times \frac{7}{8} \times 15.5}$ = 96 #/□". O.K.

Unit shear at interior end = $\frac{10{,}200}{12 \times \frac{7}{8} \times 15.5}$ = 62.8 #/□".

Unit shear at wall end = $\frac{6700}{12 \times \frac{7}{8} \times 15.5}$ = 41.2 #/□".



Bm. stem. 12" wide.

Beam "B1"

Beam "B2" similar. Clear span = 6'-8"

Stirrups 3/8"φ

WAR DEPARTMENT

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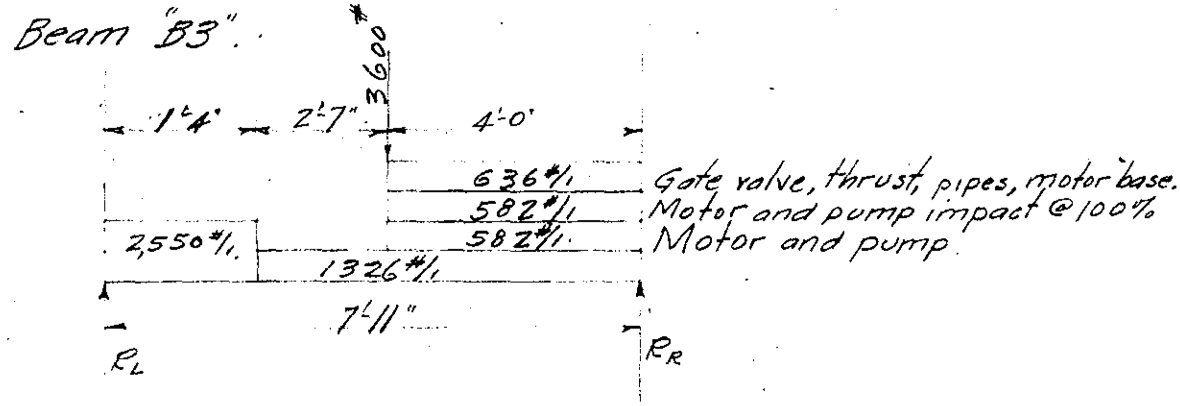
Subject Pumping Station - Tailrace #10 - Holyoke, Mass.

Computation Floorbeam Design

Computed by E.M.V. **Checked by** **Date** March 8, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam "B3".



R_L - 4 × 1,800 × 2.00 = 14,400

6.58 × 1,326 × 3.29 = 28,700

3600 × 4.00 = 14,400

1.33 × 2,550 × 7.25 = 24,700

Total = 82,200

$R_L = \frac{82,200}{7.92} = 10,400$ #

$R_R = 12,500$ #.

Max. mom. $= 12,500 \times 4.0 - 3,126 \frac{(4.0)^2}{2} = 25,000$ #.

$d = \sqrt{\frac{25,000 \times 12}{122.8 \times 17}} = 12.0''$

Make total depth 18"; make d = 15.5"

$A_s = \frac{25,000 \times 12}{\frac{7}{8} \times 15.5 \times 18,000} = 1.22\square''$ Try 4-⅝"φ bars @ 0.30 = 1.20□"

<u>Unit bond stress</u> $= \frac{12,500}{4 \times 1.96 \times \frac{7}{8} \times 15.7} = 116$ #/□"

<u>Unit shear</u> $= \frac{12,500}{12 \times \frac{7}{8} \times 15.7} = 76.0$ #/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.

Computation: Floorbeam Design.

Computed by: E.M.V. Checked by: Date: March 8, 1939.

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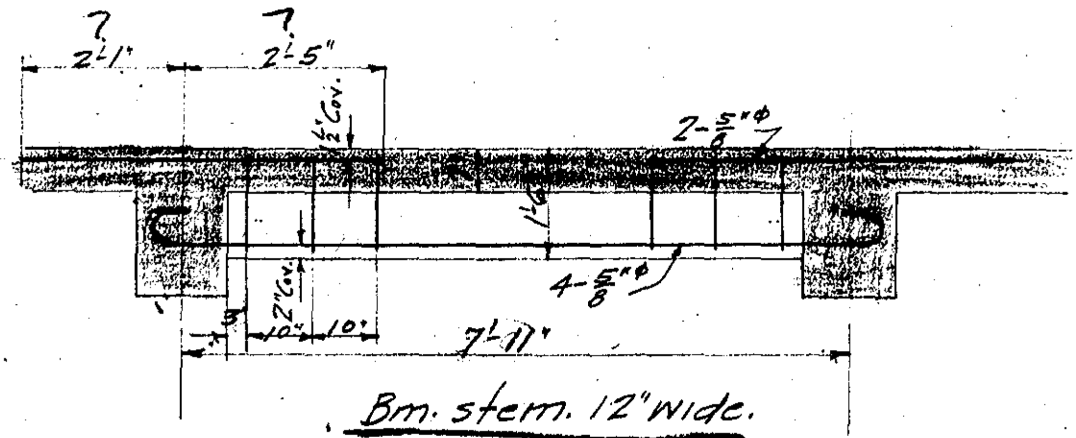
Beam "B3" (Continued from sheet #9).

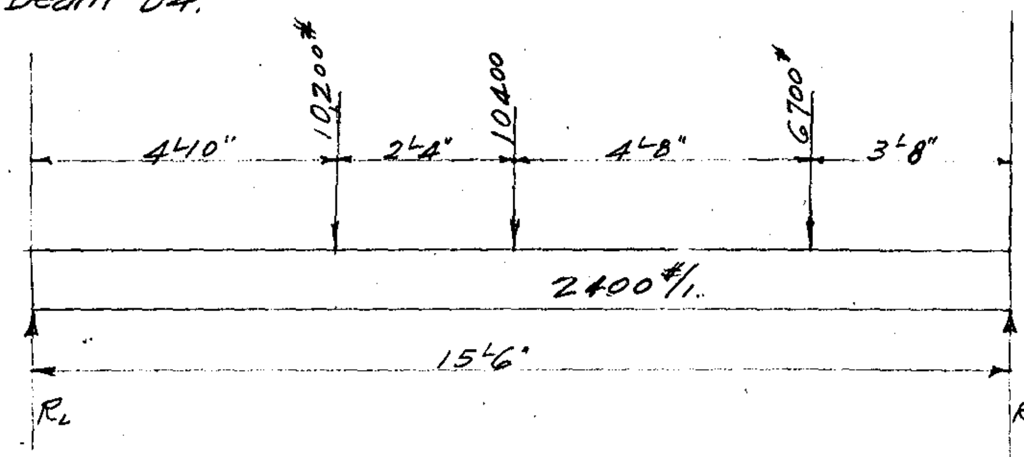


Bm. stem. 12" wide.

Stirrups 3/8" φ.

Subject: Pumping Station – Tailrace #10 – Holyoke, Mass.
Computation: Floorbeam Design
Computed by: E.M.V. Checked by: Date: March 9, 1939.

Beam "B4."



$R_L = 2400 \times 7.75 + \frac{6700 \times 3.67 + 10{,}400 \times 8.33 + 10{,}200 \times 10.67}{15.5}$
$= 32{,}800\#$

$R_R = 31{,}700\#$

$M = 32{,}800 \times 7.17 - 2400\frac{(7.17)^2}{2} - 10{,}200 \times 2.33 = 149{,}700'\#$

$d = \sqrt{\frac{149{,}700 \times 12}{490 \times .32 \times 7}} = 16.4"$ Try bm. 16" × 30"

Unit shear $= \frac{32{,}800}{16 \times \frac{7}{8} \times 27.5} = 85.0\#/\square"$. Stirrups required.

$A_s = \frac{149{,}700 \times 12}{\frac{7}{8} \times 27.5 \times 18{,}000} = 4.14\square"$

3-1"□ @ 1.00 = 3.00□"
1-1⅛"□ @ 1.26 = 1.26
Total = 4.26□"

If all the bars are run through the the unit max. bond stress $= \frac{0.30 \times 32{,}800}{\frac{7}{8} \times 4.50 \times 27.5} = 91\#/\square"$

Subject Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation Floor beam Design
Computed by E.M.V. **Checked by** ________ **Date** March 9, 1939

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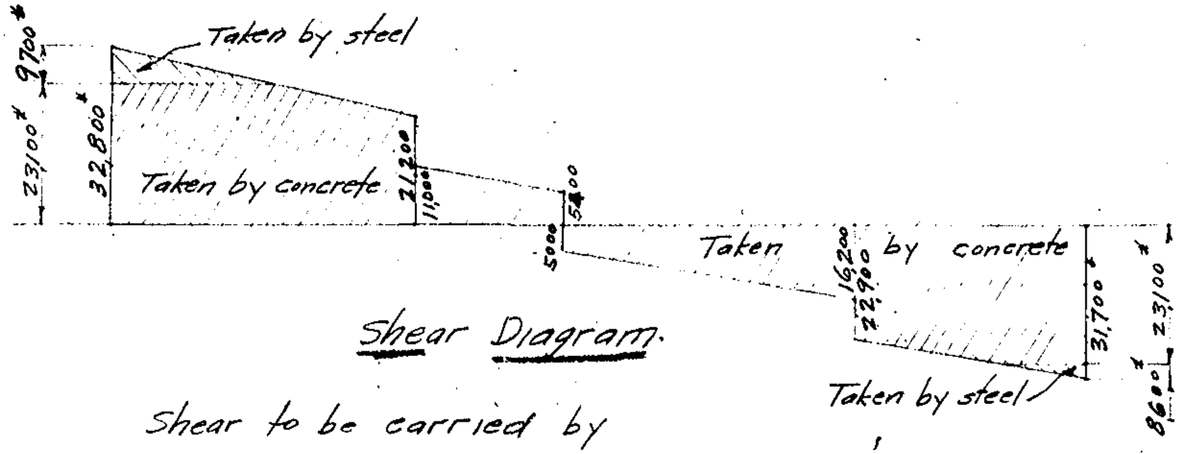
Beam "B4" (Continued from sheet #11.)

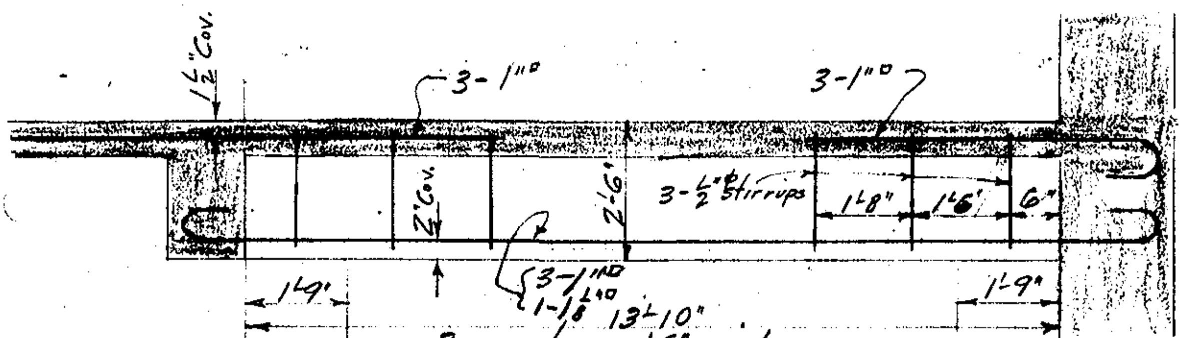


Shear Diagram.

Shear to be carried by
stirrups = ½ × 9,700 × 48.5 = 235,000 #.

No. of stirrups req'd = $\frac{235000}{14,000 \times 27.5 \times 2 \times 0.19} = 1.6$

Use - 3 - ½"φ stirrups at each end spaced 6", 18", 1'8"



Bm. stem 16" wide.

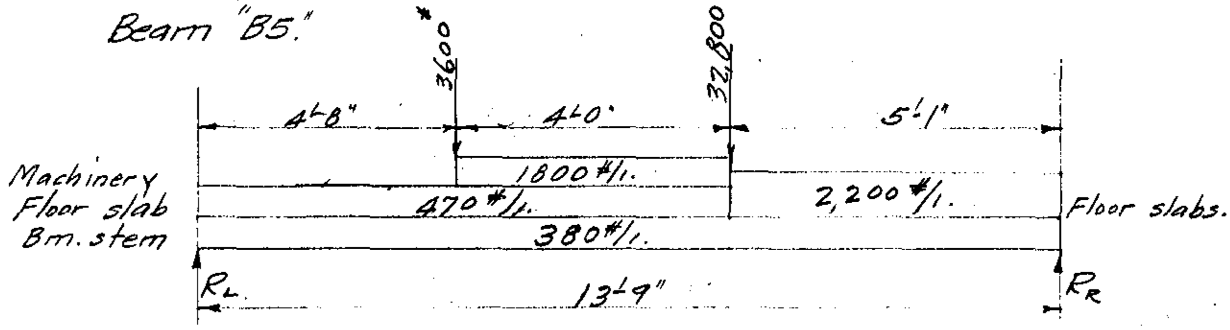
WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 13

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation: Floorbeam Design.
Computed by: E. M. V. Checked by: ________ Date: March 9, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Beam "B5."



