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59TH AVENUE BRIDGE
OVER
ARIZONA CANAL DIVERSION CHANNEL
CONTRACT FDC 82-18

STRUCTURAL CALCULATIONS

PREPARED FOR

FLOOD CONTROL DISTRICT

OF

MARICOPA COUNTY

JANUARY 1983

BENSON & GERDIN, INC.

CONSULTING ENGINEERS

3150 NORTH SEVENTH STREET PHOENIX, ARIZONA 85014 PHONE (602) 264-0136

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3335 West Durango Street
Phoenix, Arizona 85009

Reference: 59th Avenue Bridge over
Arizona Canal Diversion Channel
Contract No. FCD-82-18
Structural Calculations

Dear Sir:

Pursuant to our agreement for engineering services relative to the above referenced project, we respectfully submit the structural calculations for this project.

Yours very truly,

BENSON & GERDIN, INC.
CONSULTING ENGINEERS

Albert A. Grimm

Albert A. Grimm, P.E.

AAG:pr
Encl.

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136	SHT. NO. 1 OF 111
CLIENT: M.C. FLOOD CONTROL DISTRICT	JOB NO. 2182F
PROJ.: 59TH AVE BRIDGE OVER AZ. CANAL	BY AG DATE 10-22-82
DIVERSION CHANNEL	CHKD. DATE
	REV.

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Registered Professional Engineer (Structural)
CERTIFICATE 6887
ALBERT A. GRIMM
Date Signed 1-10-83
ARIZONA, U.S.A.

BASIS OF DESIGN

SUPERSTRUCTURE

82'-6" OVERALL WIDTH
68'-0" ROADWAY
5'-0" SIDEWALK EA. SIDE
SKEW: 43° - 01' - 04" RT.
GIRDERS: 8 - TYPE VI PC I-GIRDERS @ 10'-0 O.C.
DECK SLAB: 8" CIP CONCRETE
SPANS: 5 - SPANS CONTINUOUS ΣL = 592'-2"
END SPANS 117'-4"
INTER " 119'-2"

ABUTMENTS

EXPANSION ALLOWANCE 2½" LONGITUDINAL
RESIST TRIBUT. LAT. FORCES IN TRANSV. DIR.
CAP BEAM 4'-10 WIDE BY 4'-0+ ON 8 - 3'-6" DIA. DRILLED PIERS, ONE @ EA. GIRDER BRG.
DRILLED PIERS RESIST LAT. EARTH PRESSURE AND ALL LAT. LOADS IN TRANSV. DIRECTION.
GIRDERS BEAR ON LAMINATED ELASTOMERIC PADS 3½" THICK × 13" × 26" NOMINAL SIZE

PIERS

CAP BM W/ 4 - COLS. EA. MAKE A RIGID FRAME RESISTING TRIBUT. LAT. FORCES IN TRANSV. DIR.
LONGITUD. FORCES TO BE RESISTED BY CANTIL. ACTION OF COLS AS EMBEDDED PILES.
GIRDERS CONTINUOUS OVER CAP BEAM.

BASIS OF DESIGN (CONT'D)

CODE:

AASHTO STANDARD SPECS FOR HIGHWAY BRIDGES
1977 EDITION, REVISED TO DATE
STANDARD SPECS ARIZONA HIGHWAY DEP.
1969 EDITION, REVISED TO DATE
MARICOPA COUNTY HIGHWAY DEP. SPECS.
ACI 318 - 1977

DEAD LOAD:

ACTUAL WEIGHT OF STRUCTURE
NO ALLOWANCE FOR FUT. WEARING SURF.

LIVE LOAD:

LOADING CLASS HS 20-44

GEOT. REPORT BY

WESTERN TECHNOLOGIES INC. DATED 8 JULY 1982
WITH ADDENDUMS & SUPPLEMENTS

MATERIAL

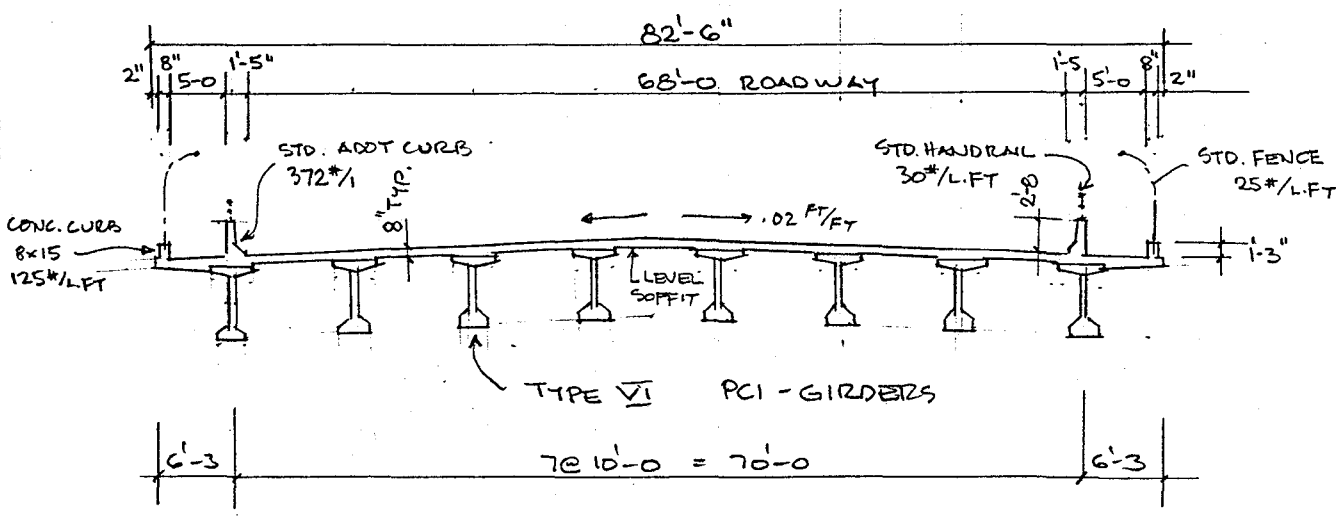
CONCRETE:

f'_c = 5500 PSI MIN. (PREST. GIRDERS)
f'_c = 4500 PSI (f_c = 1400 MAX) DECK SLAB
f'_c = 4000 PSI CAP BEAMS & COL'S
f'_c = 3000 PSI ALL OTHERS

REBAR:

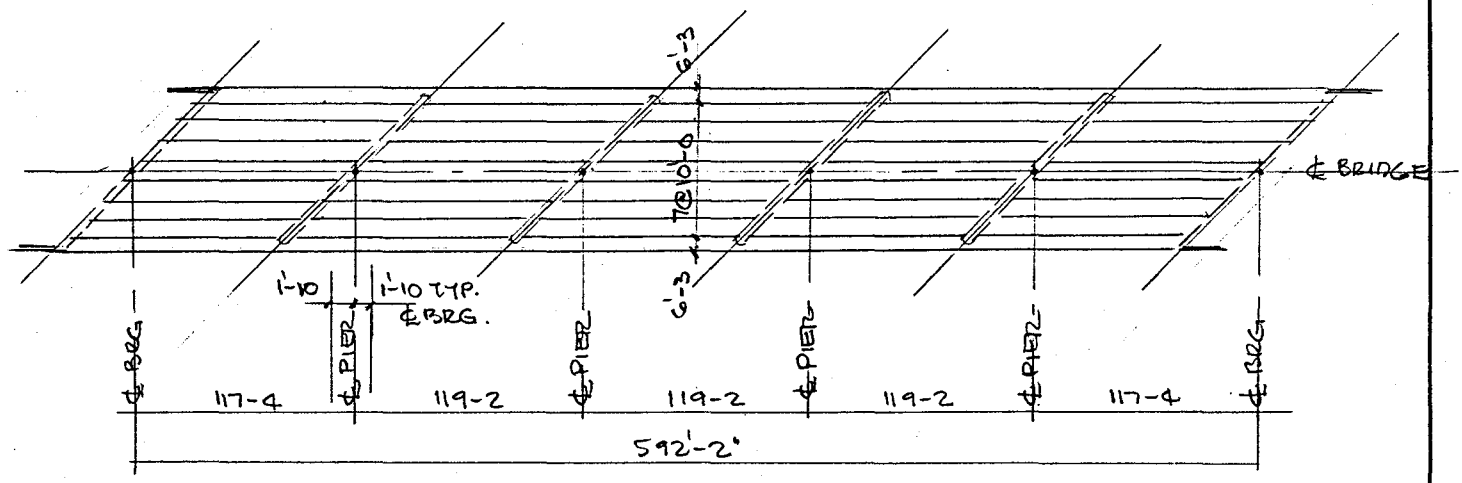
f_s = 20000 PSI GRADE 40 (#6 AND SMALLER)
f_s = 24000 PSI GRADE 60 (#7 AND LARGER)
f'_s = 270000 PSI PRESTRESSING STEEL
(½"Φ - 7 WIRE STRAND)

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0138	SHT. NO. 3 OF
	JOB NO. 2182 F
	BY AG DATE 8-5-82
	CHKD. DATE
DECK SLAB	REV.



TYP. CROSS SECTION

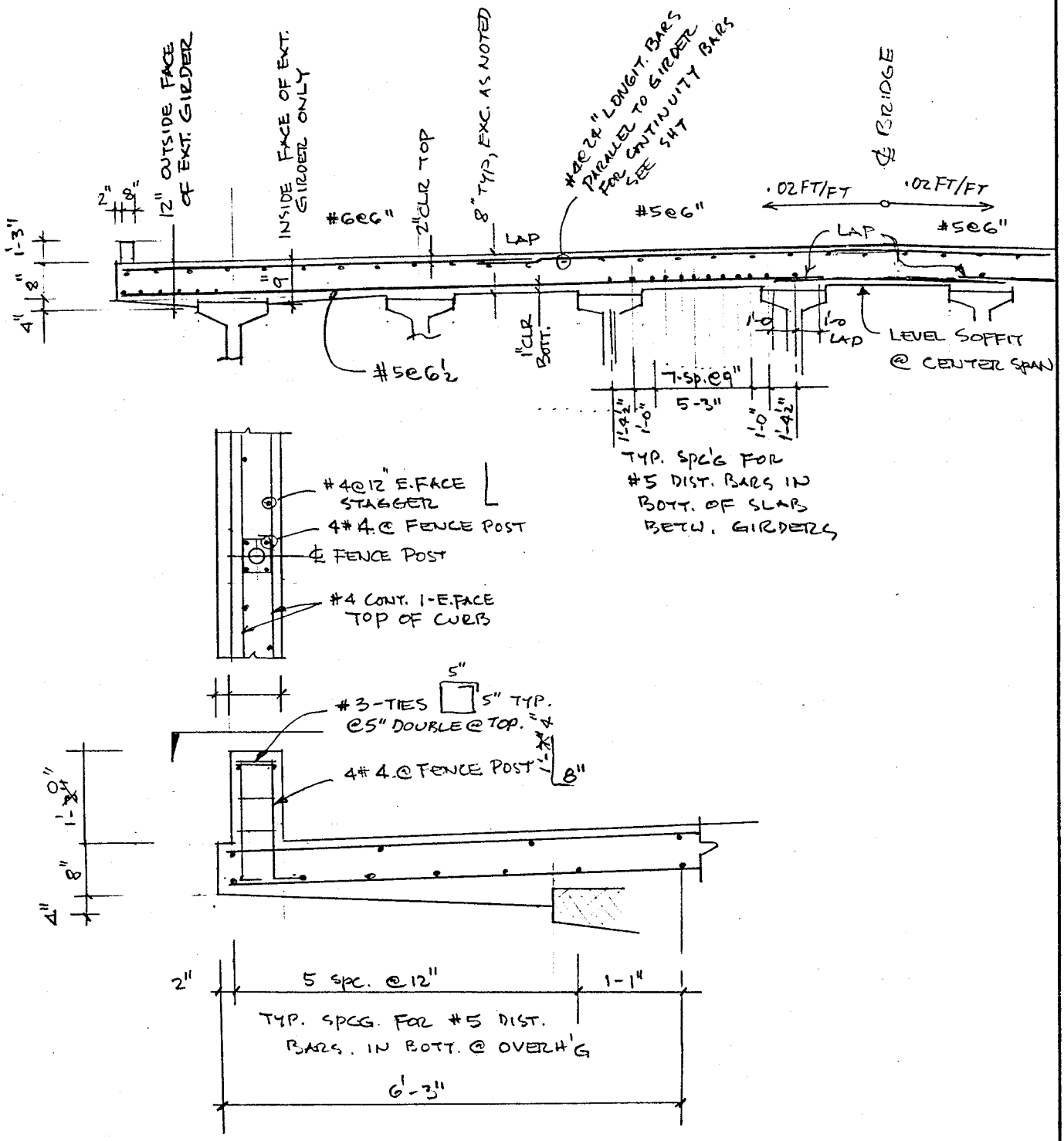
1/16" = 1'-0



TYP. GIRDER LAYOUT

1" = 100 FT

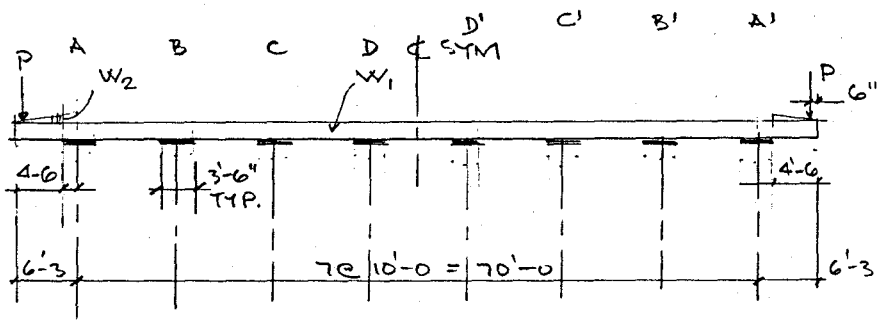
BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136	SHT. NO. 4 OF
	JOB NO. 2182 F
	BY AG DATE 8-6-82
	CHKD. DATE
DECK SLAB	REV.



TYP. SLAB REINF. DIAGS

(BARRIER NOT SHOWN SEE STD. ADOT DET.)

DECK SLAB



W_1^{DL} 8" CONC. SLAB, 100 PSF

W_2: 4" HAUNCH 50 -"-

P: CURB 125, & FENCE 25 150 #/L.FT

FIXED END MOMENTS

CANTILEVER:

(a) @ ℄ GIRDER $L_1 = 6.25$ $L_2 = 4.5$

$M_c = w_1 L_1^2/2 = 1.953$

$w_2 \frac{L_2}{2}\left(\frac{L_2}{3} + 1.75\right) = .366$

$P(5.75) = .863$

3.182 K-1

(b) @ FACE OF GIRDER: $L_1 = L_2 = 4.5$

$M_c = w_1 L_2^2/2 = 1.013$

$w_2 L_2^2/6 = .169$

$P(4.0) = .600$

1.782 K-1

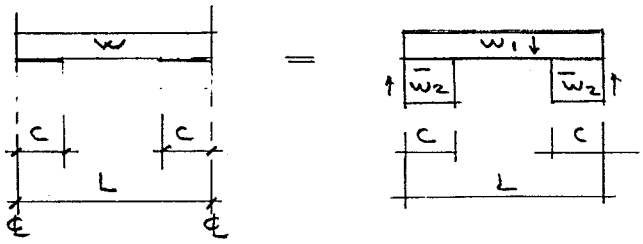
TYP. SPAN

(a) KNIVE EDGE SUPPORT $L = 10'$

$FEM = w_1 L^2/12 =$ .833 K'

TYP. FEM (CONT'D)

(b) ACCOUNT FOR WIDE SUPPORT



$\alpha = c/L$; $c = \alpha L$

$w_2 = \dfrac{w_1 L}{2c} = \dfrac{w_1}{2\alpha}$

$$FEM = w_1 L^2/12 - w_2 \frac{L^2}{6}(3\alpha^2 - 2\alpha^3) = \frac{w_1 L^2}{12}(3\alpha - 2\alpha^2)$$

$$= \frac{w_1 L^2}{12}\left[1 - 3\alpha + 2\alpha^2\right]$$

$\alpha = 1.75/10 = 0.175$

$$FEM = \frac{wL^2}{12}\left[1 - \overset{.525}{3(.175)} + \overset{.06125}{2(.175)^2}\right] = .447 \text{ K'/FT}$$

(.536)

I = 10.0

	.75 I/L	I/L	I/L	.5 I/L	℄ SYM
k	.75	1.0	1.0	0.5	
L FT	10.0	10.0	10.0	½L = 5.0	
DF:	.429	.571	.50 .50	.667	.333	CO. = 0.5 TYP.
FEM 3.182	-.447	.447	-.447 .447	-.447 .447	-.447	
	CO → -1.368				
UNBAL'D FEM	(-1.368)		(0)	(0)	
M'	.318	.424	-.116 -.116	.039	.019	
$M'_L + M'_R$	.318	.308	.308 -.077	-.077	.019	
(-) M (SUPPORT)	-3.182 -.285	.285	.639 -.640	.409	-.409	FEM + M' + ($M'_L + M'_R$)

KNIFE EDGE:

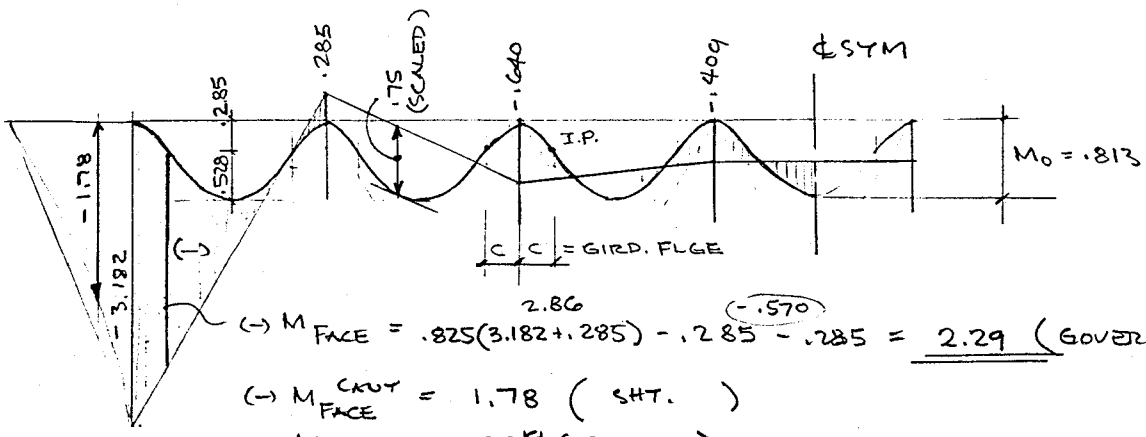
FEM 3.182	-.833	.833	-.833	.833	-.833	.833	-.833
	CO. -1.175						
UNBAL'D		(-1.175)		(0)		(0)	
M'		.273	.364	-.099	-.099	.033	.016
$M'_L + M'_R$		.273	.265	.265	-.066	-.066	.016
(-) M (SUPPORT)		.204	-.204	.999	-.998	.80	-.801

DECK SLABS

DL - MOM. DIAG'S

(a) WITH WIDE SUPPORT

$M_o = \omega_1 (1-(3.5/10)) L^2/8 = .813$



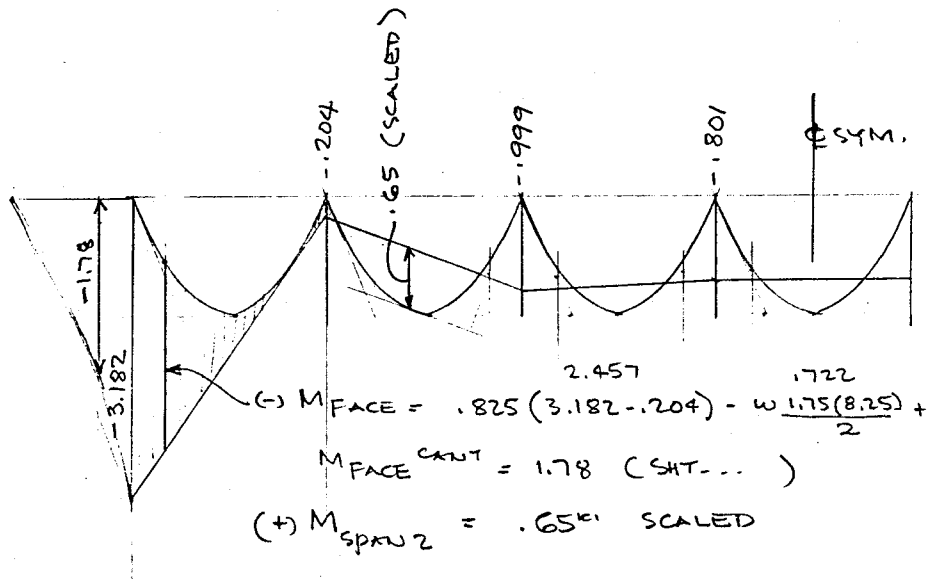
(-) $M_{FACE} = .825(3.182+.285) - .285 - .285 = \underline{2.29}$ (GOVERNS) (-.570)

(-) $M_{FACE}^{CANT} = 1.78$ (SHT.)

(+) $M_{span\,2} = .75^{k'}$ (SCALED)

(b) KNIFE EDGE SUPPORT

$M_o = \omega_1 L^2/8 = 1.25$



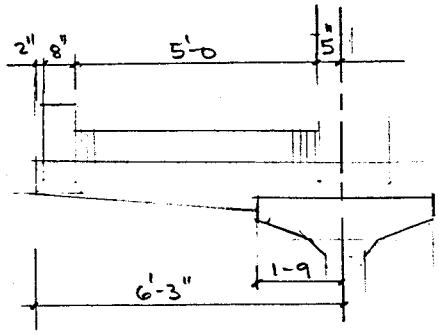
(-) $M_{FACE} = .825(3.182-.204) - \omega \frac{1.75(8.25)}{2} + .204 = 1.94^{k'}$

$M_{FACE}^{CANT} = 1.78$ (SHT-..)

(+) $M_{span\,2} = .65^{k'}$ SCALED

DECK SLAB.

SIDEWALK LL- MOMENTS



CANTILEVER MOMENTS

w_{LL} = 85 PSF SEC. 1.2.11

(a) AT ℄ GIRDER

$M_c = w(5)(2.92) = 1.241^{k'}$

(b) AT FACE OF GIRDER

$M_c = w(5)(\overset{1.17}{2.92-1.75}) = .497^{k'}$

℄ SYM

D.F.		.429	.571	.50	.50	.667	.333
FEM 1.241	0	0	0	0	0	0	0
	co.	-.621					
M'		.144	.192	-.052	-.052	.017	.009
$M'_i + M'_k$		.144	.140	.140	-.035	-.035	.009
M (support)		-.333	.332	.088	-.087	-.018	.018

		.429	.571	.50	.50	.50	.50	.50	.50 etc.
FEM 1.241	0	0	0	0	0	0	0	0	0
	co.	-.621							
M'		.144	.192	-.051	-.051	.014	.014	-.003	-.003
$M'_i + M'_k$		.144	.141	.141	-.037	-.037	.011	.011	
M (support)		-.333	.333	.090	-.088	-.023	.025	.008	

$(-)M_{FACE} = .825(\overset{1.572}{1.241+.333}) - .333 = .966$ (GOVERNS)

$(-)M_{FACE}^{CANT} = .497$

TRAFFIC LL- MOMENTS

$I = 0.3$

$S = 10.0 - 3.5 = 6.5$ FT 1.3.2 A

$P_{20} = 16.0^K$ $\gamma = 0.8$ FOR CONTINUITY

$\pm M_{LL} = \gamma (S+2) P_{20} / 32 = 3.4^{K'}$

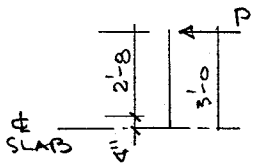
$I = .3(3.4) = 1.02$

$M_{LL+I} = \pm 4.42^K$

SLAB REINF. 2" CLR TOP
1" CLR BOTT.

SUPPORT A (RT.)

M_{DL} =	- 2.29 SHT
M_{LL} (SIDE WALK)	- .97
M_{LL+I}	- 4.42
(-) M_1	- 7.68 $^{K'}$



HORIZ. LOAD ON BARRIER SEC. 1.1.83

$P = 10.0 / 5.0 = 2.0^K$ $h = 3.0$

$M = P(h) = 6.0^{K'}$

$(-) M_{FACE} = \frac{6.0}{1.241}(.966) = 4.67$

(PRORATED FROM SIDE WALK LL- MOM. DIST.)

SHT ...

$-M_2 =$ M_{DL} = } 3.26
M_{LL} (SIDEWALK) =
M_{LL} (BARRIER) = 4.67
(-) M_2 = $7.93^{K'} > M_1$

GOVERNS

(-) $d = 8.0 - (2.0 + .3) = 5.7$ IN $n = 8$

$M_{DES} = 7.93^{K-'}$; $a = 1.44$; $A_s = M/ad = .966$

$n\rho = \frac{8(A_s)}{12(d)} = .1129$ $\gamma = 2/k_j = 6.08$

$f_c = M\gamma/d^2 = 1480$ PSI > 1400

DECK SLAB

REINF. @ SUPPORT A RT. (CONT'D)
THICKEN SLAB TO 9"

(-) $d = 9.0 - (2.0 + .38) = 6.62$ IN. $M = 7.93$
$A_{s\,req'd} = .83\ IN^2$ #5 @ 4½'

$np = .084$ $\gamma = 6.74$
$f_c = M\gamma/d^2 = 1220$ PSI

TYP. NEG. REINF. @ SUPPORT C:
DES. MOMENT:

$M_{DL} = -.64$
$M_{LL+I} = -4.42$
$M_{DES} = -5.06^{k-1}$

(-) $d = 5.7$ $a = 1.44$
$A_s = M/ad = .62\ IN^2$ #5 @ 6"

TYP. POSIT. REINF. SPAN BC
DESIGN MOMENT:

$M_{DL} = .75$
$M_{LL+I} = 4.42$
$M_{LL(SIDEW.)} = .14 = [.55(.423) - .09]$ SHT. (.333+.09)
$M_{DES} = 5.31^{k-1}$

$d = 8.0 - (1.0 + .32) = 6.68$ $a = 1.44$
$A_s = M/ad = .552\ IN^2$ #5 @ 6½'

DISTRIBUTION REINF. 1.3.2E
$S = 6'-6"$ $\% = 220/\sqrt{S} = 86.3\% > 67\%$ GOV.

$(+A_s)$
$A_{s1} = .67(.552) = .37\ IN^2/FT$ (MIDDLE HALF)
$A_{s2} = \frac{1}{2} A_{s1} = .185\ IN^2$ (EA. QUARTER)
$\Sigma A_s = \frac{1}{2} S (A_{s1} + A_{s2}) = 1.80\ IN^2$

$\frac{S}{2}(A_{s1}) = 1.20\ IN^2 = 4\ \#5$
$\frac{S}{4}(A_{s2}) = .60 = 2\ \#5$

.555

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136

SHT. NO. 11 OF
JOB NO. 2182 F
BY AG DATE 8-23-82
CHKD. MK DATE 12-82
REV.

CONTINUITY BARS TYP. GIRDER

DL 2 + LL + I

	0.1	.2	.3	.4	.5	.6	.7	.8	.9	0/1.0
SPAN AB (L=117.3)										
w_{DL2} = .19 k/'	89.8	153.5	191.1	202.5	187.8	146.9	79.9	-13.3	-132.6	-278
LL+I	-72.6	-145.2	-218	-290	-363	-436	-508	-581	-864.0	-1590 (-726)
1.67 (L+I)	-121.2	-242.5	-364	-485	-606	-727	-849	-970	-1443	-2655
1.3(w DL2 + 1.67(LL+I))	-40.9	-115.7	-224	-367	-544	-755	-999	-1278	-2048	-3813
SPAN BC L=119.2										-278/-214
w_{DL2} = .19	-150	-49	25	72	91	84	50	-11	-99	
LL+I	-850	-686	-638	-623	-608	-593	-576	-574	-778	-1590/-1500
1.3(w DL2 + 1.67(LL+I))	-2040	-1553	-1353	-1259	-1202	-1178	-1185	-1260	-1818	-3535 @ C
SPAN CD L=119.2										
w_{DL2} = .19	-93	2	69	110	123	110	69	2	-93	-214
(LL+I)	-774	-582	-537	-537	-537	-537	-537	-582	-774	-1500
1.3(w DL2 + 1.67(L+I))	-1801	-1261	-1076	-1023	-1006	-1023	-1076	-1261	-1801	-3535
W/S - DESIGN										
SPAN AB DL2+LL+I	17	9	-27	-88	-175	-289	-428	-594	-997	-1868
SPAN BC -"- -"- "-	-1000	-735	-613	-551	-517	-509	-526	-585	-877	-1714
SPAN CD " " "	-867	-580	-468	-427	-414	-427	-468	-580	-867	-1714

CONTINUITY BARS

INTER. GIRDER

(a) WS DESIGN $F_y = 40$ $a = 1.44$

$d = 72 + 4 = 76''$ CONSERV. $ad = 109$

$M_R = \Sigma A_s\, ad$ $A_{s1} = 12 \#5 = 3.72\ IN^2$

X-No. of #8	4	6	8	10	12	14	16	18
ΣA_s	6.88	8.46	10.0	11.6	13.2	14.8	16.4	17.9
$M_R = ad\Sigma A_s$ K-1	750	922	1094	1267	1439	1611	1783	1955

(b) LOAD FACTOR DESIGN

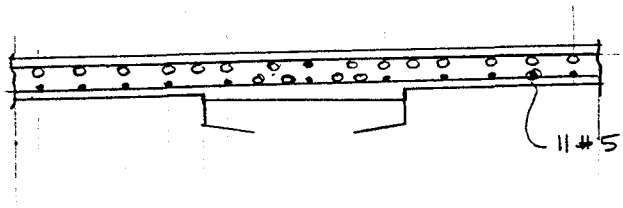
$d = 76''$ $b = 28''$ $f'_c = 5000$ PSI $f_y = 40$ $\phi = .90$

$a = \Sigma A_s f_y / .85\, b f'_c$ 12#5: $a = 1.25$

$M_R = \phi(A_s f_y)(d - a/2)/12$ $M_R = 841$

10#5 $M_R \cong 700$

X-NO. OF #8 BARS	2	4	6	8	10	12	14	16	18
ΣA_s	5.3	6.9	8.46	10.0	11.6	13.2	14.8	16.4	17.9
a	1.78	2.31	2.84	3.37	3.9	4.44	5.0	5.5	6.0
M_R	1194	1545	1893	2238	2581	2922	3260	3595	3928



19 #8 CONTINUITY BARS
(• CONTINUOUS BARS
o DISCONTINUOUS BARS)

11#5 CONT. DIST. REINF.

TYP. INTER GIRDER.

CONTINUITY BARS

BAR TERMINATION:

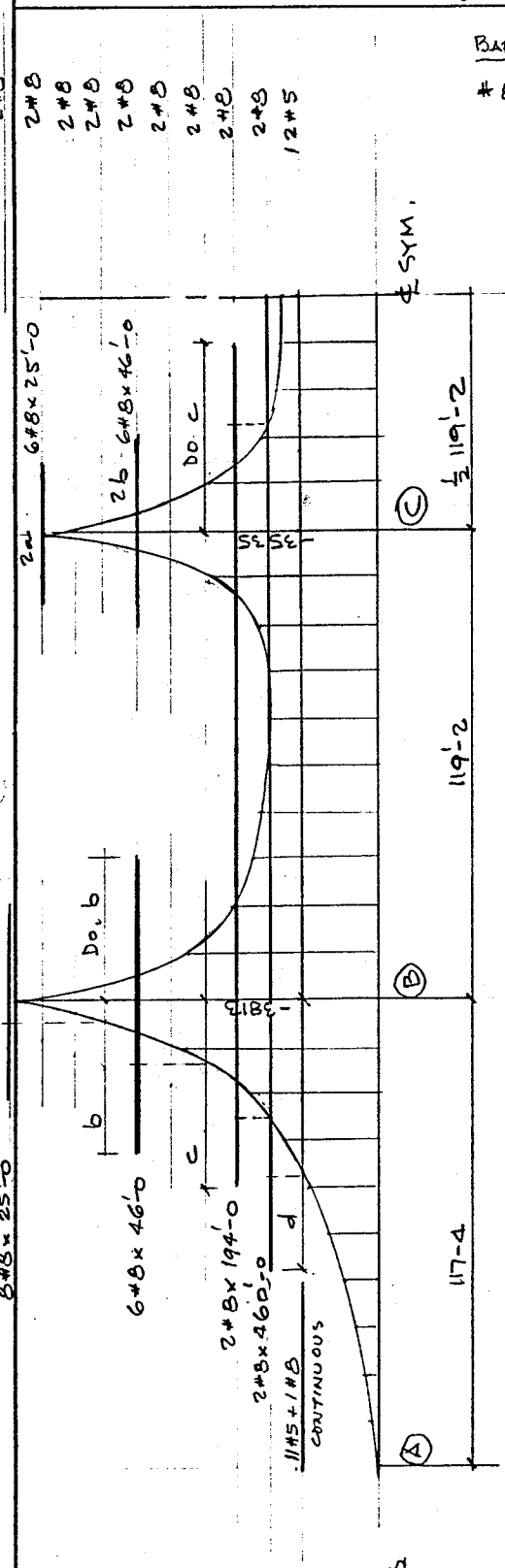
#8 BARS: $l_d = 30''$ $d = 76''$ (GOVERNS) $15 d_b = 15''$ $\frac{1}{20}(L) = 71.5''$ (119.2) $f'_c = 4000$

$a = .05(117.3) + 76/12 = 12.2$ FT SAY 12'-6"

$b = .14(117.3) + 76/12 = 22.8$ FT SAY 23'-0

$c = .26(117.3) + 76/12 = 36.8$ FT SAY 37'-0

$d = .38(117.3) + 76/12 = 50.9$ FT SAY 51'-0



FACTORED DESIGN MOMS

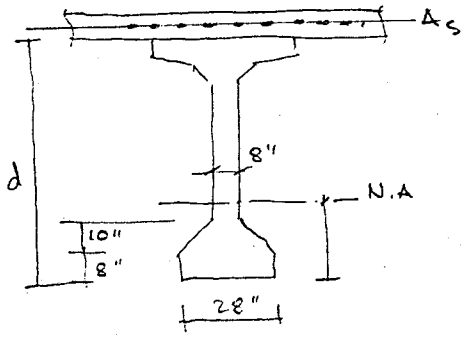
CONTINUITY BARS

PCA EB 014.01E PG. 17

COMPRESSIVE STRESS IN GIRDERS @ PIERS

$d = 72 + 1.5 + 4 = 77.5''$

$A_s = 18.23$ (11#5 3.41 + 19#8 14.82)



LOCATE N.A.

$f_c = 5500$ Psi $E_c = 4.2(10)^6$

$n = 29/4.2 = 6.9$

$8(28)(x-4) + (10)(10)(x-11.33) + (8)(10)(x-13) + 8(x-18)^2/2 = 6.9(18.23)(77.5-x)$;

$4x^2$	$224x$	-896
	$100x$	-1133
	$80x$	-1040
	$-144x$	1296
	$+126x$	-9748

$x^2 + 96.5x = 2880$

$x = -48.25 \pm 72.17 = 23.92$ IN

	A 01	d	A d 02	A d² 03 (18.00)	I_o
8(28)	224	4	896	3584	1195
10(10)	100	11.33	1133	12837	556
8(10)	80	13.0	1040	13520	666
8(5.9)	47.2	20.95	988.8	20716	137
6.9(18.23)	125.8	77.5	9749.5	755586	–
Σ	577.0		13807.34	-330403	475840
				I =	478394

$c_B = 23.93$ (77.50) $c_T = 53.67$

$M_B = -1868$ ($DL_2 + LL + I$) SEE SHT. ; P/S 1230 K e = 12.88 c = 36.38

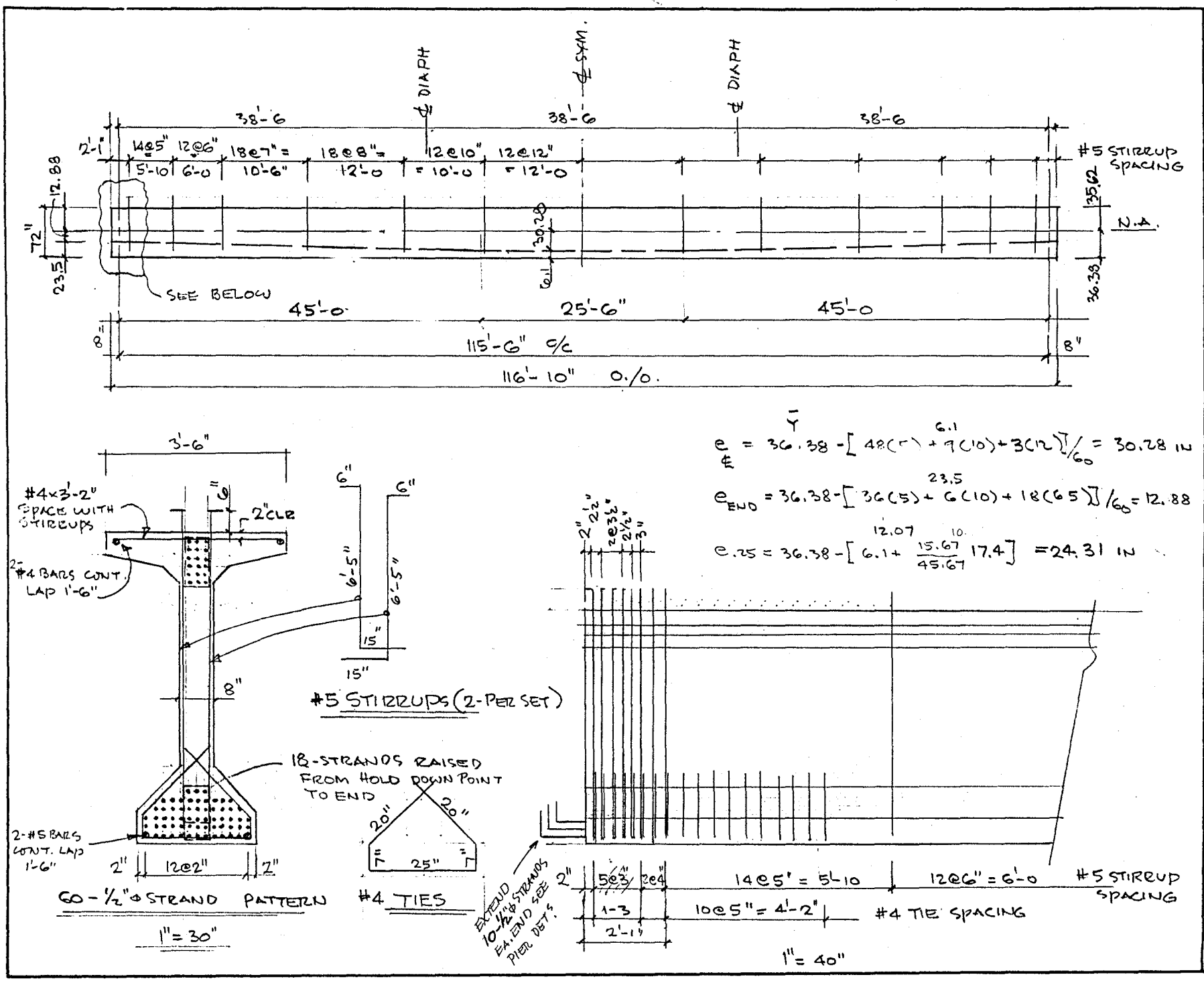
$f_{c(LL+I)} = 12(1868)23.93 \div 478393 = 1121$ Psi

f_c P/S $= 1230 / 1085 = 1134$ "

$1230(12.88)36.38 \div 733320 = 786$ "

3041 Psi

O.K. $< .6(5500) = 3300$ Psi



$$e_{℄} = \overset{\bar{Y}}{36.38} - [48(5) + \overset{6.1}{9}(10) + 3(12)]/60 = 30.28 \text{ IN}$$

$$e_{END} = 36.38 - [36(5) + \overset{23.5}{6}(10) + 18(6.5)]/60 = 12.88$$

$$e_{.25} = 36.38 - [\overset{12.07}{6.1} + \overset{10}{\frac{15.67}{45.67}}\,17.4] = 24.31 \text{ IN}$$

TYPE VI GIRDER DETS

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136

SHT. NO. 15 OF

JOB NO. 2182F

BY AG DATE 8-18-82

CHKD. MK DATE 12-82

REV.

GIRDERS

DEAD LOAD

DL 1: WT OF GIRDER, WET CONC. SLAB W/ BUILD-UP, INTERMED. DIAPHS

DL 2: BARRIERS, CURBS & FENCES, 12" WATER LINE (COMPOSITE $n_{4.5} = 8$ $n_5 = 7.0$)

EXTER. GIRDER:

w_1: GIRDER 1085 $^{150}/_{144}$ = 1130

8" SLAB: $(6.25+5)100$ = 1125

" HAUNCH $\frac{1}{2}(\overset{D}{4})\overset{W}{12.5}(\overset{L}{4.5})$ = 123

" " $\frac{1}{2}\frac{2}{3}(1)\overset{L}{6.5})(12.5)$ = 27

BUILD-UP ~ 3": $3(12.5)(3.5)$ EST'D ≅ 135

w_1 = 2540 #/FT

P_1: INTERM. DIAPH (JN. BELL ROAD): $\frac{1}{2}(\overset{4.78}{\sim 2.5})/\cos 43 = 3.4^K$

(LOCATED @ 1/3-PTS SEC. 1.6.22 C)

w_2: BARRIERS $2(\overset{WT}{372}+30)/\overset{N}{8}$ ≅ 100

FENCE & CURB: $2(125+25)/8$ ≅ 40

12" WATER LINE etc: EST'D 37+13 = 50

190 #/FT

$2[(5)^2+15^2+25^2+35)^2] = 4200$

PIPE ~ 50
WTR 50
HGR. 10
P = 110 #/1

e = 40 FT

$P_{EXT} = \frac{110(e)\overset{35.0}{c}}{I} = 37$ #/1

INTER. GIRDER:

w_1: GIRDER 1130

8" SLAB 1125 10(100) = 1000

HAUNCH $\frac{1}{2}(27)$ ~ 15

BUILD-UP EST'D 130

2400 #/FT

P_1: INTERM. DIAPH EST'D ~ 5/cos 43 6.8 K/PC

w_2: DO, EXT. 190 #/1

$w_{1\,SL}$ = 2400 - 1130 = 1270

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136

SHT. NO. 17 OF
JOB NO. 2182 F
BY AG DATE 8-9-82
CHKD. MEK DATE 11-4-82
REV.

