STRUCTURAL CALCULATIONS

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PROJECT: UNIVERSITY DRIVE BRIDGE
MESA, ARIZONA

CLIENT: FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
3335 WEST DURANGO
PHOENIX, ARIZONA 85008

Registered Professional Engineer (Structural)
CERTIFICATE NO. 5153
ERNEST M. PLUMMER
Date Signed 1/82
ARIZONA, U.S.A.

JANUARY 1984

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A121.802

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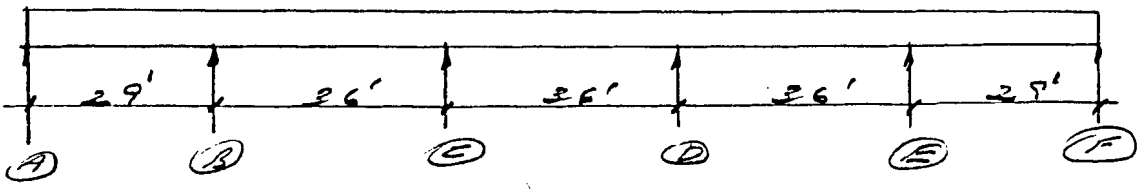
SHEET NO. 1 OF
BY EMP DATE 10/8/83
JOB NO. 423 CHECKED SH 1.5.84

univ. Bridge



Basis For Design:

Loading HS20-16 & Interstate Ldg.
25#/' For Future wearing surface
use 30% Impact
Haunches neglected in Dist of Stiffness.

DL

Assume 18" slab $t = \frac{18}{12} \times 150 = 225$ #/'
Future w/s $= \frac{25}{250}$ #/'

use 5 span Influence Lines $\sim \frac{36}{29} = 1.24$
use 1 : 1.2 ~~

(+) $M_{AB} = 0.0710 \times 250$ #/' $\times \overline{29}^2 = 14.93$ 'K
(−) $M_B = 0.1224 \times 250 \times \overline{29}^2 = 25.73$
(+) $M_{BC} = 0.0590 \times 250 \times \overline{29}^2 = 12.40$
(−) $M_C = 0.1196 \times 250 \times \overline{29}^2 = 25.14$

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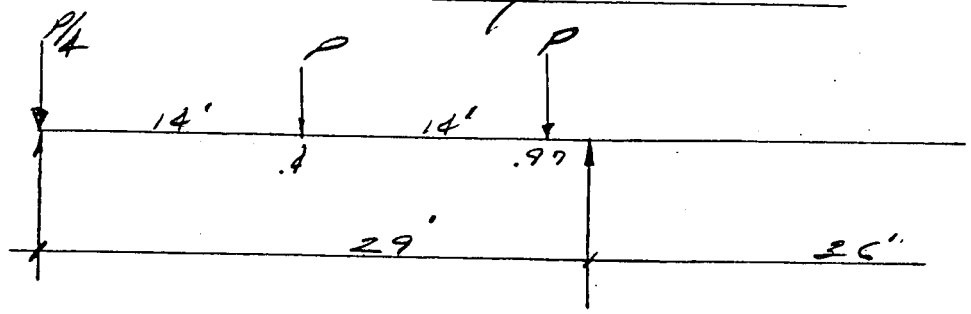
LL

E = 4 + 0.06 S
E = 4 + 0.06 × 29 = 5.74' Dist.

Truck Ldg. w = $\frac{16^k}{5.74'}$ = 2.79 k/'
Interstate Ldg w = $\frac{12^k}{5.74}$ = 2.09 k/'

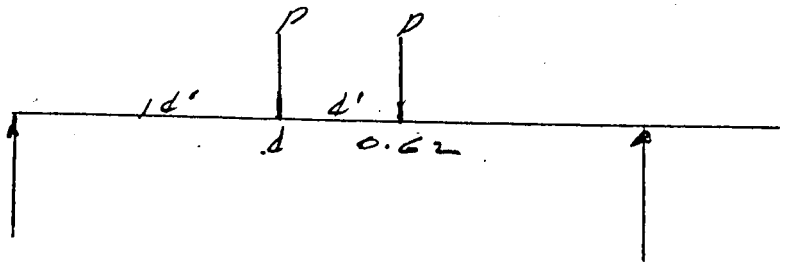
Pos. LL Mom Span #1



P @ 0.4 = 0.2070
P @ .97 = 0.0069
0.2139

M = 0.2139 × 16^k × 1.3 × 29' = 129.0
Mom ft. of slab = $\frac{129'^k}{5.74}$ = 22.47 'k/'

ck for Interstate Ldg.

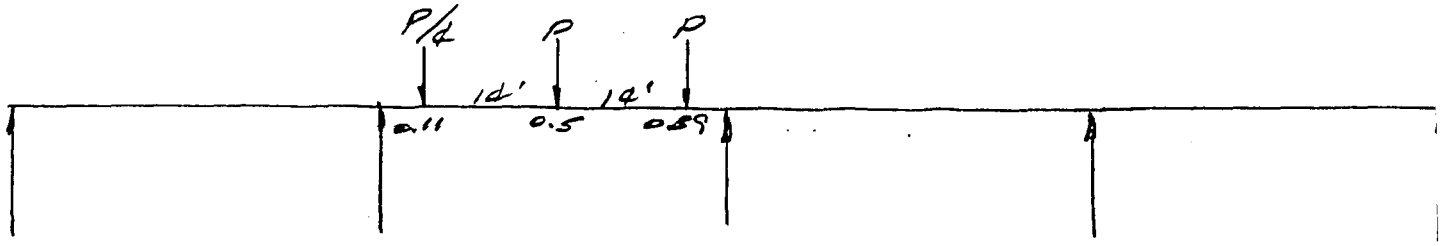


P = 0.4 = 0.2070
P @ 0.62 = 0.1149
0.3219

M = 0.3219 × 12^k × 1.3 × 26 = 130.5
Mom/ft of slab = $\frac{130.5}{5.74}$ = 22.75 'k/'

Pos. Mom. @ 0.5 pt span #2

Truck Ldg.



