



The HNTB Companies
Engineers Architects Planners

For **Cleveland InnerBelt : Field Splice - Node 5233**

N:\49633\Bridges\Design\Final Design\Unit 2\NDC65_MODEL\RFI\is[Field Splice_2013-07-22.xlsm]Type F

Made	SAE	Date	8/5/2011	Job Number	49633	Revised	DJG	Date	10/3/2012
Checked	WME	Date	8/5/2011	Sheet No.		Checked	SJL	Date	10/11/2012
Backchk'd	SAE	Date	8/5/2011			Backchk'd	DJG	Date	10/11/2011

Field Splice - Node 5233

Node 5233

For RFI 450

Updated	SJL	Date	6/6/2013	Updated	VWR	Date	7/22/2013
Checked	MM	Date	6/10/2013	Checked	HRH	Date	8/2/2013
Backchk'd	SJL	Date	6/11/2011	Backchk'd	VWR	Date	8/2/2013

For RFI 450-1

Resistance Factors (6.5.4.2)

φf	1.00
φv	1.00
φc	0.90
φu	0.80
φy	0.95
φbb	0.80
φs	0.80
φbs	0.80
φvu	0.80

A325 Bolt

Dia. (in)	1.0
A (in ²)	0.79
Fub (ksi)	120
Hole (in)	1.19 (6.13.2.4.2-1)
No. Bolt	
TF	88
Web	145
BF	64

Notes:

For RFI 450-1, the web splice and pertinent web splice input was updated. In the field, 1.125 in. dia. bolts were used in select locations the web splice where holes were reamed to 1.1875 in. dia. With a 1.125 in. bolt, Fub is reduced from 120 ksi to 105 ksi (13% reduction) but the area of the bolt is increased by 27%. Therefore using 1 in. dia. bolts and 1.1875 in. holes in this worksheet will be conservative. Flange splices were not re-evaluated.

For RFI 450-1, there was no noticeable shift in the hole location. Values computed in the geometry worksheet were changed back to the original design (i.e. changes from RFI 450 were un-done).

Determine Controlling Section

Section	Top Flange			Bottom Flange			Web	
	Area	φf Fnc	A*Fnc	Area	φf Fnc	A*Fnc	Fyw	A*Fyw
5233 L	88.00	50.00	4400.00	88.00	50.00	4400.00	50.00	4800.00
5233 R	94.50	50.00	4725.00	94.50	50.00	4725.00	50.00	4800.00

Rh = 1.00

Controlling Section = 5233 L

Section and Material Properties

Girder Section		b (in)	t (in)	L (in)	Ag (in ²)	An (in ²)	Ae (in ²)	Fy (ksi)	Fu (ksi)
Splice Plates	TF	32.00	2.75	---	88.00	61.88	67.74	50	65
	Web	96.00	1.00	---	96.00	61.56	---	50	65
	BF	32.00	2.75	---	88.00	61.88	67.74	50	65
	TF Outside	32.00	1.500	68.50	48.00	33.75	---	50	65
	TF Inside	14.50	1.750	68.50	50.75	34.13	---	50	65
	BF Inside	14.50	1.375	50.50	39.88	26.81	---	50	65
	BF Outside	32.00	1.250	50.50	40.00	28.13	---	50	65
Web	89.00	0.875	32.50	155.75	95.48	---	50	65	



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For	Made	SAE	Date	8/5/2011	Job Number	49633	Revised	DJG	Date	10/3/2012
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Cleveland InnerBelt : Field Splice - Node 5233

Flange Design Forces Strength I-V (6.13.6.1.4c)