GIRDERS

DL 2: MOM. DISTRIBUTION

$W_2 = 190^{\#}/'$

	A	B	C	C'	B'	A'
$\Sigma L = 592.2^{FT}$ L	117.3	119.2	119.2	119.2	117.3	
I/L	1.016	1.0	1.0 ℄ SYM.	1.0		
k =	$.762 = \frac{3}{4}\frac{I}{L}$					

DIST. FACTORS FOR SYMMETRY:

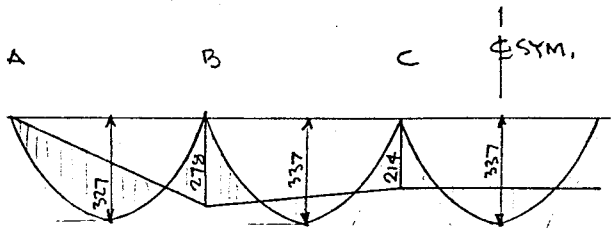
JT. B	k	DF
BA	.762	.4325
BC	1.000	.5675
Σ	1.762	1.0000

JT C:	k	DF.
CB	1.0	.667
CC'	0.5	.333
	1.5	1.000

FEM^S: $BA = \omega L_1^2/8 = 327^{K'}$

$BC = CB = CC' = \omega L_2^2/12 = 225$ $\quad M_o = 337^{K'}$

	A	B		C		℄ SYM.
		.4325	.5675	2/3	1/3	
FEM^{W2}	327	-225		225	-225	
UNBAL.		102			0	
M'	-24.36	-31.97		10.66	5.33	
$M'_i + M'_k$	-24.36	-21.31		-21.31	5.33	
END MOM'TS	278.28	-278.28		214.35	-214.34	
	~	-278			-214	K-FT
ΔM/L	±2.37		±.54		±0.0	
V_o^{W2}	11.14		11.32		11.32	



W_2: MOM. DIAG

$1'' = 600^{K-'}$

GIRDERS

DISTRIBUTION OF WHEEL LOADS 1.3.1

$S = 10.0$ FT

INTER. GIRDER: (TBLE 1.3.1(B)

$\gamma_i = S/5.5 = 1.82$ (BENDING)

EXT. GIRDER

$\gamma_e = (1.0+7.0)/10\ P = 0.8P < \gamma_i$

IMPACT: 1.2.12

$I = 50/(L+125)$

L VARIES FOR DIFFERENT LOC CONDITIONS

WHEEL LOADS FOR DESIGN

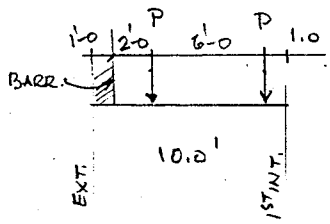
TRUCK: $P^T = \gamma(32/2) = 29.1^k$

LANE: $w^L = \gamma\ .64/2 = .58$

$P^L_m = \gamma(18/2) = 16.4$ MOM'TS

$P^L_v = \gamma(26/2) = 23.7$ SHEAR

NOTE: CHECK EXT. GIRDER FOR SIDEWALK + TRAFFIC + IMPACT



$P^T = P(1.0+7.0)/10 = 0.8P$

SIDEWALK LL:

$W = 5.0$ FT $L = 117.3$

$P_{SW} = \left(30 + \frac{3000}{L}\right)\frac{(55-5)}{50} \cong 56$ PSF

$w_{SW} = P_{SW}(W) = 280$ #/L.FT

PRORATE SIDEWALK LL FROM DL2-MOM. DIST.

$M_{01} = M_{05} = .28(117.3)^2/8 = 482^{k-1}$

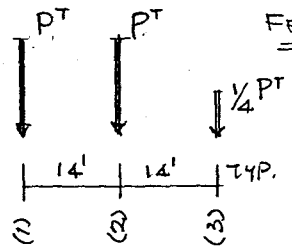
$M_{02} = M_{03} = M_{04} = .28(119.2)^2/8 = 497^{k-1}$

$(-)\ M_B = 278.3(.28/.19) = 410^{k'}$

$(-)\ M_C = 214.3(\ \ '' \ \ ) = 316^{k-1}$

GIRDERS (TRUCK MOM'S)

FEM'S FOR TRUCK LOADING

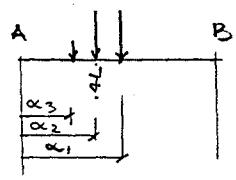


$FEM_{LT} = PL\, m_{LT}$; $m_{LT} = (\alpha - 2\alpha^2 + \alpha^3)$

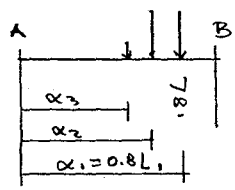
$FEM_{RT} = PL\, m_{RT}$; $m_{RT} = (\alpha^2 - \alpha^3)$

INTER. GIRDER

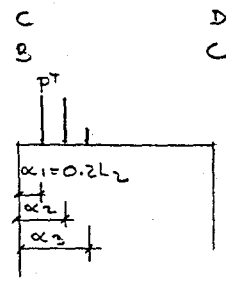
POS. MOM. END SPAN $L = 117.3$ $P^T = 29.1^k$



$\alpha_2 = 0.4L_1$	LT	RT	α
1	409.6	442.5	.519
2	491.5	327.7	.4
3	123.9	48.3	.281
Σ	1025.0	818.6	
Σ	PINNED	1331.1	

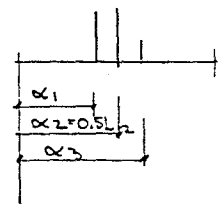


$\alpha_1 = 0.8L_1$	LT	RT	
1	109.2	436.9	.8
2	236.9	505.0	.681
3	92.2	117.9	.561
Σ	438.4	1059.9	
Σ	PINNED	1279.1	



POS. MOM. INT. SPAN $L = 119.2$ $P^T = 29.1^k$

$\alpha_1 = .2L_2$	LT	RT	
1	444.0	111.0	.2
2	513.0	238.6	.317
3	120.4	92.7	.435
Σ	1077.4	442.3	



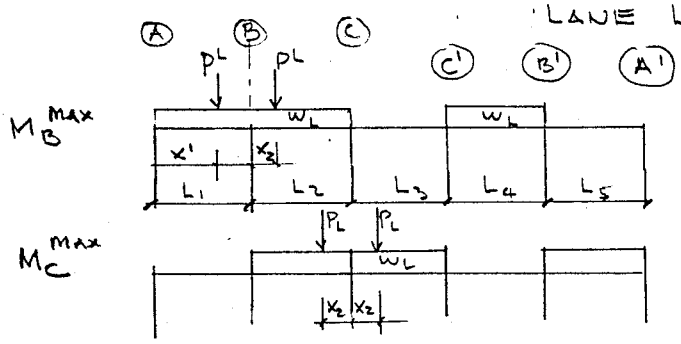
$\alpha_2 = 0.5L_2$	LT	RT	
1	505.9	313.4	.383
2	433.6	433.6	.5
3	78.4	126.5	.617
Σ	1017.8	873.5	

GIRDERS (NEG. MOM'S)

LANE LOAD GOVERNS BY INSPECTION

$w^L = .58^k/_1$ $\gamma = 1.82$

$P^L_m = 16.4^k$



$x_1 = \sqrt{\frac{1}{2}}\, L_1$

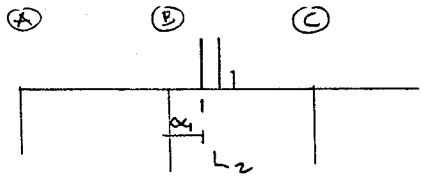
$x_2 = \frac{1}{3} L_2$

END SPAN L = 117.3

$\alpha_1 = (1-\sqrt{\frac{1}{3}})$	LT	RT	α
P	198.4	271.0	.577
w	665.0	665.0	1.0
Σ	863.4	936.0	
Σ	PINNED	1367.8	

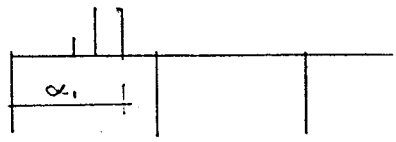
TYP SPAN L = 119.2

$\alpha_1 = \frac{1}{3}$	LT	RT	
P	289.6	144.8	.333
w	686.8	686.8	
	976.4	831.6	



MAX NEG IN END SPAN AB L_2 = 119.2 P = 29.1

$\alpha_1 = .275L_2$	LT (B)	RT (C)	α
1	501.4	190.2	.275
2	502.5	324.6	.392
3	106.2	110.5	.51
Σ	1110.1	625.3	



MAX NEG. IN SPAN BC L_1 = 117.3 P = 29.1

$\alpha_1 = .64$	LT	RT	α
1	283.1	503.3	.64
2	408.4	443.5	.521
3	122.7	82.3	.401
Σ	814.2	1029.1	
Σ		1436.3	

GIRDERS (MOM. DISTRIBUTION)

POS. MOMENTS (TRUCK)

	09	10							
(−) DF. & CO.	.216	.284		.125	.25		.25	.125	.284	.216
L	117.3	119.2			119.2		119.2		117.3
K =	.763	1.0			1.0		1.0		.763
FEM $\alpha_2=0.4L_1$	1331								
M'	-311.7	-408.6	109.5	109.5	-29.5	-29.5	8.36	6.38	
Support MOMS	0 707.7	-707.7	-189.6	189.6	50.6	-50.6	-12.8	12.8	0
FEM $\alpha_1=0.8L_1$	1279								
M'	-299.5	-392.6	105.2	105.2	-28.3	-28.3	8.03	6.13	
Support MOMS	0 680.0	-680	-182.1	182.1	48.6	-48.6	-12.3	12.3	0
FEM $\alpha_1=.2L_2$		-1077	442						
M'	0 279.9	367.0	-217	-217	58	58	-16.5	-12.6	0
Supp. MOMS	0 560	-560	375	-375	-100	100	25	-25	0
FEM $\alpha_2=0.5L_2$		-1018	874						
M'	293	384	-337	-337	91	91	-26	-20	0
Supp. MOMS	0 586	-586	584	-584	-156	156	39	-39	
FEM $\alpha_1=.2L_3$				-1077	442				
M'	-75	-98	347	347	-212	-212	60	46	0
Supp. MOMS	0 -150	150	595	-595	364	-364	-92	92	
FEM $\alpha_2=.5L_3$				-1018	874				
M'	-79	-103	364	364	-333	-333	94	72	
Supp. MOMS	0 -157	157	624	-624	572	-572	-144	144	0

GIRDERS (MOM.-DIST.)

NEG. MOMENTS

	A	B		C		D		E	F
CO×DF		.216	.284	.25	.25	.25	.25	.284	.216
L		117.3	119.2		119.2		119.2		117.3
			01		02		03		04
MAX M_B (LANE) FEM		1368	-976	832			-687	687	
M'		-25	-32	-278	-278	312	312	-283	-216
Supp. MOM's	0	1319	-1319	244	-244	346	-346	432	-432	0
MAX M_C (LANE) FEM			-832	976	-976	832			-1030
M'		176	231	19	19	-308	-308	379	289	0
Supp. MOM's	0	352	-352	1245	-1245	236	-236	451	-451
MIN M_{BA} Truck FEM			-1110	625					
M'		299	392	-273	-273	73	73	-21	-16
Supp. MOM's	0	598	-598	472	-472	-126	126	32	-32
MIN M_{BC} Truck FEM		1436							
M'		-336	-441	118	118	-32	-32	9	7
Supp. MOM's	0	763	-763	-205	205	55	-55	-14	14
MIN M_{CB} Truck FEM					-1110	625			
M'		-80	-105	371	371	-268	-268	76	58
Supp. MOM's	0	-160	160	636	-636	460	-460	-116	116	0
MIN M_{CD} Truck FEM			-625	1110					
M'		216	283	-373	-373	100	100	-28	-22
Supp. MOM's	0	432	-432	646	-646	-172	172	43	-43	0

GIRDERS (MOM - DIST)

NEG. MOM'S UNLOADED SPANS (LANE)

	A		B		C		D		E		F
Co x DF.		.216	.284	.125	.25	.25	.25	.25	.284	.216	
L		117.3	119.2		119.2		119.2			117.3	
MIN M_{BA} LANE FEM			-976	832			-976	832			
M'		301	395	-416	-416	438	438	-360		-275	
Supp MOMS	0	602	-602	394	-394	460	-460	550		-550	
MIN M_{BC} & M_{CB} LANE FEM		1368			-976	832				-1030	
M'		-401	-525	483	483	-433	-433	415		316	
Supp. MOMS	0	567	-567	442	-442	450	-450	397		-397	0
MIN M_{CD} & M_{DC} LANE FEM			-832	976			-976	832			
M'		277	363	-446	-446	446	446	-363		-277	
Supp. MOMS	0	553	-553	446	-446	446	-446	553		-553	0

POSITIVE MOM'S @ SUPPORTS

(+) M_{max} @ B (LANE)											
FEM					-976	832				-1368	
M'		-82	-107	378	378	-430	-430	511		388	
Supp. MOMS		-164	164	649	-649	350	-350	591		-591	
(+) M_{max} C (LANE)											
FEM		1368					-976	832			
M'		-299	-394	18	18	321	321	-328		-249	
Supp MOMS		769	-769	-358	358	661	-661	498		-498	
(+) M_{max} @ B (Truck) SEE SHT.					-1110	625	FEM				
		+	160	Supp. MOM							
(+) M_{max} C (Truck)							-1110	625			
				+	172						

POS. LL. MOMENTS (TRUCK)

$+M^{.4L_1} = M_0 + .4M_B^{LT}$
$= 1619 - 283 = 1336$

$+M^{.4}_{L+I} = 1611$

SPAN AB $L = 117.3$ $I = .206$ $P = 29.1$

@ $.4L_1$

$A_0 = P[(1-\alpha_1) + (1-\alpha_2) + \frac{1}{4}(1-\alpha_3)] = P\gamma$;

$M_0 = PL(\gamma\alpha_2 - \frac{1}{4}(14/L)) = mPL$ $\alpha_2 = 0.4$

$\alpha_1 = (\alpha_2 + 14/L)$ $\alpha_3 = \alpha_2 - 14/L$

$\gamma = 1.26$ $m = .474$

$A_0 = 36.68$

$M_0 @ .4L_1 = 1619^{K\text{-}FT}$ $M_B^{LT} = -708^{K'}$

@ $.8L_1$

$\gamma = \alpha_1 + \alpha_2 + \frac{1}{4}\alpha_3$ $B_0 = \gamma P$ $\alpha_1 = .8$ $= .80$

$M_0 = LB_0[1-\alpha_1] = PL\gamma(1-\alpha_1)$ $\alpha_2 = (\alpha_1 - 14/L) = .68$

$\alpha_3 = (\alpha_2 - \frac{14}{L}) =$

$\gamma = 1.621$ $B_0 = 47.17^K$

$M_0 @ .8L_1 = 1107^{K'}$ $M_B^{LT} = -680$

$(+)M_{LL}^{.8L_1} = M_0 + .8M_B^{LT}$
$= 1107 - 544 = 563$

$+M^{.8L_1}_{L+I} = 679$

SPAN BC $L = 119.2$ $I = .205$ $P = 29.1$

@ $.2L_2$

$B_0^{RT} = P[2.25 - \alpha_1 - \alpha_2 - .25\alpha_3] = P\gamma$; $\alpha_1 = 0.2 =$

$\gamma = 1.624$ $\alpha_2 = \alpha_1 + \frac{14}{L} = .317$

$M_B = -560$ $B_0^{RT} = 47.25 = P\gamma$ $\alpha_3 = \alpha_2 + \frac{14}{L} = .635$

$M_C = -375$

$M_0 @ .2L_2 = LB_0(\alpha_1) = PL\gamma\alpha_1 = 1127^{K'}$

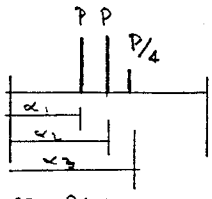
$+M.2L_2 = M_0 + .8M_B + .2M_C$
$= 1127 - 448 - 75 = 604^{K'}$ $M^{.2L_2}_{LL+I} = 728$

@ $.5L_2$

$B_0RT = P[2.25 - \alpha_1 - \alpha_2 - .25\alpha_3] = P\gamma$ $\alpha_2 = 0.5$ $= .50$

$\alpha_3 = \alpha_2 + \frac{14}{L} = .617$

$\gamma = 1.213$ $\alpha_1 = \alpha_2 - \frac{14}{L} = .383$



$B_0^{RT} = 35.3$

$M_0 @ .5L = PL(\alpha_2\gamma - \alpha_2 + \alpha_1) = 1698$

$M_B = -586$ $M_C = -584$

SEE PG 19

$(+)M.5L_2 = M_0 + .5(M_B + M_C)$
$= 1698 - 585 = 1113^{K'}$

$(+)M.5_{LL+I} = 1341^{K'}$

GIRDERS

POSS LL MOM'S (TRUCK)

SPAN CD $L = 119.2$ $I = .205$ $P = 29.1$

@ $.2L_3$:

$C_o^{RT} = 47.25$ $M_o = 1127^{k'}$ SEE SPAN BC

$M_B = -595$

$M_C = -364$

$+M_{.2L_3} = M_o + .8M_B + .2M_C$

$= 1127 - 476 - 73 = 578 <$ SPAN BC

$+M_{.2L_3}^{LL+I} = 696$

@ $.5L_3$

$C_o^{RT} = 35.3$ $M_o = 1698$ SEE SPAN BC

$M_B = -624$ $M_C = -572$

$(+)M_{.5L_3} = M_o + .5(M_B + M_C)$

$= 1698 - 598 = 1100 <$ SPAN BC

$(+)M_{.5L_3}^{LL+I} = 1326^{k'}$

NEG. LL MOMENTS

$M_B^{LL} = -1319$ $L_1 = \frac{1}{2}(117.3 + 119.2)$ $I = .2055$

$M_{B\ LL+I} = -1590^{k'}$ (LANE)

$M_C^{LL} = -1245$ $L = 119.2$ $I = .205$

$M_{C\ LL+I} = -1500^{k'}$ (LANE)

@ $.8L_1$: $B_{LT} = .58(L_1)/2 + 16.4(\sqrt{\tfrac{1}{3}}) + M_B/L_1 =$

$= 34.0 + 9.5 + 11.2 = 54.7^{k'}$

$x' = .2L_1 = 23.46$ FT

$.8M = B(x') - \omega x'^2/2 + M_B$

$1283 - 160 - 1319 = -196(1.2055) = -236$ LL+I

@ $.2L_2$ $B_{RT} = .58(L_2/2) + 16.4(\tfrac{2}{3}) + 1075/L_2 =$

$34.6 + 10.9 + 9.0 = 54.5^{k}$ $x = 23.84$

$.2M^{L_2} = B_{RT}(x) - \omega x^2/2 + M_B =$

$1299 - 165 - 1319 = -185(1.205) = -223$ LL+I

@ $.9L_1$ $M = 54.7(11.73) = 642$

$-.58(11.73)^2/2 = -90$ } -1359

$-M_B$ 1319

LL $= -717$

LL+I $= -864$

$.10L_2 = 54.5(11.92) = 650$

$-.58(11.92)^2/2 = -41$ } -1360

$-M_B$ -1319

LL $= -710$

LL+I -856

GIRDERS

NEG. LL MOM'S CONT'D

@ $.8L_2$

$C_{LT} = \overset{w}{.58}(L^3/2) + \overset{P}{16.4}\ 2/3 + \overset{\Delta M}{893}/L = 53.0^K$ (34.6, 10.9, 7.5)

$x' = .2L_3 = 23.84$

$M_{.8} = C(x') - wx'^2/2 + M_c = -146$ (1264, −165.2, −1245)

$M_{.8\ LL+I} = 1.205\ (146) = -176^{K'}$

@ $.2L_3$

$C_{RT} = 34.6 + 10.9 + 1009/L = 54.0^K$ (8.5)

$x = 23.84$

$M_{.2} = Cx - wx^2/2 + M_c$

$= 1287 - 165 - 1245 = -123$

$M_{.2\ LL+I} = -148^{K'}$

MIN. M_{BA} (UNLOADED)

TRUCK −598

LANE −602 ⇐ GOV. $LL+I = -726^L$ (.206)

MIN. M_{BC} (UNLOADED) $I = .205$

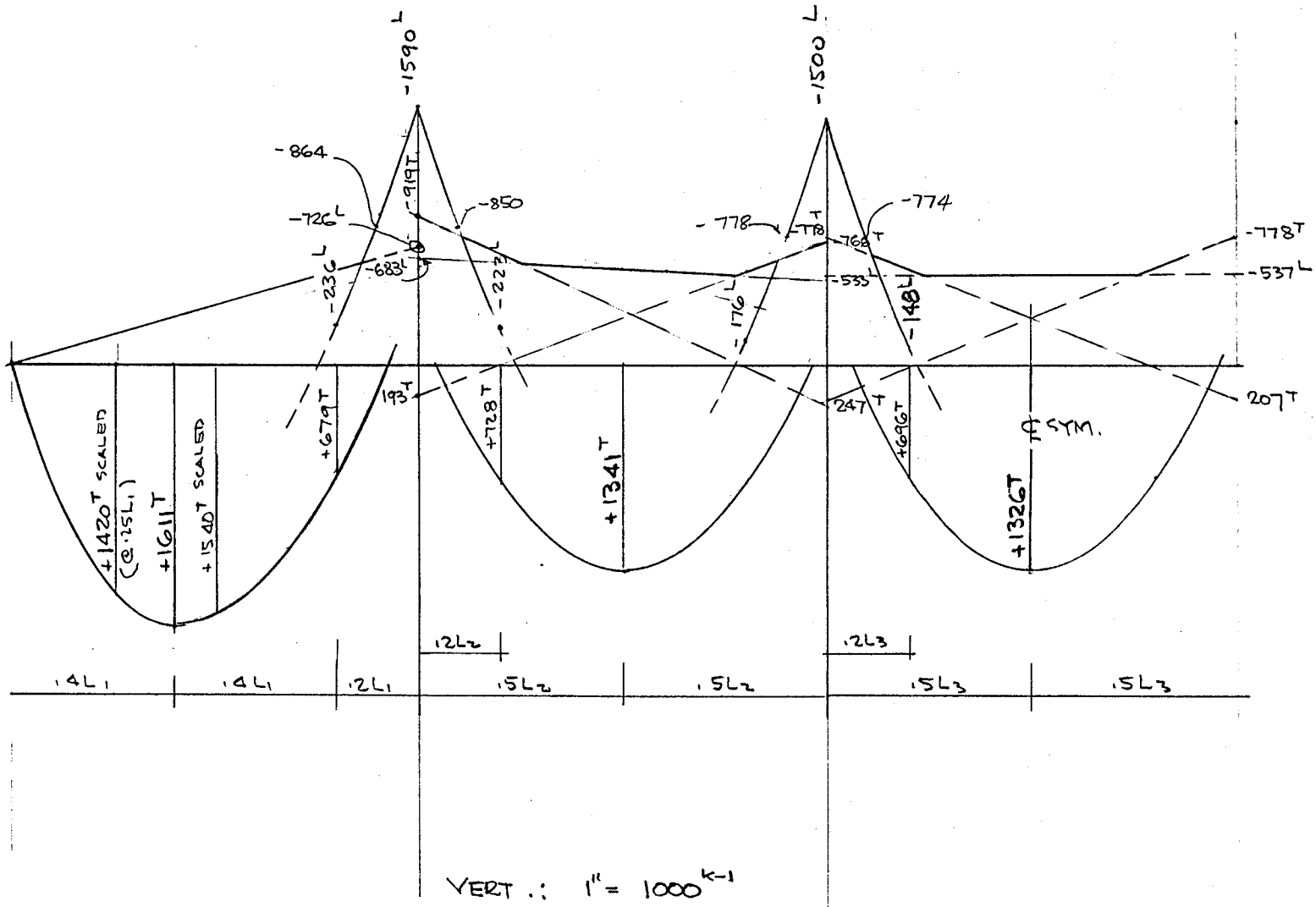
	M_B	M_C	(LL+I) M_B	M_C
TRUCK	−763	205	−919	247
LANE	567	442	−683	−533
TRUCK	160	−636	193	−766

MIN M_{CD} & M_{DC} (UNLOADED) $I = .205$

	LL M_C	LL M_D	LL+I M_C	LL+I M_D
TRUCK	−646	172	−778	207
"	172	−646	207	−778
LANE	−446	−446	−537	−537

$.9L_2 = 53(11.92) = 632$
$-.58(11.92)^2/2 = -41$
$-1245 = -1245$ } -1286
$LL = -654$
$LL+I = -788$

$.10L_3: 54(11.92) = 644$
-1286
$LL = -642$
$LL+I = -774$



VERT.: 1" = 1000 K-1

HORIZ.: 1" = .4L I.E. 1/4" = .10 L

GIRDERS (L+I MOM. CURVE)

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0138

SHT. NO. 27 OF

JOB NO. 2182F

BY AG DATE 8-10-82

CHKD. MC DATE 12-82

REV.

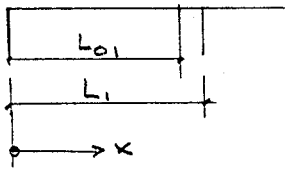
GIRDER DESIGN MOMENTS

TYP INTER.:

SLAB & DIAPH $w = 1.27^{k}/FT$ $P = 6.8$

END SPAN: $L_1 = 117.3$ $L_{01} = 115.5$ FT

$x_0 = x$



@ $.4L_1$ $x_0 = 46.92$ $x_0' = 68.58$ FT

$(+)M_{SL} = w x_0 x'/2 = 2043$

$P(L_0)/3 = 262$

$2305^{k'}$ ⇐ GOV.

@ $.5L_1$ $x_0 = x = .5L_1 = 58.65$ $x_0' = 56.85$

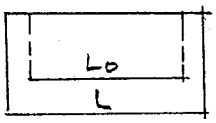
$(+)M_{SL} = w x_0 x'/2 = 2117$

$PL_0/3 = 262$

$2379^{k'}$

TYP. SPAN $L = 119.2$ $L_0 = 115.5$ FT

$x_0 = x - 1.85$



@ $0.4L$ $x_0 = 47.68 - 1.85 = 45.83$ $x_0' = 69.67$

$(+)M_{SL} = w x_0 x'/2 = 2027$

$PL_0/3 = 262$

2289 < END SPAN

@ $.5L$

$(+)M = wL_0^2/8 = 2118$

$PL_0/3$ 262

⟹ 2380 > ENDSPAN

GOV.

GIRDER: $w = 1130^{\#}/'$

$.4L_1$ $w x_0 x'/2 = 1818^{k'}$ $.4L_2 = 1804$

$.5L_2$ $wL_0^2/8 = 1884$

$x_0 = 59.6 - 1.85 = 57.75$

$x_0' = 57.75$

GIRDERS

GIRDER DESIGN MOMENTS CONT'D

TYP INTER:

DL 2 $w = .190^{k}/'$

END SPAN:

$V_\Delta = 11.14 - 2.37 = 8.77^{k}$

@ $.4L_1$: $x = 46.92$

$(+) M_{DL2} = \underset{411.5}{V_\Delta(x)} - \underset{209}{\omega x^2/2} = \underline{\underline{203^{k'}}}$

@ $.5L_1$ $x = 58.65$

$(+) M_{DL2} = \underset{514}{V_\Delta(x)} - \underset{327}{\omega x^2/2} = \underline{\underline{188}}$

MOM'S @ $.25L_1$

$x_0 = .25(117.3) = 29.33 = x$ $x_0' = 115.5 - x = 86.2$ FT

$(+) M_{SLAB} = \overset{w}{1.27}(x_0)x'/2 = 1604$

$\underset{6.8}{P}(x_0)$ $\underline{199}$

$\underline{\underline{1803}}$ ← GOVERNS

$(+) M_{GIRDER} = \overset{1.13}{\omega} x_0 x'/2 = \underline{\underline{1427}}$ ← GOVERNS

$(+) M_{DL2} = \overset{V_\Delta}{8.77}(x_0) - \overset{.19}{\omega} x_0^2/2 = 257$

$\underline{-82}$

$\underline{\underline{175^{k'}}}$

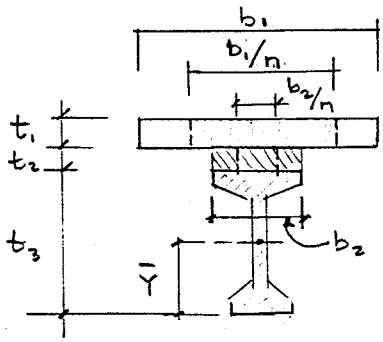
MOM'S @ $.25L_2$ ($L_2 = 119.2$)

$x_0 = .25L_2 - 1.85 = 28.0$ FT $x_0' = 87.5$ FT

$(+) M_{SL} = 1.27(---) = 1556$

$P(x_0)$ $\underline{190}$ } 1746 < END SP.

COMPOSITE GIRDER PROPERTIES



TYPE VI GIRDER

$A = 1085$ $\quad w_1 = \frac{1}{4}L = 357$ IN

$\bar{Y} = 36.38$ $\quad w_2 = s = 120$ IN

$I_o = 733320$ $\quad w_3 = 12(\overset{96}{8}) + 8 = 104$ IN

$\underline{b_1 = w_3 = 104 \text{ IN}}$

SEC. 1.6.2

$n_1 = 7$ (GIRDER $f'_c = 4600 - 5900$)

$n_2 = 8$ (SLAB $f'_c = 3600 - 4500$)

$n_2/n_1 = n = 8/7$

$S_{TG} = 20588$

$S_{BG} = 20157$

	BUILD-UP		S & C SLAB	S & C TOP GIRD.	S & C BOTT. GIRD	I
			53 349	80 711	27 955	1494975
	1.5"	S	~~52 935~~	~~79 766~~	~~28 073~~	~~1495 066~~ @ SUPP.
		C	~~28.24~~	~~18.74~~	~~53.26~~	
			28.0	18.52	53.48	
			56 035	93 993	29 000	1595709
@ .25 L	3.5"	S	~~55 624~~	~~92 837~~	~~29 115~~	~~1595 796~~ @ .25
		C	~~28.69~~	~~17.19~~	~~54.81~~	
			28.48	16.98	55.00	
			57 352	101 553	29 528	1647 114
@ .5 L	4.5"	S	~~56 942~~	~~100 270~~	~~29 647~~	~~1647 200~~ @ .4 & .5L
		C	~~28.93~~	~~16.43~~	~~55.57~~	
			28.72	16.22	55.78	

TYP. INT. GIRDER

GIRDER MOMENTS & STRESSES

	END e = 12.88			.4L e = 30.28			.5L e = 30.28		
	M^{k-1}	f_{TOP} psi	f_{BOTT} psi	M	f_{TOP}	f_{BOTT}	M	f_T	f_B
SLAB & DIAPH.^{S}	—	—	—	2305	-1344	1371	2380	-1388	1416
GIRDER	—	—	—	1818	-1060	1082	1884	-1099	1121
Σ				4123	-2404	2453	4264	-2487	2537
DL 2 (comp.)	-278	42	-119	203	-24	82	188	-22	76
Σ		42	-119		-2428	2535	4452	-2509	2613
(LL+I) (comp.)	-1590	239	-680	1611	-193	652	SCALED 1540	-184	623
Σ		281	-799		-2621	3187		-2693	3236
PRESTRESS F/A (1230, 1085)		-364 -1134	-1920 -1134		-1134	-1134		-1134	-1134
F_{eff} = 1230 SEE LOSS CALCS SHT. Fe/S_G		770	-786		1810	-1847		1810	-1847
Σ		-83 (TENSION)	-2719		-1945	206 (TENSION)		-2017	255 (TENSION)
INITIAL PRESTRESS									
F_i=1527 SHT. F_i/A		-1407	-1407		-1407	-1407		-1407	-1407
$F_i e/S_G$		1386	-1414		2247	-2293		2247	-2293
GIRDER		—	—		-1060	1082		-1099	1121
Σf_i		-21	-2821		-220	-2618		-259	-2579

GIRDER:

$I = 733320$ $Y_B = 36.38$ $Y_T = 35.62$

$S_T = I/Y_T = 20576 \text{ in}^3$

$S_B = I/Y_B = 20168 \text{ in}^3$

COMPOSITE GIRDER

	@ END	@ .4L & .5L
$S_{SL.}$	52935	56942
$S_{T.GIRD.}$	79766	100270
$S_{B.GIRD}$	28073	29641

CONC. STRENGTH REQ'D: @ RELEASE: $f'_{ci} = 2821/.6 = 4700$ psi MIN.

SEC. 1.6.12 C4 @ 28 DAYS (FIND) $-2719/.6 = 4530$ psi

SEC. 1.6.6 B2 OR $-2017/.4 = 5042$ say 5500 psi

GIRDERS

TYP. INTER.

CHECK PRESTRESS @ .25 L₁

	.25 L₁ e = 24.31 M	f^T	f^B
SLAB & DIAPH	1803	-1052	1073
GIRDER	1427	-832	849
Σ		-1884	1922
DL 2 (comp.)	175	-23	72
Σ		-1907	1994
LL+I (comp.)	1420	-170	575
Σ		-2077	2569
PRESTRESS 1230 ↓ 1085 F/A		319	-2617
		-1134	-1134
Fe/S_G		1453	-1483
Σ		-1758	-48
INITIAL:		-3237	-3398
1527 F_i A		-1407	-1407
F_i e/s		1952	-1991
GIRDER		-832	849
Σ		-287	-2549

$f'_{ci} = 2549/.6 = 4250 < 4700$ o.k.

$S_{co}^{.25} = S^T = 92837$

$S_B = 29115$

GIRDERS

PS - LOSSES SEC. 1.6.7.B

$$\Delta f_s = \overset{\text{SHRINK}}{SH} + \overset{\text{ELAST.}}{ES} + \overset{\text{CREEP CONC.}}{CR_c} + \overset{\text{RELAX OF PS-STL}}{CR_s}$$

(a) SHRINKAGE: RH = 40 FIG 1.6.7

$SH = 17000 - 150(40) = 11000$ Psi

(b) ELASTIC SHORTENING (ES) (INTERIM 1975 PG. 58)

$f'_{ci} = 4400$

$E_{ci} = 3822$

$E_s = 28(10)^6$

$E_{ci} = 33(145)^{1.5}\sqrt{5200} = 4155$ ksi

60 - ½"ø STRANDS @ .63(270) ksi

$F = 60(.153).63(270) = 1561.5^K$ $e = 30.28$

$$f_{cir} = \frac{F}{A} + \frac{Fe^2}{J} - \frac{M_G e}{I} = 2458 \text{ Psi}$$

18 000

$$ES = \frac{E_s}{E_{ci}} f_{cir} = 16563 \text{ Psi}$$

(b1) INITIAL LOSSES @ RELEASE:

RELAX LOSS ~ 3.5% OF .7(270) = 189

(1) CYCLE $F = ((1.00 - .035)189 - ES)\,60\,(.153) = 1522.2^K$

$f_{cir} = 2373$ Psi ES 15988

2355 17277 2ND CYCLE: F = 1527.5 $f_{cir} = 2384$ ES 16066

1515.7 2358 17277 3RD CYCLE: F = 1526.8 $f_{cir} = 2382$ ES 16055

(c) CREEP CONCRETE (CR_c)

$M_1 = 2380^{K'}$ SLAB & DIAPH $e_1 = 30.28$

$M_2 = 188^{K'}$ $I_{comp} = 1647200$ $e_2 = 30.28 + (55.57 - 36.38) = 49.47$ (19.19)

$$f_{cds} = \frac{M_1 e_1}{I_1} + \frac{M_2 e_2}{I_{co}} = 1179 + 68 = 1247$$

$$CR_c = 12 f_{cir} - 7 f_{cds} = 19860$$

19570

PS- LOSSES (CONT'D)

(d) RELAXATION OF PS - STEEL (CR_s)

$CR_s = 20000 - .4ES - .2(SH + CR_c) = 7405$

6975

(e) TOTAL LOSS :

$\Delta f_s = SH + ES + CR_c + CR_s = 54321$ Psi

54822

∴ EST'D 54000 Psi o.k.

ADJUST LOSSES FOR f'_{ci} REVISED = 4400 Psi

(b) REV'D :

$E_{ci} = 3822$

$f_{cir} = 2358$ Psi

$F_i = 1516^k$

ES — 17 277

(c) CR_c REV'D $12 f_{cir} - 7 f_{cds}$ = 19 570

(d) CR_s REV'D 6975

(e) Δf_s REV'D 54822

USE $\Delta f_s = 55$ Psi

$f_{es} = 189 - 55 = 134$ Psi

$F_{eff} = 134 \underset{N}{(60)} \underset{A_s}{.153} = 1230^k$

FINAL SERVICE LOAD TENSION @ .5L (F=1230) e=30.2

$-F/A - Fe/S = -2980$

$\Sigma f_{TL} = 3281$

301 Psi TENSION $< 6\sqrt{f'_c} = 465$ Psi

o.k.

GIRDER DESIGN MOMENTS

EXTER. GIRDER

SLAB & DIAPH : $w = 1.41^{k}/FT$ $P = 3.4^{k}$ ½ DIAPH

END SPAN: $L_1 = 117.3$ $L_0' = 115.5$

@ $.25 L_1$ $x_0 = 29.3$ $x_0' = 86.2$

$$(+)M = \overset{1780}{w x x'/2} + \overset{100}{P x} = \underline{1880^{k'}}$$

@ $.4 L_1$ $x_0 = 46.92$ $x_0' = 68.58$

$$(+)M = \overset{2270}{w x x'/2} + \overset{130}{P L_0/3} = \underline{2400^{k'}}$$

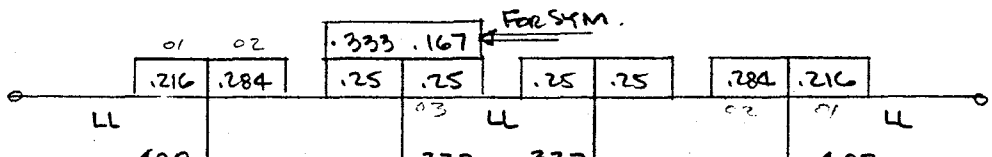
@ $.5 L_1$ $x_0 = 58.65$ $x_0' = 56.85$

$$(+)M = \overset{2350}{w x x'/2} + \overset{130}{P L_0/3} = \underline{2480^{k'}}$$

GIRDER $w = 1.13^{k}/'$ SEE TYP. INTER.

DL 2 " " "

SIDE WALK LL $w = .28^{k}/'$



FEM	482			-332	332			-482
M'	-141	-186	173	86				
	-141	-13	-13	86				
Support Mom.	200	-199	160	-160				
$\Delta M/L$ ±1.7								

	LL	150 LL		12		13 LL		14
FEM	482	-332	332			-332	332	
M'	-7	-9	-117	-117	146	146	-136	-103
	-7	-126	-126	29	29	10	10	-103
Me support	468	-467	89	-88	175	-176	206	-203

GIRDER DES. MOM'S (CONT.)

SIDEWALK LL CONT'D

$V_t = \frac{1}{2}(117.3)\ .28 = 16.4 - \overset{\Delta M/L}{1.7} = 14.7^k$

@ .25 L; $x = 29.3$

$(+)M = V_A(29.3)^{431} - \omega x^2/2^{120} = \underline{311^{k'}}$

@ .4 L, $x = 46.92$

$(+)M = V_A(x)^{690} - \omega x^2/2^{308} = 382^{k'}$

@ .5 L, $x = 58.65$

$(+)M = V_A(x)^{862} - \omega x^2/2^{481} = 381^{k'}$

@ B: $(-)M_B = 468^{k'}$

TRUCK DESIGN MOM'S

$\gamma_e = .8$ $P = .8(16) = 12.8^k$

PRORATE FROM INTER. GIRDER $\gamma_i = 1.82$

FACTOR : $C = \gamma_e/\gamma_i = .44$

@ .25 $(+)M^{INT.}_{LL+I} = 1420^{k'}$ SCALED

$(+)M^{EXT} = CM_{INT} = 625$

@ .40 $(+)M^{INT}_{LL+I} = 1611$

$(+)M^{EXT} = CM_{INT} = 710$

@ .50 $(+)M^{INT}_{LL} = 1540$

$(+)M^{EXT} = CM_{INT} = 680$

SIDEWALK + LL + I:

@ .25 : 311 + 625 = 936

@ .40 : 382 + 710 = 1092

@ .50 381 + 680 = 1061

@ B: 468 + 700 = 1168

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136	SHT. NO. 37 OF
	JOB NO. 2182F
	BY AG DATE 8-14-82
	CHKD. MK DATE 12-82
TYP EXT. GIRDER	REV.

GIRDER MOMENTS & STRESSES

	@ END e = 12.88			@ .25L e = 24.31			@ .4L e = 30.28			@ .5L e = 30.28		
	M^{k-1}	f^T	f^B	$M^{k'}$	f^T	f^B	M^{k-1}	f^T	f^B	$M^{k'}$	f^T	f^B
SLAB & DIAPH.	—	—	—	1880	-1096	1119	2400	-1400	1119	2480	-1446	1476
GIRDER	—	—	—	1427	-832	849	1818	-1060	1082	1884	-1099	1121
Σ					-1928	1968		-2460	2201		-2545	2597
DL 2 (comp)	-278	42	-119	175	-23	72	203	-24	82	188	-22	76
Σ		42	-119		-1951	2040		-2484	2283		-2567	2673
LL+I+SW(co.)	-1168	176	-499	936	-121	386	1092	-131	442	1061	-127	430
Σ		218	-618		-2072	2426		-2615	2725		-2694	3103
PREST. F/A	SEE INT.	-364	-1920		319	-2617		676	-2981		676	-2981
Fe/S_G												
Σ		-146	-2538		-1753	-191		-1939	-256		-2018	122 TENS

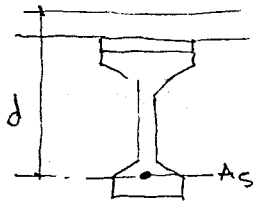
	S_T	S_B
GIRDER	20576 02	20168 03
COMP. @ .25	92837 07	29115 08
COMP. .4/.5	100270 06	29641 09
COMP. END	79766 04	28073 05

AT 28 DAYS:

@ .5L: $f_T = -2018$ $f'^{req'd}_c = 2018/.4 = 5045$

GIRDERS

FLEX. STRENGTH



$D = 72 + \overset{\text{BUILD-UP}}{3} + 8 = 83''$

$d = 83 - 6.1 = 76.9$ SAY $76''$

$b = 104\,(7/8) = 91$ IN

$A_s^* = 60\,(.153) = 9.18\ \text{IN}^2$

$p^* = A_s^* / bd = .00133$

$1.4\,d\,p^*\,f_{su}^*/f_c' = 2.35\,(10)^{-5}\,f_{su}^* = 6.2\ \text{IN}^2 < T_{FL}$ (6000, 6.155)

$f_{su}^* = f_s'\,(1 - .5\,p^* f_s'/f_c') = 262$ (261.9) (BONDED)

∴ N. AXIS IN FLGE.

$$M_u = A_s^*\,f_{su}^*\,d\left(1 - 0.6\,\frac{p^* f_{su}^*}{f_c'}\right)/12 = 14696^{k'}$$

FACTORED MOMENT:

@ .5L $M_n = 1.3(4264 + 1.67\,(188 + 1650)) = 9533^{k'}$

@ .4L $M_n = 1.3(4123 + 1.67\,(203 + 1739)) = 9576$

O.K.