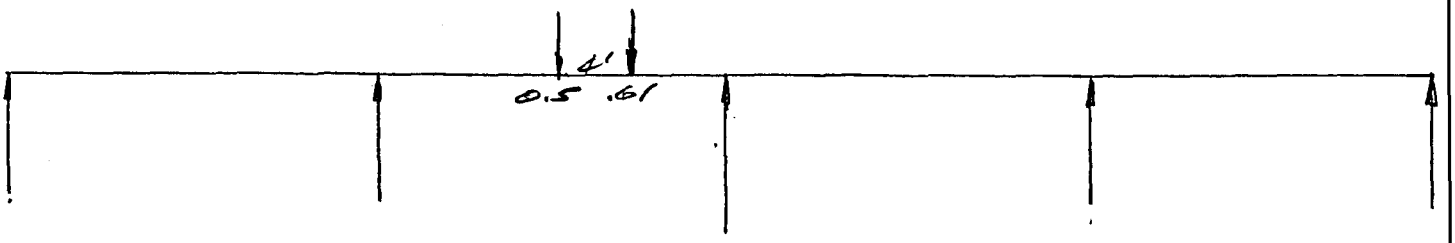
Mom @ 0.5

P @ 0.5 = 0.2042
P @ 0.81 = 0.0555
P/4 @ 0.19 = 0.0138
0.2735

M = 0.2735 × 16^k × 1.3 × 29' = 164.9'

Mom/ft. of slab = 164.9'^k / 5.74 = 28.7'^k

Interstate Ldg.



Mom @ 0.5:

P @ 0.5 = 0.2042
P @ 0.61 = 0.1433
0.3475

Mom = 0.3475 × 12^k × 1.3 × 29' = 157.2'^k

Mom/ft. of slab = 157.2 / 5.74 = 27.39'^k

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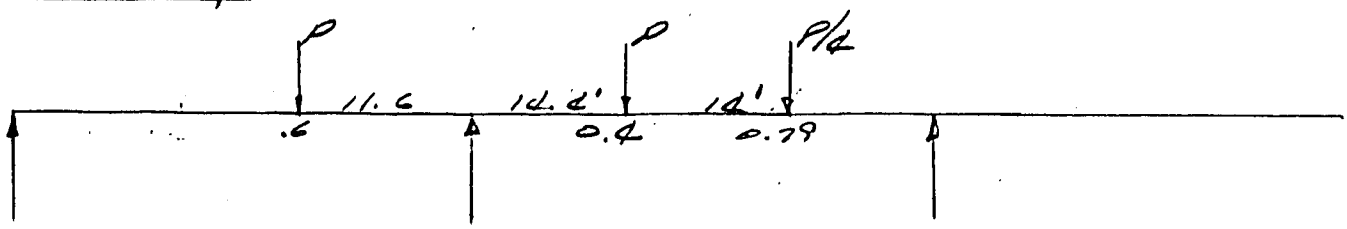
Neg. Mom. @ Pier #1

Truck Ldg



Neg Mom @ Pier:

P @ 0.6 = 0.0942
P @ 0.4 = 0.1038
P/4 @ 0.79 = 0.0107
0.2087

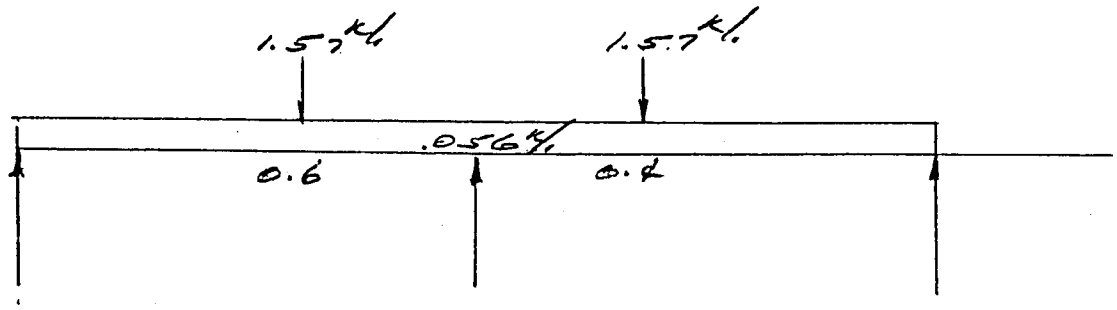
M = 0.2087 × 16^k × 1.3 × 29' = 125.9'^k/'

Mom/ft. of slab = 125.9 / 5.74 = 21.9'^k/'

Lane Ldg.

For w, E = 2 × 5.74 = 11.48 w = 0.640^k/ft / 11.48 = .056^k/'

P = 18^k / 11.48 = 1.57^k/'



Neg Mom @ Pier:

w - Span #1 = 0.0613
- #2 = 0.0775
- #4 = 0.0045
0.1433

M = 0.1433 × .056^k/' × 29^2 × 1.3 = 8.8

Conc P @ 0.6 = .0942
0.4 = .1038
0.1980

M = 0.198 × 1.57 × 29' × 1.3 = 11.7
20.5

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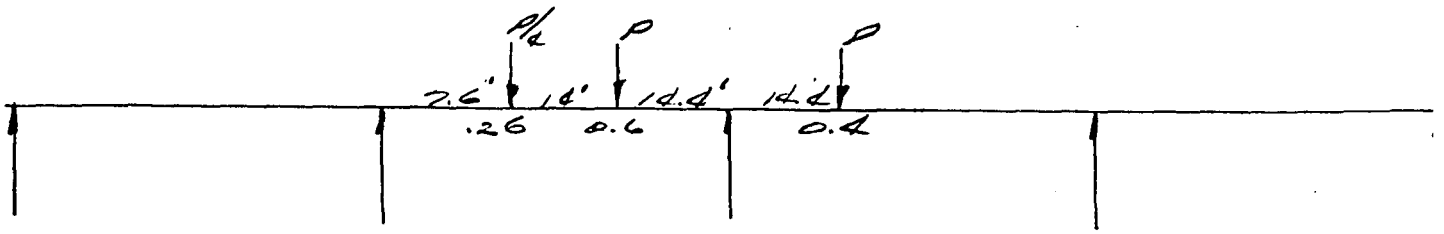
Ck. Ctr. Pier for Neg. Mom.



Neg. Mom @ Pier #2:

P @ 0.6 = 0.1016
P @ 0.40 = 0.1016
P/2 @ 0.26 = 0.0130
0.2162

M = 0.2162 × 16^k × 1.3 × 29' = 130.4'
w = 130.4 / 5.74 = 22.72'^k
Max Neg. Mom.

