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HNTB

RFI 204

Design footing and Pedistal to support Masonry Column near Pier 111

From Information Provided By Walsh of the Existing stone column.

The Column is 418" tall (above grade)
This is made of 18 layers of stone Block plus a stone Cap

3rd layer from top = 90" x 72"
10th layer from top = 103" x 82"

Interpolate to find Dimensions of 18th layer at ground line

103 - 90 = 13
82 - 72 = 10

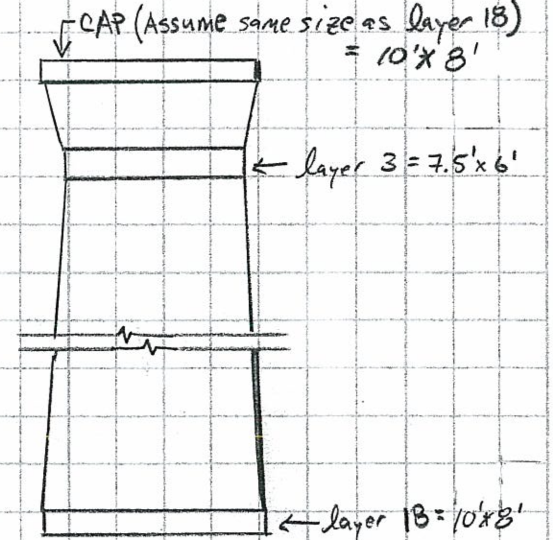
18th layer = 103 + 13 = 116"
82 + 10 = 92"

= 116" x 92"

∴ Say concrete pedistal = 10' x 8'

Assume wt of Stone = 170 pcf

Wt. of Stone Column.



layer 1, 2 and Cap $= 3\left(\frac{22"}{12} \text{tall}\right) \times \frac{(7.5\times6)+(10\times8)}{2}$

Volume 1 = 344 ft^3

layer 3 to 18 $= 16\left(\frac{22"}{12}\right)\frac{(7.5\times6)+(10\times8)}{2}$

Volume 2 = 1833 ft^3

Total Volume = 1833 + 344 = 2,177 ft^3

P_{column} = 2177 ft^3 (170 pcf)
= 370 K

Assume 2' tall Pedistal:

P_{ped} = 2(8x10)(150) = 24 K

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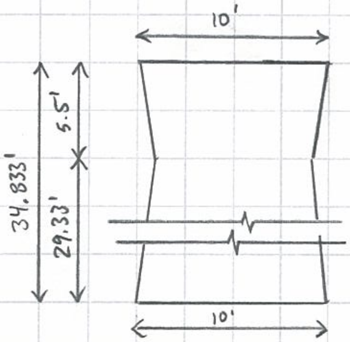
Wind on Masonry Column



Plan

$$Area = \left(\frac{10+7.5}{2}\right)(29.33) + \left(\frac{10+7.5}{2}\right)(5.5) = 305\ ft^2$$

Wind Pressure

From Standard Specifications for Structural Supports for Highway Signs ...
Table 3-7 for 90 mph wind

V_p @ 32.8' = 23.7 psf and V_p @ 41' = 24.8 psf

interpolate:

V_p @ 34.833' = 24.0 psf

use $C_d = 1.2$

$V_p = 24(1.2) = 28.8$ psf

$P_{wind} = 305(28.8) = 8.8\ k$

$M_{wind} = 8.8(34.833 \div 2) = 153.3\ k \cdot ft$

$e_{masonry} = \frac{M}{P} = \frac{153.3}{370} = 0.41' < \frac{L}{6}$ ✓ ok

Footing Design

from Bill Perkins (S&W)

$q_{allow} = 2000$ psf

Assume: 2'-thick footing
bottom of footing is 4' below grade

$q_1 = q_{allow}$ − wt. footing − wt soil Above footing

$q_1 = 2000 - 300 - 240 = 1460\ \#/ft^2$

$$Area\ Req. = \frac{370 + 24 - [2(80)120]}{1.46} = 257\ ft^2$$

Try: 13' x 21' footing

$A = 13 \times 21 = 273\ ft^2$

$P = 370 + 24 + 273(0.15)(2) = 476\ k$

$e = \frac{153.3}{476} = 0.32' < L/6$

$$q_{max} = \frac{P}{A} + \frac{Pey}{I} = \frac{476}{273} + \frac{476(0.32)(13/2)}{\frac{21(13)^3}{12}}$$