REQUIRED FLGE REINF.:

$A_{sf} = 0.85\,(f_c')\,(b - b')\,t / f_{su}^*$

$= .85\,(4.5)\,(91 - 8)\,8 / 261.9 = 9.69$

$A_{sr} = A_s^* - A_{sf} = 9.18 - 9.69 =$ NEGAT.

MIN. STEEL SEC 1.6.10 B

MOD. OF RUPT. $f_R = 7.5\sqrt{6000} = 581$ PSI

$S_B = 29641$ MAX

$M_{MIN} = 1.2\,(S f)/12000 = 1722$ KFT NOT CRIT.

NON PREST. REINF.: 1.6.11

$$\frac{A_s f_y}{b' d f_c'} + \frac{A_{sp} f_{su}^*}{b' d f_c'} - \frac{A_s' f_y'}{b' d f_c'} \le .3$$

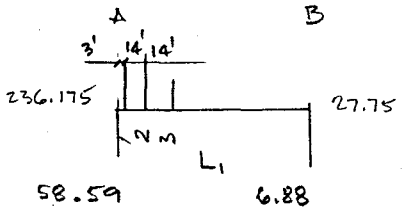
$$\frac{.62\,(40)}{8\,(76)\,6} + 0 -$$

.006

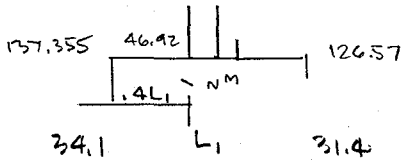
GIRDERS (TRUCK SHEARS)

INTER. GIRDER FEM's

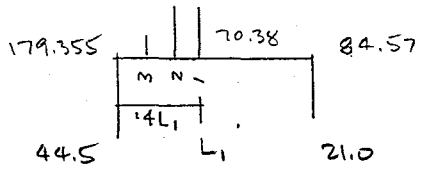
END SPAN L = 117.3 P = 29.1 k



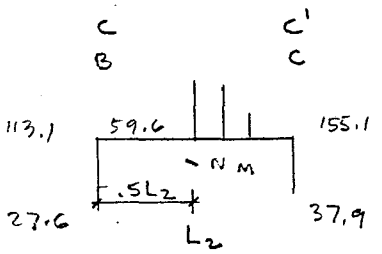
	LT	RT	α
1	83	2	.026
2	362	61	.145
3	122	44	.264
Σ	567	107	
Σ	PINNED	391	
	620	PINNED	



$\alpha_1 = 0.4L_1^{LT}$	LT	RT	
1	491.5	327.7	4
2	409.6	442.5	.519
3	71.1	125.8	.639
Σ	972.2	896.0	
Σ	PINNED	1382.1	

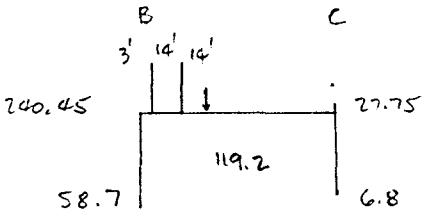


$\alpha_1 = 0.4L_1^{RT}$	LT	RT	
1	491.5	327.7	.4
2	495.7	193.4	.281
3	96.8	18.6	.161
Σ	1084.0	539.7	
Σ	PINNED	1081.7	



SHEAR IN INT. SPAN $L_2 = 119.2$

$\alpha_1 = 0.5L_2$	LT	RT	
1	433.6	433.6	.5
2	313.4	505.9	.617
3	44.8	124.2	.735
Σ	791.8	1063.6	



1	83	2	.025
2	364	61	.143
3	123	43	.26
Σ	570	106	

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SHT. NO. 40 OF

JOB NO. 2182 F

BY AG DATE 8-25-82

CHKD. MK DATE 12-82

REV.

GIRDER SHEARS (MOM - DIST.)

TRUCK LOAD

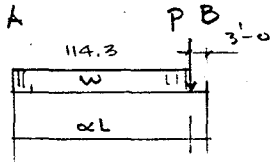
NOTE: ONLY 1-SPAN LOADED

DF x CO.		.216	.284	.250	.250	.250	.250	.284	.216
L		117.3		119.2		119.2		119.2		117.3
FEM		620					-570	106	
M'		-145	-191			174	174	-80	-61
M@ support		330	-330			301	-301	121	-121
FEM		1082					-792	1064	
M'		-253	-333			317	317	-392	-298
M@ support		576	-576			549	-549	597	-597
FEM		391			-570	106			
M'		-91	-120	174	174	-75	-75		
M@ support		208	-208	298	-298	129	-129		
FEM		1382			-792	1064			
M'		-323	-425	313	313	-371	-371		
M@ support		736	-736	537	-537	636	636		
FEM			-570	106					
M'		140	184	-78	-78				
M@ support		280	-280	135	-135				
FEM			-792	1064					
M'		252	331	-374	-374				
M@ support		504	-504	647	-647				

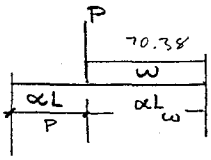
GIRDERS (LANE SHEARS)

FEMS INTER. GIRDER

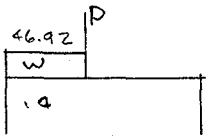
$w = .58^k/1$, $P = 23.7^k$ } SHT.



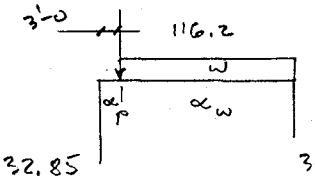
34.0 w 32.3
.6 P 23.1
34.6 55.4



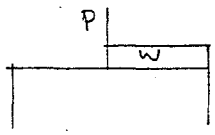
12.2 w 28.6
14.2 9.5
26.4 38.1



27.21 21.77 5.44
14.20 9.50
35.97 14.94



32.85 34.55
23.10 .60
55.95 35.15



8.6 25.9
11.9 11.9
20.5 37.8

END SPAN $L_1 = 117.3$

LOAD	LT	RT	α
w	665	663	.9744
P	2	68	"
Σ	667	731 (334)	
Σ	PINNED 1032	1065 PINNED	

END SPAN

	LT	RT	α
w	316	546	.6
P	400	267	.4
Σ	716	813	
Σ	PINNED 1123	1171 PINNED	

END SPAN

	LT	RT	α
w	349	119	.4
P	400	267	.4
Σ	749	386	
Σ	PINNED 942	761 PINNED	

INTER SPAN L = 119.2

	LT	RT	α
w	684	687	.975
P	68	2	.025
Σ	752	689	

INTER SPAN L = 119.2

	LT	RT	α
w	215	472	.5
P	353	353	.5
Σ	568	825	

GIRDER SHEARS (MOM - DIST.)

W = .58 K/'
P = 23.7 K

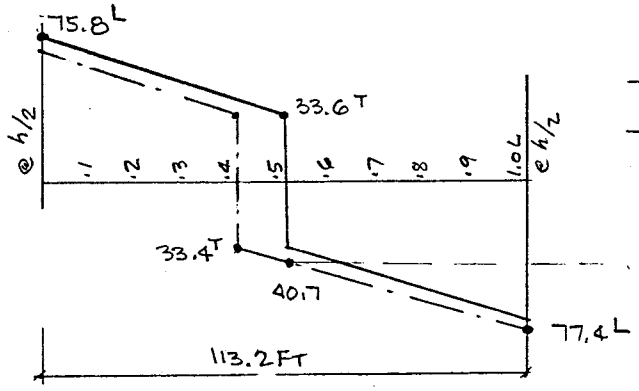
LANE - LOAD

DF × CO.		.216	.284	.250	.250	.250	.250	.284	.216
L		117.3	119.2		119.2		119.2		117.3
			3'-0						
		W	W				W		
FEM		1065	-687	687			-687	687	
M'		-30.4	-40.0	-237	-237	301	301	-281	-213
Support MOM.	0	1004	-1004	173	-173	365	-365	427	-427
		.74							
FEM		1171			-687	687			-998
M'		-333	-438	372	372	-361	-361	386	294
M @ supp.	0	505	-505	305	-305	336	-336	411	-411
		.74							
FEM		761	-687	687			-687	687	
M'		40.6	53.4	-262	-262	308	308	-283	-215
M @ support	0	842	-842	216	-216	354	-354	430	-430
			3'-0						
FEM		998	-752	689			-687	687	
M'		.5	.7	-248	-248	304	304	-282	-214
M @ support	0	999	-999	193	-193	360	-360	428	-428
			.705						
FEM		998	-568	825			-687	687	
M'		-34	-45	-273	-273	311	311	-283	-216
M @ support	0	930	-930	235	-235	349	-349	431	-431
				3'-0					
FEM			-689	752	-687	687			-998
M'		149	196	0	0	-261	-261	358	272
M @ Supp.		298	-298	948	-948	165	-165	454	-454
	3'-0								
FEM		1032			-687	687			-998
M @ supp.		-304	-395	360	360	-358	-358	385	293
		431	-431	325	-325	331	-331	412	-412

GIRDER SHEARS (MOM - DIST)

LANE LOAD CONT'D

FEM		-825	568	-687	687			-998
M'	169	222	42	42	-273	-273	361	274
M@ supp.	338	-338	875	-875	184	-184	449	-449
FEM		-687	687	-752	689			-998
M'	140	184	38	38	-272	-272	361	274
M@ supp.	280	-280	948	-948	183	-183	449	-449
FEM		-687	687	-568	825			-998
M'	149	196	-5	-5	-297	-297	368	280
M@ supp.	299	-299	874	-874	226	-226	439	-439



= END SPAN

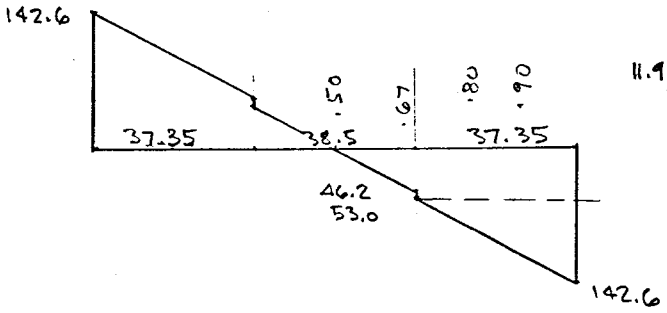
= INTER SPAN

80 USE MAX. FOR DES.

INTERPOLATE BY STRAIGHT LINE

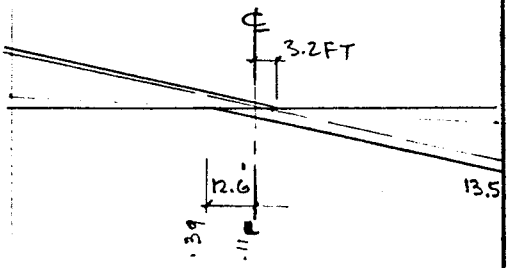
MAX GIRDER SHEARS (L+I)

WDL1:
SLAB + GIRDER
$w = 2.4^k/_1$
$P = 6.8$



DL1 - SHEAR DIAG

WDL2: $w = .19^k/_1$
$V_0 = 11.3^k$



DL2 - SHEAR DIAG

GIRDER SHEARS

SECTION 1.6.13

(a) CRITICAL SHEAR:

$x_v = h/2 \qquad h = 72 \qquad x_v = 36''$

TRANSFER LENGTH OF STRANDS (½"φ)

$l_T = 50\, d_{ST} = 25'' < x_v$

SO USE THE FULL EFFECT. PRESTR. FORCE

$s_{MAX} = \frac{3}{4}(72) \leq 54'' \leq 24'' \leq \frac{40\,000(.62)}{50(8)} = 62''$

(b) 77 EDITION:

$V_u = 1.3\left[\overset{DL1}{142.6} + \overset{DL2}{13.5} + 1.67(77.4)\right] = 371^k$

$f_{sy} = 40$ ksi

$d = (72 + \overset{81.5}{1.5} + 8) - 23.5 = 58.0 \qquad j = .8$

$V_c = .06(5.5)\,8(.8)\,58 = 122^k$

$.18(8).8(58) = 67^k$ ⇐ GOVERNS

$A_v = (V_u - V_c)s \div 2 f_{sy} jd \qquad V_u - V_c = 304$

#5: $A_v = 2(.31) = .62\ in^2$

$S_{RD} = .62(2)40(.8)58/304 = 7.6\ in$ ⇐ GOVERNS

$A_v = 100\, b' s \div f_{sy}$

$S_{RD} = .62(40)/.1(8) = 31$

AT .10L

$V_{DL1} = 89.6 \frac{\overset{62.4}{.23}}{.33} + 53.0 = 115.4^k$

$V_{DL2} = 13.5(.51/.61) = 11.3$

$V_{L+I} = 36.7\ \overset{29.4}{.4/.5} + 40.7 = 70.1$

.23
.33

$V_u = 1.3(115.4 + 11.3 + 1.67(70.1)) = 317^k$

$d = 58 + 4 = 62''$

$V_c = .18(6.4)62 = 71^k$

$V_u - V_c = 246^k$

$S_{RD} = .62(64)62/246 = 10''$

GIRDER SHEAR

(b) SHEAR REINF PER 77 EDITION (CONT'D)

AT .2 L

$V_{DL1} = 89.6\ {}^{.13}/_{.33} + 53.0 = 88.3$ (35.3)

$V_{DL2} = 13.5\,(.41)/.61) = 9.1$

$V_{L+I} = 40.7 + 36.7\ {}^{.3}/_{.5} = 62.7$ (22.0)

160.1

$V_u = 1.3(88.3 + 9.1 + 1.67(62.7)) = 263^k$ (202)

$d = 62 + 4 = 66'$

$V_c = .18(6.4)\,66 = 76^k$ $\quad V_u - V_c = 187^k$

$s_{req} = .62(64)\,66/187 = 14''$

AT .3 L

$V_{DL1} = 89.6\ {}^{.03}/_{.33} + 53.0 = 61.1$ (8.1)

$V_{DL2} = 13.5\,(.31/.61) = 6.9$

$V_{L+I} = 40.7 + 36.7\ {}^{.2}/_{.5} = 55.4$ (14.7)

123.4^k

$V_u = 1.3(61.1 + 6.9 + 1.67(55.4)) = 209^k$ (160.5)

$d = 66 + 4 = 70''$

$V_c = .18(6.4)\,70 = 80^k$ $\quad V_u - V_c = 129^k$

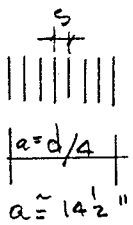
$s_{req} = .62(64)\,80/129 = 24''$

ANCHORAGE ZONE: SEC. 1.6.15

(a) $P = 1230^k$

$V = .04\,P = 49.2^k$ $\quad f_s = 20$ ksi $\quad d = 57.6''$ (=.8h)

$\frac{a}{s}(.62) = \frac{V}{f_s}$ $\quad s = \frac{d(.62)\,20}{4\,(49.2)} = 3.6$ IN



(b) NOM. REINF. AROUND PS-STL. IN BOTT. FLGE

#3 @ s = SPACING OF VERT. STIRRUPS

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GIRDER SHEARS

SEC. 1.6.13 (INTERIM 1980)

ACI SEC. 11.4

CHECK FOR SIMPLIFIED EXPRESSION ACI 11.4.1

$f_{se} = 1230/60(.153) = 134$ psi $> 0.4(270) = 108$ psi

∴ EQ. 10 APPLICABLE

(EQ. 10) $V_c = \left(.6\sqrt{f'_c} + 700\frac{V_u}{M_u}d\right)b_w d$

$d = 0.8h = 57.6$ IN (72)
$f'_c = 5500$ psi
$b_w = 8''$

$V_c^{MIN} = 2\sqrt{f'_c}\, b_w d = 68.3^K$ ⟵
$V_c^{MAX} = 5(\sqrt{f'_c})\, b_w d = 170.9^K$

@ SUPPORT

$V_u = 371^K \quad V_c = 68^k = V_c^{MIN}$

$\Delta V = 303^k = V_s$

$S_{R'D} = .62\,(\overset{f_y}{40})\,\overset{d}{57.6}\,/V_s = 4.7$ IN

@ 0.10 L:

$V_u = 317 \quad V_c = 68 \quad V_s = 249$

$S_{R'D} = .62(40)\,d/V_s = 5.7$ IN

@ .20 L

$V_u = 263 \quad V_s = 195^k$

$S_{R'D} = 7.3$ IN

@ .3 L

$V_u = 209 \quad V_s = 141^k$

$S_{R'D} = 10.1$ IN

@ .4 L:

$V_{DL_1} = 46.2\ {}^{.10}/_{.17} = 27.2$

$V_{DL_2} = 13.5\ {}^{.21}/_{.61} = 4.6$

$V_{L+I} = 40.7 + \overset{29.4}{36.7}\ {}^{.4}/_{.5} = 70.1$

$V_u = 1.3(\overset{148.9}{27.2 + 4.6} + 1.67(70.1)) = 194^K$

$V_s = 126^K$

$S_{R'D} = 11.3$ IN

GIRDER SHEARS

LL - TRUCK

SPAN AB: L = 117.3

@ A $58.6 - \overset{1.8}{208/117.3} = \underline{56.8}$ L = 114.3 I = .209

$V_A^{(L+I)} = \underline{68.7^K}$

@ $.4L_1^{LT}$ $34.1 - \overset{6.3}{736/117.3} = \underline{27.8}$ L = 70.38 I = .256

$V_{L+I} = \underline{34.9^K}$

@ $.4L_1^{RT}$ $21.0 + \overset{4.9}{576/117.3} = 25.9$ L = 46.92 I = .291

$V_{L+I} = \underline{33.4}$ ⇐ GOVERNS

@ B: LT $58.6 + \overset{2.8}{330/117.3} = 61.4$ I = .209

$V_{L+I} = \underline{74.2}$

SPAN BC L = 119.2

@ B: RT $58.7 + \overset{1.2}{145/L} = \underline{59.9^K}$ L = 116.3 I = .207

$V_{L+I} = \underline{72.3}$

$.5L_2^{LT}$ $27.6 - \overset{1.2}{143/L} = \underline{26.4^K}$ L = 59.6 I = .271

$V_{L+I} = \underline{33.6}$ ⇐ GOVERNS

$.5L_2^{RT}$ $27.6 - \overset{.4}{48/L} = 27.2$ I = .271

$V_{L+I} = \underline{34.6}$

@ C_{LT} $58.7 + \overset{1.5}{180/L} = \underline{60.2}$ I = .207

$V_{L+I} = \underline{72.7}$

SPAN CD L = 119.2

@ C_{RT} $58.7 + \overset{1.4}{169/L} = \underline{60.1}$ I = .207

$V_{L+I} = \underline{72.5}$

@ $.5L_3^{LT/RT}$ $27.6 - \overset{.8}{99/L} = 26.8$ I = .271

$V_{L+I} = \underline{34.1}$

GIRDER SHEARS

LANE

SPAN AB : L = 117.3

@ A $55.4 - \overset{3.7}{431/L} = 51.7^k$ I = .209

$V_{L+I} = 62.5$ < TRUCK

@ $.4L_1^{LT}$ $26.4 - \overset{4.3}{505/L} = 22.1$ I = .256

$V_{L+I} = 27.8$ < TRUCK

@ $.4L_1^{RT}$ $14.94 + \overset{7.2}{842/L} = 22.1$ I = .291

$V_{L+I} = 28.5$ < TRUCK

@ B^{LT} $55.4 + \overset{8.6}{1004/L} = 64.0$ I = .209

$V_{L+I} = 77.4$ > TRUCK ⇐ GOVERNS

SPAN BC: L = 119.2

@ B_{RT} $56.0 + \overset{6.8}{806/L} = 62.8$ I = .207

$V_{L+I} = 75.8$ > TRUCK ⇐ GOVERNS

@ $.5L_2^{LT}$ $20.5 + \overset{5.8}{695/L} = 26.3$ I = .271

$V_{L+I} = 33.4$ < TRUCK

@ $.5L_2^{RT}$ $20.5 + \overset{4.5}{537/L} = 24.9$ I = .271

$V_{L+I} = 31.6$ < TRUCK

@ C_{LT}: $56.0 + \overset{5.5}{650/L} = 61.5^k$ I = .207

$V_{L+I} = 74.2$ > TRUCK

SPAN CD

@ C_{RT} $56 + \overset{6.4}{765/L} = 62.4$ I = .207

$V_{L+I} = 75.3$ > TRUCK

@ $.5L_3^{LT/RT}$ $20.5 + \overset{5.4}{648/L} = 25.9$ I = .271

$V_{L+I} = 32.9$ < TRUCK

GIRDER DEFL^S

REF.: ACI 1968 EQ. 13 (10-ITEMS)

ITEM ①: INITIAL CAMBER DUE TO INITIAL PREST. FORCE F_o

$-(\Delta_i)_{F_o}$ BASED OF $F_i \cong 1520^K$ $\gamma_1 = 1.0$

ITEM ② INIT. DEAD LOAD GIRDER

$(\Delta_i)_2$ $f'_c = 4700$ $E = E_{ci}$ $\gamma_2 = 1.0$

ITEM ③ $-\alpha\left[-\frac{\Delta F}{F_o} + \left(1 - \frac{\Delta F}{2F_o}\right) k_r C_{T2}\right](\Delta_i)_{F_o} = \gamma_3 (\Delta_i) F_o$

$\alpha = .35$ $K_r = 1.0$ $\Delta F = F_i - F = 1520 - 1230 = 290^K$ $F_o = F_i$

$C_{T2} = 1.5$ TABLE 1 $\gamma_3 = .35[-.191 + (1.357)] = .408$

ITEM ④ $\gamma_4 = \gamma_3 \left(\frac{1-\alpha}{\alpha}\right) I_2/I_c$ $I_2 = 733320$ (GIRD.) $I_c = 1.55(10)^6$

$\gamma_4 = .408 \frac{.65}{.35} .73/1.55 = .357$

ITEM ⑤ $= \alpha k_r C_{T2} (\Delta_i)_2 = \gamma_5 (\Delta_i)_2$; $\gamma_5 = .35(1.5) = .525$

ITEM ⑥ $\gamma_6 = \gamma_5 \frac{1-\alpha}{\alpha} \frac{I_2}{I_c} = .459$

ITEM ⑦ SLAB DEAD LOAD (INITIAL) $= \gamma_7 (\Delta_i)_1$ $\gamma_7 = 1.0$

ITEM ⑧ SLAB DEAD LOAD, CREEP $= k_r C_{T2} \frac{I_2}{I_{co}} (\Delta_{i_1}) = \gamma_8 (\Delta_{i_1})$

$\gamma_8 = 1.5\, I_2/I_{co} = .706$

ITEM ⑨ DIFFERENTIAL SHRINKAGE:

$= Q Y_{cs} L^2 \div 8 E_c I_c$ $Q = D A_1 E_1$ (SLAB CONC. $f'_c = 4500$)

$D = .25(10)^{-3}$ SHRINK COEFF. $A_1 = 8(104) = 832 \text{ IN}^2$ $E_1 = 3.86(10)^3$ KSI

$Q = 804$ $Y_{cs} = 17.0 + 3.5 + 4.0 = 24.5''$ (N.A. TO MIDDLE OF SLAB)

$L = 119.2$ $I_c = 1.55(10)^6$ $= .84$

ITEM ⑩ Δ_{LL} DL_2 $\gamma = 1.0$

NOTE: ITEM ⑨ IS FOR SIMPLE SPAN @ ℄ ONLY

GIRDER DEFLECTIONS

BASIC EQUATIONS

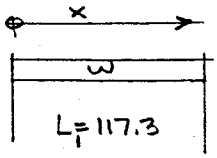
$(\Delta_i)_2$ (1) GIRDER INITIAL DL DEFL.

$w = 1.13^{k}/FT \qquad L_o = 115.5\ FT$

END SPAN: $x_o = x \quad L_1 = 117.3 \quad \xi_o = \xi\, L_1/L_o \qquad \xi = x/L_1$

$E_{ci} = 145^{1.5}(33)\sqrt{f'_c} = 3950\ ksi \qquad f'_{cir} = 4700$ (GIRDER)

$I_G = 733\,320\ IN^4$ TYPE VI GIRDER



$$\Delta_x^{@x/L} = 72\, w L_o^4 (\xi_o - 2\xi_o^3 + \xi_o^4) / E_{ci} I_G \qquad \text{EQ.1}$$

FOR INTER SPANS $\xi_o = \left(\xi \frac{L}{L_o} - \frac{1.85}{L_o}\right)$

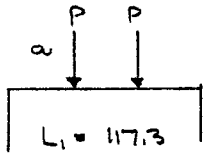
$(\Delta_i)_1$ (2) SLAB INITIAL DL DEFL.

$w = 1.27^{k}/FT \qquad L_o = 115.5 \qquad L_1 = 117.3$

END SPAN $\xi_o = \xi\, L_1/L_o$; $\xi = x/L_1 \quad I_G = 733320$

$E_c = 4273\ ksi \qquad f'_c = 5500$ (GIRDER)

$$\Delta_x^{@x/L} = 72\, w L_o^4 (\xi_o - 2\xi_o^3 + \xi_o^4) / E_c I_G \qquad \text{EQ. 1a}$$



(2a) INTERM. DIAPH. DEFL.: $(\Delta_i)_1$

$P = 6.8^{k} \quad \xi_o, E_c$ & I SEE (2) $\quad L_o = 115.5$

$a = \frac{1}{3} L_o$

$\Delta_x^{@x/L} =$

SEE SHT. FOR EQ'S

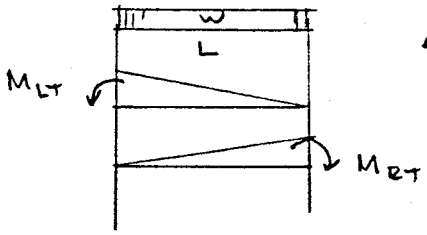
ΔDL_2 (3) DL 2 CURB & FENCES

$w = .19^{k}/_{1} \qquad L_1 = 117.3 \qquad L_2 = 119.2 = L_3$

$M_A = 0 \qquad M_B = -278 \qquad M_C = -214 = M'_C$

$f'_c = 5500$ (GIRDER) $\qquad I_{co} \cong 1550\,000$ (COMP.)

$\xi = x/L$



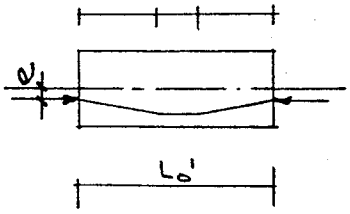
$$\Delta_x = 72\, w L^4 (\xi - 2\xi^3 + \xi^4) / E_c I_{co} \quad (E_c = 4273)$$
$$+ 288\, M_{LT} L^2 (\xi' - \xi'^3) / E_c I_{co}$$
$$+ 288\, M_{RT} L^2 (\xi - \xi'^3) / E_c I_{co}$$

GIRDER DEFL'S

BASIC EQ'S CONT'D

$(\Delta_i)_{F_o}$ (4) INITIAL PRESTR. FORCE

$F_i = 1520 \quad I_G = 733\,320 \quad f'_{ci} = 4700$



$L_o' = 115.5 + 1.3 = 116.8 \qquad a = 0.65\text{ FT}$

$\xi_o = \xi$

END SPAN: $\xi_o = \xi \frac{L}{L_o} + \frac{a}{L_o}$; $a = 0.65$ FT, $L_o = 115.5 + 1.3 = 116.8$

INT. SPAN: $\xi_o = \xi \frac{L}{L_o} - \frac{a}{L_o}$ $a = 1.2$ FT $L_o = 116.8$

$M_i^{LT} = M_i^{RT} = -F_i e^{12.88''}/12 = -1631$

$M_{P_i} = -F(e_{\mathbb{C}}^{30.28} - e_{END}^{12.88})/12 = 2204$

$P_i = M_{P_i} \div 45.0\text{ FT} = 49^k$

$M_{\Delta_x}^{@x/L} = 864\, M_{LT} L^2(\xi_o - \xi_o^2) / E_{ci} I_G$ (3950 ksi)

$P_{\Delta_x}^{@x/L} = $ SEE

(5) SHRINKAGE PCA BULLETIN PG. 4

$\varepsilon_s = .25(10)^{-3} \quad E_c = 3865 \quad f'_c = 4500$ SLAB

$A_b = 8(104) + 3(42)$ BUILD-UP $= 958\text{ IN}^2$

$c = c_T^G + 3.5$ B-UP $+ 4.0\ \frac{1}{2}$SL $= 17.5 + 7.5 = 25.0$ IN

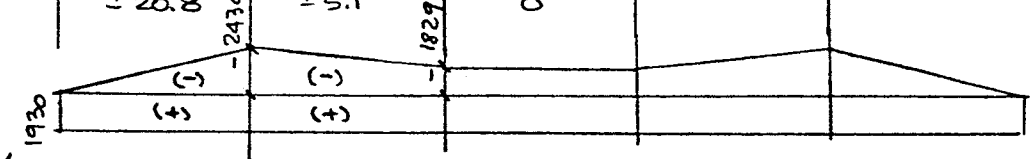
$M_s = \varepsilon_s E_c A_b (c)/12 \cong 1930^{k'}$
(S.SP. POSITIVE MOMENT)

FIXED END MOMENTS: END SPAN $M_B = -1.5 M_s$
INT. SPAN $M = -M_s$

	A	B		C		℄SYM	C'	B'	A'
		.4325	.5675	2/3	1/3				
FEM		2895	-1930	1930	-1930				
UNBAL.			965		0				
M'		-230.5	-302.4	100.8	50.4				
$M'_i + M'_K$		-230.5	-201.6	-201.6	50.4				
M @ SUPP'T		2434	-2434 (305)	1829	-1829				
M/L		±20.8	±5.1		0				

1930
965
2895

M-DIAG



NET SUPP. MOM. 1930 - 504 101 101 -504 1930

GIRDER DEFL'S

(5) SHRINKAGE CONT'D

LOCATION	.1	.2	.3	.4	.5	.6	.7	.8	.9
SPAN 1: L=117.3									
M_{LT} 1930	.218	.368	.456	.490	.479	.429	.349	.245	.126
M_{RT} = -504	-.033	-.064	-.091	-.112	-.125	-.128	-.119	-.096	-.057
Σ4	.185	.304	.365	.378	.354	.301	.230	.149	.069
SPAN 2: L=119.3									
M_L = -504	-.059	-.099	-.123	-.132	-.129	-.116	-.094	-.066	-.034
M_{RT} = 101	.007	.013	.019	.023	.026	.027	.025	.020	.012
Σ4	-.052	-.086	-.104	-.109	-.103	-.089	-.069	-.046	-.022
SPAN 3: L=119.3					℄ SYM				
Σ4: M_{LT} = M_3 = 101	.019	.033	.044	.050	.052	.050	.044	.033	.019

GIRDER DEFL^S

LOCATION IN CONT. SPAN		.1	.2	.3	.4	.5	.6	.7	.8	.9	
DEAD LOAD SLAB	W = 1.27 k/'										
DIAPH	P = 6.8										
END SPAN	W	.517	.977	1.333	1.555	1.622	1.530	1.287	.912	.440	
$\xi_0 = \xi L/L_0$	P	.064	.122	.168	.197	.205	.194	.162	.114	.055	
$(\Delta_i)_1$	Σ	.581	1.099	1.502	1.751	1.827	1.724	1.449	1.026	.495	
INTER. SPAN	W	.446	.924	1.300	1.540	1.623	1.540				
$\xi_0 = (\xi L/L_0 - \frac{1.85}{L_0})$	P	.055	.116	.164	.195	.205	.195				
						SYM					
$(\Delta_i)_1$	Σ	.502	1.039	1.464	1.735	1.828	1.735	1.464	1.039	.502	✓
CREEP DEFL. = $\gamma_B(\Delta_i)_1$		.354	.734	1.034	1.225	1.291	1.225	1.034	.734	.354	✓
γ_B = .706											
GIRDER INITIAL DEFL.											
W = 1.13 $\xi_0 = \xi$	$(\Delta_i)_2$	.453	.858	1.174	1.375	1.444	1.375	1.174	.858	.453	✓
CREEP BEFORE	γ_5 .525 $(\Delta_i)_2$	.238	.450	.616	.722	.758	.722	.616	.450	.238	½ ½
" AFTER CO.	γ_6 .459 $(\Delta_i)_2$	.208	.394	.539	.631	.663	.631	.539	.394	.208	✓
GIRDER PRESTRESS											
$M_i = -1631$	ΔM_i	-.598	-1.063	-1.395	-1.594	-1.661					
$P_i = -49$	ΔP_i	-.547	-1.048	-1.455	-1.723	-1.814					
	$\Sigma(\Delta_i)_{F_0}$	-1.145	-2.111	-2.850	-3.317	-3.475	-3.317	-2.850	-2.111	-1.145	✓
CREEP CAMBER	γ_3 .408 (Σ)	-.467	-.861	-1.163	-1.353	-1.418	-1.353	-1.163	-.861	-.467	½ ½
CREEP COMPOS.	γ_4 .357 (Σ)	-.409	-.753	-1.017	-1.184	-1.241	-1.184	-1.017	-.753	-.409	✓
DL2											
SPAN 1: L = 117.3	W = .19 k/'	.038	.073	.099	.116	.122	.116	.099	.073	.038	
	M_B = -278	-.016	-.032	-.045	-.056	-.062	-.064	-.059	-.048	-.028	
	Σ5	.022	.041	.054	.060	.060	.052	.040	.025	.010	
SPAN 2: L = 119.2	W = .19	.041	.077	.106	.124	.130	.124	.106	.077	.041	
	M_B = -278	-.029	-.049	-.061	-.066	-.064	-.058	-.047	-.033	-.017	
	M_C = -214	-.013	-.025	-.036	-.044	-.050	-.051	-.047	-.038	-.023	
	Σ5	.002	.003	.009	.014	.016	.016	.012	.006	.001	
SPAN 3: L = 119.2	W = .19	.041	.077	.106	.124	.130					
	$M_C = M_C' = -214$	-.036	-.063	-.083	-.095	-.099					
	Σ5	.005	.014	.023	.029	.031	.029	.023	.014	.005	

SUMMATION OF DEFL'S & CAMBER TYP INTER.

LOCATION IN SPAN	.1	.2	.3	.4	.5	.6	.7	.8	.9
CAMBER (ALL SPANS)									
INITIAL CAMBER $(\Delta_i)_{F_0}$	-1.145	-2.111	-2.850	-3.317	-3.475				
CREEP CAMB. 50%: $(.5)\gamma_3(\Delta_i)_{F_0}$	-.233	-.430	-.581	-.676	-.709				
CREEP GIRD. 50% $(.5)\gamma_5(\Delta_i)_2$	.119	.225	.308	.361	.379				
INITIAL GIRDER DEFL. Δ_{i2}	.453	.858	1.174	1.375	1.444				
TOTAL CAMBER Σ_1	-.806	-1.458	-1.939	-2.257	-2.361	-2.257	-1.939	-1.458	-.806
BALANCE CREEP (ALL SPANS)									
50% CREEP CAMBER $.5\gamma_3(\Delta_i)_{F_0}$	-.234	-.431	-.582	-.677	-.709				
CREEP CO. CAMBER $\gamma_4(\Delta_i)_{F_0}$	-.409	-.753	-1.017	-1.184	-1.241				
CREEP GIRD. 50% $.5\gamma_5(\Delta_i)_2$	+.119	.225	.308	.361	.379				
" " COMP. $\gamma_6(\Delta_i)_2$	.208	.394	.539	.631	.663				
TOTAL CREEP Σ_2	-.316	-.565	-.752	-.869	-.908	-.869	-.752	-.565	-.316
DL1 (SLAB & DIAPH) (ALL SPANS)									
INITIAL $(\Delta_i)_1$	.502	1.039	1.464	1.735	1.828				
CREEP $\gamma_8(\Delta_i)_1$	.354	.734	1.034	1.225	1.291				
Σ_3	.856	1.773	2.498	2.960	3.119	2.960	2.498	1.773	.856
$\Sigma 4$ & $\Sigma 5$ SEE SHTS.									
COMBINATION $(\Sigma 2+\Sigma 3+\Sigma 4+\Sigma 5) = \Sigma 6$									
SPAN AB	.747	1.553	2.165	2.529	2.625	2.444	2.016	1.382	.619
SPAN BC	.486	1.125	1.651	1.996	2.124	2.018	1.689	1.168	.519
SPAN CD	.564	1.255	1.813	2.170	2.294	2.170	1.813	1.255	.564
COMBINATION $(\Sigma 6 + \Sigma 1)$									
SPAN AB	-.059	.095	.226	.272	.264	.187	.077	-.076	-.187
SPAN BC	-.320	-.333	-.288	-.261	-.237	-.239	-.250	-.290	-.287
SPAN CD	-.242	-.203	-.126	-.087	-.067	-.087	-.126	-.203	-.242

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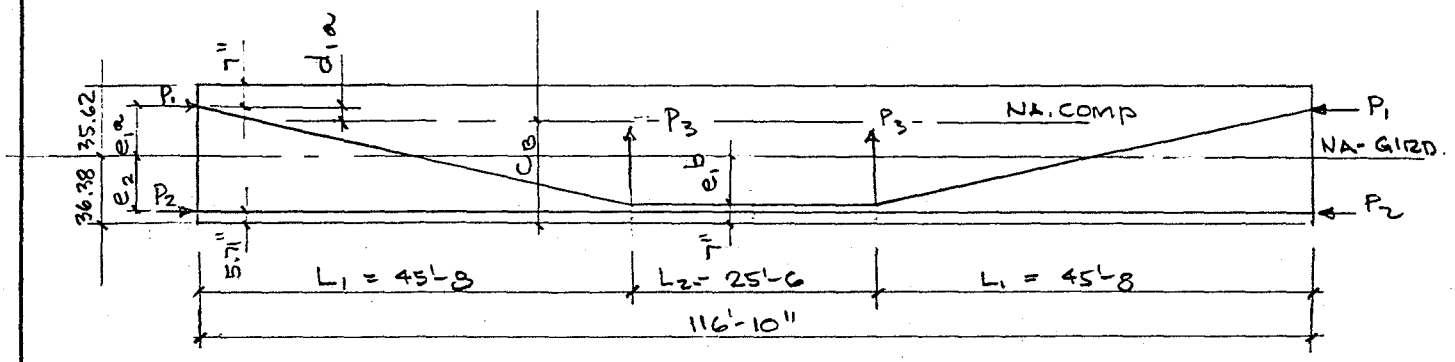
SHT. NO. 55 OF
JOB NO. 2182 F
BY AG DATE 8-31-82
CHKD. MK DATE 12-82
REV.

GIRDER POSITIVE MOM.

REF: PCA EB 014.01 E

(a) CREEP DUE TO PRESTRESS
BASED ON COMP. SECTION



$C_B = 53.26$

$d_1^a = 65 - 53.26 = 11.74''$

$d_1^b = 53.26 - 7 = 46.26''$

$d_1 = \quad = 58.00''$

$d_2 = 53.26 - 5.71 = 47.55$

$e_1^a = 35.62 - 7 = 28.62$

$e_1^b = 36.38 - 7 = 29.38$

$58.00'' = e_1$

$e_2 = 36.38 - [8(5)2 + 10(5)2 + 6(10)]/42 = 30.67$ (5.71)

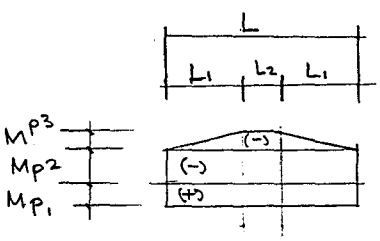
$\Sigma P = 1230^k$

$P_1 = \Sigma P \frac{18}{60} = 369^k$

$P_2 = \Sigma P \, 42/60 = 861^k$

$P_3(L_1) = P_1 d_1/12$

$P_3 = 39.1^k$



P/S - M-DIAG

$M_{P_1} = P_1 d_1^a = 361^{k'}$

$M_{P_2} = -P_2 d_2 = -3412$

$M_{P_3} = -P_3(L_1) = -1786$

SLOPE DUE TO P/S (S.SP.)

$EI\phi_A = \frac{1}{2}L[M_{P_1} + M_{P_2}] + \frac{M_{P3}}{2}[L_1 + L_2]$

$= .5(116.83)[-3051] - 893(71.17)$ (77108)

$= -.241779 = EI\phi_B$ FT²-KIPS

P/S - CREEP (CONT'D)

FEM'S

SPAN AB:

$$M_B = -\frac{3EI}{L}\phi_B = \frac{3(241779)}{116.83} = 6208^{k'}$$

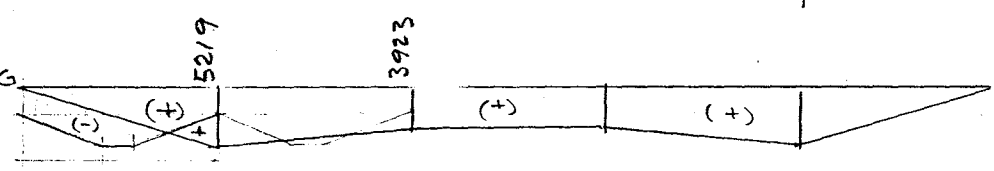
TYP. INTR. SPAN:

$$M_B = M_C = -\frac{2EI}{L}\phi_B = 4139^{k'}$$

MOM DIST.