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Max Pos. Mom –

Span #1 (LL+I) = 22.75'k
DL = 14.93
37.68'k

Neg. Mom 2nd Pier –
(LL+I) = 22.72
DL = 25.73
48.45'k

Pos. Mom Span #2 =
(LL+I) = 28.70'k
DL = 12.40
41.10'k

For balanced Design

$d = \left(\frac{M}{K}\right)^{1/2} = \left(\frac{48480}{194}\right)^{1/2} = 15.8''$
$+ 1.5$
$17.3''$ D = 17½"

For f'_c = 3,000 psi
f_y = 40,000 psi

(+) $A_s = \frac{41.10'^k \times 12}{.875 \times 20 \times 16.0} = 1.76$ use #10 @ 8½" Bott

(–) $A_s = \frac{48.48'^k \times 12}{.875 \times 20 \times 19.0} = 1.75$ use #10 @ 8½ Top

Dist Stl. = $\frac{100}{\sqrt{36}} = 0.166 \times 1.76 = 0.290''$/'

use #5 @ 12"

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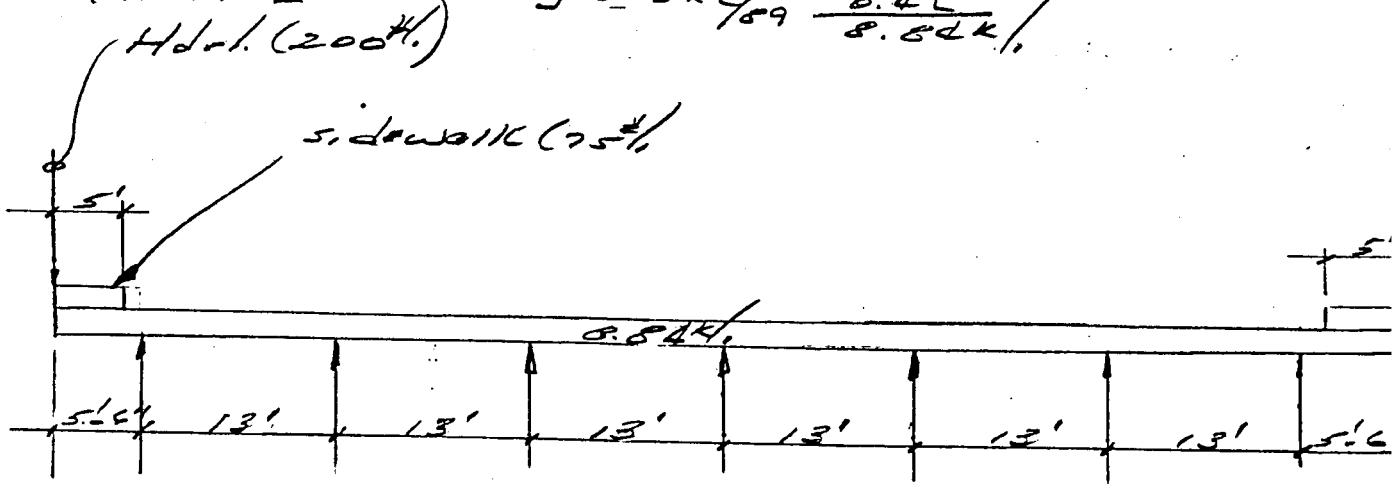
Pier Bm. Design

DL

Slab = 219#/□' × (29+36'/2) = 7.12 k/'
W.S = 25 × — = 0.81
Bm = 6.5/12 × 2 × 150#/' = 0.16
Haunch = 6.5'/12 × 4'/2 × 2 × 150 = 0.33
Sidewalk & Hdrl [200+75#/'×5] × 32.5' × 2/89' = 0.42
8.84 k/'



Cant Mom. = 8.84 k/' × 5.5²/2 = 133.71 'k
Hdrl = 200#/' × 5.5' = 1.10
Sidewalk = 75#/' × 5' × 3' = 1.13
135.94 'k

FEM = 8.84 k/' × 13²/12 = 124.5 'k

	1.0	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
-135.9	+124.5	-124.5	+124.5	-124.5	+124.5				
	+11.4								
	+135.9	+5.7							
		-2.8	-2.8						
		+121.7	-121.7	-1.4	0				
				+0.7	+0.7				
				-125.2	+125.2				

V
ΔL
ΣV
R OL

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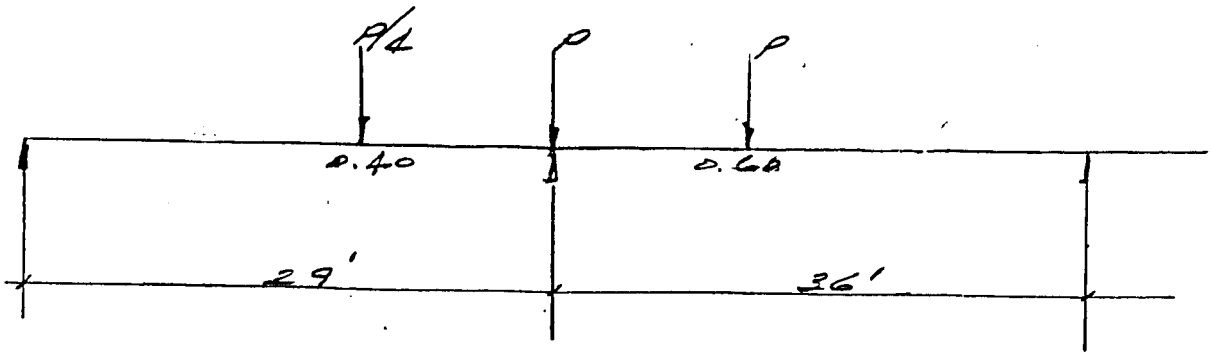
LL to Pier

$\alpha = 24.419°$



Ld to Pier:

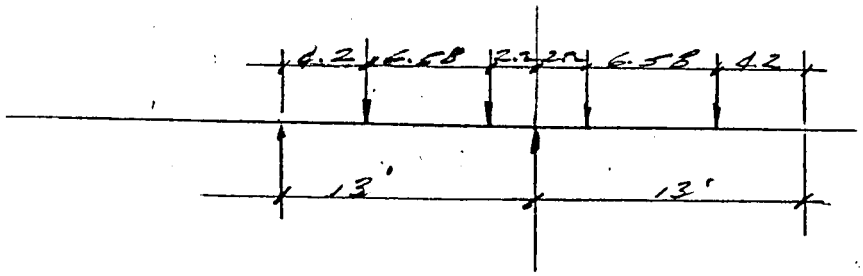
P @ Pier = 1.0000
P @ 0.40 = 0.6000
P/4 @ 0.60 = 0.1500
1.750