$q_{max} = 2.00\ k/ft^2$

✓ ok

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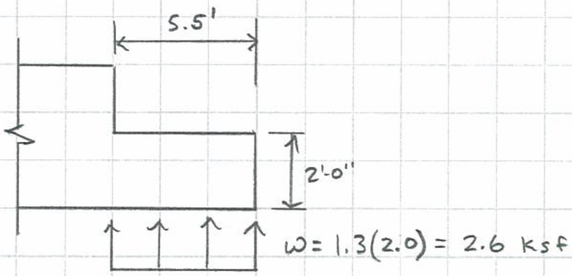
HNTB

Footing Design (cont.)

Bending



$$M_u = \frac{wl^2}{2} = 2.6(5.5)^2\left(\tfrac{1}{2}\right) = 39.3 \text{ k·ft /ft}$$

$$\tfrac{4}{3}M_u = 52.4 \text{ k·ft / ft} \Leftarrow \text{Controls}$$

$$1.2\,M_{cr} = \frac{1.2(7.5)\frac{\sqrt{4000}}{1000}\frac{(12)(24)^3}{12}}{24/2} = 54.6 \tfrac{\text{k·ft}}{\text{ft}}$$

try: #6 @ 9" ; $A_s = 0.59$ in²/ft

$$d = 24 - 3 - {}^{0.75}\!/_2 = 20.625"$$

$$a = \frac{0.59(60)}{0.85(4)(12")} = 0.87"$$

$$\phi M_n = 0.9(0.59)(60)\left(20.625 - \frac{0.87}{2}\right) \div 12 = 53.6 \tfrac{\text{k·ft}}{\text{ft}}$$

$$\phi M_n > \tfrac{4}{3}M_u \quad \checkmark \text{ ok}$$

Distribution

$$M_s = \frac{39.3}{1.3} = 30.2 \text{ k·ft /ft}$$

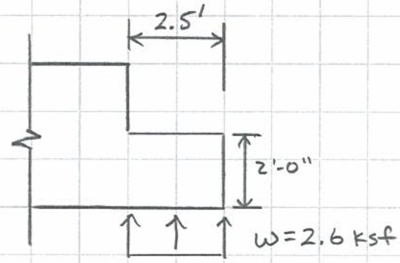
$$S_g = \frac{12(24)^2}{6} = 1152 \text{ in}^3$$

$$f = \frac{M_s}{S_g} = \frac{30.2(12)}{1152} = 0.31 \text{ ksi}$$

$$0.8 f_r = 0.8(0.24)\sqrt{4} = 0.38 \text{ ksi}$$

5.7.3.4 Does not Apply

Spacing OK



$$M_u = 2.6(2.5)^2\left(\tfrac{1}{2}\right) = 8.13 \text{ k·ft /ft}$$

$$\tfrac{4}{3}M_u = 10.8 \text{ k·ft/ft} \Leftarrow \text{Controls}$$

$$1.2\,M_{cr} = 54.6 \text{ k·ft/ft}$$

try: #5 @ 12" ; $A_s = 0.31$ in²/ft

$$d = 24 - 3 - 0.75 - \frac{0.625}{2} = 19.938"$$

$$a = \frac{0.31(60)}{0.85(4)(12")} = 0.46"$$

$$\phi M_n = 0.9(0.31)(60)\left(19.938 - \frac{0.46}{2}\right) \div 12$$

$$\phi M_n = 27.5 \text{ k·ft/ft}$$

$$\phi M_n > \tfrac{4}{3}M_u \quad \checkmark \text{ ok}$$

Distribution

$$M_s = 8.13/1.3 = 6.25 \text{ k·ft/ft}$$

$$S_g = 1152 \text{ in}^3$$

$$f = M_s/S_g = \frac{6.25(12)}{1152} = 0.07 \text{ ksi}$$

$$0.8 f_r = 0.38$$

5.7.3.4 Does not apply

Spacing Ok.

