Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	2/22/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Design Summary

Background:

For purposes of this design, the front sign shall refer to the 29'-5" sign with the letters for TREMONT cut out, and the back sign refers to the 35'-5" sign with leaves around the edges.

The front face of the back sign shall be 4' from the front face of the front sign.

Materials:

The front sign and its supports shall be made from 1" thick AISI 304 stainless steel. The front sign anchor bolts shall be ASTM A193 Type B8 stainless steel, which is the same as AISI Type 304 stainless steel.

The back sign shall be made from 1 1/2" thick Cor-Ten A plate weathering steel. The back sign supports shall be made from 1" thick Cor-Ten A plate weathering steel. Cor-Ten A is equivalent to ASTM A242.

References:

AASHTO LRFD Bridge Design Specifications, 6th Edition, 2012

AISC Steel Construction Manual, 13th Edition

Welding of Stainless Steels and Other Joining Methods , produced by AISI, available at:
http://www.ssina.com/download_a_file/weldingbook.pdf

Stainless Steel for Structural Applications Designer Handbook , available at:
http://www.ssina.com/download_a_file/applications.pdf

Information on Cor-Ten Steel found at:
http://www.centralsteelservice.com/faqs.htm

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
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TITLE: Controlling Loads for Reinforcing Designs

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Service Loads

Self Weight - (DC)

	Front Sign	Back Sign
Height	4.00 ft	4.25 ft
Length	28.92 ft	29.42 ft
Area	115.67 sft	154.94 sft
Thickness	1.00 in	1.50 in
Volume	9.64 cft	19.37 cft
Unit Weight	0.49 kcf	0.49 kcf
Weight	4.72 k	9.49 k
Stem Length	29.08 ft	29.58 ft
Stem Width	1.17 ft	1.17 ft
Stem Height	3.00 ft	3.00 ft
Volume	101.79 cft	103.54 cft
Unit Weight	0.15 kcf	0.15 kcf
Weight	15.27 k	15.53 k

Note: The area of the back sign was taken as the area of the rectangle plus 0.4 sf/leaf (from Microstation) plus 10% to account for miscellaneous details such as the stems.

	Footing
Footing Length	29.58 ft
Footing Width	7.50 ft
Footing Depth	1.00 ft
Volume	221.88 cft
Unit Weight	0.15 kcf
Weight	33.28 k

Wind Load - (WS)

P_z	40.00 psf	40.00 psf

AASHTO 3.8.1.2.3

Collision - (CT)

Note:

The sign is not a protective barrier nor is it located within an area of expected collision. Therefore, the collision load is not considered for this design.

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	2/22/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Anchor Bolt Design

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Anchor Bolt Design

Load Combinations & Factors

Service Loads & Moments:

	Front Sign	Back Sign
Sign Weight	0.16 k/ft	0.32 k/ft
Wind Load	40.00 psf/ft	40.00 psf/ft

Use Strength III for maximum moment at base plate

Component	Strength III Factors
DC	0.90
WS (Load)	1.40

Front Sign Anchor Design

	Factored Load	Sign Height	Moment about CL Sign	
Sign Weight	0.15 k/ft	0.00 ft	0.00 kip-ft/ft	Note: Weight and moment of brace
Wind Pressure	56.00 psf/ft	4.00 ft	0.45 kip-ft/ft	are neglected.
		Total Moment	0.45 kip-ft/ft	

Use ASTM A307 Grade C Anchor Bolts per AASHTO 6.4.3.1

Anchor Bolt F_u	58 ksi		AISC 13th Ed. Table 2-5
Anchor Bolt Diameter	0.75 in		
A_{bolt}	0.442 sq in		
Bolt Spacing	4.00 ft		
Number of Bolts per Face	8		

Check Shear (AASHTO 6.13.2.12)

