For Cleveland- RFI 00169	Job no. 49633	Sheet no.
Made by LER	Checked by KDG	Backchecked by LER
Date 12/7/2011	Date 12/8/11	Date 12/9/2011

HNTB

Shear Capacity @ C.J.

Evaluate shear capacity at c.j.

Ensure capacity provided by shear friction equals or exceeds that provided by $V_c + V_s$.

$$\phi V_n = c A_{cv} + \mu (A_{vf} f_y + P_c)$$ ($P_c = 0.0$)

[AASHTO 5.8.4.1]

$$\leq \phi (K_1 f'_c A_{cv}, K_2 A_{cv})$$

Assume roughened surface.

$c = 0.24$ ksi

$\mu = 1.0$

$K_1 = 0.25$

$K_2 = 1.5$ ksi

A_{cv} = area of cap @ c.j.

$= (11.5')(5.4167')(12"/')^2$

$= 8970\ in^2$

A_{vf} = area of long. steel; assume all steel in section is effective in resisting shear

$= 44(1.56\ in^2) + 44(1.56\ in^2) + 6(0.60\ in^2) \times 2$ sides

$= 144.48\ in^2$

$\phi = 0.90$

$$\phi V_n = 0.9[(0.24\ ksi)(8970\ in^2) + 1.0\ (144.48 \times 60\ ksi)]$$

$= 0.90\ [2152.8 + 8668.8]$

$= 9,739$ k

$$\phi V_{n_{max}} = \begin{cases} (1)\ 0.9(0.25)(4.0)(8970) = 8,073\ k \\ (2)\ 0.9(1.5)(8970) = 12,110\ k \end{cases}$$

$\therefore \phi V_{n_f} \leq \underline{8070\ k}$

Calculate shear capacity of a section near c.j. based on $V_c + V_s$.

$\phi = 0.90$

$V_c = 0.0316\beta\sqrt{f'_c}\, b_v d_v$

$V_s = \dfrac{A_v f_y d_v (\cot\theta + \cot\alpha)\sin\alpha}{s}$

For simplified approach, $\beta = 2$, $\theta = 45°$

For vert. stirrups, $\alpha = 90°$

$\therefore V_c = \dfrac{0.0316(2)\sqrt{f'_c}\, b_v d_v}{s}$

$V_s = \dfrac{A_v f_y d_v}{s}$

d_e = [cover] $65" - 2" - 0.875" - 1.41" - \frac{1}{2}(8")$

$= 56.715"$

$d_v = \max(0.9 d_e, 0.72h)$

$= \max(0.9(56.715), 0.72(65"))$

$= (51.0", 46.8")$

$= \underline{51.0\ in}$

For	Cleveland-RFI 001169	Job no.	49633	Sheet no.	
Made by	LER	Checked by	KDG	Backchecked by	LER
Date	12/7/11	Date	12/8/11	Date	12/9/2011

HNTB

$V_c = 0.0316(2)\sqrt{4.0}\,(138")(51")$

$= 889.6\,k$

$A_v = 6(0.60) = 3.6\,in^2$

$s = 7"$ (max)

$V_s = \dfrac{(3.6\,in^2)(60)(51")}{7}$

$= 1573.7\,k$

$\phi V_{c_v} = 0.9(889.6 + 1573.7)$

$= \underline{2217\,k} < \phi V_{c_f}$ ok

The friction capacity at the c.j. exceeds the shear capacity of the beam section, including transverse reinforcement.

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HNTB

Crack Control

To limit crack width at c.j. location, check cap design at c.j. using the more severe crack width parameter of 0.75. (8).

Near the c.j. the min. allowable spacing is ≈ 30" based on $\gamma = 1.0$. Recalculate for $\gamma = 0.75$

$$s \leq \frac{700\gamma}{\beta f_s} - 2d_s$$

$$= \frac{700(0.75)}{1.099(16.85)} - 2(3.88)$$

$$= 20.62 \text{ in} > s_{act} = 12"$$

* The current long. bar spacing of ≈ 12" is sufficient to limit the crack width for class 2 exposure conditions

ME101-1204

The JBH O[illegible]l Pier No.2 Model has been updated with 4-11'-6" X 6'-4" columns and with a 2 – 36[illegible] 18'-0" X 8'-0" footing. EVS only updated the geometry of the columns and footings from JBH's original model per JBH direction.

