FOR: Pier11 - RFI 228	JOB NO: 49633	SHEET NO:
MADE BY: LER	CHECKED BY: KDG	BACKCHECKED BY:
DATE: 1/30/12	DATE: 1/31/12	DATE:

HNTB

Issue

Note on sheet 16/90 states that concrete for second pour (above hor. c.j.) shall not be placed until the concrete in the first pour reaches 100% of its 28-day comp. strength.

The contractor would like to release the forms for the first pour and place the second pour the following day. Per ST-01.12, forms shall not be released prior to concrete reaching 85% of its 28-day strength.

Per Joel Halterman of Walsh, 85% f'c has been reach within 10 to 12 days on this project. Placement of pour 2 would then occur on day 11 to 13.

Evaluate impact of proposed change in const. sequence/timing on following items:

(1) Flexural Strength at time of P2 placement

(2) Shear strength at time of P2 placement

(3) Differential shrinkage

(1) Flexural Strength

Evaluate interim condition P1+P2 using $0.85f'_c$.

$$0.85f'_c = 3400\text{ psi}$$

See attach calculations.

Design sections 1, 2, and 3 are satisfactory for strength, and crack control.

No Δ's Required

(2) Shear Strength

Shear strength of concrete section still exceeds the factored shear load. Verify min. steel requirements.

$$A/s_{min} = 0.0316\sqrt{f'_c}\,\frac{b_v}{f_y}$$

$b_v = 144\text{ in}$

$f_y = 60\text{ ksi}$

$$A/s_{min} = 0.0314\sqrt{3.4}\,\frac{144}{60}$$

$$= 0.139\text{ in}^2/\text{in}$$

This is less than the calculated value based on $f'_c = 4\text{ ksi}$. The section is ∴ satisfactory for shear.

No Δ's Required

ME-101-1204

FOR: Pier 11 - RFI 228	JOB NO: 491033	SHEET NO:
MADE BY: LER	CHECKED BY: KPG	BACKCHECKED BY:
DATE: 1/30/12	DATE: 1/31/12	DATE:

HNTB

B) Shrinkage

Differential shrinkage calculations were based on a time lapse of 21 days between placement of P1 and P2. With the proposed change in sequence/timing, this time lapse is reduced to ≈ 13 days. This will result in a corresponding decrease in differential shrinkage forces within the capbeam and columns. The forces based on the original analysis are therefore conservative.

The pier is ∴ satisfactory for differential shrinkage forces.

No Δ's Required

ME-101-1204

For	Cleveland - Pier 11 Cap Beam	Job No.	49633	Sheet No.	
Made by	LER	Checked by	KDG	Backchecked by	
Date	11/2/11	Date	12/1/12	Date	

HNTB

SECTION 1 - P1 + P2

Section Geometry

Width:	$b =$	144.000	in	$I_g =$	35831808	in^4	
Total Depth (inc. red. for wear):	$D =$	144.000	in	$f_{cr} =$	682	psi	(LRFD AASHTO 5.4.2.6)
Cover Prim. Bar:	$c_p =$	0.875	in	$1.2{*}M_{cr} =$	407435301	lb-in	
Cover on Sec. Bar:	$c_s =$	2.000	in	$x =$	26.70	in	
Side Cover:	$c_{side} =$	3.000	in	$\beta =$	0.85		

Stirrups/Outer Bar: #6 bar — $d_{stirrup} =$ 0.750 in; $A_{stirrup} =$ 0.440 in^2

		No. Bars	Size	Layer Spa.	No./Bundle
Primary Bars:	Layer 1	32.00	#11		2
	Layer 2		#11		
	Layer 3		#11		
Secondary Bars:		18.00	#11		

No. Leges for Shear = 2

No. Legs for Torsion = 2

$d_v =$ 137.37 in

Eff. Depth for Primary Bars:	$d =$	140.97	in	$A_s =$	49.920	in^2	$d_s =$	1.410	in
Eff. Depth for Secondary Bars:	$d' =$	3.455	in	$A_s' =$	28.080	in^2	$d_s' =$	1.410	in

Materials

Concrete Compression Strength:	$f_c' =$	3400	psi
Concrete Modulas of Elasticity:	$E_c =$	3323600	psi
Modular Ratio:	$n =$	9	
Reinforcing Yield Strength:	$f_y =$	60000	psi
Reinforcing Modulas of Elasticity:	$E_s =$	29000	ksi
Crack Width Parameter:	$\gamma =$	0.75	k/in

Flexure - Crack Control

$f_s =$	31.45	ksi	
$f_c =$	0.82		
$d_c =$	3.035	in	
$\beta_s =$	1.031		
$s_{max} =$	**10.12**	in	
$s_{prov} =$	9.01	in	**OK**

→ actual s ≈ 6.5"

Resistance Factors

Flexure and Tension:	$\phi =$	0.90	*
Shear and Torsion:	$\phi =$	0.90	

Shear and Torsion

$A_{cp} =$	20736	in^2	$A_v =$	0.88	in^2
$P_{cp} =$	576	in	$A_t =$	0.44	in^2
$A_{oh} =$	19266	in^2	$p_h =$	555	in
$A_o =$	16376	in^2			