Shear Force	0.22 k/ft		
Shear in Bolt	0.90 k/bolt	= (Shear Force) x (Support Spacing)	
R_n	12.30 k/bolt		AASHTO 6.13.2.12-1
ΦR_n	9.22 k/bolt	For A307 Bolts in Shear, Φ = 0.75	AASHTO 6.5.4.2

OK in Shear

Check Combined Tension and Shear (AASHTO 6.13.2.11 & AASHTO 6.13.2.10)

Dist. CL Sign to CL Bolt	3.00 in		
Moment about CL Sign	0.45 kip-ft/ft		
Force/Foot	1.79 k/ft		
Tension in Bolt	3.58 k/bolt		
P_u/R_n	0.07	< 0.33, Use AASHTO 6.13.2.11-1	
T_n	19.47 k/bolt		AASHTO 6.13.2.11-1
ΦT_n	15.58 k/bolt	For A307 Bolts in Tension, Φ = 0.8	AASHTO 6.5.4.2

OK in Tension

Max bolt spacing = 4 ft

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	2/22/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Anchor Bolt Design

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Back Sign Anchor Design

	Factored Load	Sign Height	Moment about CL Sign
Sign Weight	0.32 k/ft	0.00 ft	0.00 kip-ft/ft
Wind Pressure	56.00 psf/ft	5.27 ft	0.78 kip-ft/ft
		Total Moment	0.78 kip-ft/ft

Use ASTM A307 Grade C Anchor Bolts per AASHTO 6.4.3.1

Anchor Bolt F_u	58 ksi		AISC 13th Ed. Table 2-5
Anchor Bolt Diameter	0.75 in		
A_{bolt}	0.442 sq in		
Bolt Spacing	4.00 ft		
Number of Bolts per Face	8		

Check Shear (AASHTO 6.13.2.12)

Shear Force	0.29 k/ft		
Shear in Bolt	1.18 k/bolt	= (Shear Force) x (Bolt Spacing)	
R_n	12.30 k/bolt		AASHTO 6.13.2.12-1
ΦR_n	9.22 k/bolt	For A307 Bolts in Shear, Φ = 0.75	AASHTO 6.5.4.2

OK in Shear

Check Combined Tension and Shear (AASHTO 6.13.2.11 & AASHTO 6.13.2.10)

Dist. CL Sign to CL Bolt	3.00 in		
Moment about CL Sign	0.78 kip-ft/ft		
Force/Foot	3.11 k/ft		
Tension in Bolt	6.21 k/bolt		
P_u/R_n	0.10	< 0.33, Use AASHTO 6.13.2.11-1	
T_n	19.47 k/bolt		AASHTO 6.13.2.11-1
ΦT_n	15.58 k/bolt	For A307 Bolts in Tension, Φ = 0.8	AASHTO 6.5.4.2

OK in Tension

Max bolt spacing = 4 ft

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	4/9/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Sign Bending Check

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.
NOTE: Outlined cells indicate input for subsequent design.
REFERENCE: AASHTO LRFD 6th Edition, 2012

Front Sign General Information

Steel Type:	AISI 304	Stainless Steel			
f_y =	42 ksi				*Welding of Stainless Steels...* - Table 1
Φf_y	42.0 ksi		For Flexure, Φ =	1.0	AASHTO 6.5.4.2

Check Bending of Steel at Base of Front Sign (assumes no supports)

Sign Thickness, h =	1.00 in	
Length of Sign, b =	12.00 in	Use 1' width for design
y =	0.50 in	
I =	1.00 in^4	
M_u =	0.45 k-ft/ft	
M_u =	5.38 k-in	
σ =	2.69 ksi	< 42 ksi… OKAY

Check Bending of Steel between Supports of Front Sign (assumes no weld to baseplate)