$S \le \frac{700\gamma}{Bf_s} - 2d_c$

Made By: EVS Date:03/28/11
Checked By: DSB Date:03/29/11

Backchecked By: EVS Date:03/31/11

Girder Load were modified on 5/4/2011. In general Girder Loads reduced. Here just showing that design Results still ok.

Modified By: EVS Date:05/04/11
Checked By: MRI Date:05/05/11

Backchecked By: EVS Date:05/16/11

Pier No. 2 Footing Output (Revised Model with 4 Columns and 2 footings)

1	-1.96	L	FACE	******	******	-390	-2312	19	-1	-62	0	12.5	0.3	19.9	T
1	1.74	L	GIRD	******	******	-643	-2634	60	-16	-144	0	15.5	0.6	18.9	T
1	1.74	R	GIRD	******	******	-643	-2634	60	-16	-144	0	15.5	0.6	18.9	T
1	4.38	R	FACE	******	******	-643	-855	48	-16	-55	0	8.1	0.3	21.3	T
1	9.10	R	D	******	******	-643	2177	114	0	-33	-3	13.8	0.5	19.4	B
1	10.68	L	GIRD	******	******	-643	3151	166	0	-48	-3	17.9	0.7	18.1	B
1	10.68	R	GIRD	******	******	-643	3151	165	0	-49	-3	17.9	0.7	18.1	B
1	12.31	L	GIRD	******	******	-643	3035	137	0	-40	-3	17.4	0.6	18.2	B
1	12.31	R	GIRD	******	******	-643	3035	137	0	-40	-3	17.4	0.6	18.2	B
1	18.32	L	D	******	******	-130	61	55	0	-58	-16	0.6	0.4	23.8	T
1	22.28	L	GIRD	******	******	-130	-1546	46	0	-97	-16	7.3	0.6	21.6	T
1	22.28	R	GIRD	******	******	-130	-1546	46	0	-97	-16	7.3	0.6	21.6	T
1	23.04	L	FACE	******	******	-130	-2007	32	0	-104	-16	9.2	0.6	21.0	T
1	29.38	R	FACE	******	******	0	-3456	66	0	-221	0	14.1	1.0	19.3	T
1	33.36	L	GIRD	******	******	0	-355	1	0	-4	0	1.5	0.0	23.5	T
1	33.36	R	GIRD	******	******	0	-355	1	0	-4	0	1.5	0.0	23.5	T

----- CAP BEAM 1 SERVICEABILITY RESULTS -----

FATIGUE LIMIT STATE DATA:
Notes: All fatigue data is computed from Fatigue Limit State.
Axial tension is negative.
T indicates top bars control; B indicates bottom bars control.
** Dead load values may include effects due to shrinkage, refer to load case data.

CAP NO.	HORZ DIST. (ft)	LOCATION	MAX LOAD CASE	MIN LOAD CASE	FATIGUE DL** AXIAL (kips)	FATIGUE DL** MOMENT (ft-k)	FATIGUE MAX LL MOM (ft-k)	FATIGUE MAX CORRES AXIAL (kips)	FATIGUE MIN LL MOM (ft-k)	FATIGUE MIN CORRES AXIAL (kips)	f MIN (ksi)	ACTUAL RANGE (ksi)	ALLOW RANGE (ksi)	NG	
1	33.45	L	GIRD	******	0	0	-331	0	0	0	0	1.4	0.0	23.6	T
1	33.45	R	GIRD	0	0	0	-331	0	0	0	0	0.0	0.0	0.0	
1	34.10	R	D	0	0	0	-284	0	0	0	0	0.0	0.0	0.0	

DISTRIBUTION OF FLEXURAL REINFORCEMENT DATA:
Note: Reinforcing steel distribution data is based on the maximum area of steel obtained from either Strength Limit State Design, or user defined limits. Moments are based on Service I Limit State.