Loads

Mu =	21600	k-ft
Ms =	17280	k-ft
Vu =	0.0	kip
Tu =	0.0	kip

$V_c =$	2306.8	kip	
$\phi V_c =$	2076.1	kip	*No Shear Rein. Reqd.*
$T_{cr} =$	~~14500~~	kip-ft	*No Torsional Rein. Reqd.*

Flexure - Strength

Analyze as Doubly Reinforced (Y/N): n

$(A_v/s) =$	0.000	in^2/in/n-legs
$(A_t/s) =$	0.000	in^2/in/leg
	0.00	in^2/in/2legs

Flexural Strength:

$R_n =$	100.65	psi			
$m =$	20.76		$A_sF_y =$	2995200	lb
$\rho =$	0.0017		$a =$	7.20	in
$A_{s\_req} =$	**34.51**	in^2	$\phi M_n =$	**30858**	kip-ft
		OK			**OK**

$s_{req} =$	#DIV/0!	in	
$s_{min} =$	6.29	in	*(AASHTO 5.8.2.5)*
$s_{max\_v} =$	24	in	*(AASHTO 5.8.2.7)*
$s_{max\_t} =$	~~12~~	in	

Minimum Steel:

$R_n =$	158.21	psi	$4/3R_n =$	134	
$m =$	20.76		$m =$	20.76	
$\rho_{min\_1} =$	0.0027		$\rho_{min\_2} =$	0.0023	
$A_{s\_min1} =$	54.81	in^2	$A_{s\_min2} =$	46.69	in^2
					OK

Maximum Steel:

*The maximum steel requirment has been removed. This provision is compensated for by adjusting the reistance factor based on whether the section is tension controlled, compression controlled, or in transistion. A section is tension controlled if c/d <= 0.375 and ϕ = 0.90)

$c = a/\beta =$	8.47	in
$c/d =$	0.06	**<=0.375, Tension Controlled**

(Use this for single and double reinforcement)

For	Cleveland - Pier 11 Cap Beam	Job No.	49633	Sheet No.	
Made by	LER	Checked by	KDG	Backchecked by	
Date	11/2/11	Date	10/1/12	Date	

HNTB

SECTION 2 - P1 + P2

Section Geometry

Width:	$b =$	144.000	in	$I_g =$	7112448	in^4			
Total Depth (inc. red. for wear):	$D =$	84.000	in	$f_{cr} =$	682	psi	(LRFD AASHTO 5.4.2.6)		
Cover Prim. Bar:	$c_p =$	2.000	in	$1.2{*}M_{cr} =$	138641179	lb-in			
Cover on Sec. Bar:	$c_s =$	2.000	in	$x =$	28.50	in			
Side Cover:	$c_{side} =$	3.000	in	$\beta =$	0.85				
Stirrups/Outer Bar:	#6	bar					$d_{stirrup} =$	0.750	in
							$A_{stirrup} =$	0.440	in^2

		No. Bars	Size	Layer Spa.	No./Bundle
Primary Bars:	Layer 1	44.00	#11		2
	Layer 2	44.00	#11	8.0 in	2
	Layer 3		#11		
Secondary Bars:		18.00	#11		

No. Leges for Shear = 2
No. Legs for Torsion = 2
$d_v =$ 68.26 in

Eff. Depth for Primary Bars:	$d =$	75.84	in	$A_s =$	137.280	in^2	$d_s =$	1.410	in
Eff. Depth for Secondary Bars:	$d' =$	3.455	in	$A_s' =$	28.080	in^2	$d_s' =$	1.410	in

Materials

Concrete Compression Strength:	$f_c' =$	3400	psi
Concrete Modulas of Elasticity:	$E_c =$	3323600	psi
Modular Ratio:	$n =$	9	
Reinforcing Yield Strength:	$f_y =$	60000	psi
Reinforcing Modulas of Elasticity:	$E_s =$	29000	ksi
Crack Width Parameter:	$\gamma =$	0.75	k/in

Resistance Factors

Flexure and Tension:	$\phi =$	0.90	*
Shear and Torsion:	$\phi =$	0.90	

Loads

Mu =	8795	k-ft
Ms =	7035	k-ft
Vu =	0.0	kip
Tu =	0.0	kip

Flexure - Strength

Analyze as Doubly Reinforced (Y/N): n

Flexural Strength:

$R_n =$	141.58	psi			
$m =$	20.76		$A_sF_y =$	8236800	lb
$\rho =$	0.0024		$a =$	19.79	in
$A_{s\_req} =$	**26.21**	in^2	$\phi M_n =$	**40738**	kip-ft
		OK			**OK**

Minimum Steel:

$R_n =$	185.99	psi	$4/3R_n =$	189	
$m =$	20.76		$m =$	20.76	
$\rho_{min\_1} =$	0.0032		$\rho_{min\_2} =$	0.0033	
$A_{s\_min1} =$	34.95	in^2	$A_{s\_min2} =$	36.04	in^2
					OK