R_L - 2,200 × 5.08 × 2.54	=	28,400
1,800 × 4.00 × 7.08	=	51,000
470 × 8.67 × 9.41	=	38,300
380 × 13.75 × 6.87	=	35,800
32,800 × 5.08	=	166,300
3,600 × 9.08	=	32,700
Total	=	352,500

$R_L = \frac{352,500}{13.75} = 25,700\#$

$R_R = 38,400\#$

$M = 38,400 \times 5.08 - 2580 \frac{(5.08)^2}{2} = 161,800'\#.$

With beam 30" deep $\frac{t}{d} = 0.25$, $d = \frac{161,800 \times 12}{490 \times 27 \times 7} = 20.9"$

Make beam 30" deep.

Stem width req'd by shear $= \frac{38,400}{\frac{7}{8} \times 120 \times 27.5} = 13.3"$

Make stem 16" wide.

Unit shear $= \frac{38,400}{\frac{7}{8} \times 16 \times 27.5} = 100\#/\square"$

WAR DEPARTMENT

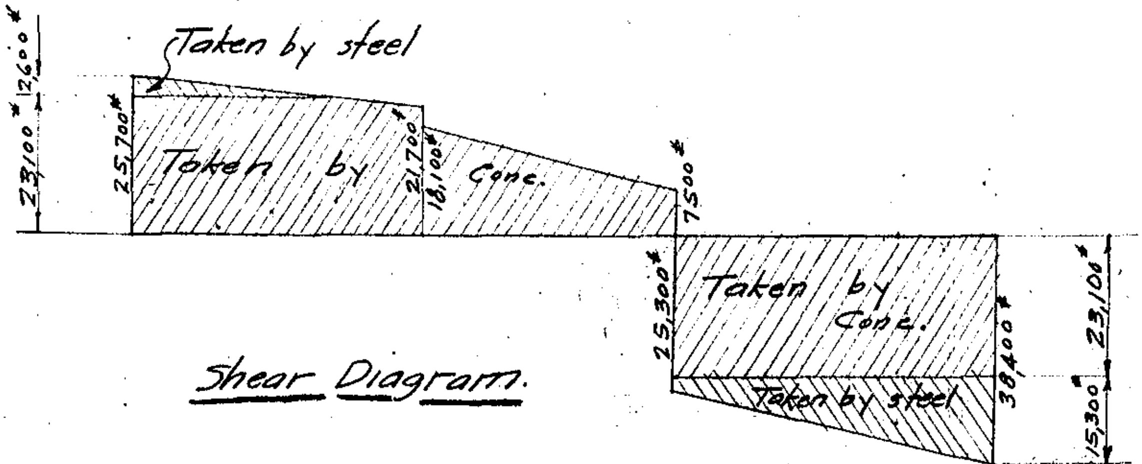
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Pumping Station - Tailrace #10 - Holyoke, Mass.

Computation Floor Beam Design

Computed by E.M.V. **Checked by** ______ **Date** March 10, 1939.

Beam "B5" (Continued from sheet #13).



Shear Diagram.

Shear to be carried by stirrups = ½(2,200+15,300) 61 = 535,000 "#

No. of stirrups req'd = $\frac{535,000}{14,000 \times 27.5 \times 2 \times 0.19}$ = 4

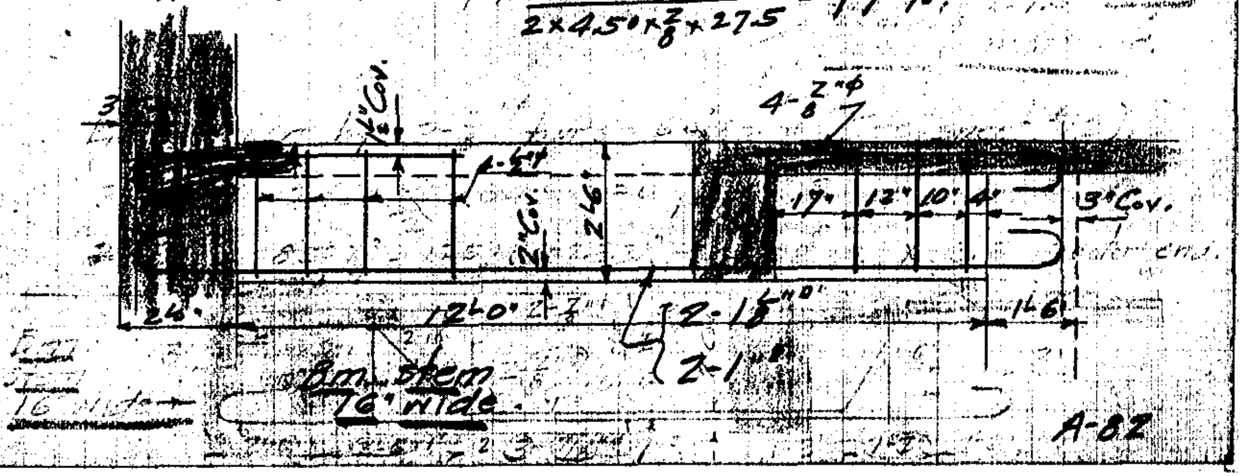
Space ½"φ stirrups 4", 10", 12", 17".

$A_s = \frac{161,800 \times 12}{\frac{7}{8} \times 27.5 \times 18,000}$ = 4.48□" 2-1⅛"□ bars @ 1.26 = 2.52□"

2-1"□ " " 1.00 = 2.00

4.52□"

Unit bond stress = $\frac{0.56 \times 38,400}{2 \times 4.50 \times \frac{7}{8} \times 27.5}$ = 99#/□"



A-82

Subject: Pumping Station - Tailrace #10 — Holyoke, Mass.
Computation: Floor beam Design
Computed by: E.M.V. Checked by: Date: March 10, 1939.

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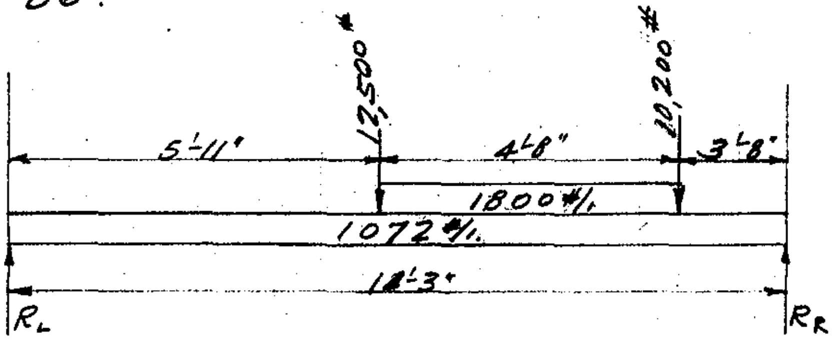
Bm. "B6".



ΣR_L — 10,200 × 3.67 = 37,400
12,500 × 8.33 = 104,000
1,800 × 4.67 × 6.00 = 50,400
1072 × 14.25 × 7.12 = 108,800
300,600

$R_L = \frac{300600}{14.25} = 21,100\#$
$R_R = 25,300\#$

$M = 25300 \times 7.57 - 10200 \times 3.67 - 1800\frac{(3.67)^2}{2} - 1072\frac{(7.57)^2}{2} = 111,300'\#$

Effective width of flge = 37".

$d = \sqrt{\frac{111,300 \times 12}{122.8 \times 28}} = 19.7"$ Make bm. 24" deep; d = 21.5"

$A_s = \frac{111,300 \times 12}{\frac{7}{8} \times 21.5 \times 18,000} = 3.90□"$ Use 4-1"□ bars = 4.00□".

With 2-bars bent up unit bond stress $= \frac{25,300}{2 \times 4.00 \times \frac{7}{8} \times 21.5}$
$= 168\#/□"$

Moment taken by 2-1"□ bars = 55,600'#.

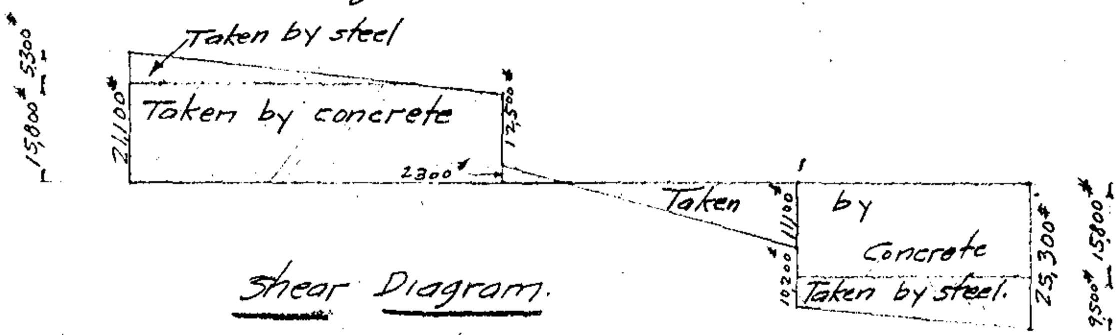
Subject Pumping Station-Tailrace #10- Holyoke, Mass.
Computation Floorbeam Design.
Computed by E.M.V. Checked by ______ Date March 10, 1939.

Beam "B6" (Continued from sheet #15).

$25,300x - 1072\left(\frac{x}{2}\right)^2 - 10,200(x-3.67) - 1800\frac{(x-3.67)^2}{2} = 55,600, \; x = 1.8'$

Run bars through without bending.

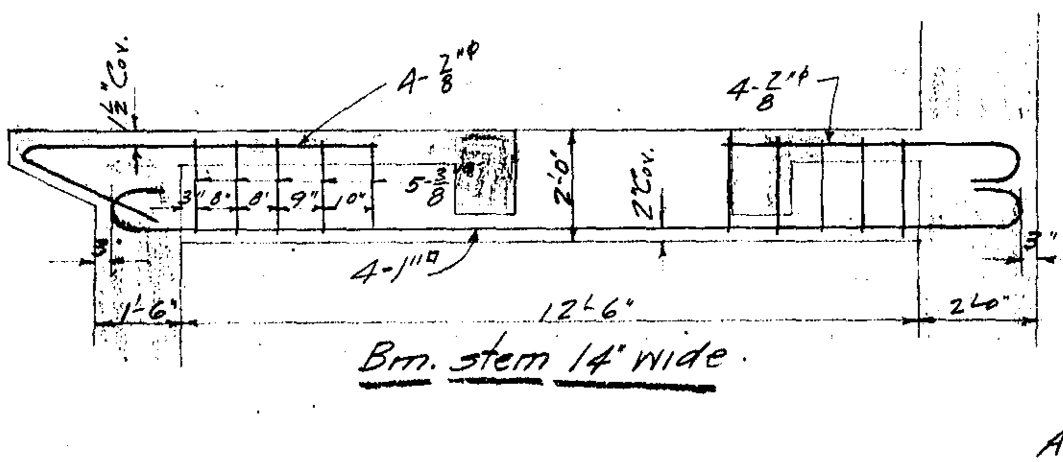
Unit shear $= \frac{25,300}{14 \times \frac{7}{8} \times 21.5} = 96\#/□''$



Shear Diagram.

Assuming $\frac{3}{8}''\phi$ stirrups, no. req'd $= \frac{\frac{1}{2}(5500+9500)44}{14,000 \times 2 \times 0.11 \times 21.5} = 5$

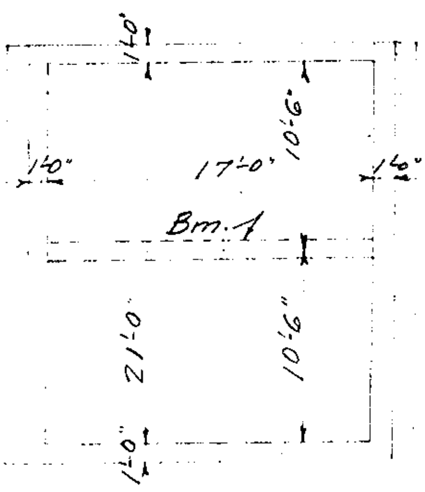
Space stirrups 3", 8", 8", 9", 10"



Bm. stem 14" wide.

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation: Roof
Computed by: E.M.V. Checked by: Date: March 11, 1939.

Roof Slab.



Assume roof slab 5" thk.	63 # per sq. ft.
" roof fill 4" thk. average	30 " " "
Roofing	6 " " "
L.L.	40 " " "
Total =	139 # " " "

Pos. mom. at center = $\frac{1}{10} \times 139 \times (10.75)^2 \times 12 = 19{,}300$ "#

Neg. " " support = $\frac{1}{8} \times 139 \times (10.75)^2 \times 12 = 24{,}100$ "#.

$d = \sqrt{\frac{19{,}300}{122.8 \times 12}} = 3.6"$; $d = \sqrt{\frac{24{,}100}{147.5 \times 12}} = 3.7"$

Make slab $5\frac{1}{2}"$ thk; d = 3.75"

Unit shear = $\frac{\frac{5}{8} \times 139 \times 10.75}{12 \times \frac{7}{8} \times 3.75} = 24$ #/□"

$A_s = \frac{24{,}100}{\frac{7}{8} \times 3.75 \times 18{,}000} = 0.41$ □" - $\frac{5}{8}$"ϕ bars, 9" c.c. over support. A-85

Subject: Pumping Stations - Tailrace #10 - Holyoke, Mass.
Computation: Roof.
Computed by: E.M.V. Checked by: Date: March 13, 1939

U.S. GOVERNMENT PRINTING OFFICE 3—10638

Roof slab (continued from sheet #17)

Unit bond stress $= \frac{5/8 \times 139 \times 10.75}{1.3 \times 1.96 \times \frac{7}{8} \times 3.7} = 113$ #/□"

A_s for positive mom. $= \frac{19,300}{\frac{7}{8} \times 3.7 \times 18000} = 0.33$ □" = 5/8" bars 11" c. to c.