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HNTB

Check Shear : One way

$V_u = 2.55 \text{ ksf} (5') = 12.75 \text{ k/ft}$

$\phi V_c = 0.85(0.0316)(2)\sqrt{4}(12'')(24'')$
$= 30.9 \text{ k/ft}$

$\frac{1}{2}\phi V_c > V_u$
$\therefore$ No Shear Reinforcing needed.

Two way

Pedistal = 8' x 10'
$d_v = 24''$
$b_o = (8'+1')(2) + (10'+1')(2) = 40'$
$\beta_c = 10/8 = 1.25$

$V_n = \left(0.063 + \frac{0.126}{1.25}\right)\sqrt{4}(40' \times 12)(24) \leq 0.126\sqrt{4}(40 \times 12)(24)$

$V_n = 0.126\sqrt{4}(40' \times 12)(24) = 2903 \text{ k}$

$\phi V_n = 0.85(2903) = 2468 \text{ k}$

$2468 \text{ k} > 370 + 24 = 394 \text{ k}$

OK

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For	Cleveland Innerbelt	Job no.	49633	Sheet no.	5
Made by	KDG	Checked by	GDH	Backchecked by	KDG
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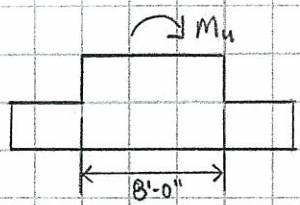
HNTB

Pedistal

$M_{wind} = 261$ k·ft

$M_u = 1.4(261) = 366$ k·ft



$4/3\ M_u = 488$ k-ft

$d = 8(12) - 3'' - 0.5'' - \frac{0.625}{2} = 92.1875''$

$b = 10(12) = 120''$

try: #5 @ 12" ; $A_s = 10(0.31) = 3.1$ in^2

$a = \frac{(3.1)(60)}{0.85(4)(120)} = 0.46''$

$\phi M_n = 0.9(3.1)(60)(92.188 - \frac{0.46}{2}) \div 12$

$\phi M_n = 1283$ k·ft

$\phi M_n > 4/3\ M_u$ ✓ ok

Distribution 5.7.3.4

$M_s = 366$ k·ft

$S_g = \frac{120(96^2)}{6} = 184{,}320$ in^3

$f = \frac{M_s}{S_g} = \frac{366(12)}{184{,}320} = 0.024$ ksi

$0.8 f_r = 0.8(0.24)\sqrt{4} = 0.38$

5.7.3.4 does not apply

Spacing ok

Temp and Shrinkage 5.10.8

$A_s \geq \frac{1.3bh}{2(b+h)f_y} = \frac{1.3(96)(24)}{2(96+24)60} = 0.21$ in^2/ft

0.31 in^2/ft provided ✓ ok

Bearing 5.7.5

$\phi P_n = 0.7(0.85) f'_c A_1 m$

$A_1 = 120 \times 96 = 11{,}520$ in^2

$m = 1$

$\phi P_n = 0.7(0.85)(4)(11520)(1)$

$= 27{,}400$ k

$\phi P_n > P_u$ ✓ ok

Ties 5.10.6.3

use #4 ties @ 12"