Sign Thickness, h =	1.00 in	
Height of Sign, b =	48.00 in	
y =	0.50 in	
I =	4.00 in^4	
Max. Length b/w Supports, L =	6.0 ft	Note: Supports should be placed to avoid interference with letter cutouts. This
Wind Pressure =	56.0 psf	represents the maximum spacing allowed.
Wind Load, w =	0.22 k/ft	= Wind Pressure x Height of Sign
M_u =	1.01 k-ft	
M_u =	12.10 k-in	
σ =	1.51 ksi	< 42 ksi… OKAY

Back Sign General Information

Steel Type:	ASTM A242	weathering steel equivalent to Cor-Ten A steel			
f_y =	46 ksi				AISC 13th Ed. Table 2-4
Φf_y	46.0 ksi		For Flexure, Φ =	1.0	AASHTO 6.5.4.2

Check Bending of Steel at Base of Back Sign (assumes no supports)

Sign Thickness, h =	1.50 in	
Length of Sign, b =	12.00 in	Use 1' width for design
y =	0.75 in	
I =	3.38 in^4	
M_u =	0.78 k-ft/ft	
M_u =	9.32 k-in	
σ =	2.07 ksi	< 46 ksi… OKAY

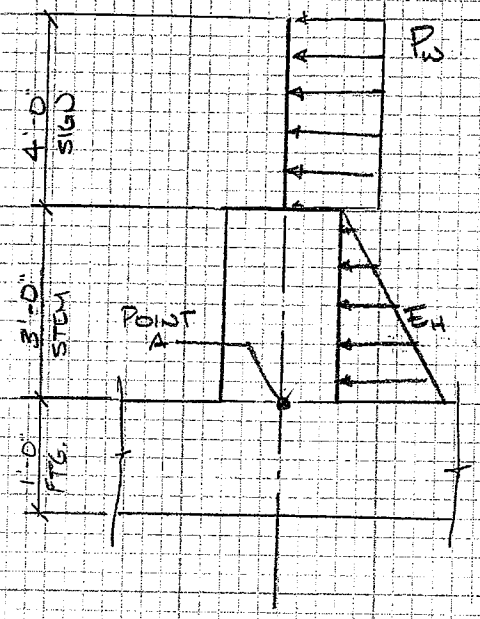
Check Bending of Steel between Supports of Back Sign (assumes no weld to baseplate)

Sign Thickness, h =	1.50 in	
Height of Sign, b =	63.21 in	
y =	0.75 in	
I =	17.78 in^4	
Max. Length b/w Supports, L =	4.25 ft	
Wind Pressure =	56.0 psf	
Wind Load, w =	0.29 k/ft	= Wind Pressure x Height of Sign
M_u =	0.67 k-ft	
M_u =	7.99 k-in	
σ =	0.34 ksi	< 46 ksi… OKAY

Calculations for	INNERBELT TREMONT SIGN	Job No. 49633	Sheet No.
Made by	JRE	Date	2/22/2013
Checked by	ZTW	Date	3/6/13
Backchecked by	JRE	Date	3/11/13

HNTB

REBAR DESIGN MOMENT FOR FRONT SIGN.



VERTICAL LOAD APPLIED THRU A, SO ARM = 0 & M = 0. ONLY MOMENT IS FROM WIND & EARTH PRESSURE

$+\circlearrowleft \Sigma M_A = 0$

$M_A = P_W(4')\left(\frac{4'}{2}+3.0'\right) + E_H\left(\frac{3.0'}{3}\right)$

$M_A = 40psf(4')\left(\frac{4'}{2}+3'\right) + 0.3(120_{pcf})\left(\frac{3^2}{2}\right)$

$M_A = 800 + 180$

$= 0.980\ k\text{-}ft/ft$

FOR STRENGTH III:

$M_u = 1.4(0.8) + 1.5(.18) = \boxed{1.390\ k\text{-}ft}$

$V_u = 1.4\left[(40)(4')\right] + \left[0.3(120)(3.0')\right] \times 1.5 \times 0.5$

$= \boxed{0.314\ k}$

DESIGN MOMENT FOR BACK SIGN

P_W HAS TWO COMPONENTS:

1) WIND ON LEAVES (TOP 3'-9")
2) WIND ON SOLID SIGN (BOT. 4'-3")

$P_{W2} = 40.0$ psf

P_{W1}:

$A_{SOLID} = 4.25(29.42') = 125.0$ SF

$A_{TOTAL} = 8.0(35.67') = 285.3$ SF

$285.3 - 125.0 = 160.3$ SF

$A_{LEAVES} = 154.94 - 125.0 = 29.9$ SF

LEAVES RATIO $= \frac{29.9}{160.3} = 0.187$

$P_{W1} = 40.0 \times 0.187 = 7.48$ psf

$+\circlearrowleft \Sigma M_A = 0$

$P_{W1}(3.75')\left(\frac{3.75'}{2}+4'+3.0\right)$
$+ P_{W2}(4.25')\left(\frac{4.25'}{2}+3.0\right)$
$+ E_H\left(\frac{3^2}{2}\right) = M_A$

$M_A = 7.48(3.75')(8.875') + 40(4.25)(5.125)$
$+ 40\left(\frac{9}{2}\right) = 1.300\ k\text{-}ft/ft$

USE $\boxed{M_A = 1.37\ k\text{-}ft/ft}$ FROM IND. CHECK

FOR STRENGTH III:

$M_u = 1.4(1.12) + 1.5(.18) = 1.838\ k\text{-}ft/ft$

USE $\boxed{M_u = 1.9\ k\text{-}ft/ft}$ FROM IND. CHECK

$V_u = 1.4\left[7.48(3.75) + 40(4.25)\right] + \left[40(3)\right] \times 1.5 \times 0.5$

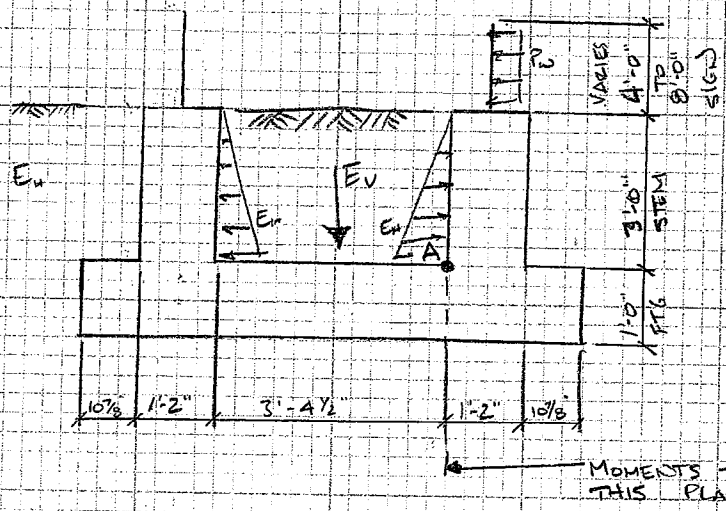
$= \boxed{.39\ k}$

USE BACK SIGN LOADS FOR BOTH STEM DESIGNS.

Calculations for	INTERBELT TREMONT SIGN	Job No. 49633	Sheet No.
Made by	JRE	Date	3/11/2013
Checked by	ZTW	Date	3/12/13
Backchecked by	JRE	Date	3/12/13

HNTB

FOOTING DESIGN LOADS



MOMENTS TAKEN ABOUT THIS PLANE

NOTES:

1) WIND CAN ONLY ACT IN 1 DIRECTION AT A TIME.
2) SIGN WILL BLOCK WIND FROM REACHING OTHER SIGN.
3) ASSUME BACKFILL IS PLACED IN BETWEEN SIGNS FIRST FOR MAX. O.T. IN STEMS & BENDING OF FOOTING.