Unit bond stress at free end $= \frac{5/8 \times 139 \times 10.75}{1.09 \times 1.96 \times \frac{7}{8} \times 3.7} = 81$ #/□"

Space bars 11" c.c., bend up every other bar, add 1-5/8"φ bar, 12" c.c. over center support.

Design of Roof Bm — Effective span = 18'-0" (17'-5")

Uniform load = $5/8 \times 139 \times 10.75$ = 935 #/'

Bm., say 200

Total = 1135 #/'

$M = \frac{1}{8} \times 1135 (18.0)^2 = 46,000$ '#.

Effective flge width = 54"

Web area req'd by shear $= \frac{9 \times 1135}{0.9 \times 120} = 95$ □"

$d = \sqrt{\frac{46,000 \times 12}{122.8 \times 54}} = 9.1"$ Make total depth of beam 16". d = 13½"

Max. shear $= (5/8 \times 139 \times 10.75 + \frac{10.5 \times 12}{144} \times 150) 9.0 = 9600$ #

Unit shear $= \frac{9600}{\frac{7}{8} \times 12 \times 13.5} = 67.8$ #/□"

$A_s = \frac{46000 \times 12}{\frac{7}{8} \times 13.5 \times 18,000} = 2.60$ □" Try 2-1"□ @ 1.00 = 2.00 □"
1-7/8"φ " 0.60 = 0.60
2.60 □"

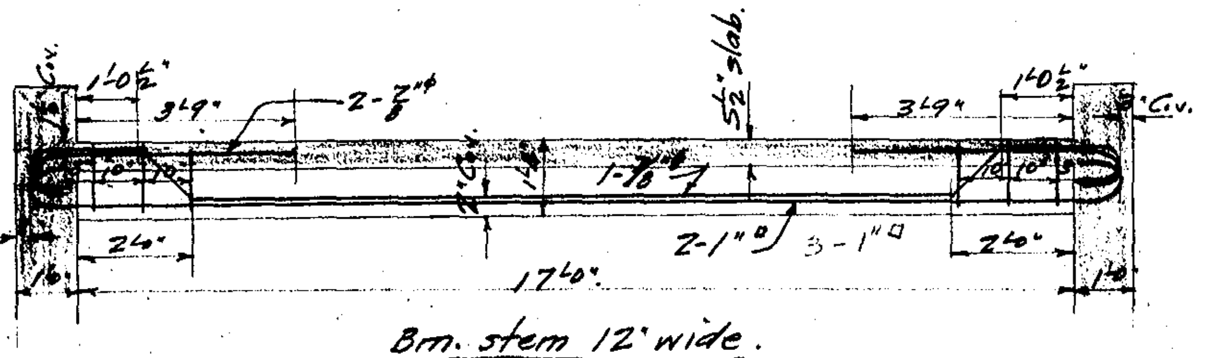
WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 19.

Subject: Pumping Station - Tailrace #10 - Holyoke, Mass.
Computation: Roof
Computed by: E.M.V. Checked by: Date: March 13, 1939.

Roof Beam (Continued from sheet #18).

With 1-$\frac{7}{8}$"φ bar bent up unit bond $= \frac{9600}{2 \times 4.00 + \frac{7}{8} \times 13.5} = 101$ #/□".



Bm. stem 12" wide.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Tailrace #10 - Holyoke, Mass.

Computation: Conduits

Computed by: E.M.V. Checked by: ______ Date: March 15, 1939.

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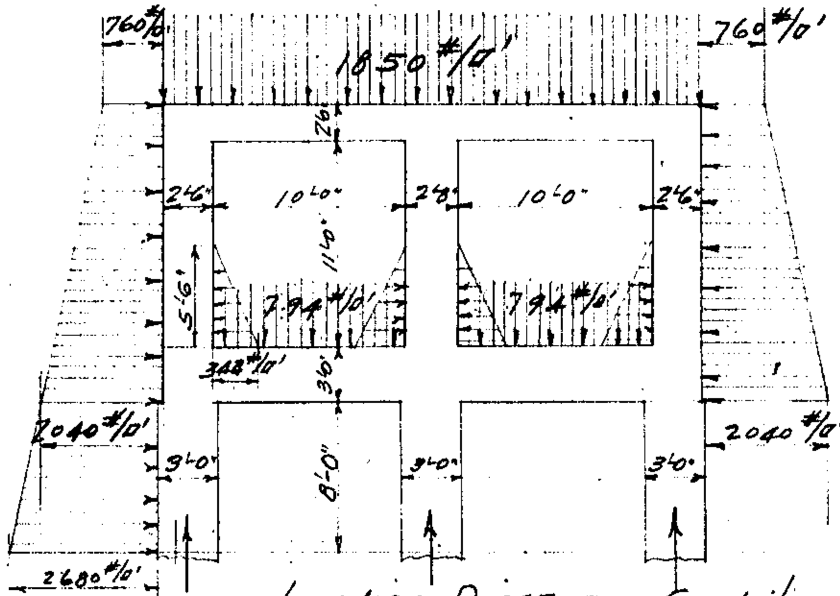


Loading Diagram - Conduits Half Full.

Assumptions -

Top of backfill at Elev. 68.0

Top of conduit at " 54.0

Backfill saturated to Elev. 60.0

Conduits normally half full of water

Wt. of saturated earth = 125# per cu. ft.

" " dry " = 100 " "

No surcharge.

Equivalent liquid pressure for dry earth = 35# per sq. ft.

" " " " sat. " = 80# " "

Subject Tailrace #10
Computation Conduits
Computed by E.M.V. **Checked by** ______ **Date** March 15, 1939.

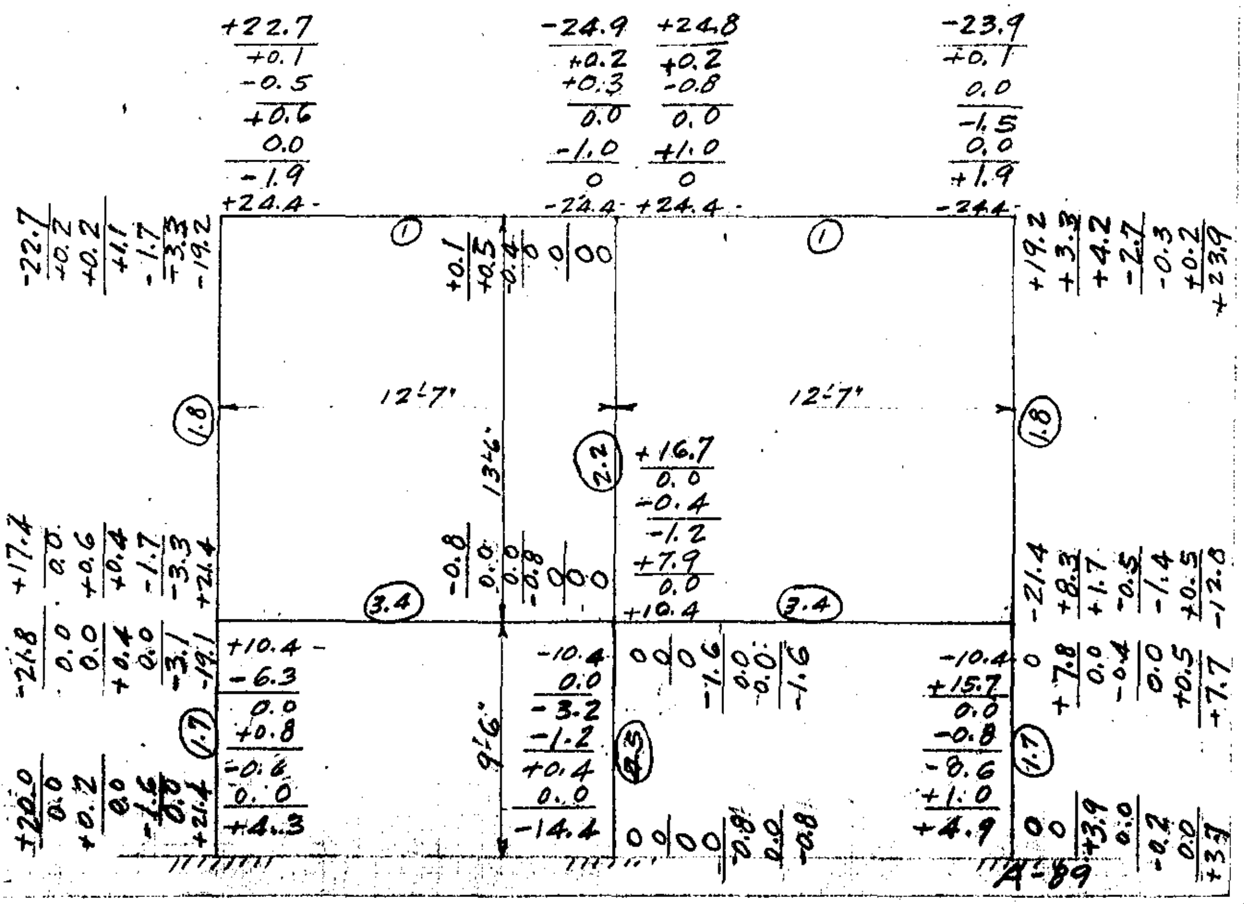
(Continued from sheet #20)

Load on conduit roof –

Dry earth	= 8×100	= 800# per sq. ft.
Sat. "	= 6×125	= 750 " " "
Conc. roof slab		= 300 " " "
		1850# " " "

Earth pressure at top of conduit = 8×35 + 6×80 = 760#/□'

" " " bot. " " = 8×35 + 22×80 = 1560#/□'



Subject Tailrace #10
Computation Conduits
Computed by E.M.V. Checked by ______ Date March 16, 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10528

I for roof slab = $\frac{1}{12} \times 12 \times 24 \times 24 \times 24$ = 13,824$''^4$

l " " " = 151"

$\frac{I}{l}$ " " " = 91.6

I for floor slab = $\frac{1}{12} \times 12 \times 36 \times 36 \times 36$ = 46,700$''^4$

l " " " = 151"

$\frac{I}{l}$ " " " = 309.0

I for sidewalls = $\frac{1}{12} \times 12 \times 30 \times 30 \times 30$ = 27,000$''^4$

l " " = 162"

$\frac{I}{l}$ " " = 166.5

I for footing sidewall = $\frac{1}{12} \times 12 \times 26 \times 26 \times 26$ = 17,600$''^4$

l " " " = 114"

$\frac{I}{l}$ " " " = 154

$\frac{I}{l}$ for roof slab = 91.6 = (1)

$\frac{I}{l}$ " floor " = 309.0 = (3.4)

$\frac{I}{l}$ " sidewalls = 166.5 = (1.8)

$\frac{I}{l}$ " footing sidewall = 183 = (7.7)

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Tailrace #10

Computation: Conduits

Computed by: E.M.V. Checked by: Date: March 16, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10688

I for center wall = $\frac{1}{12} \times 12 \times 32 \times 32 \times 32$ = 32,800"⁴

l " " " = 162"

$\frac{I}{l}$ " " " = 202.

I for center footing wall = $\frac{1}{12} \times 12 \times 36 \times 36 \times 36$ = 46,700"⁴

l " " " " = 114

$\frac{I}{l}$ " " " " = 409

$\frac{I}{l}$ for center wall = (2.2)

$\frac{I}{l}$ " " footing wall = (4.3)

End reactions –

Top slab, left half – $R_L = \dfrac{22{,}700 + 1850(12.58)^2 \times \frac{1}{2} - 24900}{12.6} = 11{,}400^{\#}$

$R_R = \dfrac{24{,}900 + 1850(12.58)^2 \times \frac{1}{2} - 22700}{12.6} = 11{,}800^{\#}$

Top slab, right half – $R_L = 11{,}700^{\#}$

$R_R = 11{,}500^{\#}$

Bot. slab, left half – $R_L = \dfrac{4300 + 794(12.58)^2 \times \frac{1}{2} - 14400}{12.6} = 4{,}200^{\#}$

$R_R = \dfrac{14{,}400 + 794(12.58)^2 \times \frac{1}{2} - 4{,}300}{12.6} = 5{,}800^{\#}$

Bot. slab, right half – $R_L = \dfrac{16700 + 794(12.58)^2 \times \frac{1}{2} + 4900}{12.6} = 6{,}700^{\#}$

$R_R = \dfrac{794(12.58)^2 \times \frac{1}{2} - 4900 - 16700}{12.6} = 3{,}300^{\#}$

Left conduit sidewall, top $R = \dfrac{22{,}700 + 840(13.5)^2 \times \frac{1}{2} + 540 \times 13.5 \times 4.5 - 17400}{13.5}$

$8{,}500^{\#}$

" " " bot. $R = \dfrac{17{,}500 + 840(13.5)^2 \times \frac{1}{2} + 540 \times 13.5 \times 9.0 - 22{,}700}{13.5}$

$= 10{,}100^{\#}$

Right conduit sidewall, top $R = \dfrac{23{,}900 + 840(13.5)^2 \times \frac{1}{2} + 540 \times 13.5 \times 4.5 - 12800}{13.5}$

$= 8900^{\#}$

" " " , bot. $R = \dfrac{12800 + 840(13.5)^2 \times \frac{1}{2} + 540 \times 13.5 \times 9.0 - 23900}{13.5}$

$= 9{,}700^{\#}$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10 - Holyoke, Mass.