Mom Corr. For Lds

P = ΔM/L with P/4 @ 0.60 = .0235/29' = 0.0081
P = — — P @ 0.40 = 0.1038/29' = 0.0036
0.0117

ΣP = 1.750 × 32^k × 4 Loads = 224.0^k
ΔM/L = .0117 × 224.0 × 29' = 76.0
300.0 ← ΣP

P/wheel = 300/8 × 1.3 = 48.8^k



$\frac{a}{L} = \frac{4.2}{13} = 0.32$ FEM = $48.8^k \times \frac{.1483}{.0696} \times 13' = 94.1'^k/44.2$

$\frac{a}{L} = \frac{10.78}{13} = 0.83$ FEM = $48.8^k \times \frac{0.0238}{.1172} \times 13 = 15.1'^k/74.3$

109.2/118.5

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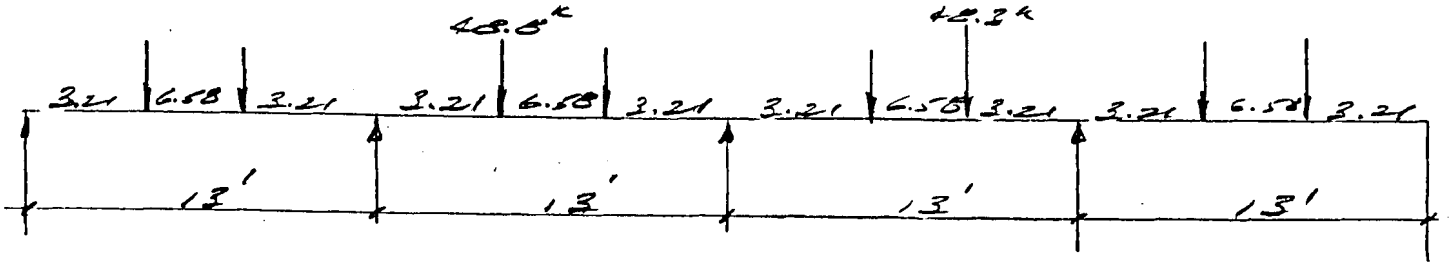
½	½	½	½	½	½	½	½	½
		0	+109.2	+118.5	+118.5	-109.2	0	
		-54.6	-54.6	0	0	+54.6	+54.6	
				-27.3	+27.3			
				0	0			
				-145.8	+145.8			



$\frac{a}{L} = \frac{3.21}{13} = 0.25$ FEM $= \frac{0.1408}{.0468} \times 48.8 \times 13' = 89.3^{'k} / 29.7^{'k}$

1.0	½	½	½	½	½	½	½	½
-118.9	+118.9	-118.9	+118.9	-118.9	+118.9	-118.9		
+118.9	0	0						
	+59.5							
	-27.7	-27.5						
			-13.8					
-13.8			+6.9	+6.9				
+13.8			+112.0	-112.0				
0					+3.5			
	+6.9				-1.8	-1.8		
	-3.5	-3.5			+120.7	-120.7		
	+149.9	-149.9						

Max LL Mom Neg. = 149.9 145.8
" DL Mom Neg. = 125.2 118.7
275.1'k 264.5

Max

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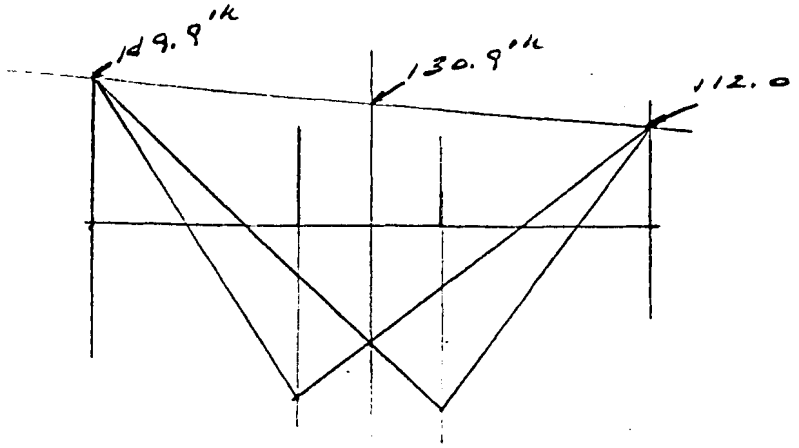
Max Pos. Mom -



LL SBM = $48.8^k \times \frac{3.21 \times 9.79}{13}$ = $117.9 \times \frac{6.5}{9.79}$ = 78.3'k

× 2

156.6

(-) 130.9

25.7'k LL

DL SBM = $8.84 \times 13^2/8$ = $186.7 + \left(\frac{129.7 - 115.9}{13}\right)$ → 187.7 DL

213.4

Neg As = $\frac{275.1'^k \times 12}{0.875 \times 20 \times 19}$ = 9.93 □" use 8 #10 in 2 Rows

Shear to Bm.

LL = 6.58' 6.42'

$48.8^k + 48.8 \times \frac{6.42}{13}$ = 72.9k

$\Delta M/L = \left(\frac{149.9 - 112.0}{13}\right)$ = 2.9

75.8

DL = 8.43 k/' × 13'/2 = 54.8

130.6'k

$v = \frac{130{,}600}{.875 \times 30 \times 19}$ = 261.8 #/□"

#5 Dble Stirrups use 6 @ 4" Bal. @ 12" to ℄

$S = \frac{0.31 \times 8 \times 20 \times .875 \times 19}{(261.3 - 75)}$ = 4.43"

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SHEET NO. 11 OF
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Substructure Design

1. Superstructure Loads

A. DL to Piers.

Deck = 8.84 k/' × 89' = 786.7 k
W.S.
etc

B. DL to Abut –

slab = 219 #/' × 29'/2 = 3175 #/'

W.S. = 25 #/' × – = 363

Bm = 7.5" × 24/12 × 150 = 2250

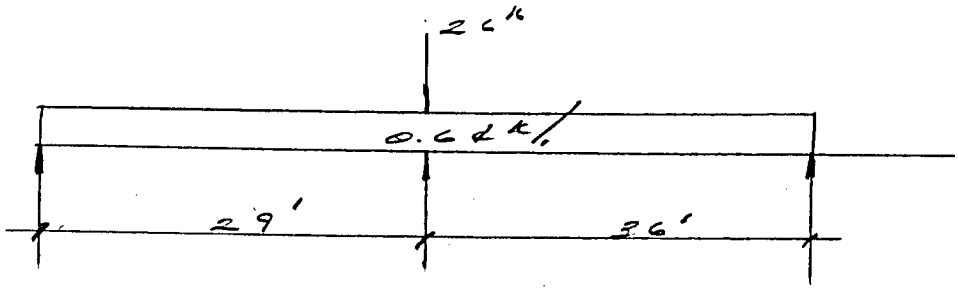
Sidewalk, Hdrl.