	A	B	C	℄ SYM	D	E	F
		.4325 / .5675	2/3 / 1/3				
FEM		-6208 / 4139	-4139 / 4139				
		648	-216 / -108				
		988 / 432	432 / -108				
M @ support		-5220 / 5219	-3923 / 3923				

P/S - CREEP - M - DIAG



(b) DL - CREEP RESTRAINT MOMENT L = 115.5 FT

$w_1 = 2.4^{k}/'$

$P = 6.8^{k}$

FEM'S SPAN AB FEM = $wL^2/8$ = 4002

$P(1.5)\frac{38.5}{115.5}(115.5-38.5) =$ 262

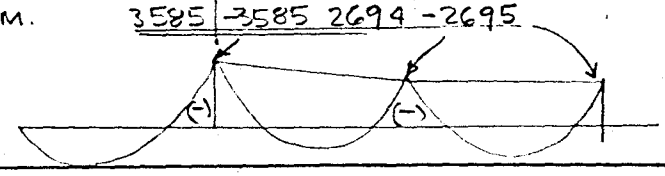
4264

TYP. SPAN FEM = $wL^2/12$ 2668

$P\frac{38.5}{115.5}(115.5-38.5) =$ 175

2843

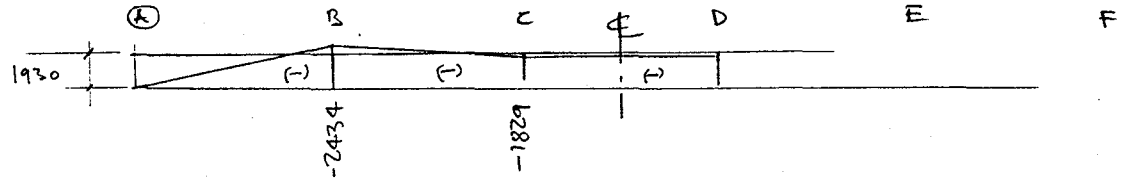
			℄	
	4264	-2843	2843	-2843
		-445	148	74
	-679	-297	-297	74
DL CREEP REST. MOM.	3585	-3585	2694	-2695



GIRDER POS. MOMS

(C) SHRINKAGE RESTRAINT MOM'S (NOT ADJUST'D FOR CREEP F.)

SEE SHT. GIRDER DEFL'S.



(d) POS. LL+I MOMENTS SEE SHT. .. I = 1.206

(+) M_B^L = 164 ki M_B^{L+I} = +198 ki (LANE)

(+) M_C^L = 358 M_C^{L+I} = +432 (")

EVALUATION OF CREEP FACTORS

f'_{ci} = 4700 psi
E_{ci} = 3.9 (10)^6 } @ RELEASE

FIG 5: SPECIFIC CREEP @ 20 YEARS: = .37 (10)$^{-6}$ IN/IN/psi

FIG 6: ADJUST. FOR RELEASE @ 2 DAYS:

α_2 = 1.66

1.66 (.37) (10)$^{-6}$ = .61 (10)$^{-6}$ IN/IN/psi

FIG 7 & TBLE 1: r = 4.4 V/S TABLE 1:

α_3 = 1.18 FIG. 7 (SIZE COEFF. FOR CREEP.

1.18 (.61) = .72 (10)$^{-6}$ IN/IN/psi

FIG 8: .4 @ 28 DAYS

.6 LEFT TO OCCUR:

.6 (.72) 10^{-6} = .432 (10)$^{-6}$ IN/IN/psi

f'^{28}_c = 5500 psi E_c^{28} = 4.2 (10)^6 psi

$\phi = \varepsilon_c / \varepsilon_e = \varepsilon_c E^{28}$ = .432 (10)$^{-6}$ (4.2) 10^6 = 1.81

FIG 9: $\left(1 - e^{-\phi}\right)$ = .836

$\left(\frac{1 - e^{-\phi}}{\phi}\right)$ = .462

e = 2.718281828

GIRDER POS. MOM'S

SUMMATION OF POSIT. RESTRAINT MOMENTS

$$\Sigma M = (P/S + DL)(1 - e^{-\phi}) + SHR(1 - e^{-\phi})/\phi$$

$$+M_B = (5219 - 3585) \cdot .836 - 2434(.462)$$
$$= 1366 - 1125 = 241$$
$$M_{LL+I} = 198$$
$$439$$

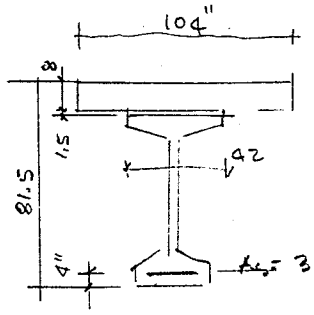
$$+M_C = (3923 - 2695) \cdot .836 - 1829(.462)$$
$$= 1027 - 845 = 182$$
$$M_{LL+I} = 432$$
$$614^{k'}$$

(+) M = 650$^{k'}$ DESIGN MOM'T

$f_s = 20$ ksi $d = 72 + 9.5 - 5.5 = 76''$ $j = .9$

A_s req'd $= 650(12)/20(76).9 = 5.70 \text{ in}^2$ (MILD-STEEL
10 #7 OR 13 #6

STRANDS: TRY 10-½ ϕ $A_s^{10-½} = 1.53 \text{ in}^2$ $f_s = 74.5$



LOCATE NA:

E_c (SLB BULDUP) = 3.88 (f'_c = 4500)
E_c GIRDER = 4.2 (f'_c = 5500)
$n = 29/3.88 = 7.47$

$$104(8)(x-4) + 42(1.5)(x - 8.75) = 7.47(1.53)(77.5 - x)$$

$$832x + 63x + 11.43x = 886 + 3328 + 551$$
$$906.43x = 4765$$
$$x = 5.26 \text{ (IN FLGE)}$$

1366
1620

$$104(x)^2 = 2(7.47)1.53(77.5 - x) = -22.85x + 17.72$$
$$x^2 + .22x = 17.0$$
$$x = -.11 \pm 4.12 = 4.0''$$

GIRDER POS. MOMENTS

MOM. OF INERTIA:

$x = 4.0 \quad B = 104 \quad n = 7.47 \quad A_s = 3.06 \quad d = 77.5$

$$I = \overset{2219}{104(x)^3/3} + \overset{61743}{nA_s(d-x)^2} = 63969$$

$$f_c = \overset{+M}{12(650)}(4.0/I = 488 \text{ psi}$$

$$f_s = 12(650)(73.5)7.47/I = 66.9 \text{ ksi} \quad \text{o.k}$$

7.5 - 5.62 = 7.9

CHECK BOND STRESS (SEE BELOW)

TENSILE STRESS IN GIRDER @ MID SPAN

POSITIVE CREE REST. MOMENT.

℄ SPAN AB (+) M = 1/2 (241) = 121 ki

℄ SPAN BC (+) M = 182 + ½ 59 = 212 ki ⇐ GOV.

℄ SPAN CC' + M = 182 ki

$S_B \cong 29000 \text{ in}^3$ @ BOTT. COMP. SHT

$f_c = 12(212)/S = 88$ psi

f_c OTHER LOADS = 255 " (SHT. ...)

$\Sigma f_c = 343$ psi

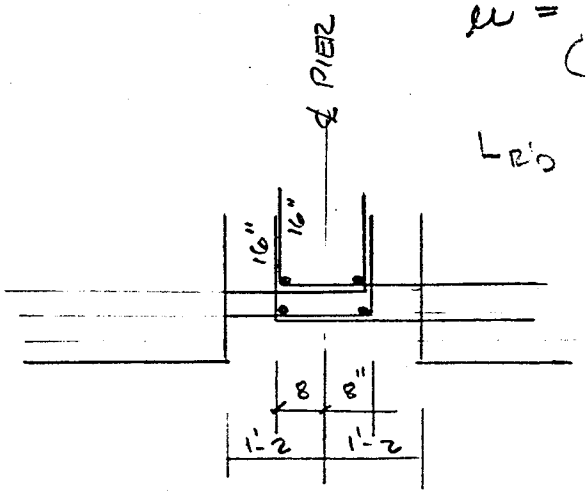
$f_c^{AL} = .8(7.5)\sqrt{5500} = 44.5$ psi $< \Sigma f_c$

CHECK BOND STRESS:

$\mu = \frac{1}{2}500 = 250$ psi

(½ - OF DEFORMED BAR PER ACI 318-63)

$$L_{B'D} = \frac{d f_s}{4\mu} = \frac{1}{2}\frac{66.9}{4(.250)} = 33.5 \text{ in}$$



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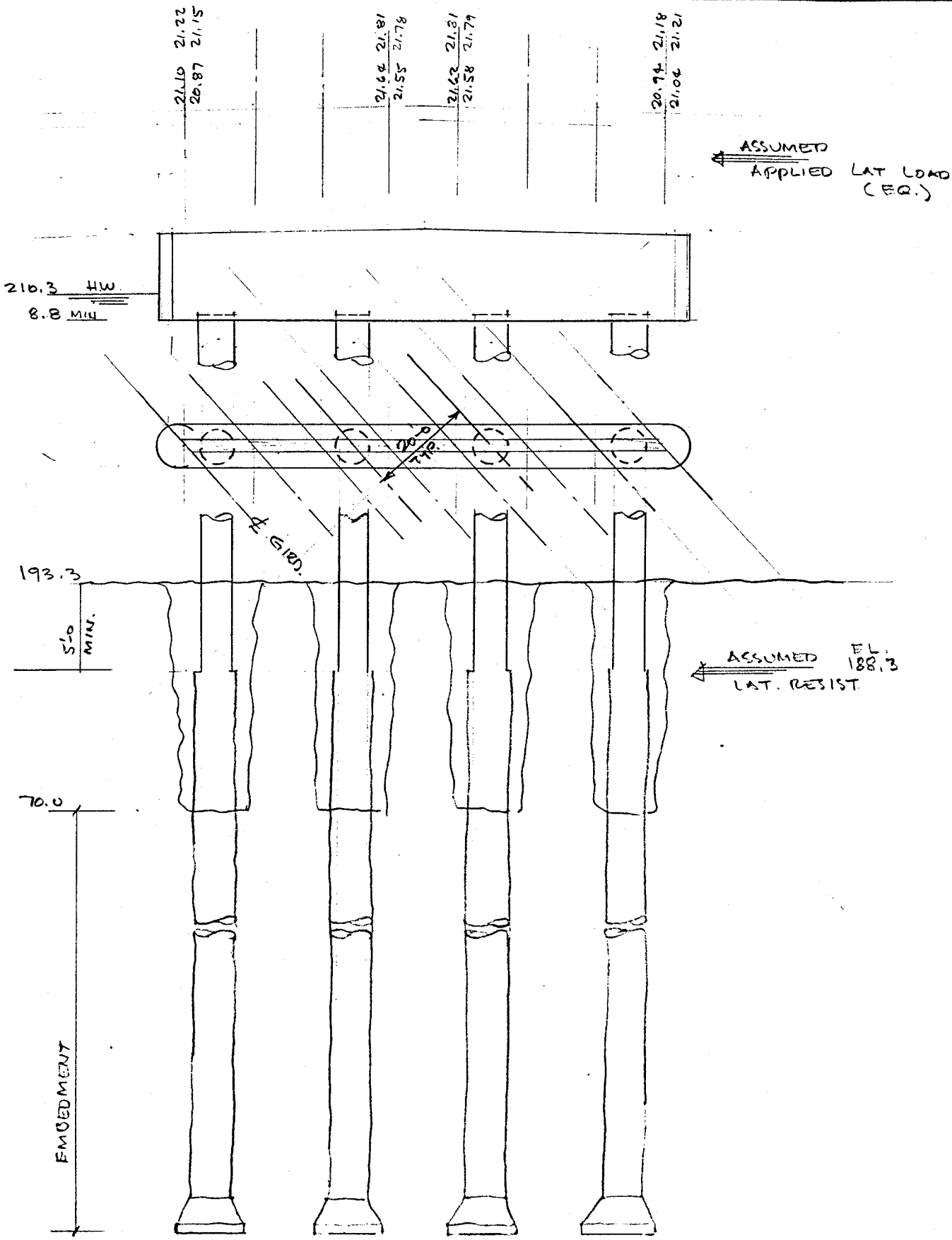
	JOB NO. 2182 F
	BY AG DATE 9-30-82
	CHKD. DATE
PIER	REV.



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	JOB NO. 2182F
	BY AG DATE 9-29-82
	CHKD. MK DATE 12-82
PIERS	REV.

GIRDER REACTIONS

DEAD LOAD REACT.

	EXT.	INT.
GIRDER : 1.13 (115.5/2 + 0.7)	66.0	66.0
8" SL. & BUILD UP : (115.5/2 + 1.83) 1.41 EX / 1.15 INT.	84.0	68.5
9" DIAPH INTERM.	3.4	6.8
DL2: (13.5 + 11.9) 1/2 =	17.7	17.7
1/2 P	171.1	159.0
P_{DL} =	342.2	318.0

$\bar{w}$ = .64 L_{AVE} = 118.25

$\bar{P}$ = 26.0

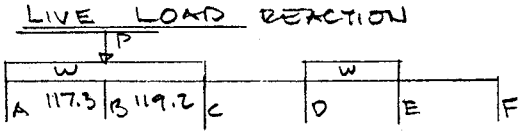
$\bar{R}_B$ = 1.218 $w L_{AVE}$ + P =

= 92.2 + 26 = 118.2^k

I = .1383 16.4

$\bar{R}_{L+I}$ = 134.6^k

LIVE LOAD REACTION



L_I = 117.3 + 119.2 = 236.5

R_{LL} = $\frac{1}{2}$(118.2) (1.82) = 107.6

$\frac{1}{2}$ 26 (3 − $\frac{10}{10}$ − 1.82) = 2.3

R_{LL} = 109.9

I 15.2

R_{L+I} = 125.1^k

BEARING PAD:

L = 28" p_{TL} = 800 PSI P_{TL} = 171.1 + 68.2 = 239.3 NO IMP.

$b_{R'D}$ = P_{TL} / L_p = 10.7

p_{DL} = 500 PSI P_{DL} = 171.1

$b_{R'D}$ = P / L_p = 12.2

FOR SHAPFACTOR S = 6.0 L = 28 W = 13

$t_{R'D}$ = LW ÷ 2S (L + W) = .74 (3/4")

USE 3/4 × 13 × 28 ELAST. PAD DURO. 50

OR 7/8 × 16 × 28 " "

LL GIRDER SHEAR : w = .58 P = 23.7 = 1.82 (13); L = 117.3

V_B^{LT} = .620 (w) L = 42.2

P 23.7

13 (3 − 1 − 1.82 2.3

V_B^{LT} LL = 68.2

I = .206 (68.2) = 14.1

V_B^{LT} LL+I = 82.3

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PIERS

PIER DIAPH WT:

$h = 6.0 + (\overset{B\text{-}UP}{1.5} + \overset{PAD}{4.0})/12 \cong 6.5$ FT

$b = 24"$

$w_D = 6.5(.3) = 1.95^k/FT$

CAP BM WT:

$w_B = 6.0(5.0)(.15) = 4.5^k/FT$

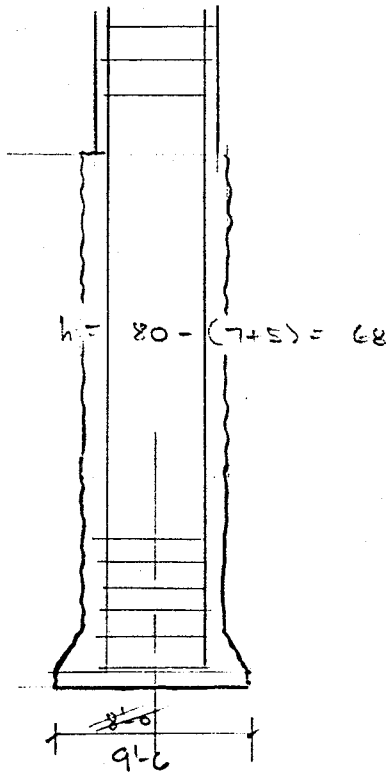
TOTAL BENT WT:

Σ DL: EXT. GIRD^S 2(342.2) = 684.
INT. GIRD 6(318) = 1908 } 9.5 24624
DIAPH $\left(\frac{70}{\cos\alpha} + 4.0\right)$ 1.95 = 195 8.0 1584
CAP BM $\left(\frac{70}{\cos\alpha} + 6\right)$ 4.5 = 458 2.6 } 12.01
" $\frac{\pi 6^2}{4}(5)$ .15 = ~~4~~ 21.2 2.6
3249^k 28409
3266 8.7

Σ LL: 6-LANES R = 75%

$\Sigma LL = .75(\overset{R}{\cancel{6}}\ \overset{N}{5})\ 109.9 = \cancel{495}^k$ 412

COL. WT: 5' ϕ = 2.95^k/FT



MAX COL. LOAD:

P = DL: 3249/4 = 812^k
LL 412 ~~495~~/4 = ~~124~~ 103
COL. 68(2.95) 201 ~~20~~
~~956~~^{k} 1116

(a) FRICTION PIER:

$P_{AL} = 131\ D = \cancel{956}^k$ 1116

$\therefore D_{R'D} = \cancel{7.3}$ FT 8.5

(b) END-BRG PIER

$P_a = 20.^k/\square'$ $A_{R'D} = \cancel{956}$ 1116 $/p = \cancel{47.8}$ 55.8 $\square'$

$D_{R'D} = \sqrt{4A/\pi} = \cancel{7.8}$ 8.4 ϕ

USE 9'-6 SEE SHT. 85

PIER

DETERMINE EMBEDMENT LENGTH OF PIER COLS BASED ON SEISMIC LONGITUDINALLY (REF.: REESE & MATLOCK GRAPHS)

EQ. WT:

ΣP_{DL}: ABUT'S: $2(2(168)_{EXT} + 6(161)_{INT}) = 2600$

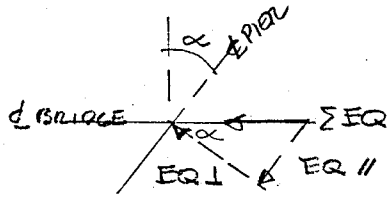
PIERS: $4(3249)$ PG ... $= 13000$

COL'S $4(4)\,10.0_{1/2\,HT}\,(3.0) = 480$

16080 K

C = .09 F = 1.0 CANTIL. COL.

$\Sigma EQ = .09(16080) = 1450^K/4 = 362^K/PIER$



$EQ\perp = \Sigma EQ(\cos\alpha) = 265^K/PIER$

$EQ\parallel = \Sigma EQ(\sin\alpha) = 247^K/PIER$

4- COLS PER PIER:

$EQ\perp = 265/4 = 66^K/COL.$

ELEV. OF RESIST. @ FUT. CHANNEL BED

EL. 188.3 FT

ELEV. OF APPLIED EQ. LOAD:

EL. $208.8 + 9.2_{FST\,D} = 218$ FT

CANTIL. COL. LENGTH $L_C = 218 - 188 \cong 30$ FT

COL. DL:

$P_{DL} = 3249/4_{812} + 20.5_{H\,COL.}(2.95)_{GO} = 872^K$

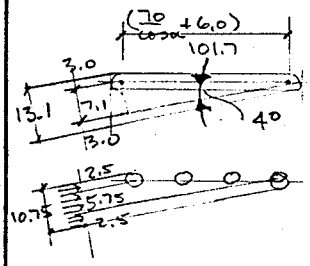
BOYANCY WT.: PER COL.

COL: $20.5(19.6)(.0624) = 25.1$

CAP: $\left(\frac{70}{\cos\alpha} + 6\right)1.5(6).0624)/4 = 14.3$

$\left((\pi 6^2/4)\,1.5(6).0624\right)/4 = 4.0$

43.4^K say 43^K



$\Sigma SF.$ $K = 2/3$ $V = 5.5$ FPS

$P = 2/3\,(5.5)^2 = 20.2$ #/□'

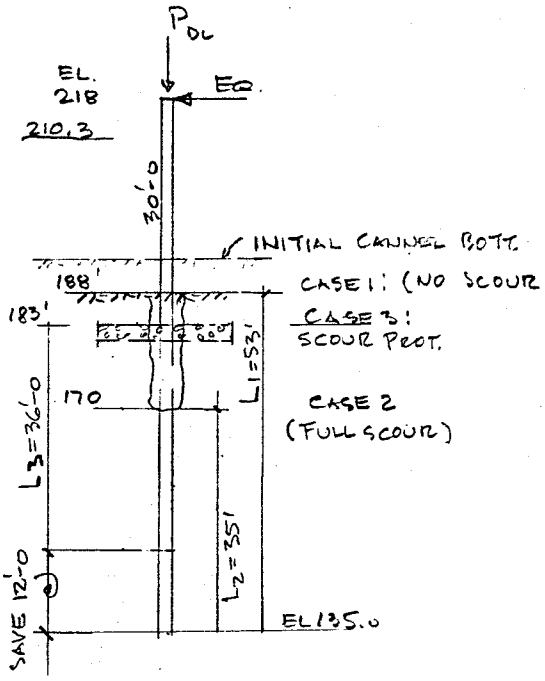
$SF\perp = 4.9(\sin 40°) = .4^K$ (NEGL. COLS: $10.75_B\,(20.5_H)(p) = 4.5^K\,(10.25_{ARM}) = 46.1$

$SF\parallel = 4.9(\cos 40°) = 4.9^K$ CAP. $13.1\,(1.5_{HT})(p) = .4^K\,(21.25) = 8.4$

54.5

C.G. @ h = $54.5/4.9 = 11.1$ FT

PIER COL. EMBED'T (CONT'D)



$EQ. = 66^k$ $\quad P_{DL} = 872^k$

CASE 1: RESIST @ EL. 188

$L_1 = 53$ FT $\quad I = 60^4\pi/64 = 636173$

$n_h = 65$ PCI $\quad E = 3.1(10)^3$

$T = 5\sqrt{\frac{EI}{n_h}} = 125$ IN $/12 = 10.4$ FT

$L/T = 5.1$

RIGID PILE $\quad L_{MAX} = 2T = 20.8$ FT $< L$

SO FLEXIBLE PILE:

LOADING @ GROUND SURFACE

$P = EQ. = 66^k$

$M = P(30) = 1980^{k'}$

DEFL. @ GROUND SURFACE $\quad Z = 0 \quad f'_c = 3000$ PSI

$A_y = 2.35 \quad B_y = 1.65$

$Y_{01} = \frac{A_y (P) T^3}{EI} = \quad .1536$

$\frac{B_y (M) T^2}{EI} = \quad .3106$

$.4642$

ELASTIC DEFL. @ EL. 218:

$Y_{02} = \frac{P(30)^3 (12)^3}{3(EI).4} = \quad 1.3012$ IN

REDUCED COL. STIFF'S

$f'_c = 4000$ PSI $\quad \Sigma y = \sqrt{\frac{3}{4}}(1.77) = 1.53$ IN

$\Sigma y = 1.7654$ o.k.

@ EL. 218

CASE 2: RESIST @ EL. 170'

$L_2 = 35$ FT $> 2T \quad M = 66(48) = 3168$

SO FLEX. PILE

$L/T = 35/10.4 = 3.4$

$A_y = 2.6 \quad B_y = 1.7$

$Y_{01} = A_y (P) T^3 / EI = \quad .1700$

$B_y M (T)^2 / EI = \quad .5120$

$Y_{02} = P(48)^3 12^3 / (3EI .4) = \quad 5.330$

$\Sigma y = \quad 6.012$

$f'_c = 4000 = 5.2$ IN

CASE 3: PROVIDE SCOUR PROTECTION @ EL. 183'-0

MAKE COL. 6'-0 ⊕ BELOW SCOUR PROT.

$I = 1319167$ REDUCED TO 40% FOR $I_{eff.}$ $E = 3100^{ksi}$

$n_h = 65$ PCI

$T = \sqrt[5]{EI_g/n_h} = 144 IN / 12 = 12.0 FT$

RIGID PILE $L_{max} = 2(T) = 24$ FT $> L_3 = 36$

SO FLEX. PILE $L/T = 3.0$

DEFL. @ 183':

$A_Y = 2.7$ $B_Y = 1.75$ $P = 66^k$ $M = 66(35) = 2310^{ki}$

$Y_{01} = A_Y P T^3 / E(.4I) =$ .325

$B_Y M (T)^2 12 / (E .4I) =$ .615

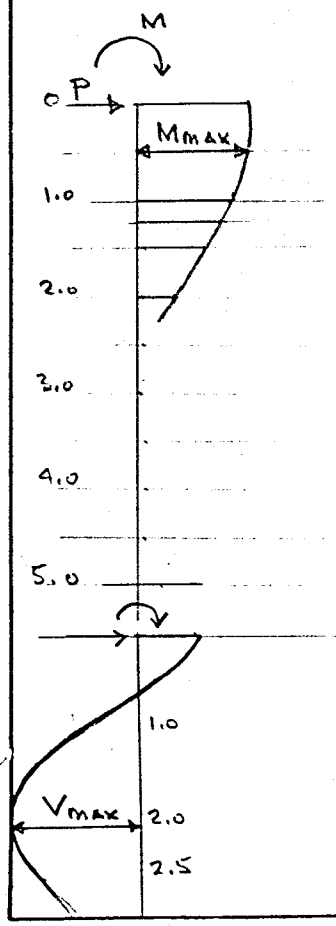
$\Sigma Y_{01} =$ .940

DEFL @ 218: (CANTIL.)

$Y_{02} = P(35)^3 (12)^3 / 3(E .4I) = Y_{02}$ 1.000

ΣY @ 218' = 1.94 IN

FOR 4000 PSI CONC. ΣY = 1.68 IN



COL. MOMENTS: (CASE 3)

Loc. Z	0.0	.5	1.0	1.5	2.0	1.2
A_m	0.0	.46	.69	.65	.42	.71
B_m	1.0	.97	.83	.59	.32	.75
$M_A = A_m PT$	0	364	546	515	333	562
$M_B = B_m M$	2310	2241	1917	1363	739	1733
ΣM	2310	2605	2463	1878	1072	2295

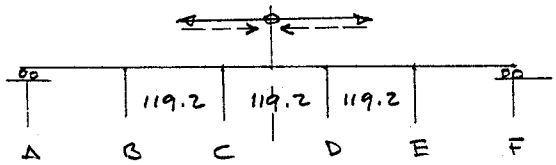
SO MAX MOM. @ .5 = EL. 183 - 3.6 = 179.4

$M_{max} = 2605^{ki}$

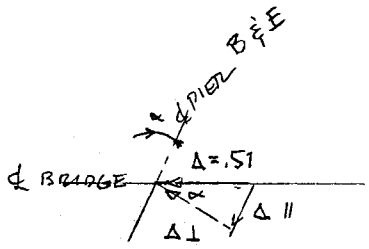
COL. SHEARS: (CASE 3)

Loc.	0.0	.5	1.0	1.5	2.0	2.5
A_V	1.0	.74	.20	-.3	-.56	-.5
B_V	0.0	-.15	-.4	-.54	-.53	-.35
$V_A = A_V P$	66.0	48.8	13.2	-19.8	-37.0	-33.0
$V_B = B_V M/T$	0.0	-28.9	-77.0	-104.0	-102.0	-67.4
ΣV	66.0	19.9	-63.8	-123.8	-139.0	-100.4

COL. MOM'S & SHEARS DUE TO TEMP. CHANGE



$\alpha^T = 6(10)^{-6}$	COL. B/E L	COL. B/E Δ° IN	COL. C/F L	COL. C/F Δ° IN
RISE 30°	179	.39	60	.13
FALL 40°	↓	.51	↓	.17
$\Sigma T = 70°$		.90		.30



CASE 1: COL. REST. @ 193'
(INITIAL CHANNEL BOTT.)

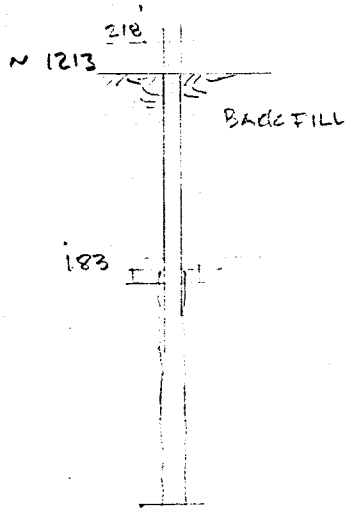
$h = 25$ FT $\quad \Delta = PL^3/3EI$

$E = 3.1(10)^3$; $I = 636173$; $L = h$; $\Delta = .51$ IN

$\Delta^\circ_\perp = \cos\alpha\,\Delta = .37$ IN $\quad \Delta^\circ_{\parallel} = .35$ IN

$P^\perp = 3EI\Delta^\perp/L^3 = 81^K$
$M^\perp = P(L) = 2027$ K' } COL. B & E

CHECK COL'S IF BACKFILLED TO BOTT. OF CAP BEAM DUE TO TEMP:



ASSUME GRANULAR FILL $n_h = 24$ PCI

$T = \sqrt[5]{\frac{EI}{nh}} = 153''/12 = 12.7$ FT $\quad E = 3.1(10)^3 \quad I = 636170$

∴ FLEX. COL. $L/T > 5.0$

$A_Y = 2.4$

$Y_0 = A_Y P T^3/EI$ @ SURFACE $= 0.37$ IN $\Delta\perp$

$P = .37(EI)/A_Y T^3 = 85^K$

MOM. DUE TO P:

$M_{MAX} = A_m^{.78} PT = .78(85)12.7 = 842^{K'}$

FOR $n_h = 64$ K' $\quad T = 125''$ 10.4 FT $\quad A_Y = 2.4$

$P = .37\,EI/A_Y T^3 = 156^K$

$M_{MAX} = .78\,PT = 1263$ K'

PIER

EQ. ⊥ STRUCTURE:

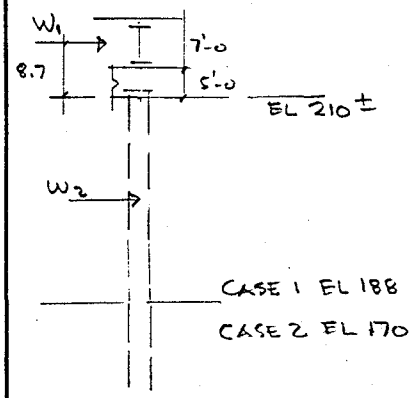
WTS TO PIER, (SEE PG . . .)

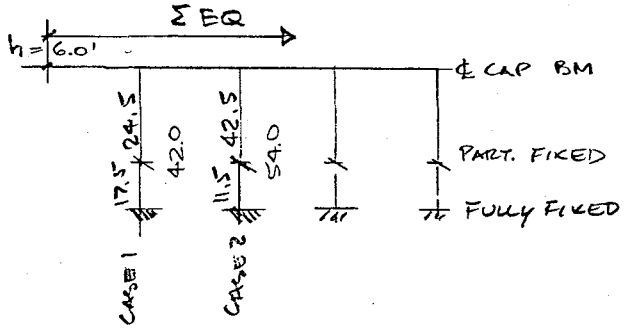
$W_1^{DL} = 3249^k$

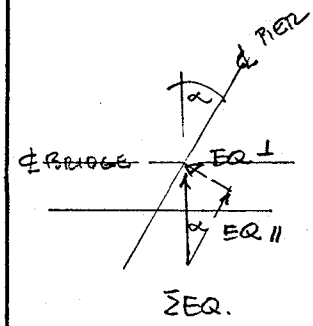
$W_2^{H} = 40(2.95) = 120^k$ (COL WT.)

C.G: $W_1(8.7)/(W_1 + \frac{1}{2}W_2) = 8.5$ FT

$h = 8.5 - \frac{1}{2}$ CAP BM $= 6.0$







Σ EQ. $= .09(W_1 + \frac{1}{2}W_2) = 300^k$

EQ ⊥ $= 205^k / 4 = 51^k$/COL. $= \Sigma EQ(\sin\alpha)$

EQ ∥ $= \Sigma EQ(\cos\alpha)(.8) = 176^k$/FRAME

SF ⊥ STRUCTURE SEE SHT. . .

SF ∥ $\cong 5^k$/FRAME

<u>TRANSF ΣEQ. TO ℄ CAP BM</u>

$M = \Sigma EQ(6.0) = 1800^{k'}$

$I = 2(30)^2 + 2(10)^2 = 2000$

$P_1 = Mc/I = \pm 1800(30)/2000 = \pm 27^k$

$P_2 = 1800(10)/2000 = \pm 9^k$

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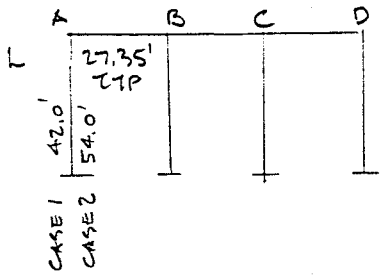
PIER

DL + EQ + SF ⊥ (CONT'D)



FRAME PROPERTIES

$f'_c = 4000$ PSI $\quad E_c = 3640$

$I_c = \pi\, 60^4/64 = 636173$ GROSS

$I_g = 72(60)^3/12 = 1296000$ GROSS

EFF. EI PER ACI 10.10 COMMENTARY:

$EI_g = 0.5(3.64)10^3(1.296)10^6 = 2.36(10)^9$ BM

$\rho_{COL} = \overset{40\#11}{62.4} / \overset{A_G}{2827} = .022$

$1.2\,\rho\, E_s/E_c = .21$

$EI_c = .41(3.64).636(10)^9 = .95(10)^9$ COL.

BM SPAN: $L = 20.0/\cos\alpha = 27.35$ FT

COL. HT: CASE 1 = 42.0 FT

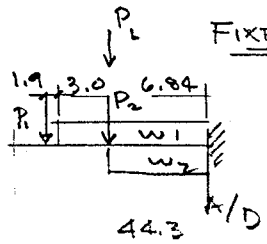
CASE 2 = 54.0 FT

	JOINTS A/D:	K	DF	JT. B&C	DF
CASE 1:	BM EI/L	8.6	.79	8.6	.44
	COL EI/L	2.3	.21	8.6	.44
		10.9	1.00	2.3	.12
				19.5	1.00

	JT A/D			JT B/C	DF
CASE 2:	BM	8.6	.83	8.6	.45
	COL.	1.8	.17	8.6	.45
		104	1.00	1.8	.10
				19.0	1.00

PIER

FIXED END MOMENTS FROM GRAVITY LOAD



w_1	44.3
w_2	13.7
P_1	10.6
P_2	342.2
ΣV_{DL}	410.8 ^{k}

CANTIL:

		DL
P_1 CAP BM $\frac{1}{2}(5)\,.15\,(28.3)$	=	10.6^k
P_2: EXT. GIRD.		342.2^k
w_1: CAP BM 6(5)(.15)	=	4.5^k/'
w_2: DIAPH	=	2.0

GIRDER LL:

P_L = 144.2^k / LANE

P_L = 110^k / GIRDER

R = .90 (3-LANES

R = .75 (4-LANES & MORE)

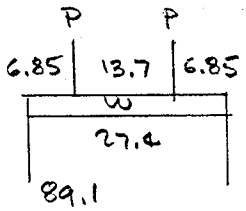
CANTIL. MOMENT

51.9	4.9	P_1(11.74)	=	124.4
		P_2(6.84)	=	2340.6
20.3	$(8.0)^2/2$	$w_1(9.84)^2/2$	=	217.9
72.2		$w_2(6.84)^2/2$	=	46.8
		$M_{c\,DL}$	=	2729.7$^{k'}$

$M_{c\,LL}$ = 110(.9) 6.84 = 677

I = .3 M_c = 203

$M_{c\,L+I}$ = 880 $^{k'}$



w	89.1
P_{DL}	318.0
ΣV_{DL}	407.1
V_{LL+I}	128.0
ΣV_{TL}	535.1^k

$M_{o\,DL}$ = 407.1 (6.85) = 2789

$-\,w\,6.85^2/2$ − 152

ΣM_o @ P = 2637

$w\,13.7^2/8$ = 152

ΣM_o @ ℄ = 2789

SPAN AB / BC & CD:

w: CAP BM 4.5 + DIAPH 2.0 = 6.5^k/'

P_{DL}: INT. GIRD. 318.0^k

P_{LL+I} = 1.3 (110) .9 = 128^k

FEM.	LT = RT
$wL^2/12$	407
$P_{DL}L$(.1875)	1634
ΣFEM_{DL}	2041
P_{L+I}	658
P_{TL}	2699

PIER

DL - MOM. DIST.

CASE 2 PROPERTIES

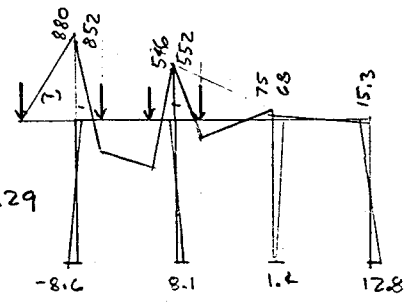
		.415		.225	.225		.225	.225		.415
L		27.4			27.4			27.4		
DL: FEM	2730	-2041	2041		-2041		2041	-2041	2041	-2730
UNBAL'D		689			0	℄ SYM.		0	-	689
M'		-325	94		94		-94	-94	325	
ΣM'		-231	-231		0					
M_{BM}	2730	-2597	1904		-1947					
M_{COL}	-133	693	43							
ΔM/L		±25.3			0			±25.3		

FULL LL+I - MOM. DIST. (ALL LANES R = .75)

FEM = 658(.75/.90) = 548 K' & M_c = 880 .75/.90 = 733

LL FEM	733	-548	548		-548		548	-548	548	-733
UNBAL'D		185			0	℄ SYM.		0	-	185
M'		-87.3	25.3		25.3		-25.3	-25.3	87.3	
ΣM'		-62.0	-62.0		0		0			
M_{BM}	733	-697.3	511.3		-522.7					
M_{COL}	-35.7	186	11.3							
ΔM/L		±6.8			0			±6.8		

M_o = 128 (6.85) = 877 K'·.75/.90 = 731



M'' = 10.29

M_{COL}	-8.6	8.1	1.4	12.8
ΔM	306	477	53	
ΔM/L	±11.2	17.4	±1.9	

L+I ON ½ OF BRIDGE

SEE PG. FOR MOM. DIST

128/4 = 32(3 = 96
477/27.4 17.4
113.4

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REV.

PIER

LL-3-LANES

P_{L+I} P_{L+I} P_{L+I} P_{L+I}

LL ON 1/2-PIER

+222 .415 .225 +165 .225 .225 +165 .225 .415 0

880 .085 -658 658 .05 -493 165 .05 0 0 .085 0

-92.4 -9.64 -2.14 -9.64 -40.05 -8.9 -40.05 12.35 2.53

-18.93 102.0 -102.0 8.15 -49.7 -49.70 1.4 -27.70 -27.70 12.82

8.6

-27.6 -852 546 6.0 -552 75.3 -7.5 -67.8 -15.3 15.3

0 .375 M'' = 10.29 .375 10.29 .375 10.29 .375 10.29

-8.6 8.1 1.4 12.8

EQ = 176^k

0 .415 .225 0 .225 .225 0 .225 .225 0 .415 0

.085 471.4 149.5 .05 149.5 149.5 .05 149.5 471.4 .085

96.5 620.9 MG 33.2 448.5 448.5 33.2 770.4 1092.2 96.5

1092.2 770.4

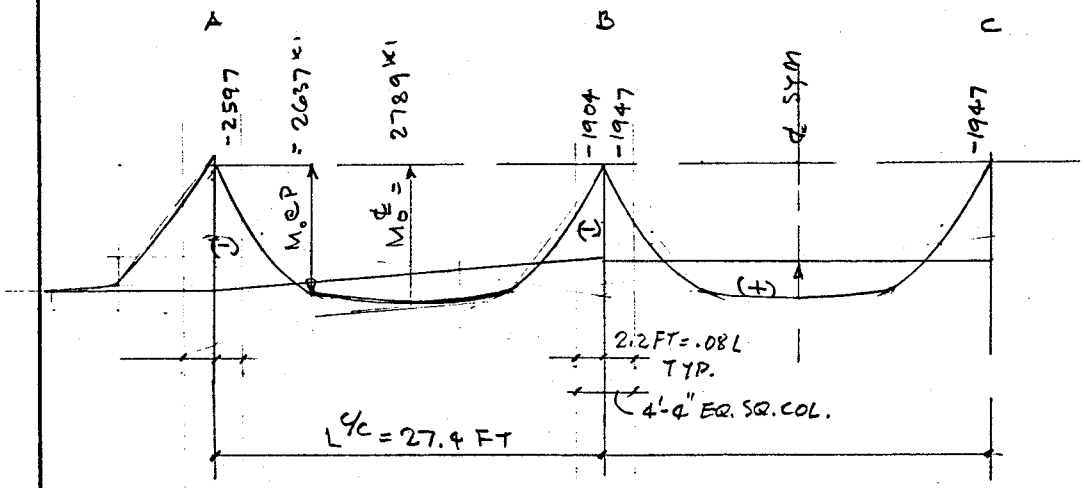
-1092.2 M_{COL} -1219 -1219 -1092

3168 .375 M'' = -1285.3 .375 -1285.3 .375 -1285.3 .375 -1285.3

h = 54'
Q = EQ. 4/3 = 3168

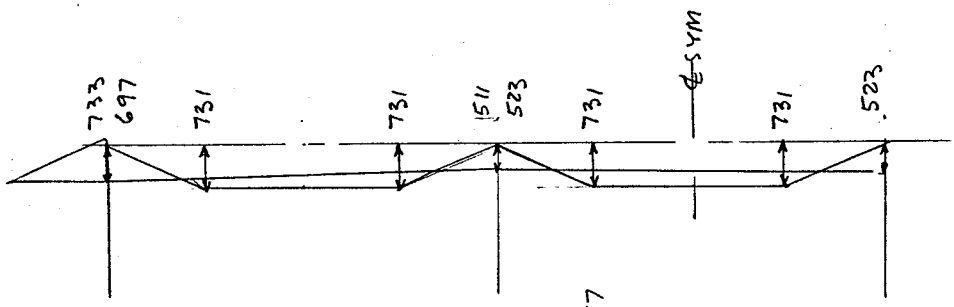
-1189 -1252 -1252 -1189

PIER MOM - DIAGS

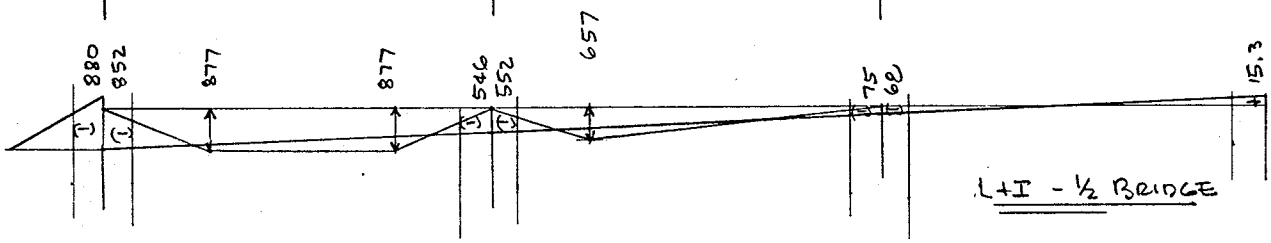


DL- MOM DIAG

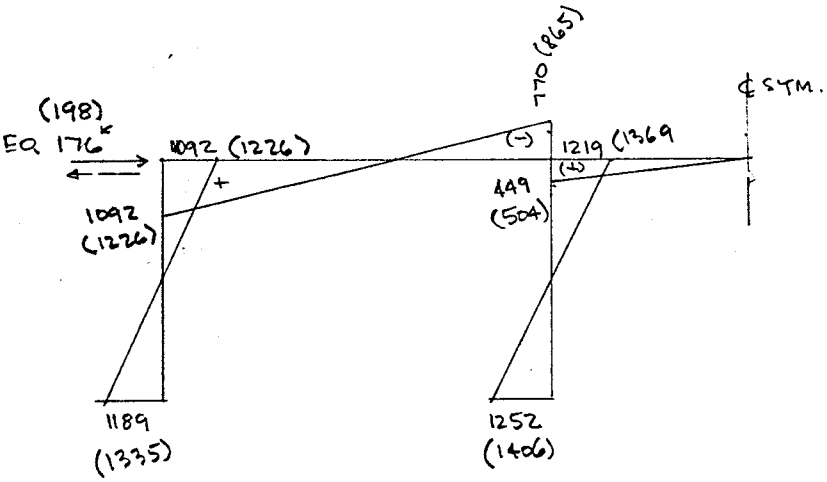
1" = 4000 K'



FULL L+I- MOM. DIAG.