	MAX FX		MIN FX		MAX FY		MIN FY		MAX MY		MIN MY		MAX MZ		MIN MZ	
	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
f (ksi)	1.52	1.65	-9.38	10.35	-7.12	5.45	11.23	-8.50	2.05	-3.85	-8.85	9.99	-12.12	21.38	11.51	-15.46
φ Fnc (ksi)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	47.27	50.00	50.00	50.00	50.00	50.00	47.37
f / φ Fnc	0.03	0.03	0.19	0.21	0.14	0.11	0.22	0.17	0.04	0.08	0.18	0.20	0.24	0.43	0.23	0.33
α	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	0.95
f _{cf} (ksi)	1.65	1.65	10.35	10.35	-7.12	5.45	11.23	11.23	2.05	-3.85	-8.85	9.99	-12.12	21.38	11.51	-15.46
F _{cf} (ksi)	37.50	37.50	37.50	37.50	-37.50	37.50	37.50	37.50	9.20	-35.45	3.75	37.50	1.75	37.50	2.30	-35.53
F _{cf} (kip)	2540.13	2540.13	-9.38	2540.13	-3300.00	2540.13	2540.13	2540.13	2540.13	-3119.59	-8.85	2540.13	-37.50	2540.13	37.50	-3126.32
f _{ncf} (ksi)	1.52	1.52	3.62	3.62	-3300.00	2540.13	-3300.00	-3300.00	2.05	-3119.59	-8.85	2540.13	-12.12	2540.13	11.51	-15.46
R _{cf}	22.68	22.68	3.62	3.62	-3300.00	2540.13	-3300.00	-3300.00	9.20	-35.45	3.75	37.50	1.75	37.50	2.30	-35.53
F _{ncf} (ksi)	37.50	37.50	-37.50	37.50	-3300.00	2540.13	-3300.00	-3300.00	37.50	-37.50	-37.50	37.50	-37.50	37.50	37.50	-35.53
F _{ncf} (kip)	2540.13	2540.13	-3300.00	2540.13	-3300.00	2540.13	-3300.00	-3300.00	2540.13	-3300.00	-3300.00	2540.13	-3300.00	2540.13	2540.13	-3126.32

Flange Design Forces - Service II (6.13.6.1.4c)

	MAX FX		MIN FX		MAX FY		MIN FY		MAX MY		MIN MY		MAX MZ		MIN MZ	
	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
f (ksi)	-3.22	1.51	-6.93	7.52	-5.29	4.04	8.14	-6.31	-2.64	-1.94	-6.55	7.26	-8.82	15.29	0.98	-9.20
F _s (ksi)	-3.22	1.51	-6.93	7.52	-5.29	4.04	8.14	-6.31	-2.64	-1.94	-6.55	7.26	-8.82	15.29	0.98	-9.20
F _s (kip)	-283.73	132.59	-609.44	661.73	-465.40	355.43	716.60	-554.93	-232.07	-171.05	-576.76	639.13	-776.49	1345.91	85.95	-809.96

Max Flange Design Forces

Pu	Strength I		Service II	
	TF	BF	TF	BF
Tension	2540.13	2540.13	85.95	1345.91
Comp	3300.00	3126.32	776.49	809.96

φ_vV_n (kip) = 1375.39
e_v (in) = 8.25

Web Design Forces (6.13.6.1.4b)

	MAX FX		MIN FX		MAX FY		MIN FY		MAX MY		MIN MY		MAX MZ		MIN MZ	
	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF	TF	BF
V _u (kip)	436.02	628.15	832.44	184.75	494.44	620.79	491.39	479.10	320.09	450.13	600.17	136.85	361.36	444.93	350.52	353.50
V _{uw} (kip)	654.03	942.23	1103.91	277.12	741.66	931.19	737.08	718.65	---	---	---	---	---	---	---	---
M _v (k*ft)	449.65	647.78	758.94	190.52	509.89	640.19	506.74	494.07	220.06	309.46	412.61	94.09	248.44	305.89	240.98	243.03
H _w (kip)	3451.30	168.82	-422.39	437.46	-797.80	204.18	779.49	779.49	-82.44	28.52	-59.99	88.18	-219.88	34.02	310.59	-394.91
M _w (k*ft)	198.26	4574.91	4236.81	4216.72	3473.85	4527.76	3967.19	3760.69	302.77	924.48	596.97	924.75	44.38	884.28	1543.56	651.57
M _u (k*ft)	647.91	5222.69	4995.75	4407.24	3983.74	5167.95	4473.94	4254.76	522.83	1233.95	1009.58	1018.84	292.82	1190.17	1784.55	894.61

Note: M_u = M_{uw} + M_v



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Web Bolt Force

	Strength I										Service II									
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MZ	MAX MZ	MIN MY	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ			
PX1 (Huw)	23.80	1.16	2.91	3.02	5.50	1.41	5.38	3.00	0.57	0.20	0.41	0.61	1.52	0.23	2.14	2.72				
PY1 (VuW)	4.51	6.50	7.61	1.91	5.11	6.42	4.96	5.08	2.21	3.10	4.14	0.94	2.49	3.07	2.42	2.44				
PX2 (Mu)	3.48	28.01	26.80	23.64	21.37	27.72	22.82	24.00	2.80	6.62	5.42	5.47	1.57	6.38	9.57	4.80				
PY2 (Mu)	0.50	4.00	3.83	3.38	3.05	3.96	3.26	3.43	0.40	0.95	0.77	0.78	0.22	0.91	1.37	0.69				
Pu (kip)	27.73	31.01	31.84	27.18	28.08	30.92	29.37	28.31	4.26	7.93	7.62	6.31	4.11	7.72	12.31	8.14				

