STRUCTURAL CALCULATIONS

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

ENGINEERING DIVISION
LIBRARY

PROJECT: **ARIZONA CANAL DIVERSION CHANNEL**
Arizona Channel Diversion Canal
Phoenix, Arizona

CLIENT: Mathews Kessler & Associates
4045 E. McDowell
Phoenix, AZ 85008

PLUMMER HASAN & ASSOCIATES
CONSULTING ENGINEERS, INC.
3666 NORTH MILLER RD.
SCOTTSDALE, ARIZONA 85251
941-2061

FLOOD CONTROL DISTRICT
RECEIVED
FEB 06 1985

	CH ENG		P & PM
	DEP		HYDRO
	ADMIN		LMGT
	FINANCE		FILE
	C & O		
	ENGR		

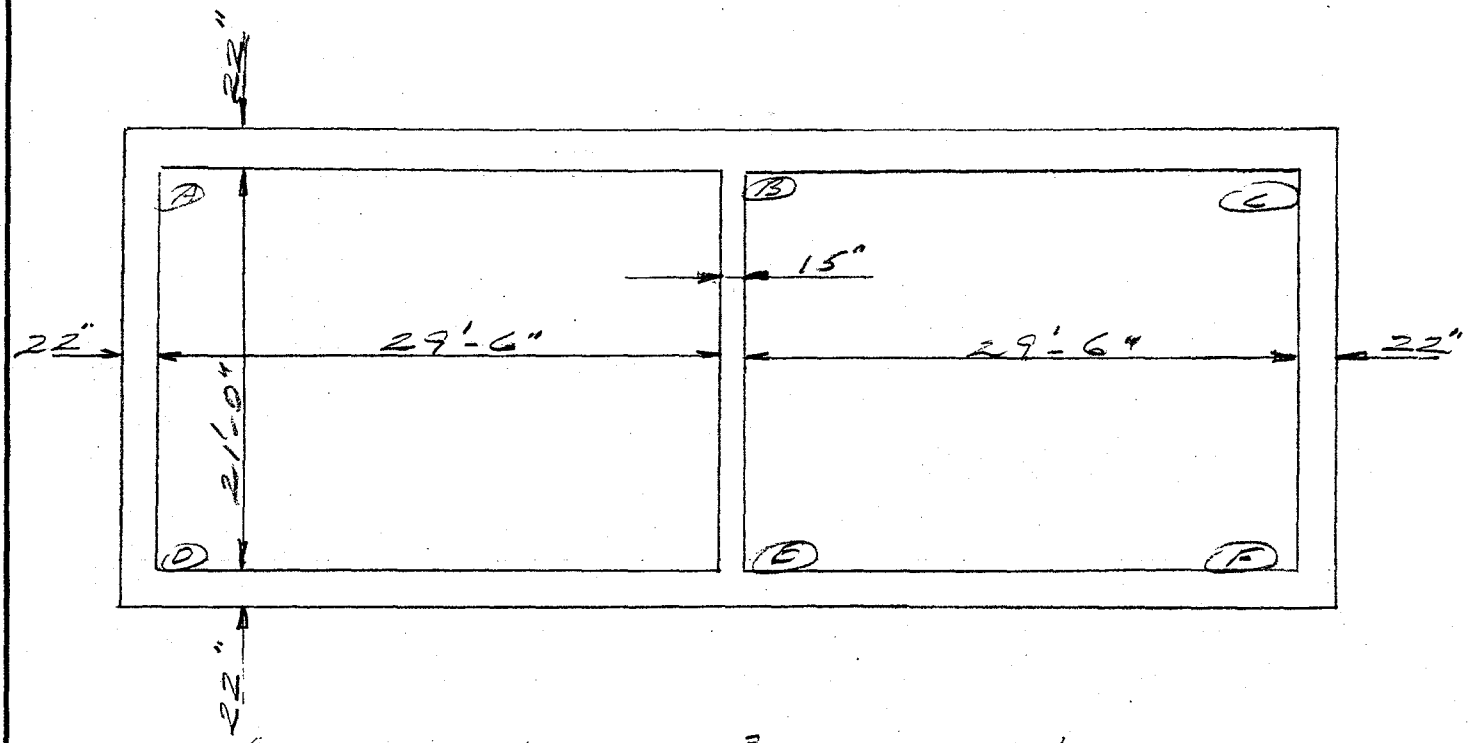
REMARKS

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/24/88 BY EMP	SHT. NO. 1 OF

Box Culvert Design w/8'-3" Fill

DL. Analysis

Concrete DL



I of slab = $\frac{1}{12} \times 12 \times 22^3 = 10,648$ in^4

I of Int. wall = $\frac{1}{12} \times 12 \times 15^3 = 3375$ in^4

I of Bott. slab = $\frac{1}{12} \times 12 \times 22^3 = 10,648$ in^4

@ Int. wall

$K_{BA} = \frac{10,648}{31} = 343.5 \div 836.7 = 0.41$

$K_{BE} = \frac{3375}{22.54} = 149.7$ — $= 0.18$

$K_{BC} = \text{——} = \frac{343.5}{836.7}$ — $= \frac{0.41}{1.00}$ —

@ Ext. wall

$K_{AB} = 10,648/31 = 343.5 \div 815.9 = 0.42$

$K_{AD} = 10,648/22.54 = \frac{472.4}{815.9}$ — $= \frac{0.58}{1.00}$ ✓

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/90 BY EMP	SHT. NO. 2 OF

@ Bottom Slab -

Ext. - $K_{DE} = \frac{10,646}{31} = 343.5 \div \Sigma = 0.42$

$K_{DA} = \frac{10,646}{22.5'} = \frac{472.8}{815.7} = \frac{0.58}{1.00}$

Int. @ Bottom - $K_{EB} = \frac{3375}{22.5'} = 149.7 \div \Sigma = 0.18$

$K_{ED} = \frac{10,646}{31} = 343.5 = 0.41$

$K_{EF} = \frac{10,646}{31} = \frac{342.5}{836.7} = \frac{0.41}{1.00}$

Box wt. -

Top slab - 1.83' x 150#/c.f. x 63.75' = 17.49 k/'

Ext. walls - 1.83' x 21' x 2 x 150#/c.f. = 11.50

Ctr wall - 1.25' x 21' x 150#/c.f. = 3.93

Bott. slab - 1.83' x 64.5' x 150#/c.f. = 17.82

50.74 k/'

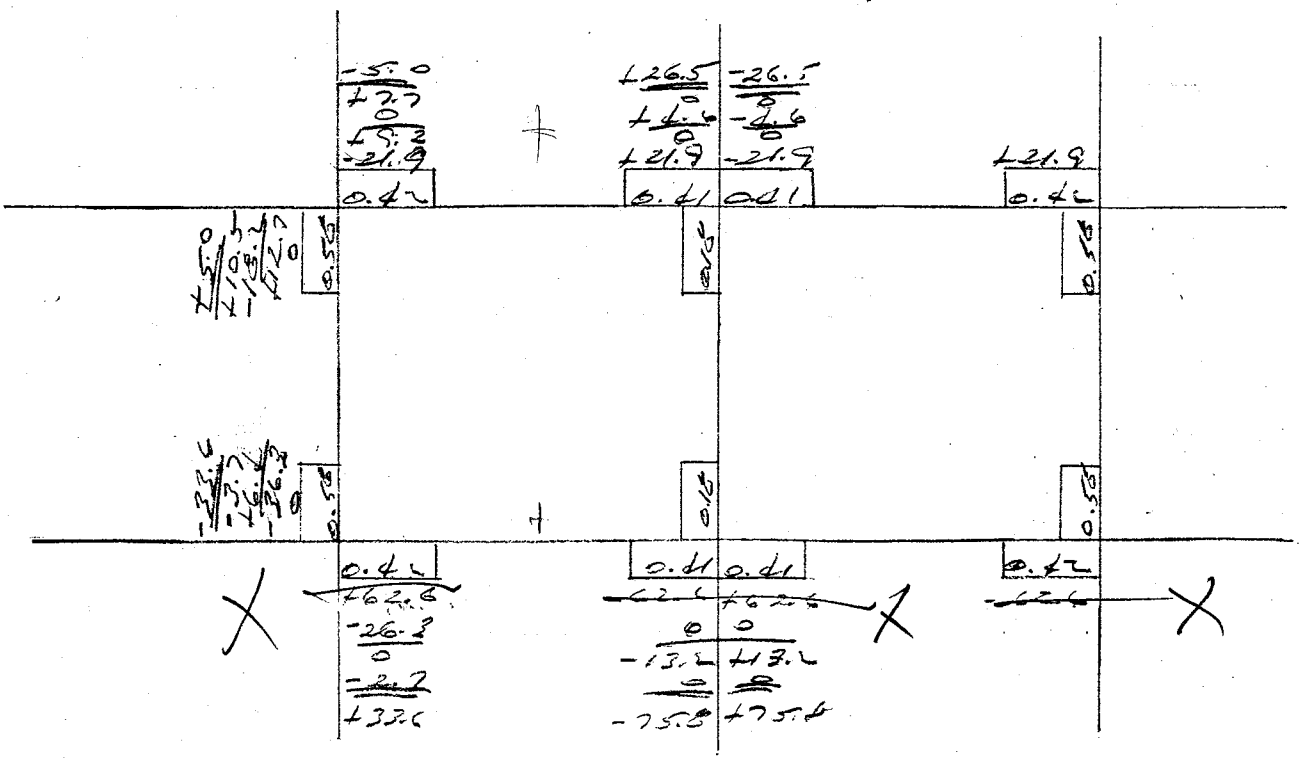
w = 50.74 k/'/64.5' = 0.78 k/'

Less Bot Slab = 1.67 x .15 = 0.251

.531

$FEM_{A-B,\ B-A} = 2.74\#/c.f. \times 31^2/12 = 21.9$ 'k/'

$FEM_{D-E,\ E-F} = \cancel{0.78}\ .531\ k/' \times 31^2/12 = \cancel{42.6}\ 41.5\ k/'$



(+) M_{A-D} = (+) 19.3 'k

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/88 BY EMP	SHT. NO. 3 OF

(4) M_{A-B}, $B-C$ = $274\,\#/ft \times 31^2/8 - \left(\frac{5.0'^k + 26.5'^k}{2}\right)$

= $32.9'^k - 15.8'^k$

= $\underline{17.1'^k}$

V_A = $274\,\#/ft \times \frac{31'}{2} - \left(\frac{26.5'^k - 5.0'^k}{31'}\right)$

= $4.25^k - 0.70$

= $\underline{3.6^k} - 0.274\,k/ft \times 2.5' = \underline{2.91^k}$

V_B = $274\,\#/ft \times \frac{31'}{2} + 0.70$

= $4.25 + 0.70$

= $\underline{4.95^k} - 0.274\,k/ft \times 2.5 = \underline{4.26^k}$

(4) M_{D-E}, $E-F$ = $782\,\#/ft \times 31^2/8 - \left(\frac{75.6'^k + 33.6'^k}{2}\right)$

= $93.9'^k - 54.7$

= $39.2'^k$

V_D = $782\,\#/ft \times \frac{31'}{2} - \left(\frac{75.6'^k - 33.6}{31'}\right)$

V_D = $12.12 - 1.36$

V_D = $10.76^k - 0.782\,k/ft \times \frac{26.5''}{12} = \underline{9.03^k}$

V_E = $12.12 + 1.36$

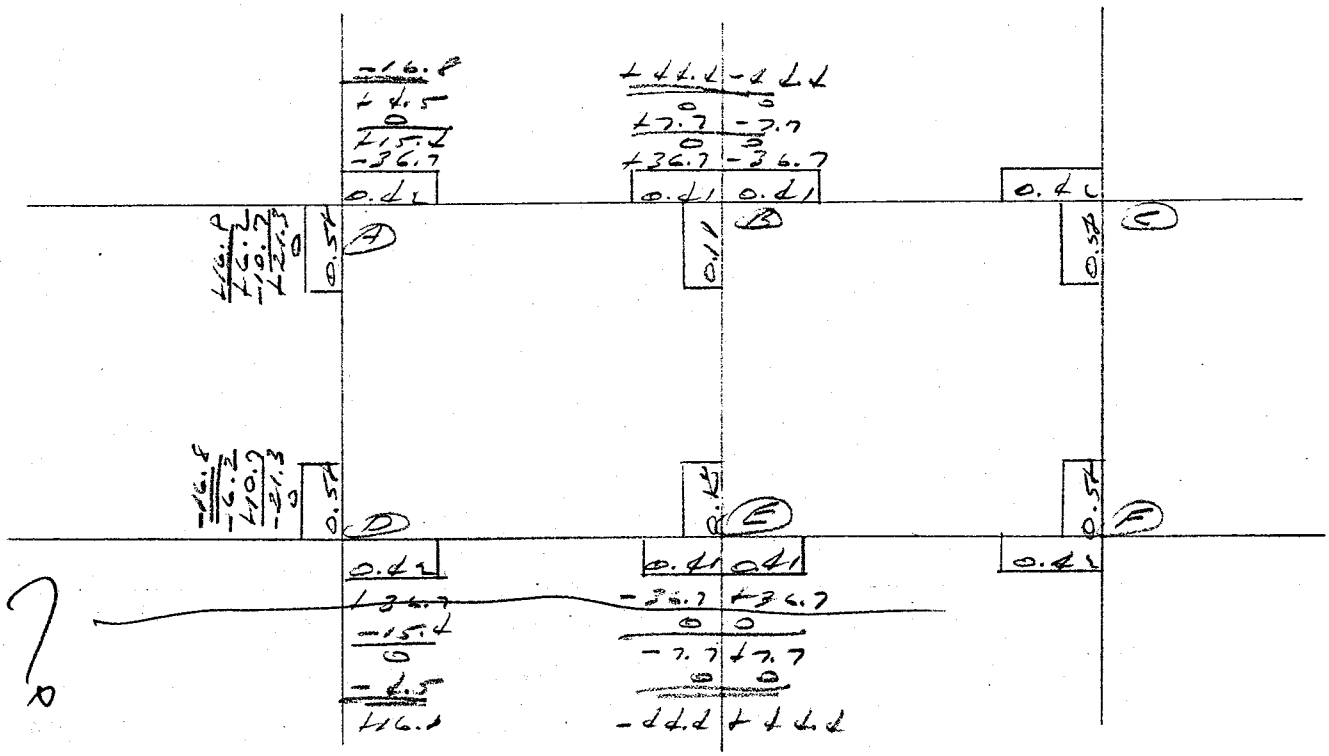
V_E = $13.48^k - 0.782\,k/ft \times \frac{26.5''}{12} = \underline{11.75^k}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/88 BY EMP	SHT. NO. 4 OF

LL Top Fill on Box

Uniform Fill wt w = 140#/ft × 3.27' = 458#/'

FEM = 458#/' × 31²/12 = 36.7'k



(+) M_{AB} = 458#/' × 31²/8 − (+44.4 × 16.8/2)

= 55.0 − 30.7 = 24.3'k

V_A = 458#/' × 31'/2 − (44.4'k − 16.8'k)/31

= 7.09 − 0.89

= 6.20 − 0.458#/' × 26.5'/12 = 5.19'k

V_B = 458#/' × 31'/2 + 0+1/2 = 7.98'k − 0.458#/' × 26.5'/12 = 6.97'k

(+) M_{DE} = 458#/' × 31²/8 − (+44.4 × 16.8/2)

= 55 − 30.7

= 24.3'k

V_D = 458#/' × 31'/2 − (+44.4'k − 16.8'k)/31

= 7.09 − 0.89

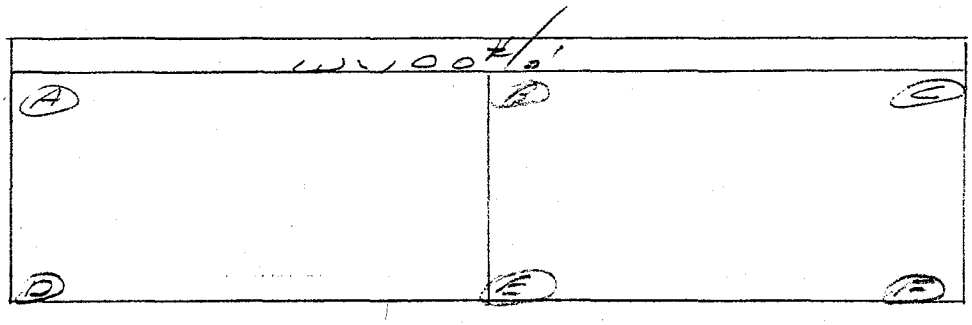
= 6.20 − 0.458#/' × 26.5'/12 = 5.19

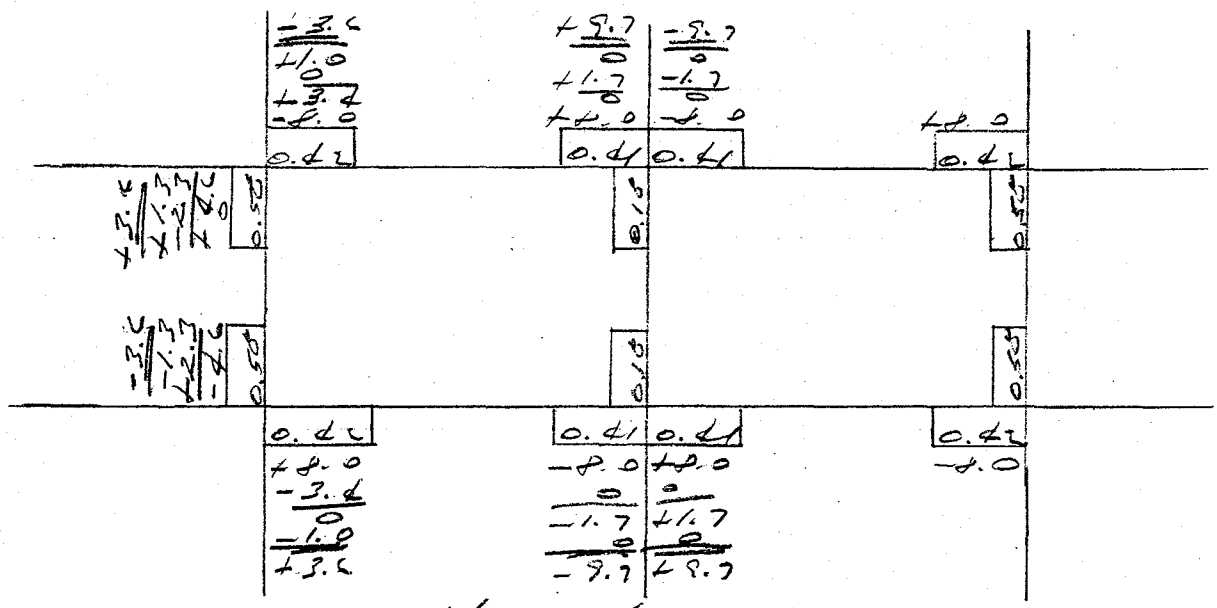
V_E = 6.97'k

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/3/88 BY EMP	SHT. NO. 5 OF

LL (100#/□')

FEM = 100#/□' × 31²/12 = 8.0'k





(+) $M_{A-B} = 100\#/□' \times 31^2/8 - \left(\frac{9.7'k + 3.6'k}{2}\right) = 5.36'k$

$V_A = 100\#/□' \times 31'/2 - \left(\frac{9.7'k - 3.6'k}{31}\right) = 1.35^k - 0.1 \times 2.5' = 1.1^k$

$V_B = 100\#/□' \times 31'/2 + \quad — \quad = 1.75 - 0.1 \times 2.5' = 1.5$

(+) $M_{D-E} = 100\#/□' \times 31^2/8 - \left(\frac{9.7'k + 3.6'k}{2}\right) = 5.36'k$

$V_D = 100\#/□' \times 31'/2 - \left(\frac{9.7'k - 3.6'k}{31}\right) = 1.35^k$

$V_E = 100\#/□' \times 31'/2 + \quad — \quad = 1.75^k - 0.1 \times \frac{2.5}{2}$

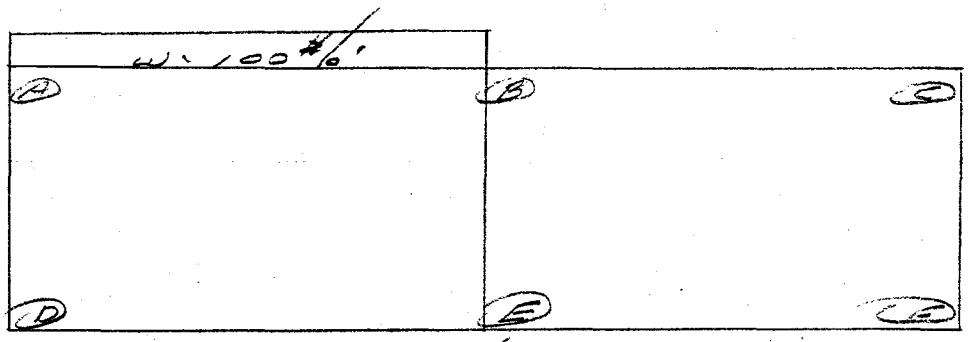
$= 1.5^k$

$M_{A-D} = 3.6'k$

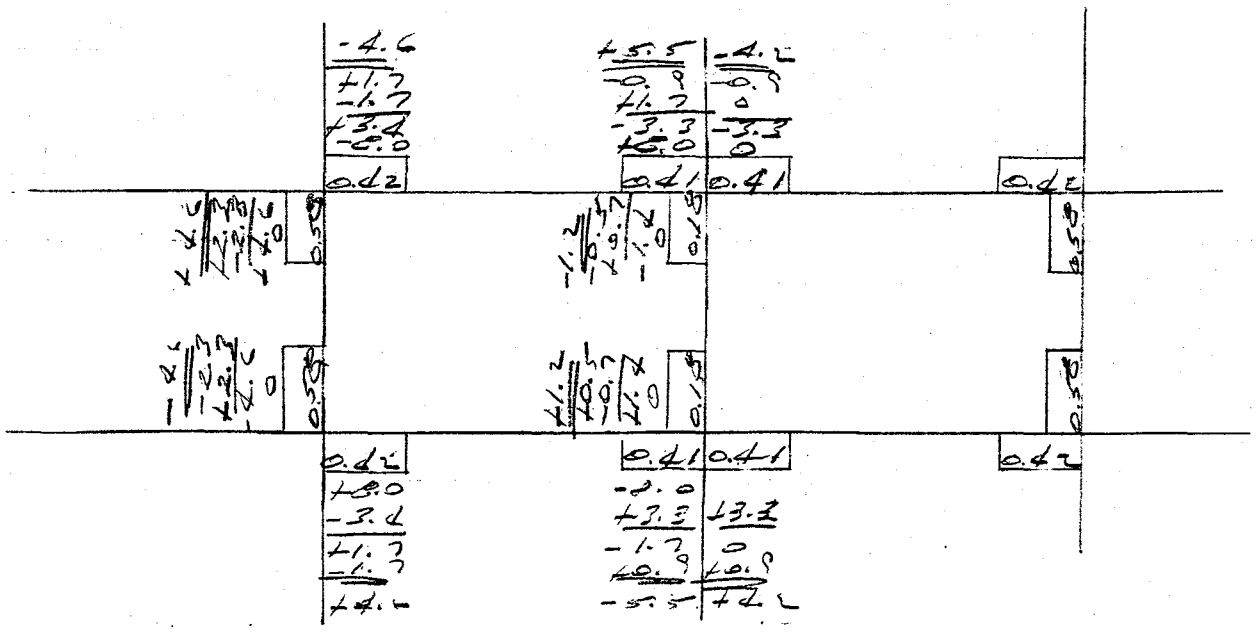
PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/26/88 BY EMD	SHT. NO. OF 6

(LL con't - 100 #/ft)

Partial Loading



$FEM = 100\,\#/ft \times 31^2/12 = 8.0^{'k}$



$(+)M = 100\,\#/ft \times 31^2/8 - \left(\frac{4.6^{'k} + 5.5^{'k}}{2}\right) = 6.96^{'k}$

$V_A = 100\,\#/ft \times \frac{31'}{2} - \left(\frac{5.5^{'k} - 4.6^{'k}}{31}\right) = 1.55^k - 0.25 = 1.27^k$

$V_B = 100\,\#/ft \times 31'/2 + \quad - \quad = 1.55^k - 0.25 = 1.33^k$

$V_D = 100 \times 31'/2 - \left(\frac{5.5^{'k} - 4.6^{'k}}{31}\right) = 1.55 - 0.25 = 1.27^k$

$V_E = 1.55^k - 0.25 = 1.33^k$

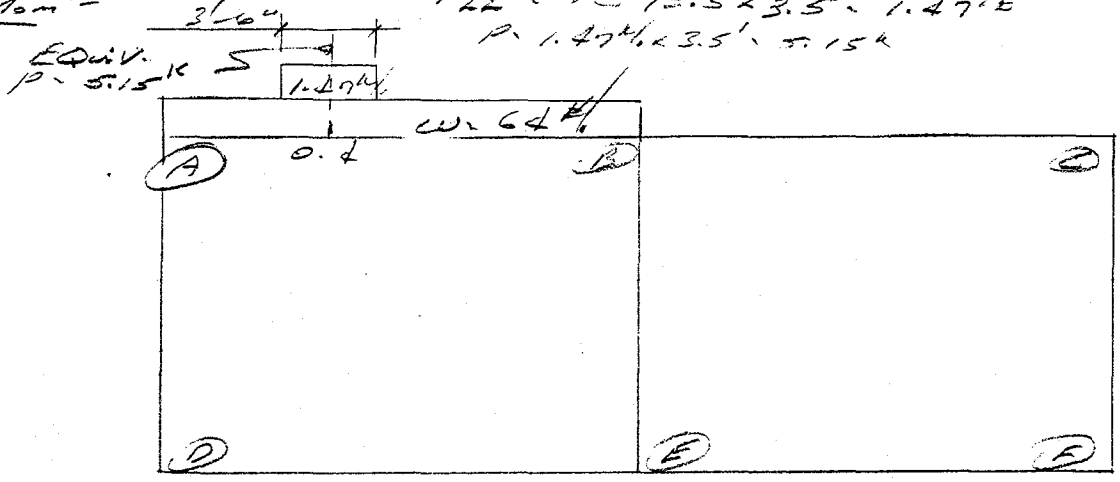
$M_{A-D} = 4.6^{'k}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/88 BY EMP	SHT. NO. 7 OF