Computation: Conduits -

Computed by: E.M.V. Checked by: Date: March 16, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10525

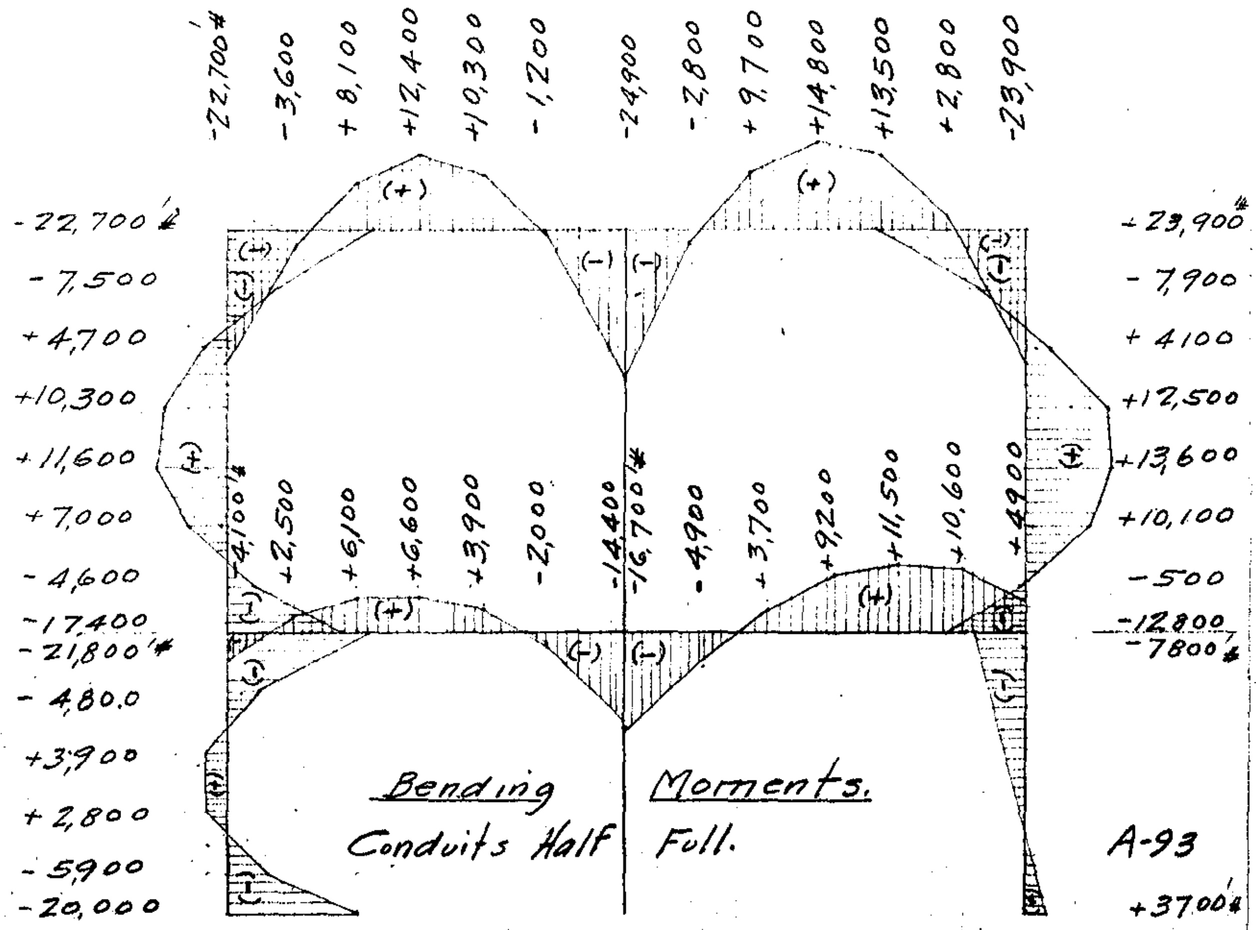
End reaction (Continued from sheet #24)

Left footing sidewall - bot. $R = \frac{20000 + 1920(9.5)^2 \times \frac{1}{2} + 380 \times 9.5 \times 6.3 - 21800}{9.5} = 11300^{\#}$

top $R = \frac{21800 + 1920(9.5)^2 \times \frac{1}{2} + 380 \times 9.5 \times 3.2 - 20000}{9.5} = 10500^{\#}$

Center footing sidewall - horizontal reactions negligible.

Right footing sidewall - bot. $R = \frac{3700 + 7700}{9.5} = 1200^{\#}$; Top $R = 1200^{\#}$



Bending Moments.

Conduits Half Full.

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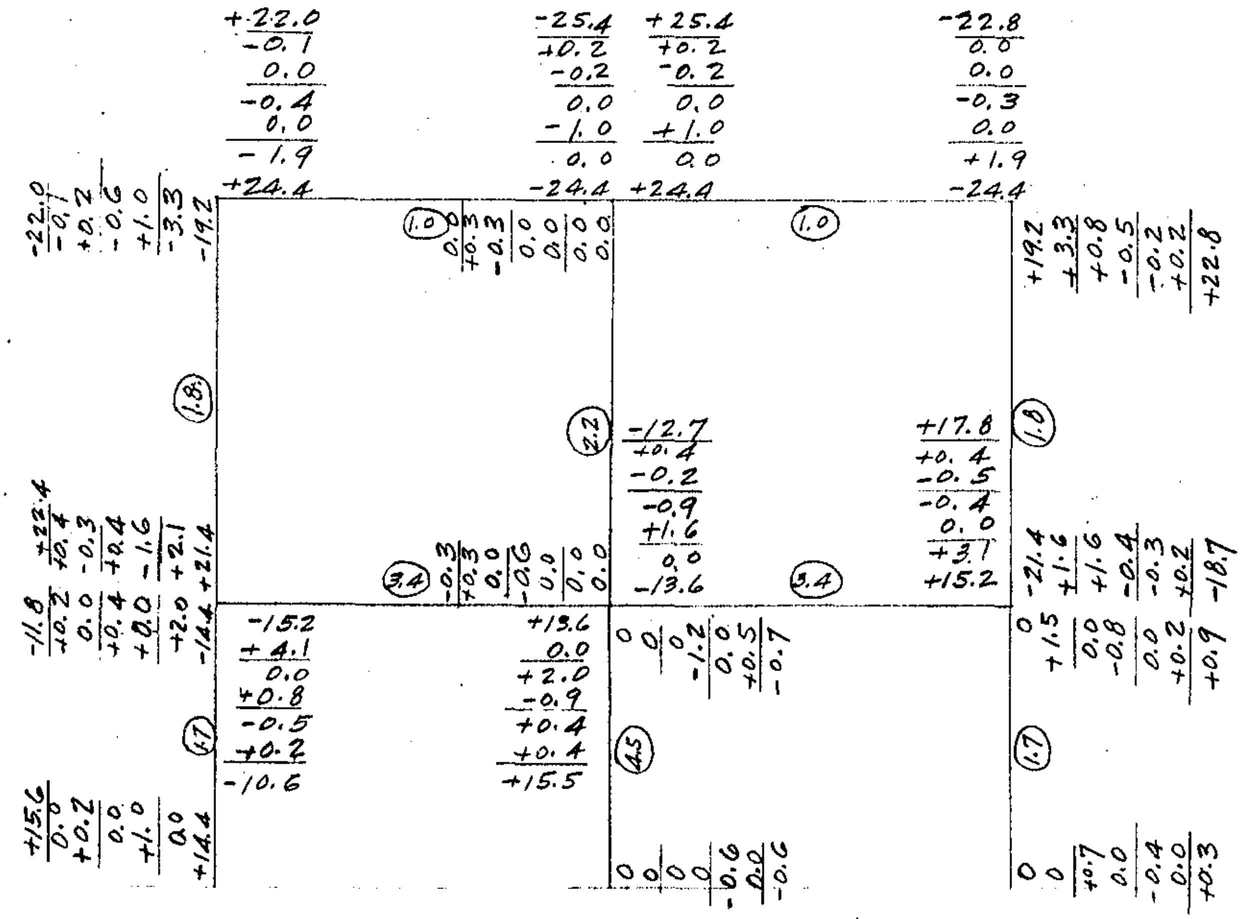
WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

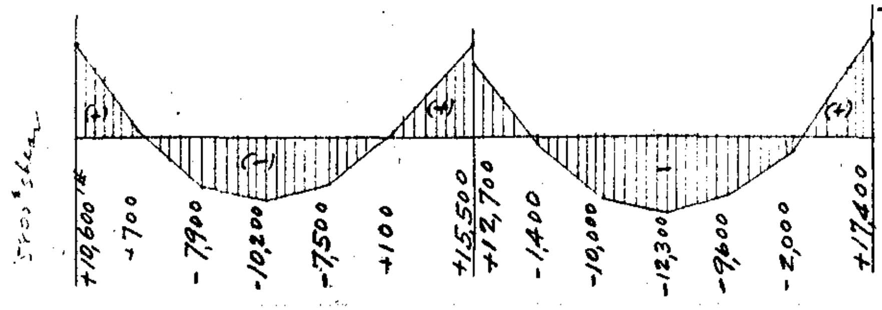
Subject: Tailrace #10 – Holyoke, Mass.

Computation: Conduits With River at Elev. 79.75

Computed by: E.M.Y. Checked by: Date: March 24, 1939.



Moment Distribution Diagram for Max. Hydrostatic Pressure Under Conduit Slabs.



← Bending Mom. Diagram for Bot. Slabs.

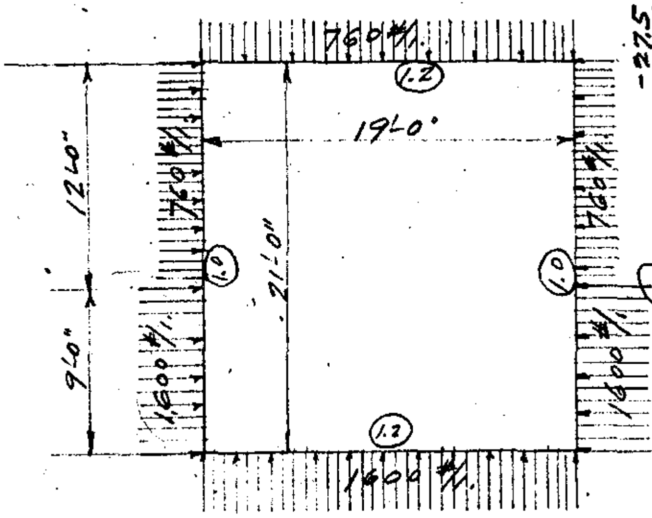
Subject Tailrace #10
Computation Pump Sump Walls - Section Above Sluice Gate
Computed by E.M.V. Checked by ____ Date March 20, 1939

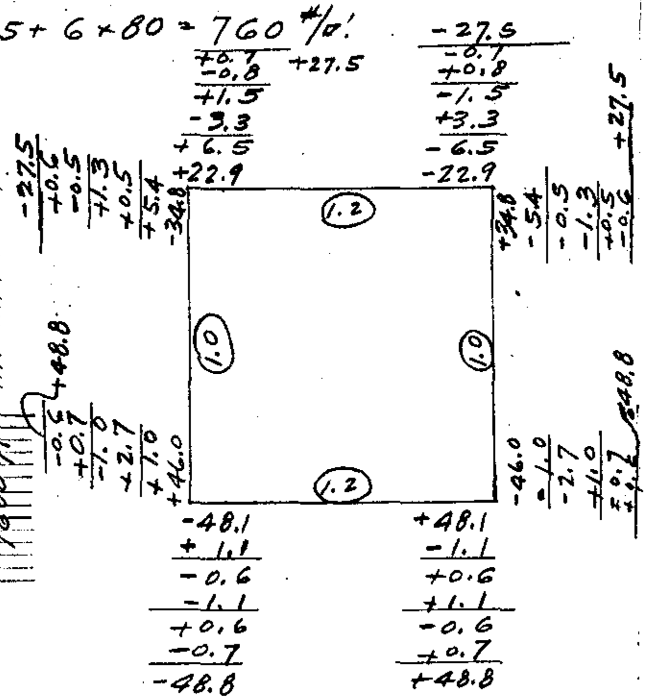
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assumed that at max. high water conduits will run full and elevation of water in sump will be at 52.0. Since the conduit sidewall and sump wall are common to Elev. 54.0 figure moments in sump walls at Elev. 54.0. Neglect the effect of the restraining action of the discharge sluice gate walls.