[200 #/' + 75 #/' × 5] 2 × 29'/2 / 89 = 188

5976 #/' × 89' = 531.8 k

2. LL to Piers.

1. Lane Ldg



Span #1 Loaded – ΔM/L = .067/29' = .0023

P = 0.0023 × 0.64 k/' × 29²/2 = 1.23 k

0.64 k/' × (36' + 29'/2) = 20.80

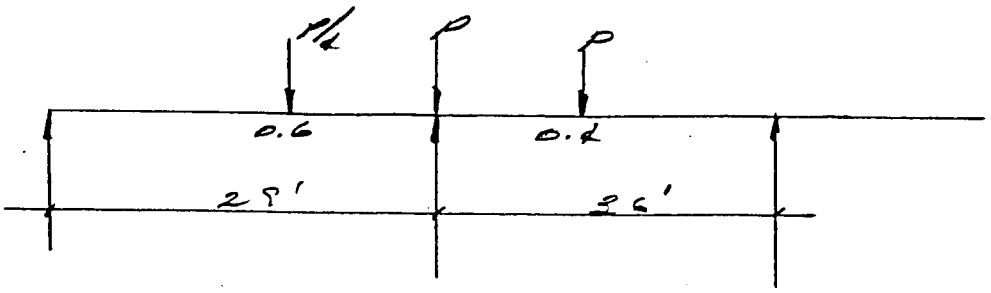
P = 26.00

48.03

× 4 Lanes

192.12 k

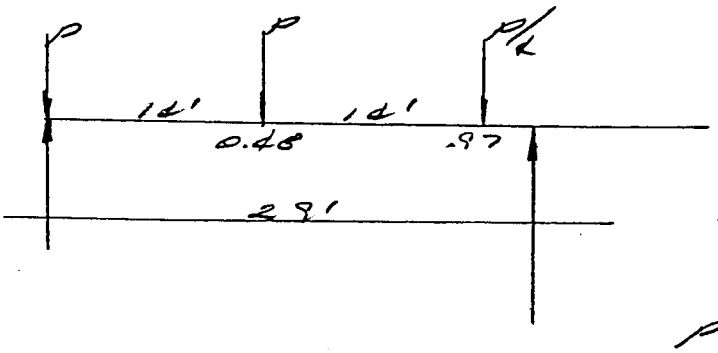
Truck Ldg.



LL to Pier: P = 1.000 P
P @ 0.4 = 0.600
P/2 @ 0.6 = 0.15
1.75 P

P = 1.75 × 32^k × 4 Lanes = 224^k
ΔM/L = .0117 × 224.0 × 29 = 76
300^k ← Max

3. LL to Abut.



P @ Abut = 1.0000
P @ 0.48 = 0.5200
P/2 @ 0.97 = .03/2 = 0.008
1.528

P = 1.528 × 32^k × 4 = 195.6^k

P = ΔM/L w/P @ 0.48 = .0896
P − w/P/2 @ 0.97 = .0009
.0905/29' = .0031

P = ΔML = .0031 × 195.6 × 29' = 17.58^k

∴ R = 195.6 − 17.6 = 178.0^k

4. Wind on superstructure: Skew = 24° 25' 10"

24.4194°
$\sin\alpha = 0.4134$
$\cos\alpha = 0.9105$
$\tan\alpha = 0.4540$

A. Transv. –

H'drl. = 2.0'
Curb = 1.0
DK = 1.5
4.5'

$P = 4.5' \times 50^{\#/\square'} \times \left(\frac{29' + 36'}{2}\right) = 7.31^k$

$P_\perp = 7.31^k \times \overset{.4134}{\sin\alpha} = \underline{3.02^k}$ ←

$P_{\parallel} = 7.31^k \times \overset{0.9105}{\cos\alpha} = \underline{6.66^k}$ ←

B. Long. wind –

$P = 0.012^{k/\square'} \times 4.5 \times \left(\frac{\overset{32.5}{29' + 36'}}{2}\right) = 1.76^k$

$P_\perp = 1.76^k \times \overset{0.9105}{\cos\alpha} = \underline{1.60^k}$

$P_{\parallel} = 1.76^k \times \overset{0.4134}{\sin\alpha} = \underline{0.73}$

C. Net Wind Force

$P_\perp = 3.02^k + 1.60^k = \underline{4.62^k}$ ←

$P_{\parallel} = 6.66 - 0.73 = \underline{5.93^k}$ ←

5. Long. Force

LL = $640^{\#/\square'} \times 32.5' \times 4$ Lanes = 83.2^k
$18^k \times$ – = 72.0
155.2^k

LF = $155.2^k \times 0.05 = 7.76^k$

$P_\perp = 7.76^k \times \overset{.9105}{\cos\alpha} = \underline{7.07^k}$ ←

$P_{\parallel} = 7.76^k \times \overset{0.4134}{\sin\alpha} = \underline{3.21^k}$ ←

6. Seismic Forces:

Σ slab, bm, H'drl + sidewalk = 8.84k/' x 89' = 786.8k

$V = 786.8^k \times .06 = 47.2^k$

Transv. Loads

$P_\perp = 47.2^k \times \overset{0.4134}{\sin\alpha} = \underline{19.51^k}$

$P_{\parallel} = 47.2^k \times \overset{0.9105}{\cos\alpha} = \underline{42.98}$

Long. Loads

$P_\perp = 47.2^k \times \overset{.9105}{\cos\alpha} = \underline{42.98^k}$

$P_{\parallel} = 47.2^k \times \overset{0.4134}{\sin\alpha} = \underline{19.51^k}$

7. Wind on LL

A Transv.