Note: $P_u = \sqrt{(P_{X1} + P_{X2})^2 + (P_{Y1} + P_{Y2})^2}$

Splice Plate Design

Flange Splice Plates in Tension (6.13.5.2)

	Pu (kip)	Pry (kip)	Pru (kip)	Avg (in2)	Avn (in2)	Atn (in2)	Ptbs (kip)	Rr (kip)	Check
TF Outside	1234.70	2280.00	1755.00	96.00	58.59	29.53	3302.81	1755.00	OK
TF Inside	1305.43	2410.63	1774.50	224.00	136.72	24.28	5386.06	1774.50	OK
BF Inside	1268.08	1894.06	1394.25	126.50	77.52	19.08	3329.93	1394.25	OK
BF Outside	1272.05	1900.00	1462.50	57.50	35.23	24.61	2342.36	1462.50	OK

Tension Plate Parameters

U	1.0
Rp	1.0
Ubs	1.0

assumed drilled holes

Flange Splice Plates in Compression (6.13.6.1.4c)

	Pu (kip)	Rr (kip)	Check
TF Outside	1604.05	2160.00	OK
TF Inside	1695.95	2283.75	OK
BF Inside	1560.72	1794.38	OK
BF Outside	1565.61	1800.00	OK

Web Splice Plates in Axial Flexure (6.13.6.1.4b)

	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
Stress (ksi)	25.52	28.21	28.66	25.70	25.81	28.15	27.10	26.03
Check	OK	OK	OK	OK	OK	OK	OK	OK

S (in3) = 2310.3

Web Splice Plates in Shear (6.13.5.3)

	Vu (kip)	Check
Vu (kip)	1103.91	
Rr (kip)	2879.81	
Check	OK	



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Splice Bolt Design

Shear Resistance (6.13.2.7 & 6.13.6.1.5)

Ns = 1

	Fill PI (in)	R	L Factor	Rr (kip)
TF	0.50	0.87	1.0	31.37
Web	0.00	1.00	1.0	36.19
BF	0.50	0.86	1.0	31.02

Slip Resistance (6.13.2.8)

	Kh	Ks	Ns	Pt	Rr
	1.0	0.33	1.0	51.0	16.83

(Class A)

Flange Bolt

	Shear Resistance			Slip Resistance		
	Pu (kip)	Pu/Bolt	Check	Ps	Ps/Bolt	Check
TF	1695.95	19.27	OK	399.06	4.53	OK
BF	1565.61	24.46	OK	674.01	10.53	OK

Web Bolt

	Shear Resistance			Slip Resistance		
	Pu (dbl)	Pu (sngl)	Check	Ps (dbl)	Ps (sngl)	Check
	31.84	15.92	OK	12.31	6.16	OK

	Bearing Resistance (6.13.2.9)			
	Pu	Pu/Bolt	Lc	Rr (kip)
TF Outside	1604.05	18.23	1.41	131.63
TF	3300.00	37.50	1.41	241.31
TF Inside	1695.95	19.27	1.41	153.56
BF Inside	1560.72	24.39	1.41	120.66
BF	3126.32	48.85	1.41	241.31
BF Outside	1565.61	24.46	1.41	109.69

	Bearing Resistance (6.13.2.9)			
	Pu/Bolt	Lc	Rr (kip)	Check
Web	31.84	1.41	87.75	OK
Web SPL	15.92	1.41	76.78	OK

Design Factor of Safety Summary

Plate	Tension	Comp
TF Outside	1.42	1.35
TF Inside	1.36	1.35
BF Inside	1.10	1.15
BF Outside	1.15	1.15