L+I - ½ BRIDGE



EQ. - MOM. DIAG

$SF := \frac{5}{176}(EQ.)$

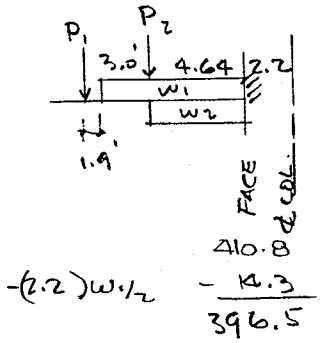
NUMBERS IN (---) ARE FOR EQ. IN LONGIT. DIRECTION:

$\gamma = 0.8 \left(\frac{247}{176}\right) = 1.122(176) = 198^K$ (F; PG 63)

CAP BEAM DESIGN MOMENT

NEG. MOMENTS @ FACE OF SUPPORTS X = 2.2 FT

CANT.



FOR LOADS SEE FEM.

$M_{DL} = P_1(9.54) = 101.1$

$P_2(4.64) = 1587.8$

$w_1(7.64)^2/2 = 131.3$

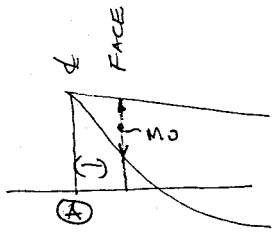
$w_2(4.64)^2/2 = 21.5$

$M_{DL} = 1841.7 \cong \underline{\underline{1842^{k'}}}$

$M_L = 110(4.64) = 510$

$I = .3(L) = 153$

$\Sigma M_{L+I} = \underline{\underline{663^{k'}}}$



INTER. FACE OF 1ST COL:

$M_o^{DL} = 407.1(2.2) = 896$

$- 6.5(2.2)^2/2 = \underline{-16}$

$880^{k'}$

$(-)M_A = 2597 \quad (-)M_B = 1904 \quad \Delta M = 693$

$(-)M_{DL} = M_A \quad 2597$

$- \Delta M(2.2)/27.4 = -55$ } -935

$- M_o = \underline{-880}$

$(-)M_A^{RT} = \underline{\underline{1662}} < M_{CANT}$

1/2-LL

$M_o^{LL} = 128(2.2) = 282$

$(-)M_A = 852 \quad (-)M_B = 546 \quad \Delta M = 306$

$(-)M_{LL} = M_A \quad 852$

$- \Delta M(2.2)/27.4 \quad -24$ } 306

$M_o \quad \underline{-282}$

$M_{L+I} \quad \underline{\underline{546}} < M_{CANT}$

EQ $(-)M_A = 1092 \quad (-)M_B = 770 \quad \Sigma M = 1862$

$M_{EQ} = \overset{1092}{M_A} - \overset{150}{\Sigma M}(2.2)/27.4 = \underline{\underline{\pm 942(\gamma)}} = 1058$

(PG 72

SF = EQ. $5/176 = 28^{k'}$

CAP BM DESIGN MOMENTS CONT'D

MOM'TS @ B_{LT} (FACE)

$M_0^{DL} = 880$ $\Delta M^{DL}(2.2)/27.4 = 55$ $M_B = 1904$

$(-)M_{B\,DL}^{LT} = \overset{1904}{M_B} + 55 - \overset{880}{M_0} = \underline{(-)1079}$ DL

$(-)M_{B\,LL+I}^{LT} = \overset{570}{546} + 24 - 282 = \underline{(-)288^{k'}}$ ½-LL

$\Delta M = 186(2.2)/27.4 = 15$ FULL LL

$(-)M_{B\,LL+I}^{LT} = \overset{526}{511} + 15 - 235 = \underline{(-)291^{k'}}$

EQ. $(770 - 150)\,\gamma^{PG72} = \pm \overset{696}{\cancel{620}}$

SF : $18^{k'}$ SF

MOM'S @ B_{RT} (FACE)

$M_0^{DL} = 880$

$(-)M_{B\,RT} = 1947 - M_0 = -1067^{k'}$ DL

½-LL: $M_0 = 96(2.2) = 211$

$(-)M_B = 552$ $(-)M_C = 75$ $\Delta M = 477^{k'}$

$\Delta M\,(2.2/27.4 = 38$

$M_{L+I} = 552 - \overset{249}{38} - 211 = \underline{303^{k'}}$ ½ LL

FULL LL: $M_0 = 176$

$(-)M_B = 523 = M_C$

$M_{L+I} = 523 - 176 = \underline{347}$ FULL LL

EQ. = $(-)M_B = M_C = 449$ $\Sigma M = 898$

$M_{EQ} = 449 - \overset{72}{898}(2.2)/27.4 = \underline{\pm 377^{k'}}$ TRANSV.

$377(\gamma) = \underline{423}$ LONGIT.

PG 72

SF = 11.0

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PIER

CAP BEAM DESIGN MOM'TS (CONT'D)

POSITIVE MOMENTS

SPAN AB:

DL $V_A^{DL} = V_o = 407.1$

$\Delta M\ 693 / 27.4^{L} = 25.3$

432.4^{k}

$x_o = (432.4 - \overset{P}{318}) / \overset{w}{6.5} = 17.6$ FT

$(+)\ M_{DL} = V_A(x_o) = 7610$

$- P(x_o - 6.85) = -3419$

$- \underset{1007}{w x_o^2/2} - \underset{2597}{M_B} = -3604$ } 7023

$+ M_{DL} = 587$

DL + FULL LL:

$V_A = \overset{V_o}{407.1} + \overset{106.7}{128^{175}/.9} = 513.8$ $\Delta M = 693 + 186 = 879^{k'}$

$\Delta M/L = 879/27.4$ 32.8

546.6

$P = 318 + 106.7 = 424.7$

$x_o = (546.6 - 424.7)/6.5 = 18.75$ FT $M_B = \begin{array}{r} 2597 \\ 697 \\ \hline 3294 \end{array}$

$(+)\ M_{DL+LL} = V_A(x_o) = 10251$

$- P(x_o - 6.85) = -5056$

$- \overset{1143}{w x_o^2/2} - \overset{M_B}{3294} = -4437$ } 9493

$758^{k'}$

693
306

DL + ½ LL: $V_A = 407.1 + 128.0 = 535.1$

$(\overset{\Delta M}{693 + 306})/27.4 = 36.5$

999

$V_{\mathbb{C}} = 571.6$

$\begin{array}{r} 2597 \\ 852 \\ \hline 3449 \end{array}$ 999

$\begin{array}{r} 1904 \\ 546 \\ \hline 2450 \end{array}$

$P = 318 + 128 = 446$

$x_o = (571.6 - 446)/6.5 = 19.32$

$(+)\ M_{DL+LL} = V_A(x_o) = 11045$

$- P(x_o - 6.85) = -5563$

$\overset{1213}{w x_o^2/2} - 3449 = -4662$ } 10225

$820 \Leftarrow$ GOV.

$\begin{array}{r} 27.4 \\ 19.32 \\ \hline 8.1 \end{array}$ $\begin{array}{r} 770 \\ 550 \\ \hline 220 \end{array}$ $1862\ \frac{8.1}{27.4}$

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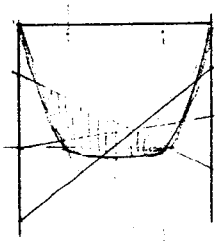
CAP BEAM DES. MOMENTS (CONT'D)

DL + EQ IN SPAN AB:

(a) → EQ: $V_{EQ} = (1092 + 770)/27.4 = -68^k(\gamma) = 76^k$

$V_A = V_{DL}^{432.4} + V_{EQ}^{\cancel{-68}\ 76} = \cancel{364.4}\ 356.4$

$M_A = -2597 + \cancel{1092}\ 1226 = -\cancel{1505}\ -1371$



$x_0 = (V - 318)/6.5 = \cancel{7.14}\ 5.9\ FT$

$(+)\ M = V_A(x_0) = \cancel{2601}\ 2103$

$- \cancel{P(x_0 - 6.85)} = \cancel{-92}\ \} -\cancel{1762}$

$- \omega x^2/2 - \cancel{1505}\ \cancel{165} = -\cancel{1670}\ \} -1484$

$-113 - 1371$

$+\cancel{839}$ EQ + DL

$+619$

b ← $M_A = -\cancel{3689}\ -3823$ $M_B = -\cancel{1134}\ -1039$ $\Delta M = \cancel{2555}\ -2784$

$V_{B_{LT}} = 407.1 - \Delta M/L = \cancel{313.9}\ 305.5$ ($\cancel{93.2}$ 101.6)

$\bar{x}_0 = 6.85$

$(+)\ M = V_B(x_0) = \cancel{2150}\ 1986$

$- \omega(x_0^2/2 = -152\ \} -\cancel{1286}\ -1191$

$- M_B = -\cancel{1134}\ 1039$

$+\cancel{864}$

$+795$

770
− 466
314

1862 6.85
27.4

CAP BEAM REINF.:

GROUP I DL + (L + I) + SF

TOP REINF: @ A:

			INT. FACE
(−) M = CANTIL.	DL	1842	1662
	LL + I	663	546
	⟹ GOVERNS	2505	28 SF
			2236

GROUP VII: DL + SF + EQ

INTER FACE @ A: 1662 DL

(γ) 942 EQ 1058

28 SF

$\cancel{2632}\ 2748/1.33 = \cancel{1980}\ 2066$

⟹ USE WS: $a = 1.76$ $d = 60 - 4 = 56$ $A_s = 25.4\ IN^2$ $d_{RD} = \left(\frac{M}{6(1.246)}\right)^{1/2} = 41^{IN}$

ULT: $a = 4.3$ $A_s = 3834/ad = 15.92\ IN^2$

FACTORED LOADS:

GROUP I: $M = 1.3(1842 + 1.67(663)) = 3834$ ⟸ GOVERNS

GROUP VI: $M = 1.3(2632) = 3422$

PIER

CAP BM REINF (CONT'D)

TOP REINF @ B:

GROUP I:

B_{LT} = DL 107.9 + LL+I 29.1 + SF 1.8 = 1388 K'

B_{RT} = DL 106.7 + 34.7 + 1.1 = 1425 ⇐

GROUP VII:

B_{LT} = 107.9 + 62.0 (EQ.) + 1.8 = 1717/1.33 = 1291

B_{RT} = 106.7 + 37.7 + 1.1 = 1455/1.33 = 1094

WS: a = 1.76 d = 56 A_s = 1425/ad = 14.5 IN²

BOTT. REINF:

SPAN AB:

GROUP I: (+)M = DL + ½ LL (820) + SF $\frac{5}{176}$(220) (6.0) = 826 ⇐

GROUP VII (+)M = DL+EQ. 864 + SF $\frac{5}{176}$(314) (9) = 873/1.33 = 656

a = 1.76 d = 60 - 6 = 54 A_s = 826/ad = 6.7 IN²

$A_{s\,MIN}$ = .0033 (72) 54 = 12.83 > A_s

SHEAR:

CANTIL. @ FACE

V = V_{DL} = 396.5

V_L = 110(.9) = 99.0

I = 1.3V_L = 29.7

V_{DL+L+I} = 525.2 K

f'_c = 4000 v_c = .95$\sqrt{f'_c}$ = 60 PSI b = 72 d = 56

V_c = vbd = 241.9 K V□ = 283.3 K

#5 [] S_{RD} = 4(.31)20(d)/V□ = 4.9 IN [1]

S = 7.35 [1][1] ⇐

V @ P_2^{RT} = V_{DL} = 410.8 - 6.84(6.5) (44.4) = 366.4

V_{L+I} 128.7

495.1

V□ = 495.1 - 241.9 = 253.2

#5 S_{RD} = 80(.31) d/V□ = 5.5" [1]

8.2" [1][1]

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CAP BM REINF. (CONT'D)

SHEAR @ A_{RT}

$V_A = V_0$ $\overset{DL}{407.1} + \overset{L+I}{128.0}$ = 535.1

$\Delta M / L = 999/27.4$ = 36.5

$-2.2(6.5$ −14.3

557.3

SF ~ 2.7

$\Sigma V = 560.0^k$

571.6
2.7
574.3

$V_c = 242$ $V\square = 318^k$

#5 $s = 6(.31)20(56)/V\square = 6.55''$

@ $P_{LEFT} = 574 - \overset{44.5}{6.85(6.5)} = 530$ $V\square = 288$

$s = 120(.31)\cdot 56/V\square = 7.2$ IN

@ 12"

@ $P_{RT} = 530 - (\overset{446}{318 + 128}) = 84 < V_c$ USE MIN.

MAX A_s = .62(40000)/50(72) = 6.9"

1.24 — " — = 13.8"

1.86 = 20.7"

DL + EQ. + SF

$V_A^{RT} = \overset{DL}{432.4} + \overset{EQ}{68} + \overset{SF}{2} = 502.4$ NOT CRITICAL

SHEAR @ B^{LT} $\Delta M = \overset{DL}{693} + \overset{L+I}{306}$

DL + ½ LL + SF :

V : DL+L+I : 535.1 − $\overset{36.4}{999/27.4}$ = 498.7

SF 2.3

501.0^k

−2.2(6.5) −14.3

487.7
241.9

$V\square = 245.8^k$

$s = 120(.31)56/V\square = 8.5$

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CAP PM REINF (CONT'D)

SHEAR @ P-RT

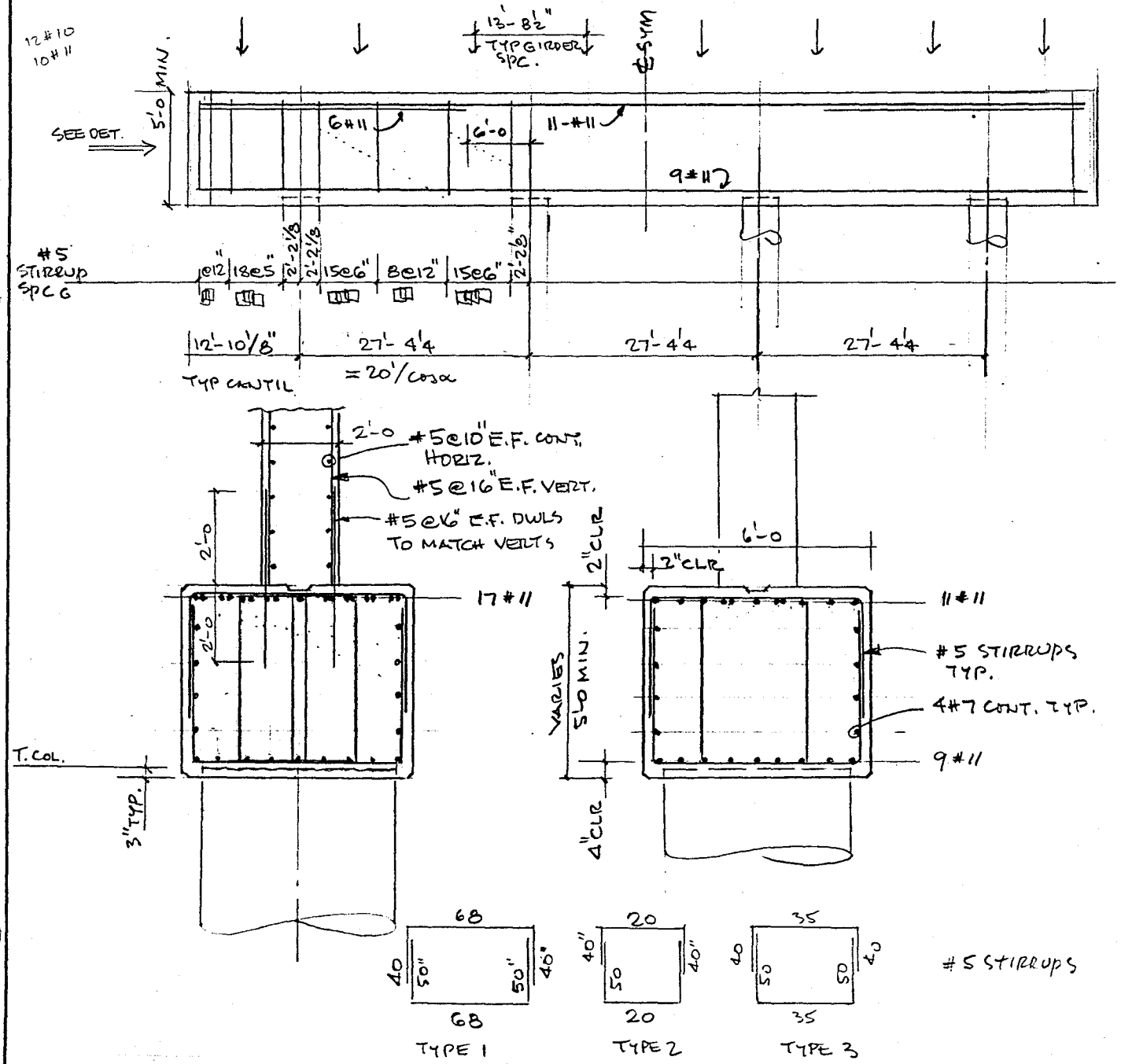
$V = \overset{535.1}{DL + LL + I} + \overset{\sim 1.9}{SF}$

@ FACE

537.0
− 14.0
523.0
242

$V_{\square} = 281^K$

$S = 120(.31)56 / V_{\square} = 7.4 \text{ IN}$



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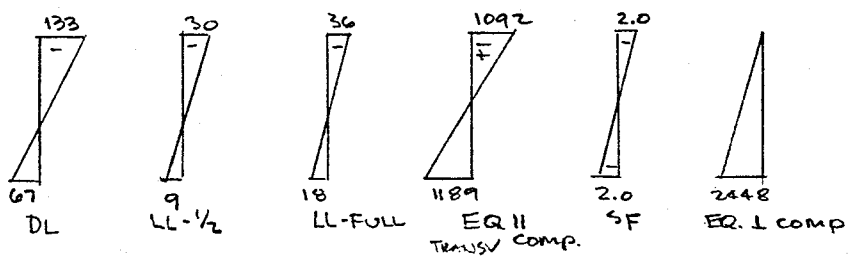
COL. LOADS

COL. A

		P
	DL: CANTILEVER 410.8 + SPAN 407.1	817.9
	$\Delta M/L$	25.3
		843.2
LL ON ½-BRIDGE	L+I: CANT. 99 + SPAN 128 + $\Delta M/L$ 11.2 =	238.2
LL ON FULL BRIDGE	L+I: $227\left(\frac{.75}{.90}\right)$ (189.2) + 6.8 ($\Delta M/L$)	196.0
EQ. LONGIT. $\Sigma EQ = 176^k$/FRAME	EQ: (1092 + 770) / 27.4 = ±	68.0
	SF: EQ 5/176 =	1.9
	BOYANCY: FULL SCOUR: −(2(25) + 18) = −	68.0^k

MOMENTS:



COL. MOMENTS M_x:

DL + EQ + SF $M_x = 1227^{k'}$

DL + L+I + SF $M_x = 171^{k'}$

M_y:

EQ. ⊥ COMPONENT ($F_H = 51^k$/COL.)

$M_y = F_h(30+18) = 2448^{k'}$

COL. A (EQ. LONGIT. $\Sigma EQ^{\parallel} = 247^k(.8) = 198^k$/FRAME. (F SEISMIC)

$P_{EQ} = \pm 68(198/176 = \pm 77^k$

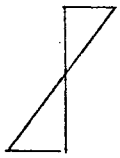
MOMENTS

EQ. TOP OF COL. 1092 (198/176) = 1229

BOT " 1189 (") = 1338

EQ. ⊥ $F_H = 66^k$/COL.

$M_y = F_h(48) = 3168$



EQ. LONGIT. ∥ COMP.

COL. A (CONT'D)

DESIGN LOAD & MOMENT COMBINATIONS

(1) DL + EQ. LONGIT. + SF GROUP VII @ FULL SCOUR LEV.

$P_U = 1.3(.75(\overset{632}{843}) - \overset{B}{68} - \overset{SF}{2} - \overset{EQ.}{68}) = 642^k$

$1.3(.75(\overset{HT}{40})(\overset{COL.WT}{2.95}))$ 115

$P_U = 757^k$

$M_{Ux} = 1.3(\overset{DL}{67} + \overset{SF}{2} + \overset{EQ}{1338}) = 1829$

$M_{Uy} = 1.3(3168)$ 4118

$M_U = \sqrt{M_{Ux}^2 + M_{Uy}^2} = 4506^{k'}$

$e = M_U / P_U = 71.5$ IN

(2) SAME LOADING @ SCOUR PROTECT. LEVEL.

$P_U = 642$

$1.3(.75(27)2.95)$ 78

$P_U = 720^k$

$M_{Ux} = 1829$ CONSERV.

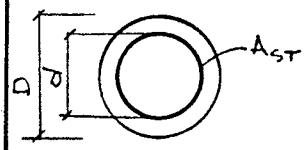
$M_{Uy} = 1.3(66)35 = 3003$

$M_U = \sqrt{M_{Ux}^2 + M_{Uy}^2} = 3516^{k'}$

$e = M_U / P_U = 58.6^{IN}$

CHECK COL. 5'-0 ⌀

$D = 60''$ $d = 51.5''$ $A_g = 2827$ IN^2 $f'_c = 4000$ $f_y = 60$



A_{ST}	$p_T m$	e/P_{ALL}	e/P_{UALL}
62.4 (40#11)	.389	71.5/840	51.5/1339

PIER

COL. A CONT'D

CHECK MAGNIFICATION FACTOR:

$C_{mx} = 0.4$ (DBLE CURVATURE)

$C_{my} = 1.0$ (CANTIL. COL.)

$EI = E_c I_g \div (2.5(1+\beta_d)) = 890(10)^6$ as

$M_{DL} = 133$

$M_{TL} = 1394$ (DL + FULL LL+I + EQ LL + SF) TOP

$M_{TL_x} = 1425$ (" ") BOT

$M_{TL_y} = 3168$ EQ.

$M_{max} = \sqrt{1425^2 + 3168^2} = 3474^{k'}$

$\beta_d = 133/3474 = .04$

$E_c = 3640$ (4.0) $I_g = 636173$

$L_1 = 52$ FT $kL_u = 2(12)40 = 960$ (CANTIL. k)

$P_{c_1} = \pi^2 EI / (kL_u)^2 = 9536^k$

$P_u = 757^k$ $\phi = .70$

$\delta_x = C_{mx} \div (1 - P_u/\phi P_c) = .45 < 1.0$

$\delta_y = C_{my} \div (\quad) = 1.13 < 1.0$

MAGNIFIED MOMENT:

$\delta M_u = [\quad (1829))^2 + (1.13(4118))^2]^{\frac{1}{2}} = 5000$

$P_u = 757$

$e = \delta M_u / P_u = 79.3''$

42 #11 $p_t m = .409$ $e = 79.3$ $P_{nu} = 784 > P_u$ o.k.
($A_s = 65.52$)

$d = 60 - (2(2) + 2(\frac{1}{2}) + 1.5)$

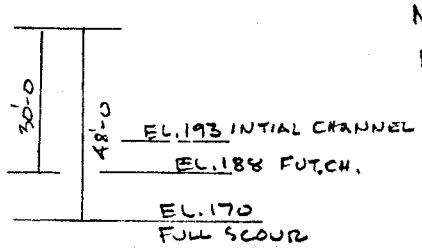
$d = 53.5$ SAY 53"

USE 5'-0 Φ COL. w/
42 #11 VERTS &
#4 @ 12" HOOPS

PIER

COL A CONT'D

Check COL. @ EL. 188'



$M_x \simeq \frac{1}{2}\,1407$ $\quad M_{ux} = 1.3(M_x) = 915^{k'}$

$M_y = \overset{F_h}{66}(30)$ $\quad M_{uy} = 1.3\,M_y = 2574$

P_u = GIRD & CAP BM 642

COL. 1.3(.75) $\overset{HT}{22}$(2.95) 63

705^k

$M_u = \sqrt{M_{ux}^2 + M_{uy}^2} = 2732$

$\delta M_u = [(915))^2 + (1.13(2574))^2]^{\frac{1}{2}} = 3049$

$e = \delta M_u / P_u \cong 51.9$ IN

A_{ST}	IN^2	$P_T m$	e/P_{ALL}
22 #11	32.76	.204	52/770 > 705

$A_{S\,MIN} = 1\%\,A_g = 28.27\,IN^2$

∴ CONTINUE w/ 21 #11 @ ELEV. 188 FT

COL. B:

VERTICAL LOADS

DL: SPANS 2(407.1) (814) − 25.0 ($\Delta M/L$) 789

LL ON ½ BRIDGE — LL+I: 128 (SPAN AB) + 96 (SPAN BC) + 6.2 ($\Delta M/L$) 230

LL ON FULL — LL+I 2(.75)128 − 7.0 199

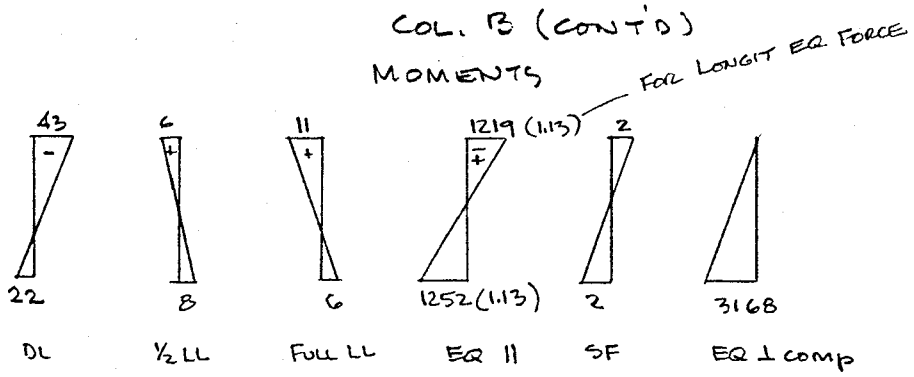
EQ. (1862 − 898) (964) / 27.4 ± 35

SF: EQ. 5/176 1.0

BOYANCY FULL SCOUR − 68

COL. B (CONT'D)

MOMENTS



DESIGN LOAD & MOM. COMBINATION

(1) GROUP VII @ FULL SCOUR ELEV. 170.0

$P_U = 1.3(.75(789) - \overset{B}{68} - \overset{SF}{1} - \overset{EQ}{35}) = 658^k$

COL. SEE COL. A 115

$P_U = 773^k > \text{COL A}$

$M_{Ux} = 1.3(\overset{DL}{22} + \overset{EQ}{1415} + \overset{SF}{2}) = 1871$

$M_{Uy} =$ SEE COL. A 4118

$\delta M_U = [(1871)^2 + (1.13(4118))^2]^{\frac{1}{2}} = 5015$

$e = \delta M_U / P_U = 77.9$ IN SAY 78

42 #11 $P_{AU} = 802^k > 773$ o.k.

(2) AT EL. 188'

$P_U = 658 +$ COL. C3 $= 721^k > \text{COL A}$

$\delta M_U \simeq 3049$ COL. A

$e = \delta M_U / P_U = 49'' < 50''$

21 #11 o.k.

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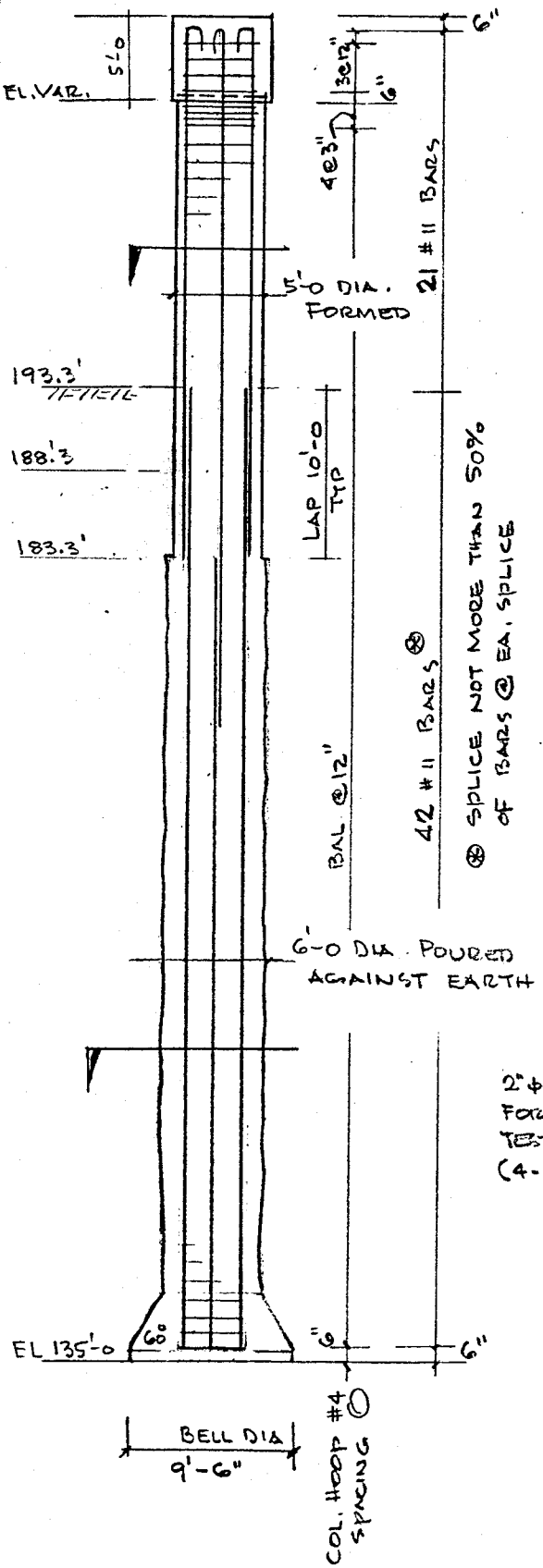
PIER	REV.



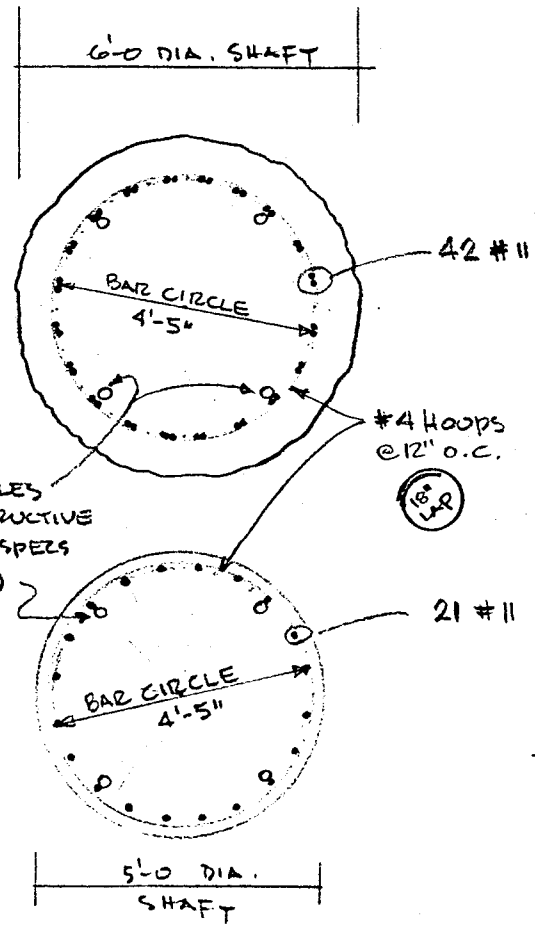
SOIL BRG CAPACITY

COL. A:

ΣP.:	DL: SL & CAP BM	843.2
	COL 22 HT (2.95 5'ϕ) =	64.9
	" 53 (4.24 6'ϕ) =	224.7
	LL 238.2/1.3	183.3
	SF	2.0
		1318.1

COL. B:

ΣP:	DL.	789
	COL.	290
	LL 230/1.3	177
	SF	1.0
		1257.0 < A



BELL DIA. 9'-6"

A = 70.8 □' P_{ALL} = A (20) = 1418 K > C

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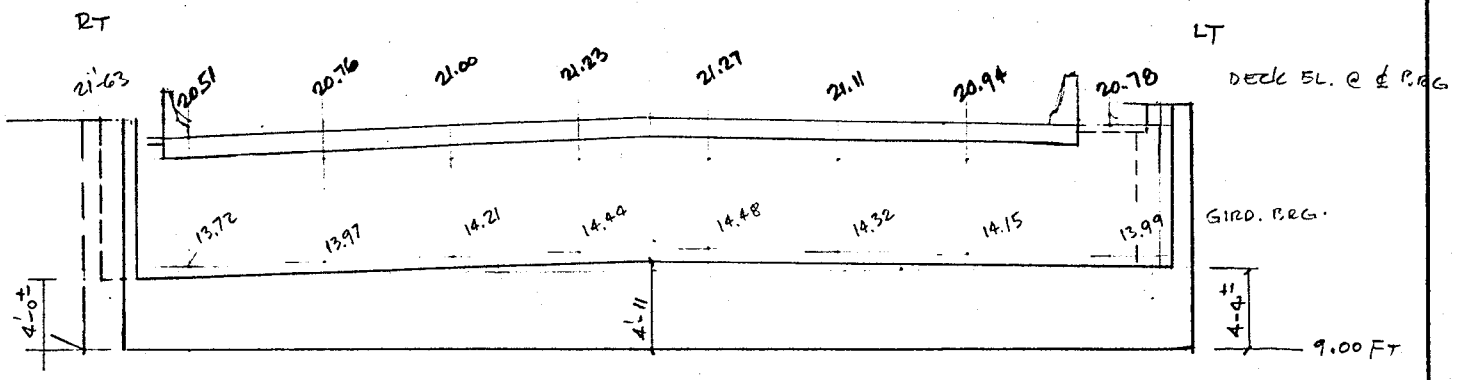
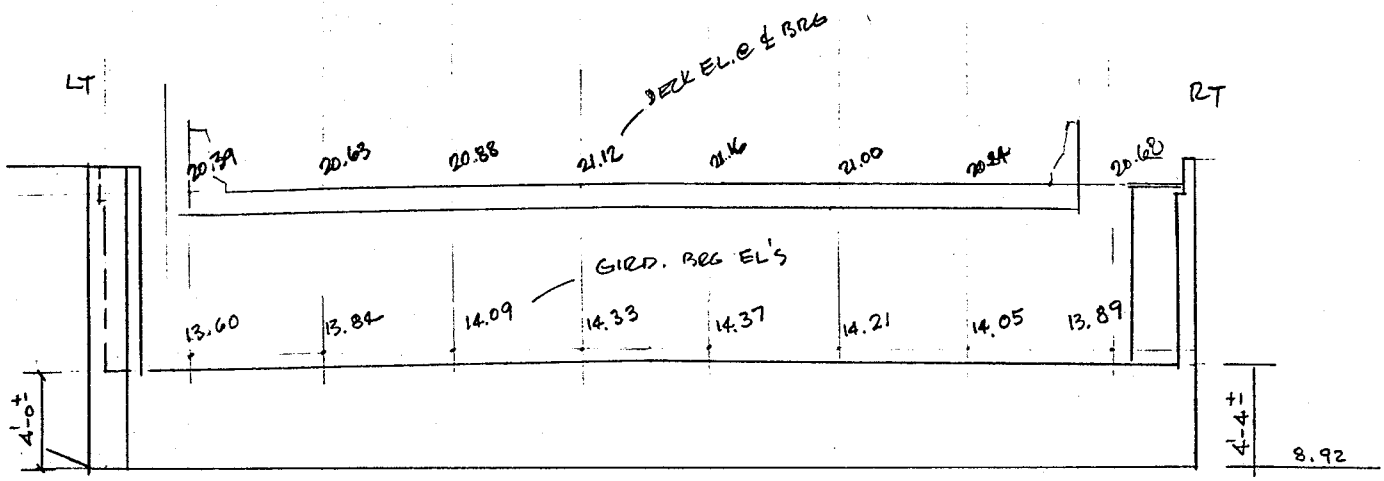


ABUT #1

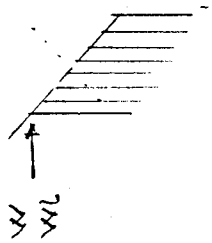


ABUT. #2

ABUT.

WIND LOAD REACTION (W) SEE LAT. LOADS

(a) SUPERSTR.



$W = .500\left(\tfrac{1}{2}117.3 + 2.5\right) = 30.6^k$

$WL = .100\left(\quad '' \quad \right) = 6.1^k$ (6'-0 ABOVE DECK)

(b) SUBSTRUCT:

$W^T = 30.6$ TRANS. } SIMULT

$= 1.2(6.1) = W^L = 7.3$ LONGIT

$WL^T = 6.1$ TRANSV. } SIMULT. (6'-0 ABOVE DECK)

$.4(6.1) = WL^L = 2.4$ LONGIT.

(c) OVERT. FORCE @ 1/2 P_T ↑

$P\uparrow = 1.65\left(\tfrac{1}{2}117.3 + 2.5\right) = 100^k$ GROUP II

$P\uparrow = 100\ 6/20 = 30^k$ -"- III

(d) SHRINKAGE:

$\varepsilon = .0002$ $L = 299$ FT SEE ELASTOM. PAD

$\Delta_{SH} = \varepsilon(L) = .72$ IN

FORCE TO ELAST. PAD: $M = 110^{PSI}$ (50 DURO.)

$F = \frac{M A \Delta}{3} = 8.9^k$/GIRDER $A = 338\ IN^2$, $T = 3''$

(e) TEMPERATURE

	Δ	F
$\Delta^{30°} = 299(6)10^{-6})\,30°(12) =$	.646	8.0
$\Delta^{40°} = (\ -''-\ )\,40°(12) =$	.861	10.7
	1.507	18.7 k/GIRDER

(f) EQ. S. REPORT SUPPL. #1 A = .22g FIG 1.2.20 D

C = .09 COMBINED RESP. COEFF.

F = 1.0 W = DEAD WT:

$EQ = CFW = .09(1)W = .09W.$

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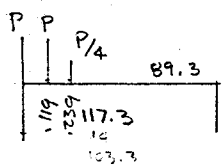
ABUT:

GIRDER REACTIONS

	EXT.	INT.
GIRDER $\overset{w}{1.13}$ (115.5/2 + 0.7)	66.0	66.0
8" SLAB : w : 1.41 EXT / 1.15 INT (115.5/2 + 2.5)	85.0	69.3
9" DIAPH. (INTERMED.)	3.4	6.8
BARRIERS DL 2	8.8	8.8
12" DIAPH @ ABUT.	4.4	8.8
4" THICKENED SLAB : $\frac{4}{12}(.15)(2.5)\,10$	.6	1.3
DL 1 & 2	168.2	161.0

LIVE LOAD REACTION

P = 29.1



FEM	LT	RT	α
1	316	42.8	
2	118	37.0	
2	434	79.8	
	PINNED	297.0	

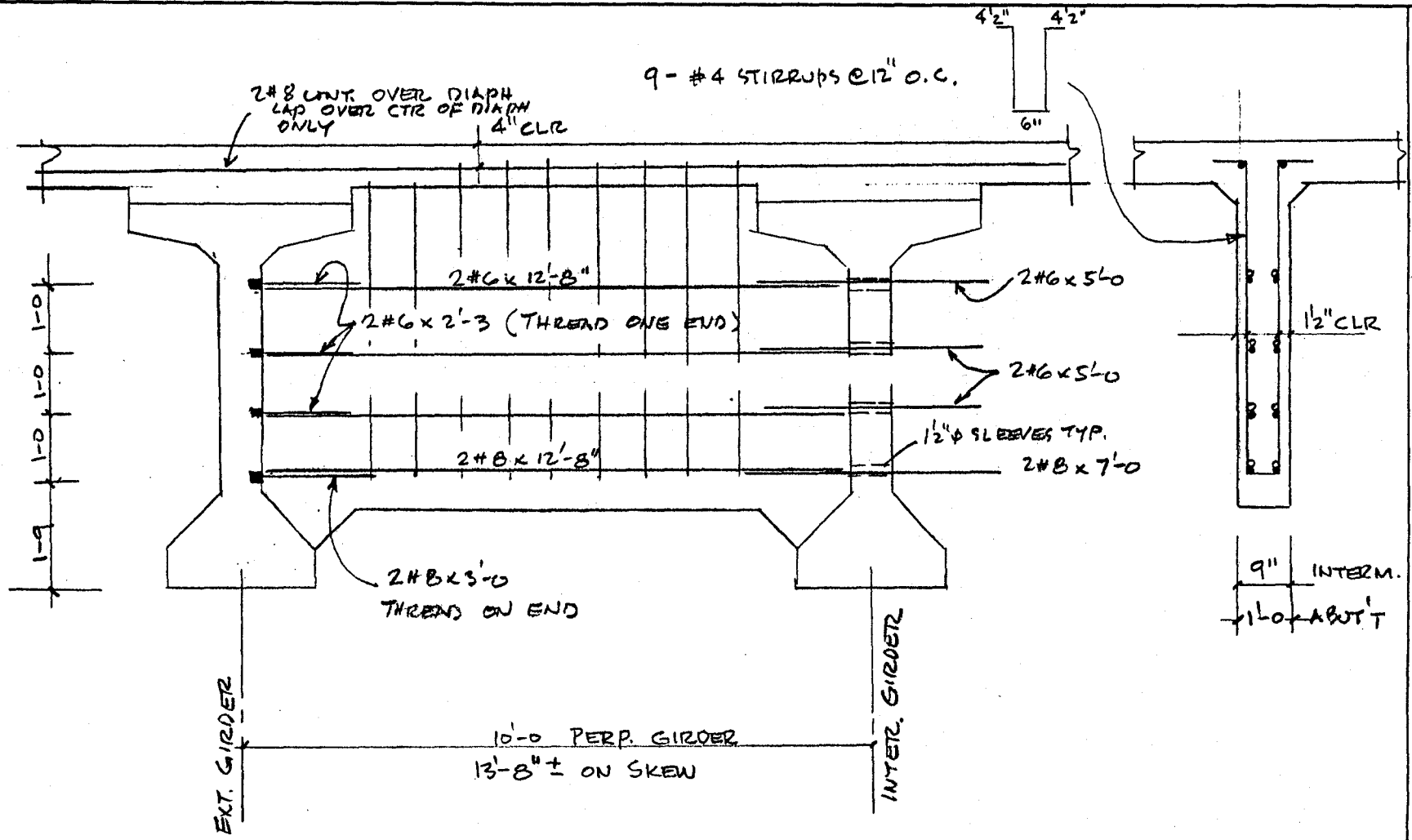
1.0 P
.881
.190
2.071P = 60.3

MOM DIST.