$P = 100^{\#}/' \times 36' = 3.6^k$

$P_\perp = 3.6^k \times \overset{.4134}{\sin\alpha} = 1.49^k$

$P_{\parallel} = 3.6^k \times \overset{.9105}{\cos\alpha} = 3.28^k$

B. Long. wind

$P = 40^{\#}/' \times 36' = 1.44^k$

$P_\perp = 1.44^k \times \overset{.9105}{\cos\alpha} = 1.31$

$P_{\parallel} = 1.44 \times \overset{.4134}{\sin\alpha} = 0.60$

Net $P_\perp = 1.49 + 1.31 = \underline{2.80^k}$

$- P_{\parallel} = 3.28 - 0.60 = \underline{2.68^k}$

8. Substructure wind

Cols = 1.33' x 10' x 40#/□' x $\frac{2}{3}$ x 7 cols = 2.48^k

Long.:

$P_{\parallel}$ = 2.48^k x 0.4134 sin α = 1.03^k

$P_{\perp}$ = 2.48^k x .9105 cos α = 2.26^k

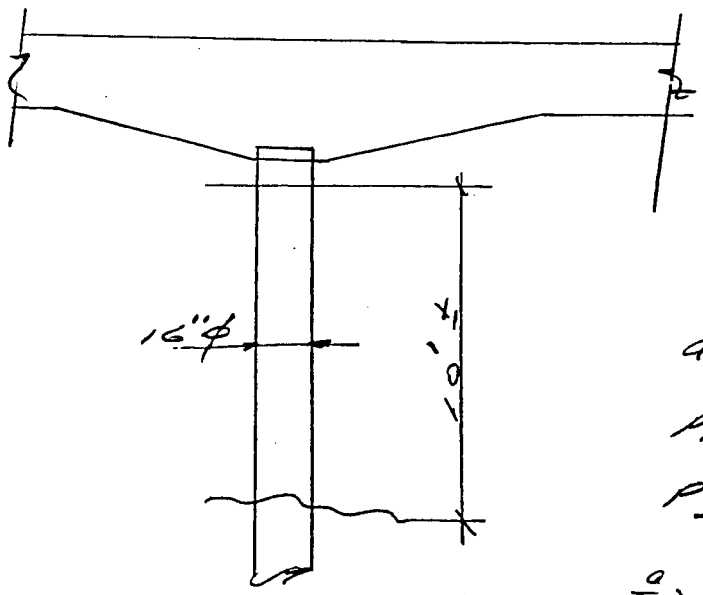
Transv.

$P_{\parallel}$ = 1.33 x 10 x $\frac{2}{3}$ x 40#/□' = 0.35^k

$P_{\parallel}$ = 1.03

1.38^k ←

9. Stream Flow to Pier



use Flow @ 30° Max to Caissons.

use V = 8.5 ft/sec.

P = KV = $\frac{2}{3}$ x $\overline{8.5}^2$ = 50#/□'

a = 50#/□' x 1.33' = 67.2#/'/col.

$P_{\parallel}$ = 67.2#/' x cos 30° = 58.2#/'/col.

$P_{\perp}$ = 67.2#/' x sin 30° = 33.6#/'/col.

$\frac{a}{L}$ = $\frac{10}{20}$ = 0.50

FEM_{Top} = .0573 x 58.2#/' x $\overline{20}^2$ = 1.33'^k

− Bott = .026 x − x − = 0.60

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(Stream Flow Con't.)

$I_{bm} = \frac{1}{12} \times 2 \times \bar{2}^3 = 1.33$

$I_{col} = .049 \times \overline{1.33}^4 = 0.15$

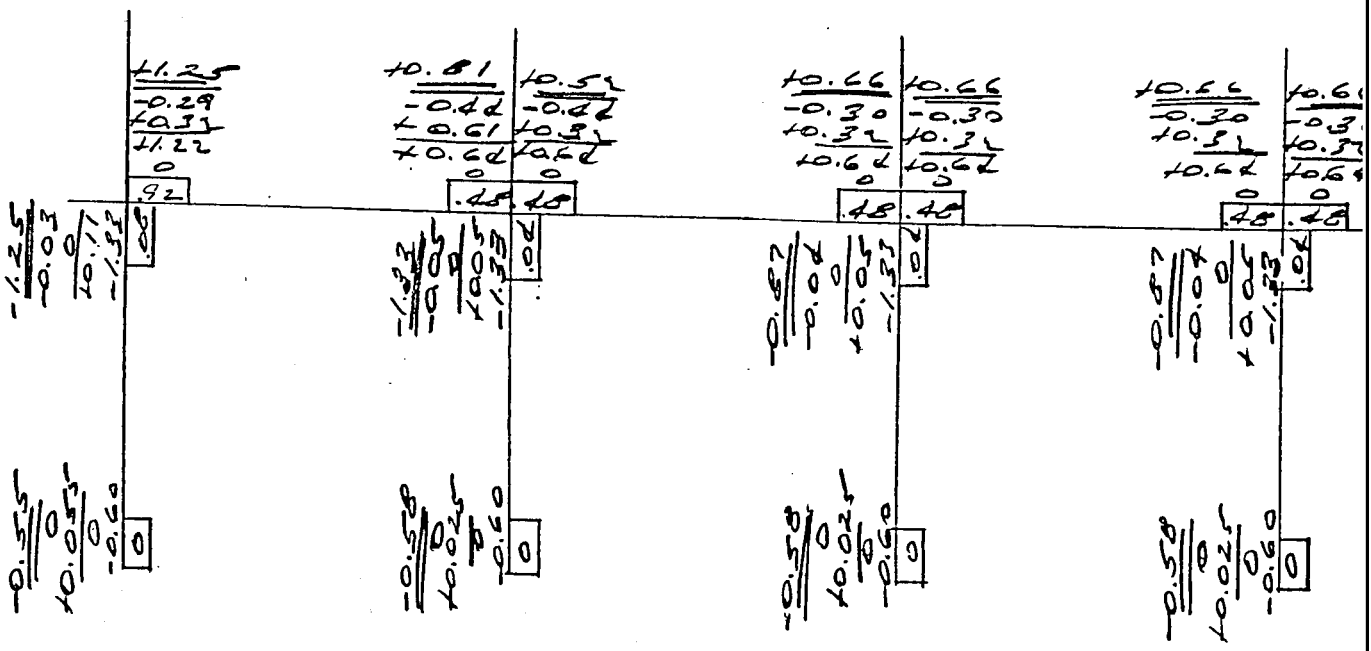
$K = \frac{I}{L} = \frac{1.33}{13} = 0.100 \div .108 = .92$ ✓