Truck LL (HS20-44 on 31'6" span) $w_{LL} = 64\#/'$ (No Impact w/ Fill > 2')

Pos. Mom - $P_{LL} = 18^k/5.5' \times 3.5' = 1.47^k/'$

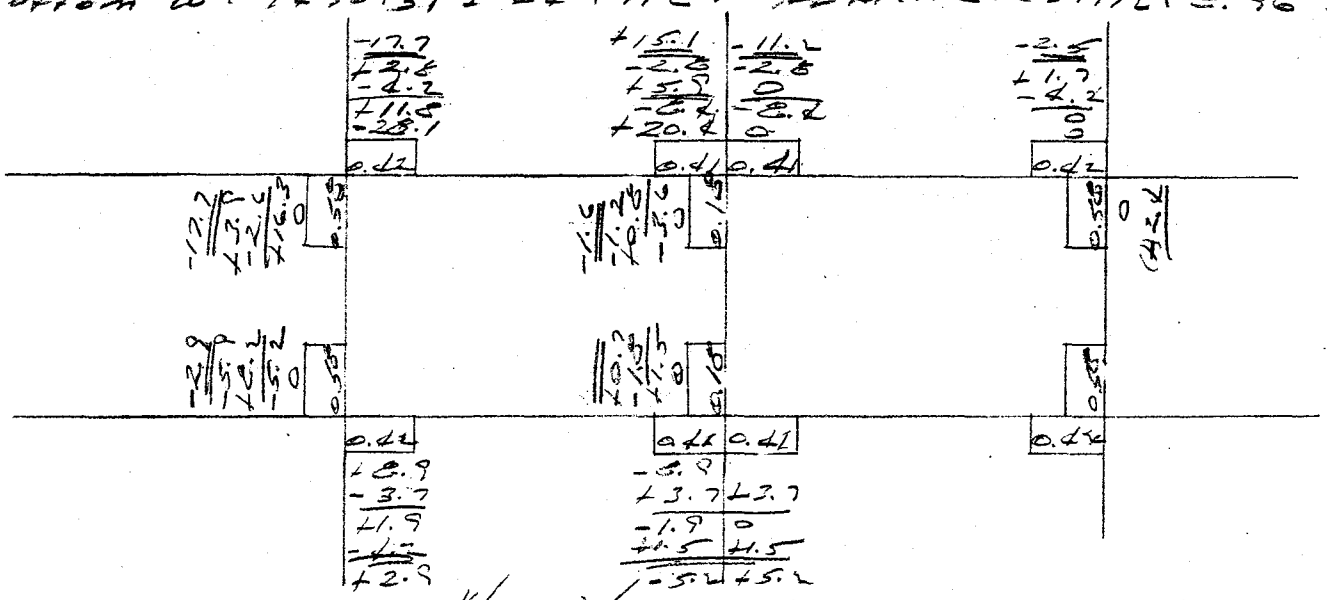
$P = 1.47^k/' \times 3.5' = 5.15^k$



FEM $w = 64\#/' \times 31^2/12 = 5.13^k/'$

FEM P ~ For $\frac{a}{L} = 0.4$ - FEM $= 0.144 \times 5.15^k \times 31' = \frac{23.0'^k}{15.3}$ .0960

Bottom $w = 1470\#/31' \times 64\#/' = 112\#/'$ FEM $= 112\#/' \times 31^2/12 = 8.96'^k$



(4) Me 0.4 $= 64\#/' \times 31^2/8 = 7.69'^k - \frac{0.4 \times 0.6}{0.52} = 7.38'^k$

Pe 0.4 - SBM $= 5.15^k \times \frac{12.4 \times 18.6}{31} - \frac{(17.8'^k + 15.2'^k)}{2} = \frac{38.3}{45.68'^k}$ (-) $\frac{16.50}{29.18'^k}$

$V_A = 64\#/' \times 31'/2 + 5.15^k \times \frac{18.6}{31} + \left(\frac{17.7'^k - 15.1'^k}{31}\right)$

$V_A = 0.99 \times 3.09 + 0.08$

$V_A = 4.2^k - 0.064 \times 2.5' = 4.04^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/4/82 BY EMP	SHT. NO. 2 OF

$V_B = 64\#/' \times \frac{31'}{2} + 5.15^k \times \frac{12.4}{31} - \Delta M/L$

$= 0.99 \times 2.06 + .05$

$= 3.13^k - 0.064 \times 2.5 = \underline{2.97^k}$

(+) $M_{D.E} = 112\#/' \times \overline{31}^2/6 - \left(\frac{4.7^{'k} + 5.9^{'k}}{2}\right)$

$= 13.5 - 5.8$

$= 6.2^{'k}$

$V_D = 112\#/' \times \frac{31'}{2} - \left(\frac{5.9^{'k} - 4.7^{'k}}{31}\right)$

$= 1.74^k - 0.4$

$= 1.74 - 0.11^k/' \times 2.5' = \underline{1.46^k}$

$V_E = 1.74^k - 0.11^k/' \times 2.5' = \underline{1.50}$

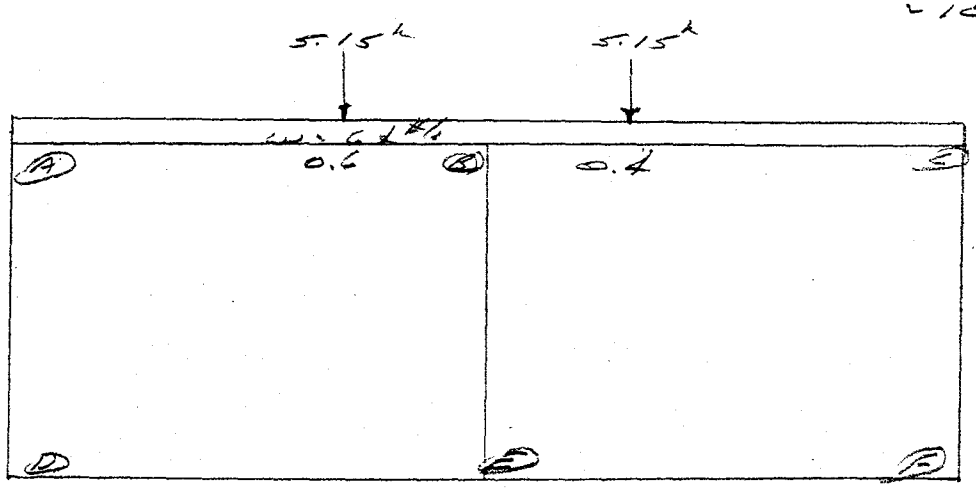
PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/86 BY EMP	SHT. NO. 9 OF

(HS20-44 Truck LL Cont.)

NEG. MOM

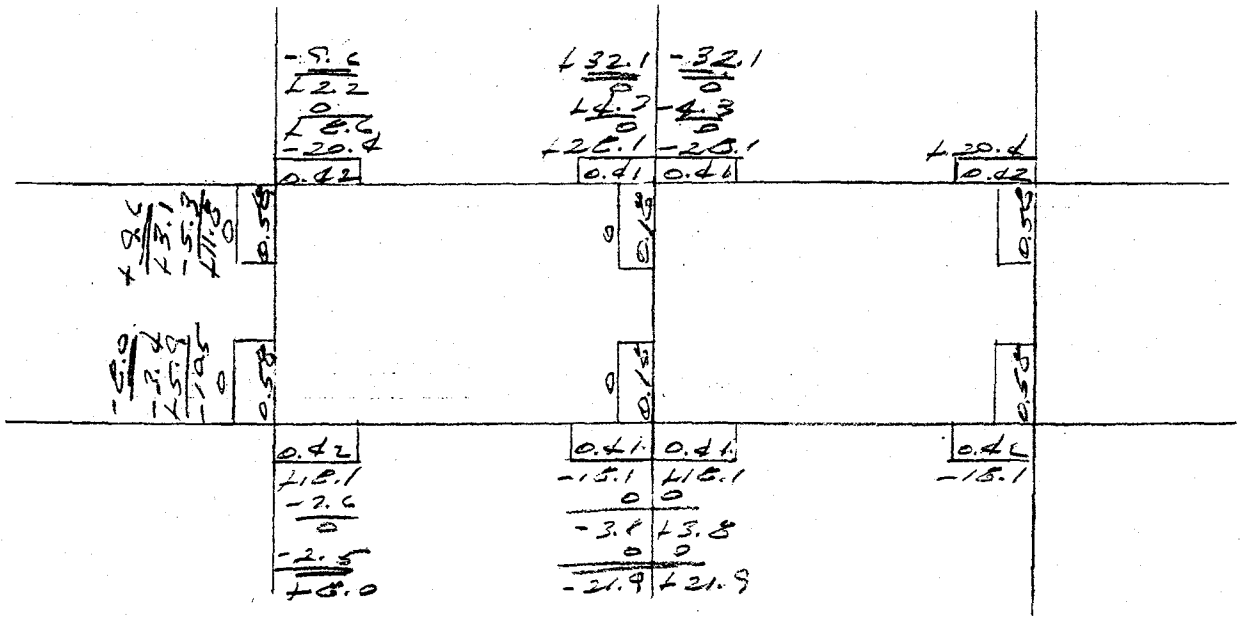
Both. w = $\frac{5.15^k \times 2}{23.75}$ + 64 #/' = 226 #/'

FEM = 226 #/' × 31²/12 = 18.1'k



FEM = 64 #/' × 31²/12 = 5.13'k

For $\frac{a}{L}$ 0.6 FEM: $\frac{.0960}{.144}$ × 5.15k × 31' = $\frac{15.3'k}{23.0}$



NEG MOM @ B = 32.1'k

V_A = 64 #/' × 31'/2 + 5.15k × 12.4/31 − ΔM/L

= 0.99 + 2.06 − 0.73 = 2.32k

V_B = 0.99 + 2.06 + 0.73 = 3.78k

(A MOE = 226 #/' × 31²/8 − $\left(\frac{21.9'k + 8.0'k}{2}\right)$ = 12.2'k

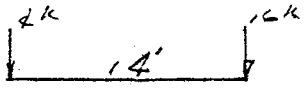
V_D = 226 #/' × 31/2 − $\left(\frac{21.9'k - 8.0'k}{31}\right)$ = 3.06k

V_E = 3.94k

M_{A-D} = 6.8'k

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/4/88 BY EMP	SHT. NO. 10 OF

LL (H10-44 Truck) on Box (no Fill)



wheel Ld. $\frac{16^k}{2} \times 1.3$ Impact $= 10.4^k$

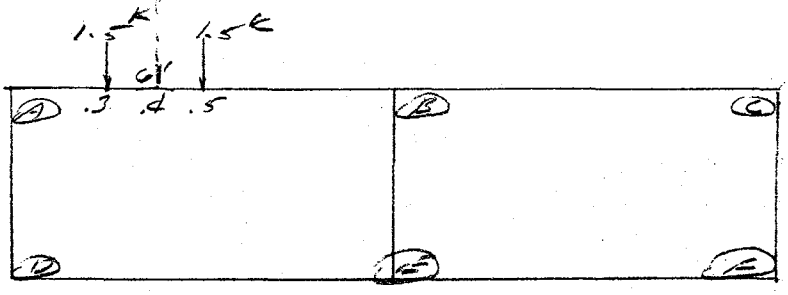
wheel Dist. E. $8' \times + 3.75$
$= 8' \times 6' + 3.75 =$ use 7' Max

$P = 10.4^k / 7' = 1.5^k$

Bottom cw. $\frac{1.5^k \times 2}{31} = 97\#/'$

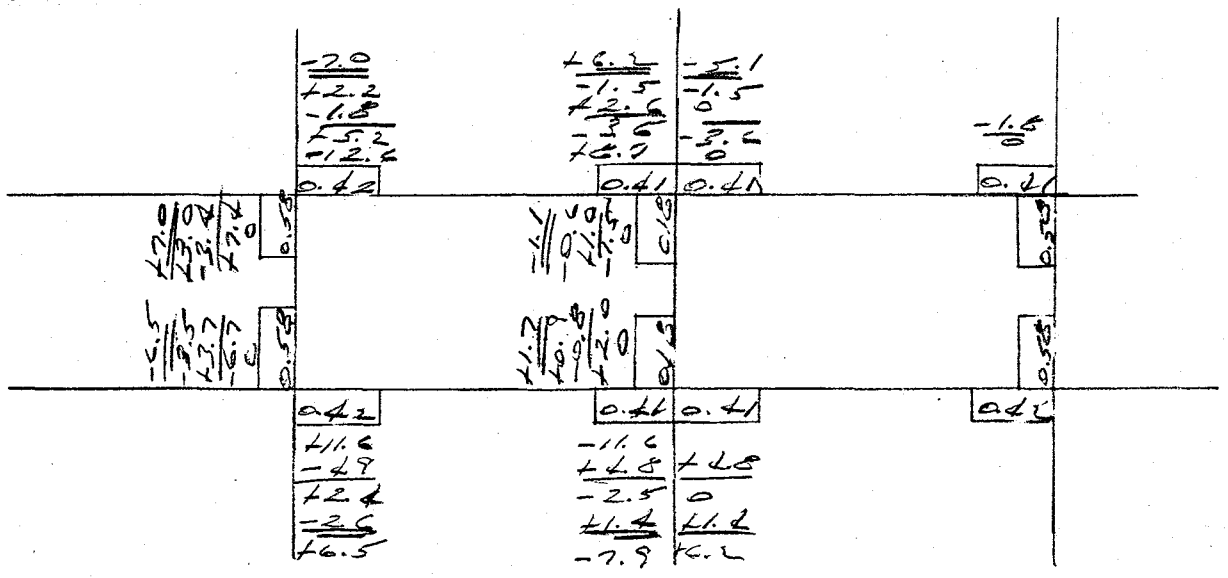
FEM $= 97\#/' \times 31^2/8 = 11.6'^k$

Max Pos. Mom @ 0.4pt



For $\frac{a}{L} = 0.3$ FEM $= \frac{0.127}{0.0628} \times 1.5^k \times 31' = \frac{6.84'^k}{2.92}$

For $\frac{a}{L} = 0.5$ FEM $= 0.125 \times 1.5^k \times 31' = 5.8'^k$



Pos. Mom @ 0.5 $= \frac{1.5^k \times 9.3' \times 21.7}{31} = 9.77'^k \times \frac{15}{12.6} = 8.14^k$

$1.5^k \times 31'/4 = 11.6$ — 11.60

$19.74'^k$

$(+)\left[7.0 - \frac{4.5}{2}\right] \times 4 = 6.60$

$13.14'^k$

$V_A = 1.5^k\left(\frac{29.2}{31} + \frac{23.25}{31}\right) = 2.54^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/21/88 BY EMP	SHT. NO. 11 OF

(+) M_{D-E} = $97^{\#}/_{ft} \cdot 31^2/8 - \left(\frac{6.5^{k} \times 7.9^{k}}{L}\right)$

= $11.7^{k} - 7.2^{k}$

= 4.5^{k}

$V_D = V_E$ = $97^{\#}/_{ft} \cdot \frac{31'}{2} - \left(\frac{6.5^{k} - 7.9^{k}}{31}\right) = 1.45^{k}$

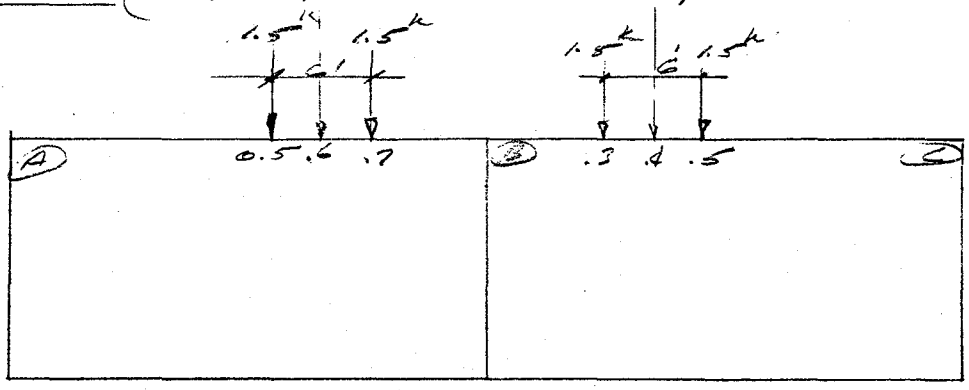
(+) M_{A-B} = $64^{\#}/_{ft} \cdot 31^2/8 + 1.5^{k} \times \frac{12.6' \times 12.4' \times 15.5}{31} - \left(\frac{7.0^{k} + 6.6^{k}}{L}\right)$

= $7.69^{k} + 9.3 - 6.6 = 10.4^{k}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/26/88 BY EMP	SHT. NO. 12 OF

LL (H10-44 Truck Ld.)

Neg. Mom (w/2 H10-44 Truckes)

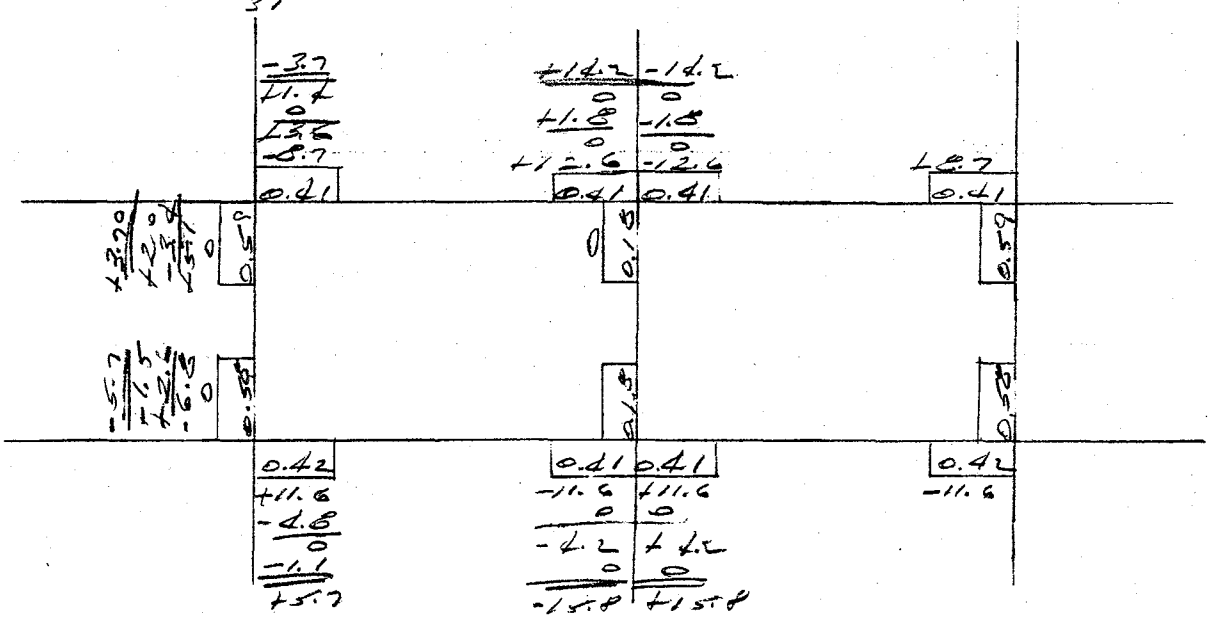


Span A-B:

For $\frac{a}{L} = 0.5$ FEM $= 0.125 \times 1.5^k \times 31' = 5.81^k$

For $\frac{a}{L} = 0.7$ FEM $= \underset{0.1470}{.0625} \times 1.5^k \times 31' = \underset{6.80}{\underline{2.92}}^{'k}$

Both w $= \frac{1.5^k \times 2}{31} = 97\#/' \times \frac{31'^2}{12} = 11.6^{'k}$



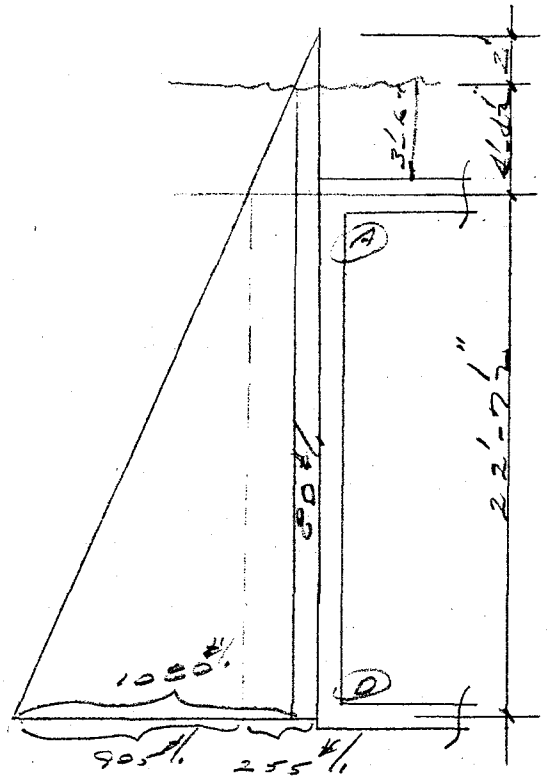
$V_A = V_B = 1.5\left(\frac{29.2}{31} + \frac{23.25}{31}\right) = 3.52^k$

$V_D = 97\#/' \times \frac{31'}{2} - \left(\frac{15.8^{'k} - 5.7^{'k}}{31}\right) = 1.17^k$

$V_E = 1.52 + 0.32 = 1.83^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/26/88 BY EMP	SHT. NO. 13 OF

Soil Pressure on Box



use 40#/' Eq. Fluid Pres.

w = 40#/'x 27' = 1080#/'

Surcharge = 40#/'x 2' = 80#

w. e Lid & Below Grade

w. = 175#/'

Σ = 175#/' + 80#/' = 255#/'

Σ_2 = 1080#/' - 175 = 905#/'

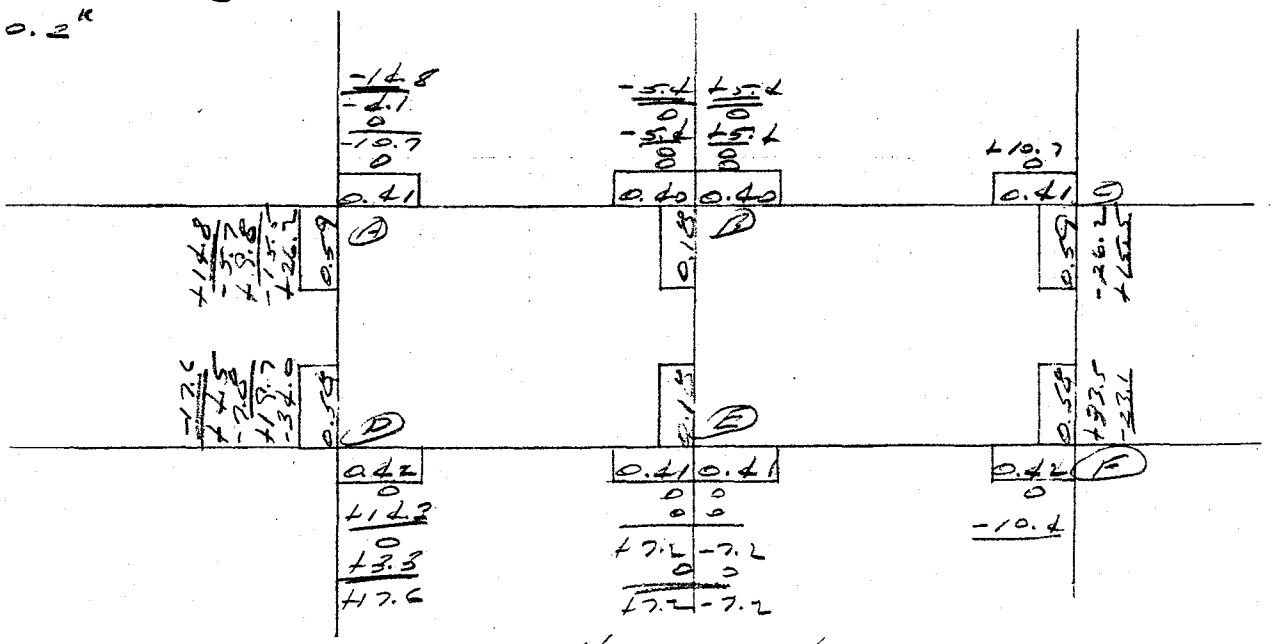
$FEM_{\overline{AD}}$ = 255#/' x $22.63^2/12$ = 10.2'k

$FEM_{\overline{DA}}$ = 905#/' x $22.63^2/20$ = 23.2'k

$FEM_{\overline{DA}}$ = 905#/' x $22.63^2/30$ = 15.4'k

W = 905#/' x 22.63/2

W = 10.2^k



(HM @ E wall = 255#/' x $22.63^2/8$ = 16.32'k

Δ — — = 10.2^k x 22.63 x .125 = 28.55 / 45.87 'k

Net Mom = 45.87'k - (17.6 + 14.8 / 2) = 28.6'k

V @ D = 255#/' x 22.63'/2 + 10.2^k x 15.0 / 22.63 - ΔM/L = 9.52^k

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/9/88 BY EMD	SHT. NO. 14 OF

Load Summaries
- w/3'-3" Fill Above Top Slab -

Joint	Concrete (DL)	Fill on Top of Slab	LL 100#/ft² (Full Ld)	LL 100#/ft² (Partial Ld)	H20-44 on 3' Fill (Partial Ld)	H20-44 on 3' Fill (Full Ld)	Earth Press. w/ 2' Surchg
A	(-)50.0 ok	(-)16.8 ok	(-)3.6 ok	(-)4.6	(-)7.0	(-)3.7	(-)14.8
	(+)17.1	(+)24.3	(+)1.4	(+)6.8	(+)13.1	(+)8.3	(+)10.1
B	(-)126.5	(-)44.4	(-)9.7	(-)5.5	(-)6.6	(-)14.6	(-)5.4
	(+)17.1	(+)26.2	(+)1.4	—	—	(+)8.3	(+)10.1
C	(-)50.0	(-)16.8	(-)3.6	—	(-)1.8	(-)3.7	(-)14.8
(A-D)	(+)19.3	(+)16.8	(+)3.6	(+)4.6	(+)6.8	(+)4.7	(+)29.6
D	(-)33.6	(-)16.8	(-)3.6	(-)4.6	(-)6.5	(-)5.7	(-)17.6
	(+)39.6	(+)24.3	(+)5.4	(+)7.0	(+)4.5	(+)3.3	(+)12.6
E	(-)75.8	(-)44.4	(-)9.7	(-)5.5	(-)7.8	(-)15.8	(-)7.6
	(+)39.6	(+)24.3	(+)5.4	—	—	—	(+)12.2
F	(-)33.6	(-)16.8	(-)3.6	—	—	—	(-)12.2

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/88 BY EMP	SHT. NO. 15 OF

Combination 1 DL+LL(100% on Fill) + Fill + E.P.