Maximum Steel:

*The maximum steel requirment has been removed. This provision is compensated for by adjusting the reistance factor based on whether the section is tension controlled, compression controlled, or in transistion. A section is tension controlled if c/d <= 0.375 and ϕ = 0.90)

$c = a/\beta =$ 23.28 in

$c/d =$ 0.31 **<=0.375, Tension Controlled**

(Use this for single and double reinforcement)

Flexure - Crack Control

$f_s =$	9.27	ksi	
$f_c =$	0.62		
$d_c =$	4.16	in	
$\beta_s =$	1.074		
$s_{max} =$	**44.39**	in	
$s_{prov} =$	6.43	in	**OK**

↳ actual s ≈ 6.5"

Shear and Torsion

$A_{cp} =$	12096	in^2	$A_v =$	0.88	in^2
$P_{cp} =$	456	in	$A_t =$	0.44	in^2
$A_{oh} =$	10877	in^2	$p_h =$	433	in
$A_o =$	9246	in^2			

$V_c =$	1146.2	kip	
$\phi V_c =$	1031.6	kip	*No Shear Rein. Reqd.*
$T_{cr} =$	~~6236~~	kip-ft	*No Torsional Rein. Reqd.*

$(A_v/s) =$	0.000	in^2/in/n-legs
$(A_t/s) =$	0.000	in^2/in/leg
	0.00	in^2/in/2legs

$s_{req} =$	#DIV/0!	in	
$s_{min} =$	6.29	in	*(AASHTO 5.8.2.5)*
$s_{max\_v} =$	24	in	*(AASHTO 5.8.2.7)*
$s_{max\_t} =$	~~12~~	in	

For	Cleveland - Pier 11 Cap Beam	Job No.	49633	Sheet No.	
Made by	LER	Checked by	KDG	Backchecked by	
Date	11/2/11	Date	1/9/12	Date	

HNTB

SECTION 3 - P1 + P2

Section Geometry

Width:	$b =$	144.000	in	$I_g =$	35831808	in^4			
Total Depth (inc. red. for wear):	$D =$	144.000	in	$f_{cr} =$	682	psi	(LRFD AASHTO 5.4.2.6)		
Cover Prim. Bar:	$c_p =$	0.875	in	$1.2{*}M_{cr} =$	407435301	lb-in			
Cover on Sec. Bar:	$c_s =$	2.000	in	$x =$	26.70	in			
Side Cover:	$c_{side} =$	3.000	in	$\beta =$	0.85				
Stirrups/Outer Bar:	#6	bar					$d_{stirrup} =$	0.750	in
							$A_{stirrup} =$	0.440	in^2

		No. Bars	Size	Layer Spa.	No./Bundle			
Primary Bars:	Layer 1	32.00	#11		2	No. Leges for Shear =	2	
	Layer 2		#11			No. Legs for Torsion =	1	
	Layer 3		#11			$d_v =$	137.37	in
Secondary Bars:		18.00	#11					

Eff. Depth for Primary Bars:	$d =$	140.97	in	$A_s =$	49.920	in^2	$d_s =$	1.410	in
Eff. Depth for Secondary Bars:	$d' =$	3.455	in	$A_s' =$	28.080	in^2	$d_s' =$	1.410	in

Materials

Concrete Compression Strength:	$f_c' =$	3400	psi
Concrete Modulas of Elasticity:	$E_c =$	3323600	psi
Modular Ratio:	$n =$	9	
Reinforcing Yield Strength:	$f_y =$	60000	psi
Reinforcing Modulas of Elasticity:	$E_s =$	29000	ksi
Crack Width Parameter:	$\gamma =$	0.75	k/in

Resistance Factors

Flexure and Tension:	$\phi =$	0.90	*
Shear and Torsion:	$\phi =$	0.90	

Loads

Mu =	22940	k-ft
Ms =	18355	k-ft
Vu =	0.0	kip
Tu =	0.0	kip

Flexure - Strength

Analyze as Doubly Reinforced (Y/N): n

Flexural Strength:

$R_n =$	106.89	psi			
$m =$	20.76		$A_sF_y =$	2995200	lb
$\rho =$	0.0018		$a =$	7.20	in
$A_{s\_req} =$	**36.54**	in^2	$\phi M_n =$	**30858**	kip-ft
		OK			**OK**

Minimum Steel:

$R_n =$	158.21	psi	$4/3R_n =$	143	
$m =$	20.76		$m =$	20.76	
$\rho_{min\_1} =$	0.0027		$\rho_{min\_2} =$	0.0024	
$A_{s\_min1} =$	54.81	in^2	$A_{s\_min2} =$	48.72	in^2
					OK

Maximum Steel:

*The maximum steel requirment has been removed. This provision is compensated for by adjusting the reistance factor based on whether the section is tension controlled, compression controlled, or in transistion. A section is tension controlled if c/d <= 0.375 and $\phi = 0.90$)