		.216	.284	.25	.25	.25	.25	.284	.216	
L		117.3	119.2		119.2		119.2		117.3	
FEM		297.0	0	0	0	0	0	0	0	
M'	0	-69.4	-91.3	24.5	24.5	-6.6	-6.6	1.9	1.4	0
Supp. MOM.	0	158.1	-158.1	-42.3	42.3					

M/L ±1.35 2.9

$$R_A = (60.3 - 1.3) + 16\left(3 - \frac{10}{10_5} - 1.82\right) = 59 + 2.9 = 61.9^k$$



WT. OF ABUT. DIAPH.

$.150\left(\frac{5.5}{12}\right)(6.5)$	=	.447
$.15\left(\frac{3}{12}\right)(7.6)$	=	.285
$.15\left(\frac{4}{12}\right)(9.0)$	=	.450
$.15(3.5)(9.33)$	=	4.898
$.15(10/12)(8.5)$	=	1.063
$-.15(8/12)(7.0)$	=	-.700
		6.443 / $\cos\alpha$ = 8.81

$\alpha = 43° 01'-04"$

INTERM. DIAPH

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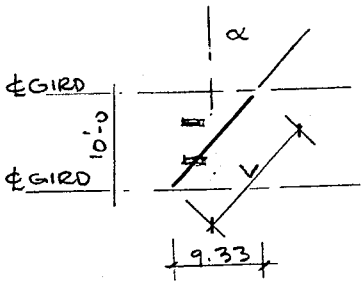
INTERM. DIAPH.

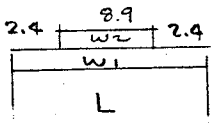


SKEW $\alpha = 43^\circ\ 01'\ 04''$

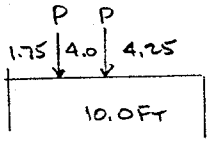
$L = 10/\cos\alpha = 13.7$ FT
4.8

$w_1 = \overset{H}{5.3}(100) = 530^{\#}/_{'}$ DIAPH.

$w_2 = 5.0(100)\frac{9.33}{13.7} = 340^{\#}/_{'}$ SLAB



$s = 6.0/\cos\alpha = 8.2$ FT



LL FOR SHEAR: $P = 16^k$ $I = 1.3$

$P_v = P(1 + 4.25/8.25) = 24.2^k$

LL FOR MOM.

$P_{m_1} = 2P(3/5) = 19.2$

$P_{m_2} = P = 16.0$

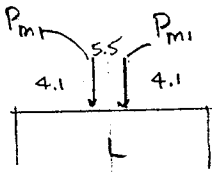
SHEAR

$V_{DL} = \frac{1}{2}L\overset{3.63}{w_1} + \frac{1}{2}w_2\overset{1.51}{8.9} = 5.14^k$

$V_{LL} = P_v(11.3/13.7) = 20.0$

$I \qquad 6.0$

$\Sigma V = 31.14^k$ DL+L+I

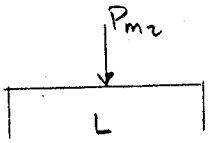


MOM.:

$M_{DL} = \overset{12.43}{w_1 L^2/8} + w_2\overset{7.0}{\frac{8.9}{4}}(13.7 - 4.45) = 19.43^{k'}$

$M_{L1} = P_{m_1}(4.1) = 78.7^{k'}$ ⇐ GOVERNS

$M_{L2} = P_{m_2}(L/4 = 54.8$



$\Sigma M = \overset{DL}{19.4} + \overset{L}{78.7} + 23.6 = 121.7^{k'}$

INTER. DIAPH

SIZE BENDING STEEL FOR CONTINUITY

FEM :

		L	R=L	α	M_L	M_R
DL	$w_1^{DL} L^2/12$	8.3				
DL	$w_2 L^2$ (m)	4.5		.65	.0698	
LL	P_{m1} (L) m	55.2		.30	.21	
I		16.6				

$$M_u = 1.3\left(\overset{DL}{12.8} + 1.67\left(\overset{L+I}{71.8}\right)\right) = 172.5^{k'}$$

CLEAR SPAN: $(10.0 - 2.3)/\cos\alpha = 10.53$ FT $= L'$

DEPTH : $D \cong 5.3$ FT $\quad D/L' = .50 > 0.4$

$D_{EFF} = 0.4(L') = 4.2$ FT $\cong 50''$

VOID

(a) $\hookrightarrow d = 50 - 24 = 26'' \quad b = 8''$

$f'_c = 4500$ psi $\quad \phi = 0.9$

$K_u = 12M/bd^2\phi f'_c = .095 \quad a_u = 2.8$

$f_y = 40$

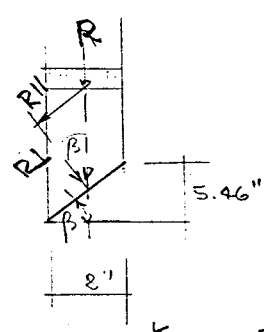
$A_s = M_u / a_u d = 2.37 \text{ in}^2$

(b) $\hookrightarrow d = 50 - 4 = 46'' \quad K_u = .03 \quad a_u = 2.9$

$A_s = M_u / a_u d = 1.29 \text{ in}^2$

USE 2#8 $(A_s = 1.58 > 1.29)$ TOP & BOTT

SKEW BEARING ON GIRDER FLGE



$\beta = \text{INV tan} \frac{5.46}{8} = 34.3°$ (-3)

$R_{\parallel} = R \sin\beta =$

$R_{\perp} = R \cos\beta =$

$R_{DL+LL+I} = 31.14^k \qquad R_{\parallel} = 17.6^k$

$R_{\perp} = 25.7^k$

SHEAR FRICTION: 1.5.29 D

$R = R_{\parallel} = 17.6 \quad \mu = 0.7 \quad f_s = 20$ ksi

$A_{vf} = V/f_s\mu = 1.26 \text{ in}^2 \quad (4\#6 = 1.76 > A_{vf})$

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ELASTOMERIC PADS @ ABUT.	REV.

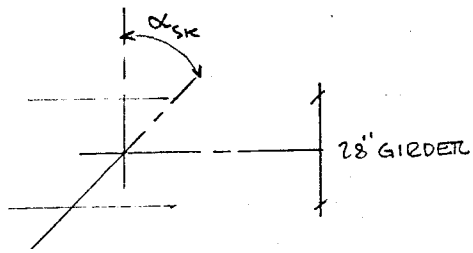
EXT. GIRD: SEC. 1.12.2

$P_{DL} = 168^k$

$P_{LL} = 62^k$ (NO IMPACT)

INT. GIRD

$P_{DL} = 161^k$



TEMP. CHANGE

RISE 30° FALL 40° $C_T = 6(10)^{-6}$

$\Delta^{100FT} = 100(C_T)70 = .042\,FT\,(12) = .504\,IN$

$L = [2(117.3) + 3(119.2)]\frac{1}{2} + 2.5 = 298.6$

$\Delta = \Delta^{100}(L)/100 = 1.505\,IN$

EL. PAD

$T_{MIN} = 2\Delta = 3.0" = ERT$ (EFF. RUBBER THICKNESS)

$P_{TL}^{EX} = 230^k$ $P_{TL}^{INT} = 223^k$

UPLIFT $.25P_{DL} = 42^k$ 40

$L = 28 - 2 = 26"$

$p_{ALL} = 800\,PSI$ TL 500 psi DL

$b_{R'D} = P/pL = 11.1\,IN^{TL\,EX}$ $10.7\,IN^{TL-INT}$

$= -"- = 12.9\,IN^{DL\,EX}$ $12.4\,IN^{DL-INT}$

$LL_{UPLIFT}^{TR} = \frac{M_B}{L_1} = \frac{598}{117.3} = 5.1^k$

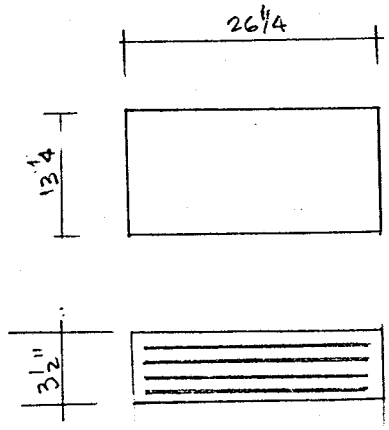
$LL_{UPL}^{LANE} = " = \frac{602}{117.3} = 5.13^k$ ← GOV.

$.75\,DL^{161} - LL_{UPL}^{5.1} = 115^k$

$p = 115/338 = 340\,PSI > 200$ o.k.

MIN. $b = 2(ERT) = 6"$

MIN. $L = 3(ERT) = 9"$



EL PAD 26 x 13 $A = 338\,IN^2$

$p_{DL} = 497 < 500^{EXT.}$ $476 < 500^{INT}$

$p_{TL} = 680 < 800$ $660 < 800$

PLY - THICKNESS

$t = LW \div (2S)(L+W)$

SHAP FACT.	PLY THICKN. t CALCULATED	USED	NO OF PLYS REQ'D ΣT
USE → 6.0	.722	11/16	3.0 / 11/16 = 4.36
5.0	.867	13/16	3.0 / 13/16 = 3.69

4-LAYERS @ 11/16"

1-LAYER @ 1/4"

4-INTERNAL PLS @ 1/8"

(60-DUROMETER HARDNESS)

INTERNAL PLATES: $t = 1/8"$ THICK FOR $A \leq 350\,IN^2$

FINAL BRG HT:

$H = 4(11/16)^{2.75} + 1(.25) + 4(1/8) = 3\frac{1}{2}"$

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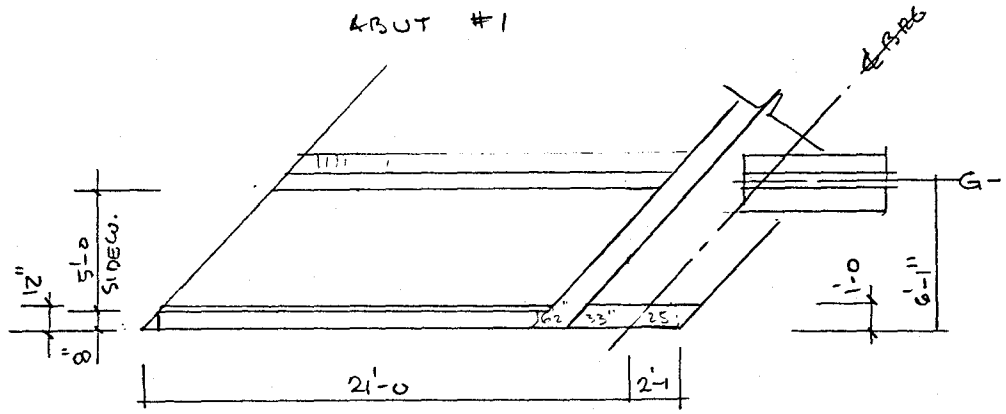
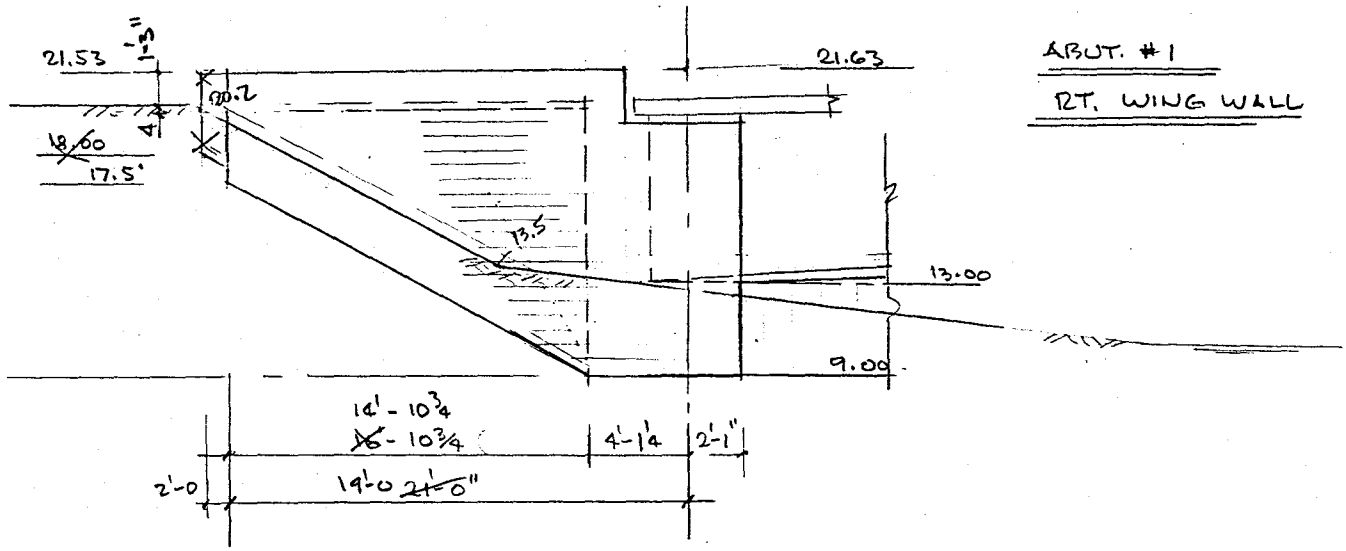
WING WALLS	REV.

ABUT #1

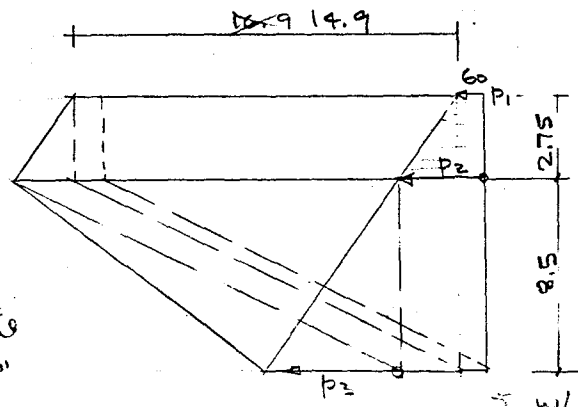




ABUT. #1

RT. WING WALL

LATERAL LOADS



p_a = 30 PSF

p_1 = 2 (30) = 60

p_2 = 4.75 (30) = 142.5

p_3 = 8.5(30) = 255

	H	ARM	M
$(14.9)2.75(p_1+p_2)\frac{1}{2}$ =	4.15	7.45	30.9
$14.9(p_2)8.5\frac{1}{2}$ =	9.0	14.9/3	44.8
$14.9(\frac{1}{6})p_3\ 8.5$ =	5.4	14.9/4	20.1
Σ w/ SURCHARGE	18.55		95.8
SURCH: $14.9(2.75)p_1$ =	-2.46	7.45	-18.3
$14.9(p_1)8.5\frac{1}{2}$ =	-3.80		-18.9
Σ w/o SURCH.	12.29		68.6 K-1

K = .197

W/ SURCH: $d_{rb} = \sqrt{\frac{114.7}{10(.197)}}$ = 7.6 IN

W/O SURCH. $d_{rb} = \sqrt{\frac{69.5}{10(.197)}}$ = 6"

WING WALLS

ABUT. #1 RT

VERT LOADS	V	ARM	MOM
FENCE .025 (14.9)	.4	7.45	2.8
.125 (14.9 L) (1.25 HT)	2.3	7.45	17.3
.150 (14.9) (2.75)	6.2	7.45	45.8
.150 (14.9) (8.5) 1/2	9.5	14.9/3.	47.2
Σ	~~18.4~~		113.1 12" THICK
	14 / 12(18.4) = 21.5		132.0 14" THICK

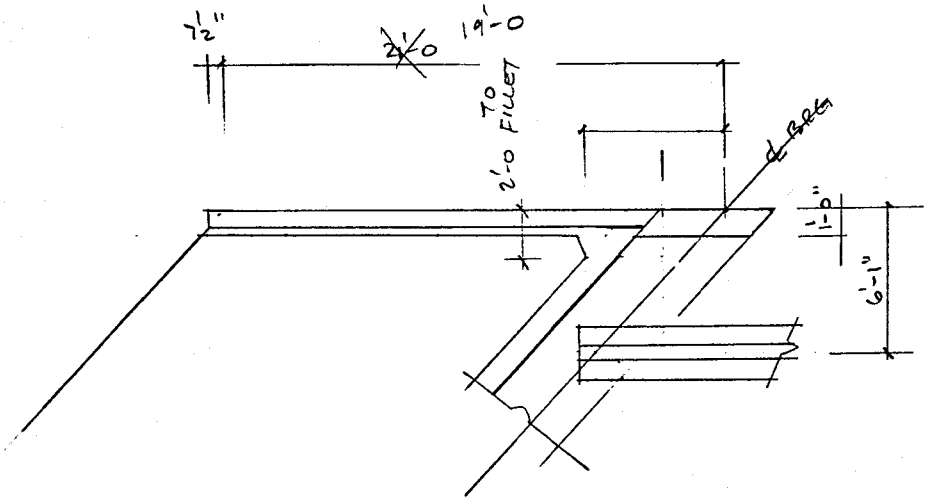
$d = 11(12) - 6" = 126$ $a = 1.44$

$A_s = M/ad = .62\ IN^2$ (2#6 = .88 o.k)

HORIZ. REINF:

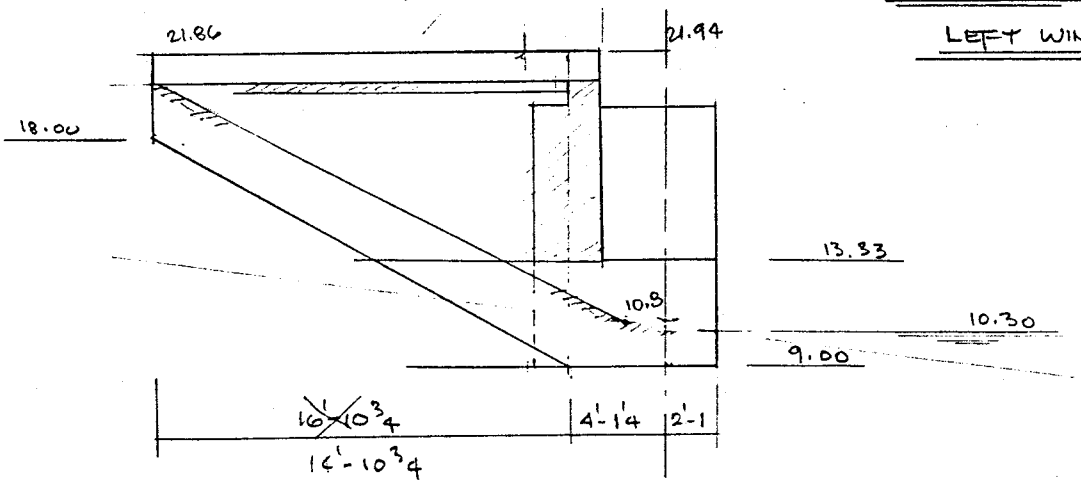
$d = 12.0 - (2.5) = 9.5"$ $M = 95.8^{k'}$ o.k. w/SURCH.

$\Sigma A_s = M/ad = 7.0^{IN^2}/.44$ (16 #6 = 7.04 IN^2 o.k.)



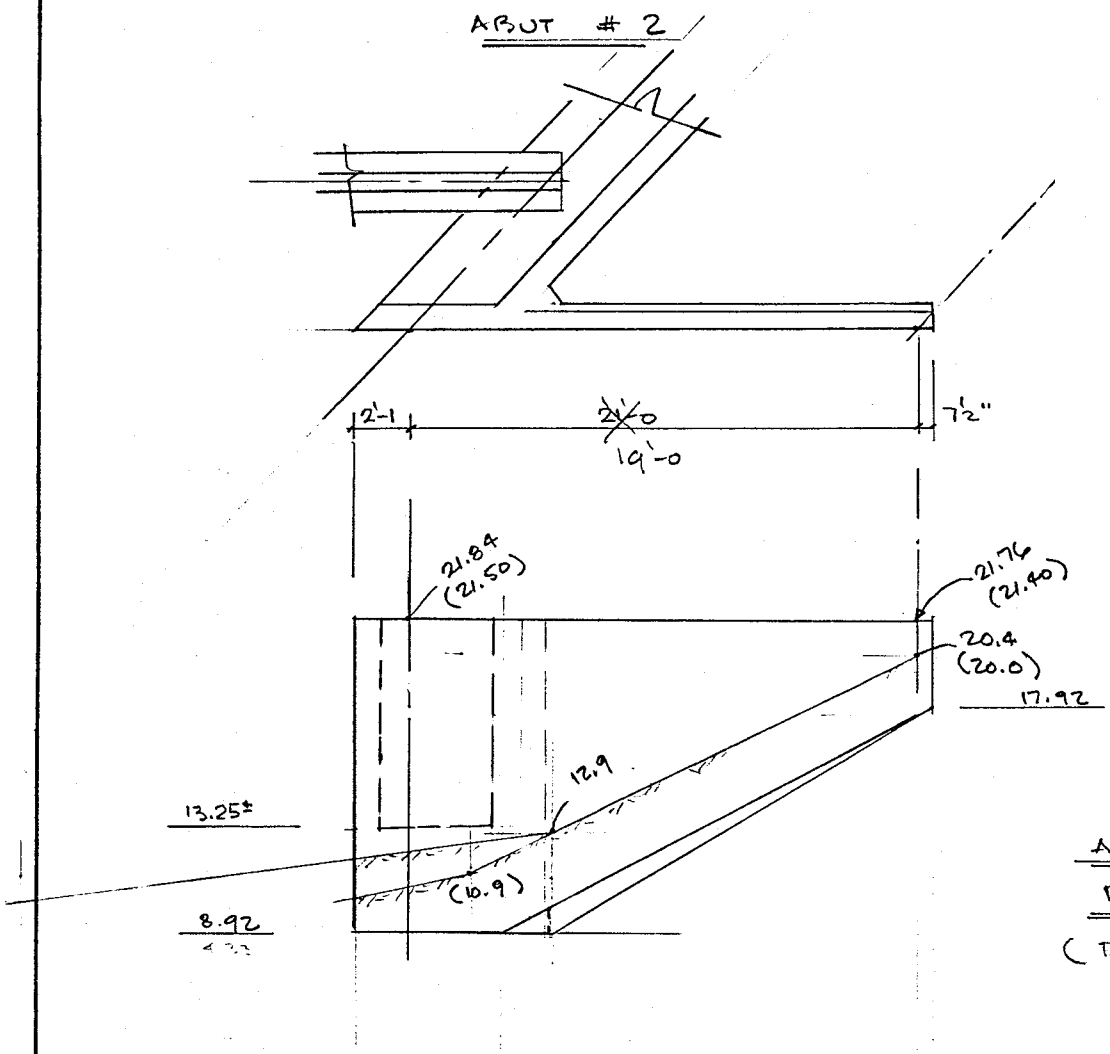
ABUT #1

LEFT WING WL.



WING WALLS

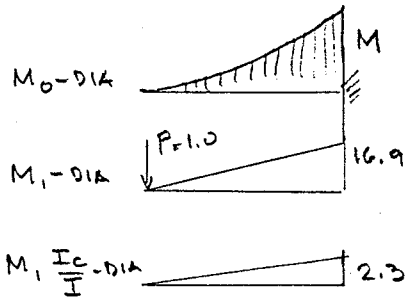
ABUT # 2



ABUT. #2

RT. WING WALL

(T.L. IN (---) ARE FOR LT. WING WALL.



CHECK HORIZ. DEFL. OF WING WALL FROM EARTH PRESSURE (APPROX.)

$M = 115^{k'}$ (W/ SURCHARGE) CONSERVATIVE

$I_1 = 18(12)^3/12 = 2600 = I_c$

$I_2 = 132(12)^3/12 = 19000$

$E I_c \Delta = (12)^3 \int M M_1 \frac{I_c}{I}$

$\int = \frac{1}{4}(16.9)\, M\, M_1 \frac{I_c}{I} = 1350$

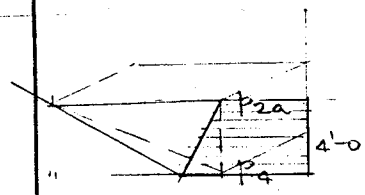
$E = 57\sqrt{3000} = 3120$ ksi

$$\Delta = \frac{12^3(\int)}{E I_c} = .24 \text{ IN}$$

ABUT.

TYP. WING WALL (CONT'D)

TRANSFER MOM. FROM EP INTO CAP BM



EP-DIAG @ CAP BM.

$p_4 = p_3 + p_2 = 398$

$p_{2a} = p_4 - 4(30) = 278$

TOTAL HORIZ. MOMENT $\Sigma M_H = 95.8^{k'}$

HORIZ. MOM'T DIRECT TRANSFER INTO CAP BM:

H	ARM	MOM'
$p_{2a}(4.0)(7.0)\frac{1}{2} = 3892$	$\times$ 7/3	9.081
$(\overset{120}{p_4} - p_{2a})\,4\,(7)\,\frac{1}{6} = 560$	$\times$ 7/4	1.98
	$\Delta M =$	10.06

BALANCE OF MOMENT TO BE TRANSFERRED INTO CAP BM BY TORSION:

$M_T = \Sigma M_H - \Delta M \cong 96 - 10 = 86^{k'}$

(1) DIRECT MOMENT INTO CAP BM:

$M = 10.1^{k'}$ $d = 14 - 2.5 = 11.5$ $a = 1.44$

$A_s = M/ad = .61\ in^2$

$3\#6 = 1.32\ in^2$ EFFECTIVE!

(2) TOTAL SHEAR @ FACE OF CAP BM

$V_c = \overset{v_c}{52}(\overset{d}{120})(\overset{b}{14}) = 87.4^k$

$V = 18.4\,(14)/12 = 21.5 < V_c$

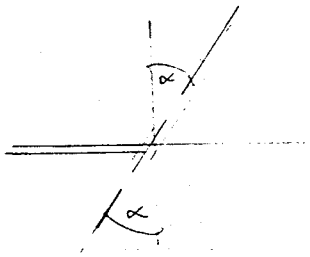
(3) MOM'T ABOVE CAP BM

$M = 86^{k'}$ $d = 11.5$ $a = 1.44$

$A_s = 5.20\ in^2$

$12\#6 = 12(.44) = 5.28\ in^2$

(4) TORS. MOMENT $M_T = 86^{k'}$



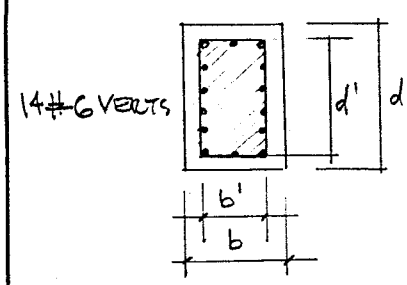
α (SKEW) = 43° 01' - 04"

$\tan\alpha = .933$

ABUT.

WING WALL TORSION CONT'D

EFFECTIVE TORS. SECTION



$b = 24''$ $d = 4'-8''$

$b' = b - 5'' = 19''$ } c/c TIES
$d' = d - 5'' = 51''$

$M_T = 86^{k-1}$

LONGIT. REINF:

$A_{SL} = M_T(b' + d') \div (f_s b' d' 0.6)$

$= 12(86)(70) \div (20(19)51(.6)) = 6.2 \text{ IN}^2$

USE 14 #6 VERTS $(14(.44) = 6.16$ o.k.$)$

CLOSED TIES:

#6 $A_{SV} = 0.44 \text{ IN}^2$

$s = A_{SV}(2) f_s b' d'(.6) \div M_T = 9.9 \text{ IN}$

USE 9 #6 (2-PERP SET) IN TORS. SECT. ABOVE ABUT.

$h = 74''$ $s = h/9 = 8.2 < 9.9 \text{ IN}$

ACTUAL LENGTH OF TORS. SECTION

ABUT. $B = 4'-10'' = 58''$

ON SKEW: $B_{SKEW} = 80.16''$

SECT. WIDTH $b = 24''$

$d = 79.33 - 74(\tan \alpha) = 56.94$ (22.39)

$d' = 56.94 - 5.0 = 51.94 > 51''$ o.k.

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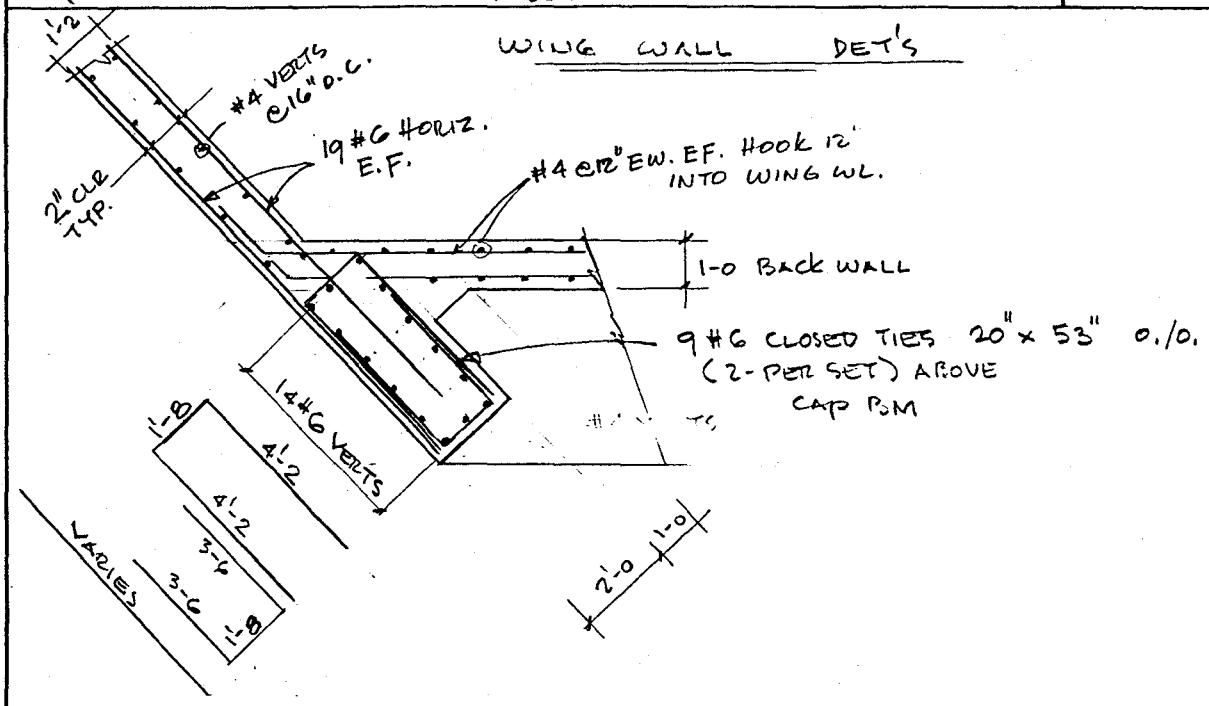
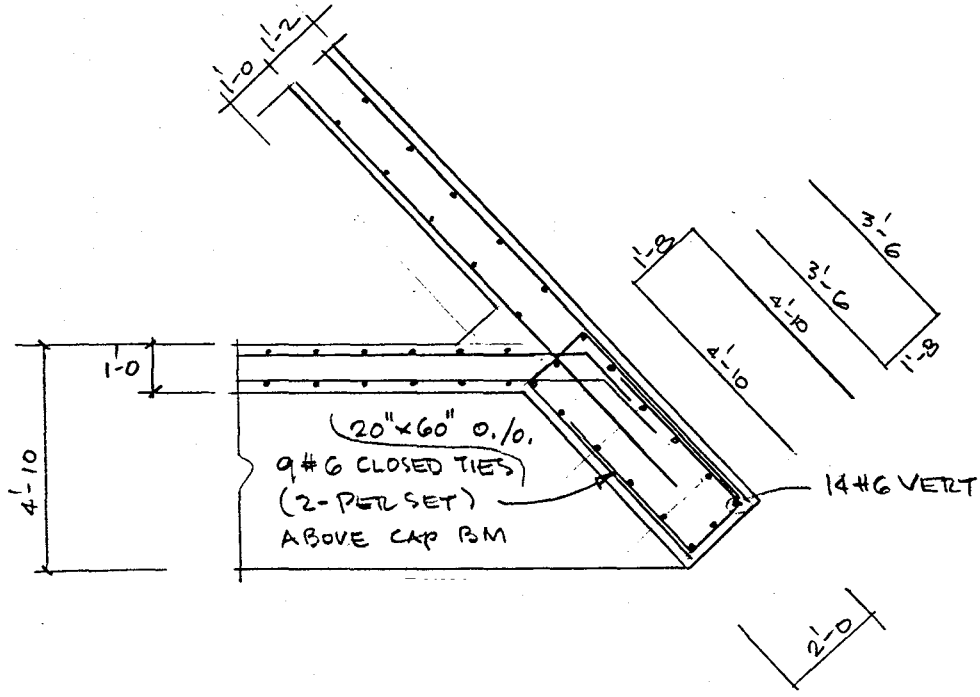
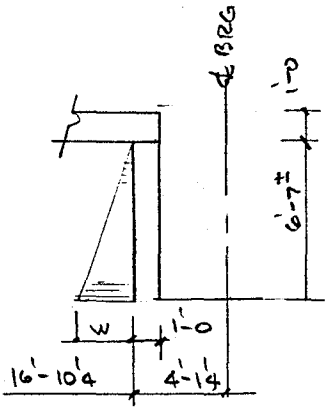
WING WALL DET'S





ABUT.



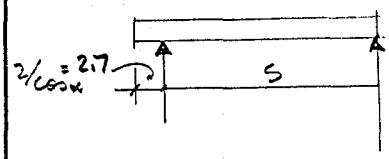
BACKWALL & APPROACH SL.

HT.: SL & BUILD-UP 8+1½ — 9½
GIRDER 72" + ELAST. 3½ — 75½
CONC. PAD. EST. — 6
h = 7'-7" = 91"

p_a = 30 PSF (SOILS REPORT); h_1 = 6.6 FT
$w = 6.6(p_a) = 198$ #
$F_H = w h_1/2 = 653$ #
$M = F_H(h_1)/3 = 1440$ '-#
$d = 12 - 2.5 = 9.5$ IN $a = 1.64$
$A_s = M/ad = .11$ IN²

USE 12" THICK BACKWALL w/
4 @ 12" E.W. E. FACE

APPROACH SLAB.



ΣL = 14.9 FT
$S = \Sigma L - 2.7 = 12.2$ FT
$E = 4.0 + .06S = 4.73$ FT
$P = \frac{16}{E}(1.3) = 4.4^k$ $w = .15$

$M_{DL} = .15(S)^2/8 = 2.8$
$PS/4 = 13.4$
$16.2^{k'}$

#8 @ 8" = 1.185
$np = \frac{9(1.264)}{12(9)} = .099$
$2/kj = 6.36$
$f_c = \frac{M(6.36)}{(9)^2} = 1272$ PSI ~1200

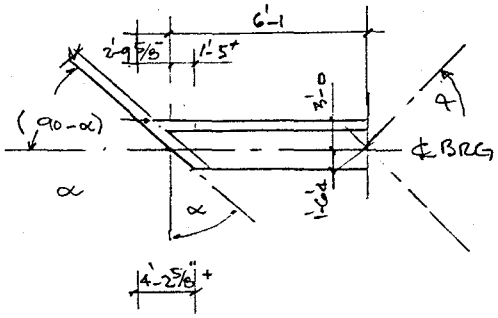
$d = 12 - 3 = 9"$ $a = 1.76$
$A_s = M/ad = 1.02$ IN² #8 BARS $S_{req'd} = 9.3$ IN

DIST. REINF: $\frac{100}{\sqrt{S}} = 28.6\%$
$A_s^{60} = .286(1.185) = .34$ IN²
$A_s^{40} = A_s^{60}\left(\frac{24}{20}\right) = .41$ IN²
#5 @ 9 (= .41 IN²)

USE #8 @ 8" BOTT. REINF ($A_s = 1.185 > A_s^{req'd}$)
w/ #5 @ 9" DIST. REINF.
& #4 @ 18" EW. TOP.
CONC. STRENGTH: f'_c = 3000 PSI
$f_{c\,all} = .4 f'_c = 1200$ PSI

ABUT

BM @ ABUT #1



LOAD ON CANTILEVER (RT) $\alpha = 43°-01'-4''$

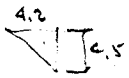
Cap BM: $\overset{B}{4.52}(\overset{HT}{4.0})\overset{W}{.15}$ 2.7 k/'

$L = (6'-1)-(1'-5) = 4'-8'' = 4.7$

WING WL. OVER CAP BM:

$\overset{L}{6.2}(\overset{HT}{8.63})(\overset{t}{\cancel{1.0}}\ 2.0)(.15)$ = ~~8.0~~ k 16.0

$L = 6'-1'' = 6.1$



BACK WALL:

$\overset{HT}{7.5}(\overset{TH}{1.1})(.15)$ = 1.1 k/'

$L = 6.1 + 1.0 = 7.0$ FT

WING WALL

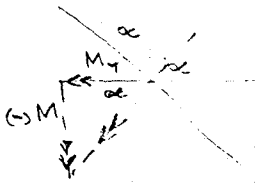
P SEE WING WALL ~~18.4~~ k 21.5

$L = 8.2$ FT $Y = 4.5/2 = 2.25$ FT

APPROCH SLAB

$4.5(.15)$ .7 k/'

WING WL.



APPLIED MOM'T @ BACK FROM VERT. LOAD

M_V = ~~96~~ k' 132 SEE RT ABUT #1

RESOLVE INTO COMPONENTS:

$M_T = M_V(\cos\alpha)$ = ~~70~~ k' 96 k'

$(-)M = M_V(\sin\alpha)$ = ~~65~~ k' 90 k'

TOTAL CANTIL. MOM:

(-) M = Cap BM: $2.7(4.7)^2/2$ = 29.8 } 64.4

" $\overset{L}{4.2}(\overset{B}{4.5})\overset{H}{4.0}(.15)\frac{1}{2}(4.7+1.4)$ = 34.6

WING WL: ~~8~~ 16.0 (6.1) + ~~18.4~~ 21.5 (8.2) = ~~199.7~~ 273.9

" (-) M = ~~65.0~~ 90.0

Back WL. $1.1(7)^2/2$ + App. Sl. = ∅ = 27.5 27.5

~~356.6~~ k' 455.8

TOTAL TORS. CANTIL. MOM.

M_T = Cap BM $2.7(\overset{e}{.25})$ = .68 k/'

" $4.2(4.5)\frac{1}{2}(.15)(4)(\overset{e}{1.0})$ ≅ 6.

WING WL. ~~18.4~~ 21.5 ~~46.5~~ 56 (2.5) + M_T = ~~70.0~~ 96 = ~~116~~ k' 150

" $8(.25)$ ≅ 2

Back WL. $1.1(2.0)$ = 2.2 k/'

ABUT

BM @ ABUT #1 CONT.

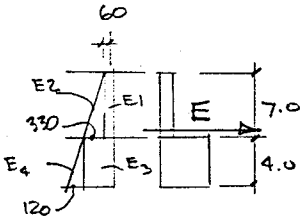
TOTAL CANTIL. SHEAR:

V = CAP BM 2.7 K/1

" " 5.7 K

WING WL: ~~8.0~~ 16.0 ~~18.4~~ 21.5 = ~~26.4~~ 37.5

BACK WL. 1.1 K/1



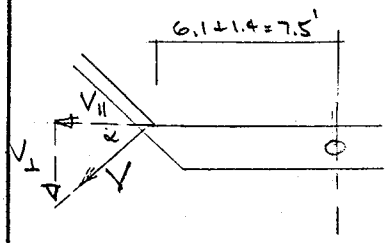
MOMENTS & REACTIONS FROM EARTH PRESSURE

$E_1 = 60(7) = 420^{\#}$ SURCH

$E_2 = 210(7)/2 = 735^{\#}$ @ 7/3 = 2.33

$E_3 = 270(4) = 1080^{\#}$

$E_4 = 120(4)_2 = 240$ @ 1.33'



RESOLVE WING WL. SHEAR INTO COMPONENTS:

$V = H = 18.6^K$ (w/ SURCH.)