U = 1.5D + 1.9L + 1.9 E.P

Joint A: U = 1.5×5.0^k + 1.9×4.6^k + 1.9×16.8^k + 1.9×14.8^k = 78.2

(A-B): U = 1.5×17.1^k + 1.9×6.9^k + 1.9×24.3^k - 1.9×10.1×50% = 75.2

Joint B: U = 1.5×26.5^k + 1.9×19.7^k + 1.9×44.4^k + 1.9×5.4^k = 171.9

(A-D): U = 1.5×19.3^k + 1.9×4.6^k + 1.9×16.8^k + 1.9×29.6^k = 125.7

Joint D: U = 1.5×33.6^k + 1.9×4.6^k + 1.9×16.8^k + 1.9×17.6^k = 124.4

(D-E): U = 1.5×39.2^k + 1.9×7.0 + 1.9×20.8^k + 1.9×12.2^k = 116.9

Joint E: U = 1.5×75.8^k + 1.9×9.7^k + 1.9×44.4^k + 1.9×7.2^k = 230.[illegible]

Combination 2 DL + LL(Fill) + LL(HS20-44) + LL(E.

Joint A: U = 1.5×5.0^k + 1.9×16.8^k + 1.9×17.7^k + 1.9×14.8^k = 101.2^k

(A-B): U = 1.5×17.1^k + 1.9×6.4^k + 1.9×29.2^k + 1.9×10.1^k = 150.6

Joint B: U = 1.5×26.5^k + 1.9×44.4^k + 1.9×32.1^k + 1.9×5.4 = 241.2

(A-D): U = 1.5×19.3^k + 1.9×16.8^k + 1.9×10.4^k + 1.9×29.6 = 137.7

Joint D: U = 1.5×33.6^k + 1.9×16.8 + 1.9×6.9 + 1.9×17.6 = 130.9

(D-E): U = 1.5×39.2^k + 1.9×20.9 + 1.9×12.2^k + 1.9×12.2^k = 144.7

Joint E: U = 1.5×75.8^k + 1.9×44.4 + 1.9×12.9 + 1.9×7.2^k = 236.3

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/84 BY EMP	SHT. NO. 16 OF

Combination 3 DL + LL (H10-44 Truckon slab)

$u = 0.75(1.5D + 1.9L)$

Joint A: $u = 0.75(1.5 \times 5.0^{k} + 1.9 \times 7.0) = 15.6^{k}$

(A-B): $u = 0.75(1.5 \times 17.1^{k} + 1.9 \times 13.1) = 37.8$

Joint B: $u = 0.75(1.5 \times 26.5^{k} + 1.9 \times 14.2) = 50.0^{k}$

(A-D): $u = 0.75(1.5 \times 17.1^{k} + 1.9 \times 6.8^{k}) = 24.9$

Joint D: $u = 0.75(1.5 \times 19.3^{k} + 1.9 \times 6.5^{k}) = 31.0$

(D-E): $u = 0.75(1.5 \times 33.2^{k} + 1.9 \times 4.5^{k}) = 44.3$

Joint E $u = 0.75(1.5 \times 75.8^{k} + 1.9 \times 15.8^{k}) = 107.8$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/88 BY EHP	SHT. NO. 17 OF

Ck Shear on Box

Ref: ACI

$V_u \leq \phi V_n$

$V_n = V_c + V_s \qquad V_s = 0$

$V_n = V_c$

$d_v = \dfrac{V_u}{(\phi)(2\sqrt{f'_c})(b)}$ (slab)

$d_v = \dfrac{V_u}{(\phi)\left[2 + 1\left(+\dfrac{N_u}{2000 A_g}\right)\right](\sqrt{f'_c})(b)}$ (wall)

Combination 1. DL + LL(Fill) + LL(100#/ft on Fill)

Joint A $u = 1.5 \times 2.9^k + 1.9 \times 5.5^k + 1.9 \times 1.27^k = 17.2^k$

Joint B $u = 1.5 \times 4.26^k + 1.9 \times 7.4^k + 1.9 \times 1.33^k = 22.8$

Joint D $u = 1.5 \times 9.03^k + 1.9 \times 6.04 + 1.9 \times 1.27 = 27.21$

Joint E $u = 1.5 \times 11.75 + 1.9 \times 6.98 + 1.9 \times 1.33^k = 33.42^k$

Combination 2. DL + LL(Fill) + LL(H520-44)

Joint A - $u = 1.5 \times 2.9^k + 1.9 \times 5.5^k + 1.9 \times 4.04^k = 22.5^k$

Joint B - $u = 1.5 \times 4.26^k + 1.9 \times 7.4^k + 1.9 \times 2.97 = 26.09$

Joint D - $u = 1.5 \times 9.03 + 1.9 \times 6.04 + 1.9 \times 1.46 = 27.80$

Joint E - $u = 1.5 \times 11.75 + 1.9 \times 6.98 + 1.9 \times 1.50 = 33.75$

Comb. 3 $0.75(1.5D + 1.9L)$ L = H10-44 Truck

Joint A - $u = 0.75(1.5 \times 2.9 + 1.9 \times 2.5) = 6.4^k$

Joint B - $u = 0.75(1.5 \times 4.26^k + 1.9 \times 2.5) = 8.4^k$

Joint D - $u = 0.75(1.5 \times 9.03^k + 1.9 \times 1.45) = 12.23$

Joint E - $u = 0.75(1.5 \times 11.75 + 1.9 \times 1.45) = 15.3$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/02 BY EMP	SHT. NO. 16 OF

Top slab — $d_v = \frac{26,080}{0.85 \times 2\sqrt{4000} \times 12} = 20.2$ 22" OK

1291.3

Bott. slab @ (D) $d_v = \frac{27,800}{K} = 21.5 + 3 = 24.5"$ Say 26"

Bott slab @ (E) $d_v = \frac{33,750}{K} = 26.1 + 3 = 29.1"$ Say 30"

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/88 BY EMP	SHT. NO. 18 OF

Joint A: $M_{Max} = 101.3^{'k}$

$$\frac{M_u}{\phi b d^2} = \frac{101.3^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 281$$

$\rho = 0.006$

$$\rho_{min} = \frac{200}{40000} = 0.0042$$

$$\rho_{Max} = 0.375 \times 0.85 \times \frac{f_c}{f_y} \times \frac{87000}{87000 + 40000}$$

$$\rho_{Max} = 0.175 \frac{f_c'}{f_y} = 0.175 \times \frac{4}{40} = 0.0175$$

For Joint A: $A_s = \rho b d$

$= 0.006 \times 12 \times 20 = \underline{1.44^{in^2}}$

A-B: $M_{Max} = 150.6^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{150.6^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 418$$

$\rho = 0.009$

$A_s = 0.009 \times 12 \times 20 = \underline{2.16^{in^2}}$

Joint B: $M_{max} = 241.6^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{241.6^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 671$$

$\rho = 0.0145$

$A_s = 0.0145 \times 12 \times 20 = \underline{3.48^{in^2}}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/2/88 BY EMP	SHT. NO. 20 OF

(A - D): $M_{Max} = 137.7^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{137.7^{'k} \times 12000}{0.9 \times 12 \times \overline{20}^2} = 383$$

$\rho = 0.005$

$A_s = 0.005 \times 12 \times 20 = \underline{1.92}^{\square''}$ ←

Joint D: $M_{Max} = 130.9^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{130.9^{'k} \times 12000}{.9 \times 12 \times \overline{23}^2} = 274$$

$\rho = 0.005$

$A_s = 0.005 \times 12 \times 23 = \underline{1.38}^{\square''}$ ←

(D - E) $M_{Max} = 144.7^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{144.7^{'k} \times 12000}{0.9 \times 12 \times \overline{19}^2} = 445$$

$\rho = 0.0095$

$A_s = 0.0095 \times 12 \times 19 = \underline{2.16}^{\square''}$ ←

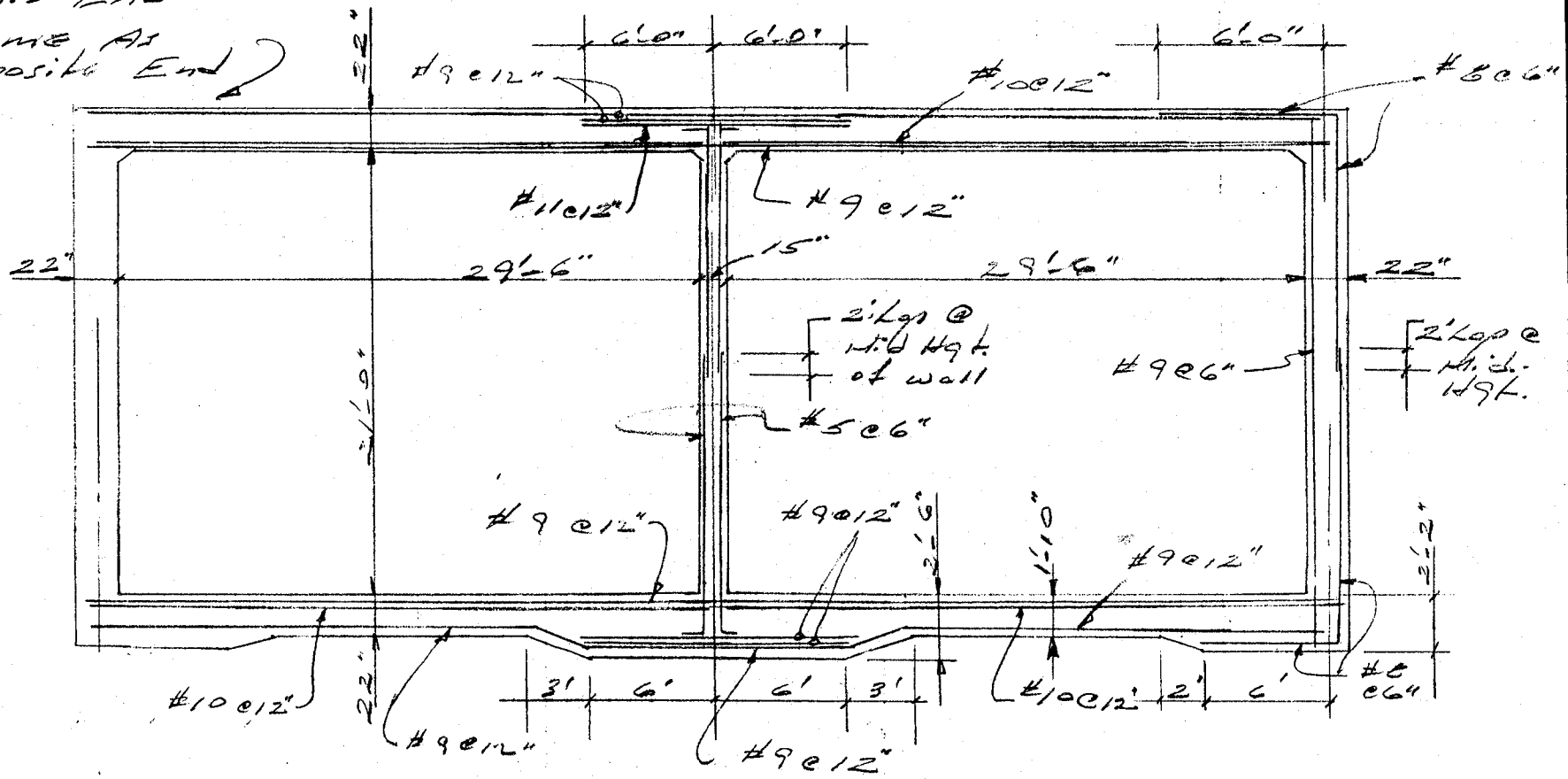
Joint E $M_{Max} = 236.3^{'k}$

$$K = \frac{M_u}{\phi b d^2} = \frac{236.3^{'k} \times 12000}{0.9 \times 12 \times \overline{27}^2} = 360$$

$\rho = 0.008$

$A_s = 0.008 \times 12 \times 27 = \underline{2.60}^{\square''}$ ←

This End
Same As
Opposite End



Box Cross Section

PLUMMER HASAN & ASSOCIATES
CONSULTING ENGINEERS, INC.

ACDC

JOB NO.
DATE 11/6/84
BY EMD

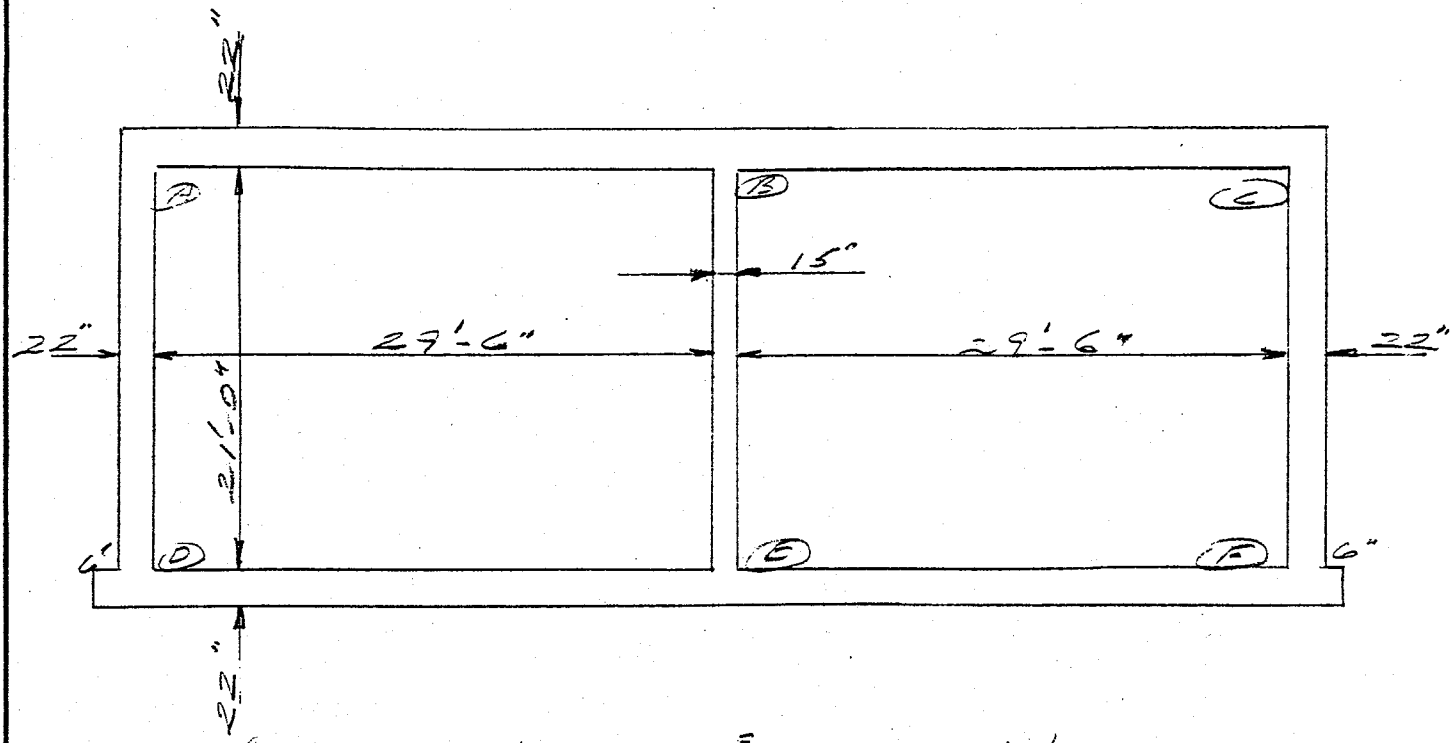
SHT. NO. 21
OF

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/24/88 BY EMP	SHT. NO. 22 OF

Box Culvert Design W 3' Fill

DL Analysis

Concrete DL



I of slab = $\frac{1}{12} \times 12 \times 22^3 = 10,648$ in^4

I of Int. wall = $\frac{1}{12} \times 12 \times 15^3 = 3375$ in^4

I of Both slab = $\frac{1}{12} \times 12 \times 22^3 = 10,648$ in^4

@ Int. wall

$K_{BA} = \frac{10,648}{31} = 343.5 \div 836.7 = 0.41$

$K_{BE} = \frac{3375}{22.54} = 149.7 \div \quad = 0.18$

$K_{BC} = \quad = \frac{343.5}{836.7} \quad = \frac{0.41}{1.00}$

@ Ext. wall

$K_{AB} = 10,648/31 = 343.5 \div 815.9 = 0.42$

$K_{AD} = 10,648/22.54 = \frac{472.4}{815.9} \quad = \frac{0.58}{1.00}$ ✓

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/90 BY E.M.P	SHT. NO. 23 OF

@ Bottom Slab -

Ext. - $K_{DE} = \frac{10,646}{31} = 343.5 \div \Sigma = 0.41$

$K_{DD} = \frac{10,646}{22.54} = \frac{472.4}{815.7} = \frac{0.58}{1.00}$

Int. @ Bottom - $K_{EB} = \frac{3375}{22.54} = 149.7 \div \Sigma = 0.18$

$K_{ED} = \frac{10,646}{31} = 343.5 = 0.41$

$K_{EF} = \frac{10,646}{31} = \frac{343.5}{836.7} = \frac{0.41}{1.00}$

Box wt. -

Top slab - 1.83' x 150#/c.f. x 63.75' = 17.49 K/'

Ext. walls - 1.83' x 21' x 2 x 150#/c.f. = 11.50

Ctr wall - 1.25' x 21' x 150#/c.f. = 3.93

Bott. slab - 1.83 x 64.9' x 150#/c.f. = 17.52

50.74 K/'

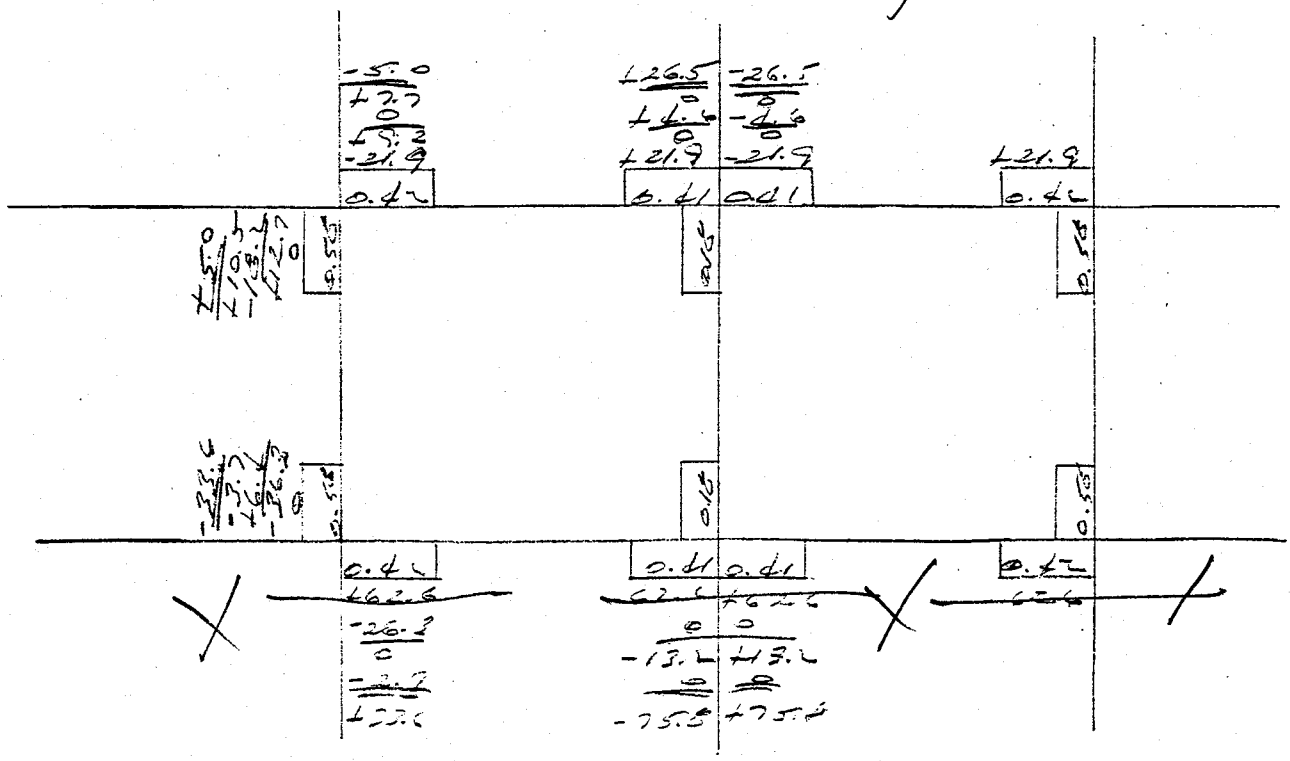
w = 50.74 K/' / 64.9' = 0.78 K/'

Bot Slab: 1.85 x .15 = -.251

.531

$FEM_{A-B,\ B-A} = 2.74\ K/' \times 31^2/12 = 21.9'K$

$FEM_{D-E,\ E-F} = \cancel{0.78\ K/' \times 31^2/12 = 62.5'K}$



(+) $M_{A-D} = (+)19.3'K$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 10/25/86 BY EMP	SHT. NO. 24 OF

(4) M_{A-B}, $B-C$ = $274^{\#}/_{ft} \times 31^2/8 - \left(\frac{5.0^{'k} + 26.5^{'k}}{2}\right)$

= $32.9^{'k} - 15.8^{'k}$

= $\underline{17.1^{'k}}$

V_A = $274^{\#}/_{ft} \times \frac{31'}{2} - \left(\frac{26.5^{'k} - 5.0^{'k}}{31'}\right)$

= $4.25^k - 0.70$

= $\underline{3.6^k} - 0.274^k/_{ft} \times 2.5' = \underline{2.91^k}$

V_B = $274^{\#}/_{ft} \times \frac{31'}{2} + 0.70$

= $4.25 + 0.70$

= $\underline{4.95^k} - 0.274^k/_{ft} \times 2.5 = \underline{4.26^k}$

(4) M_{D-E}, $E-F$ = $782^{\#}/_{ft} \times 31^2/8 - \left(\frac{75.6^{'k} + 33.6^{'k}}{2}\right)$

= $93.9^{'k} - 54.6$

= $39.2^{'k}$

V_D = $782^{\#}/_{ft} \times \frac{31'}{2} - \left(\frac{75.6^{'k} - 33.6}{31'}\right)$

V_D = $12.12 - 1.36$

V_D = $10.76^k - 0.782^k/_{ft} \times \frac{26.5''}{12} = \underline{9.03^k}$

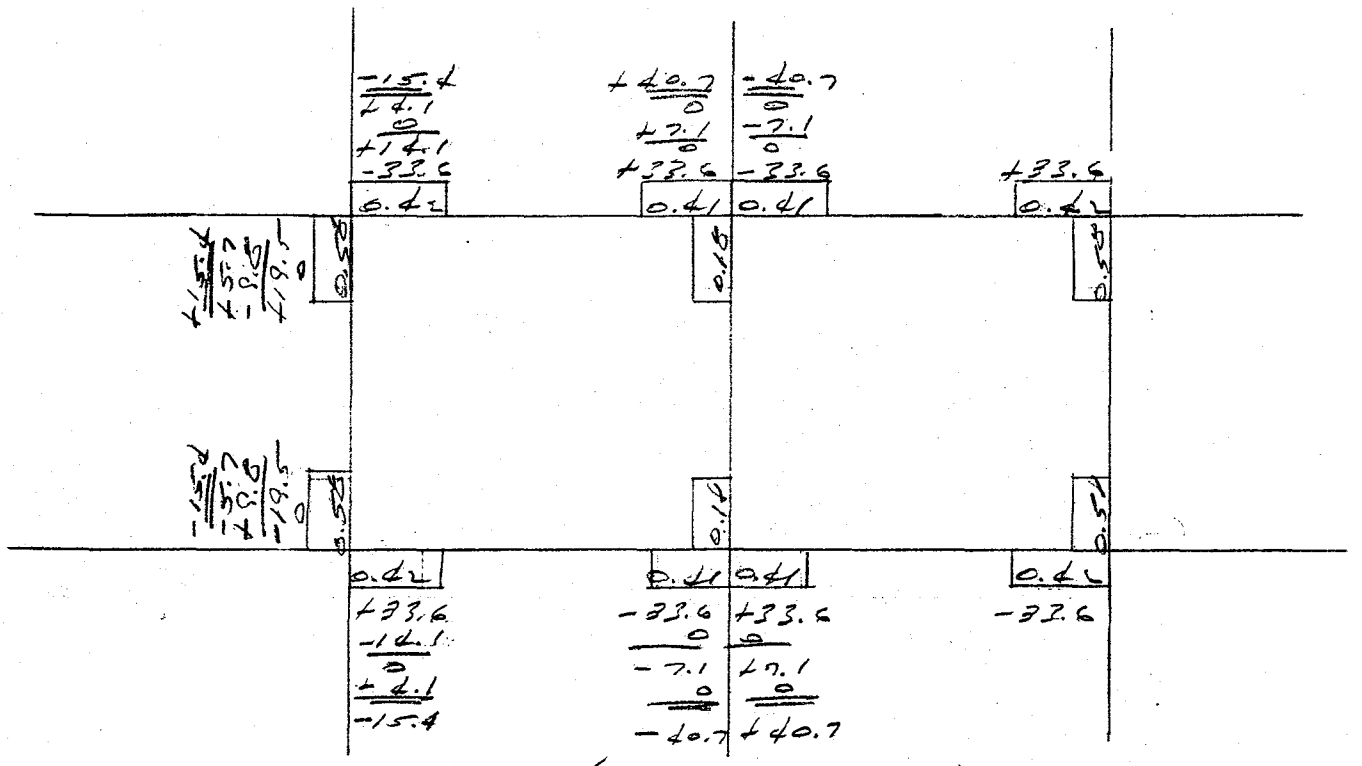
V_E = $12.12 + 1.36$

V_E = $13.48^k - 0.782^k/_{ft} \times \frac{26.5''}{12} = \underline{11.75^k}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/9/88 BY EMP	SHT. NO. 25

L.L. – 700 Fill on Box
(use Fill wt. = w. 140#/c' × 3.0' = 420#/'

FEM = 420#/' × 31²/12 = 33.6'k



(+) M_{A-B} 420#/' × 31²/8 − (40.7'k + 15.4'k)/2

(+) M = 50.5'k − 28.0'k

M = 22.5'k

V_A = 420#/' × 31'/2 − (40.7'k − 15.4'k)/31 = 5.69 − 0.420 × 2.5 = 4.