Bolt	Shear	Slip	Bearing
TF	1.63	3.71	6.44
Web	2.27	2.73	2.76
BF	1.27	1.60	4.48

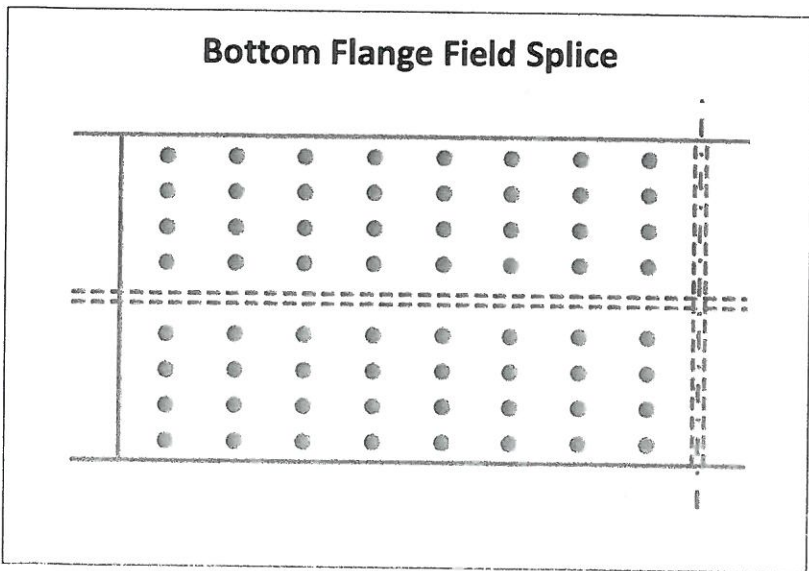
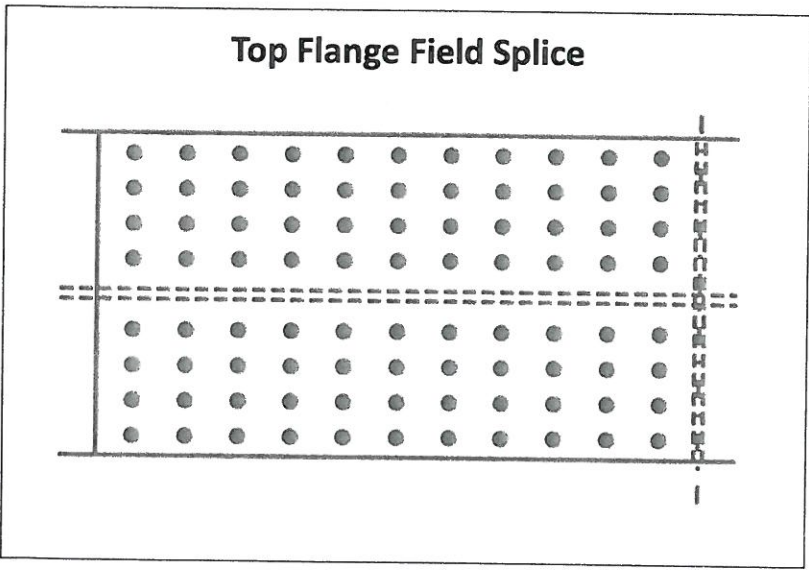
Plate	Shear	Flexure
Web	2.61	1.74

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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Flange Bolt Pattern - Node 5233	Revised	DJG	Date	10/3/2012	Revised	VWR	Date	7/22/2013
	Checked	SJL	Date	10/11/2012	Checked	HRH	Date	8-2-13
	Backchk'd	DJG	Date	10/11/2011	Backchk'd	VWR	Date	8-2-13
	Revised	SJL	Date	6/6/2013				
	Checked	MM	Date	6/10/2013				
TF Bolt Coordinates (in)	BF Bolt Coordinates (in)	Backchk'd	SJL	Date	6/11/2011			

x (long)	y (trans)	x (long)	y (trans)
0	0	0	0
0	3.5	0	3.5
0	7	0	7
0	10.5	0	10.5
0	17.5	0	17.5
0	21	0	21
0	24.5	0	24.5
0	28	0	28
3	0	3	0
3	3.5	3	3.5
3	7	3	7
3	10.5	3	10.5
3	17.5	3	17.5
3	21	3	21
3	24.5	3	24.5
3	28	3	28
6	0	6	0
6	3.5	6	3.5
6	7	6	7
6	10.5	6	10.5
6	17.5	6	17.5
6	21	6	21
6	24.5	6	24.5
6	28	6	28
9	0	9	0
9	3.5	9	3.5
9	7	9	7
9	10.5	9	10.5
9	17.5	9	17.5
9	21	9	21
9	24.5	9	24.5
9	28	9	28
12	0	12	0
12	3.5	12	3.5
12	7	12	7
12	10.5	12	10.5
12	17.5	12	17.5
12	21	12	21
12	24.5	12	24.5
12	28	12	28
15	0	15	0
15	3.5	15	3.5
15	7	15	7
15	10.5	15	10.5
15	17.5	15	17.5
15	21	15	21
15	24.5	15	24.5
15	28	15	28
18	0	18	0
18	3.5	18	3.5
18	7	18	7
18	10.5	18	10.5
18	17.5	18	17.5
18	21	18	21
18	24.5	18	24.5
18	28	18	28
21	0	21	0
21	3.5	21	3.5
21	7	21	7