$\Sigma M_A = 0$

$$M_{PW} + M_{EH} + M_{EV} - M_{EH} + M_A = 0$$

$$M_A = 1.300 - 0.18 + (3'-4\tfrac{1}{2}")\left(\frac{3'-4\frac{1}{2}"}{2}\right)(0.12)(3'-0")$$

M_{EH} - FRONT SIGN
$M_{PW} + M_{EH}$ - BACK SIGN

SERVICE: $M_A = 3.17$ k-ft/ft

$$M_A = 1.4(1.12) + 1.5(.18) - 1.5(.18) + 1.35(2.05)$$

STRENGTH III: $M_A = 4.36$ k-ft/ft

$$V = 1.35(0.12)(3'-4\tfrac{1}{2}")(3'-0")$$

$V = 1.64$ k/ft

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	4/9/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Support Check

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Front Sign Steel Information

Steel Type:	AISI 304	Stainless Steel			
f_y =	42 ksi				*Welding of Stainless Steels...* - Table 1
Φf_y	42.0 ksi		For Flexure, Φ =	1.0	AASHTO 6.5.4.2

Back Sign Steel Information

Steel Type:	ASTM A242	weathering steel equivalent to Cor-Ten A steel			
f_y =	50 ksi				AISC 13th Ed. Table 2-4
Φf_y	50.0 ksi		For Flexure, Φ =	1.0	AASHTO 6.5.4.2

Support Geometry

Length in Plan =	5.25 in	
Thickness =	1.00 in	
y =	2.63 in	
I =	12.06 in^4	

Front Sign

Moment taken about front of sign at baseplate

Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Support Spacing, S =	6.00 ft	
Distributed Wind Load, w =	0.34 k/ft	
Sign Height, L =	4.0 ft	
Overturning Moment, M_u =	2.69 k-ft	
Overturning Moment, M_u =	32.26 k-in	
σ =	7.02 ksi	< 42 ksi… OKAY

Back Sign

Moment taken about front of sign at baseplate

Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Support Spacing, S =	4.25 ft	
Distributed Wind Load, w =	0.24 k/ft	
Sign Height, L =	5.27 ft	
Overturning Moment, M_u =	3.30 k-ft	
Overturning Moment, M_u =	39.62 k-in	
σ =	8.62 ksi	< 50 ksi… OKAY

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	4/9/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Welding Check

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.
NOTE: Outlined cells indicate input for subsequent design.
REFERENCE: AASHTO LRFD 6th Edition, 2012

Front Sign Steel Information

Steel Type:	AISI 304	Stainless Steel			*Welding of Stainless Steels...* - Table 1
F_{exx} =	42 ksi		Φ_{e2} =	0.8	AASHTO 6.5.4.2
R_r =	20.2 ksi	AASHTO 6.13.3.2.4b-1			

Back Sign Steel Information

Steel Type:	ASTM A242	weathering steel equivalent to Cor-Ten A steel			AISC 13th Ed. Table 2-4
F_{exx} =	50 ksi		Φ_{e2} =	0.8	AASHTO 6.5.4.2
R_r =	24.0 ksi	AASHTO 6.13.3.2.4b-1			

Weld Between Support and Base Plate

Front Sign

Fillet Leg Thickness =	0.625 in	
Effective Throat, t =	0.4419 in	
Weld Length, L =	4.75 in	
Weld Area =	4.20 sq in	= t * L * 2 Faces
I_{Weld} =	7.89 in^4	= t * L^3 / 12 * 2 Faces
y =	2.375 in	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Brace Spacing, S =	6.00 ft	
Distributed Wind Load, w =	0.34 k/ft	
Sign Height, L =	4.0 ft	
Shear, V_u =	1.34 k	
Shear Stress, σ_V =	0.32 ksi	
Overturning Moment, M_u =	32.26 k-in	(From Stiffener Check)
Bending Stress, σ_B =	9.70 ksi	
Resultant Stress, σ =	9.71 ksi	< 20.16 ksi… OKAY