V_B = 420#/' × 31'/2 + — = 7.33'k − 420 × 2.5 = 6.

(+) M_{DE} = 420#/' × 31²/8 − (40.7'k + 15.4'k)/2

= 50.4'k − 28.0'k = 22.4'k

V_D = 420#/' × 31/2 − (40.7'k − 15.4'k)/31

= 7.59 − 0.33 = 5.69'k − 0.42'k/' × 26.5/12 = 4.6'k

V_E = 420#/' × 31'/2 + 0.33 = 6.51'k − 0.42'k × 26.5/12 = 5.5

(+) M_{AD} = (+) 15.4

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	A<D C	JOB NO. DATE 11/9/88' BY EMP	SHT. NO. OF 26

HS20-44 (Parallel to Box)

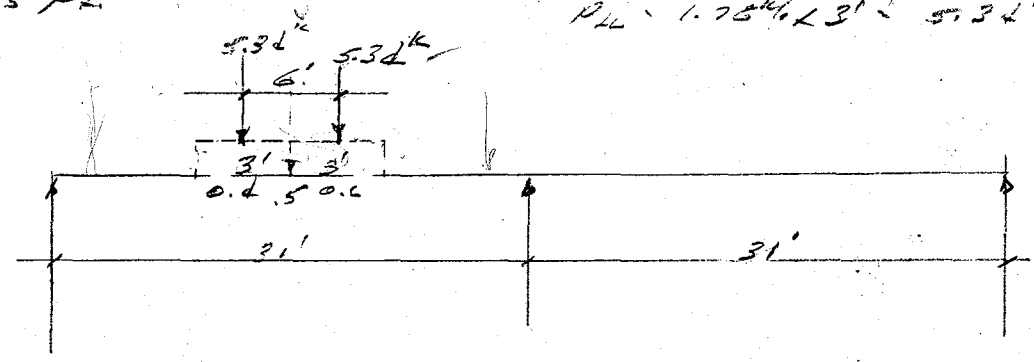
on 3' Fill

Pos. Mom
e 0.5 PL

wheel Ld = 16^k (No Impact)

$P_{LL} = 16^k / 3' \times 3' = 1.78^k/ft^2$

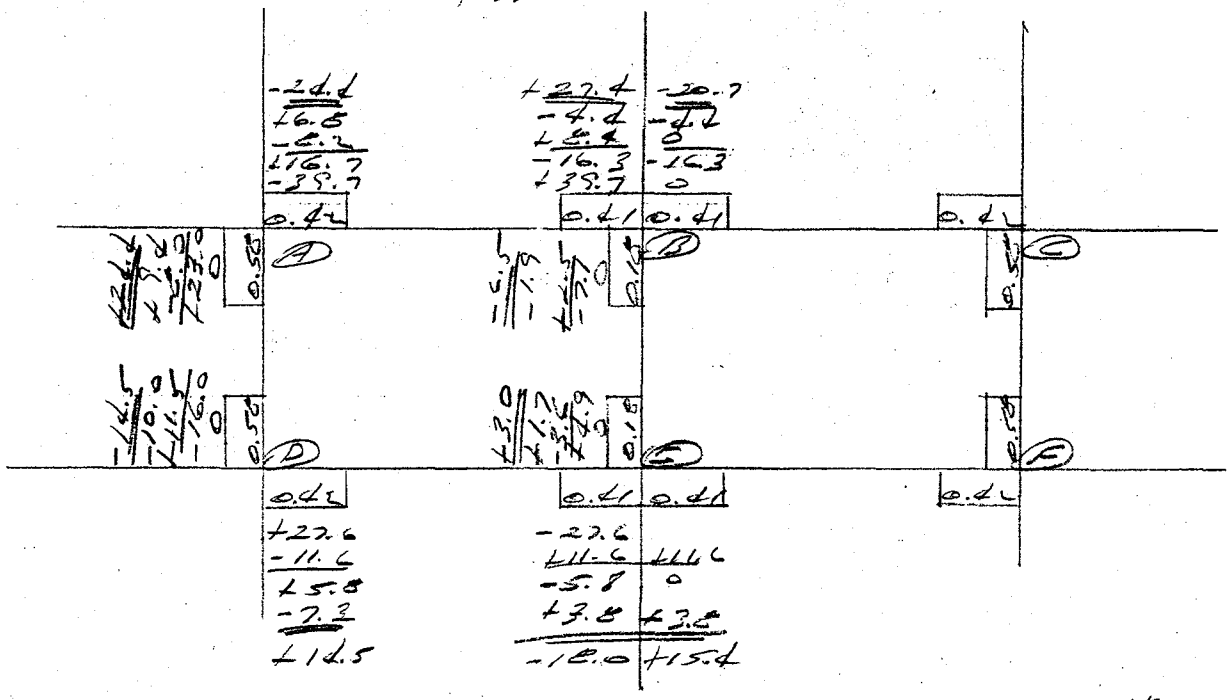
$P_{LL} = 1.78^k/ft^2 \times 3' = 5.34^k$



For $\frac{a}{L} = 0.4$ FEM = $0.1440 \times 5.34^k \times 31' = 23.6^{'k}$ (.096 / 15.9)

FEM = $.096 \times 5.34^k \times 31' = 15.9^{'k}$ (0.1440 / 23.6)

Bottom - $5.34^k \times 2/31' = 345^{\#}/'$ FEM = $345 \times 31^2/12 = 27.6'$



(+) $M_{A-B} = 5.35^k \times \frac{12.4 \times 18.6}{31} = 39.8^k \times \frac{15.5}{18.6} \times 2 = 66.3^{'k}$

(-) $\left[\frac{27.4 \times 2.4}{2}\right] = 25.9$ (40.4'k)

(+) $M_{D-E} = 345^{\#}/' \times 31^2/8 - \left(\frac{14.5^{'k} + 18.0^{'k}}{2}\right) = 25.1^{'k}$

$V_{A-B} = 5.34^k\left(\frac{29.25}{31} + \frac{23.25}{31}\right) = 9.02^k \div 5' \text{ Dist} = 1.80^k/'$

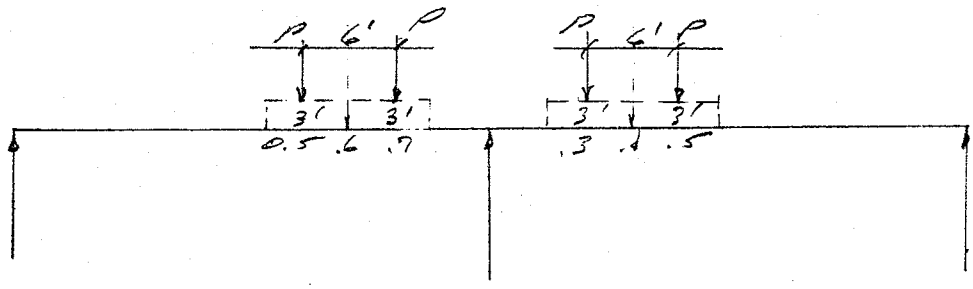
$V_D = 345^{\#}/' \times 31'/2 - \left(\frac{18 - 14.5}{31}\right) = 5.26^k/5' = 1.05^k$ $V_E = 5.46^k/5' = 1.10^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/9/84 BY EMP	SHT. NO. OF 27

(HS20-44 Truck on 3' Fill)

Neg. Mom

P = 5.34k

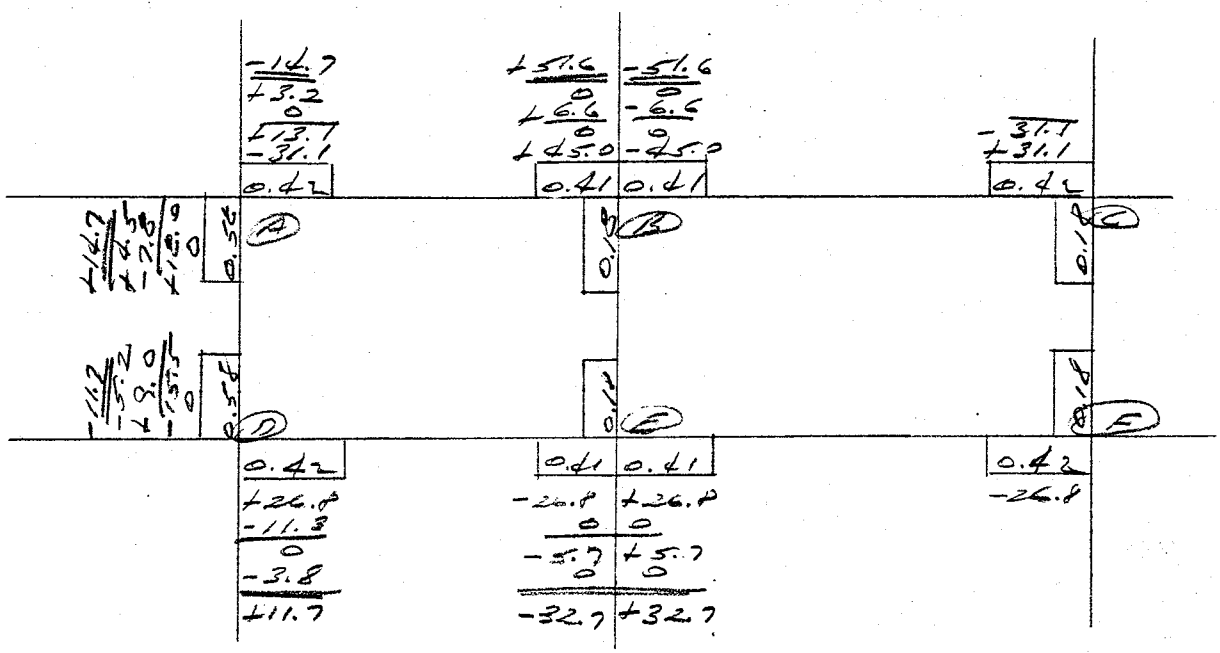


For $\frac{a}{L} = 0.5$ FEM = .125 × 5.34k × 31' = 20.7'k

For $\frac{a}{L} = 0.7$ FEM = $\frac{.0628}{0.1470}$ × 5.34k × 31' = $\frac{10.4'k}{24.3}$

Bottom w = 5.34k × 4/63.75' = 335#/'

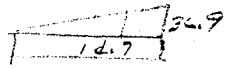
FEM = 335#/' × $31^2/12$ = 26.8'k



PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/6/88 BY EMP	SHT. NO. 28 OF

HS20-44 Ldg. Cont
(Neg. Mom Cont.)

(+) M_{A-B} = $5.34^k \times 31'/4 + 5.34^k \times \frac{21.7' \times 9.3}{31} \times \frac{15.5}{21.7} = 66.2'^k$



$(-)\ 36.9'^k \times 2 \times (22.1'^k + 14.7) \times (-)\ \frac{36.5}{29.4'^k}$

$V_A = V_B = 5.34^k + \left(\frac{29.45}{31} + \frac{23.3}{31}\right) = 9.02^k$

(+) $M_{D-E} = 335^{\#}/ft \times 31^2/8 - \left(\frac{32.7'^k + 11.7'^k}{2}\right) = 18.0'^k$

$V_D = 335^{\#}/ft \times \frac{31'}{2} - \Delta M/L$

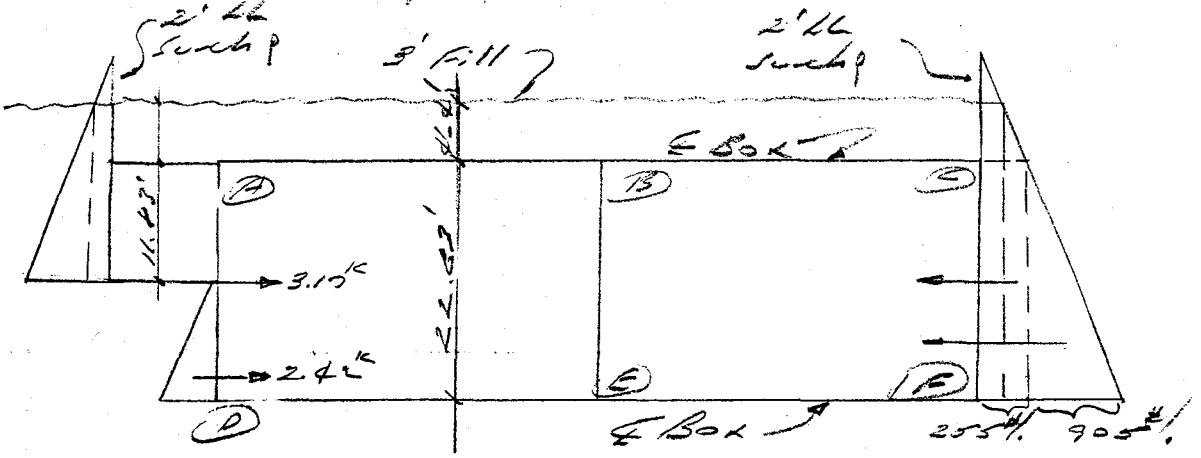
$V_D = 4.57^k/st = 0.80^k$

$V_E = 335^{\#}/ft \times \frac{31'}{2} + \Delta M/L$

$V_E = 5.87^k/st = 1.17^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/15/84 BY EMD	SHT. NO. OF 29

Box w/underpass one side & fill other side



At underpass -

@ A FEM = $\frac{3.17^k \times 11.83' \times 11^2}{22.83^2}$ = 5.71'k

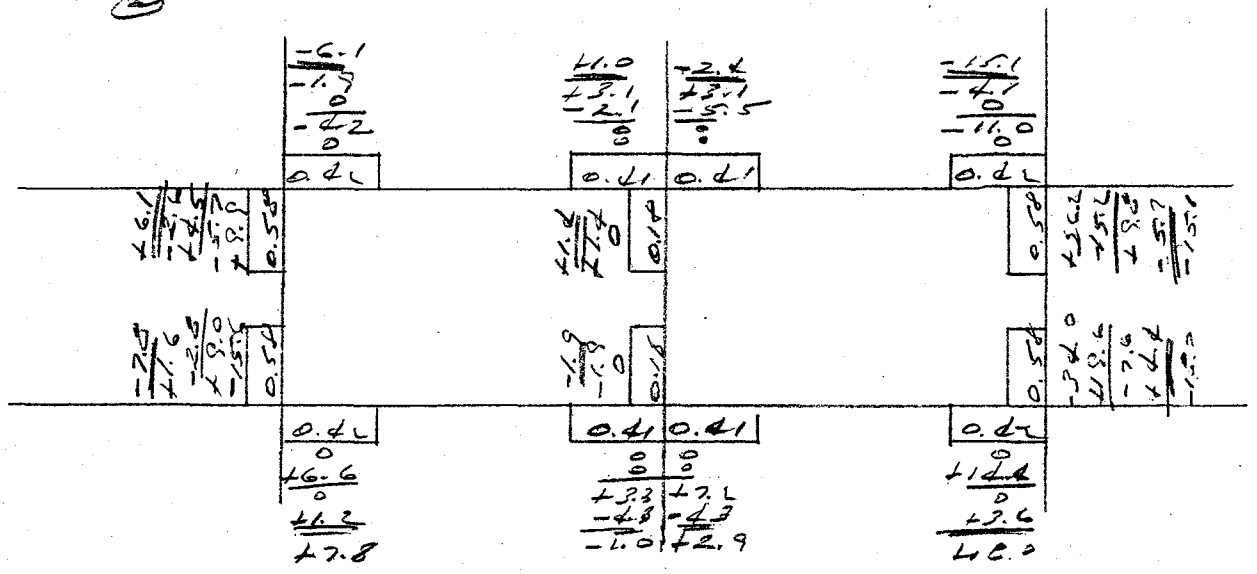
FEM = $\frac{2.42^k \times 3.67^2 \times 18.16}{22.83^2}$ = 1.20'k

@ D FEM = $\frac{3.17^k \times 11.83^2 \times 11}{22.83^2}$ = 9.36'k

FEM = $\frac{2.42^k \times 3.67' \times 18.16^2}{22.83^2}$ = 6.26

FEM @ C = 26.2'k

FEM @ D = 34.0



PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/16/88 BY EHP	SHT. NO. OF 30

(H) M_{A-D} : $3.17^{k} \times \frac{11.83' \times 11.0}{22.83} = 14.07'^{k}$

$+ 2.42^{k} \times \frac{3.67' \times 19.16}{22.83} \times \frac{11.83}{19.16} = \frac{4.60}{22.67}$

$(-)\left[\frac{6.1'^{k} + 3.6'^{k}}{2}\right] = \frac{6.85}{15.72'^{k}}$

(H) M_{C-E} : $255^{\#}/_{k} \times \frac{22.83^{2}}{8} = 16.6'^{k}$

$\frac{905^{\#}/_{k} \times 22.83}{2} \times \frac{3.61' \times 15.2}{22.83} \times \frac{16.2}{15.2} = \frac{3.8}{20.4'^{k}}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/12/88 BY EMP	SHT. NO. OF 31

Comb. 1 - DL + LL(Fill) + LL(HS20-44 Truck)

Joint A - $U = 1.5 \times 2.91^k + 1.9 \times 4.6^k + 1.9 \times 1.60 = 16.53^k$

Joint B - $U = 1.5 \times 4.20 + 1.9 \times 6.3^k + 1.9 \times 1.60 = 21.8$

Joint D - $U = 1.5 \times 9.03 + 1.9 \times 4.66^k + 1.9 \times 1.10 = 24.49$

Joint E - $U = 1.5 \times 11.75 + 1.9 \times 5.50 + 1.9 \times 1.17 = 30.45$

Top slab - $d = \frac{V_u}{\phi 2\sqrt{f'_c}\, L}$

$= \frac{21,800}{0.85 \times 2 \times \sqrt{4000} \times 12} = 16.6''$

use 22"

Bottom slab @ Joint D - $d = \frac{24,490}{k} = 18.9$

cover + 3.0

20.9 use 22

Bott. slab @ Joint E - $d = \frac{30,450}{k}$

$d = 23.6$

Cover + 2.0

25.6 use 26"

For U = 1.5 DL + 1.9(Fill + E.P. + HS20-44 Truck)

Joint A:

$M = 1.5 \times 5.0^{'k} + 1.9(15.4^{'k} + 6.1^{'k} + 24.4^{'k}) = (+)94.7^{'k}$

$(+)M_{(A-B)} = 1.5 \times 17.1^{'k} + 1.9(22.5^{'k} - 7.0^{'k} \times .50 + 40.4) = (+)138.4^{'k}$

Joint B:

$M = 1.5 \times 26.5^{'k} + 1.9(40.7^{'k} + 24^{'k} + 51.6^{'k}) = (-)219.7^{'k}$

$(+)M_{B-C} = 1.5 \times 17.1^{'k} + 1.9(22.5^{'k} - 17.6^{'k} \times .5 + 40.4^{'k}) = 128.4^{'k}$

Joint C

$M = 1.5 \times 5.0^{'k} + 1.9(15.4^{'k} + 15.1^{'k} + 24.4^{'k}) = 111.8^{'k}$

$(+)M_{A-D} = 1.5 \times 19.3 + 1.9(22.4^{'k} + 4.4 + 18.0^{'k}) = 114.0^{'k}$

Joint D

$M = 1.5 \times 33.6^{'k} + 1.9(15.4^{'k} + 7.8 + 14.5^{'k}) = 122.0^{'k}$

$(+)M_{D-E} = 1.5 \times 39.2^{'k} + 1.9(22.4^{'k} + 4.4^{'k} + 25.1^{'k}) = 157.4^{'k}$

Joint E

$M = 1.5 \times 33.6^{'k} + 1.9(40.7^{'k} + 28 + 32.7^{'k}) = 195.3^{'k}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/16/2001 BY EMP	SHT. NO. 33 OF

Stl. Reqments

Joint (A) $K = \frac{M_u}{\phi b d^2} = \frac{94.7^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 263$

$A_s = 0.0055 \times 12 \times 20 = 1.32^{\square''}$

(+) A-B $K = \frac{138.4^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 384$

$A_s = 0.0060 \times 12 \times 20 = 1.92^{\square''}$

Joint (B) $K = \frac{298.7^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 608$

$A_s = .0135 \times 12 \times 20 = 3.24^{\square''}$

(+) B-C $K = \frac{128.4^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 357$

$A_s = 0.0075 \times 12 \times 20 = 1.80^{\square''}$

Joint (C) $K = \frac{111.8^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 310$

$A_s = .0065 \times 12 \times 20 = 1.56^{\square''}$

(+) A-D $M_u = 11k$ use $1.56^{\square''}$

Joint (D) $K = \frac{122^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 338$

$A_s = .0075 \times 12 \times 20 = 1.80^{\square''}$

(+) D-E $K = \frac{157.4^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 437$

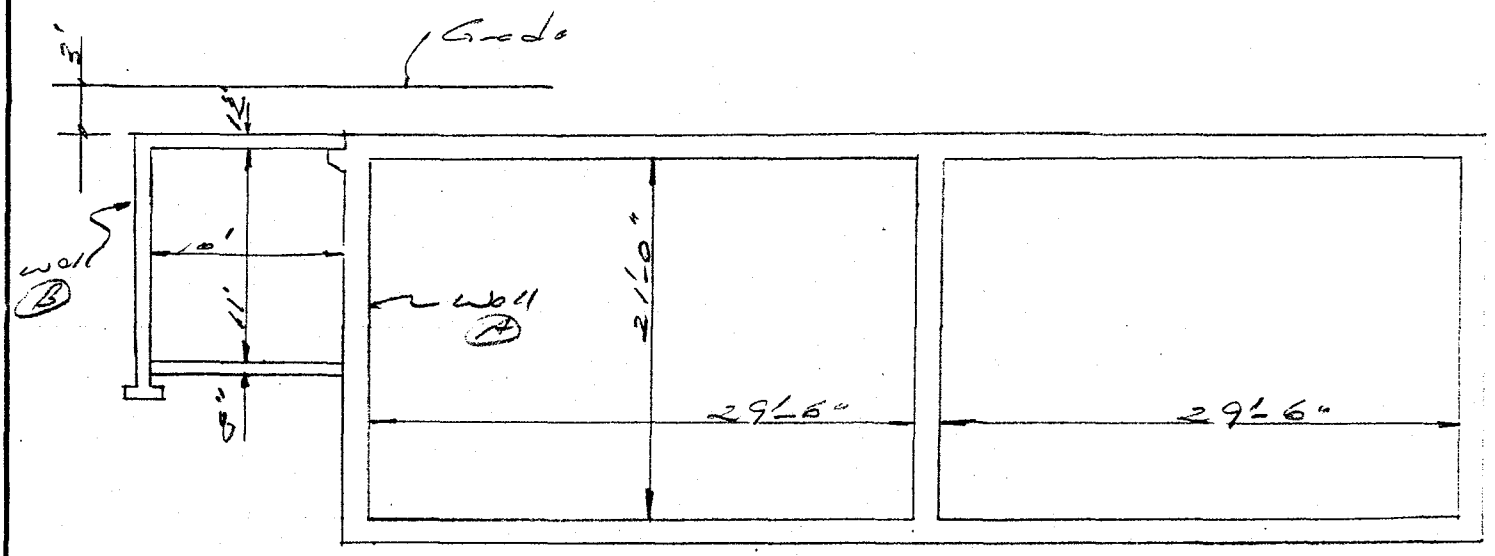
$A_s = .0095 \times 12 \times 20 = 2.28^{\square''}$

Joint (E) $K = \frac{195.3^{'k} \times 12000}{0.9 \times 12 \times 20^2} = 543$

$A_s = 0.012 \times 12 \times 20 = 2.88^{\square''}$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/10/88 BY EMP	SHT. NO. 34 OF

Box @ Pedestrian underpass

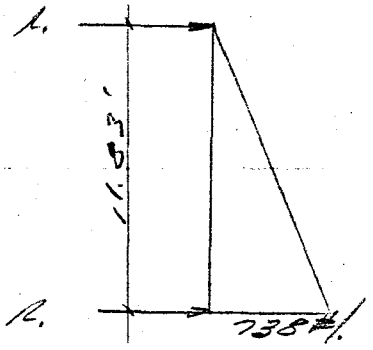


wall (A) Design (w/Channel Full) – $w = 62.4\,\#/\text{cf} \times 11.83' = 738\,\#/'$

$P = 738\,\#/' \times \frac{11.83'}{2} = 4.36^k$

$R_1 = 4.36^k \times 3.94'/11.83 = 1.45^k$

$R_2 = 4.36^k \times 7.89/11.83 = 2.91^k$



$V = 0 @ 1250 = \left(\frac{738x}{11.83}\right)\left(\frac{x}{2}\right)$

$1250 = \frac{738x^2}{23.7}$

$x^2 = \frac{1250 \times 23.7}{738} = 40.57$

$x = 6.42'$

$M = 1250^k \times 6.42' - \left(\frac{738 \times 6.42}{11.83}\right)\left(\frac{6.42}{2}\right)\left(\frac{6.42}{3}\right)$