$c = a/\beta =$	8.47	in	
$c/d =$	0.06	**<=0.375, Tension Controlled**	

(Use this for single and double reinforcement)

Flexure - Crack Control

$f_s =$	33.41	ksi	
$f_c =$	0.87	ksi	
$d_c =$	3.035	in	
$\beta_s =$	1.031		
$s_{max} =$	**9.17**	in	
$s_{prov} =$	9.01	in	**OK**

↳ actual s ≈ 6.5"

Shear and Torsion

$A_{cp} =$	20736	in^2	$A_v =$	0.88	in^2
$P_{cp} =$	576	in	$A_t =$	0.44	in^2
$A_{oh} =$	19266	in^2	$p_h =$	555	in
$A_o =$	16376	in^2			

$V_c =$	2306.8	kip	
$\phi V_c =$	2076.1	kip	*No Shear Rein. Reqd.*
$T_{cr} =$	~~14509~~	kip-ft	*No Torsional Rein. Reqd.*

$(A_v/s) =$	0.000	$in^2/in/n\text{-legs}$
$(A_t/s) =$	0.000	$in^2/in/leg$
	0.00	$in^2/in/2legs$

$s_{req} =$	#DIV/0!	in	
$s_{min} =$	6.29	in	*(AASHTO 5.8.2.5)*
$s_{max\_v} =$	24	in	*(AASHTO 5.8.2.7)*
$s_{max\_t} =$	~~12~~	in	

FOR:	JOB NO:	SHEET NO:
MADE BY:	CHECKED BY:	BACKCHECKED BY:
DATE:	DATE:	DATE:

HNTB

Excerpts from Pier 11 Horizontal Construction Joint Design Computations.

ME-101-1204

Section ① - Inside face right column

D_i = total depth, pour 1
D = total final depth

D_i = 144"
D = 192"

Design Loads (-M)

	M_u (k·ft)	M_s (k·ft)
Stage 1	12,725	9995
Stage 2	21,600	17,280
* Final (1)	65,470	42,285
(2)	65,470	42,295

Stage 1: 16 Bund. 2-#11 @ ≈ 6.5"

ϕM_n = 30,998 k·ft ok
S_{max} = 23.5" > 6.5" ok

Stage 2: 16-Bund. 2-#11 @ ≈ 6.5"
ϕM_n = 31,119 k·ft ok
S_{max} = 11.6" > 6.5" ok

* Final (1) - Loads from cap design including truck load on all units (U2, U3, Ramp A5)

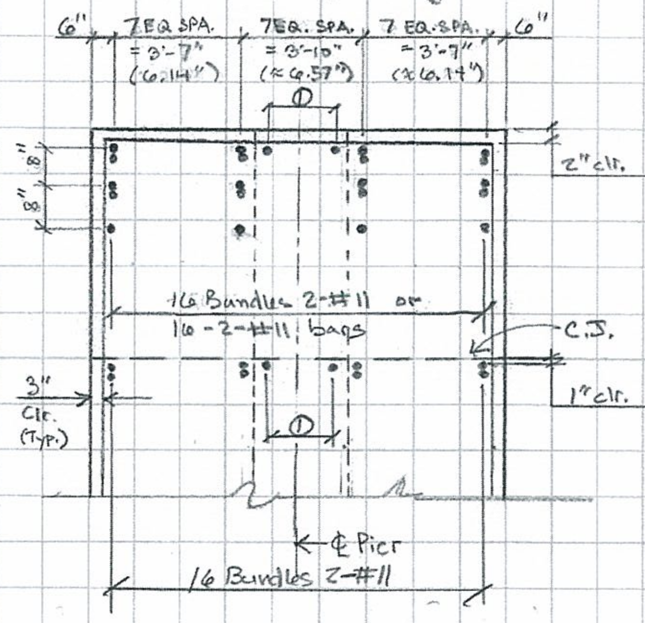
(2) - Loads from cap design excluding truck load on U2.

Final: ① 16-Bund 2#11, ② 16-Bund 2#11, ③ 16-#11 — s ≈ 6.5"

ϕM_n = 97,603 k·ft ok
*S_{max} = 7.49" > 6.5" ok

*Includes tension due to restrained shrinkage on Pour 2 section, F_{sh} = 860 k.

The bars must be detailed to fit around the 3' wide access hole opening.



① 6 #6 Bars, EQ Spa.

For Cleveland - Pier 11	Job no. 49633	Sheet no.
Made by LEP	Checked by PDB	Backchecked by
Date 10/3/11	Date 11/08/11	Date

HNTB

Section ③ - Inside face left column.