$K = \frac{I}{L} = \frac{0.15}{20} = \frac{0.008}{0.108} = \frac{.08}{1.00}$ ✓

$K_{bm} = 0.10 \div 0.208 = 0.48$ ✓

$K_{bm} = 0.10$ — $= 0.48$ ✓

$K_{col} = \frac{0.008}{0.208}$ — $= \frac{0.04}{1.00}$ ✓



Thermal Exp. & Contraction

Deck Lgth Bet. Piers = 36'

$I_{cols} = 0.049 \times 16^4 \times 7 = 22.47 \times 10^3$

Pile Embedment = 20' + 10' = 30'

$\Delta = 0.00021 \times 36' \times 12 = 0.091''$

$P = \frac{3\Delta EI}{L^3} = \frac{3 \times 0.091 \times 3.5 \times 10^3 \times 22.47 \times 10^3}{(30 \times 12)^3} = 0.46^{k/'}$

46.6×10^6

Total P for Bridge width = $0.46^{k/'} \times 81' = 37.2^k$

$P_\perp = 37.2 \times \overset{0.9105}{\cos\alpha} = 33.87^k$

$P_{\parallel} = 37.2 \times \overset{0.4132}{\sin\alpha} = 15.38^k$

$M_\perp = 33.87^k \times 30'/7 \text{ piles} = 145.2'^k/\text{pile}$

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Load to Caissons

1. Group I TL = DL + LL + I + E + B + SF (100%)

Superst. DL = 786.7^k
LL + I = 300 × 1.30 = 390.0
1176.7^k

M⊥ (S.F.) = 33.6#/' × 10' (10'/2 + 20') = 8.4'^k
M∥ (S.F.) = 58.2#/' × 7 cols × 10' × 25' = 101.8'^k

2. Group II TL = DL + E + B + SF + W (125%)
ΣDL = 531.8^k

Mom to Piles (⊥):
SF ———— = 8.4^k
wind (superst.) = 4.62^k × 20'/7 Piles = 13.2
wind (subst) = 2.26^k × 20'/7 Piles = 6.5
28.1'^k/Pile

Mom to Piles (∥)
SF ———— = 101.8'^k
wind (superst.) = 5.93^k × 20' = 118.6
wind (sub) = 1.38^k × 20' = 27.6
248.0'^k/Bent

3. Group III TL = Group I + LF + 30% wind + WL (130%)
DL + LL = 1176.7

Mom to Piles (⊥)
SF ———— 8.4'^k
LF = 7.07^k × 20^k/7 Piles ———— 20.2
30% wind = (13.2 + 6.5) 0.30 ———— 5.9
WL = 2.80^k × 20/7 Piles ———— 8.0
42.5^k/Pile

Mom to Piles (∥)
SF ———— = 101.8'^k
LF = 3.21^k × 20' ———— = 64.2
30% wind = (118.6 + 27.6) 0.30 ———— = 43.8
WL = 2.68 × 20' ———— = 53.6
263.4'^k/Bent

d. Group IV TL = DL + LL + CF + B + SF + T

DL + LL = 1176.7

Mom to Piles (⊥)

SF = 8.4 'k

T = 145.2

153.6 'k

Mom to Piles (∥)

SF = 101.8 'k

T = 15.38 × 20' = 307.6

409.4 'k

5. Group V TL = D + E + SF + W + T(140%)

DL = 531.8 k

Mom. to Piles (⊥):

SF = 8.4 'k

W = 19.7

T = 145.2

173.3 'k/pile

Mom to Piles (∥)

SF = 101.8

W = 146.2

T = 307.6

555.6 'k/Bent

6. Group VI TL = D + LL + CF + B + SF + 0.3W + WL + LF + T(140%)

DL + LL = 1176.7 k

Mom. to Piles (⊥):

SF = 8.4

0.3W = 5.9

WL = 6.0

LF = 20.2

T = 145.2

187.7 'k

(Group VI Cont.)

Mom to Piles (II)

SF = 101.8
0.3W = 95.8
WL = 58.6
LF = 64.2
T = 307.6
571.0^k/Bent

Group VII TL = DL + EQ + BL + SF (133%)
DL = 531.8^k

Mom to Piles (⊥):
SF = 8.4^k/Pile
EQ = 42.9 × 20/7 = 122.5
131.0^k/Pile

Mom. to Piles (II):
SF = 101.8^k
E.Q = 19.57^k × 20' = 390.0
491.8^k/Bent

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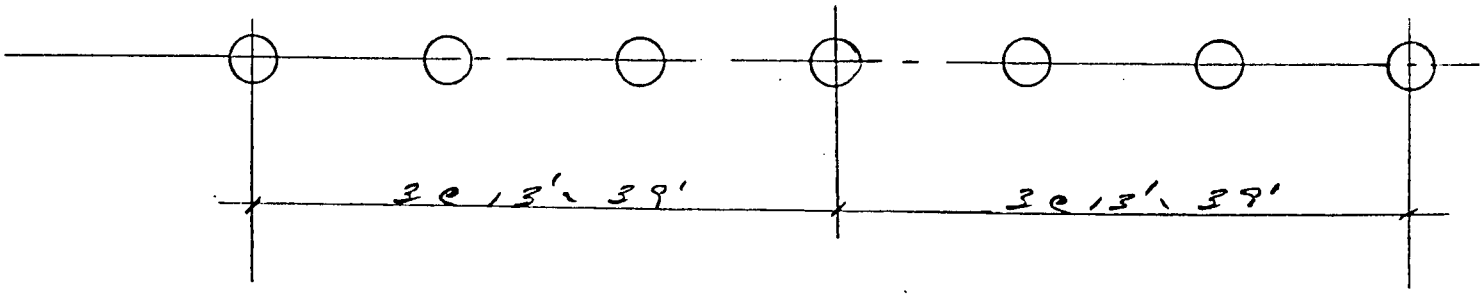
Max Load to Piles



I of Piles = $2 \times \overline{13}^2 = 338$
$2 \times \overline{26}^2 = 1352$
$2 \times \overline{39}^2 = 3042$
4732 ft^2

Group I = $\frac{1176.7}{7} + \frac{101.8 \times 39}{4732} = 168.1 + .8 = 168.9^k$ (100%)

II = $\frac{531.8}{7} + \frac{248 \times 39}{4732} = 75.9^k + 2.0 = 97.9^k$ (125%) 78.3

III = $\frac{1176.7}{7} + \frac{263.4 \times 39'}{4732} = 168.1 + 2.2 = 170.3$ (125%) 136.2