CAP NO.	HORZ DIST. (ft)	LOCATION	LOAD CASE	FACE	STEEL DISTRIBUTION SERV I AXIAL (kips)	SERV I MOMENT (ft-k)	h (in)	dc (in)	ßs	STRESS fs (ksi)	SPACING ACTUAL (in)	SPACING ALLOW. (in)	NG	
1	-57.60	L	GIRD	704617	TOP	0	-223	60.00	3.88	1.099	0.92	6.2	130.8		
1	-57.60	R	GIRD	967953	TOP	-6	-238	60.00	3.88	1.099	1.02	6.2	130.8		
1	-56.68	L	D	967569	TOP	-5	-566	60.00	3.88	1.099	2.36	6.2	130.8		
1	-55.98	L	GIRD	967569	TOP	-5	-821	60.00	3.88	1.099	3.40	6.2	130.8		
1	-55.98	R	GIRD	887059	TOP	-14	-843	60.00	3.88	1.099	3.56	6.2	130.8		
1	-51.96	L	FACE	887060	TOP	-16	-5151	60.00	3.88	1.099	21.24	6.2	22.2		
1	-47.48	L	GIRD	967628	TOP	187	-5883	60.00	3.88	1.099	22.73	6.2	20.3		
				687125	BOT	-1002	822	60.00	3.88	1.099	11.01	6.2	50.1		
1	-47.48	R	GIRD	967628	TOP	182	5893	60.00	3.88	1.099	22.81	6.2	20.2		
				687125	BOT	-998	831	60.00	3.88	1.099	11.02	6.2	50.0		
1	-45.62	R	FACE	967628	TOP	182	-4399	60.00	3.88	1.099	16.68	6.2	30.4		
				687125	BOT	-998	1376	60.00	3.88	1.099	13.49	6.2	39.5		
1	-40.90	R	D	806552	TOP	136	-1034	60.00	3.88	1.099	3.25	6.2	130.8		
				848163	BOT	-921	2959	60.00	3.88	1.099	19.31	6.2	25.2		
1	-37.36	L	GIRD	888329	BOT	-926	4696	60.00	3.88	1.099	26.40	6.2	16.4		
1	-37.36	R	GIRD	848073	BOT	-926	4700	60.00	3.88	1.099	26.36	6.2	16.4		
1	-34.73	L	GIRD	887076	BOT	-944	5354	60.00	3.88	1.099	29.22	6.2	14.1		
1	-34.73	R	GIRD	889592	BOT	-961	5311	60.00	3.88	1.099	29.17	6.2	14.1		
1	-31.68	L	D	887224	BOT	-973	3045	60.00	3.88	1.099	20.07	6.2	24.0		

← Max Neg. Service Moment

← Max pos. Service Moment

C.J.

1	-29.98	L	GIRD	849419	TOP	-972	1518	60.00	3.88	1.099	0.42	6.2	130.8
				887217	BOT	-966	1854	60.00	3.88	1.099	15.21	6.2	34.1
1	-29.98	R	GIRD	847214	TOP	-975	1353	60.00	3.88	1.099	0.99	6.2	130.8
				887217	BOT	-967	1851	60.00	3.88	1.099	15.21	6.2	34.1
1	-26.96	L	FACE	847214	TOP	-975	-1540	60.00	3.88	1.099	14.01	6.2	37.7
				726040	BOT	-1063	-567	60.00	3.88	1.099	5.19	6.2	115.1
1	-20.62	R	FACE	887262	TOP	-688	-2854	60.00	3.88	1.099	17.03	6.2	29.7
1	-19.41	L	GIRD	887292	TOP	-690	-1862	60.00	3.88	1.099	13.03	6.2	41.1

----- CAP BEAM 1 SERVICEABILITY RESULTS -----

DISTRIBUTION OF FLEXURAL REINFORCEMENT DATA:
Note: Reinforcing steel distribution data is based on the maximum area of steel obtained from either Strength Limit State Design, or user defined limits. Moments are based on Service I Limit State.