Max. hydrostatic head = 79.5 - 54.0 = 25.5 ft.
Hydrostatic pressure = 25.5 × 62.5 = 1600# per sq. ft.

Max. earth pressure = 8 × 35 + 6 × 80 = 760 #/□'.
Walls 2'-0" thk.





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — Page 27

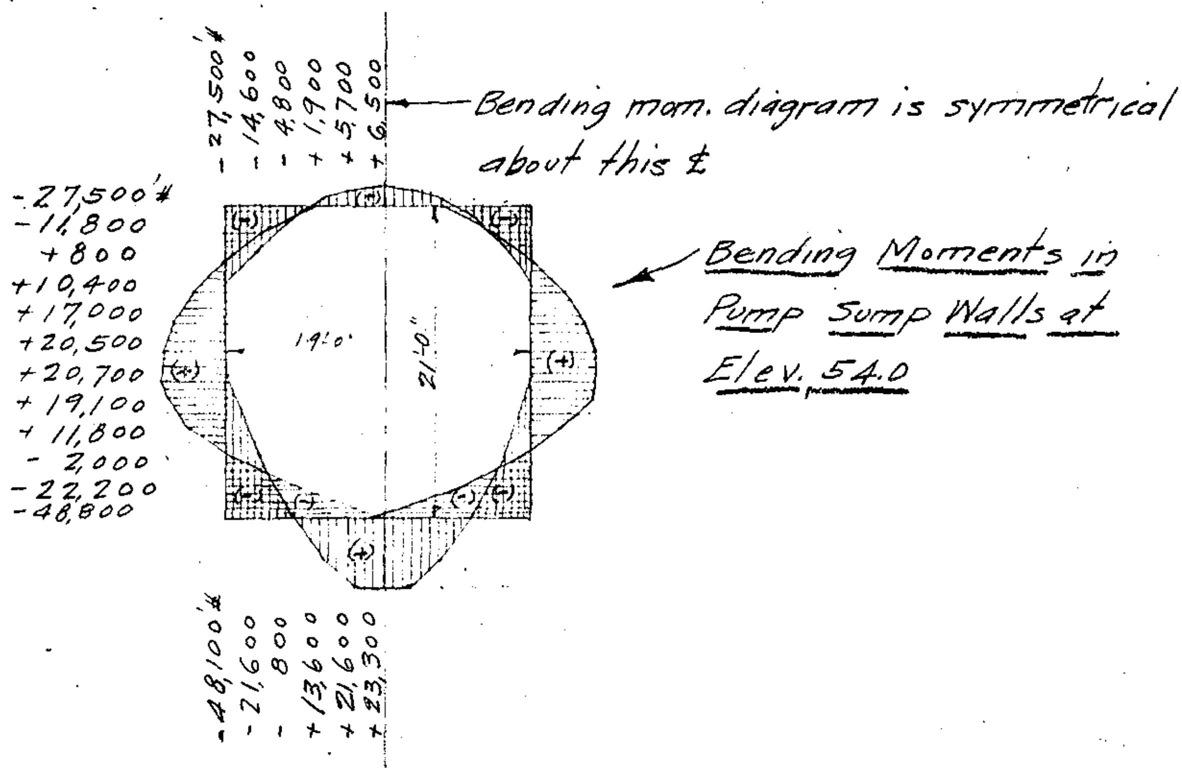
Subject: Tailrace #10

Computation: Pump Sump Walls - Above Sluice Gate

Computed by: E.M.V. Checked by: Date: March 20, 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet # 26)



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 27a.

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Design of Pump Sump Walls - Above Sluice Gate
Computed by: E. M. Y.   Checked by: Date: March 25, 1938.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Wall on River side -

Max. pos. mom. = 23,300'#.

Max. neg. " = 40,200

$d = \sqrt{\frac{40200}{122.8}} = 18.1''$. Effective depth = 20.5"

A_s for pos. mom. = $\frac{23300 \times 12}{\frac{7}{8} \times 20.5 \times 18000} = 0.87^{\square''}$ = 1"φ, 10½" c.c.

A_s for neg. mom. = $\frac{40,200 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 1.50^{\square''}$ = 1"φ, 6" c.c.

Unit shear = $\frac{1600 \times 8.5}{12 \times \frac{7}{8} \times 20.5} = 63.2$ #/□" O.K. with special anchorage.

Unit bond stress = $\frac{1600 \times 8.5}{2 \times 3.14 \times \frac{7}{8} \times 20.5} = 120$ #/□" O.K. " ".

Walls at right ∠s to river -

Max. pos. mom. = 20,700'# = 1"φ, 12" c.c.

" neg. " at river end = 40,200'#. = 1"φ, 6" c.c.

" " " " land " = 22,800'#. = 1"φ, 10½" c.c.

Rear Wall -

Max. pos. mom. = 6,500'# = 5/8"φ, 12" c.c.

" neg. " = 22,800'# = 1"φ, 10½" c.c.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

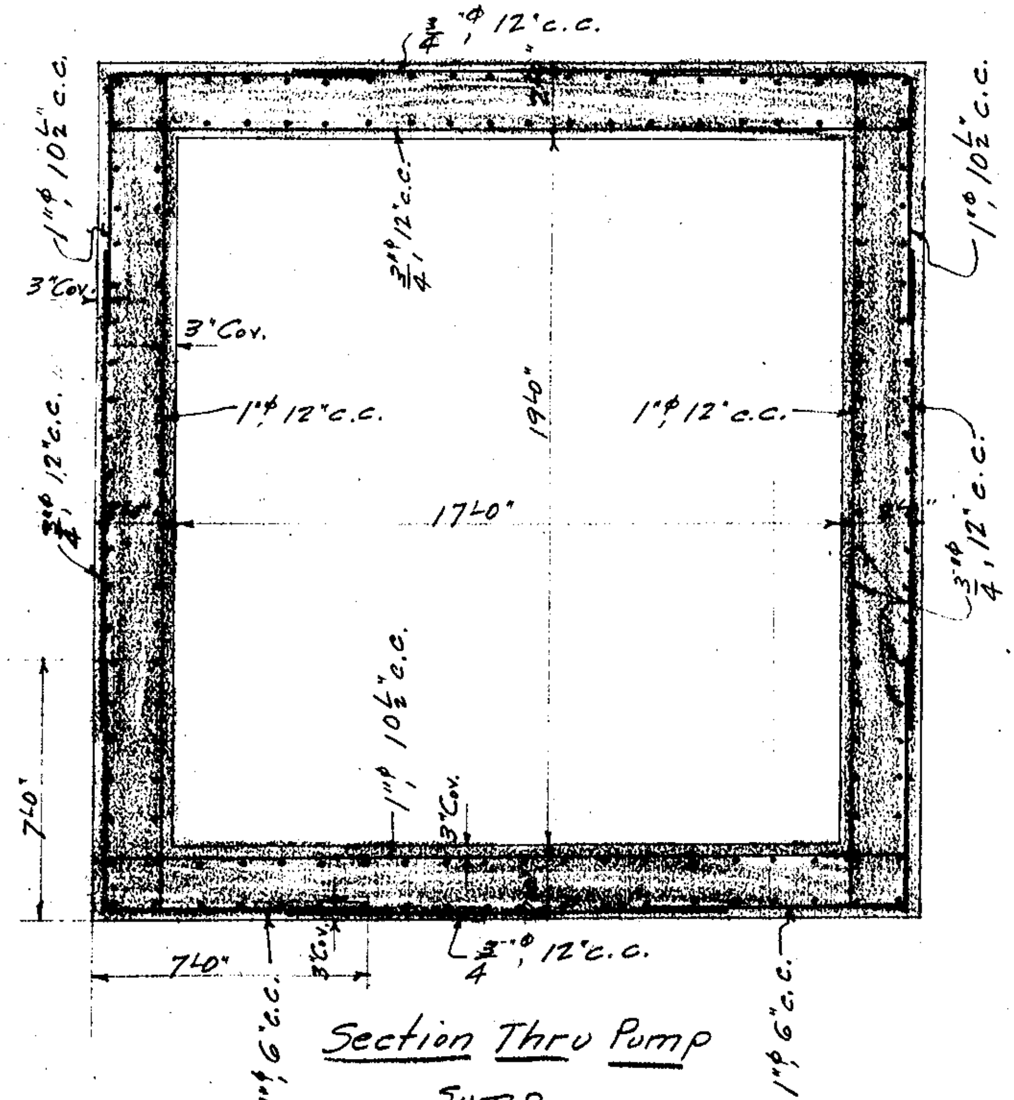
Page 27b.

Subject Tailrace # 10 - Holyoke, Mass.

Computation Pump Sump Walls - Above Sluice Gates

Computed by E.M.V. Checked by ______ Date March 25, 1939.

U. S. GOVERNMENT PRINTING OFFICE 8—10528



Section Thru Pump Sump.

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

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Subject: Tailrace #10.
Computation: Rear Wall at Main Sluice Gates.
Computed by: E.M.V. Checked by: Date: March 21, 1939.

Max. horizontal pressure against wall occurs at Elev. 60.0

Hydrostatic pressure = (79.5 - 60.0) 62.5 = 1218 #/□'

Counter earth pressure = 8 × 35 = 280

Net = 938 #/□'

Effective span = say 10'-9".

Max. pos. mom. = 1/10 × 938 (10.75)² = 10,800'#

" neg. " at middle support = 1/8 × 938 (10.75)² = 13,600'#.

Max. shear = 5/8 × 938 × 10.75 = 6300#.

Depth req'd by mom. = $\sqrt{\frac{10800}{122.7}}$ = 9.4".

" " " shear = $\frac{6300}{\frac{7}{8} \times 60 \times 12}$ = 10" with special anchorage.

Total thickness of 1'-6" (2'-0") is O.K. d = 14.5" - 20.5"

A_s for pos. mom. = $\frac{10,800 \times 12}{\frac{7}{8} \times 14.5 (20.5) \times 18000}$ = 0.57 (0.40) □" = 7/8"φ (3/4"φ) bars 12" c.c. both faces from Elev. 54.0 to Elev. 68.0; 3/4"φ bars 12" c.c. both faces from Elev. 68.0 to top of wall.

A_s for neg. mom. = $\frac{13,600 \times 12}{\frac{7}{8} \times 14.5 (20.5) \times 18000}$ = 0.80 (0.570) □". Add 1/2"φ bars 12" c.c. to steel in outside face only over middle support. Make these bars 10'-0" lg. and run full height of wall.

Unit bond stress = $\frac{6300 \times \frac{0.60}{0.80}}{2.75 (2.35) \times \frac{7}{8} \times 14.5 (20.5)}$ = 135 (112) #/□" at middle support.

Wall 1'-6" (2'-0") thk.

Subject: Tailrace #10
Computation: Front Wall at Main Sluice Gates
Computed by: E.M.V. Checked by: Date: March 21, 1939.

This wall may be subjected to ice pressures applied at elevations which will vary with the river stages.
Assume that the pressure exerted by ice = 1000# per ft. of wall applied at any elevation, and assume further that this pressure will be resisted by a strip of wall 2'-0" deep. Then—

Effective span = 10'-9".
Max. pos. mom. = $\frac{1}{10} \times 500 \times (10.75)^2$ = 5800'#
" neg. " = $\frac{1}{8} \times 500 \times (10.75)^2$ = 7200'#

Wall is 1'-6" thk. d = 14.5"

A_s for positive mom. = $\frac{5800 \times 12}{\frac{7}{8} \times 14.5 \times 18000}$ = 0.305□" = 5/8"φ, 12" c.c.

A_s for negative " = $\frac{7200 \times 12}{\frac{7}{8} \times 14.5 \times 18,000}$ = 0.38□"

Use 5/8"φ bars 12" c.c. in both faces.

Bond stress = $\frac{5/8 \times 500 \times 10.75}{1.94 \times \frac{7}{8} \times 14.5}$ = 149#/□"

Wall 1'-6" thk.

Subject: Tailrace #10
Computation: Beam in Front of Sluice Gate Wall at Elev. ~~76.75~~ 77.00
Computed by: Checked by: Date: March 21, 1939

Beam may be subjected to a horizontal ice load of 1000# per lin. ft.

Span = 10'-9"

Max. pos. mom. $= \frac{1}{10} \times 1000 \times (10.75)^2 = 11,600'\#$

" neg. " $= \frac{1}{8} \times 1000 \times (10.75)^2 = 14,400'\#$

$d = \sqrt{\frac{11,600 \times 12}{122.8 \times 18}} = 7.9"$

$d = \sqrt{\frac{14400 \times 12}{147.5 \times 18}} = 8.1"$

Beam is 12" deep, 8.5" effective.