ME101-1204

Table 3–7. Effective Velocity Pressures, vp_z, Pa (psf) for Indicated Wind Velocity, m/s (mph)[1]								
Height, m (ft)	38 (85)	40 (90)	45 (100)	49 (110)	54 (120)	58 (130)	63 (140)	67 (150)
5.0 (16.4) or less	873 (18.2)	967 (20.4)	1224 (25.2)	1451 (30.5)	1763 (36.4)	2034 (42.7)	2399 (49.5)	2714 (56.8)
7.5 (24.6)	951 (19.9)	1053 (22.3)	1333 (27.5)	1581 (33.3)	1920 (39.6)	2215 (46.5)	2613 (53.9)	2955 (61.9)
10.0 (32.8)	1010 (21.1)	1119 (23.7)	1416 (29.2)	1679 (35.3)	2040 (42.1)	2353 (49.4)	2776 (57.3)	3140 (65.7)
12.5 (41.0)	1059 (22.1)	1173 (24.8)	1485 (30.6)	1760 (37.0)	2138 (44.1)	2466 (51.7)	2910 (60.0)	3291 (68.9)
15.0 (49.2)	1100 (23.0)	1219 (25.8)	1543 (31.8)	1829 (38.5)	2221 (45.8)	2563 (53.8)	3024 (62.4)	3420 (71.6)
17.5 (57.4)	1136 (23.7)	1259 (26.6)	1594 (32.9)	1889 (39.8)	2295 (47.3)	2647 (55.5)	3123 (64.4)	3533 (73.9)
20.0 (65.6)	1169 (24.4)	1295 (27.4)	1639 (33.8)	1943 (40.9)	2360 (48.7)	2723 (57.1)	3212 (66.2)	3633 (76.1)
22.5 (73.8)	1198 (25.0)	1327 (28.1)	1680 (34.6)	1992 (41.9)	2419 (49.9)	2791 (58.6)	3293 (67.9)	3724 (78.0)
25.0 (82.0)	1225 (25.6)	1357 (28.7)	1718 (35.4)	2037 (42.9)	2474 (51.0)	2854 (59.9)	3367 (69.4)	3808 (79.7)
27.5 (90.2)	1250 (26.1)	1385 (29.3)	1753 (36.1)	2078 (43.7)	2524 (52.0)	2912 (61.1)	3435 (70.8)	3885 (81.3)
30.0 (98.4)	1273 (26.6)	1410 (29.8)	1785 (36.8)	2116 (44.5)	2570 (53.0)	2965 (62.2)	3499 (72.2)	3957 (82.8)
35.0 (114.8)	1315 (27.5)	1457 (30.8)	1844 (38.0)	2186 (46.0)	2655 (54.8)	3063 (64.3)	3614 (74.5)	4088 (85.6)
40.0 (131.2)	1352 (28.3)	1498 (31.7)	1896 (39.1)	2249 (47.3)	2731 (56.3)	3150 (66.1)	3717 (76.7)	4204 (88.0)
45.0 (147.6)	1386 (29.0)	1536 (32.5)	1944 (40.1)	2305 (48.5)	2799 (57.7)	3230 (67.8)	3810 (78.6)	4310 (90.2)
50.0 (164.0)	1417 (29.6)	1571 (33.2)	1988 (41.0)	2357 (49.6)	2862 (59.0)	3302 (69.3)	3896 (80.3)	4406 (92.2)
55.0 (180.5)	1446 (30.2)	1602 (33.9)	2028 (41.8)	2405 (50.6)	2920 (60.2)	3369 (70.7)	3975 (82.0)	4496 (94.1)
60.0 (196.9)	1473 (30.8)	1632 (34.5)	2065 (42.6)	2449 (51.5)	2974 (61.3)	3431 (72.0)	4048 (83.5)	4579 (95.8)
70.0 (229.7)	1521 (31.8)	1686 (35.6)	2134 (44.0)	2530 (53.2)	3072 (63.4)	3544 (74.4)	4182 (86.2)	4730 (99.0)
80.0 (262.5)	1565 (32.7)	1734 (36.7)	2194 (45.3)	2602 (54.8)	3160 (65.2)	3645 (76.5)	4301 (88.7)	4865 (101.8)
90.0 (295.3)	1604 (33.5)	1777 (37.6)	2250 (46.4)	2667 (56.1)	3239 (66.8)	3737 (78.4)	4409 (90.9)	4987 (104.4)
100.0 (328.1)	1640 (34.3)	1817 (38.4)	2300 (47.4)	2727 (57.4)	3312 (68.3)	3821 (80.2)	4508 (93.0)	5099 (106.7)

Notes:
1. $vp_z = 0.613\ K_z\ G\ V^2\ I_r\ C_d$ ($vp_z = 0.00256\ K_z\ G\ V^2\ I_r\ C_d$) for I_r and C_d equal to 1.0, and G = 1.14
2. Effective velocity pressures may be interpolated.