$M = 8.03^{'k} - 3.29$

$M = 6.60^{'k}/'$

$K = \frac{M_u}{\phi b d^2} = \frac{6.6^{'k} \times 1.8 \times 1200}{0.9 \times 12 \times 50^2} = 25$ (use min)

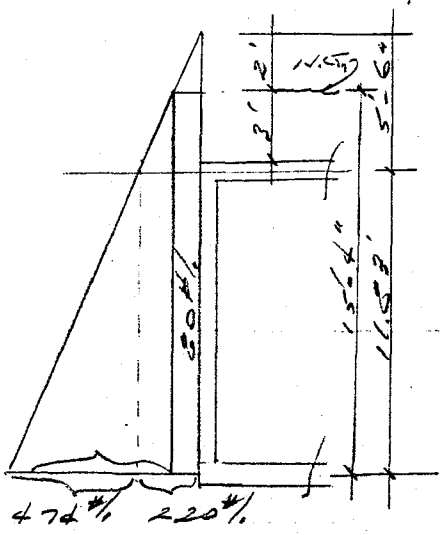
$A_s = .004 \times 12 \times 50 = 1.01^{\square''}$ – use #6 @ 6" –

$1.58^{\square''} > 1.01^{\square''}$

ok

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/10/88 BY EMP	SHT. NO. 35 OF

wall @ Pod underpass w/ 3' Fill + 2' LL. surcharge



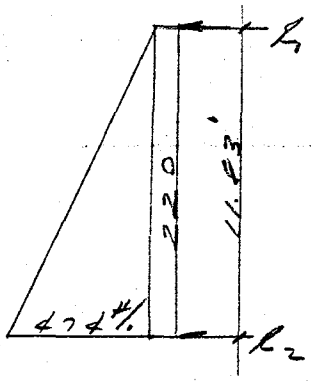
$w = 40\#/'' \times 15.33' = 614\#/'$

$w_1 = 3'\text{-}6''$ Below Grade

$= 3.5' \times 40\#/' = 140\#/'$

$\Sigma w_1 = 140\#/' + 80 = 220\#/'$

$\Sigma w_2 = 614\#/' - 140\#/' = 474\#$



$R_1 = 220\#/' \times \frac{11.83'}{2} + 472\#/' \times \frac{11.83'}{2} \times \frac{3.94}{11.83}$

$R_1 = 1.30 + 0.935 = 2235\#$

$R_2 = 1300 + 1869 = 3169\#$

$V = 0 @ \; 2235 - 220x - \left(\frac{472x}{11.83}\right)\left(\frac{x}{2}\right)$

$2235 - 220x - \frac{472x^2}{23.7}$

$2235 = 220x - 19.9x^2$

$x^2 + 11.1 = 112.9$

$(x + 5.55)^2 = 112.9 + 30.8 = 143.7$

$x + 5.55 = 12.0$

$x = 6.52'$

$M = 2235\# \times 6.52' - 220 \times \frac{6.52^2}{2} - \left(\frac{472 \times 6.52}{11.83}\right)\left(\frac{6.52}{2}\right)\left(\frac{6.52}{3}\right)$

$M = 14.57'^k - 4.68'^k - 1.85$

$M = 8.04'^k/'$

$\frac{M_u}{\phi b d^2} = \frac{8.0\,d'^k \times 1.8 \times 12000}{0.9 \times 12 \times 10^2} = 170$ use M_{min}

$A_s = 0.0042 \times 12 \times 10 = 0.50\,\square''/'$

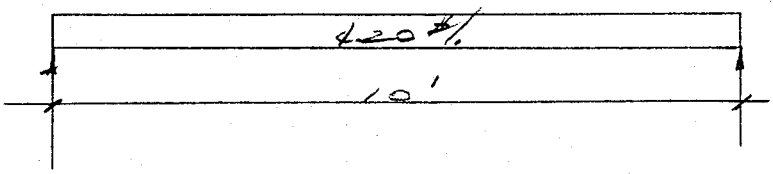
use #5 @ 7"

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/10/84 BY EMP	SHT. NO. 36 OF

Pedestrian underpass Roof

Fill

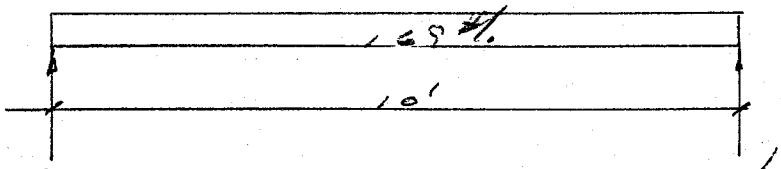
Fill = 140#/c.f. × 3' = 420#/'



M = 420#/' × 10²/8 = 5.25'k
R = 420#/' × 10'/2 = 2.1k

Slab DL

For 13½ slab
w = 169#/'



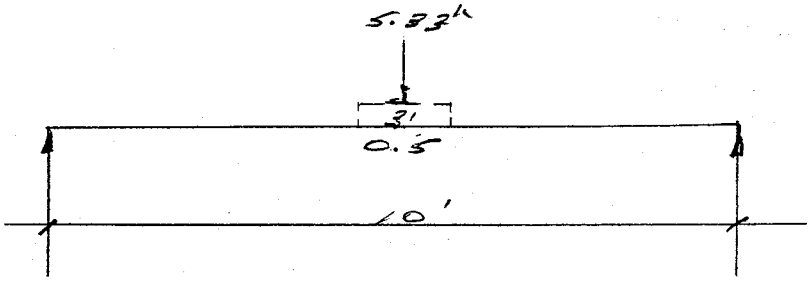
M = 169#/' × 10²/8 = 2.11'k/'
R = 169#/' × 10'/2 = 845#/'

LL

P = 16k / 3k 3' = 1.78k/'

For 1' sect P = 1.78k/' × 3' = P = 5.33k

No Impact since soil d > 2'



M_{LL} = 5.33k × 10'/4 = 13.3'k

V_{max} = 5.33k × 9.167/10 = 4.89k

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/10/88 BY EMP	SHT. NO. 37 OF

Comb. 1

$V_u = 1.5D + 1.8L$

$V_u = 1.5 \times 0.85^k + 1.8 \times 2.1^k + 1.8 \times 4.68^k$

$V_u = 1.28 + 3.78 + 8.28$

$V_u = 16.56^k$

$d_v = \frac{V_u}{(\phi)(2\sqrt{f'_c})(b)} = \frac{16,560}{0.85 \times 2 \times \sqrt{4000} \times 12}$ = 11.26

+ 2.00

13.26

use 13.5"

Steel Design

$u = 1.5D + 1.8L$

$u = 1.5 \times 2.11^k + 1.8(5.25^k + 4.68^k)$

$u = 22.5^k$

$K = \frac{M_u}{\phi b d^2} = \frac{22.5^k \times 12000}{0.8 \times 12 \times 11.5^2}$

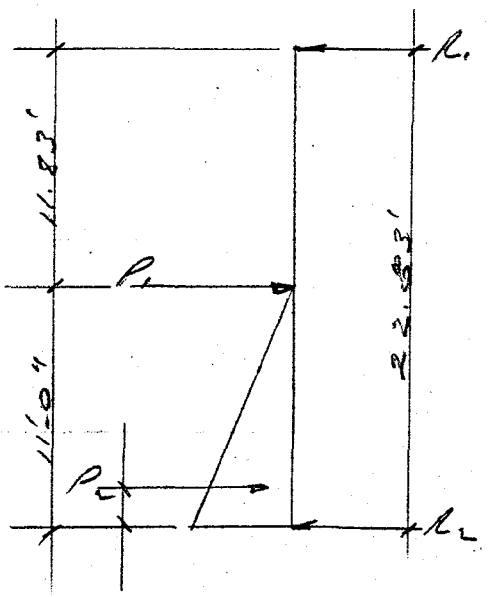
$K = 188$ — use Min.

$\rho = 0.0042 \times 12 \times 11.5" = 0.58 in^2/ft$

use 13½" slab w/ #6 @ 8"

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/10/88 BY EMD	SHT. NO. 38 OF

CK Conc. Ld on Channel wall w/ Conc. Ld. From Ped. underpass. w/ Channel Empty.



P_1 (Ped. underpass) = 2.91 k/'

$w = 40\,\#/'' \times 11' = 440\,\#/'$

$P_2 = 440\,\#/' \times \frac{11'}{2} = 2.42\,k/'$

$R_1 = 2.91^k \times \frac{11}{22.83} + 2.42^k \times \frac{3.47}{22.83}$

$R_1 = 1.404 + 0.39 = \underline{1.79^k}$

$R_2 = 2.91^k \times \frac{11.83}{22.83} + 2.42 \times \frac{19.16}{22.83}$

$R_2 = 1.51 + 2.03 = \underline{3.54^k}$

$M_u = 1.79^k \times 1.8 \times \frac{11.83' \times 11.0'}{22.83}$

$M_u = 19.40'^k$

$d = \frac{3.54^k \times 1.8 \times 1000}{0.85 \times 2 \times \sqrt{4000} \times 12}$ = 5.21" d-ok

$K = \frac{M_u}{\phi b d^2} = \frac{19.40'^k \times 1.8 \times 12000}{0.9 \times 12 \times 20^2} = 104$

use Min.

$A_s = 0.004 \times 12 \times 20 = 1.01^{in^2}$

	use #7 @ 7"	

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/11/88 BY EMP	SHT. NO. 39 OF

Footing for Pedestrian overpass

Fill = 120#/cf × 10'/2 = 2.10 k/'
D.L. slab = 169#/cf × 10'/2 = 0.85
wall = 1' × 13.67' × 150 = 2.05
LL = 5.33
10.33 k/'
Ftg. wt. 0.80
11.13 k/'/3.0 k/' = 3.71' use 4' ftg.

use pad
4' × 10" w/
#5 @ 12" Transv.
5-#5 Long

Corbel Design

V (Fill) = 2.10k × 1.9 = 3.99k
V (DL) = 0.85k × 1.5 = 1.28
V (LL) = 5.33k × 1.9 = 10.13
15.40k — Vu

$d = \frac{V_u}{(\phi)(2\sqrt{f'_c})(b)} = \frac{15,400}{0.85 \times 2 \times \sqrt{4000} \times 12} = 11.9$

say 12
cover 2
14

use 6" Corbel
Mu = 15.4k × 4" = 61.6 "k

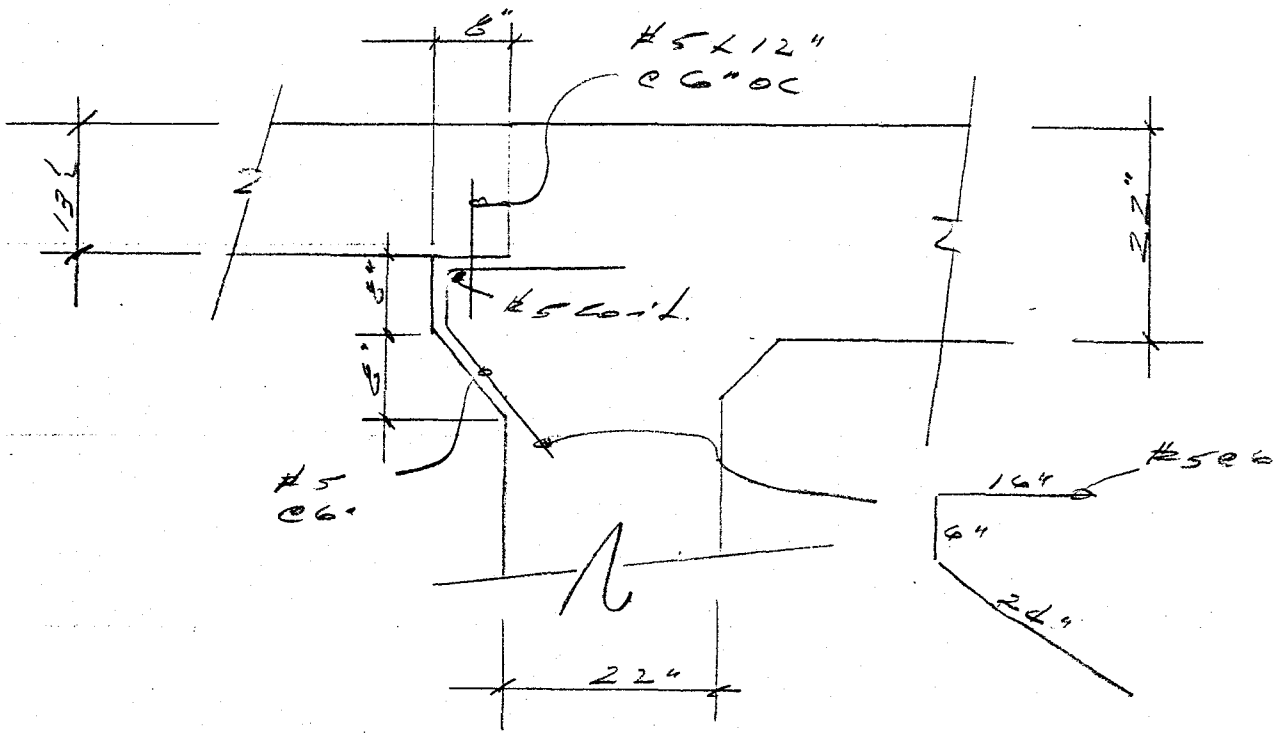
$A_s = \frac{M_u}{\phi f_y j d} = \frac{61.6}{0.9 \times 40 \times 0.9 \times 12} = 0.13 \text{ in}^2$

Shear Reinf.

$A_v = \frac{V_u}{\phi f_y u} = \frac{15.4k}{0.85 \times 40 \times 1.4} = \frac{0.27}{0.40} \text{ in}^2$

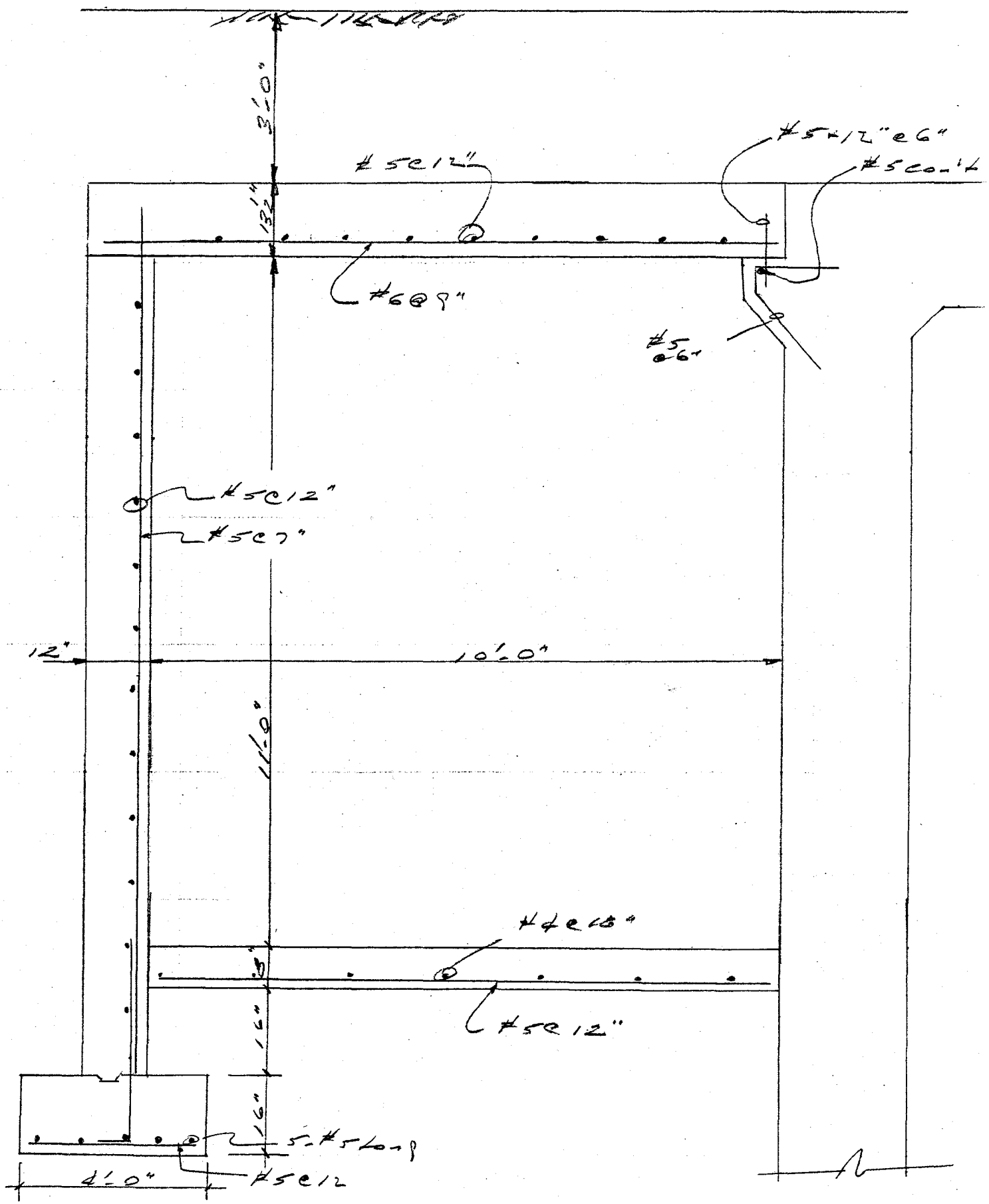
Min $A_s = .04 f'_c / f_y = .04 \times 4/40 = .00333$
$A_s = .00333 \times 12 \times 12 = 0.479 \text{ in}^2$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/11/85 BY EMP	SHT. NO. 40 OF



Corbel Detail

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/11/88 BY EMP	SHT. NO. 41 OF



PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/11/88 BY EMP	SHT. NO. 42 OF

Box w/ vert. Load from underpass

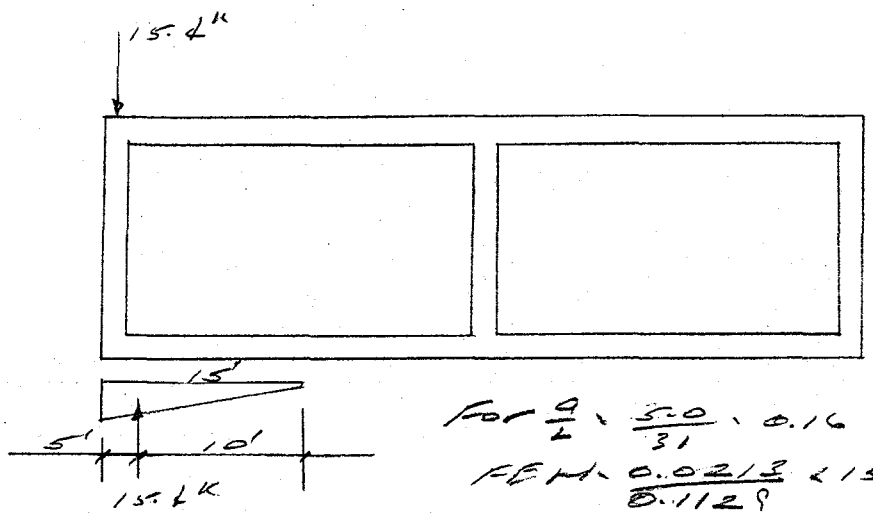
Conc Load from underpass –

Fill: $R = 2.1^k \times 1.9 = 3.99^k$

Slab DL: $R = 0.845 \times 1.5 = 1.27$

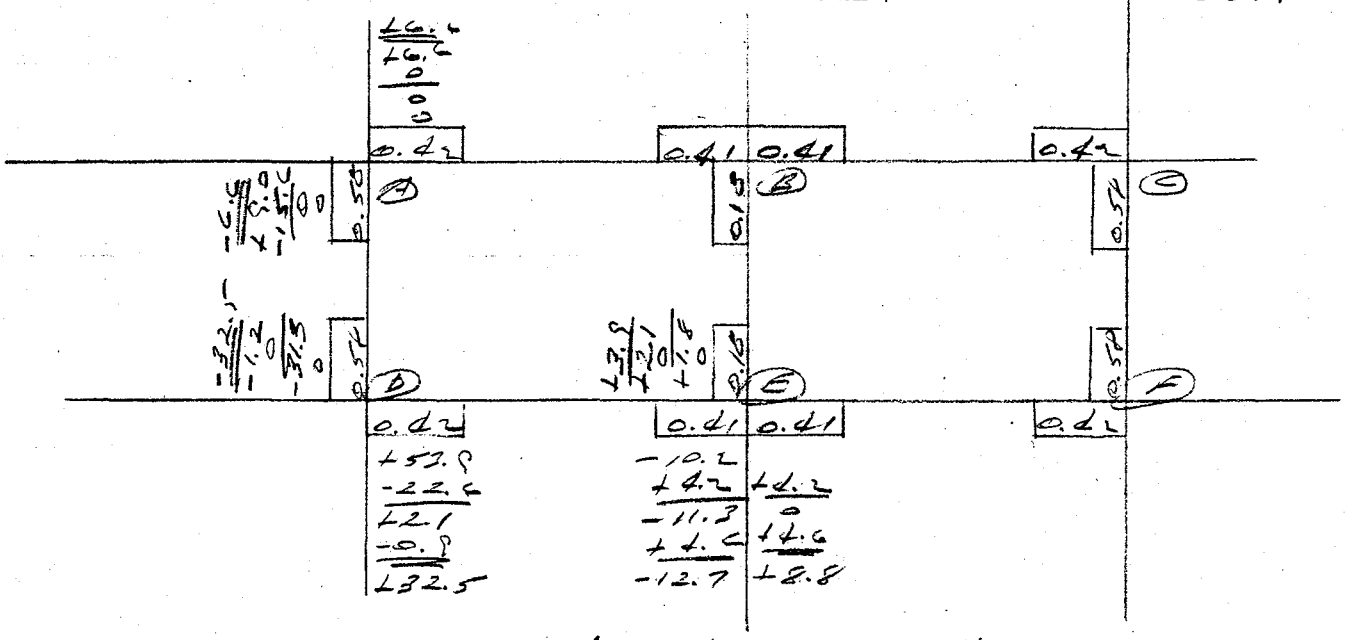
LL: $5.33^k \times 1.9 = 10.13$

15.39^k



For $\frac{a}{L} = \frac{5.0}{31} = 0.16$

$FEM = \frac{0.0213}{0.1129} \times 15.4^k \times 31' = \frac{10.2'^k}{53.9}$



(4) $M_{D-E} = 15.4^k \times \frac{5' \times 26'}{31} = 64.6'^k \times \frac{15.5}{26'} = 38.6'^k$

$V_D = 15.4^k \times \frac{26.0}{31} = 12.9^k$

PLUMMER HASAN & ASSOCIATES CONSULTING ENGINEERS, INC.	ACDC	JOB NO. DATE 11/14/88 BY EMP	SHT. NO. 43 OF

ck slab @ D w/ overpass Loads

V_D (see sht 17) = 27.8^k

overpass V_D = 12.9 / 40.7^k

$d_v = \frac{V_u}{\phi 2\sqrt{f'_c}\, b} = \frac{40{,}700}{0.85 \times 2 \times \sqrt{4000}\ \text{psi} \times 12}$ = 31.5"

42.0 cov
33.5

(-) M_{OD} = 130.9^k

overpass M = 32.5 / 163.4

(+) M_{D-E} = 144.7^k

overpass M = 38.6 / 183.3

@ D ~ $K = \frac{M_u}{\phi b d^2} = \frac{163.4^k \times 12{,}000}{0.9 \times 12 \times 31.5^2} = 183$

A_s = 0.0042 × 12 × 31.5" = 1.58 □"

use #9 @ 6"

+ M_{D-E} = 183.3^k

$K = \frac{183.3^k \times 12000}{0.9 \times 12 \times 19^2} = 562$

A_s = 0.0142 × 12 × 19 = 2.72 □"

use #11 @ 12" Alt w/ #10 @ 12"

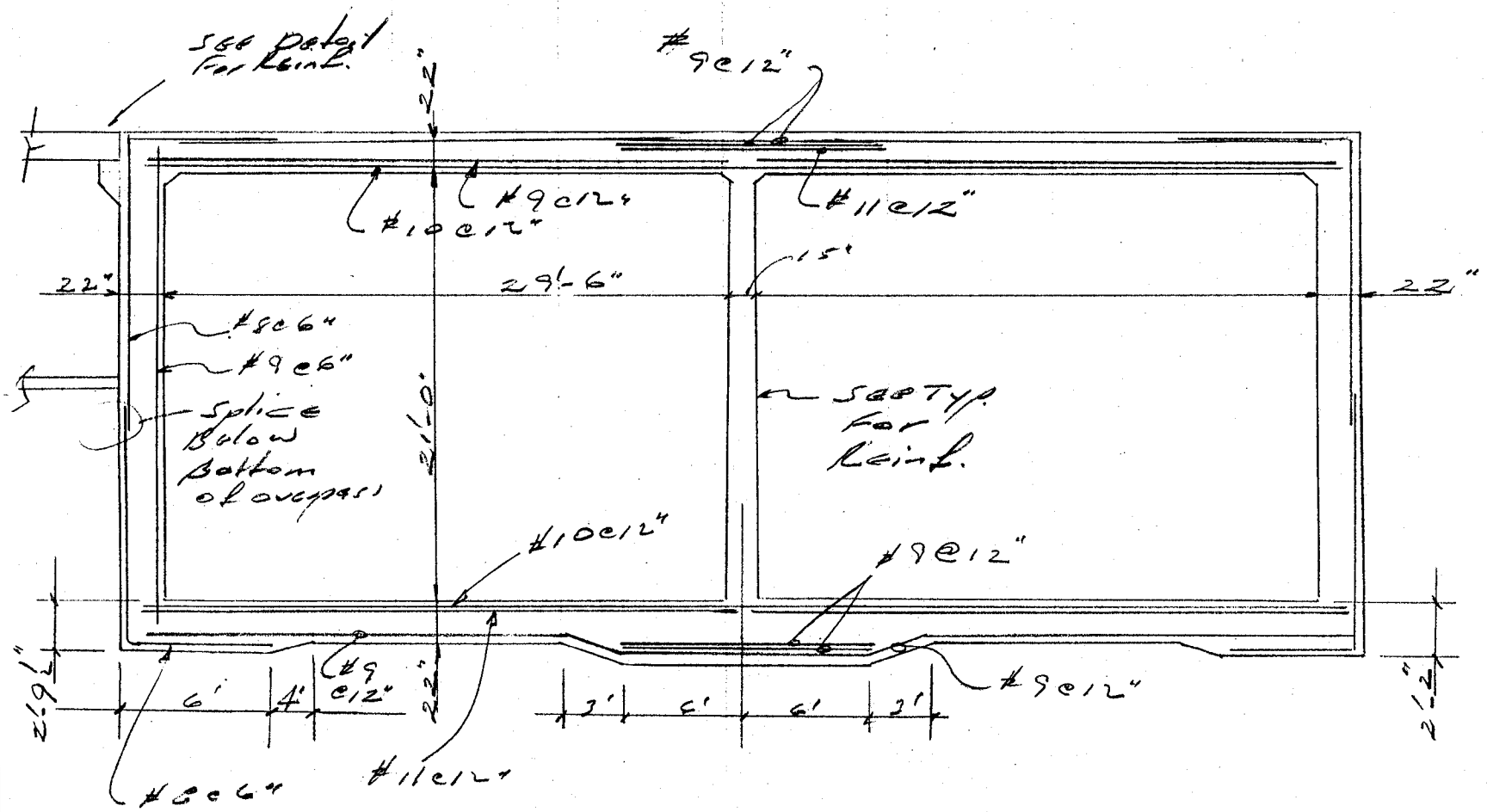
@ E = M_u = 236.7^k

overpass M_u = 12.7 / 249.0^k

$K = \frac{249^k \times 12000}{0.9 \times 12 \times 27^2} = 380$

A_s = 0.0092 × 12 × 27 = 2.99 □"

use 3-#9 @ 12"



Box Cross Section
@ Pedestrian underpass

(See Typ For other Stl. Not Shown)

PLUMMER HASAN & ASSOCIATES
CONSULTING ENGINEERS, INC.