D_i = 144"
D = 220" (use height to top of second step from right)

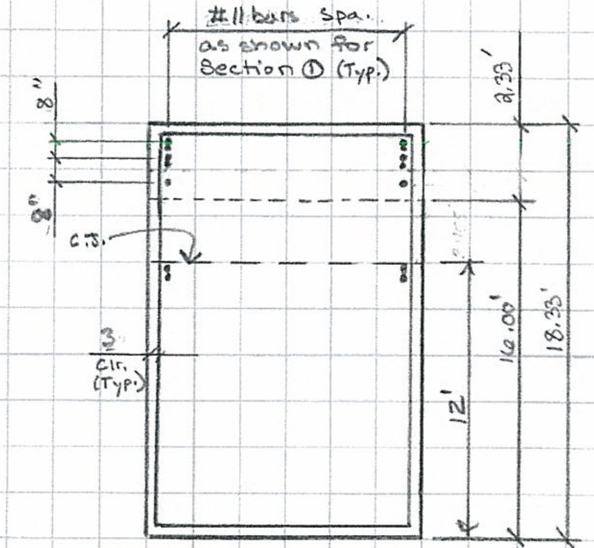
Design Loads

	Mu (k·ft)	Ms (k·ft)
Stage 1	12,725	9,995
Stage 2	22,940	18,355
Final (1)	68,880	51,840
(2)	70,170	52,540

Stage 1: Loading and design section is identical to that for Section ①.

Stage 2: 16 Bund. 2-#11 @ ≈ 6.5"
ϕM_n = 31,119 k·ft ok
S_{max} = 10.6" > 6.5" ok.

Final:



ϕM_n = 113,328 k·ft ok
S_{max} = 6.75" > 6.5" ok.

Additional 1'-2" step not show.

Add 22-#6 bars to face of 3rd step spa. sim. to main bars for section ① & ③.

ME101-1204

For Cleveland - Pier 11	Job no. 49633	Sheet no.
Made by LER	Checked by KDG	Backchecked by
Date 12/13/11	Date 12/15/11	Date

HNTB

Minimum Shear Requirements

Determine min. shear reinforcement requirements for portion of pour 1 where $V_u > \frac{1}{2}\phi V_c$.
(see shear diagram).

$$A/s_{min} = 0.0316\sqrt{f'_c}\,\frac{b_v}{f_y}$$

$b_v = 144$ in

$f_y = 60$ ksi

$$A/s_{min} = 0.0316\sqrt{4}\,\frac{144\text{ in}}{60\text{ ksi}}$$

$$= 0.152\text{ in}^2/\text{in}$$

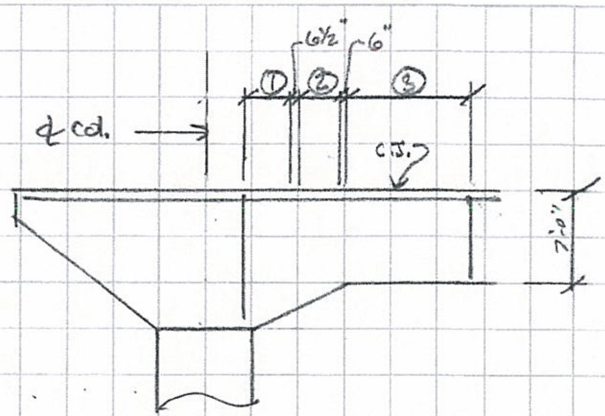
$S = 6\frac{1}{2}$" max.

$$\therefore A_v = 0.152\text{ in}^2/\text{in}\,(6.5")$$
$$= 0.99\text{ in}^2$$

4 #5 - 1.24 in²

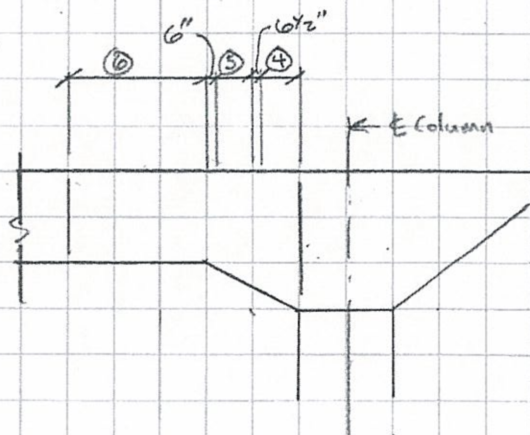
Use 2-#5 ⊓ to match shear reinforcement.

Provide stirrups to ≈ x = 55'
or 55 - 23.5 - 6 ≈ 26' from face of column.

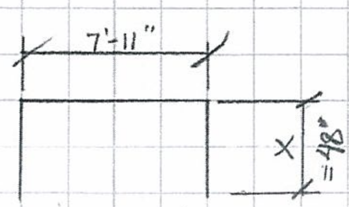


Elev. Near Left Col.