A_s for pos. mom. $= \frac{11600 \times 12}{\frac{7}{8} \times 8.5 \times 18,000} = 1.03 \square"$

A_s for neg. mom. $= \frac{14,400 \times 12}{\frac{7}{8} \times 8.5 \times 18,000} = 1.28 \square"$

Use 2-5/8"φ bars } rear face full length
2-1/2"φ " }

Use 2-5/8"φ bars full length, } front face.
2-5/8"φ 10'-0" lg. over center support }

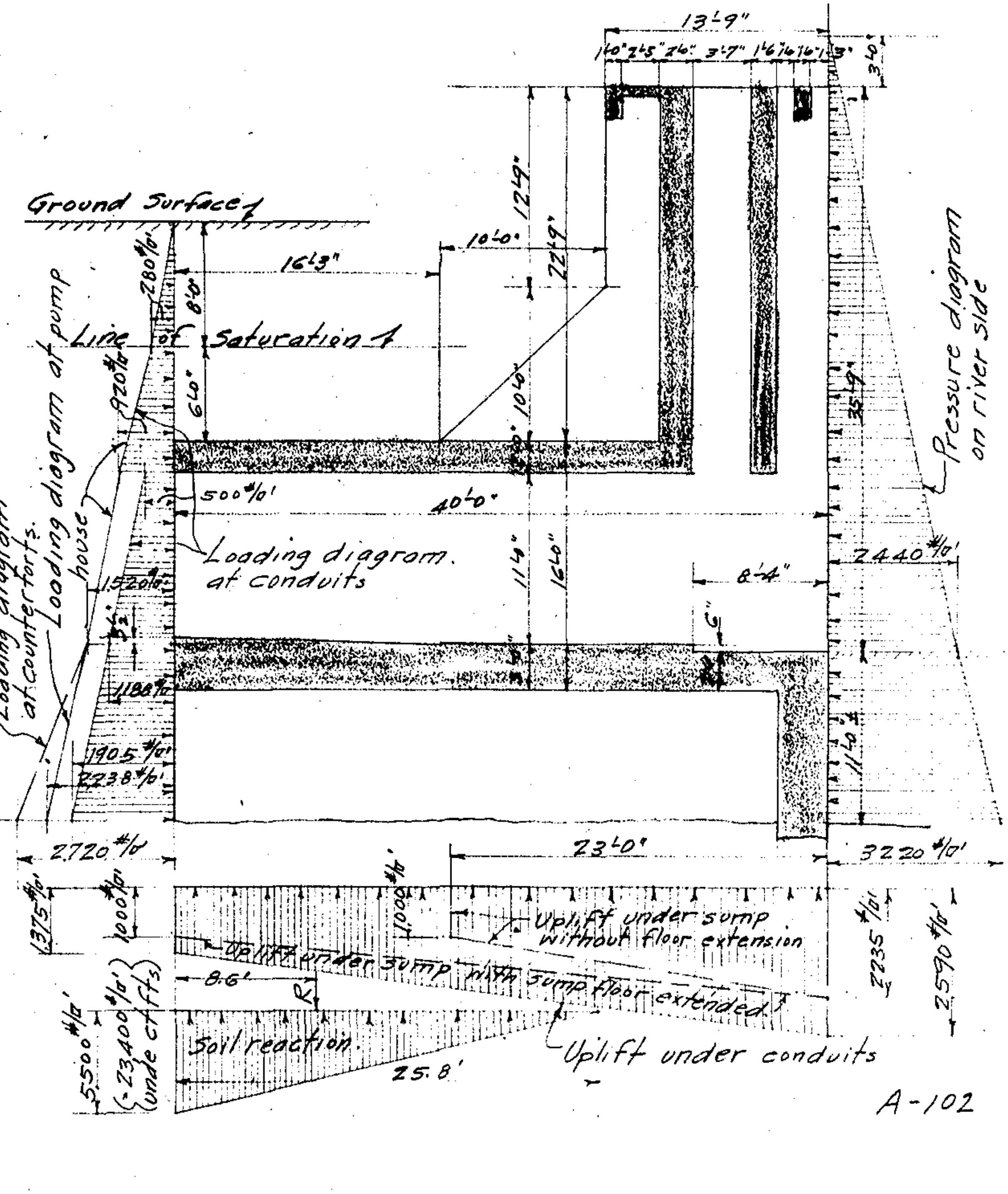
WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10 - Holyoke, Mass.

Computation: Stability of Structure - High Water

Computed by: E.M.V. Checked by: Date: March 21, 1939.



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WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: Date: March 21, 1939.

Weight and Center of Gravity; moments about rear edge.-

No. Pieces	Member	Weight, lbs.	Lever Arm, Ft.	Moment, Ft. Lbs.
3	Conduit Ftg Walls	153,800	18.5	2,842,000
1	Cut-off wall	120,800	38.5	4,650,000
1	Conduit Floor Slab	522,000	20.0	10,440,000
2	" Roof "	184,000	15.4	2,835,000
1	Counterfort Wall	323,800	24.8	8,030,000
1	" "	346,000	24.8	8,580,000
1	Ctft & Sump Wall	415,000	25.9	10,750,000
1	" " " "	608,000	22.6	13,770,000
1	Sump Cut-off Wall	143,600	38.5	5,540,000
1	" Front "	177,500	39.0	6,920,000
1	" Rear "	155,500	18.0	2,800,000
1	Pump House Roof	38,000	28.5	1,082,000
1	" " Floor	62,000	28.5	1,765,000
1	Sump Floor Slab	145,500	28.5	4,130,000
2	Sluice Gate Walls	214,000	33.9	7,250,000
2	" " Walk Bms.	9000	33.3	300,000
1	" " " Slab	3600	29.5	106,000
	Pump Room Machinery	38,000	28.5	1,082,000
		3,660,100		92,872,000

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WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailrace #10.

Computation Stability of Structure - High Water

Computed by E.M.V. Checked by ...... Date March 21, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10526

(Continued from sheet #32)

No. Pieces	Member	Weight, Lbs.	Lever Arm, Ft.	Moment, Ft. Lbs.
1	Sluice Gate in Sump	5,000	22.0	110,000
2	" " " Wall	30,000	32.5	975,000
1	Manhole	42,600	5.7	243,000
	Earth Fill	1241000	15.4	19110000
1	Sump Sluice Gate Wall	49500	24.0	1188,000
		1,368,100		21,626,000
	Brought forward	3660,100		92,872,000
	Totals	5028,200#		114,498,000

Position of center of gravity = $\frac{114,498,000}{5,028,200}$ = 22.8' from rear edge.

Wt. of structure per lin. ft. = $\frac{5,028,200}{49.0}$ = 102,600#

Assume that with the river stage at Elev. 79.5 that conduit will flow full and that water in sump will reach to Elev. 60.0

Wt. of water in conduits = 2 × 11.0 × 10.0 × 40 × 62.5 = 555,000#

" " " " sump = 17 × 19 × 13 × 62.5 = 265,000

" " " " sluice gate wells = 6.3 × 10 × 27.5 × 2 × 62.5 = 216,000

1,036,000#

Subject Tailrace #10 - Holyoke, Mass.
Computation Stability of Structure - High Water
Computed by E. M. V. Checked by ______ Date March 22, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10526

(Continued from sheet #33)

Center of gravity of water in structure -

555,000 × 20.0 = 11,100,000
265,000 × 29.7 = 7,875,000
216,000 × 36.0 = 7,775,000
26,750,000

Center of gravity of water $= \frac{26,750,000}{1,036,000} = 25.8'$ from rear edge.

Wt. of water per lin. ft. of structure $= \frac{1,036,000}{49.0} = 21,200^{\#}$

{ Position of horizontal resultant on land side below Elev. 68.0

280 × 8 × ½ × 49.0 × 5.33 = 54900 × 5.33 = 293,000
280 × 8.0 × 49.0 × 12.00 = 110,000 × 12.00 = 1,320,000
640 × 8.0 × ½ × 49.0 × 13.33 = 125,300 × 13.33 = 1,670,000
500 × 22.5 × 10.0 × 2.0 × 27.25 = 224,500 × 27.75 = 6,235,000
1405 × 22.5 × ½ × 10.0 × 2.0 × 31.00 = 316,200 × 31.00 = 9,820,000
920 × 11.0 × 19.0 × 21.5 = 192,000 × 21.50 = 4,125,000
600 × ½ × 11.0 × 19.0 × 23.33 = 62,700 × 23.33 = 1,460,000
1520 × 11.5 × 19.0 × 32.75 = 332,000 × 32.75 = 10,890,000
718 × 11.5 × ½ × 19.0 × 34.67 = 78,500 × 34.67 = 2,720,000
920 × 22.5 × 10.0 × 27.25 = 206,300 × 27.25 = 5,630,000
1800 × ½ × 22.5 × 10.0 × 31.00 = 202,000 × 31.00 = 6,270,000
207 × ½ × 9.0 × 37.0 × 36.00 = 34,400 × 36.00 = 1,239,000
1,930,800 51,672,000

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: ______ Date: March 22, 1939.

(Continued from sheet # 34)

Position of horizontal resultant on land side

$= \frac{51,672,000}{1,938,800} = 26.7'$ below Elev. 68.0

Magnitude of horizontal resultant on land side = 1,938,800#

Magnitude of horizontal resultant on land side per ft. of structure $= \frac{1,938,800}{49.0} = 39,600$#

Position of horizontal resultant on water side below Elev. 68.0 -

$\frac{1}{2} \times 2440 \times 39.0 \times 14.50 = 47,500 \times 14.50 = 690,000$

$2440 \times 11.0 \times 33.0 = 26,800 \times 33.00 = 886,000$

$\frac{1}{2} \times 880 \times 11.0 \times 34.83 = 4800 \times 34.83 = 169,000$

Totals: 79,100 — 1,754,000

Position of horizontal resultant on water side

$= \frac{1,754,000}{79,100} = 22.2'$ below Elev. 68.0.

Magnitude of horizontal resultant on water side = 79,100# per ft. of structure.

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Magnitude of hydrostatic uplift under entire structure

$= \frac{1}{2}(1375+2590)\,40 \times 32 + \frac{1}{2}(1000+2235)\,23 \times 16.5 = 3,149,000$#

Position of uplift resultant:

$1375 \times 32 \times 40 \times 20.0 = 35,200,000$

$\frac{1}{2} \times 1215 \times 32 \times 40 \times 26.6 = 20,600,000$

$1000 \times 23 \times 16.5 \times 28.5 = 10,800,000$

$\frac{1}{2} \times 1235 \times 23 \times 16.5 \times 32.3 = 7,560,000$

Total: 84,160,000

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Stability of Structure. - High Water
Computed by: E.M.V. Checked by: Date: March 22, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10525

(Continued from sheet #35)

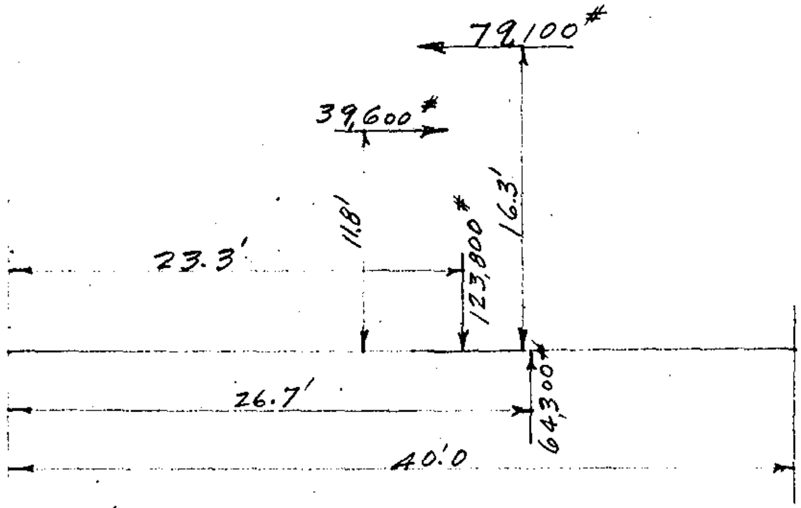
$\frac{84,160,000}{3,149,000} = 26.7'$. Hydrostatic uplift per ft. $= \frac{3,149,000}{49} = 64,300^{\#}$

Magnitude of downward loads per lin. ft. of structure

$= 102,600 + 21,200 = 123,800^{\#}$

Position of resultant for downward loads

$= 22.8 + \frac{21,200 \times 3.0}{123,800} = 23.3'$ to right of rear edge.



Load on foundation—

39,600 × 11.8 =	467,500	
79,100 × 16.3 =		1,290,000
123,800 × 3.3 =	409,000	
64300 × 6.7 =		431,000

$\Sigma M = 853500'^{\#}$ ←

$\Sigma V = 59,500^{\#}$ ↓

$\Sigma H = 39,500^{\#}$ ←

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: Date: March 23, 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #36).

Eccentricity $= \frac{853500}{59,500} = 14.3'$

Max. pressure $= \frac{59500 \times 2}{3(20.0-14.3)} = 7,000$ # per sq. ft.

Max. pressure under vert. foundation walls

$= \frac{7000 \times 49}{11.7} = 29,300$ # per sq. ft.

To reduce the max. foundation pressure continue sump floor slab to rear edge of structure and place earth fill on top of this slab, then -

Additional load $= 17.0 \times 16.5 \times 3.0 \times 150 = 126,300$ #
$17.0 \times 17.0 \times 13.0 \times 125 = 469,000$
$17.0 \times 17.0 \times 8.0 \times 100 = 231000$
$17.0 \times 6.0 \times 6.0 \times 125 = 76,400$
$17.0 \times 6.0 \times 8.0 \times 100 = 81,700$
$984,400$ #

Revised c.g. $= \frac{114,498,000 + 984,400 \times 8.5}{5,028,200 + 984,400} = 20.4'$ from rear edge.