Table 3–6. Wind Drag Coefficients, C_d (see note 1)

Sign Panel (by ratio of length to width)			
L/W = 1.0	1.12		
2.0	1.19		
5.0	1.20		
10.0	1.23		
15.0	1.30		
Traffic Signals (see note 2)	1.2		
Luminaires (with generally rounded surfaces)	0.5		
Luminaires (with rectangular flat side shapes)	1.2		
Elliptical Member	Broadside Facing Wind $1.7\left(\frac{D}{d_o}-1\right)+C_{dD}\left(2-\frac{D}{d_o}\right)$	Narrow Side Facing Wind $C_{dd}\left[1-0.7\left(\frac{D}{d_o}-1\right)^{1/4}\right]$	
Two members or trusses (one in front of other) (all trusses with small solidity ratios) (see note 3)	1.20 (cylindrical) 2.00 (flat)		
Single Member or Truss Member	**$C_vVd \le 5.33$ (39)**	**5.33(39) $< C_vVd <$ 10.66(78)**	**$C_vVd \ge$ 10.66(78)**
Cylindrical	1.10	$\frac{9.69}{(C_vVd)^{1.3}}$ (SI) $\frac{129}{(C_vVd)^{1.3}}$ (U.S. Customary)	0.45
Flat (See note 4)	1.70	1.70	1.70
Hexdecagonal: $0 \le r < 0.26$	1.10	$1.37+1.08r-\frac{C_vVd}{19.8}-\frac{C_vVdr}{4.94}$ (SI) $1.37+1.08r-\frac{C_vVd}{145}-\frac{C_vVdr}{36}$ (U.S. Customary)	**0.83 - 1.08r**
Hexdecagonal: $r \ge 0.26$	1.10	$0.55+\frac{(10.66-C_vVd)}{9.67}$ (SI) $0.55+\frac{(78.2-C_vVd)}{71}$ (U.S. Customary)	0.55
Dodecagonal (see note 5)	1.20	$\frac{3.28}{(C_vVd)^{0.6}}$ (SI) $\frac{10.8}{(C_vVd)^{0.6}}$ (U.S. Customary)	0.79
Octagonal	1.20	1.20	1.20