$V_{\parallel} = V\cos\alpha = 13.6^K$ LONGIT. TENSION

$V_{\perp} = V\sin\alpha = 12.7^K$

$\Sigma M_y = (E_1 + E_2 + E_3 + E_4)(7.5)^2/2 = .70^{K'}$ (2.475)

$V_{\perp}(7.5 + 0.7) = 104$

$174^{K'}$

$M_T = E_1(3.5 + 2.0) = 2.31$

$E_2(2.33 + 2.0) = 3.18$

$-E_4(.67) = -.16$

$\Big\} 5.33^{K'}/_{FT}$

$\Sigma E = E_1 + E_2 + E_3 + E_4 = 2.475^K/1$

$V_{\perp}^E = 12.7^K$

LOCATE EP RESULTANT

$x_v = [.42(7.5) + .735(6.33) + 1.08(2.0) + .24(1.33)]/2.475 = 4.15$ FT

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BM @ ABUT #1 (CONT'D)

REINF. DESIGN: (RIGHT CANTIL.)

VERT MOM:

(-) $M_V = \cancel{356.6}^{456}$ k' $d = 48 - 4 = 44$ IN $a = 1.76$

(-) $A_{SV}^{60} = M/ad = 5.89$ IN^2

HORIZ. MOM'T

$M_H = 174$ k' $d = 54 - 4 = 50''$ $a = 1.76$

(-) $A_{SH}^{60} = 2.0$ IN^2

$A_{SH}^{40} = A_{SY}^{60}\ 24/20 = 2.37$ IN^2

VERT. SHEAR

(AT DIST. d FROM FACE OF COL.)

$x_v = \overset{1/2\,COL}{1.0} + \overset{3.6}{44}/12 = 4.6$ FT

V_v = CAP BM: $2.7(6.1 - 4.6)$ = 4.1 } 9.8

-"-"- $4.2(4.5)4.0\frac{1}{2}(.15)$ = 5.7

WING WL. $\overset{16.0}{\cancel{8.0}} + \overset{21.5}{\cancel{18.4}}$ = ~~26.4~~ 37.5

BACK WL $1.1(7.0 - 4.6)$ = 2.6 2.6

~~38.8~~ k 49.9 k

$b = 54$ $d_v = 44$

$v_v = V/bd = \overset{21}{\cancel{16}}$ PSI o.k.

HORIZ. SHEAR

V_H = EARTH PR.: $4.28(\overset{2.9}{7.5} - 4.6)$ = 12.4

" $V_\perp$ 12.7

$\Sigma V_H = 25.1$ k

$b = 48$ $d = 50$

$v_H = \Sigma V_H / bd = 10$ PSI

TORSIONAL MOMENT: @ ℄ COL.

$M_T = .68(\overset{3.2}{4.7}) + 6.0$ = 9.2

WING WL. 150 + 2 152.0

BACK WL. 2.2(7.0) = 15.4

176.6 k'

E.PR. 5.33(7.5) = 40.0

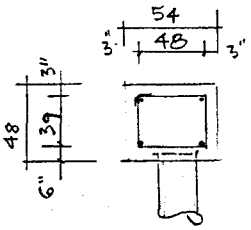
136.6

BM @ ABUT #1 (RIGHT CANTIL.)

REINF. CONT'D

TORS. STRESS IN CAP BM:

$r = 54/48 = 1.13$ $\quad \gamma_T = .21$ $\quad M_T = \cancel{142.6}\ 176.6^{k'}$ (w/o E.PR) ~ 143



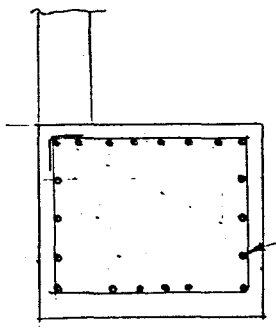
$$V_T = \frac{M_T(12)}{\gamma_T (48)^2 54} = 81 \text{ psi}$$

$$A_s^T = \frac{\overset{M^T}{177}(12)(39+48)}{\underset{f_s}{24}(39)48(.6)} = 6.85 \text{ IN}^2$$

$$A_s^{\square} = a M_T / 2 f_s b' d'$$

#4 □ $a = 0.2(2)20(39)48 / 12(143) = 7''$

#5 □ $a = 10.9$ IN



7 #9 $A_s^T = 7.0 \text{ IN}^2 > 6.85$

2 #9 $A_{sH} = 2.0 \text{ IN}^2 = A_{s\,req'd}$ (SYM.)

6 #9 $A_{sV} = 6.0 \text{ IN}^2 > 5.89$

$\Sigma A_s = 20\#9 = 20.0 \text{ IN}^2$

LEFT CANTIL.

VERT MOM'T:

$(-) M_V = \overset{456}{\text{RT. CANTIL}} - \overset{180}{2(90)} = 276^{k'}$ o.k.

HORIZ. MOMENT

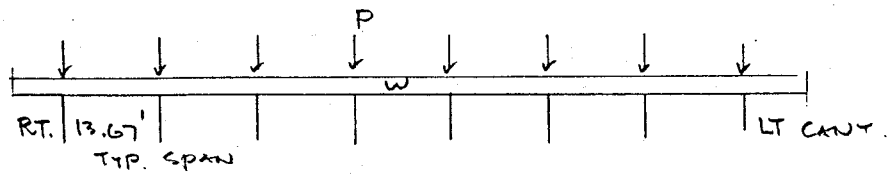
$(-) M_H = 70 - \overset{V_\perp}{104} = -34^{k'}$ o.k.

SHEAR & TORS. MOM SAME AS RT. CANTIL.

USE SAME REINF

ABUT

BM @ ABUT #1



$w_1^{AVE} = 4.5(4.5)(.15) = 3.04^{k}/_{1}$

w_2 = BACK WL: $6.75(.15) = 1.01''$

App. SL. $(4.5+1.0)(.15) = .83$

$\Sigma w_2 = 1.84^{k}/_{1}$

(−) $M = (w_1+w_2)L^2/10 = 91.0^{k'}$ $-d = 44$

(+) $M = (w_1+w_2)L^2/11 = 83^{k'}$ $+d = 38$ $a = 1.76$

(+) $A_s = M/ad = 1.24\ in^2$ $b = 54$

(−) $A_s = -''- = 1.18$

$A_{s\,min} = .0033bd = 6.84\ in^2$ OK

T. & B. 1/3 MORE THAN REQ'D BY DESIGN:

$A_{s\,min} = 1.24(4/3) = 1.65\ in^2$

MOV. LIVE LOAD:

$P_L = 16(1.82) = 29.1^{k}$ $I = 1.3$ $P_{L+I} = 37.9$

$M^P_{L+I} = PL/5 = 104^{k'}$

(+) $\Sigma M = 83 + 104 = 187^{k'}$ $+A_s = 2.8\ in^2$ (3#9 = 3.0)

(−) $\Sigma M = 91 + 104 = 195^{k'}$ $(-)A_s = 2.5\ in^2$ (3#9 = 3.0)

TORSION:

$m_T = w_2(2.0) = 3.68^{k}/_{1}$

$w_1(.25) = .76$

$4.44^{k}/_{1}$

LOCATION OF C.G.

$(w_1(2.25) + w_2(.5))/\Sigma w = 1.59$ FT FROM ℄

& .91 FT FROM CTR. PIERS

@ DIST. d: $x \cong 4.0$

$M_T = (6.85 - x)(m_T) + 37.9(2.0)\frac{(13.67-4)}{13.67} = 67^{k'}$

E. PRESSURE: $(6.85 - x)\,5.33$ -15

NET = $52^{k'}$

ABUT

BM @ ABUT #1 (CONT'D)

TORSION CONT'D:

$M_T = 67^{k'}$ FOR DESIGN (CONSERVATIVE)

$A_s^T = \dfrac{67(12)(87)}{24(39)48(.6)} = 2.6 \text{ IN}^2$

#4□ $s = 0.2(2)20(39)48/12(67) = 18.6$ IN

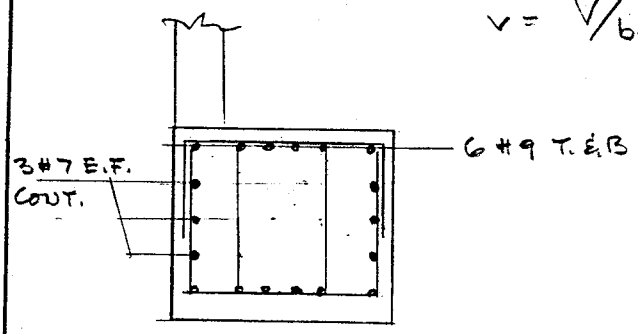
SHEAR:

$V = 2.85(\omega_1 + \omega_2) \cong 13.9^k$ $b = 56$ $d = 38$

$P_{L+I}(9.67)/13.67 = 26.8$

40.7

$v = V/bd = 19$ PSI o.k.



HORIZ. BENDING:

$\omega_H = 2.5$ EP

$M = \omega_H (L)^2/10 = 47^{k'}$ $d = 50''$

$A_s = M/ad = .53 \text{ IN}^2$

A_s^T : 4#9 = 4.0 IN²

A_s^H : 3#7 1.8 " ×2 (SYM)

A_{sV} : 4#9 4.0 ×2 (T.&B.)

$\Sigma A_s = 12\#9 = 12.0 \text{ IN}^2$

$6\#7 = 3.6$

15.6 IN^2

REACTIONS TO CAISSONS

INTER:

P: VERT $(\omega_1 + \omega_2)L$ = 66.7^k

GIRDER DL 161.0^k

$P_{DL} = 228.^k$

LL+I = 62(1.3) 81.0

$309.^k$

F_H: E.PR.: $4.28(L)(\cos\alpha)$ = 58.5^k

M: BM & APP. SL. 4.44(L) = $61^{k'}$

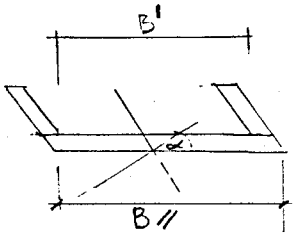
WHEEL LOAD P_{L+I} = 54 } 115

DL GIRDER 161(.5) = 81

E.PR: $[15.1(L) + 4.28(2.0)(L)]$ = 323

(+) $A_{sm} = .0033(58)38 = 7.3 \text{ IN}^2$

ABUT



REACTIONS TO CAISSONS (CONT'D)
(EARTH PR. AS A UNIT)

$B\perp = 82'-2$ $\alpha = 43'-01'-04''$

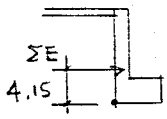
$B// = B\perp / \cos\alpha = 112.4$ FT

$B' = B// - 2(1.0)/\cos\alpha = 109.7$ FT

ASSUME EP. TO WING WALLS CANCELS

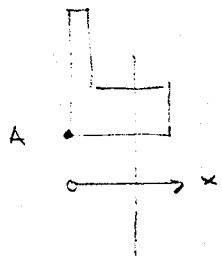
$\Sigma E = B'(2.5) = 274^k / 8 = 34$ / PILE

$M_E^{OT} = 274(4.15) = 1137/8 = 142^{k'}$ / PILE



TOTAL VERT. LOAD:

		d	→ Pd
CAP. BM & BACK WL. @ 4.88 k/'			
$\Sigma P = 4.88(B//)$	599	1.59	873 ?
WING WL. OVER C.BM 2(8)	16	2.25	36 } 909
" WLS: 2(18.6	37	(→)3.8	−141
	602		768



$x = 768/602 = 1.28$ FT

GIRDER DL. REACTIONS:

$\Sigma P = 2(168^{EXT}) + 6(161^{INT}) = 1302^k$ (3) 3906

$x = 3.0$ FT

TOTAL RESULTANT

	V	x	Vx
CAP BM etc.	602	1.28	768 ?
GIRDERS	1302	3.00	3906 ?
E.P.	—	—	1137
	1904		5811

$x^{DL} = \frac{4674}{1904} = 2.45''$

$x^{DL+EP} = 5811/1904 = 3.05$ FT

LOCATE PIERS @ $x \cong 3.0$ FT ±

VERT LOAD PER PIER (N=8)

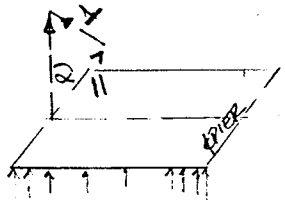
$P = 1904/8 = 238^k$

ADD 10% 24

262^k FOR DESIGN

$EP = 274/8 \cong 34^k$ / PIER

ABUT



EQ.:

W_{DL} = ΣP GIRDERS @ ABUT. 1302^k

EQ = .09(W) = 117.2^k

COMPONENTS:

$EQ_{\perp}$ = 117.2 (sin α) = 80^k

$EQ_{\parallel}$ = -"- (cos α) = 86^k

WIND:

W = 30.6^k $W^{\perp}$ = 21^k $W^{\parallel}$ = 24^k

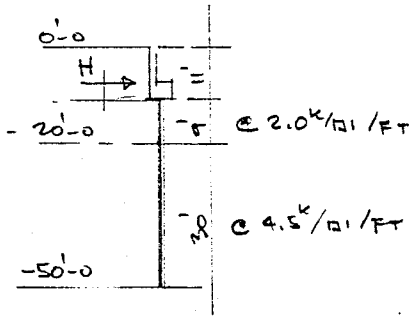
WL = 6.1^k $WL^{\perp}$ = 4.2 $W^{L}_{\parallel}$ = 4.5^k

TRY 2'-6" ϕ DRILLED PIERS

PER S. REPORT PG. 6:

DEPTH 0-50

P_{AH} = 147 (2.5) = 368^k / PIER



LAT RESIST. PG 7 OF SOILS REP.

D = 3.0 FT

F_{AH} = 2.0 (9)²/2 (D)
4.5 (30)²/2 (D) } NOT CRITICAL

CHECK PIER:

n = .024^k/IN³ E = 3.1 (10)³ ksi

I = 82448 = π 36⁴/64

T = $5\sqrt{\frac{EI}{n}}$ = 101 IN /12 = 8.45 FT

RIGID PILE

L_{MAX} = 2(T) = 16.9 FT < 39 FT

∴ FLEXIBLE PILE

REF.:

REESE & MATLOCK GRAPHS

"FORCES & DISPLACEMENTS OF LATERALLY LOADED PILES".

PCA

RESIST TO E-PRESSURE (FREE-HEADED PILE)

H = 34^k/ PILE L/T = 5.3 > 4.0

y_{Δ} = 2.3 y_m = 178 y_v = 1.0 @ SURFACE

M_{PILE} = HT (y_m) = 224 KFT (EP)

$\Delta_c = y_{\Delta}(H)T^3/EI$ = .32 IN O.K

ABUT

RESIST. TO EQ. LOAD

$\Sigma H =$ EQ. 11

ABUT. $.09(602) =$ 86 + 54 = 140^k N=8 PILES

$H = \Sigma H / N = 18^k$ FIXED HEAD

$\gamma_m = -.9$ @ Top (FIX'D PILE)

$M = \gamma_m H(T) = 137^{k'}$

APPLIED E-P. MOMENT $M = 142^{k'}$

LOC.:

0.0 $M_x = 142 + 0 = 142^{k'}$ EP. $M_y = 137^{k'}$ EQ.

@ .5 $M_x = .46(34)8.45 + .98(142) = 271^{k'}$ EP. (132, 139)

$M_y = .68(18)\,8.45 = 103^{k'}$ EQ.

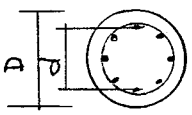
@ 1.0 $M_x = .73(287.3) + .85(142) = 331^{k'}$ EP (210, 121)

$M_y = .06(152) = 9^{k'}$ EQ.

@ 1.5 $M_x = .77(287.3) + .65(142) = 313^{k'}$ EP (221, 92)

$M_y = .18(152)$ $27^{k'}$ EQ.

PIER REINF. (FACTORED LOADS)



GROUP I

$P_{DL} = 238^k$ MIN. 262 MAX $P_{LL} = 61$ MIN 68 MAX

$V = 34^k$ E. PR. $V = 18^k$ EQ.

$M_{EP} = 181 + 122 = 303^{k'}$

$M_{EQ} = 96^{k'}$

(a) DL + LL + E GROUP I

$P_U = 1.3(262 + 1.67(68) + 0 E +) = 488^k$ (DL)

$M_U = 1.3(1.3)331 = 560^{k'}$

$e = 13.8''$

(b) DL + EP + EQ GROUP VII

$P_U = 1.3(.75(238) + 0 + 0) = 232^k$

M_U @ .5:

$M_x = 1.3^2(271) = 458$ $M_y = 1.3(103) =$ 134

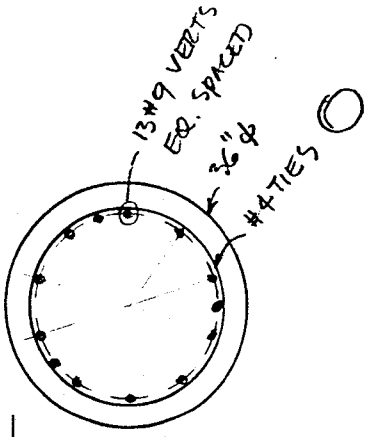
$M_U = \sqrt{M_x^2 + M_y^2} = 477$ $e = 24.7$ IN

M_U @ 1.0:

$M_x = (1.3)^2(331) = 560$ $M_y = 1.3(9)$ 12

$M_U = \sqrt{M_x^2 + M_y^2} = 560$ $e = 29$ IN ⟸

ABUT



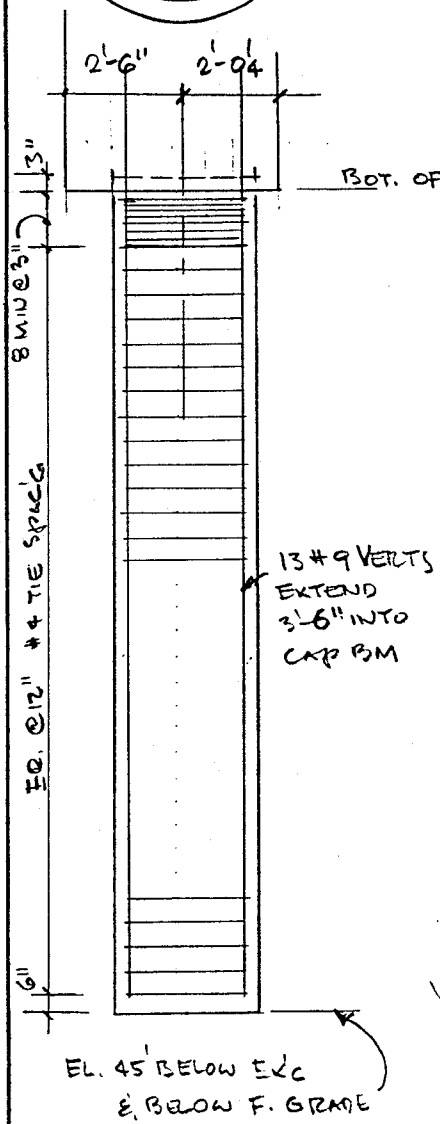
PIER REINF (CONT'D)

(REF. ACI JOURNAL NOV. 1956)

~~D = 30" A_g = 707 IN²~~
~~d = 22"~~
~~14 #10 = 17.78 (2.5%)~~
~~s = 4.9"~~
~~e = 29" $p_t m$ = .592 f'_c = 3.0~~
~~P_{all} = 266^k > 232~~
~~12 #10 = 15.24 (2.16%)~~
~~e = 29" P_{all} = 232^k~~

D = 36" A_g = 1018
d = 28'
10#10 = 12.7 IN² (1.25%)
e = 29 $p_t m$ = .294
P_{all} = 288^k > 232^k

e = 14"
P_{all} = 823^k > 188
USE 13#9 A_s = 13.0 IN²



SHEAR:

V_{EP} = 34^k V_{EQ} = 18^k

(a) GROUP I: $V_u = 1.3(1.3)34 = 58^k$

(b) " VII: $V_u = [58^2 + (1.3(18))^2]^{\frac{1}{2}} = 63^k$ ⟸ GOV.

$v_c = 2\sqrt{f'_c} = 110$ PSI SEC. 1.5.35

$b_w = D = 36$

$d = .318(d) + \frac{1}{2}D = 23.9$ IN $\phi = .85$ (8.9, 15)

$V_c = v_c b_w d \phi = 80^k$

TIES #4 @ 12" $f_y = 40$ $A_s = 2(0.2) = 0.4$ IN²

$V_s = \frac{.4(40)d}{s}\phi = 32.0^k$

$V_c + V_s = 112^k > 63$ o.k.

VERT. LOAD CAPACITY

45 FT BELOW EXC GRADE & BELOW F. GRADE

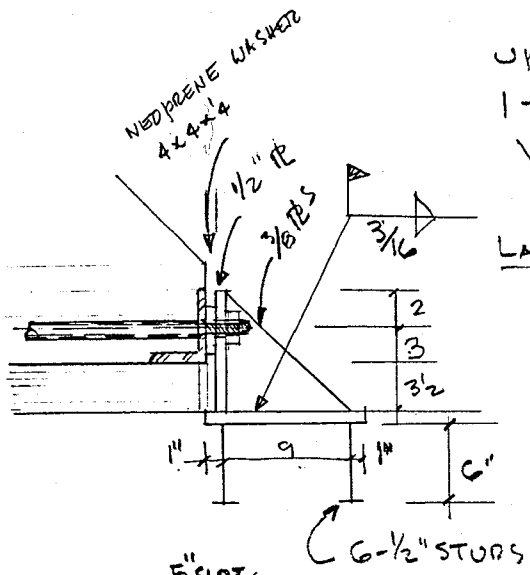
$P_{all} = 3(116.5) = 349^k > 262^k$

ABUT.

GIRER CONX. TO ABUT.

UPLIFT 42^k SEE SHT

EQ. = 117 / 8 = 15^k (HORIZ.) SHT.



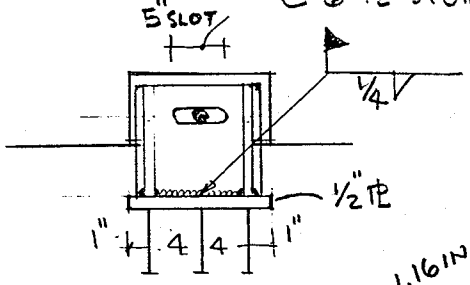
UPLIFT

1-1"Φ A325 N OR X

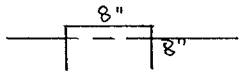
$V_{AU} = 2(16.5)(1.33) = 43.9^k > 42$

LATERAL EQ = 15^k

DESIGN FORCE $F = EQ/1.33 = 11.3^k$



PROPERTIES OF SEC.



A	d	A d	A d²	I₀
8.0	0	0		0
8.0	4.0	32	128 } 256	42.66
8.0	4.0	32	128	42.66
24		64	- 170.67	85.33
				170.66

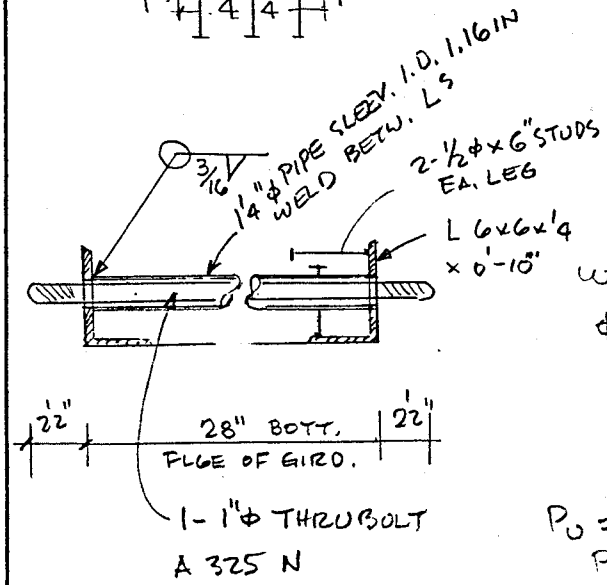
$c_T = 2.67$

$c_B = 5.33$

$M = F(6")$

$f = Mc/I$ = TOP $1.06^k/8 = 133^{\#}/_1$
$2.12/2 = 1.06^k$

$V = F/2(8) = .706^k/IN$



WELD PL W/ SHEAR STUDS: (PCI HANDBOOK)

$\phi P_c = 82^k$ TBLE 5.20.11 Y=0 x=8 $l_c = 6"$

$b = 11"$ $f'_c = 3000$

$a = \phi P_c \div (.85(11)3) = 2.92$ IN

$jd = 10 - \frac{1}{2}a = 8.54$ IN

$P_u = T = M_u/jd = 1.7(15)^{EQ}(6)/8.54 = 17.9^k$

$P_u/\phi P_c = 17.9/82 = .22$

$\phi V_c = 6(9.0)\sqrt{3/4} = 46.8^k$

$V_u/\phi V_c = 1.7(15)/\phi V_c = .545$

ABUT.

GIRDER CONX CONT'D

COMBINED CAPACITY:

$(P_u/\phi P_c)^{4/3} + (V_u/\phi V_c)^{4/3} = .133 + .445 = .58 < 1.0$

$\phi P_s = 3(10.6) = 31.8$

$C = T = .85(3.0)\,11\,a = 31.8^k$

$a = 1.13$ IN $\qquad jd = 10 - .56 = 9.44$

$P_u = M_u/jd = 1.7(15)6/9.44 = 16.2^k \qquad P_u/\phi P_s = .51$

$\phi V_s = 6(8.8) = 52.8^k \qquad V_u/\phi V_s = 1.7(15)/52.8 = .48$

COMBINED CAPACITY

O.K SEE FIG. 5.20.16.

Registered Professional Engineer (Structural)
CERTIFICATE NO. 6887
ALBERT A. GRIMM
Date Signed 1-10-83
ARIZONA, U.S.A.

BENSON & GERDIN, INC.

CONSULTING ENGINEERS

3150 NORTH SEVENTH STREET PHOENIX, ARIZONA 85014 PHONE (602) 264-0136

ROGER D. BENSON, P.E.

FLOOD CONTROL DISTRICT
RECEIVED
FEB 28 '84

February 27, 1984

	CH ENG		HYDRO
	ASST		I Mgt
	ADMIN		SUPP
3	C & MP	6	FN FCD83-20
4	FMPA		DESTROY
	FINANCE	1	WCA

2 EOK
5 ER

Maricopa County Flood Control District
3335 West Durango Street
Phoenix, AZ 85009

Attention: Mr. Warren Anderson
Chief Construction Inspector

Reference: FCD No. 83-20
59th Avenue Bridge over the Arizona Canal Diversion Channel
Precast Deck Slabs

Gentlemen:

We have received a submittal through Artcraft Construction, from their supplier Stanley Structures, concerning the rejected deck slabs.

As you are aware, on Thursday morning February 16, two truck loads of deck panels were delivered to the jobsite for erection. We noticed that there appeared to be excessive deflection in many of the panels and upon closer inspection we found that the 3/8 inch prestressing strands were 3/8 inch or more above the centerline of the slab. The specifications require the strands to be in the center of the slab with a tolerance of ±1/8 inch. We rejected all of the slabs except five.

Our review of the slabs, at that time, indicated that the slabs could not be used in the deck as originally intended without overstressing the bottom of the slab in tension.

After several discussions with the contractor and his supplier, a proposal was presented to us, on Friday, February 24. The proposal was as follows:

1. After the slabs were erected, shoring would be placed along the centerline of the slab, parallel to the girder centerline;

2. The maximum strand eccentricity allowed would be 3/8 inch above the centerline of the slab.

The intention of this proposal would be to allow the deck concrete to support its own weight in composite action rather than the slab supporting the weight as a simple beam.

We have reviewed the proposal based upon our original design. Our findings indicate that although the slabs will be stressed to a higher value than the original design allowed the stresses will be within acceptable limits.

We therefore feel that we can accept the proposal with the following stipulations;

1. That the bottom of the strand be no more than 1-11/16" from the bottom of the deck slab

2. That the slabs be used only in locations where 3 or more slabs are adjacent, i.e. avoiding the corners of the skewed bridge at the abutments

3. That the deflection of the panel under its own weight not exceed 1/4"

4. That all panels that have visible cracks on the bottom surface be rejected.

5. The slab shall be supported at its centerline for the full longitudinal distance and the shoring should be designed to limit construction deflection to 0.10 of an inch.

6. Shoring design shall include calculations sealed by a registered engineer and be submitted for approval prior to installation.

We have enclosed a copy of Stanley Structures calculations as well as our own for your review. Stanley Structures will not proceed until approval has been received from your office. We might point out that final erection will require the recasting of approximately 10 to 15 percent of the panels.

The cost of our review of this proposal as well as preliminary review and meetings is $1,271.00.

BENSON & GERDIN

CONSULTING ENGINEERS

As soon as we hear from you, we will notify Artcraft to proceed.

Yours very truly,

BENSON & GERDIN, INC.
CONSULTING ENGINEERS

Michael E. Kennelly

Michael E. Kennelly, P.E.

MEK:lr
Encl.
cc: Artcraft Construction Co.
Albert Grimm

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136	SHT. NO. 1 OF
59TH AVENUE BRIDGE	JOB NO. 21820
	BY MEK DATE 2-24-84
	CHKD. TI DATE 2-27-84
Precast Deck Panel Analysis	REV.

Problem: $\frac{3}{8}$" strands eccentric to Top of Panel
Specs require ℄ Panel ± $\frac{1}{8}$"

Contractor proposal:
1. Use Panels with ecc. to $\frac{3}{8}$"
2. Shore ℄ Panels until deck reaches strength and then remove shoring

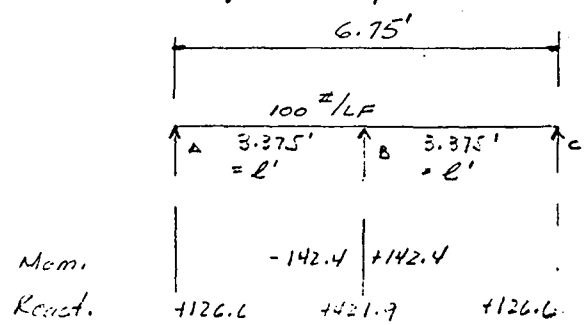
Ref. Original Calcs pgs 213 to 216
AASHTO Section 1.6

Design: Deck and Panel Conc. $f'_c = 4500$ $f_c = 1400$
Tension $6\sqrt{f'_c}$ = 400 psi
Mod. of Rupture $7.5\sqrt{f'_c}$ = 500 psi

Review: Deck Conc. $f'_c = 4500$ $f_c = 1400$ } Per Albert Grimm Benson & Gerdin
Panel Conc. $f'_c = 5000$
actual Panel $f'_c = 7000$ (mean of 50 test less 1 standard deviation)
Min. - f'_c:
P strands = 29.68^K A_{sp} = .204"^{2}

Loads: Deck 5" = 62.5#/□' D.L. 1 D.L. Mom. 750'# (pg 7 calcs)
Panel 3" = 37.5#/□' D.L. 2 M_{DL2} = 241'#
Const. LL = 20#/□'
LL + I 4420'# (3 adjacent spans or more)
5525'# (Less than 3 adjacent spans)

Non-comp. Panel: A = 36□"
I = 27"^{4}
$c_t = c_b$ = 1.5"



Pos. Mom @ .375ℓ'

$126.6 \times 1.266 - \frac{100 \times 1.266^2}{2} = 80.1'\#$

R_B DL-1 = .625 × 4219 = 263.6
R_B Const LL = .20 × 4219 = 85.4

Properties of Composite Section:

$A = 36''^2$ $I = 512''^4$

Deck $f'_c = 4500$ $n = 7$
Panel $f'_c = 5000$ $n = 7$
① Top of Deck $C_1 = 4''$
② Top of Panel $C_2 = -1''$
③ Bottom of Panel $C_3 = -4''$

1. Construction Load:

@ Support B:

		f_t ②	f_b ③
P/A	29680/36	-824	-824
Pec/I	(29680×.375×1.5)/27	-618	+618
DL-2	(.241×12×1.5)/27	-161	+161
DL-1	(.625×142.4×12×1.5)/27	+59	-59
Constr. LL.	(.2×142.4×12×1.5)/27	+19	-19
⟹		-1525	-123

$.4f'_c = .4 \times 5000 = 2000$ OK
orig. des. 1400 psi = 8.9% over

@ .375ℓ'

P/A		-824	-824
Pec/I		-618	+618
DL-2	(158×12×1.5)/27	-105	+105
DL-1	(.625×80.1×12×1.5)/27	-33	+33
Constr. LL	(.2×80.1×12×1.5)/27	-11	+11
⟹		-1591	-57

@ $.4f'_c = 2000$ psi OK
@ 1400 psi 13.6% over

2. Service Load
@ ℄ Panel R_B - rc applied in downward direction

3 or More Spans	f_t @	f_b @
Previous stress less constr. Load.	-1544	-104
R_B $\left(\frac{263.6 \times 6.75 \times 12}{4}\right) \times c/512$	+10	+42
LL+I $(4420 \times 12) \times c/512$	+104	+414
⟹	-1430	+352
		< 424

c 2000 psi OK
s 1400 psi 2.1% over
$c\sqrt{5000} = 424$ psi
$1.5\sqrt{5000} = 530$ psi

$\frac{530}{352} = 1.5$ OK

Less than 3 Spans	f_t @	f_b @
Previous stress less Constr. Load.	-1544	-104
R_B $\left(\frac{263.6 \times 6.75 \times 12}{4}\right) \times c/512$	+10	+42
LL+I $(5525 \times 12)\ c/512$	+130	+518
	-1404	+456
	OK	> 424

Restrict use of Panel to 3 or more adjacent spans:

Check for expected Panel Deflection at time of Erection (avg age 4 mos.

$F_o = 35.4^k$ $F_c = 29.68^k$ $E_{ci} = 3156$ ksi $\Delta F = 5.72$

$(\Delta_i)_{DL}$ ① DL defl. 3" slab $w = 37.5^{\#}/ft^2$ $= \dfrac{5 \times \frac{.0375}{12} \times \overline{84}^4}{384 \times 3156 \times 27} = .024''$

$M = 241^{k'}$

$(\Delta_i)_{F_o}$ ② $= \dfrac{35.4 \times .375 \times \overline{84}^2}{8 \times 3156 \times 27} = .137''$

$K(\Delta_i)_{F_o}$ ③ F_o creep $\left[-\overset{-.162}{\dfrac{5720}{35400}} + \left(1 - \overset{.919}{\dfrac{5720}{2 \times 35400}}\right) \times 1.0 \times 1.5 \right] \times .137'' = .166''$

$K(\Delta_i)_{DL}$ ④ DL creep. $1.0 \times 1.5 \times .024''$ $= .036''$

$.166'' + .036'' = 0.363''$

$\cong \frac{3}{8}''$

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0138	SHT. NO. 1 OF
59TH AVENUE BRIDGE	JOB NO. 21920
PRELIMINARY REVIEW	BY MEL DATE 2-16-84
Precast Deck Panels Analysis	CHKD. DATE
	REV.

check Panels for 3/8" + strand ecc.

3" Panel DL 37.5#/ft² P = 29680#
5" Deck DL 62.5#/ft²
Constr. LL 20#/ft²
LL+I 44.0'K (3 spans or more) 55.25'K less than 3 spans

L panel 36" I panel 27"⁴ I comp. = 512"⁴

CONSTRUCTION LOADING:		Slab f_t	f_b
①	P/A 29680/27	-824	-824
②	Fec/I : (29680 × .375 × 1.5)/27	-618	+618
③	DL (panel + deck) $\left(\frac{100 \times 6.75^2}{8}\right) \times \frac{12 \times 1.5}{27}$	-380	+380
	constr LL $\left(\frac{20 \times 6.75^2}{8}\right) \times \frac{12 \times 1.5}{27}$	-76	+76
⟹		-1898	+250

deck $f'_c = 4500$ $f_c = \underline{\underline{1400}}$
$.4 f'_c = 1800$

(35.5% over design stress
54% over min allow.

Service Load (3 or more adj.)		f_t	f_b
Items ①, ② & ③		-1822	+174
LL+I	4420 × 12 × 9/512		
	$c_t = -1"$ $c_b = -4"$	+104	+414
		-1718	+588

design $f_c = 1400$ 22.7% over
max $f_c = 1800$ OK

Tension $6\sqrt{f'_c} = 400$?
modulus rupture $7.5\sqrt{f'_c} = 500$

excessive Tension. not acceptable

Stanley Structures
A Subsidiary of The Stanley Works

Job Title 59th Avenue Bridge Planks By A. A. Date 2/24/84 Job No. 15133
Subject SECTION PROPERTIES Checked By _____ Date _____ Sheet 1 Of _____

RECEIVED
FEB 2 1984
BENSON AND GERDIN
Consulting Engineers

SECTION FRI 24 FEB 84 10:37

59TH AVENUE BRIDGE PLANKS; 3 IN. P/C + 5 IN. CIP

HNC = 3.000 HC = 8.000 (TPG E)/(PREC E) = 0.775

$\sqrt{3000/5000}$

"TRAPEZOID" ELEMENTS

V1	V2	B-BOT	B-TOP	UNITS	TYPE
0.000	3.000	12.000	12.000	1	PRECAST
3.000	8.000	12.000	12.000	1	TOPPING

Dist. to Bottom

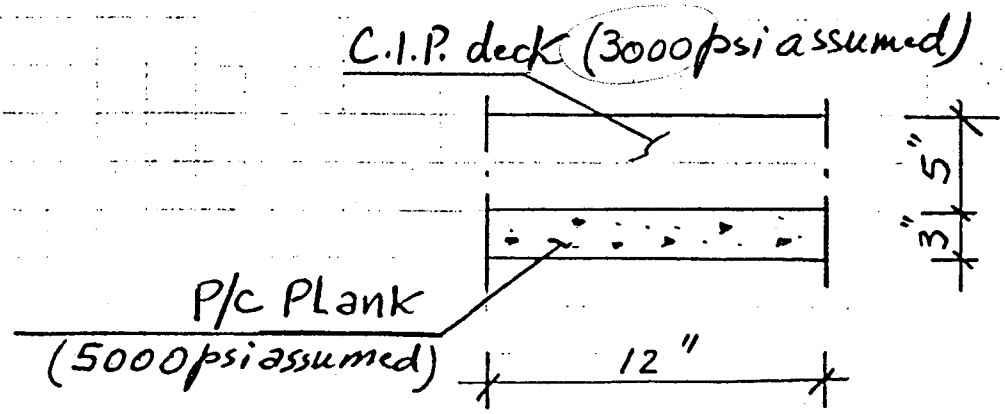
PRECAST SECTION PROPERTIES

A, in^2	I, in^4	YB	YT	SB, in^3	ST
36.000	27.000	1.500	1.500	18.000	18.000

COMPOSITE SECTION PROPERTIES

AC	IC	YBC	YTC	SBC	STC
82.500	448.530	3.755	-0.755	119.463	-594.437

Plans calls for 4500 psi



A) PLANK DEAD LOAD : $w_D = 3 \times 0.0125 = 0.0375$ KLF

$$M_D = (0.0375 \times 7^2/8)12 = 2.76 \text{"K/ft}$$

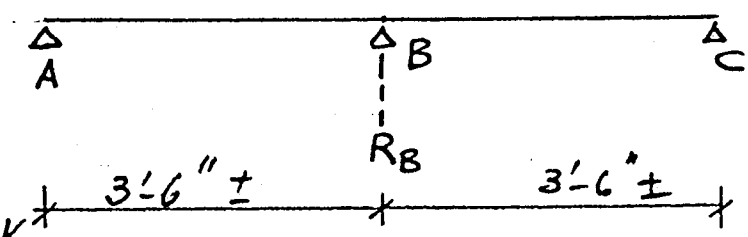
5" [illegible]

B) C.I.P. SLAB : assume $5\frac{1}{2}$" slab = 0.069 KLF

For full span $M_{CIP} = (0.069 \times 7^2/8)12 = 5.07$ "K/ft

C) CONSTRUCTION LOAD : assume 20 psf = 0.020 KLF

D) EFFECT OF SHORING :



$R_{B_1} = 1.25 \times 3.5' \times .069 = 0.302^K$

$R_{B2} = 1.25 \times 3.5 \times .020 = 0.088^K$

0.390^K

$M_B^- = (0.069 \times 3.5^2/8)12 + (0.020 \times 3.5^2/8)12 = 1.27\text{"K} + 0.37\text{"K}$

$= 1.64$ "K/ft

REMOVING SHORE, REAPPLY FORCE R_B DOWNWARD:

$M_{B_1}^+ = PL/4 = (0.302^K \times 7'/4)12 + (0.088 \times 7'/4)12$

$= 6.34\text{"K} + 1.85\text{"K}$

$= 8.19$ "K/ft

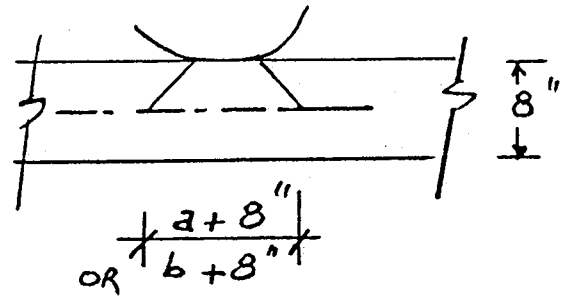
USE "PUCHER" CHART #1 AS PER AASHTO 1.3.2(C), 1.3.8 AND COMMENTARY 1.3.2 OF INTERIM 1981,

TIRE CONTACT AREA: 8" x 20"

ADD 8" TO SLAB CENTROID,

THEN DISTRIBUTION AREA IS:

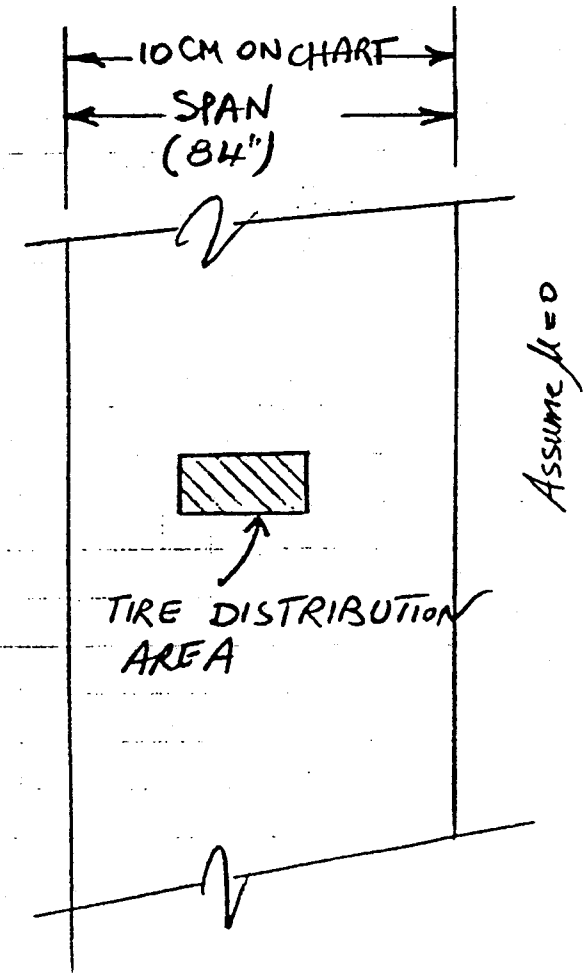
$(8+8)(20+8) = 16'' \times 28''$.