Wt. of structure per ft. $= \frac{6,012,600}{49.0} = 122,800$ #

Downward load per ft. of structure $= 122,800 + 21,200$
$= 144,000$ #.

Position of resultant for downwards
$= 20.4 + \frac{21200 \times 5.4}{144,000} = 21.2'$ to right of rear edge.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailrace #10 - Holyoke, Mass.
Computation Stability of Structure - High Water
Computed by E.M.V. **Checked by** ______ **Date** March 23, 1939.

(Continued from sheet #37)

Uplift = 1375×32×40 = 1,755,000#
½×1215×32×40 = 775,000
1000×16.5×40 = 640,000
½×1235×16.5×40 = 408,000
Total Uplift = 3,578,000# = 73,000# per ft. of structure.

Position of uplif resultant-

1755,000×20.0 = 35,100,000
775,000×26.7 = 20,700,000
640,000×20.0 = 12,800,000
408,000×26.7 = 10,900,000
79,500,000

$\frac{79,500,000}{3,578,000}$ = 22.2' to right of rear edge.

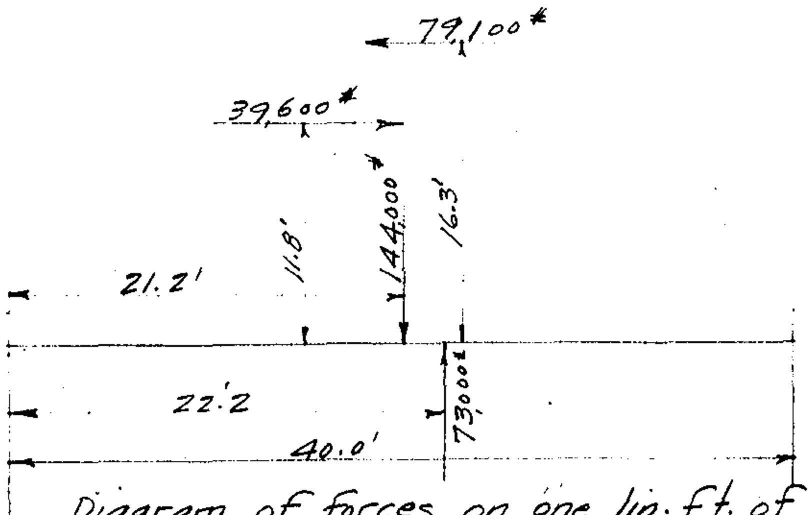


Diagram of forces on one lin. ft. of the structure with river at Elev. 79.75

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Subject: Tailrace #10 - Holyoke, Mass.
Computation: Stability of Structure - High Water
Computed by: E.M.V. Checked by: Date: March 23, 1939

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(Continued from sheet #38)

Load on foundation -

39,600 × 11.8 =	467,500	
79,100 × 16.3 =		1,290,000
144,000 × 1.2 =	173,000	
73,000 × 2.2 =		160,500

$\Sigma M = 810,500'^{\#}$

$\Sigma V = 71,000^{\#}$

$\Sigma H = 39,600^{\#}$

Eccentricity $= \frac{810,500}{71,000} = 11.4'$

Max. pressure under foundation walls

$= \frac{71,000 \times 2}{3(20.0 - 11.4)} \times \frac{49}{11.7} = 23,400^{\#}/\square'$

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WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10 - Holyoke, Mass.

Computation: Design of Counterforts - High Water

Computed by: E.M.V. Checked by: Date: March 23, 1939.

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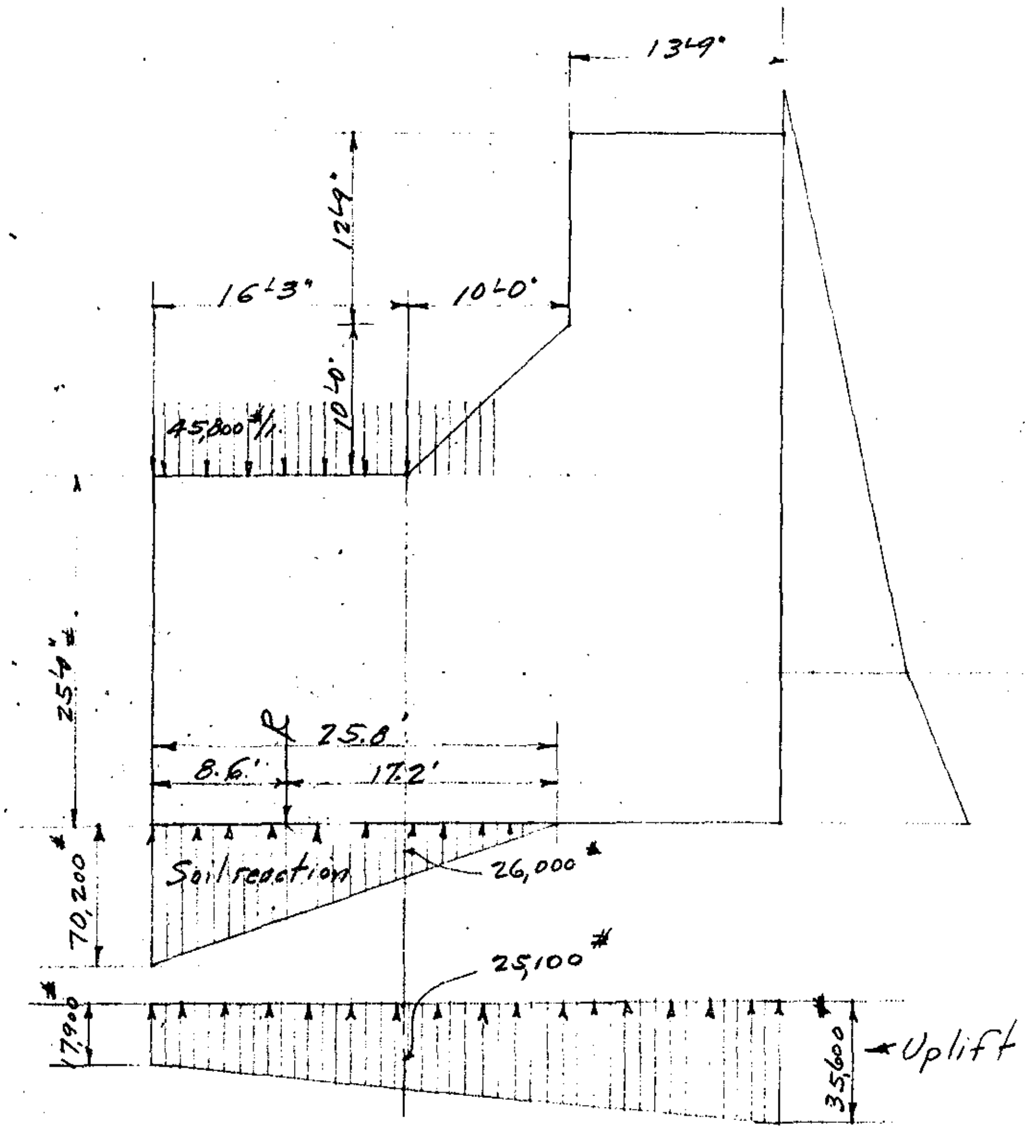

Loading Diagram on Base of Counterforts at Max. High Water

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Design of Counterforts - High Water
Computed by: E.M.V. Checked by: Date: March 23, 1939.

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(Continued from sheet #40)

M at base of fillet -

$26{,}000 \times (16.25)^2 \times \frac{1}{2} = 3{,}350{,}000'^{\#}$

$\frac{1}{2} \times 44{,}200 \times 16.25 \times 10.83 = 3{,}890{,}000$

$17{,}900 \times (16.25)^2 \times \frac{1}{2} = 2{,}360{,}000$

$\frac{1}{2} \times 7200 \times 16.25 \times 5.42 = 316{,}000$

$9{,}916{,}000$

Deduct $45{,}800 (16.25)^2 \times \frac{1}{2} = 6{,}040{,}000$

Net M = $3{,}876{,}000'^{\#}$.

$d = \sqrt{\frac{3{,}876{,}000 \times 12}{122.8 \times 32}} = 108''$. Depth is O.K. = 300".

$A_s = \frac{38.76\cancel{000} \times 12}{\frac{7}{8} \times 3\cancel{00} \times 18{,}\cancel{000}} = 9.85 \square''$. Tr 8-$1\frac{1}{8}''\square$ bars = $10.0\square''$

Unit shear = $\frac{\left[\frac{1}{2}(17{,}900 + 25{,}100 + 70{,}200 + 26{,}000) - 45{,}800\right] 16.25}{\frac{7}{8} \times 32 \times 300}$

$= \frac{23{,}800 \times 16.25}{\frac{7}{8} \times 32 \times 300} = 46^{\#}/\square''$. O.K.

Unit bond stress $= \frac{23{,}800 \times 16.25}{8 \times 4.5 \times \frac{7}{8} \times 300} = 41^{\#}/\square''$ O.K.

<u>Use 8-$1\frac{1}{8}''\square$ bars in bot. of wall full length.</u>

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Subject: Tailrace #10 - Holyoke, Mass.

Computation: Design of Counterforts - Low Water

Computed by: E.M.V. Checked by: Date: March 23, 1939.

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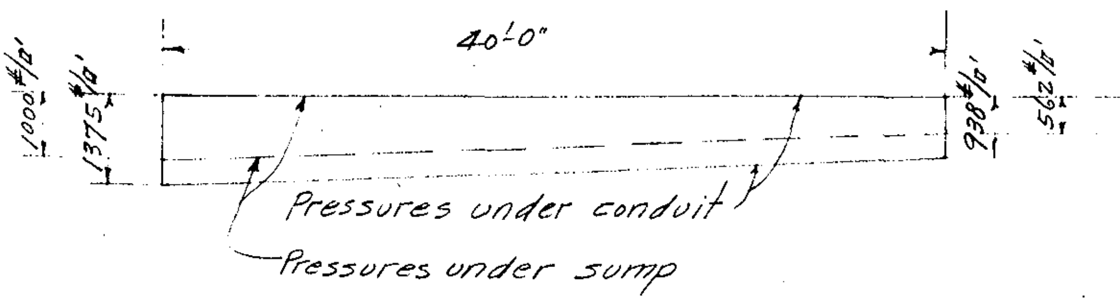
(Continued from sheet #41)

Assume the river to be at Elev. 53.0 and tail water at Elev. 60.0, then the hydrostatic pressure on the base will be as shown —



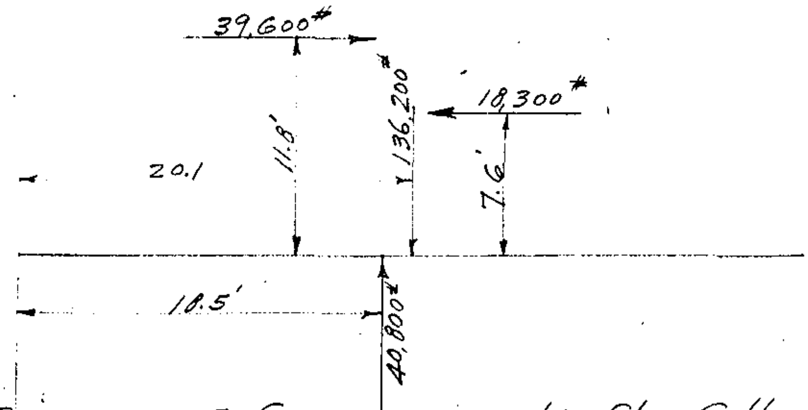


Diagram of forces on one lin. ft. of the structure with the river at Elev. 53.0

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Tailrace #10 - Holyoke, Mass.

Computation: Design of Counterforts - Low Water

Computed by: E.M.V. Checked by: .... Date: March 24, 1939.

(Continued from sheet #42)

Load on foundation -

		↻	↺
39,600 × 11.8	=	467,500	
18,300 × 7.6	=		139,000
136,200 × 0.1	=	13,600	
40,800 × 1.6	=	65,300	

ΣM = 407,400'# ↻

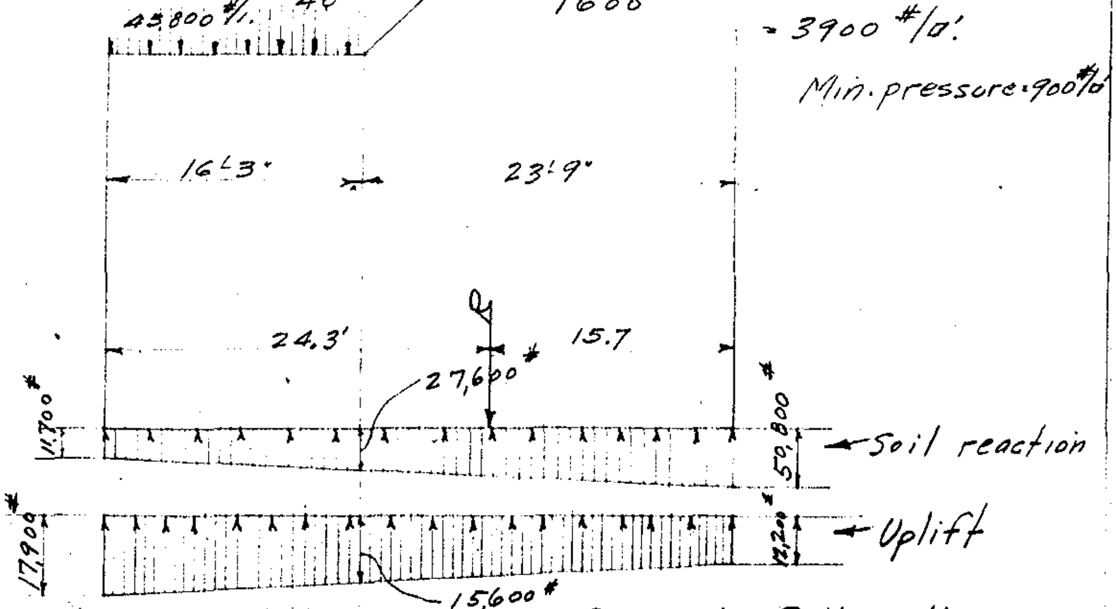
ΣV = 95,600#

ΣH = 21,300#

Eccentricity = $\frac{407400}{95600}$ = 4.3'

Max. pressure = $\frac{95600}{40} + \frac{95,600 \times 4.3 \times 6}{1600}$ = 2400 + 1500 = 3900 #/□'

Min. pressure = 900#/□'



Loading Diagram on Base of Counterforts with River at Elev. 53.0

(Continued from sheet # 43).