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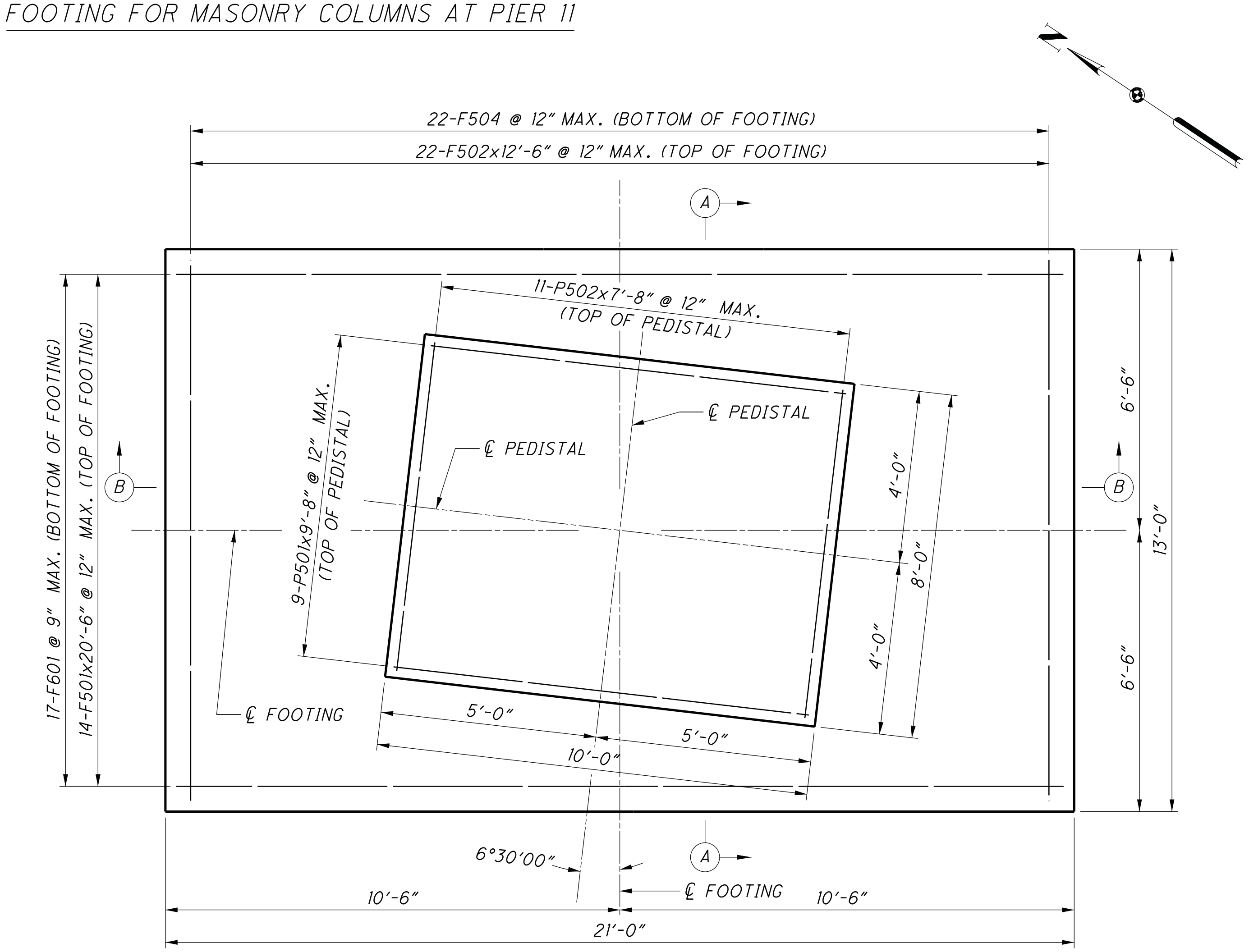
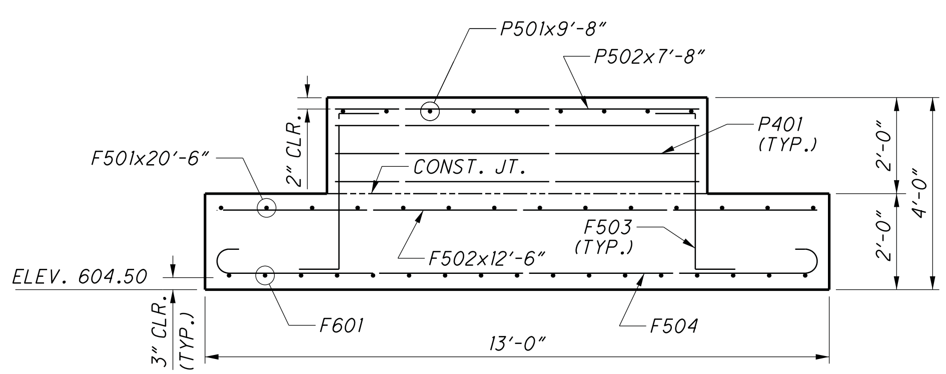
FOOTING FOR MASONRY COLUMNS AT PIER 11



PLAN



SECTION A-A

NOTES:

1. CONCRETE SHALL BE CLASS QSC1 - COMPRESSIVE STRENGTH 4.0 KSI
2. REINFORCNG STEEL SHALL BE ASTM A615 OR A996 GRADE 60, MINIMUM YEILD STRENGTH 60 KSI, EPOXY COATED, AND PER CMS 509.
3. THE MASONRY COLUMN FOOTINGS, AS DESIGNED, PRODUCE A MAXIMUM BEARING PRESSURE OF 2000 POUNDS PER SQUARE FOOT. THE ALLOWABLE BEARING PRESSURE IS 2000 POUNDS PER SQUARE FOOT.