WHEN SCALED TO SLAB SPAN ON CHART 1, ATTACHED, THIS AREA BECOMES EQUAL TO:

$\frac{28''}{84''} \times 10\text{ cm} = 3.3\text{ cm}$

$\frac{16''}{84''} \times 10\text{ cm} = 1.9\text{ cm}$



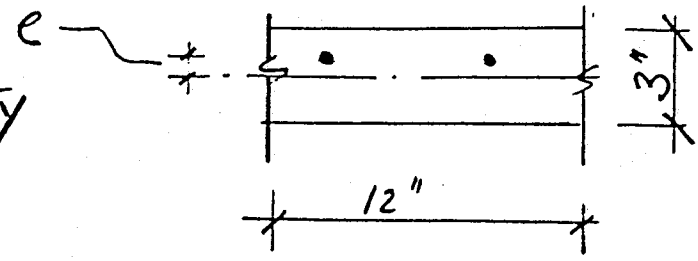
Average reading on chart: 4.8

$M_{LL} = \left(\frac{4.8}{8\pi}\right) 16^K \times 1.30 \times 12 \times 0.8 = 38.1''k/ft$

impact

reduction for continuity as per AASHTO

EFFECT OF PRESTRESS



ASSUME AN AVERAGE ECCENTRICITY
$e = 3/8"$; STRANDS: $3/8" \phi$

$P_{final} = 2.426 \text{ strands} \times 16.1^K \times 0.80$

$= 31.2 \text{ Kips}$

$f_{o,top} = 31.2\left(\frac{1}{36} + \frac{0.375}{18}\right) = 1.517 \text{ ksi}, C$

$f_{o,bot} = 31.2\left(\frac{1}{36} - \frac{0.375}{18}\right) = 0.217 \text{ ksi}, C$

D.L. PLANK : $f_{1,top} = 2.76/18 = 0.153 \text{ ksi}, C$

$f_{1,bot} = 2.76/18 = 0.153 \text{ ksi}, T$

C.I.P SLAB : $f_{2,top} = 1.27/18 = 0.070 \text{ ksi}, T$

$f_{2,bot} = 1.27/18 = 0.070 \text{ ksi}, C$

CONSTRUCTION LOAD

$f_{3,top} = 0.37/18 = 0.021 \text{ ksi}, T$

$f_{3,bot} = 0.37/18 = 0.021 \text{ ksi}, C$

SHORE REMOVAL (ON COMPOSITE SECTION)

$f_{4,top} = 6.34^{"k}/594.4 = 0.010 \text{ ksi}, T$

$f_{4,bot} = 6.34/119.5 = 0.053 \text{ ksi}, T$

$f_{5,top} = 1.85/594.4 = 0.003 \text{ ksi}, T$

$f_{5,bot} = 1.85/119.5 = 0.016 \text{ ksi}, T$

I) DURING CONSTRUCTION

a) Before shore removal:

$f_{top} = 1.517 + 0.153 - 0.070 - 0.021 = 1.570$ ksi, C

$f_{bot} = 0.217 - 0.153 + 0.070 + 0.021 = 0.155$ ksi, C

b) After shore removal:

$f_{top} = 1.570 - (0.010 + 0.003) = 1.557$ ksi, C

$f_{bot} = 0.155 - (0.053 + 0.016) = 0.086$ ksi, C

II) UNDER MAX LIVE LOAD (HS-20 WHEEL)

$f_{top} = 1.557 - 38.1/594.4 = 1.493$ ksi, C

$f_{bot} = 0.086 - 38.1/119.4 = -0.233$ ksi, T

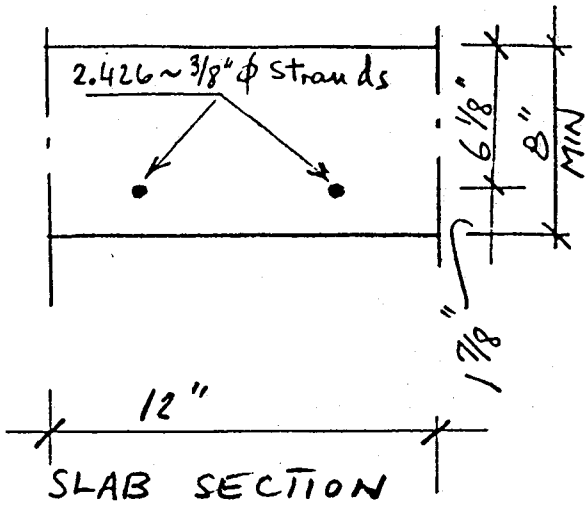
less than $6\sqrt{f'_c}$; OK

Req'd $M_{DL,u}$: $1.30(M_D + M_{CIP}) =$

$= 1.30(2.76 + 5.07) = 10.2$ "k/ft

Req'd $M_{LL,u} = 2.17(38.1) = 82.7$ "k/ft

Req'd $M_u = 92.9$ "k/ft



SLAB SECTION

For provided M_u:

check $f_{su} = \frac{l_x}{D} + \frac{2 f_{se}}{3} = \frac{60''}{(3/8)} + \frac{2(144)}{3} = \underline{256 \text{ ksi}}$

$A_s = 2.426(0.085) = 0.206 \text{ in}^2/\text{ft}$

Assume: $d = 6\frac{1}{8}'' = 6.125''$

$p = A_s/bd = \frac{0.206}{12 \times 6.125} = 0.0028$; $f_c' = 4.5$ ksi

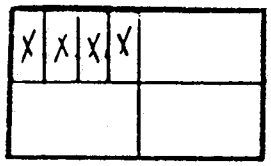
Max $f_{su} \leq 270(1 - 0.5\, p f_s'/f_c') = 270(0.916) = \underline{247.3 \text{ ksi}}$
211

Use: $f_{su} = 247.3$ ksi

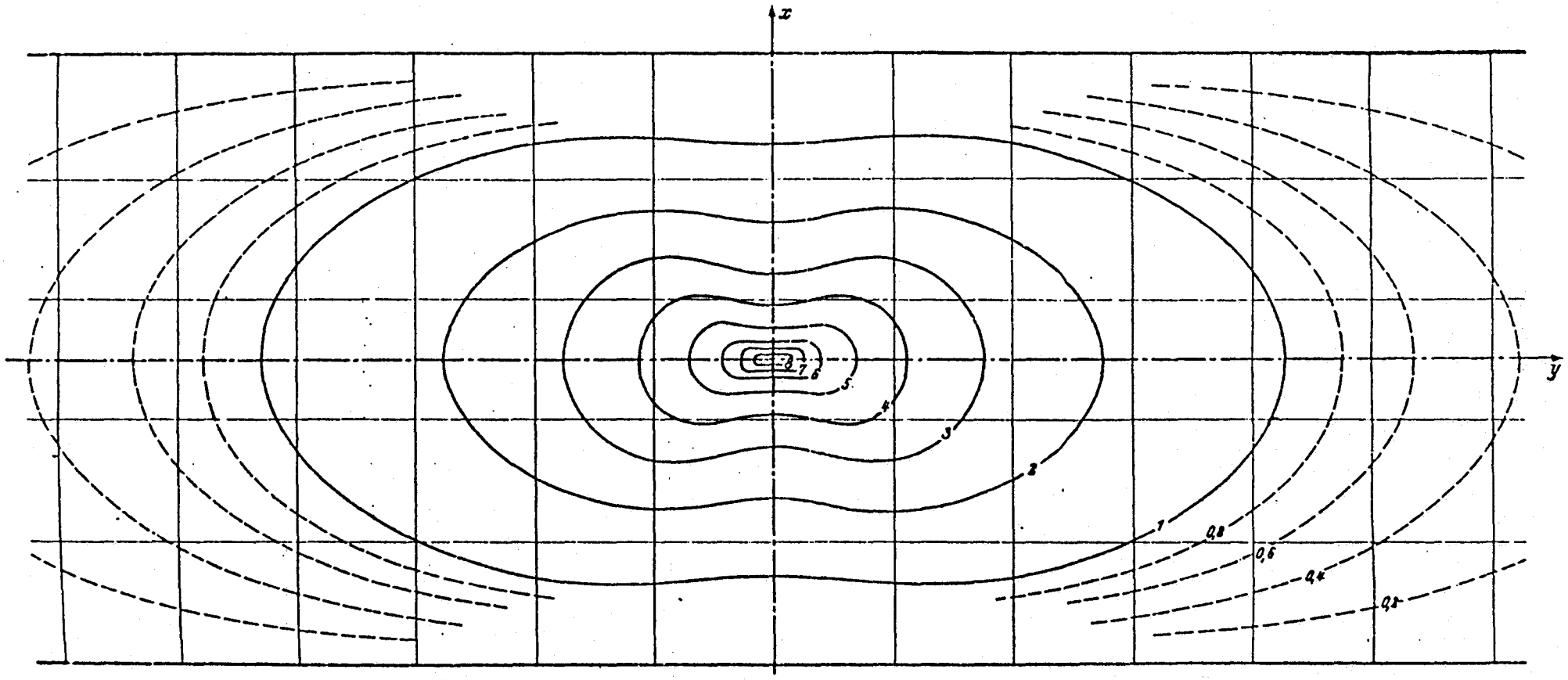
Resisting $M_u = 0.2062(247.3)6.125''\left(1 - 0.6 \times \frac{0.0028 \times 247.3}{4.5}\right)$

$M_u = 283.4$ "k/ft $\gg 92.9$ "k/ft, OK
242

TIRE DISTRIBUTION AREA



Tafel 1. m_x-*Einflußfeld für die Feldmitte eines Plattenstreifens mit zwei frei aufliegenden Rändern (8 π-fach)*
Chart 1. m_x-*Influence surface for the center of a plate-strip with two supported edges (8 π-times)*



1.6.26—DECK PANELS

(A) General

Precast prestressed deck panels, that are used as permanent forms spanning between stringers, may be designed compositely with the cast-in-place portion of the slabs to support additional dead loads and live loads.

The panels shall be prestressed with pretensioned strands. The strands shall be in a direction transverse to the stringers when the panels are placed on the supporting stringers. The top surface of the panels shall be roughened in such a manner as to insure composite action between the precast and cast-in-place concrete.

The panels shall be designed assuming they support their self weight, any construction loads and the weight of the cast-in-place concrete, and shall be designed assuming they act compositely with the cast-in-place concrete to support moments due to additional dead loads and live loads.

Except as otherwise provided in this Article, the provisions of Section 6-Prestressed Concrete shall apply to the analysis and design of precast prestressed deck panels.

(B) Bending Moment

Live load moments shall be computed in accordance with Article 1.3.2(C).

(C) Reinforcement

Reinforcing bars, or equivalent mesh, shall be placed in the panel transverse to the strands to provide at least 0.11 sq. in. per ft. (232.77mm²/m) of panel.

The prestressing strands shall be spaced symmetrically and uniformly across the width of the panel. They shall not be spaced farther apart than 1½ times the total composite slab thickness nor more than 18 in. (.457m).

The miminum amount of nonprestressed longitudinal reinforcement provided in the cast-in-place portion of slabs utilizing precast prestressed deck panels shall be 0.25 sq. in. per ft. (529mm²/m) of slab width.

(D) Prestressed Strand Development Length

At ultimate load, the stress in the prestressing steel as defined in Article 1.6.9(C), shall be limited to:

$$f_{su} = \frac{l_x}{D} + \frac{2f_{se}}{3} \text{ or } \left(6.895\frac{l_x}{D} + \frac{2\,f_{se}}{3}\right)$$

but not greater than f_{su} as given by the equations in Article 1.6.9(C).

In the above equation:

D = nominal diameter of strand, in. (m).

f_{se} = effective stress in prestressing strand after losses, ksi (MPa).

l_x = distance from end of prestressing strand to center of panel, in. (m).

(E) Negative Moment

In calculating stresses in the deck panel due to negative moment near the stringer, no compression due to prestressing shall be assumed to exist.

(C) Bending Moment

Bending moment per foot (m) width of slab shall be calculated according to methods given under Cases A and B, unless more exact methods are used considering tire contact area. The tire contact area needed for exact methods is given in Article 1.3.8.

In Cases A and B:

S = Effective span length, in feet (m), as defined under "Span Lengths" Articles 1.3.2(A) and 1.5.23(F)

E = Width of slab in feet (m) over which a wheel load is distributed

P = Load on one rear wheel of truck (P_{15} or P_{20}) ($P_{13.5}$ or P_{18})

$P_{15}(P_{13.5})$ = 12,000 pounds (54kN) for H15 (M13.5) loading

$P_{20}(P_{18})$ = 16,000 pounds (72kN) for H20 (M18) loading

Case A—Main Reinforcement Perpendicular to Traffic (Spans 2 to 24 feet (.610 to 7.315m) inclusive)

The live load moment for simple spans shall be determined by the following formulas (impact not included):

HS20 (MS18) Loading:

$$\left(\frac{S+2}{32}\right) P_{20} = \text{Moment in foot-pounds per foot-width of slab}$$

$$\text{or } \left(\left(\frac{S+.61}{9.74}\right) P_{18}\right) = \text{Moment in kNm/m}$$

In slabs continuous over three or more supports, a continuity factor of 0.8 shall be applied to the above formulas for both positive and negative moment.

1.3.8—TIRE CONTACT AREA

The tire contact area shall be assumed as a rectangle with an area in square inches of 0.01P, and a Length in Direction of Traffic/Width of Tire ratio of 1/2.5, in which P = wheel load in pounds.

Note: this amounts to assuming a contact area of 8" x 20" = 160 sq inches(or 0.01 x 16,000) for HS-20 Truck.

COMMENTARIES—1981 INTERIM

ARTICLE 1.3.2

Since the present AASHTO method is from references which date back to the 1930–1945 period, it is appropriate to allow more recent and accurate methods based on Elastic Plate Theory, such as Pucher's influence surfaces, Finite-Element methods, etc. One important reason for the addition is that more bridges and decks are being precast today and cost savings will result when more accurate methods are used.

(A) Prestressing steel

Temporary stress before loss due to creep and shrinkage . . . . . $0.70f'_s$
Stress at service load* after losses . . . . . $0.80f^*_y$

(Overstressing to $0.80f'_s$ for short periods of time may be permitted provided the stress, after transfer to concrete in pretensioning or seating of anchorage in post-tensioning, does not exceed $0.70f'_s$).

(B) Concrete

(1) Temporary Stresses Before Losses Due to Creep and Shrinkage:

Compression
Pretensioned members . . . . . $0.60f'_{ci}$
Post-tensioned members . . . . . $0.55f'_{ci}$

Tension
Precompressed tensile zone . . . . . No temporary allowable stresses are specified. See Article 1.6.6(B)(2) for allowable stresses after losses.

Other Areas
In tension areas with no bonded reinforcement . . . 200 psi or $3\sqrt{f'_{ci}}$ or (1.379 MPa or $.249\sqrt{f'_{ci}}$)
Where the calculated tensile stress exceeds this value, bonded reinforcement shall be provided to resist the total tension force in the concrete computed on the assumption of an uncracked section. The maximum tensile stress shall not exceed . . . . . $7.5\sqrt{f'_{ci}}$ or ($.623\sqrt{f'_{ci}}$).

(2) Stress at Service Load After Losses have Occurred:

Compression . . . . . $0.40f'_c$
Tension in the precompressed tensile zone
(a) For members with bonded reinforcement . . . . $6\sqrt{f'_c}$ or ($.498\sqrt{f'_c}$)
For severe corrosive exposure conditions, such as coastal areas . . . . . $3\sqrt{f'_c}$ or ($.249\sqrt{f'_c}$)
(b) For members without bonded reinforcement 0

Tension in other areas is limited by the allowable temporary stresses specified in Article 1.6.6(B)(1).

(3) Cracking Stress**

Modulus of rupture from tests or if not available:
For normal weight concrete . . . . . $7.5\sqrt{f'_c}$ or ($.623\sqrt{f'_c}$)
For sand-lightweight concrete . . . . . $6.3\sqrt{f'_c}$ or ($.523\sqrt{f'_c}$)
For all other lightweight concrete . . . . . $5.5\sqrt{f'_c}$ or ($.457\sqrt{f'_c}$)

*Service load consists of all loads contained in Article 1.2.1 but does not include overload provisions.

**Refer to Article 1.6.10.

Figure 7. Structural analysis of a panel deck.

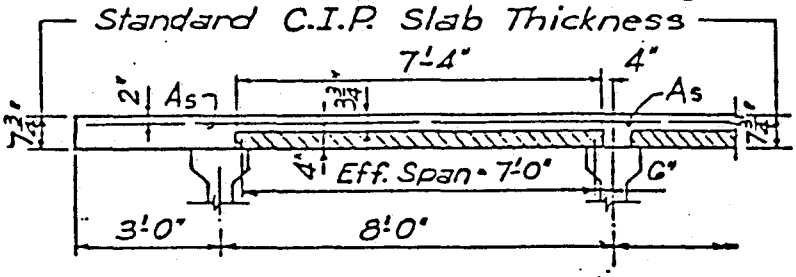
DESIGN R.L.R. DATE 6/20/78
CK. DSN. ..... DATE .....
DESIGN FOR PRESTRESSED PANEL DECK

TEXAS
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BRIDGE DIVISION

COUNTY .....
CONTROL .....
I.P.E. .....
HIGHWAY .....
SHEET ..... OF .....

HS20 Loading — 8'-0" Beam Spacing

Standard C.I.P. Slab Thickness



Try Standard Panels
4" Thick
f'_{ci} = 4000 p.s.i.
f'_c = 5000 p.s.i.
3/8"φ 270K Strands @ 6" c.c.
Cast-in-Place
f'_c = 3000 p.s.i.
f_y = 60 k.s.i.

$DLM = \frac{1}{8} \times .0969 \times 7^2 = 0.59^{k'}$

$LLM = \frac{.8(7+2)}{32} 16 \times 1.3 = \pm 4.68^{k'}$

Panels:

DL $S = \frac{12 \times 4^2}{6} = 32 \text{ in}^3$

DL $f_c = \frac{.59 \times 12000}{32} = -221$ p.s.i.

LL $S = \frac{12 \times 7.75^2}{6} = 120 \text{ in}^3$

LL $f_c = \frac{4.68 \times 12000}{120} = -468$ p.s.i.

Design Total $f_c = -689$ p.s.i

Prestress $= \frac{16{,}100 \times .8 \times 2}{4 \times 12} = +538$ p.s.i.

Final Panel $f_c = -151$ p.s.i.

Allow. $= 6\sqrt{5000} = -424$ O.K.

Cast-in-Place Slab:

Req'd d (Overhang) $= \sqrt{\frac{4.68}{.197}} = 4.87"$

2.
6.87"

Provided 7.75" O.K.

$A_s = \frac{4.68 \times 12}{20 \times .875 \times 5.75} = .558 \square"$

#5 @ 6½" c.c. O.K.

Check Ultimate Moment: +M

$f_{su}^* = f'_s\left(1 - \frac{.50 \rho^* f'_s}{f'_c}\right)$ AASHTO 1.6.9(C)

$= 270\left(1 - \frac{.5 \times .0854 \times 2 \times 270}{5.75 \times 12 \times 3}\right) = 240$ k.s.i.

or

$f_{su}^* = \frac{L}{D} + \frac{2 f_{se}}{3}$ AASHTO 1.6.18

$= \frac{44}{.375} + \frac{2 \times .7 \times 270 \times .8}{3} = 218$ k.s.i.

Use

$M_u = A_s^* f_{su}^* d\left(1 - \frac{.6 \rho^* f_{su}^*}{f'_c}\right)\phi$ AASHTO 1.6.9(A)

$= 2 \times .0854 \times 218 \times \frac{5.75}{12}\left(1 - \frac{.6 \times .0854 \times 2 \times 218}{5.75 \times 12 \times 3}\right).9$

$= 14.3^{k'}$

Check Ultimate Moment: −M

$M_u = A_s f_y d\left(1 - \frac{.6 \rho f_y}{f'_c}\right)\phi$ AASHTO 1.5.32(B)

$= .567 \times 60 \times \frac{5.75}{12}\left(1 - \frac{.6 \times .567 \times 60}{5.75 \times 12 \times 3}\right).9$

$= 13.2^{k'}$

Req'd $M_u = 1.3(DLM + \frac{5}{3} LLM)$

$= 1.3(.59 + 1.67 \times 4.68) = 10.9^{k'}$ O.K.

Standard Panels Adequate

one foot (') = .3048 m, one inch (") = 2.54 cm, one square inch (□") = 6.45 cm²
one kip foot = 1,356 Nm, one pound per square inch (p.s.i) = 6.895 KPa
one kip per square inch (k.s.i.) = 6.895 MPa

ARIZONA DEPARTMENT OF TRANSPORTATION

HIGHWAYS DIVISION

206 South Seventeenth Avenue Phoenix, Arizona 85007

BRUCE BABBITT
Governor

WILLIAM A. ORDWAY
Director

THOMAS R. LAMMERS
Assistant Director
and State Engineer

February 23, 1984

Mr. William B. Mancini, P.E.
Stanley Structures, Inc.
2702 N. 3rd Street, Suite 2010
Phoenix, AZ 85001

Dear Mr. Mancini:

Reference is made to your letter of February 22 concerning Informational Bulletin No. 108, dated March 1, 1977, relative to structural concrete for bridges. We offer the following comments in regard to the items enumerated in your letter:

1. In April 1976, the Federal Highway Administration issued a new directive prescribing policies and guidelines for bridge deck construction. The intent of these regulations was to improve the quality of bridge deck design and construction in order to deter their premature deterioration. One of the requirements of the FHWA was that concrete with a minimum compressive strength of 4,500 psi be used for bridge deck slabs. The Informational Bulletin was issued to inform consulting engineers that this would be a requirement for the design of bridges on federal-aid projects.

   In order to avoid the use of thin slabs having excessive flexibility, ADOT limited the allowable concrete design stress for bridge deck slabs to 1400 psi regardless of the minimum ultimate compressive strength of the concrete used.

2. The Informational Bulletin was intended to apply to cast-in-place non-prestressed structural concrete for bridges.

3. At the time the Informational Bulletin was issued in 1977, ADOT had not considered the use of precast/prestressed concrete stay-in-place bridge deck planking. Therefore, the provisions were intended to apply to conventional cast-in-place full depth deck slabs.

We hope our comments fully answer your questions. Please let us know if you would like any further information.

Very truly yours,

R. C. Brechler

R. C. Brechler
Assistant State Engineer

RCB:mah

cc: F. D. Davis

TO: Greg Black

February 23, 1984

FROM: Alex Aswad, PHD P.E.
Member, P.C.I. Bridge Committee

Re: Prestressed Bridge Deck Panels
59th Avenue Bridge
Stanley Structures Job No. 15133

With reference to our conversations in the last two days, please note I contacted the following agencies and persons:

1. F.H.W.A.'s Office of Western Bridge Design: (303-234-4475)

   I met with Mr. James Roller, Director, and Mr. Jim Keeley. They gave me a copy of "Transmittal 188" (it has nothing to do with stresses.) They also confirmed that there is no Federal Directive over and beyond what section 1.6.26 of A.A.S.H.T.O. 1977 and interim 1979 dictate. Therefore, $0.4f'_c$ is the allowable stress in compression and $6\sqrt{f'c}$ in tension for the planks.

2. F.H.W.A.'s Regional Office in Denver: (303-234-4633)

   Mr. Larry Lutz, Regional Engineer

3. F.H.W.A.'s Washington Office: (703-285-2072)

   Mr. Craig Ballinger, Structural Research Engineer
   Mr. Ballinger is a prime mover for the bridge deck panels specification.

4. Colorado D.O.T.: (303-657-9337)

   Mr. Mike Perino, Bridge Structural Design Chief

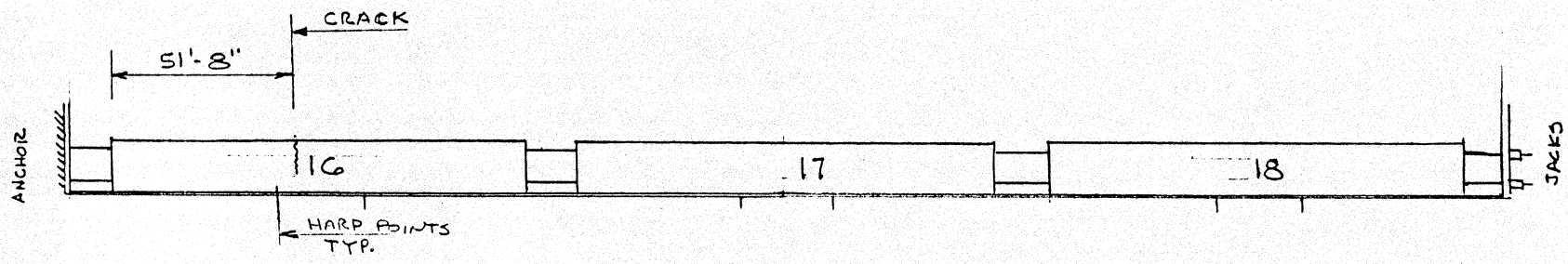
5. P.C.I. Bridge Committee Chairman:

   Mr. Don Goldberg

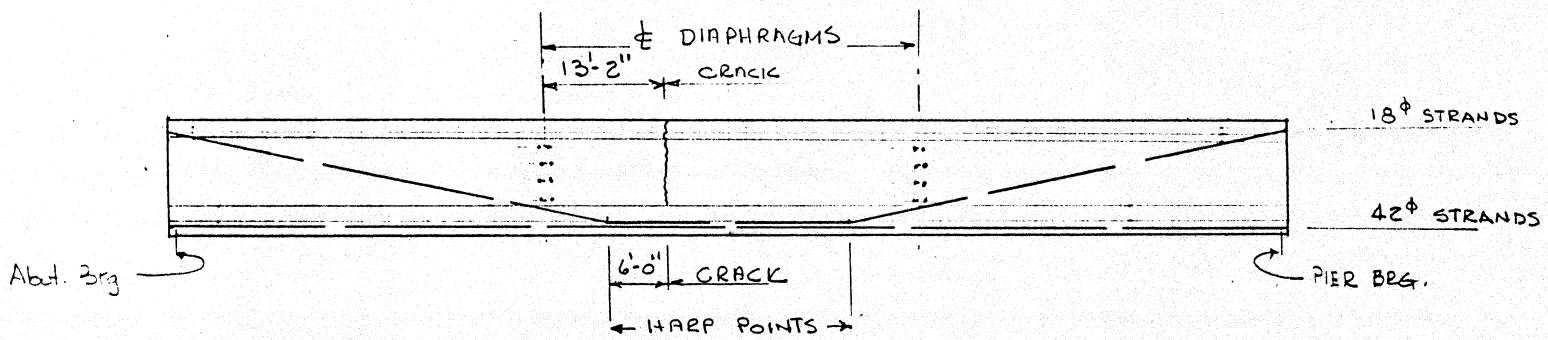
6. Mr. James Barker, V.P. of Figg & Muller Engineers:

   Mr. Barker is a former State of Illinois Chief Bridge Engineer for structures, and the actual author of A.A.S.H.T.O. interim 1977 section 1.6.26 on Bridge Deck Panels.

All persons confirmed that there is no Federal Directive over and beyond what section 1.6.26 of A.A.S.H.T.O. 1977 and interim 1979 dictate.



ELEVATION OF CASTING BED



ELEVATION OF GIRDER 16

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0130

59TH AVENUE BRIDGE

OVER ARIZONA CANAL DIVERSION CHANNEL

SHT. NO. 1 OF 6

JOB NO. 2182K

BY HEK DATE 10-83

CHKD. DATE

REV.

59TH AVENUE BRIDGE
OVER ARIZONA CANAL DIVERSION CHANNEL

JOB NO. 2182K
BY MEK DATE 10-83
CHKD. DATE
REV.

Girder Properties

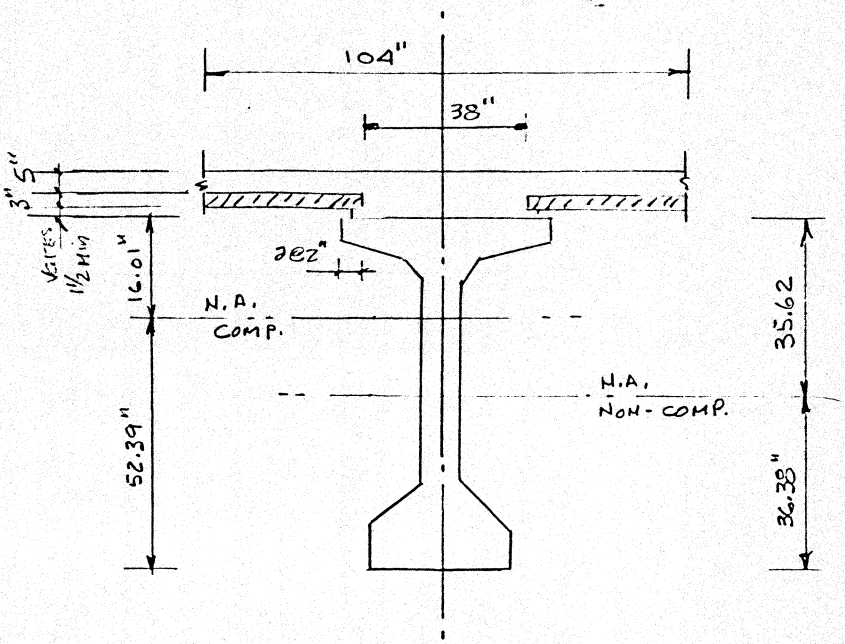
design f'_c = 5500 psi

ACTUAL f'_c = 7500 psi *

60 - 1/2 ϕ STRANDS
$F_o = F_i$ = 1520 K
F = 1230 K

e @ 51' = 30.28"

AREA GIRDER 1085 □"



NON-COMPOSITE

	C =	+ 35.62" Top Gir. I/c	- 27.38" Bot. Crack I/c	- 36.38" Bot. Gir. I/c
I				
733320		20587	26783	20157

COMPOSITE

	C =	+ 16.01 Top. Gir I/c	- 46.99 Bot. Crack I/c	- 52.39 Bot. Gir I/c
I				
1,446,152		90328	30776	27604

* 28 day breaks - G-316 #1 7760
#2 7840
Avg 7800

BENSON & GERDIN, INC. CONSULTING ENGINEERS PHONE (602) 264-0136 | SHT. NO. 3 OF 6

59TH AVENUE BRIDGE

OVER ARIZONA CANAL DIVERSION CHANNEL

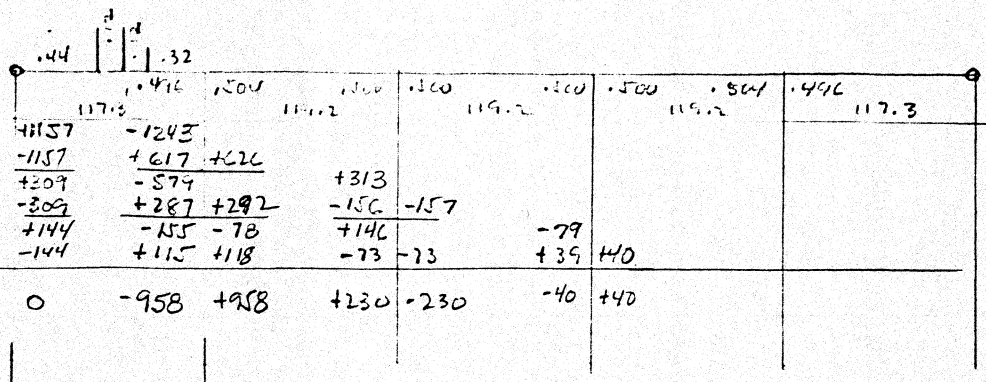
JOB NO. 2182 K

BY MEK DATE 11-83

CHKD. DATE

REV.

SHEAR: $P = 29.1^K$ $I = 50 / .44(117.3) + 125 = .283$ $P+I = 37.4$

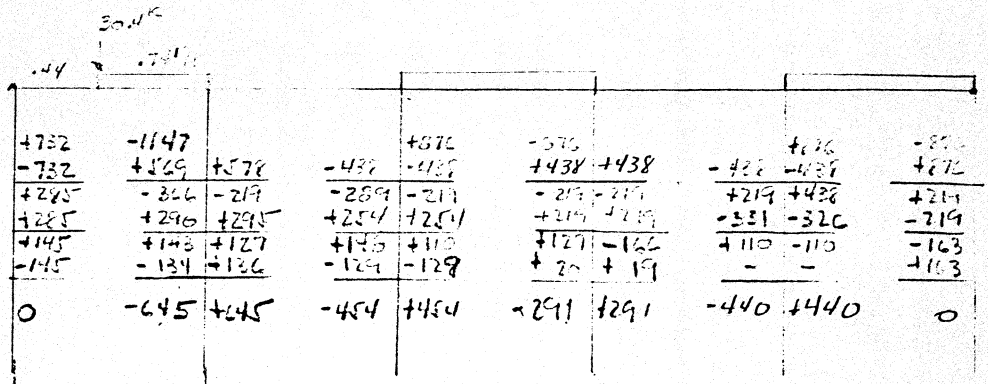


+1157	-1243						
-1157	+617	+626					
+309	-579		+313				
-309	+287	+292	-156	-157			
+144	-155	-78	+146		-79		
-144	+115	+118	-73	-73	+39	+40	
0	-958	+958	+230	-230	-40	+40	

Reaction:	P	40.39	43.76
	M	-8.17	+8.17
TOTAL		32.2	51.9

V_{LL} @ .44 L = 32.2^K ⟵ CONTROLS

$w = 0.53^{K/'}$ $P = 23.1^K$ $I = .283$



+732	-1147			+876	-876			+876	-876
-732	+569	+578	-438	-438	+438	+438	-438	-438	+876
+285	-366	-219	-289	-219	-219	-219	+219	+438	+219
+285	+290	+295	+254	+254	+219	+219	-331	-326	-219
+145	+143	+127	+146	+110	+127	-166	+110	-110	-163
-145	-134	+136	-129	-129	+20	+19	-	-	+163
0	-645	+645	-454	+454	-291	+291	-440	+440	0

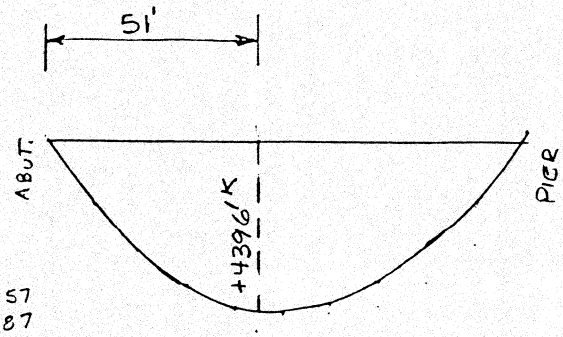
REACTION:	P	30.63	48.37
	M	-5.50	+5.50
		25.13	53.87

V_{LL} @ .44L = 25.1^K

Vm

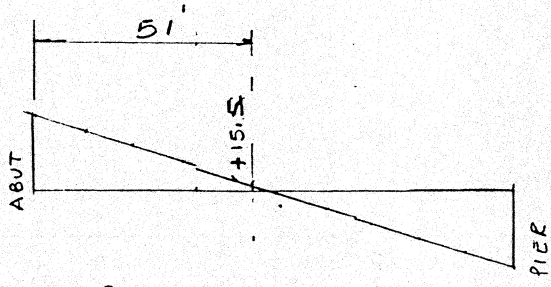
59TH AVENUE BRIDGE
OVER ARIZONA CANAL DIVERSION Channel

FIRST SPAN A-8



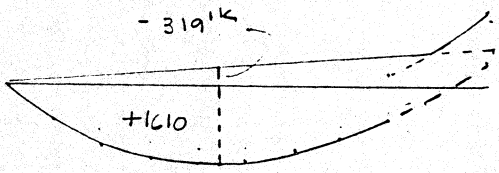
Girder: 1857
Slab: 2087
DIAPH: 262
CURB: 190
4396

DEAD LOAD MOMENTS

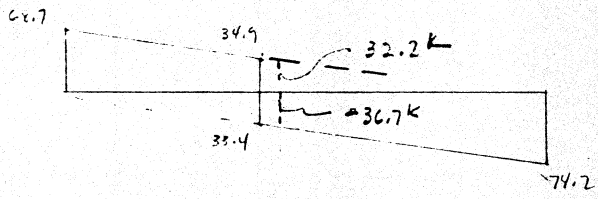


GIRDER: +8.0
SLAB: +8.6
DIAPH: -0-
CURB: -1.1
+15.5

DEAD LOAD SHEAR



LIVELOAD MOMENTS



LIVELOAD SHEAR

NOTE: the effect of the shrinkage and creep restraining moments was ignored in this analysis

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SHT. NO. 5 OF 6
JOB NO. 2182K
BY MBK DATE 10-83
CHKD. DATE
REV. 11-83

59TH AVENUE BRIDGE
OVER ARIZONA CANAL DIVERSION CHANNEL

△ (+) TENSION △ (−) COMPRESSION

	f_c △ Top Girder	Bottom crack	Bottom Girder	d comp. block	Area 8×d	P^K $\frac{f_c \times A}{2}$	V^K	V_u	Factor, SAFETY *
I									
F/A	−1133.6	−1133.6	−1133.6						
Fec/I	+1809.1	−1390.6	−1847.7						
Girder M	−1082.4	+832.0	+1105.5				+8.0	+10.4	
Σ I	−406.9	−1692.2	−1875.8	72"	576□"	639.3	+8.0	+10.4	32.0
II									
SLAB M	−1216.5	+935.1	+1242.4				+8.6		
DIAPH M	−152.7	+117.4	+156.0				-0-		
Curb M	−25.2	+74.1	+82.6				−1.1		
Σ II + Σ I	−1801.3	−565.6	−394.8	72"	576□"	632.5	+15.5	+20.2	16.3
III									
Pos (LL+I) M.	−213.9	+627.8	+699.9				32.2		
Σ III + Σ I + Σ II	−2015.2	+62.2	+305.1	62.5"	500□"	503.8	−47.7	90.0	4.2 ⇐
IV									
NEG (LL+I) M	+42.4	−124.4	−138.7						
Σ IV + Σ I + Σ II	−1758.9	−690.0	−533.5	72"	576				

* $f.s. = \frac{P^K \times 0.4}{V^K}$ (coeff. of friction: assume 0.4)

A.C.I Section 11.7 shear friction $V_n = A_{VF} f_y \mu$

$V_u \leq \phi V_n$ $0.2 f_c = 0.2 \times 7200 = 1560$ max = 800 $\mu = 1.4$ (11.7.4)

2-#4 & 7-#5 Grade 40 A_{VF} 2.57 Slab.

2-#4 + 4-#5 Grade 40 $A_{VF} = \frac{1.64 \text{ s.i}}{4.21 \text{ s.i}}$ Girder

$V_n = 800 \times 5 \times 72 = 460.8^K$ (Limit)

$V_n = 4.21 \times 40 \times 1.4 = 235.8^K$ ⇐

$V_u = 235.8 \times .85 = 200.4^K$ actual $V_u = 90.0$ OK

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59TH AVENUE BRIDGE
OVER THE ARIZONA CANAL DIVERSION Channel

JOB NO. 2182K
BY MEK DATE 11-83
CHKD. DATE
REV. 11-83

$f'_c = 7000$ (pg. 2) $M_u = 1.3(DL + 1.67\,LL) \Leftarrow$

$f^*_{su} = \left(1 - 0.5\frac{\rho^* f'_s}{f'_c}\right) f'_s = \left(1 - 0.5\frac{.00133 \times 270}{7.8}\right) f'_s = .977\, f'_s$

$f'^*_c = .85 \times 7000 = 6630$ Area Conc. $= \frac{.977 \times 270}{6630} \times 60 \times .153'' = 365.25^{\square''}$

$w = 104'' \times 6/8$ $t = 365.25/78 = 4.68''$ $kd = 72'' - 6.1 - 4.68/2 = 63.6''$

n_{deck} Fu 8 n_{Gir} 6 Area deck $= 104 \times 6/8 \times 5 + 38 \times 6/8 \times 4.5 = 58.25$

use $8 \times 6/8 \times 9.5 = 57$

M_u	f'_c psi (+) TEN (−) comp. Top Deck	Top Girder	Bottom Crack	Bottom Girder	d Comp block	Area 57 + 8×d	P^K $\frac{f_c}{2} \times A$	V	V_u	Factor Safety *
I										
F/A: 1230/1025	-0-	−1133.6	−1133.6	−1133.6						
Fe: 3102.7 K	-0-	+1809.1	−1390.6	−1847.7						
Girder: 2414.1 K	-0-	−1407.1	+1081.6	+1437.2				8.0	10.4	
ΣI	-0-	−731.6	−1442.6	−1544.1	72"	576 □"	655.4	8.0	10.4	25.2
II										
SLAB: 2[illegible] K	-0-	−1581.4	+1215.6	+1615.2				8.6	11.2	
DIAPH: 340.6 K	-0-	−198.5	+152.6	+202.8				-0-	-0-	
CURB: 247.0 K	−52.3	−32.8	+96.3	+107.4				−1.1	−1.4	
ΣI + ΣII	−52.3	−2544.3	+21.9	+381.3	9½ 63.6	57 500.8	639.5	15.5	20.2	12.7
III										
Pos (LL+I) 3425.3	−739.9	−464.3	+1362.9	+1519.5				32.2	69.9	
	−792.2	−497.1 −3008.6	+1414.8	+1900.8	9.5 44.1	57 352.8	567.5	47.7	90.1	2.5

Resisting Shear @ Beam Ultimate $M^*_u = .977 \times 270 \times 60 \times .153 \times 63.6/12 = 12834.4^{'K}$

stress block $8'' \times 4.68'' = 37.44^{K''} \times 6630 = 248.2^K = P$

V^*_u 248.2 × .4 = 99.3^K