	Top Flange	Bottom Flange
No. Bolts =	88.0	64.0
Splice Plate to First Column (in) =	2.000 OK	2.000 OK
No. Longitudinal Space =	10.0	7.0
Longitudinal Spacing (in) =	3.000 OK	3.000 OK
Last Column to End Girder (in) =	2.000 OK	2.000 OK
Gap (in) =	0.500	0.500
Edge Flange to First Row (in) =	2.000 OK	2.000 OK
No. Trans Space (per side of web) =	3.0	3.0
Transverse Spacing (in) =	3.500 OK	3.500 OK
Center Row to CL Web (in) =	3.500	3.500
Bolt Stagger =	NO	NO





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For **Cleveland InnerBelt : Field Splice - Node 5233**

Flange Bolt Pattern Cont. - Node 5233

21	10.5	21	10.5
21	17.5	21	17.5
21	21	21	21
21	24.5	21	24.5
21	28	21	28
24	0		
24	3.5		
24	7		
24	10.5		
24	17.5		
24	21		
24	24.5		
24	28		
27	0		
27	3.5		
27	7		
27	10.5		
27	17.5		
27	21		
27	24.5		
27	28		
30	0		
30	3.5		
30	7		
30	10.5		
30	17.5		
30	21		
30	24.5		
30	28		

For	HNTB The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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Cleveland InnerBelt : Field Splice - Node 5233							

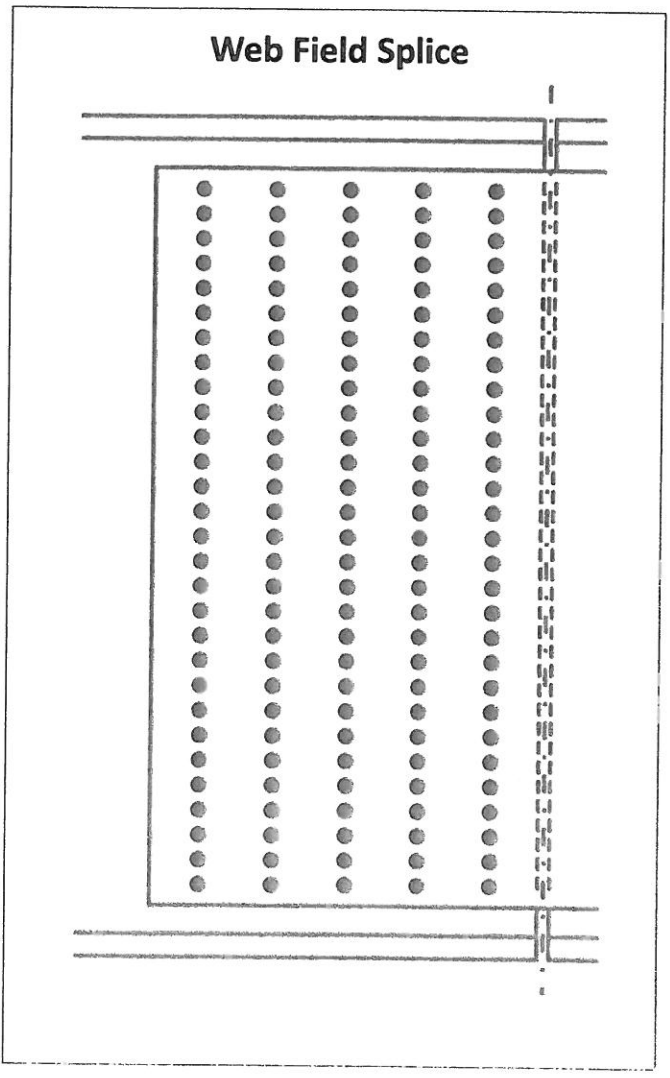
Web Bolt Pattern - Node 5233

* Note: Girder web and girder field splice plates are all flame cut. For a 1.125" dia. bolt, minimum edge distance is 1.50", which is less than the 2" provided. OK.