Back Sign

Fillet Leg Thickness =	0.625 in	
Effective Throat, t =	0.4419 in	
Weld Length, L =	4.75 in	
Weld Area =	4.20 sq in	= t * L * 2 Faces
I_{Weld} =	7.89 in^4	= t * L^3 / 12 * 2 Faces
y =	2.375 in	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Support Spacing, S =	4.25 ft	
Distributed Wind Load, w =	0.24 k/ft	
Sign Height, L =	5.27 ft	
Shear, V_u =	1.25 k	
Shear Stress, σ_V =	0.30 ksi	
Overturning Moment, M_u =	39.62 k-in	(From Stiffener Check)
Bending Stress, σ_B =	11.92 ksi	
Resultant Stress, σ =	11.92 ksi	< 24 ksi… OKAY

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	4/9/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Welding Check

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Weld Between Sign and Base Plate

Front Sign

Fillet Leg Thickness =	0.3125 in	
Effective Throat, t =	0.221 in	
Weld Length, L =	12.00 in	(Assume 1' Design Section)
Weld Area =	5.30 sq in	= t * L * 2 Faces
I_{Weld} =	1.00 in^4	= L * t^3 / 12 + A * d^2
y =	0.6105 in	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Design Width =	1.00 ft	
Distributed Wind Load, w =	0.06 k/ft	
Sign Height, L =	4.0 ft	
Shear, V_u =	0.22 k	
Shear Stress, σ_V =	0.04 ksi	
Overturning Moment, M_u =	5.38 k-in	= V * L/2
Bending Stress, σ_B =	3.29 ksi	= M * y / I
Resultant Stress, σ =	3.29 ksi	< 20.16 ksi… OKAY

Back Sign

Fillet Leg Thickness =	0.3125 in	
Effective Throat, t =	0.221 in	
Weld Length, L =	12.00 in	
Weld Area =	5.30 sq in	= t * L * 2 Faces
I_{Weld} =	1.97 in^4	= L * t^3 / 12 + A * d^2
y =	0.8605 in	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Design Width =	1.00 ft	
Distributed Wind Load, w =	0.06 k/ft	
Sign Height, L =	5.27 ft	
Shear, V_u =	0.29 k	
Shear Stress, σ_V =	0.06 ksi	
Overturning Moment, M_u =	9.32 k-in	= V * L/2
Bending Stress, σ_B =	4.06 ksi	= M * y / I
Resultant Stress, σ =	4.06 ksi	< 24 ksi… OKAY

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	4/24/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

TITLE: Deflection Check

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

NOTE: Outlined cells indicate input for subsequent design.

REFERENCE: AASHTO LRFD 6th Edition, 2012

Back Sign Steel Information

Steel Type:	ASTM A242	weathering steel equivalent to Cor-Ten A steel		AISC 13th Ed. Table 2-4
f_y =	50 ksi		Φ_{e2} = 0.8	AASHTO 6.5.4.2
R_r =	24.0 ksi	AASHTO 6.13.3.2.4b-1		

Front Sign Deflection

Treat support as cantilevered beam subject to uniform distributed load. Assume sign provides no resistance to bending.

Steel Type:	AISI 304	Stainless Steel
Modulus of Elasticity, E :	29000 ksi	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Support Spacing, S =	6.00 ft	
Distributed Wind Load =	0.34 k/ft	
Distributed Wind Load, w =	0.028 k/in	
Support Height =	3.75 ft	
Support Height =	45.00 in	
Support Length, h =	5.25 in	
Support Thickness, b =	1.00 in	
I =	12.06 in^4	
δ =	0.041 in	Deflection is negligible

Back Sign Deflection

Treat support as cantilevered beam subject to uniform distributed load. Assume sign provides no resistance to bending.