Two Sets
① 17 - 11P550 @ 6½" = 8'-8"
② 7 - 11P550 @ 6½" = 3'-3"
③ 28 - 11P550 @ 6" = 13'-6"



Two Sets
④ 15 - 11P550 @ 6½" = 7'-7"
⑤ 9 - 11P550 @ 6½" = 4'-4"
⑥ 28 - 11P550 @ 6" = 13'-6"

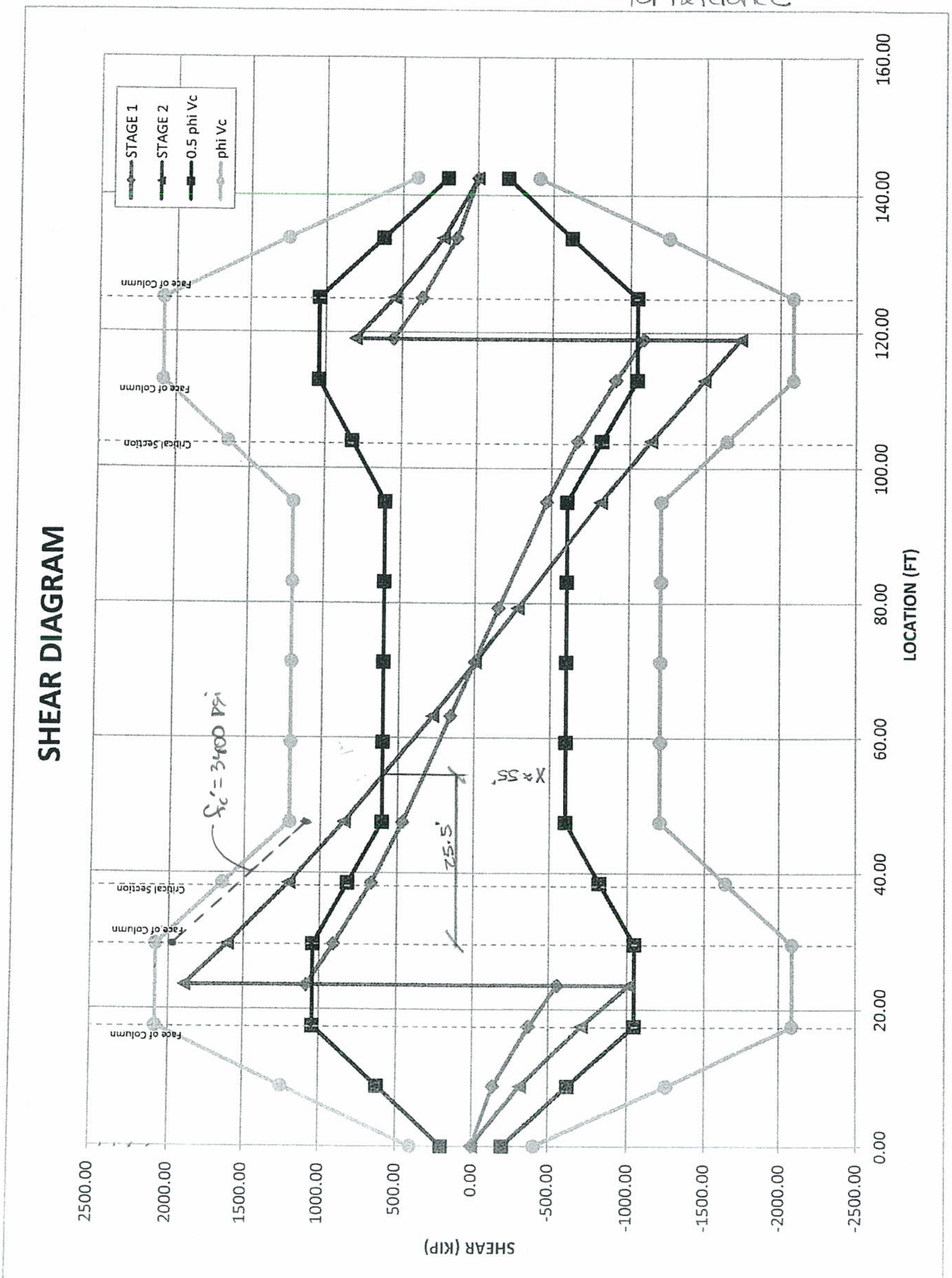


11P550

X > class C splice
≥ 37" (>6" space, Epoxy)

ME101-1204

For Reference



For	Cleveland - Pier 11 Cap Beam	Job No.	49633	Sheet No.	
Made by	LER	Checked by	KDG	Backchecked by	
Date	11/2/11	Date	12/15/11	Date	

HNTB

SECTION 1 - P1 + P2

Recheck crack control w/ new d.

Section Geometry

Width:	$b =$	144.000	in	$I_g =$	35831808	in^4
Total Depth (inc. red. for wear):	$D =$	144.000	in	$f_{cr} =$	740	psi (LRFD AASHTO 5.4.2.6)
Cover Prim. Bar:	$c_p =$	0.875	in	$1.2 \cdot M_{cr} =$	441925632	lb-in
Cover on Sec. Bar:	$c_s =$	2.000	in	$x =$	25.33	in
Side Cover:	$c_{side} =$	3.000	in	$\beta =$	0.85	
Stirrups/Outer Bar:	#6	bar				

		No. Bars	Size	Layer Spa.	No./Bundle
Primary Bars:	Layer 1	32.00	#11		2
	Layer 2		#11		
	Layer 3		#11		
Secondary Bars:		18.00	#11		