CAP NO.	HORZ DIST. (ft)	LOCATION	LOAD CASE	FACE	STEEL DISTRIBUTION SERV I AXIAL (kips)	SERV I MOMENT (ft-k)	h (in)	dc (in)	ßs	STRESS fs (ksi)	SPACING ACTUAL (in)	SPACING ALLOW. (in)	NG	
1	-19.41	R	GIRD	887292	TOP	-692	-1865	60.00	3.88	1.099	13.06	6.2	41.1	
				687251	BOT	-698	-1188	60.00	3.88	1.099	0.08	6.2	130.8	
1	-15.90	R	D	726270	TOP	-698	-253	60.00	3.88	1.099	6.22	6.2	94.6	
				887282	BOT	-677	466	60.00	3.88	1.099	7.03	6.2	82.8	
1	-12.02	L	GIRD	687272	TOP	-708	1097	60.00	3.88	1.099	0.33	6.2	130.8	
				887282	BOT	-677	2833	60.00	3.88	1.099	16.85	6.2	30.1	
1	-12.02	R	GIRD	726270	TOP	-712	1078	60.00	3.88	1.099	0.40	6.2	130.8	
				848283	BOT	-686	2534	60.00	3.88	1.099	15.72	6.2	32.8	
1	-8.82	L	GIRD	684764	TOP	-703	313	60.00	3.88	1.099	3.70	6.2	130.8	
				848283	BOT	-686	1533	60.00	3.88	1.099	11.68	6.2	46.8	
1	-8.82	R	GIRD	684764	TOP	-699	322	60.00	3.88	1.099	3.63	6.2	130.8	
				967793	BOT	206	2879	60.00	3.88	1.099	10.29	6.2	54.2	
1	-6.68	L	D	687290	TOP	-699	-570	60.00	3.88	1.099	7.67	6.2	75.4	
				924982	BOT	-684	0	60.00	3.88	1.099	4.98	6.2	120.2	
1	-1.96	L	FACE	848244	TOP	-691	-3331	60.00	3.88	1.099	18.99	6.2	25.8	
1	1.74	L	GIRD	887350	TOP	-1037	-3752	60.00	3.88	1.099	23.43	6.2	19.4	
1	1.74	R	GIRD	887350	TOP	-1038	-3755	60.00	3.88	1.099	23.46	6.2	19.4	
1	4.38	R	FACE	887318	TOP	-1030	-1156	60.00	3.88	1.099	12.72	6.2	42.3	
				687320	BOT	-1166	-254	60.00	3.88	1.099	7.35	6.2	79.0	
1	9.10	R	D	848362	BOT	-1073	3417	60.00	3.88	1.099	22.37	6.2	20.7	
1	10.68	L	GIRD	847106	BOT	-1070	4829	60.00	3.88	1.099	28.07	6.2	14.9	
1	10.68	R	GIRD	848362	BOT	-1071	4832	60.00	3.88	1.099	28.09	6.2	14.9	
1	12.31	L	GIRD	848318	BOT	-1054	4688	60.00	3.88	1.099	27.37	6.2	15.5	
1	12.31	R	GIRD	848318	BOT	-1049	4699	60.00	3.88	1.099	27.38	6.2	15.5	
1	18.32	L	D	767832	TOP	176	-1138	60.00	3.88	1.099	3.40	6.2	130.8	
				887359	BOT	-1040	2798	60.00	3.88	1.099	19.61	6.2	24.7	
1	22.28	L	GIRD	928888	TOP	214	-3394	60.00	3.88	1.099	12.33	6.2	43.9	
				726339	BOT	-1105	1980	60.00	3.88	1.099	16.84	6.2	30.1	
1	22.28	R	GIRD	928888	TOP	215	-3391	60.00	3.88	1.099	12.31	6.2	44.0	
				726351	BOT	-1083	2005	60.00	3.88	1.099	16.76	6.2	30.3	
1	23.04	L	FACE	928888	TOP	216	-4016	60.00	3.88	1.099	14.87	6.2	35.1	
				726362	BOT	-1113	1672	60.00	3.88	1.099	15.64	6.2	33.0	
1	29.38	R	FACE	928852	TOP	-16	-4689	60.00	3.88	1.099	19.34	6.2	25.2	
1	33.36	L	GIRD	928851	TOP	-14	-402	60.00	3.88	1.099	1.75	6.2	130.8	
1	33.36	R	GIRD	848335	TOP	-6	-382	60.00	3.88	1.099	1.61	6.2	130.8	
1	33.45	L	GIRD	848335	TOP	-5	-343	60.00	3.88	1.099	1.45	6.2	130.8	
1	33.45	R	GIRD	684489	TOP	0	-331	60.00	3.88	1.099	1.36	6.2	130.8	

for $\gamma = 0.75$

$S = \frac{700(0.75)}{(1.099)(16.8)} - 2(3.8)$

$= 20.6''$

$S_{act} \approx 12''$

OK