ACDC

JOB NO.
DATE 11/14/80
BY EMP

SHT. NO.
OF 44

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

ARIZONA CANAL DIVERSION CHANNEL REACH 3: H=20 ft (Road)

WALL GEOMETRY

H =	20.000 ft	T =	12.0 in	CLw =	2.50 in
Hb =	10.000 ft	Tw1 =	12.0 in	CLs =	3.50 in
W =	60.000 ft	Tw2 =	21.0 in		
Lf =	25.250 ft	Tc =	8.0 in		
Lh =	.500 ft	Ts =	23.0 in		
Lb =	16.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
14.00	.42 ft
24.00	5.42 ft
100.00	5.42 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	Ø	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	1.00	1.00	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc'= 3000. psi
fy = 48000. psi
As(max) = 4.69 sq-in

p (bal) = .02910
p (max) = .00728
p (min) = .00417
p (tmp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

WALL PRESSURE Feet above invert	CASE 1	CASE 2	CASE 3	
20.00	0.	285.	122.	psf
19.00	76.	285.	157.	psf
18.00	152.	285.	191.	psf
17.00	228.	285.	226.	psf
16.00	304.	285.	260.	psf
15.00	380.	285.	294.	psf
14.00	456.	342.	329.	psf
13.00	532.	399.	363.	psf
12.00	608.	456.	398.	psf
11.00	684.	513.	432.	psf
10.00	760.	570.	467.	psf
9.00	836.	627.	501.	psf
8.00	912.	684.	536.	psf
7.00	988.	741.	570.	psf
6.00	1064.	798.	605.	psf
5.00	1140.	855.	639.	psf
4.00	1216.	912.	674.	psf
3.00	1292.	969.	708.	psf
2.00	1368.	1026.	743.	psf
1.00	1444.	1083.	777.	psf
.00	1520.	1140.	812.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
20.00	*	0.	9.50	.18	.00158	.05426	.00
19.00	*	67.	9.50	.18	.00158	.05426	.03
18.00	*	290.	9.50	.18	.00158	.05426	.05
17.00	*	705.	9.50	.18	.00158	.05426	.08
16.00	*	1345.	9.50	.18	.00158	.05426	.11
15.00	*	2245.	9.50	.18	.00158	.05426	.13
14.00	*	5140.	9.50	.20	.00178	.06117	.16
13.00	*	7059.	9.50	.28	.00246	.08441	.20
12.00	*	9377.	9.50	.37	.00328	.11280	.24
11.00	*	12151.	9.50	.48	.00417	.14318	.29
10.00	*	11851.	9.50	.48	.00417	.14318	.36
9.00	2	19295.	10.40	.54	.00430	.14789	.40
8.00	2	23779.	11.30	.61	.00450	.15468	.43
7.00	2	28947.	12.20	.69	.00471	.16188	.47
6.00	2	34856.	13.10	.78	.00493	.16942	.51
5.00	1	42750.	14.00	.89	.00531	.18263	.55

4.00	1	51883.	14.90	1.02	.00572	.19646	.58
3.00	1	62231.	15.80	1.16	.00612	.21042	.62
2.00	1	73872.	16.70	1.31	.00653	.22450	.66
1.00	1	86881.	17.60	1.47	.00695	.23871	.00
.00	1	101333.	18.50	1.63	.00736	.25306	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
23.00	0.	0.	0.	psf
22.00	0.	0.	1.	psf
21.00	0.	0.	35.	psf
20.00	0.	31.	69.	psf
19.00	0.	83.	102.	psf
18.00	20.	134.	136.	psf
17.00	103.	186.	170.	psf
16.00	186.	238.	204.	psf
15.00	270.	290.	237.	psf
14.00	353.	341.	271.	psf
13.00	436.	393.	305.	psf
12.00	520.	445.	339.	psf
11.00	603.	497.	372.	psf
10.00	686.	548.	406.	psf
9.00	769.	600.	440.	psf
8.00	853.	652.	474.	psf
7.00	936.	704.	508.	psf
6.00	1019.	755.	541.	psf
5.00	1103.	807.	575.	psf
4.00	1186.	859.	609.	psf
3.00	1269.	911.	643.	psf
2.00	1353.	962.	676.	psf
1.00	1436.	1014.	710.	psf
.00	1519.	1066.	744.	psf
Heel	1707.	1182.	820.	psf
SUM OF FORCES				
Horizontal	= 15200.	12113.	9335.	lbs
Vertical (Net)	= 17482.	13507.	9954.	lbs
NET PRESSURE LENGTH =	20.49	22.85	24.28	ft
GROSS SOIL PRESSURE				
Channel Center	= 190.	143.	103.	psf
Channel Heel	= 2253.	1592.	1116.	psf

FOOTING DESIGN

FT FROM WALL	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
23.00	*	0.	4.50	.13	.00247	.08485	.00
22.00	*	0.	4.50	.13	.00247	.08485	.00
21.00	*	6.	4.50	.13	.00247	.08485	.00
20.00	*	47.	4.50	.13	.00247	.08485	.01
19.00	*	156.	4.50	.13	.00247	.08485	.03
18.00	*	368.	4.50	.13	.00247	.08485	.05
17.00	*	716.	4.50	.13	.00247	.08485	.08
16.00	*	1233.	4.50	.13	.00247	.08485	.12

15.00	*	1954.	5.32	.14	.00216	.07432	.14
14.00	*	2913.	6.14	.18	.00242	.08327	.16
13.00	*	4143.	6.97	.22	.00269	.09230	.19
12.00	*	5677.	7.79	.28	.00295	.10139	.22
11.00	*	7624.	8.61	.34	.00325	.11165	.25
10.00	*	10265.	9.43	.41	.00366	.12563	.28
9.00	*	13453.	10.25	.50	.00407	.13973	.31
8.00	*	17242.	11.08	.55	.00417	.14318	.35
7.00	*	19106.	11.90	.59	.00417	.14318	.40
6.00	*	23179.	12.72	.64	.00417	.14318	.44
5.00	2	32728.	13.54	.70	.00431	.14798	.48
4.00	1	40068.	14.36	.81	.00470	.16165	.53
3.00	1	49117.	15.18	.94	.00518	.17813	.57
2.00	1	59436.	16.01	1.09	.00567	.19493	.61
1.00	1	71107.	16.83	1.25	.00617	.21203	.00
.00	1	84214.	17.65	1.41	.00668	.22944	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	.86	cy	@	80.00	$/cy = $	69.07
Concrete Footing	1.06	cy	@	62.30	$/cy = $	66.17
Concrete Invert	.17	cy	@	57.20	$/cy = $	9.89
Steel (Flexural)	131.21	lbs	@	.34	$/lb = $	44.61
Steel (T&S)	93.02	lbs	@	.34	$/lb = $	31.63
Excavation	33.15	cy	@	2.55	$/cy = $	84.53
Backfill	8.83	cy	@	3.20	$/cy = $	28.25

Total = $ 334.14 per foot of half channel

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

ARIZONA CANAL DIVERSION CHANNEL REACH 3: H=21 ft (Road)

(Combine wit Section 53)

WALL GEOMETRY

H =	21.000 ft	T	= 12.0 in	CLw =	2.50 in
Hb =	10.000 ft	Tw1	= 12.0 in	CLs =	3.50 in
W =	60.000 ft	Tw2	= 23.0 in		
Lf =	26.417 ft	Tc	= 8.0 in		
Lh =	.500 ft	Ts	= 24.0 in		
Lb =	16.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
14.00	.42 ft
24.00	5.42 ft
100.00	5.42 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	Ø	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	1.00	1.00	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc'= 3000. psi
fy = 48000. psi
As(max) = 4.69 sq-in

p (bal) = .02910
p (max) = .00728
p (min) = .00417
p (imp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

WALL PRESSURE Feet above invert	CASE 1	CASE 2	CASE 3	
21.00	0.	285.	146.	psf
20.00	76.	285.	180.	psf
19.00	152.	285.	213.	psf
18.00	228.	285.	246.	psf
17.00	304.	285.	280.	psf
16.00	380.	285.	313.	psf
15.00	456.	342.	346.	psf
14.00	532.	399.	380.	psf
13.00	608.	456.	413.	psf
12.00	684.	513.	446.	psf
11.00	760.	570.	480.	psf
10.00	836.	627.	513.	psf
9.00	912.	684.	546.	psf
8.00	988.	741.	580.	psf
7.00	1064.	798.	613.	psf
6.00	1140.	855.	646.	psf
5.00	1216.	912.	680.	psf
4.00	1292.	969.	713.	psf
3.00	1368.	1026.	746.	psf
2.00	1444.	1083.	780.	psf
1.00	1520.	1140.	813.	psf
.00	1596.	1197.	847.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
21.00	*	0.	9.50	.18	.00158	.05426	.00
20.00	*	79.	9.50	.18	.00158	.05426	.03
19.00	*	337.	9.50	.18	.00158	.05426	.05
18.00	*	809.	9.50	.18	.00158	.05426	.08
17.00	*	1527.	9.50	.18	.00158	.05426	.11
16.00	*	2525.	9.50	.18	.00158	.05426	.13
15.00	*	5140.	9.50	.20	.00178	.06117	.16
14.00	*	7059.	9.50	.28	.00246	.08441	.20
13.00	*	9377.	9.50	.37	.00328	.11280	.24
12.00	*	12151.	9.50	.48	.00417	.14318	.29
11.00	*	12874.	9.50	.48	.00417	.14318	.36
10.00	2	19295.	9.50	.59	.00520	.17882	.43
9.00	2	23779.	10.60	.65	.00515	.17691	.46
8.00	2	28947.	11.70	.72	.00514	.17676	.49
7.00	2	34856.	12.80	.80	.00518	.17789	.52

6.00	1	42750.	13.90	.90	.00540	.18542	.55
5.00	1	51883.	15.00	1.01	.00564	.19370	.58
4.00	1	62231.	16.10	1.14	.00588	.20217	.61
3.00	1	73872.	17.20	1.27	.00613	.21080	.64
2.00	1	86831.	18.30	1.40	.00639	.21957	.67
1.00	1	101333.	19.40	1.55	.00665	.22847	.00
.00	1	117306.	20.50	1.70	.00691	.23748	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
24.00	0.	0.	0.	psf
23.00	0.	0.	14.	psf
22.00	0.	0.	47.	psf
21.00	0.	14.	80.	psf
20.00	0.	67.	114.	psf
19.00	1.	120.	147.	psf
18.00	86.	174.	180.	psf
17.00	170.	227.	214.	psf
16.00	254.	280.	247.	psf
16.00	254.	280.	247.	psf
15.00	339.	334.	280.	psf
14.00	423.	387.	313.	psf
13.00	507.	440.	347.	psf
12.00	592.	493.	380.	psf
11.00	676.	547.	413.	psf
10.00	761.	600.	447.	psf
9.00	845.	653.	480.	psf
8.00	929.	706.	513.	psf
7.00	1014.	760.	547.	psf
6.00	1098.	813.	580.	psf
5.00	1183.	866.	613.	psf
4.00	1267.	920.	647.	psf
3.00	1351.	973.	680.	psf
2.00	1436.	1026.	713.	psf
1.00	1520.	1079.	746.	psf
.00	1604.	1133.	780.	psf
.00	1604.	1133.	780.	psf
Heel	1808.	1261.	860.	psf
SUM OF FORCES				
Horizontal =	16758.	13281.	10423.	lbs
Vertical (Net) =	19378.	14934.	11111.	lbs
NET PRESSURE LENGTH =	21.43	23.68	25.83	ft
GROSS SOIL PRESSURE				
Channel Center =	190.	143.	103.	psf
Channel Heel =	2378.	1689.	1169.	psf

FOOTING DESIGN

FT FROM WALL	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
24.00	*	0.	4.50	.13	.00247	.08485	.00
23.00	*	0.	4.50	.13	.00247	.08485	.00
22.00	*	16.	4.50	.13	.00247	.08485	.01

21.00	*	78.	4.50	.13	.00247	.08485	.02
20.00	*	221.	4.50	.13	.00247	.08485	.04
19.00	*	477.	4.50	.13	.00247	.08485	.06
18.00	*	880.	4.50	.13	.00247	.08485	.10
17.00	*	1464.	4.50	.13	.00247	.08485	.14
16.00	*	2261.	4.50	.19	.00353	.12143	.18
16.00	*	2261.	4.50	.19	.00353	.12145	.18
15.00	*	3305.	5.37	.23	.00363	.12481	.20
14.00	*	4629.	6.24	.28	.00377	.12964	.21
13.00	*	6266.	7.11	.34	.00394	.13538	.23
12.00	*	8251.	7.97	.39	.00412	.14172	.26
11.00	*	10616.	8.84	.44	.00417	.14318	.28
10.00	*	13393.	9.71	.49	.00417	.14318	.32
9.00	*	16618.	10.58	.53	.00417	.14318	.36
8.00	*	20323.	11.45	.57	.00417	.14318	.40
7.00	*	24541.	12.32	.62	.00417	.14318	.44
6.00	2	31559.	13.19	.69	.00438	.15056	.48
5.00	1	38708.	14.06	.80	.00475	.16312	.53
4.00	1	47599.	14.93	.93	.00520	.17872	.57
3.00	1	57757.	15.79	1.07	.00566	.19455	.61
2.00	1	69267.	16.66	1.23	.00613	.21060	.66
1.00	1	82212.	17.53	1.39	.00660	.22687	.00
.00	1	96677.	18.40	1.56	.00708	.24336	.00
.00	1	96682.	18.40	1.56	.00708	.24337	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	.93	cy	@	80.00	$/cy = $	74.39
Concrete Footing	1.12	cy	@	62.30	$/cy = $	70.07
Concrete Invert	.15	cy	@	57.20	$/cy = $	8.47
Steel (Flexural)	146.95	lbs	@	.34	$/lb = $	49.96
Steel (T&S)	98.44	lbs	@	.34	$/lb = $	33.47
Excavation	35.40	cy	@	2.55	$/cy = $	90.27
Backfill	9.86	cy	@	3.20	$/cy = $	31.56

Total = $ 358.19 per foot of half channel

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

APIZONA CANAL DIVERSION CHANNEL REACH 3: H=22 ft (Road)

WALL GEOMETRY

H =	22.000 ft	T	= 12.0 in	CLw	= 2.50 in
Hb =	10.000 ft	Tw1	= 12.0 in	CLs	= 3.50 in
W =	60.000 ft	Tw2	= 24.0 in		
Lf =	27.500 ft	Tc	= 8.0 in		
Lh =	.500 ft	Ts	= 26.0 in		
Lb =	16.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
14.00	.42 ft
24.00	5.42 ft
100.00	5.42 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	ϕ	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	1.00	1.00	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc'= 3000. psi
fy = 48000. psi
As(max) = 4.69 sq-in

p (bal) = .02910
p (max) = .00728
p (min) = .00417
p (tmp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
WALL PRESSURE				
Feet above invert				
22.00	0.	285.	163.	psf
21.00	76.	285.	196.	psf
20.00	152.	285.	228.	psf
19.00	228.	285.	261.	psf
18.00	304.	285.	294.	psf
17.00	380.	285.	326.	psf
16.00	456.	342.	359.	psf
15.00	532.	399.	392.	psf
14.00	608.	456.	424.	psf
13.00	684.	513.	457.	psf
12.00	760.	570.	490.	psf
11.00	836.	627.	522.	psf
10.00	912.	684.	555.	psf
9.00	988.	741.	588.	psf
8.00	1064.	798.	620.	psf
7.00	1140.	855.	653.	psf
6.00	1216.	912.	686.	psf
5.00	1292.	969.	719.	psf
4.00	1368.	1026.	751.	psf
3.00	1444.	1083.	784.	psf
2.00	1520.	1140.	817.	psf
1.00	1596.	1197.	850.	psf
.00	1672.	1254.	1407.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
22.00	*	0.	9.50	.18	.00158	.05426	.00
21.00	*	87.	9.50	.18	.00158	.05426	.03
20.00	*	369.	9.50	.18	.00158	.05426	.05
19.00	*	880.	9.50	.18	.00158	.05426	.08
18.00	*	1651.	9.50	.18	.00158	.05426	.11
17.00	*	2716.	9.50	.18	.00158	.05426	.13
16.00	*	5140.	9.50	.20	.00178	.06117	.16
15.00	*	7059.	9.50	.28	.00246	.08441	.20
14.00	*	9377.	9.50	.37	.00328	.11280	.24
13.00	*	12151.	9.50	.48	.00417	.14318	.29
12.00	*	13588.	9.50	.48	.00417	.14318	.36
11.00	2	19295.	9.50	.59	.00520	.17882	.43
10.00	2	23779.	9.50	.74	.00650	.22323	.52
9.00	2	28947.	10.70	.80	.00622	.21361	.54

8.00	2	34856.	11.90	.86	.00604	.20759	.56
7.00	1	42750.	13.10	.96	.00612	.21026	.58
6.00	1	51883.	14.30	1.07	.00624	.21441	.61
5.00	1	62231.	15.50	1.19	.00638	.21920	.63
4.00	1	73872.	16.70	1.31	.00653	.22450	.66
3.00	1	86881.	17.90	1.44	.00670	.23020	.69
2.00	1	101333.	19.10	1.58	.00687	.23624	.71
1.00	1	117306.	20.30	1.72	.00706	.24255	.00
.00	1	134875.	21.50	1.87	.00725	.24909	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
25.00	0.	0.	0.	psf
24.00	0.	0.	22.	psf
23.00	0.	0.	55.	psf
22.00	0.	14.	88.	psf
21.00	0.	67.	121.	psf
20.00	7.	119.	155.	psf
19.00	89.	172.	188.	psf
18.00	172.	225.	221.	psf
17.00	254.	278.	254.	psf
16.00	337.	330.	287.	psf
15.00	419.	383.	321.	psf
14.00	502.	436.	354.	psf
13.00	584.	489.	387.	psf
12.00	667.	541.	420.	psf
11.00	749.	594.	454.	psf
10.00	832.	647.	487.	psf
9.00	914.	700.	520.	psf
8.00	997.	752.	553.	psf
7.00	1079.	805.	587.	psf
6.00	1161.	858.	620.	psf
5.00	1244.	911.	653.	psf
4.00	1326.	963.	686.	psf
3.00	1409.	1016.	719.	psf
2.00	1491.	1069.	753.	psf
1.00	1574.	1122.	786.	psf
.00	1656.	1174.	819.	psf
Heel	1862.	1306.	902.	psf
SUM OF FORCES				
Horizontal =	18392.	14507.	11756.	lbs
Vertical (Net) =	21030.	16174.	12249.	lbs
NET PRESSURE LENGTH =	22.58	24.76	27.15	ft
GROSS SOIL PRESSURE				
Channel Center =	190.	143.	103.	psf
Channel Heel =	2480.	1769.	1237.	psf

FOOTING DESIGN

FT FROM WALL	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
25.00	*	0.	4.50	.13	.00247	.08485	.00
24.00	*	2.	4.50	.13	.00247	.08485	.00

23.00	*	25.	4.50	.13	.00247	.08485	.01
22.00	*	103.	4.50	.13	.00247	.08485	.02
21.00	*	270.	4.50	.13	.00247	.08485	.04
20.00	*	557.	4.50	.13	.00247	.08485	.07
19.00	*	1000.	4.50	.13	.00247	.08485	.11
18.00	*	1630.	4.50	.14	.00253	.08692	.15
17.00	*	2481.	4.50	.21	.00389	.13361	.19
16.00	3	3587.	4.50	.23	.00427	.14678	.25
15.00	*	4979.	5.47	.27	.00417	.14318	.25
14.00	*	6693.	6.45	.32	.00417	.14318	.26
13.00	*	8761.	7.42	.37	.00417	.14318	.27
12.00	*	11215.	8.39	.42	.00417	.14318	.30
11.00	*	14091.	9.36	.47	.00417	.14318	.33
10.00	*	17419.	10.34	.52	.00417	.14318	.36
9.00	*	21235.	11.31	.57	.00417	.14318	.40
8.00	*	25571.	12.28	.61	.00417	.14318	.44
7.00	2	31258.	13.26	.68	.00429	.14743	.48
6.00	1	38399.	14.23	.78	.00459	.15765	.51
5.00	1	47172.	15.20	.90	.00496	.17029	.55
4.00	1	57189.	16.18	1.03	.00533	.18304	.59
3.00	1	68533.	17.15	1.17	.00570	.19589	.63
2.00	1	81286.	18.12	1.32	.00608	.20884	.67
1.00	1	95530.	19.09	1.48	.00646	.22190	.00
.00	1	111347.	20.07	1.65	.00684	.23507	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	.98	cy	@	80.00	$/cy = $	78.52
Concrete Footing	1.21	cy	@	62.30	$/cy = $	75.47
Concrete Invert	.12	cy	@	57.20	$/cy = $	7.06
Steel (Flexural)	171.07	lbs	@	.34	$/lb = $	58.16
Steel (T&S)	101.22	lbs	@	.34	$/lb = $	34.41
Excavation	37.73	cy	@	2.55	$/cy = $	96.21
Backfill	10.97	cy	@	3.20	$/cy = $	35.10

Total = $ 384.93 per foot of half channel

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

ARIZONA CANAL DIVERSION CHANNEL REACH 3: H=23 ft (Road)

WALL GEOMETRY

H =	23.000 ft	T	= 12.0 in	CLw	= 2.50 in
Hb =	10.000 ft	Tw1	= 12.0 in	CLs	= 3.50 in
W =	60.000 ft	Tw2	= 26.0 in		
Lf =	28.667 ft	Tc	= 8.0 in		
Lh =	.500 ft	Ts	= 27.0 in		
Lb =	16.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
14.00	.42 ft
24.00	5.42 ft
100.00	5.42 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	ø	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	1.00	1.00	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc'= 3000. psi
fy = 48000. psi
As(max) = 4.69 sq-in

p (bal) = .02910
p (max) = .00728
p (min) = .00417
p (tmp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

WALL PRESSURE Feet above invert	CASE 1	CASE 2	CASE 3	
23.00	0.	285.	169.	psf
22.00	76.	285.	201.	psf
21.00	152.	285.	234.	psf
20.00	228.	285.	267.	psf
19.00	304.	285.	300.	psf
18.00	380.	285.	332.	psf
17.00	456.	342.	365.	psf
16.00	532.	399.	398.	psf
15.00	608.	456.	431.	psf
14.00	684.	513.	463.	psf
13.00	760.	570.	496.	psf
12.00	836.	627.	529.	psf
11.00	912.	684.	561.	psf
10.00	988.	741.	594.	psf
9.00	1064.	798.	627.	psf
8.00	1140.	855.	660.	psf
7.00	1216.	912.	693.	psf
6.00	1292.	969.	725.	psf
5.00	1368.	1026.	758.	psf
4.00	1444.	1083.	791.	psf
3.00	1520.	1140.	824.	psf
2.00	1596.	1197.	857.	psf
1.00	1672.	1254.	912.	psf
.00	1748.	1311.	1311.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
23.00	*	0.	9.50	.18	.00158	.05426	.00
22.00	*	90.	9.50	.18	.00158	.05426	.03
21.00	*	381.	9.50	.18	.00158	.05426	.05
20.00	*	907.	9.50	.18	.00158	.05426	.08
19.00	*	1699.	9.50	.18	.00158	.05426	.11
18.00	*	2791.	9.50	.18	.00158	.05426	.13
17.00	*	5140.	9.50	.20	.00178	.06117	.16
16.00	*	7059.	9.50	.28	.00246	.08441	.20
15.00	*	9377.	9.50	.37	.00328	.11280	.24
14.00	*	12151.	9.50	.48	.00417	.14318	.29
13.00	*	13892.	9.50	.48	.00417	.14318	.36
12.00	2	19395.	9.50	.59	.00520	.17882	.43
11.00	2	23779.	9.50	.74	.00650	.22323	.52