$d_{stirrup} =$	0.750	in
$A_{stirrup} =$	0.440	in^2
No. Leges for Shear =	2	
No. Legs for Torsion =	2	
$d_v =$	137.91	in

Eff. Depth for Primary Bars:	$d =$	140.97	in	$A_s =$	49.920	in^2	$d_s =$	1.410	in
Eff. Depth for Secondary Bars:	$d' =$	3.455	in	$A_s' =$	28.080	in^2	$d_s' =$	1.410	in

Materials

Concrete Compression Strength:	$f_c' =$	4000	psi
Concrete Modulas of Elasticity:	$E_c =$	3605000	psi
Modular Ratio:	$n =$	8	
Reinforcing Yield Strength:	$f_y =$	60000	psi
Reinforcing Modulas of Elasticity:	$E_s =$	29000	ksi
Crack Width Parameter:	$\gamma =$	0.75	k/in

Flexure - Crack Control

$f_s =$	31.34	ksi	
$f_c =$	0.86		
$d_c =$	3.035	in	
$\beta_s =$	1.031		
$s_{max} =$	**10.18**	in	
$s_{prov} =$	~~9.01~~ 6.14"	in	**OK**

Resistance Factors

Flexure and Tension:	$\phi =$	0.90	*
Shear and Torsion:	$\phi =$	0.90	

Shear and Torsion

$A_{cp} =$	20736	in^2	$A_v =$	0.88	in^2
$P_{cp} =$	576	in	$A_t =$	0.44	in^2
$A_{oh} =$	19266	in^2	$p_h =$	555	in
$A_o =$	16376	in^2			
$V_c =$	2511.9	kip			
$\phi V_c =$	2260.7	kip	*No Shear Rein. Reqd.*		
$T_{cr} =$	~~13738~~	kip-ft	*No Torsional Rein. Reqd.*		

Loads

Mu =	21600	k-ft
Ms =	17280	k-ft
Vu =	0.0	kip
Tu =	0.0	kip

Flexure - Strength

Analyze as Doubly Reinforced (Y/N): n

$(A_v/s) =$	0.000	in^2/in/n-legs
$(A_t/s) =$	0.000	in^2/in/leg
	0.00	in^2/in/2legs

$s_{req} =$	#DIV/0!	in	
$s_{min} =$	5.80	in	*(AASHTO 5.8.2.5)*
$s_{max\_v} =$	24	in	*(AASHTO 5.8.2.7)*
$s_{max\_t} =$	~~12~~	in	

Flexural Strength:

$R_n =$	100.65	psi			
$m =$	17.65		$A_sF_y =$	2995200	lb
$\rho =$	0.0017		$a =$	6.12	in
$A_{s\_req} =$	**34.51**	in^2	$\phi M_n =$	**30979**	kip-ft
		OK			**OK**

Minimum Steel:

$R_n =$	171.60	psi	$4/3R_u =$	134	
$m =$	17.65		$m =$	17.65	
$\rho_{min\_1} =$	0.0029		$\rho_{min\_2} =$	0.0023	
$A_{s\_min1} =$	58.87	in^2	$A_{s\_min2} =$	46.69	in^2
					OK

Maximum Steel:

*The maximum steel requirment has been removed. This provision is compensated for by adjusting the reistance factor based on whether the section is tension controlled, compression controlled, or in transistion. A section is tension controlled if c/d <= 0.375 and ϕ = 0.90)

$c = a/\beta =$	7.20	in
$c/d =$	0.05	**<=0.375, Tension Controlled**

(Use this for single and double reinforcement)

For	Cleveland - Pier 11 Cap Beam	Job No.	49633	Sheet No.	
Made by	LER	Checked by	KDG	Backchecked by	
Date	11/2/11	Date	12/15/11	Date	

HNTB

SECTION 3 - P1 + P2

Recheck crack control w/ new d.

Section Geometry

Width:	$b =$	144.000 in	$I_g =$	35831808 in^4		
Total Depth (inc. red. for wear):	$D =$	144.000 in	$f_{cr} =$	740 psi	(LRFD AASHTO 5.4.2.6)	
Cover Prim. Bar:	$c_p =$	0.875 in	$1.2{*}M_{cr} =$	441925632 lb-in		
Cover on Sec. Bar:	$c_s =$	2.000 in	$x =$	25.33 in		
Side Cover:	$c_{side} =$	3.000 in	$\beta =$	0.85		
Stirrups/Outer Bar:	#6	bar			$d_{stirrup} =$	0.750 in
					$A_{stirrup} =$	0.440 in^2

		No. Bars	Size	Layer Spa.	No./Bundle			
Primary Bars:	Layer 1	32.00	#11		2	No. Leges for Shear =	2	
	Layer 2		#11			No. Legs for Torsion =	1	
	Layer 3		#11			$d_v =$	137.91	in
Secondary Bars:		18.00	#11					

Eff. Depth for Primary Bars:	$d =$	140.97 in	$A_s =$	49.920 in^2	$d_s =$	1.410 in
Eff. Depth for Secondary Bars:	$d' =$	3.455 in	$A_s' =$	28.080 in^2	$d_s' =$	1.410 in