Steel Type:	ASTM A242	weathering steel equivalent to Cor-Ten A steel
Modulus of Elasticity, E :	29000 ksi	
Wind Pressure =	56.00 psf	(From Sign Bending between Supports Calculations)
Support Spacing, S =	4.25 ft	
Distributed Wind Load =	0.24 k/ft	
Distributed Wind Load, w =	0.020 k/in	
Support Height =	3.75 ft	
Support Height =	45.00 in	
Support Length, h =	5.25 in	
Support Thickness, b =	1.00 in	
I =	12.06 in^4	
δ =	0.029 in	Deflection is negligible

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	2/22/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

HNTB

TITLE: Stem Vertical Reinforcing Design

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

REFERENCE: 2012 AASHTO LRFD 5.7 & 5.8, 6th Ed.

Height, h =	14.00 in	(Thickness of Stem)	Clear Cover, C_v =	2.00 in
Width, b =	12.00 in		Stirrup Size =	None
Number of Bars in Row 1 =	1.00	#4 bar	Vertical Row Spacing =	0.00 in
Number of Bars in Row 2 =	0	#4 bar	f_y =	60 ksi
Number of Bars in Row 3 =	0	#4 bar	f'_c =	4.0 ksi
Number of Bars in Row 4 =	0	#4 bar		7.56
Service Moment, M_{SL} =	1.37 k-ft		Factored Moment, M_u =	1.90 k-ft

REINFORCEMENT DESIGN

Minimum Reinforcement

AASHTO 5.7.3.3.2

$1.2M_{cr} = 1.2\ (0.37\ \sqrt{f'_c})\ 1/6\ b\ h^2$ = 29.0 k-ft

Maximum Reinforcement

This criteria was eliminated in 2005 interims, see Commentary in Section 5.7.3.3

Moment Capacity

AASHTO 5.7.3.2.2

Design Moment, M_{Design} =	2.5 k-ft	
Area of Steel, A_s =	0.20 in^2	
Centroid of Reinforcement, C_R =	2.250 in	
Effective Depth, $d_e = h - C_v$ - Stirrup Bar - C_R =	11.750 in	
$a = (A_s f_y) / (0.85 f'_c b)$ =	0.294 in	AASHTO 5.7.2.2
$\phi M_n = 0.9 A_s f_y (d_e - a/2)$ =	10.4 k-ft	**O.K., 2.5 k-ft <= 10.4 k-ft**

Service Load Check: Crack Control

AASHTO 5.7.3.4

$r = A_s / b d_e$ =	0.00142	
$k = (2 n \rho + (n \rho)^2)^{0.5} - n \rho$ =	0.136	
$j = 1 - k/3$ =	0.955	
$f_s = M_{SL}$ (12in/ft) / (A_s j d_e) =	7.33 ksi	
Exposure Factor, γ_e =	1.00 k/in	
$d_c = C_V$ + Stirrup Bar + d_{bar} / 2 =	2.25 in	
Strain Ratio, $\beta_s = 1 + d_c / [0.7\ (h - d_c)]$ =	1.274	
Spacing Limit, $s_{max} = (700\ \gamma_e / \beta_s f_s) - 2\ d_c$ =	70.50 in	Eq'n (5.7.3.4-1)
Actual Spacing =	12.00 in	**OK! < Max spa**

Shear Design:

AASHTO 5.8

V_u =	0.39 kips			
Stirrup Size =	None			
No. Legs =	0			
d_v = Greater of 0.9d_e, 0.72 h, or (d_e - a/2) =	11.603 in	Eq'n (5.8.2.9-1)		
b =	2.0	AASHTO 5.8.3.4.1		
$\phi V_c = 0.9\ (0.0316)\ b\ \sqrt{f'_c}\ b\ d_v$ =	15.84 kips	Eq'n (5.8.3.3-3)		
$V_{s,Req'd}$ =	0.00 kips			
v_c =	0.00 ksi			
s =	N/A	Eq'ns (5.8.2.5-1) & (5.8.3.3-4)	Req'd Spacing =	0.00 in
s_{max} =	N/A	AASHTO 5.8.2.7	Actual Spacing =	0.00 in **OK**

Calculations For	Innerbelt Tremont Sign	Job No.	49633	Sheet No.
Made by	JRE	Date	2/22/2013	
Checked by	ZTW	Date	3/5/2013	
Backchecked by	JRE	Date	3/11/2013	

HNTB

TITLE: Footing Reinforcing Design

NOTE: Input data is denoted by shading. All other values are calculations performed by the spreadsheet.