M at base of fillet –

$11,700 \times (16.25)^2 \times \frac{1}{2}$	= 1,540,000 '#
$\frac{1}{2} \times 1,5900 \times 16.25 \times 5.42$	= 700,000
$15,600 \times (16.25)^2 \times \frac{1}{2}$	= 2,100,000
$\frac{1}{2} \times 2300 \times 16.25 \times 10.83$	= 202000
	4,542000 '#
Deduct $45,800 (16.25)^2 \times \frac{1}{2}$	= 6,040,000
Net M	= 1,498,000 '#.

$A_s = \frac{1,498,000 \times 12}{\frac{7}{8} \times 300 \times 18,000} = 3.81 \square''$

Use 4-1"□ bars in wall at top of conduits.

Moment in upper 12'-9' of wall due to hydrostatic pressure.

$M = \frac{1}{2} \times 1000 \times 16.0 \times 5.3 \times 13.0 = 552,000$ '#.

Assumed effective depth = 150"

$A_s = \frac{552,000 \times 12}{\frac{7}{8} \times 150 \times 18,000} = 2.81 \square''$.

Use 5-$\frac{7}{8}$"ϕ bars @ 0.60 = 3.00□" spaced equally around curved nosings.

Subject: Tailrace #10 - Holyoke, Mass.
Computation: Design of Conduits.
Computed by: E.M.V. Checked by: Date: March 24, 1939

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Roof Slabs—

Max. pos. mom. = 14,800'#

Max. neg. mom. = -20,000'#

Max. shear = 9300#

$d = \sqrt{\frac{14800}{122.8}} = 10.8"$; $d = \sqrt{\frac{20,000}{147.5}} = 11.6"$ d = 20.5" O.K.

Unit shear = $\frac{9300}{\frac{7}{8} \times 12 \times 20.5} = 43.2$ #/□" O.K.

A_s for pos. mom. = $\frac{14,800 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.55$ □" = 3/4"φ bars 9" c.c.

" " neg. mom. = $\frac{20,000 \times 12}{\frac{7}{8} \times 20.5 \times 18,000} = 0.74$ □" = 3/4"φ bars 7" c.c.

Bond stress = $\frac{9,300}{1.7 \times 2.35 \times \frac{7}{8} \times 20.5} = 129$ #/□" O.K.

Floor Slabs-

Max. pos. mom. = 11,500'# at center; 11,600'# at ends.

" neg. " = 12,300'# " " ; 12,900'# " "

Max. shear = 6,600#

$A_s = \frac{12,900 \times 12}{\frac{7}{8} \times 31.5 \times 18,000} = 0.31$ □" = 5/8"φ, 12" c.c.

Use 3/4"φ bars 10" c.c. top and bot.

Subject Tailrace #10- Holyoke, Mass.
Computation Design of Conduits.
Computed by E. M. V. Checked by Date March 24, 1939.
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(Continued from sheet #45)

Sidewalls -

Max. pos. mom. = 13,600'#

" neg. " = 19,700'#.

" shear = 7,600#

A_s for pos. mom. $= \frac{13600 \times 12}{\frac{7}{8} \times 26.5 \times 18{,}000} = 0.39 \square''$ = ¾"φ 12"c.c.

A_s for neg. mom. $= \frac{19{,}700 \times 12}{\frac{7}{8} \times 26.5 \times 18{,}000} = 0.57 \square''$ = ¾"φ 9"c.c.

Sump. Floor slab Extension -

Slab 3'-0" thk; effective span = 19'-6".

Wt. of slab 450#/'

Saturated earth 13×125 = 1625

Dry earth 8×100 = 800

Total = 2,875#per lin. ft.

$R_L = R_R = 2875 \times 8.25 = 23{,}600^{\#}$

$M = \frac{1}{8} \times 2875 \times \overline{19.5}^2 = 136{,}200'^{\#}$

$d = \sqrt{\frac{136200}{122.8}} = 33.2''$ Make d = 30.5"

$A_s = \frac{136{,}200 \times 12}{\frac{7}{8} \times 30.5 \times 18000} = 3.41 \square''$ - 1⅛"□ bars 4½" c.c. in bot.

Bond stress $= \frac{23{,}600}{2.67 \times 4.5 \times \frac{7}{8} \times 30.5} = 73.5^{\#}/\square''$

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Unit shear $= \frac{23600}{12 \times \frac{7}{8} \times 30.5} = 73.7^{\#}/\square''$ O.K. with special anchorage.

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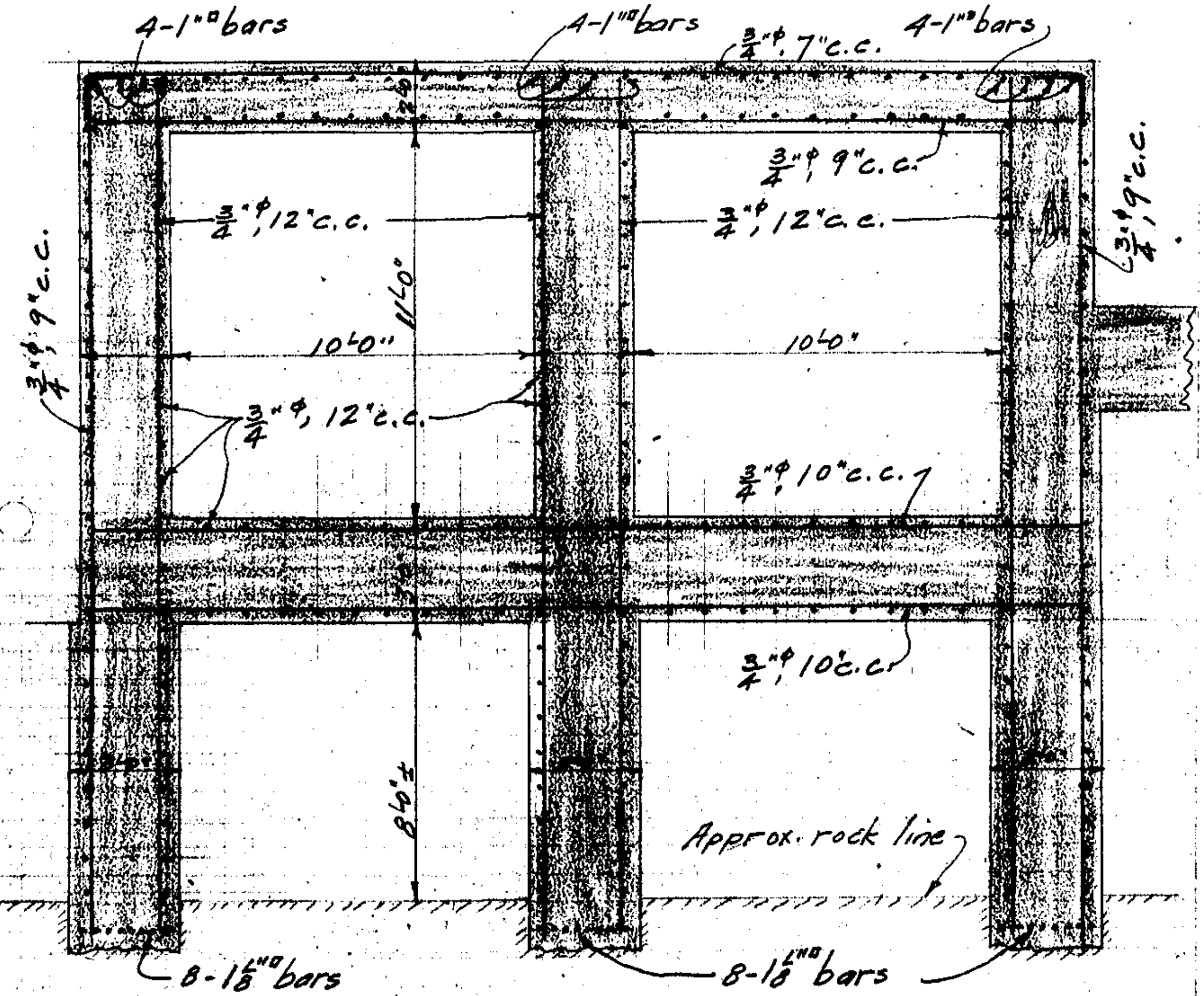
Subject: Tailrace #10 - Holyoke, Mass.

Computation

Computed by: E. M. V. Checked by Date: March 24, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10328



Section Thru Conduits

Note:- For extension of bot. slab of conduits to face of the gate structure use 3/4"φ, 4"c.c. top and bot.

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Subject: Tailrace #10 - Holyoke, Mass.

Computation: Desig of Sump Floor Slab

Computed by: E. M. V. Checked by ________ Date: March 25, 1939.

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(Continued from sheet #46)

Sump Floor slab —

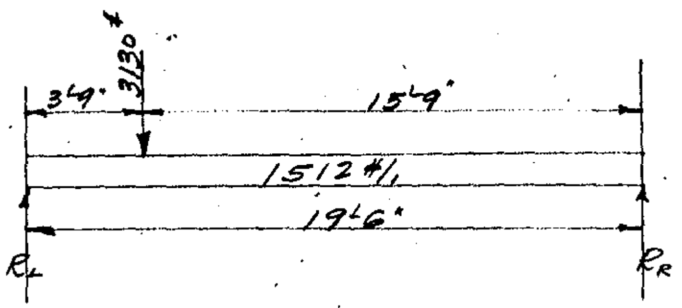
slab 3'-0' thk; effective span = 19'-6".

Wt. of slab 450 #/□'

Wt. of water = 17 × 62.5 = 1062 #/□'

} = 1512 #/□'.

Wt. of sluice gate sump wall = 1.50 × 150 × 21 − 1.5 × 62.5 × 17 = 3130 #/'



$R_L = \frac{1512 \times 9.75 + 3130 \times 15.75}{19.5} = 17{,}200\#$

$R_R = 15{,}300\#$.

$M = 15300 \times 10 \times \frac{1}{2} = 76{,}500'\#$.

$A_s = \frac{76{,}500 \times 12}{\frac{7}{8} \times 30.5 \times 18{,}000} = 1.91\square'' = 1\frac{1}{8}''\square$ bars 8" c.c.

Use $1\frac{1}{8}''\square$, 8" c.c. in bot.

" $1\frac{1}{8}''\square$, 10" c.c. in top.

WAR DEPARTMENT

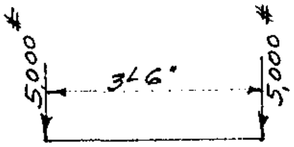
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Tailrace #10- Holyoke, Mass.

Computation Crane Bms.

Computed by E.M.V. **Checked by** ______ **Date** March 27, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10588



Crane Wheel Concentrations

Span = 10'-0".

Assume 1-8"WF @ 31# $\frac{l}{b} = \frac{120}{8} = 15$

" rail @ 25

D.L. = 56# per lin. ft.

D.L. Mom. = $\frac{1}{8} \times 56 \times (10.0)^2$ = 700'#

L.L. " = $10,000 \frac{(4.12)^2}{10}$ = 17,000

Impact @ 25% = 4300

Total = 22,000'#.

Mom. due to side thrust = $400 \frac{(4.12)^2}{10} = 680$ '#.

Unit stress due to vert. loads + impact = $\frac{22,000 \times 12}{27.4}$ = 9630#/□".

" " " " side thrust = $\frac{680 \times 12}{4.6}$ = 1770

11,400 #/□".

Try 1-8"WF @ 24#. $\frac{l}{b} = 18.5$ Allowable stress = 17,100#/□".

Unit stress due to vert. loads plus impact = $\frac{22,000 \times 12}{20.8}$ = 12,670#/□".

" " " " side thrust = $\frac{680 \times 12}{2.8}$ = 2920

15590#/□".

O.K.

Use 1-8"WF 24# for crane bms.

(or 1-12"WF 40# full length)

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