Materials

Concrete Compression Strength:	$f_c' =$	4000	psi
Concrete Modulas of Elasticity:	$E_c =$	3605000	psi
Modular Ratio:	$n =$	8	
Reinforcing Yield Strength:	$f_y =$	60000	psi
Reinforcing Modulas of Elasticity:	$E_s =$	29000	ksi
Crack Width Parameter:	$\gamma =$	0.75	k/in

Flexure - Crack Control

$f_s =$	33.29	ksi	
$f_c =$	0.91	ksi	
$d_c =$	3.035	in	
$\beta_s =$	1.031		
$s_{max} =$	**9.23**	in	
$s_{prov} =$	~~9.01~~ 6.14"	in	**OK** ✓

Resistance Factors

Flexure and Tension:	$\phi =$	0.90	*
Shear and Torsion:	$\phi =$	0.90	

Shear and Torsion

$A_{cp} =$	20736 in^2		$A_v =$	0.88	in^2
$P_{cp} =$	576 in		$A_t =$	0.44	in^2
$A_{oh} =$	19266 in^2		$p_h =$	555	in
$A_o =$	16376 in^2				
$V_c =$	2511.9 kip				
$\phi V_c =$	2260.7 kip	*No Shear Rein. Reqd.*			
$T_{cr} =$	~~13738~~ kip-ft	*No Torsional Rein. Reqd.*			

Loads

Mu =	22940	k-ft
Ms =	18355	k-ft
Vu =	0.0	kip
Tu =	0.0	kip

Flexure - Strength

Analyze as Doubly Reinforced (Y/N): n

$(A_v/s) =$	0.000	in^2/in/n-legs
$(A_t/s) =$	0.000	in^2/in/leg
	0.00	in^2/in/2legs

Flexural Strength:

$R_n =$	106.89 psi				
$m =$	17.65		$A_sF_y =$	2995200	lb
$\rho =$	0.0018		$a =$	6.12	in
$A_{s\_req} =$	**36.54**	in^2	$\phi M_n =$	**30979**	kip-ft
		OK			**OK**

$s_{req} =$	#DIV/0!	in	
$s_{min} =$	5.80	in	*(AASHTO 5.8.2.5)*
$s_{max\_v} =$	24	in	*(AASHTO 5.8.2.7)*
$s_{max\_t} =$	~~12~~	in	

Minimum Steel:

$R_n =$	171.60	psi	$4/3R_n =$	143	
$m =$	17.65		$m =$	17.65	
$\rho_{min\_1} =$	0.0029		$\rho_{min\_2} =$	0.0024	
$A_{s\_min1} =$	58.87	in^2	$A_{s\_min2} =$	48.72	in^2
					OK

Maximum Steel:

*The maximum steel requirment has been removed. This provision is compensated for by adjusting the reistance factor based on whether the section is tension controlled, compression controlled, or in transistion. A section is tension controlled if c/d <= 0.375 and $\phi = 0.90$)

$c = a/\beta =$	7.20	in
$c/d =$	0.05	**<=0.375, Tension Controlled**

(Use this for single and double reinforcement)

For Cleveland - Pier 11 CJ	Job no. 49633	Sheet no.
Made by LER	Checked by PDB	Backchecked by
Date 10/31/11	Date 11/08/11	Date

HNTB

Shrinkage & Restraint Forces

The time lapse between placement of the first and second pours will result in a differential shrinkage strain, generating internal forces in the two sections in addition to restraint forces due to the continuity between the cap and columns. The magnitude of these forces will be estimated using the CEB-FIP Model Code 1990 and HNTB's proprietary structural analysis software, T187.

Assumptions

1. Assume shrinkage of a pour starts at end of 7-day curring period required by CMS 511.17. Set concrete age to Ø days for pours 1 and 2. Start erection analysis at t = 7 (Day 7).
2. Assume second pour is placed 21 days after first pour. This includes 14 days for concrete to reach 85% of 28-day strength prior to form removal and loading plus 7 days to setting of additional forms, etc. Pour 2 placed at t = 21 (Day 21). Start computing shrinkage of pour 2 at end of 7 day cure period, t = 28 (Day 28).
3. Ignore creep.
4. Assume gross section properties apply (i.e. ignore cracking).
5. The stiffness of the footing will be included.
6. Run the analysis out to t = 75 years (Day 27375) at the following increments:
   - 7 – Activate pour 1 members
   - 14 – Release forms
   - 21.0 – Pre-pour 2
   - 21.1 – Place Pour 2
   - 27.9
   - 28 – Activate Pour 2 members
   - 35
   - 50
   - 100 { 200, 400, 800 }
   - 1600
   - 3200
   - 6400
   - 12800
   - 25600
   - 27375 – End of service (EOS) – 75 years
7. Assume in-service humidity of 70% (Design Criteria II.B.4.b)
8. When calculating volume to surface ratio, the shared surface of the two pours will be excluded throughout the analysis.
9. Construction joint set 8' from bottom of cap beam soffit.

Over →