REFERENCE: 2012 AASHTO LRFD 5.7 & 5.8, 6th Ed.

Height, h =	12.00 in	(Thickness of Footing)	Clear Cover, C_v =	3.00 in
Width, b =	12.00 in		Stirrup Size =	None
Number of Bars in Row 1 =	1.00	#4 bar	Vertical Row Spacing =	0.00 in
Number of Bars in Row 2 =	0	#4 bar	f_y =	60 ksi
Number of Bars in Row 3 =	0	#4 bar	f'_c =	4.0 ksi
Number of Bars in Row 4 =	0	#4 bar		7.56
Service Moment, M_{SL} =	3.17 k-ft		Factored Moment, M_u =	4.36 k-ft

REINFORCEMENT DESIGN

Minimum Reinforcement

AASHTO 5.7.3.3.2

$1.2M_{cr} = 1.2\ (0.37\ \sqrt{f'_c})\ 1/6\ b\ h^2$ = 21.3 k-ft

Maximum Reinforcement

This criteria was eliminated in 2005 interims, see Commentary in Section 5.7.3.3

Moment Capacity

AASHTO 5.7.3.2.2

Design Moment, M_{Design} =	5.8 k-ft	
Area of Steel, A_s =	0.20 in^2	
Centroid of Reinforcement, C_R =	3.250 in	
Effective Depth, $d_e = h - C_v$ - Stirrup Bar - C_R =	8.750 in	
$a = (A_s f_y) / (0.85 f'_c b)$ =	0.294 in	AASHTO 5.7.2.2
$\phi M_n = 0.9 A_s f_y (d_e - a/2)$ =	7.7 k-ft	**O.K., 5.8 k-ft <= 7.7 k-ft**

Service Load Check: Crack Control

AASHTO 5.7.3.4

$r = A_s / b d_e$ =	0.00190	
$k = (2 n \rho + (n \rho)^2)^{0.5} - n \rho$ =	0.156	
$j = 1 - k/3$ =	0.948	
$f_s = M_{SL}$ (12in/ft) / (A_s j d_e) =	22.93 ksi	
Exposure Factor, γ_e =	1.00 k/in	
$d_c = C_V$ + Stirrup Bar + d_{bar} / 2 =	3.25 in	
Strain Ratio, $\beta_s = 1 + d_c / [0.7\ (h - d_c)]$ =	1.531	
Spacing Limit, $s_{max} = (700\ \gamma_e / \beta_s f_s) - 2 d_c$ =	13.45 in	Eq'n (5.7.3.4-1)
Actual Spacing =	12.00 in	**OK! < Max spa**

Shear Design:

AASHTO 5.8

V_u =	1.64 kips	
Stirrup Size =	None	
No. Legs =	0	
d_v = Greater of 0.9d_e, 0.72 h, or (d_e - a/2) =	8.640 in	Eq'n (5.8.2.9-1)
b =	2.0	AASHTO 5.8.3.4.1
$\phi V_c = 0.9\ (0.0316)\ b\ \sqrt{f'_c}\ b\ d_v$ =	11.79 kips	Eq'n (5.8.3.3-3)
$V_{s,Req'd}$ =	0.00 kips	
v_c =	0.02 ksi	
s =	N/A	Eq'ns (5.8.2.5-1) & (5.8.3.3-4)
s_{max} =	N/A	AASHTO 5.8.2.7

Req'd Spacing = 0.00 in

Actual Spacing = 0.00 in **OK**