Date:1/12/2012
Model:WorkSheet
File:49633-S-BR-RET01-Unit3.dgn

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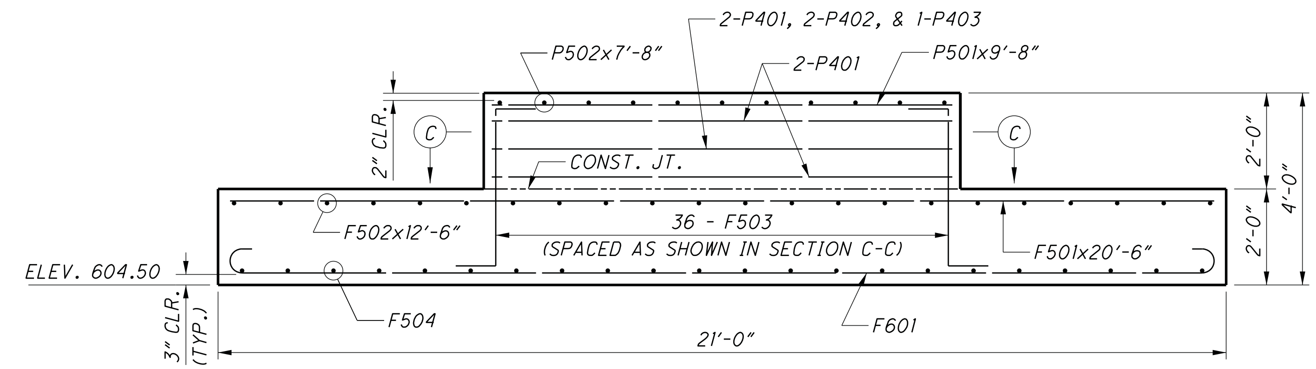
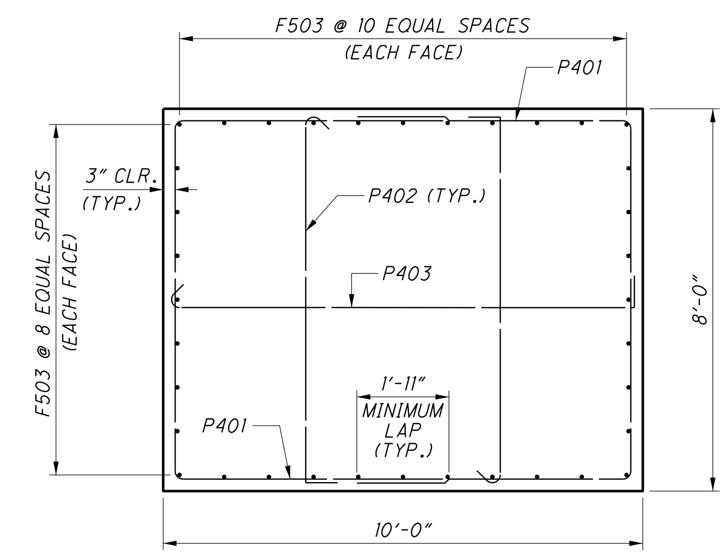
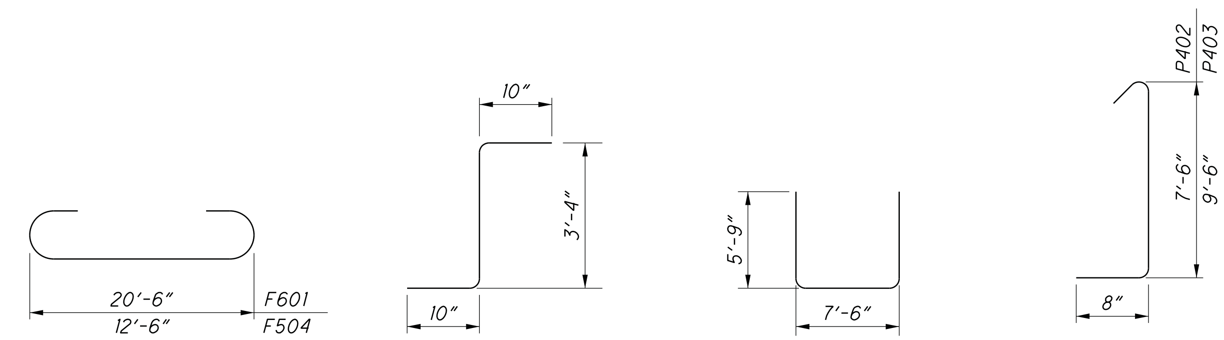
For Cleveland Innerbelt - RFI0204	Backchecked by KDG	Date 01-11-12	



SECTION B-B



SECTION C-C



F601 & F504 F503 P401 P402 & P403

Date:1/12/2012
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