IV = $\frac{1176.7}{7} + \frac{409.4 \times 39'}{4732} = 168.1 + 3.4 = 171.4$ (125%) 137.1

V = $\frac{531.8}{7} + \frac{555.6 \times 39}{4732} = 75.9 + 4.6 = 80.5$ (140%) 57.4

VI $\frac{1176.7}{7} + \frac{571.0 \times 39'}{4732} = 168.1 + 4.7 = 172.8$ (140%) 123.4

VII = $\frac{531.8}{7} + \frac{491.8 \times 39}{4732} = 75.9 + 4.1 = 80.0$ (135%) 60.2

use caisson
w/ Max Ld.
of 132.5^k

Caisson Lgth = 25'±

wt = $\frac{\pi \times \overline{2}^2}{4} \times 25 \times 150 = 11.8^k$

$+ 168.9$

180.7

For $16^k/\square'$ bag $A = \frac{180.7^k}{16^k/\square'} = 11.3^{\square''}$

$A = \frac{\pi d^2}{4}$ $d = \left(\frac{4A}{\pi}\right)^{1/2} = \left(\frac{4 \times 11.3}{3.14}\right)^{1/2} = \overline{14.4}^{1/2} = 3.79'$

use 4'-0" ϕ Bell.

Design Caissons For Group VII

DL = $531.8^k / 1.33 = 400^k$

M = $131.0'^k / 1.33 = 98.5'^k$

Col. $I = .049 \times \overline{1.33}^4 = 0.15$ $K = \frac{I}{L} = \frac{0.15 \times 7 \text{ cols}}{20} = .05$

Bm $I = \frac{1}{12} \times 2 \times \overline{2}^3 = 1.33$

Bm $\frac{I}{L} = \frac{1.33}{13} = 0.10$

$\psi_{Top} = \frac{\Sigma \frac{EI}{L_c} (\text{cols})}{\Sigma \frac{EI}{L_B} (\text{Bm})} = \frac{.05}{.10} = 0.50$

$\psi_{Bott.} = 0$

use Min K = 1.2

$I_g = .049 \times \overline{16}^4 = 3211$

$B_d = 1.0$

$EI = 3.7 \times 10^9$

$P_c = \frac{\pi^2 EI}{(K l_u)^2} = \frac{\overline{3.14}^2 \times 3.7 \times 10^9}{(1.2 \times 20 \times 12)^2} = 444.8^k$

$.082 \times 10^6$

$\delta = \frac{C_m}{1 - \frac{P_u}{\phi P_c}} = \frac{1.0}{1 - \frac{1.3 \times 400 / 7 \text{ cols}}{0.75 \times 444.8}} = 1.28$

$M = 1.28 \times 98.5'^k = 126.3'^k$

Col. Design

$P = 400^k/7 = 57.1^k$ $\quad P_u = 57.3 \times 1.3 = 74.5^k$

$M = 126.3'^k$

$e = \frac{126.3'^k}{74.5} = 1.70'$ or $20.3''$

$\frac{e}{t} = \frac{20.3}{16} = 1.27$

$K = P_u / f_c D^2 = \frac{74.5}{3 \times 16^2} = 0.10$

$\rho t m = 0.80$ $\quad m = \frac{60}{.85 \times 4} = 17.65$

$\rho = \frac{0.80}{17.65} = 0.05$

$A_s = 0.050 \times \frac{\pi \times 16^2}{4} = 10.2$ $\quad$ use 12-#9

Spiral Reinf.

$A_g = \pi \times 15.5^2/4 = 188.6''$

$A_c = \pi \times 15.75^2/4 = 194.4$

$\rho' = 0.45\left(\frac{A_g}{A_c} - 1\right)\frac{f_c'}{f_s}$

$\rho' = 0.45\left(\frac{188.6}{194.4} - 1\right)\frac{3}{40}$

$\rho' = 0.018$

$A_s = 12'' \times .018 = 0.22$

use 12-#9 Bars w/ #3 spiral @ 3"

Abut Design

1. DL to Abut = 531.8k

2. LL to Abut = 178.0k

Cap Bm DL = 1'×2'×150×61' = 2.4k

ΣDL+LL = 531.8k+2.4k+178.0k = 712.2k

Ld/Caisson = 712.2k/7 = 101.7k

wt of Caisson = $\pi \times \frac{1.33^2}{4} \times 25' \times 150$ = 5.21k
+101.7
106.9k

For 16k/□' Bng ~ A = $\frac{106.9k}{16k/□'}$ = 6.68 □'

d = $\left(\frac{4 \times 6.68}{3.14}\right)^{1/2}$ = 2.92' use 36"φ

use 16"φ Caisson
w/36"φ Bell
use same stl
As for Pier

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Abut Bm Design

DL

slab = 219#/□' × 29'/2 = 3.18 k/'

w.s. - 25#/□' × " = 0.36

Bm = 2.75' × 3' × 150 = 1.24

H'dwall = 0.75 × 2' × 150 = 0.23

Sidewalk + H'drl —— = 0.42

5.43 k/'

Cant Mom = 5.43 k/' × 5.5²/2 = 82.1 'k

H'drl = 200#/□' × 5.5' —— = 1.1

Sidewalk = 75#/□' × 5' × 3' = 1.1

84.3 'k

FEM = 5.43 k/' × 13²/12 = 76.5 'k

	1.0	½	½	½	½	½	½
-82.1	+76.5	-76.5	+76.5	-76.5	+76.5	-76.5	+76.5
	+5.6						
		+2.8					
		-1.4	-1.4				

LL ~ From Pier Mom. Dist ~

LL Neg. Mom = 178/300 × 145.8 = 86.5 'k

LL Pos. Mom = 178/300 × 25.6 = 15.2

Σ DL + LL Mom Neg = 76.5 + 86.5 = 163 'k

As = 163.0 'k × 12 / 0.875 × 33 × 33 = 2.05 □" use Min

As = .00333 × 33 × 33 = 3.63 □" (6 - #8 Top) & Bott.

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Shear to Bm: P wheel = 178/8 × 1.3 = 28.9^k

LL = 28.9^k + 28.9 × 6.42 / 13 = 43.2^k

ΔM/L = 2.9'^k × 28.9 / 48.8 = 1.7

44.9

DL = 5.43 k/' × 13.0'/2 = 35.3

80.2^k

v = 80,200 / 0.875 × 31 × 33 = 84.2 #/'

use Min
#4 @ 12"

use 31" × 36"
Bm w/ 6-#8
TAB w/ #4
Ties @ 12"