10.00	2	28947.	9.50	.92	.00803	.27599	.61
9.00	2	34856.	10.90	.95	.00729	.25056	.61
8.00	1	42750.	12.30	1.03	.00700	.24063	.62
7.00	1	51863.	13.70	1.12	.00684	.23501	.64
6.00	1	62231.	15.10	1.22	.00675	.23182	.65
5.00	1	73872.	16.50	1.33	.00670	.23037	.67
4.00	1	86881.	17.90	1.44	.00670	.23020	.69
3.00	1	101333.	19.30	1.56	.00672	.23101	.70
2.00	1	117306.	20.70	1.68	.00677	.23258	.72
1.00	1	134875.	22.10	1.81	.00683	.23476	.00
.00	1	154115.	23.50	1.95	.00691	.23742	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
26.00	0.	0.	0.	psf
25.00	0.	0.	21.	psf
24.00	0.	0.	55.	psf
23.00	0.	0.	88.	psf
22.00	0.	51.	122.	psf
21.00	0.	105.	155.	psf
20.00	72.	159.	189.	psf
19.00	155.	213.	222.	psf
18.00	239.	267.	256.	psf
17.00	322.	321.	289.	psf
16.00	406.	375.	323.	psf
16.00	406.	375.	323.	psf
15.00	489.	429.	356.	psf
14.00	573.	484.	390.	psf
13.00	656.	538.	423.	psf
12.00	740.	592.	457.	psf
11.00	823.	646.	490.	psf
10.00	907.	700.	524.	psf
9.00	990.	754.	557.	psf
8.00	1074.	808.	591.	psf
7.00	1157.	862.	624.	psf
6.00	1240.	916.	658.	psf
5.00	1324.	970.	691.	psf
4.00	1407.	1024.	724.	psf
3.00	1491.	1078.	758.	psf
2.00	1574.	1133.	791.	psf
1.00	1658.	1187.	825.	psf
.00	1741.	1241.	858.	psf
.00	1741.	1241.	858.	psf
Heel	1964.	1385.	948.	psf
SUM OF FORCES				
Horizontal	= 20102.	15789.	12759.	lbs
Vertical (Net)	= 23103.	17733.	13409.	lbs
NET PRESSURE LENGTH =	23.53	25.61	28.29	ft
GROSS SOIL PRESSURE				
Channel Center	= 190.	143.	103.	psf
Channel Heel	= 2605.	1866.	1295.	psf

FOOTING DESIGN

FT FROM WALL	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
26.00	*	0.	4.50	.13	.00247	.08485	.00
25.00	*	1.	4.50	.13	.00247	.08485	.00
24.00	*	24.	4.50	.13	.00247	.08485	.01
23.00	*	101.	4.50	.13	.00247	.08485	.02
22.00	*	267.	4.50	.13	.00247	.08485	.04
21.00	*	553.	4.50	.13	.00247	.08485	.07
20.00	*	995.	4.50	.13	.00247	.08485	.11
19.00	*	1625.	4.50	.14	.00252	.08667	.15
18.00	*	2478.	4.50	.21	.00388	.13343	.19
17.00	3	3586.	4.50	.23	.00427	.14674	.25
16.00	3	4982.	4.50	.33	.00604	.20751	.31
16.00	3	4982.	4.50	.33	.00604	.20751	.31
15.00	3	6702.	5.52	.36	.00537	.18441	.31
14.00	3	8777.	6.54	.39	.00499	.17151	.31
13.00	3	11242.	7.55	.43	.00478	.16411	.32
12.00	3	14130.	8.57	.48	.00466	.16000	.34
11.00	3	17474.	9.59	.53	.00460	.15800	.38
10.00	3	21309.	10.61	.58	.00458	.15744	.42
9.00	3	25667.	11.62	.64	.00460	.15791	.45
8.00	3	30582.	12.64	.70	.00463	.15912	.49
7.00	1	37044.	13.66	.79	.00481	.16539	.53
6.00	1	45655.	14.68	.91	.00516	.17715	.56
5.00	1	55506.	15.70	1.04	.00550	.18899	.60
4.00	1	66681.	16.71	1.17	.00585	.20092	.64
3.00	1	79264.	17.73	1.32	.00620	.21294	.67
2.00	1	93337.	18.75	1.47	.00655	.22506	.71
1.00	1	108985.	19.77	1.64	.00690	.23727	.00
.00	1	126291.	20.79	1.81	.00726	.24958	.00
.00	1	126291.	20.79	1.81	.00726	.24958	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	1.05	cy	@	80.00 $/cy	= $	83.83
Concrete Footing	1.28	cy	@	62.30 $/cy	= $	79.45
Concrete Invert	.10	cy	@	57.20 $/cy	= $	5.65
Steel (Flexural)	189.35	lbs	@	.34 $/lb	= $	64.38
Steel (T&S)	105.94	lbs	@	.34 $/lb	= $	36.02
Excavation	40.09	cy	@	2.55 $/cy	= $	102.23
Backfill	12.11	cy	@	3.20 $/cy	= $	38.77

Total = $ 410.32 per foot of half channel

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

ARIZONA CANAL DIVERSION CHANNEL REACH 3: H = 23 ft (Sloped)

WALL GEOMETRY

H =	23.000 ft	T	= 12.0 in	CLw	= 2.50 in
Hb =	10.000 ft	Tw1	= 12.0 in	CLs	= 3.50 in
W =	60.000 ft	Tw2	= 27.0 in		
Lf =	29.750 ft	Tc	= 9.0 in		
Lh =	.500 ft	Ts	= 29.0 in		
Lb =	16.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
2.00	.06 ft
12.00	5.06 ft
100.00	5.06 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	Ø	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	1.00	1.00	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc'= 3000. psi
fy = 48000. psi
As(min) = 4.69 sq-in

p (bal) = .02910
p (max) = .00728
p (min) = .00417
p (tmp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

WALL PRESSURE Feet above invert	CASE 1	CASE 2	CASE 3	
23.00	0.	285.	209.	psf
22.00	76.	285.	239.	psf
21.00	152.	285.	268.	psf
20.00	228.	285.	298.	psf
19.00	311.	285.	328.	psf
18.00	421.	316.	360.	psf
17.00	531.	398.	397.	psf
16.00	641.	481.	432.	psf
15.00	752.	564.	468.	psf
14.00	824.	618.	504.	psf
13.00	896.	672.	539.	psf
12.00	967.	725.	575.	psf
11.00	1039.	779.	611.	psf
10.00	1110.	833.	647.	psf
9.00	1182.	886.	682.	psf
8.00	1253.	940.	718.	psf
7.00	1325.	994.	754.	psf
6.00	1396.	1047.	790.	psf
5.00	1468.	1101.	826.	psf
4.00	1540.	1155.	861.	psf
3.00	1611.	1208.	897.	psf
2.00	1683.	1262.	933.	psf
1.00	1754.	1316.	969.	psf
.00	1826.	1369.	1004.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
23.00	*	0.	9.50	.18	.00158	.05426	.00
22.00	*	110.	9.50	.18	.00158	.05426	.03
21.00	*	458.	9.50	.18	.00158	.05426	.05
20.00	*	1075.	9.50	.18	.00158	.05426	.08
19.00	*	1990.	9.50	.18	.00158	.05426	.11
18.00	*	3233.	9.50	.18	.00158	.05426	.14
17.00	*	5179.	9.50	.20	.00179	.06165	.17
16.00	*	7190.	9.50	.29	.00250	.08601	.21
15.00	*	9681.	9.50	.39	.00339	.11656	.26
14.00	*	12169.	9.50	.48	.00417	.14318	.33
13.00	2	16399.	9.50	.50	.00439	.15076	.41
12.00	2	20739.	9.50	.64	.00562	.19299	.50
11.00	2	25804.	9.50	.81	.00709	.24370	.60

10.00	2	31648.	9.50	1.01	.00886	.30430	.70
9.00	1	39449.	11.00	1.08	.00818	.28095	.69
8.00	1	48590.	12.50	1.16	.00777	.26687	.70
7.00	1	58984.	14.00	1.26	.00749	.25755	.71
6.00	1	70703.	15.50	1.36	.00732	.25140	.72
5.00	1	83819.	17.00	1.47	.00720	.24748	.73
4.00	1	98403.	18.50	1.58	.00713	.24517	.74
3.00	1	114526.	20.00	1.70	.00710	.24406	.76
2.00	1	132261.	21.50	1.83	.00710	.24389	.00
1.00	1	151678.	23.00	1.96	.00711	.24444	.00
.00	1	172849.	24.50	2.10	.00715	.24558	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
27.00	0.	0.	0.	psf
26.00	0.	0.	19.	psf
25.00	0.	0.	52.	psf
24.00	0.	0.	85.	psf
23.00	0.	42.	118.	psf
22.00	0.	96.	151.	psf
21.00	71.	149.	183.	psf
20.00	152.	203.	216.	psf
19.00	233.	256.	249.	psf
18.00	314.	310.	282.	psf
17.00	395.	363.	315.	psf
16.00	476.	417.	348.	psf
15.00	557.	470.	381.	psf
14.00	639.	524.	414.	psf
13.00	720.	577.	447.	psf
12.00	801.	631.	480.	psf
11.00	882.	684.	512.	psf
10.00	963.	738.	545.	psf
9.00	1044.	791.	578.	psf
8.00	1125.	845.	611.	psf
7.00	1206.	898.	644.	psf
6.00	1287.	952.	677.	psf
5.00	1369.	1006.	710.	psf
4.00	1450.	1059.	743.	psf
3.00	1531.	1113.	776.	psf
2.00	1612.	1166.	808.	psf
1.00	1693.	1220.	841.	psf
.00	1774.	1273.	874.	psf
Heel	1997.	1420.	965.	psf
SUM OF FORCES				
Horizontal	= 22072.	17262.	13702.	lbs
Vertical (Net)	= 24589.	18848.	14146.	lbs
NET PRESSURE LENGTH =	24.62	26.54	29.33	ft
GROSS SOIL PRESSURE				
Channel Center	= 190.	143.	103.	psf
Channel Heel	= 2686.	1937.	1338.	psf

FOOTING DESIGN

FT FROM	GOVN ULT MOMENT	d	As	REQ'D	p/p(bal)	SHEAR

WALL	CASE	(ft-lbs)	(in)	(sq-in)	p	RATIO	(Vu/ØVn)
27.00	*	0.	4.50	.13	.00247	.08485	.00
26.00	*	1.	4.50	.13	.00247	.08485	.00
25.00	*	22.	4.50	.13	.00247	.08485	.01
24.00	*	94.	4.50	.13	.00247	.08485	.02
23.00	*	251.	4.50	.13	.00247	.08485	.04
22.00	*	526.	4.50	.13	.00247	.08485	.07
21.00	*	951.	4.50	.13	.00247	.08485	.10
20.00	*	1560.	4.50	.13	.00247	.08485	.14
19.00	*	2386.	4.50	.20	.00373	.12833	.19
18.00	*	3460.	4.50	.23	.00417	.14318	.24
17.00	3	4817.	4.50	.31	.00583	.20019	.30
16.00	3	6489.	4.50	.43	.00802	.27570	.37
15.00	3	8508.	5.62	.45	.00665	.22859	.35
14.00	3	10909.	6.74	.48	.00588	.20222	.35
13.00	3	13723.	7.86	.51	.00542	.18619	.36
12.00	3	16984.	8.98	.55	.00512	.17602	.39
11.00	3	20724.	10.10	.60	.00493	.16947	.42
10.00	3	24977.	11.22	.65	.00481	.16531	.46
9.00	3	29775.	12.34	.70	.00474	.16280	.49
8.00	1	36096.	13.46	.78	.00483	.16603	.52
7.00	1	44478.	14.58	.89	.00509	.17480	.55
6.00	1	54066.	15.70	1.01	.00535	.18372	.58
5.00	1	64942.	16.82	1.13	.00561	.19277	.61
4.00	1	77186.	17.94	1.27	.00588	.20194	.65
3.00	1	90880.	19.06	1.41	.00615	.21121	.68
2.00	1	106104.	20.18	1.55	.00642	.22058	.71
1.00	1	122941.	21.30	1.71	.00669	.23005	.00
.00	1	141470.	22.42	1.88	.00697	.23960	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	1.06	cy	@	80.00	$/cy = $	85.00
Concrete Footing	1.36	cy	@	62.30	$/cy = $	84.92
Concrete Invert	.07	cy	@	57.20	$/cy = $	4.24
Steel (Flexural)	210.43	lbs	@	.34	$/lb = $	71.55
Steel (T&S)	107.40	lbs	@	.34	$/lb = $	36.52
Excavation	42.38	cy	@	2.55	$/cy = $	108.06
Backfill	14.32	cy	@	3.20	$/cy = $	45.83

Total = $ 436.10 per foot of half channel

***** ANALYSIS OF CHANNEL L-WALL v1.15 *****

ARIZONA CANAL DIVERSION CHANNEL REACH 3: H = 22.5 ft (Rock)

WALL GEOMETRY

H =	22.500 ft	T	= 12.0 in	CLw	= 2.50 in
Hb =	12.000 ft	Tw1	= 12.0 in	CLs	= 3.50 in
W =	50.000 ft	Tw2	= 32.0 in		
Lf =	28.167 ft	Tc	= 8.0 in		
Lh =	.500 ft	Ts	= 34.0 in		
Lb =	18.000 ft				

BACKFILL SURFACE

Distance from top of channel wall

Horizontal	Vertical
.00	.00 ft
10.00	5.00 ft
100.00	5.00 ft

EXCAVATION SLOPE

Zx = 1.000 ft
Zs = 1.333 slope

LOADING CONDITIONS

			CASE 1	CASE 2	CASE 3	
Concrete :	Wc	=	150.00	150.00	150.00	pcf
Backfill :	Ws	=	136.00	136.00	136.00	pcf
	Ø	=	34.00	34.00	34.00	degrees
	δ	=	25.50	25.50	25.50	degrees
	KWmin	=	40.00	40.00	40.00	pcf
	SMF	=	.67	.67	1.00	
Surcharge :	Q	=	.00	.00	.00	psf
	Qb	=	.00	.00	.00	feet
	Qe	=	.00	.00	.00	feet
Compaction :	CE	=	.00	200.00	.00	psf
Seismic :	Kh	=	.00	.00	.05	G
	Kv	=	.00	.00	.03	G

ULTIMATE STRENGTH DESIGN

"Hydraulic Structure"

fc' = 3000. psi
fy = 48000. psi
As(max) = 4.69 sq-in
p (bal) = .02910

p (max) = .00728
p (min) = .00417
p (tmp) = .00125

	CASE 1	CASE 2	CASE 3
Ultimate Load Factors			
Live Load	1.900	1.425	1.000
Dead Load	1.900	1.425	1.000

SOIL PRESSURE ANALYSIS

WALL PRESSURE Feet above invert	CASE 1	CASE 2	CASE 3	
22.50	0.	285.	210.	psf
21.50	233.	285.	253.	psf
20.50	347.	285.	296.	psf
19.50	462.	347.	339.	psf
18.50	577.	433.	382.	psf
17.50	691.	519.	418.	psf
16.50	806.	605.	450.	psf
15.50	921.	691.	482.	psf
14.50	1035.	777.	515.	psf
13.50	1150.	863.	547.	psf
12.50	1265.	949.	579.	psf
12.00	1322.	992.	595.	psf
11.50	1379.	1035.	611.	psf
10.50	1494.	1121.	644.	psf
9.50	1609.	1207.	676.	psf
8.50	1723.	1293.	709.	psf
7.50	1838.	1379.	741.	psf
6.50	1953.	1465.	773.	psf
5.50	2067.	1551.	806.	psf
4.50	2182.	1637.	838.	psf
3.50	2297.	1723.	871.	psf
2.50	2411.	1808.	903.	psf
1.50	2526.	1894.	935.	psf
.50	2641.	1980.	968.	psf
.00	2698.	2023.	984.	psf

WALL DESIGN

FT FROM INVERT	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/ØVn)
22.50	*	0.	9.50	.18	.00158	.05426	.00
21.50	*	112.	9.50	.18	.00158	.05426	.03
20.50	*	477.	9.50	.18	.00158	.05426	.05
19.50	*	1137.	9.50	.18	.00158	.05426	.08
18.50	*	2137.	9.50	.18	.00158	.05426	.13
17.50	*	3517.	9.50	.18	.00158	.05426	.19
16.50	*	5920.	9.50	.23	.00205	.07059	.26
15.50	*	9056.	9.50	.36	.00317	.10835	.34
14.50	*	11846.	9.50	.48	.00417	.14318	.43
13.50	1	18204.	9.50	.56	.00489	.16820	.53
12.50	1	24447.	9.50	.76	.00668	.22995	.65
12.00	1	28035.	9.50	.88	.00776	.26655	.71
11.50	1	31954.	10.37	.92	.00745	.25599	.71

10.50	1	40840.	12.00	1.01	.00703	.24158	.72
9.50	1	51220.	13.67	1.11	.00678	.23301	.73
8.50	1	63209.	15.33	1.22	.00664	.22811	.75
7.50	1	76922.	17.00	1.34	.00657	.22567	.77
6.50	1	92472.	18.67	1.47	.00655	.22496	.79
5.50	1	109976.	20.33	1.60	.00656	.22552	.82
4.50	1	129546.	22.00	1.74	.00661	.22702	.84
3.50	1	151299.	23.67	1.89	.00667	.22927	.87
2.50	1	175348.	25.33	2.05	.00675	.23209	.89
1.50	1	201809.	27.00	2.22	.00685	.23538	.00
.50	1	230795.	28.67	2.39	.00696	.23905	.00
.00	1	246271.	29.50	2.48	.00701	.24101	.00

FOOTING PRESSURE ANALYSIS

	CASE 1	CASE 2	CASE 3	
NET FOOTING PRESSURE				
Feet from wall				
25.00	0.	0.	23.	psf
24.00	0.	9.	59.	psf
23.00	50.	73.	96.	psf
22.00	139.	138.	133.	psf
21.00	229.	203.	169.	psf
20.00	318.	268.	206.	psf
19.00	408.	333.	242.	psf
18.00	497.	397.	279.	psf
17.00	587.	462.	315.	psf
16.00	677.	527.	352.	psf
15.00	766.	592.	388.	psf
14.00	856.	657.	425.	psf
13.00	945.	722.	462.	psf
12.00	1035.	786.	498.	psf
11.00	1125.	851.	535.	psf
10.00	1214.	916.	571.	psf
9.00	1304.	981.	608.	psf
8.00	1393.	1046.	644.	psf
7.00	1483.	1110.	681.	psf
6.00	1572.	1175.	718.	psf
5.00	1662.	1240.	754.	psf
4.00	1752.	1305.	791.	psf
3.00	1841.	1370.	827.	psf
2.00	1931.	1434.	864.	psf
1.00	2020.	1499.	900.	psf
.00	2110.	1564.	937.	psf
Heel	2394.	1769.	1053.	psf
SUM OF FORCES				
Horizontal =	31622.	23994.	13844.	lbs
Vertical (Net) =	31978.	24150.	15148.	lbs
NET PRESSURE LENGTH =	26.72	27.30	28.17	ft
GROSS SOIL PRESSURE				
Channel Center =	190.	143.	126.	psf
Channel Heel =	3201.	2375.	1491.	psf

FOOTING DESIGN

FT FROM WALL	GOVN CASE	ULT MOMENT (ft-lbs)	d (in)	As (sq-in)	REQ'D p	p/p(bal) RATIO	SHEAR (Vu/Vcn)

25.00	*	-1478.	4.50	.13	.00247	.08485	.00
24.00	*	-1460.	4.50	.13	.00247	.08485	.01
23.00	*	-1383.	4.50	.13	.00247	.08485	.02
22.00	*	-1210.	4.50	.13	.00247	.08485	.05
21.00	*	-905.	4.50	.13	.00247	.08485	.08
20.00	*	-430.	4.50	.13	.00247	.08485	.11
19.00	*	250.	4.50	.13	.00247	.08485	.18
18.00	*	2556.	4.50	.22	.00401	.13778	.27
17.00	*	4201.	5.73	.28	.00407	.13979	.30
16.00	*	6433.	6.96	.35	.00417	.14318	.33
15.00	*	9341.	8.19	.41	.00417	.14318	.36
14.00	*	13015.	9.41	.47	.00417	.14318	.39
13.00	*	14906.	10.64	.53	.00417	.14318	.42
12.00	*	19294.	11.87	.59	.00417	.14318	.45
11.00	*	24468.	13.10	.65	.00417	.14318	.48
10.00	1	37167.	14.33	.75	.00437	.15022	.51
9.00	1	46016.	15.56	.86	.00460	.15813	.55
8.00	1	56169.	16.78	.97	.00484	.16618	.58
7.00	1	67715.	18.01	1.10	.00507	.17435	.61
6.00	1	80744.	19.24	1.23	.00531	.18264	.64
5.00	1	95345.	20.47	1.37	.00556	.19102	.67
4.00	1	111609.	21.70	1.51	.00581	.19949	.71
3.00	1	129624.	22.93	1.67	.00605	.20804	.74
2.00	1	149480.	24.15	1.83	.00631	.21667	.00
1.00	1	171267.	25.38	2.00	.00656	.22538	.00
.00	1	195074.	26.61	2.18	.00681	.23415	.00

COMPARATIVE COST ANALYSIS

Concrete Wall	1.18 cy	@	80.00	$/cy	= $	94.32
Concrete Footing	1.57 cy	@	62.30	$/cy	= $	97.78
Concrete Invert	.00 cy	@	57.20	$/cy	= $	.00
Steel (Flexural)	251.87 lbs	@	.34	$/lb	= $	85.64
Steel (T&S)	108.95 lbs	@	.34	$/lb	= $	37.04
Excavation	38.40 cy	@	2.55	$/cy	= $	97.92
Backfill	14.82 cy	@	3.20	$/cy	= $	47.41

Total = $ 460.10 per foot of half channel

STRUCTURAL REVIEW COMMENTS

14 Sep 1988

PROJECT:
Pre-Final, Reach 3
Arizona Canal Diversion Channel
Phoenix, Arizona

REVIEWER:
Gary Sjelin
(213) 894-6264
SPLED-DG

SHEET 17

1. PROFILE : For covered channel section "See Note 4" should read "See Note 1".

2. PROFILE : For manhole and access ladder "See Note 2" should read "See Note 4".

SHEET 18

3. PROFILE : For manhole and access ladder "See Note 10" should read "See Note 9" in 2 places.

4. PLAN : Recommend eliminating skewed end of covered channel at Dunlap Ave. similar to Central Ave.

SHEET 36

5. NOTES : Delete Note 4.

6. Show "SIDE DRAIN TABLE" similiar to attached table from Reach 2c.

7. PLAN OUTLET STRUCTURE "A" : Block-out Detail is shown on sheet 37 not "hereon".

? 8. ELEVATION A-A : Indicate length of #5 bars as pipe diameter plus 2 feet.

9. ELEVATION A-A : Show 3" clear between bars and inside of pipe.

10. SECTION C-C : "Cast in place on 2" dry pack..." should read "Cast in place or 2" dry pack...".

11. SECTION C-C : "Space Opening" should read "Square Opening".

12. PLAN TOP SLAB OUTLET STRUCTURE "C" : "Some dia and spacing..." should read "Same dia and spacing..."

? 13. PLAN TOP SLAB OUTLET STRUCTURE "C" : "Const Jt or Exp Jt (See note No. 4 hereon)" should read "Exp. Jt. Type "D"" in 2 places.

14. PLAN TOP SLAB OUTLET STRUCTURE "C" : Delete 1'-4" dimension.

SHEET 36 (cont.)

15. SECTION D-D : Show arrow for channel wall note.

16. SECTION D-D : Delete arrow head on channel face reinf. for top note "Hook Earth Face Reinf. at Opening."

17. SECTION D-D : "Cast in place on 2" dry pack..." should read "Cast in place or 2" dry pack...".

SHEET 37

18. SECTION E-E : Delete "for walls and inverts."

19. PLAN OR ELEVATION CONCRETE COLLAR DETAIL : #4@12'-6" should read #4@1'-6" in 2 places.

20. BLOCK-OUT DETAIL : Delete "(TYP.)" from title.

21. BLOCK-OUT DETAIL : Delete "or brick up for future drain."

SHEET 38

22. GENERAL STRUCTURAL NOTES : The general structural notes should be similar to the attached notes from Reach 2c with modifications to reflect the use of Grade 60 reinforcement and fc'=4000 psi for the covered channel.

SHEET 39

23. WALL SCHEDULE : Revise design of wall sections for the following criteria as discussed previously with COE.

    A. ETL 1110-2-312, Live LF=1.9, Dead LF=1.9, fy=48000, p(max)=0.25p(bal).

    B. At-Rest Soil Pressure (Kw=60pcf) between stations 741+20 and 743+50.

    C. Soil weight of 136 pcf.

    D. Sloping backfill where appropriate.

    E. Horizontal construction load of 200 psf at the top of the wall until soil calculated soil pressure is greater.

24. TYPICAL WALL SECTION : Delete shear key at base of wall and replace with construction joint 3" above the invert.

25. TYPICAL WALL SECTION : Move horizontal temperature reinforcement in channel face of wall outside of vertical support bars.

26. TYPICAL WALL SECTION : Delete Lb1 and Lb2 dimensions.

27. TYPICAL WALL SECTION : Delete 20'-0" dimension.

28. TYPICAL WALL SECTION : In top of footing change longitudinal T Bar to #6@12" and transverse #4@2'-0" to #4@12", also extend transverse bar into heel.

29. TYPICAL WALL SECTION : In 8" invert change longitudinal #4@1'-6" to #5@12" and transverse #5@12" to #4@12".

30. TYPICAL WALL SECTION : Indicate 2-#4 Trimmer Bars in top of wall.

31. TYPICAL WALL SECTION : Change W Bar in wall and #5@2'-0" longitudinal bar in footing to #4@36".

32. TYPICAL WALL SECTION : Change clear cover on reinforcement from 2 1/2" to 2" for earth face of wall.

33. APPROX. WALL OFFSET VALUES FOR TYP CHANNEL WALL : Delete this detail and show a 0.008 to 1 batter on the channel face of the TYPICAL WALL SECTION.

SHEET 40

34. Revise design of box culvert for the following criteria.

    A. ETL 1110-2-312, Live LF=1.9, Dead LF=1.5, fy=48000, p(max)=0.375p(bal). Note this ETL requires shear design in accordance with ACI Building Code rather than AASHTO, and the vertical load due to soil weight is considered a live load not dead load.

    B. Saturated soil weight of 140 pcf and equivalent fluid pressure of 40 pcf.

    C. Depth of fill over box should be 5.1 feet less the roof thickness (see profile at Basketball Court).

    D. Uniform live load of 100 psf for the High School playground (UBC). This would include possible alternate span loading.

    E. Short duration (0.75LF) construction load equivalent to one H 10-44 truck moving parrallel to the culvert. Specifications should include a restriction on construction equipment for placing fill on top of box. Limit combined weight of any equipment including impact effects to less than 20,000 lbs.

35. Eliminate shear keys and use a straight construction joint 3 inches above the invert.

36.? Eliminate bend in flexural reinforcement in roof and invert. At least one bar should be continuous across the top of the roof and bottom of the invert.

37.? Reinforcement in the inside face should extend into or through supports.

38. Concrete cover on reinforcement in the top face of the roof should be 2".

39. Longitudinal reinforcement should be 0.18 percent of gross concrete area, half in each face including top of roof and bottom of invert.

SHEET 41

40. Revise design of box culvert for the following criteria.

A. ETL 1110-2-312, Live LF=1.9, Dead LF=1.5, fy=48000, p(max)=0.375p(bal). Note this ETL requires shear design in accordance with ACI Building Code rather than AASHTO, and the vertical load due to soil weight is considered a live load not dead load.

B. Saturated soil weight of 140 pcf and equivalent fluid pressure of 40 pcf.

C. Depth of fill over box should be 4.7 feet less the roof thickness (see profile at Parking Lot).

D. Traffic load should be HS 20-44 moving parallel to the channel. This would include possible alternate span loading due to multiple traffic lanes.

E. Only 50% of the lateral earth pressure may be used to reduce positive moment in roof.

F. A 2 foot live load surcharge on the side of box.

G. Reduced lateral earth pressure due to underpass, additional loads from underpass, and hydraulic forces on wall next to underpass from channel full condition.

✓41. Eliminate shear keys and use a straight construction joint 3 inches above the invert.

42.? Eliminate bend in flexural reinforcement in roof and invert. At least one bar should be continuous across the top of the roof and bottom of the invert.

43.? Reinforcement in the inside face should extend into or through supports.

44. Concrete cover on reinforcement in the top face of the roof should be 2".

45. Longitudinal reinforcement should be 0.18 percent of gross concrete area, half in each face including top of roof and bottom of invert.

46. Provide a corbel to support underpass roof.

47. Recommend eliminating skew design.

48. The section on this sheet should also be used under parking lot and Central Ave.

SHEET 46

49. SECTION A-A, B-B, C-C : Revise design of wall sections for the following criteria as discussed previously with COE.

    A. ETL 1110-2-312, Live LF=1.9, Dead LF=1.9, fy=48000, p(max)=0.25p(bal).

    B. Soil weight of 136 pcf.

    E. Horizontal construction load of 200 psf at the top of the wall until soil calculated soil pressure is greater.

50. SECTION A-A, B-B, C-C : Delete shear key at base of wall and replace with construction joint 3" above the invert.

51. SECTION A-A, B-B, C-C : Move horizontal temperature reinforcement in channel face of wall outside of vertical support bars.

52. SECTION A-A, B-B, C-C : Show location of optional construction joint in invert.

53. SECTION A-A, B-B, C-C : In top of footing change longitudinal #5@12" to #6@12" and transverse #4@2'-0" to #4@12", also extend transverse bar into heel.

54. SECTION A-A, B-B, C-C : In 8" invert change longitudinal #4@1'-6" to #5@12" and transverse #5@12" to #4@12".

55. SECTION A-A, B-B, C-C : Indicate 2-#4 Trimmer Bars in top of wall.

56. SECTION A-A, B-B, C-C : Change #5@2'-0" longitudinal bar in footing to #4@36".

57. SECTION A-A, B-B, C-C : Change clear cover on reinforcement from 2 1/2" to 2" for earth face of wall.

58. Change 2" AC Pavement over 4" Aggregate Base to 8" concrete footing as shown on sheet 47.

SHEET 47

59. SECTIONS A,B,C,D,E,F : Revise design of wall sections for the following criteria as discussed previously with COE.

    A. ETL 1110-2-312, Live LF=1.9, Dead LF=1.9, fy=48000, p(max)=0.25p(bal).

    B. Soil weight of 136 pcf.

    C. Sloping backfill where appropriate.

    D. Horizontal construction load of 200 psf at the top of the wall until soil calculated soil pressure is greater.

60. SECTIONS A,B,C,D,E,F : Delete shear key at base of wall and replace with construction joint 3" above the invert.

61. ? SECTIONS A,B,C,D,E,F : Move horizontal temperature reinforcement in channel face of wall outside of vertical support bars.

62. ? SECTIONS A,B,C : Label the optional construction joint in the invert.

63. ? SECTIONS C,D,E,F : In top of footing change longitudinal #5 Bar to #6@12" and transverse #4@2'-0" to #4@12", also extend transverse bar into heel.

64. ? SECTIONS A,B,C : In 8" invert change longitudinal #4@1'-6" to #5@12" and transverse #5@12" to #4@12".

65. ? SECTIONS A,B,C,D,E,F : Indicate 2-#4 Trimmer Bars in top of wall.

66. SECTIONS A,B,C,D,E,F : Change longitudinal spacer bar in earth face of wall and footing to #4@36".

67. SECTION A,B,C,D,E,F : Change clear cover on reinforcement from 2 1/2" to 2" for earth face of wall.

SHEET 48

68. SECTION G and TYPICAL SECTION OF INVERT ACCESS RAMP : Delete shear key at base of wall and replace with construction joint 3" above invert.

69. DETAIL "A" : Show fourth #4 vertical at corner.

70. DETAIL "A,B" : Access ramp end wall should be 1'-6" thick as shown in section G.

SHEET 49

71. FENCE DETAIL : Delete.

SHEET 50

72. UNDERPASS TOP and FLOOR PLAN : Eliminate skewed ends.

73. UNDERPASS SECTION B-B : Provide minimum flexural reinforcement in earth face of wall.

74. UNDERPASS SECTION B-B : Extend vertical #6@12" in wall into roof.

75. UNDERPASS SECTION B-B : Notch for underpass roof interfers with covered channel reinforcement. Provide corbel to support underpass roof.

SHEET 51

76. PLAN : Eliminate skewed ends on underpass.

SHEET 52

77. 8"X8" POST MOUNT SECTION : Delete.

78. STEEL PICKET GATE : Delete.

79. STEEL PICKET FENCE : Delete.

80. INVERT SLAB JOINT DETAIL : Does this detail represent condition at existing bridges. Show cross sections at existing bridges to clarify channel construction.

SHEET 53

81. TYPICAL FENCE ELEVATION : Show arrows for steel picket note.

82. SECTION B-B : Indicate 13"+/-1/8" radius for bend at top of pickets.

83. DETAIL "A" : Clarify weld arrow going to 1 1/4" tubing not 1 1/2" tubing.

84. DETAIL "B" : Show splice in #3 tie.

85. DETAIL "C" : 3 1/2" clear cover on wall reinforcement should read 2 1/2".

86. DETAIL "C" : "See struct. details sheet 52 for wall reinf." should read "... sheet 39...".

SHEET_55

87. PIPE GATE DETAIL : 12" centerline dimension on post footing should read 12" diameter.

88. KEY & NOTCH GATE CONNECTION TO COLUMN : Change this title to something that makes sense.

89. INVERT ACCESS LADDER, REINFORCEMENT DETAILS : "See applicable wall on structural details on sheet 23" should read "... sheet 39".

90. INVERT ACCESS LADDER, REINFORCEMENT DETAILS : Indicate 4-#4 vertical bars in channel face behind ladder.

91. INVERT ACCESS LADDER, REINFORCEMENT DETAILS : Indicate 12" concrete thickness at ladder and variable thickness of channel wall.

92. INVERT ACCESS LADDER, REINFORCEMENT DETAILS : Indicate vertical reinforcement in earth face at ladder is typical wall reinforcement and horizontal reinforcement is #4@12".

93. INVERT ACCESS LADDER, SECTIONS A & B : Delete rung 1 foot above top of wall and extend sides of ladder 5'-0" above top of wall.

94. INVERT ACCESS LADDER, SECTIONS A & B : Delete 6'-06" dimension.

SHEET_64

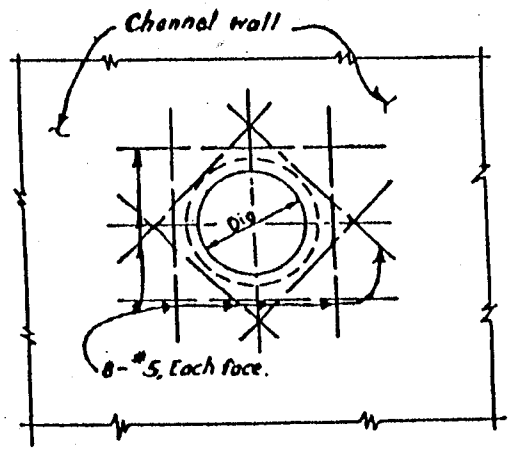
95. SECTION 'C'-'C' : Change title to indicate this is a typical catch basin detail and not Section C-C shown on GRADING & PAVING PLAN.

96. GRADING & PAVING PLAN : Delete Section C-C.

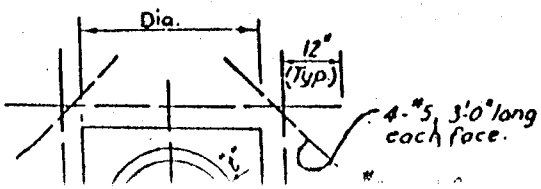
SIDE DRAIN TABULATION

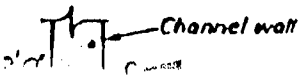
APPROX. STATION	SHEET NUMBER	EXISTING CONSTRUCTION PIPE DIA.	EXISTING CONSTRUCTION PIPE TYPE	EXISTING CONSTRUCTION PIPE REMOVE LENGTH APPROX.	NEW CONSTRUCTION PIPE DIA.	NEW CONSTRUCTION PIPE TYPE	NEW CONSTRUCTION PIPE CLASS	NEW CONSTRUCTION PIPE CONST. LENGTH APPROX.	NEW CONSTRUCTION INLET/CONNECTION TYPE	NEW CONSTRUCTION INLET/CONNECTION ELEV. "X"	NEW CONSTRUCTION OUTLET STRUCTURE TYPE	NEW CONSTRUCTION OUTLET STRUCTURE ELEV. "Y"	NEW CONSTRUCTION OUTLET STRUCTURE GATE	REMARKS
553+50 Lt	8	12"	PVC	4'	12"	PVC	–	6'	Join Exist. PVC	1219.33 ±	B	1215.75	Flap	Underpass Drain, See Note 5
550+71 Rt	8	36"	RCP	18'	36"	RCP	II	14'	Collar	1224.10	A	1217.00	–	
550+55 Lt	8	12"	PVC	5'	12"	PVC	–	6'	Join Exist. PVC	1219.40 ±	B	1215.75	Flap	Underpass Drain, See Note 5
550+17 Rt	8	6"	PVC	68'	6"	PVC	–	12'	Join Exist. PVC	–	B	1219.00	Flap	See Note 5
549+55 Rt	8	6"	PVC	68'	6"	PVC	–	12'	Join Exist. PVC	1225.28 ±	B	1219.00	Flap	
23+03 Rt	9	6"	PVC	80'	6"	PVC	III	60'	Collar	1236.35 ±	-	1223.33	–	Cave Creek Channel
16+30 Lt	10	–	–	–	48"	RCP	III	125'	Junction Str.	1227.80	A	1219.00	–	Cave Creek Channel

NOTE:
1. For collar and outlets see details hereon.
2. For underpass see details sheet 16.
3. For junction structure see details sheet 19.
4. Pipe at Station 23+03 to be coordinated with C.O.P. Contractor.
5. Contractor to verify location and elevation of existing pipe
6. Lt/Rt = Left and right side of channel looking downstream.



ELEVATION C-C
NOT TO SCALE





GENERAL STRUCTURAL NOTES

1. ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

2. ALL STATIONING SHOWN IS ON PROJECT CENTERLINE OR NORMAL TO CENTER LINE OF CONSTRUCTION.

3. TRANSVERSE AND LONGITUDINAL JOINTS IN INVERT SLAB WILL BE REQUIRED AT THE END OF EACH CONTINUOUS POURING OPERATION AND SHALL BE CONSTRUCTION JOINT TYPE A, VERTICAL JOINTS IN CHANNEL WALLS WILL BE CONSTRUCTION JOINT TYPE B AND REQUIRED AT INTERVALS OF 30 FEET MINIMUM AND 60 FEET MAXIMUM, UNLESS SHOWN OTHERWISE AND AS APPROVED BY THE CONTRACTING OFFICER.

4. IN CURVE SECTIONS TRANSVERSE BARS SHALL BE PLACED NORMAL TO THE PROJECT CENTER LINE.

5. ALL SLAB REINFORCING STEEL SPACING AROUND CURVES SHALL BE MEASURED AT THE OUTSIDE FACE OF CHANNEL WALLS.

6. ALL SINGLE LAYER REINFORCEMENT SHALL BE PLACED IN THE CENTER OF CONCRETE UNLESS OTHERWISE NOTED.

7. SPLICES OF REINFORCING BARS SHALL BE IN ACCORDANCE WITH THE FOLLOWING:

LAP SPLICE LENGTH IN INCHES
f'c = 3,000 psi & fy = 40,000 psi

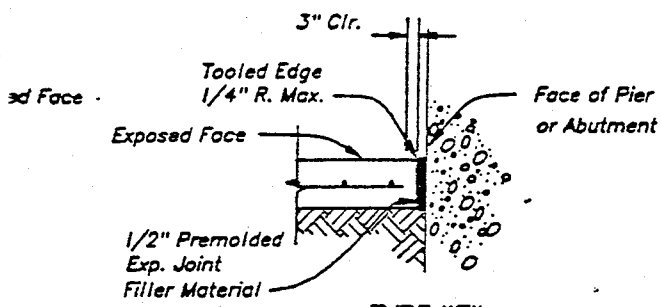
BAR SIZE	#4	#5	#6	#7	#8	#9	#10	#11
TOP BARS	15"	18"	23"	32"	42"	53"	68"	83"
OTHER BARS	12"	13"	17"	23"	30"	38"	48"	59"

a. ALL SPLICES TO BE SPLICE LENGTH OF THE SMALLER BAR BUT NOT LESS THAN 12 INCHES.

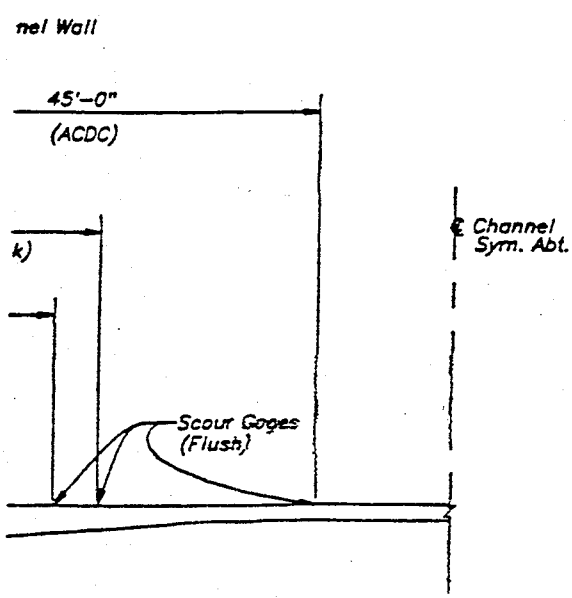
b. SPLICES SHALL BE STAGGERED SO THAT NO MORE THAN 50% OF THE AREA OF STEEL IN A LAYER IS SPLICED WITHIN THE REQUIRED LAP LENGTH.

c. TOP BARS ARE HORIZONTAL BARS WITH MORE THAN 12 INCHES OF CONCRETE BELOW THE BAR.

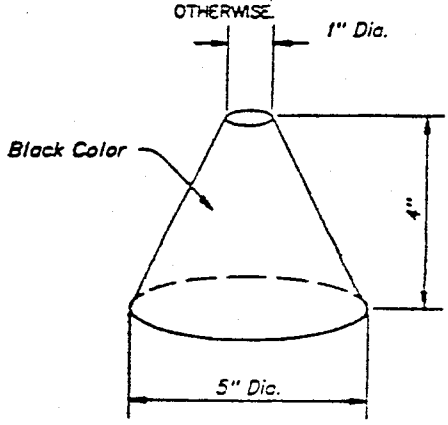
8. ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED 3/4 INCHES, UNLESS NOTED OTHERWISE.
9. ALL REBAR CLEARANCE IS 2 INCHES MINIMUM UNLESS OTHERWISE NOTED.
10. CONCRETE COMPRESSIVE STRENGTH SHALL BE 3000 PSI AND REINFORCEMENT SHALL CONFORM TO ASTM A615 GRADE 40, FOR ALL STRUCTURES UNLESS SHOWN OTHERWISE.



TYPE "E"



NNEL SECTION



SCOUR GAGE DETAIL

CONCRETE SCOUR GAGES
NOT TO SCALE

NOTE: Scour gages shall be placed from ACDC Sta. 580+00 to Sta. 550+00, and Cave Creek Sta. 20+00 to 10+00 at 1000' intervals. Paint Station Markers on left channel wall for ACDC, and both left and right channel walls for Cave Creek where scour gages are located.

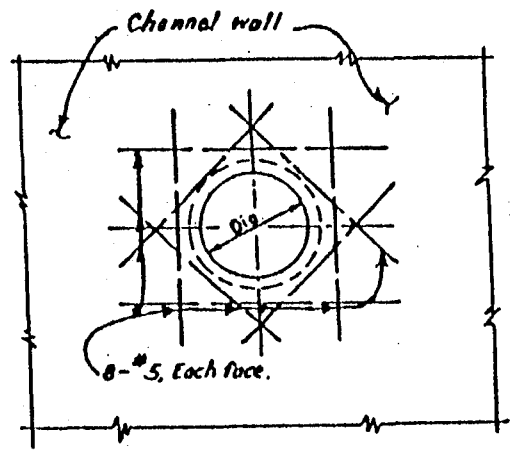
℄ Channel

NEERING PAYS

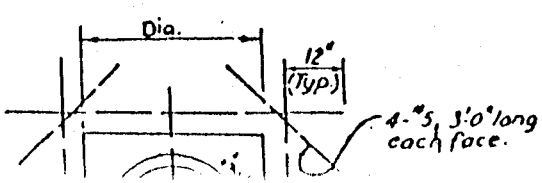
SIDE DRAIN TABULATION

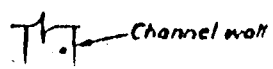
APPROX. STATION	SHEET NUMBER	EXISTING CONSTRUCTION PIPE DIA.	EXISTING CONSTRUCTION PIPE TYPE	EXISTING CONSTRUCTION PIPE REMOVE LENGTH APPROX.	NEW CONSTRUCTION PIPE DIA.	NEW CONSTRUCTION PIPE TYPE	NEW CONSTRUCTION PIPE CLASS	NEW CONSTRUCTION PIPE CONST. LENGTH APPROX.	NEW CONSTRUCTION INLET/CONNECTION TYPE	NEW CONSTRUCTION INLET/CONNECTION ELEV. "X"	NEW CONSTRUCTION OUTLET STRUCTURE TYPE	NEW CONSTRUCTION OUTLET STRUCTURE ELEV. "Y"	NEW CONSTRUCTION OUTLET STRUCTURE GATE	REMARKS
553+30 Lt	8	12"	PVC	4'	12"	PVC	–	6'	Join Exist. PVC	1219.33 ±	B	1215.75	Flap	Underpass Drain, See Note 5
550+71 Rt	8	36"	RCP	18'	36"	RCP	II	14'	Collar	1224.10	A	1217.00	–	
550+55 Lt	8	12"	PVC	5'	12"	PVC	–	6'	Join Exist. PVC	1219.40 ±	B	1215.75	Flap	Underpass Drain, See Note 5
550+17 Rt	8	6"	PVC	68'	6"	PVC	–	12'	Join Exist. PVC	–	B	1219.00	Flap	See Note 5
549+55 Rt	8	6"	PVC	68'	6"	PVC	–	12'	Join Exist. PVC	1225.28 ±	B	1219.00	Flap	
23+03 Rt	9	6"	PVC	80'	6"	PVC	III	60'	Collar	1236.35 ±	–	1223.33	–	Cave Creek Channel
16+30 Lt	10	–	–	–	48"	RCP	III	125'	Junction Str.	1227.80	A	1219.00	–	Cave Creek Channel

NOTE:
1. For collar and outlets see details hereon.
2. For underpass see details sheet 16.
3. For junction structure see details sheet 19.
4. Pipe at Station 23+03 to be coordinated with C.O.P. Contractor.
5. Contractor to verify location and elevation of existing pipe
6. Lt/Rt = Left and right side of channel looking downstream.



ELEVATION C-C
NOT TO SCALE





GENERAL STRUCTURAL NOTES

1. ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

2. ALL STATIONING SHOWN IS ON PROJECT CENTERLINE OR NORMAL TO CENTER LINE OF CONSTRUCTION.

3. TRANSVERSE AND LONGITUDINAL JOINTS IN INVERT SLAB WILL BE REQUIRED AT THE END OF EACH CONTINUOUS POURING OPERATION AND SHALL BE CONSTRUCTION JOINT TYPE A, VERTICAL JOINTS IN CHANNEL WALLS WILL BE CONSTRUCTION JOINT TYPE B AND REQUIRED AT INTERVALS OF 30 FEET MINIMUM AND 60 FEET MAXIMUM, UNLESS SHOWN OTHERWISE AND AS APPROVED BY THE CONTRACTING OFFICER.

4. IN CURVE SECTIONS TRANSVERSE BARS SHALL BE PLACED NORMAL TO THE PROJECT CENTER LINE.

5. ALL SLAB REINFORCING STEEL SPACING AROUND CURVES SHALL BE MEASURED AT THE OUTSIDE FACE OF CHANNEL WALLS.

6. ALL SINGLE LAYER REINFORCEMENT SHALL BE PLACED IN THE CENTER OF CONCRETE UNLESS OTHERWISE NOTED.

7. SPLICES OF REINFORCING BARS SHALL BE IN ACCORDANCE WITH THE FOLLOWING:

LAP SPLICE LENGTH IN INCHES
f'c = 3,000 psi & fy = 40,000 psi

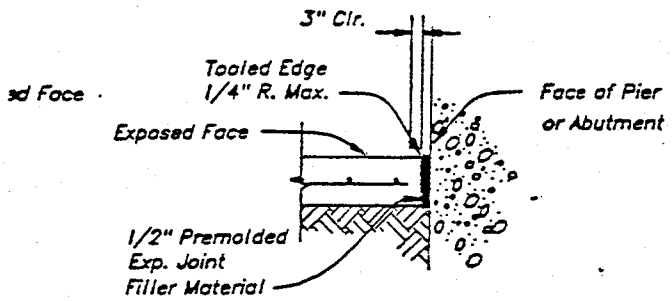
BAR SIZE	#4	#5	#6	#7	#8	#9	#10	#11
TOP BARS	15"	18"	23"	32"	42"	53"	68"	83"
OTHER BARS	12"	13"	17"	23"	30"	38"	48"	59"

a. ALL SPLICES TO BE SPLICE LENGTH OF THE SMALLER BAR BUT NOT LESS THAN 12 INCHES.

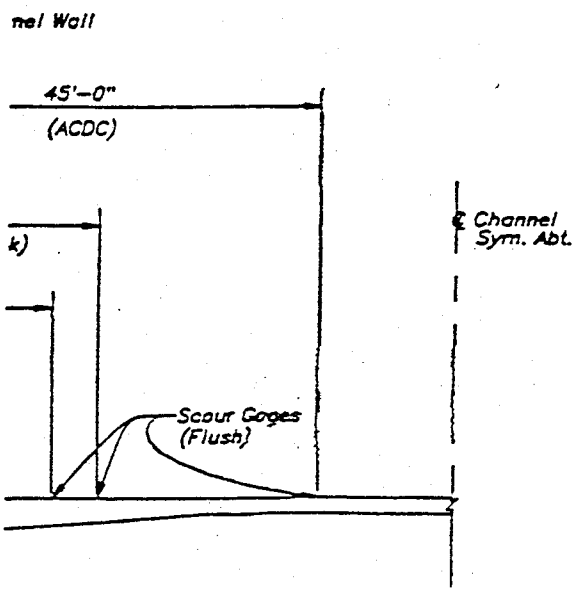
b. SPLICES SHALL BE STAGGERED SO THAT NO MORE THAN 50% OF THE AREA OF STEEL IN A LAYER IS SPLICED WITHIN THE REQUIRED LAP LENGTH.

c. TOP BARS ARE HORIZONTAL BARS WITH MORE THAN 12 INCHES OF CONCRETE BELOW THE BAR.

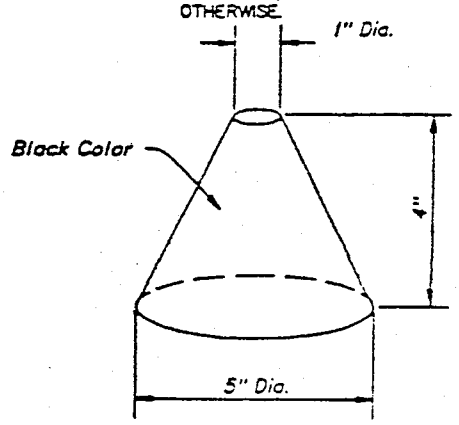
8. ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED 3/4 INCHES, UNLESS NOTED OTHERWISE.
9. ALL REBAR CLEARANCE IS 2 INCHES MINIMUM UNLESS OTHERWISE NOTED.
10. CONCRETE COMPRESSIVE STRENGTH SHALL BE 3000 PSI AND REINFORCEMENT SHALL CONFORM TO ASTM A615 GRADE 40, FOR ALL STRUCTURES UNLESS SHOWN OTHERWISE.



TYPE "E"



NNEL SECTION



SCOUR GAGE DETAIL

CONCRETE SCOUR GAGES
NOT TO SCALE

NOTE: Scour gages shall be placed from ACDC Sta. 580+00 to Sta. 550+00, and Cave Creek Sta. 20+00 to 10+00 at 1000' intervals. Point Station Markers on left channel wall for ACDC, and both left and right channel walls for Cave Creek where scour gages are located.

℄ Channel