Bolt Coordinates (in)			
x (long)	y (vert)	(x-x _{bar}) ²	(y-y _{bar}) ²
0	0.0000	36	1764
0	3.0000	36	1521
0	6.0000	36	1296
0	9.0000	36	1089
0	12.0000	36	900
0	15.0000	36	729
0	18.0000	36	576
0	21.0000	36	441
0	24.0000	36	324
0	27.0000	36	225
0	30.0000	36	144
0	33.0000	36	81
0	36.0000	36	36
0	39.0000	36	9
0	42.0000	36	0
0	45.0000	36	9
0	48.0000	36	36
0	51.0000	36	81
0	54.0000	36	144
0	57.0000	36	225
0	60.0000	36	324
0	63.0000	36	441
0	66.0000	36	576
0	69.0000	36	729
0	72.0000	36	900
0	75.0000	36	1089
0	78.0000	36	1296
0	81.0000	36	1521
0	84.0000	36	1764
3	0.0000	9	1764
3	3.0000	9	1521
3	6.0000	9	1296
3	9.0000	9	1089
3	12.0000	9	900
3	15.0000	9	729
3	18.0000	9	576
3	21.0000	9	441
3	24.0000	9	324
3	27.0000	9	225
3	30.0000	9	144
3	33.0000	9	81
3	36.0000	9	36
3	39.0000	9	9
3	42.0000	9	0
3	45.0000	9	9
3	48.0000	9	36
3	51.0000	9	81
3	54.0000	9	144
3	57.0000	9	225
3	60.0000	9	324
3	63.0000	9	441
3	66.0000	9	576
3	69.0000	9	729
3	72.0000	9	900
3	75.0000	9	1089
3	78.0000	9	1296
3	81.0000	9	1521
3	84.0000	9	1764
6	0.0000	0	1764

No. Bolts = 145.0
 Splice Plate to First Column (in) = 2.000 OK
 No. Longitudinal Space = 4.0
 Longitudinal Spacing (in) = 3.000 OK
 Last Column to End Girder (in) = 2.000 OK *
 Gap (in) = 0.500
 Top/Bot Web to First Row (in) = 6.000 OK
 Splice Plate to First Row (in) = 2.500 OK
 No. Vertical Space = 28.0
 Vertical Spacing (in) = 3.000 OK
 Bolt Stagger = NO

x_{bar} (in) = 6
 y_{bar} (in) = 42
 Σ(x-x_{bar})² (in²) = 2610
 Σ(y-y_{bar})² (in²) = 91350
 Σd² (in²) = 93960





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Web Bolt Pattern Cont. - Node 5233

6	3.0000	0	1521
6	6.0000	0	1296
6	9.0000	0	1089
6	12.0000	0	900
6	15.0000	0	729
6	18.0000	0	576
6	21.0000	0	441
6	24.0000	0	324
6	27.0000	0	225
6	30.0000	0	144
6	33.0000	0	81
6	36.0000	0	36
6	39.0000	0	9
6	42.0000	0	0
6	45.0000	0	9
6	48.0000	0	36
6	51.0000	0	81
6	54.0000	0	144
6	57.0000	0	225
6	60.0000	0	324
6	63.0000	0	441
6	66.0000	0	576
6	69.0000	0	729
6	72.0000	0	900
6	75.0000	0	1089
6	78.0000	0	1296
6	81.0000	0	1521
6	84.0000	0	1764
9	0.0000	9	1764
9	3.0000	9	1521
9	6.0000	9	1296
9	9.0000	9	1089
9	12.0000	9	900
9	15.0000	9	729
9	18.0000	9	576
9	21.0000	9	441
9	24.0000	9	324
9	27.0000	9	225
9	30.0000	9	144
9	33.0000	9	81
9	36.0000	9	36
9	39.0000	9	9
9	42.0000	9	0
9	45.0000	9	9
9	48.0000	9	36
9	51.0000	9	81
9	54.0000	9	144
9	57.0000	9	225
9	60.0000	9	324
9	63.0000	9	441
9	66.0000	9	576
9	69.0000	9	729
9	72.0000	9	900
9	75.0000	9	1089
9	78.0000	9	1296
9	81.0000	9	1521
9	84.0000	9	1764
12	0.0000	36	1764
12	3.0000	36	1521
12	6.0000	36	1296
12	9.0000	36	1089
12	12.0000	36	900
12	15.0000	36	729
12	18.0000	36	576
12	21.0000	36	441
12	24.0000	36	324



The HNTB Companies
Engineers Architects Planners

Made	SAE	Date	8/5/2011	Job Number	49633
Checked	WME	Date	8/5/2011		
Backchk'd	SAE	Date	8/5/2011	Sheet No.	

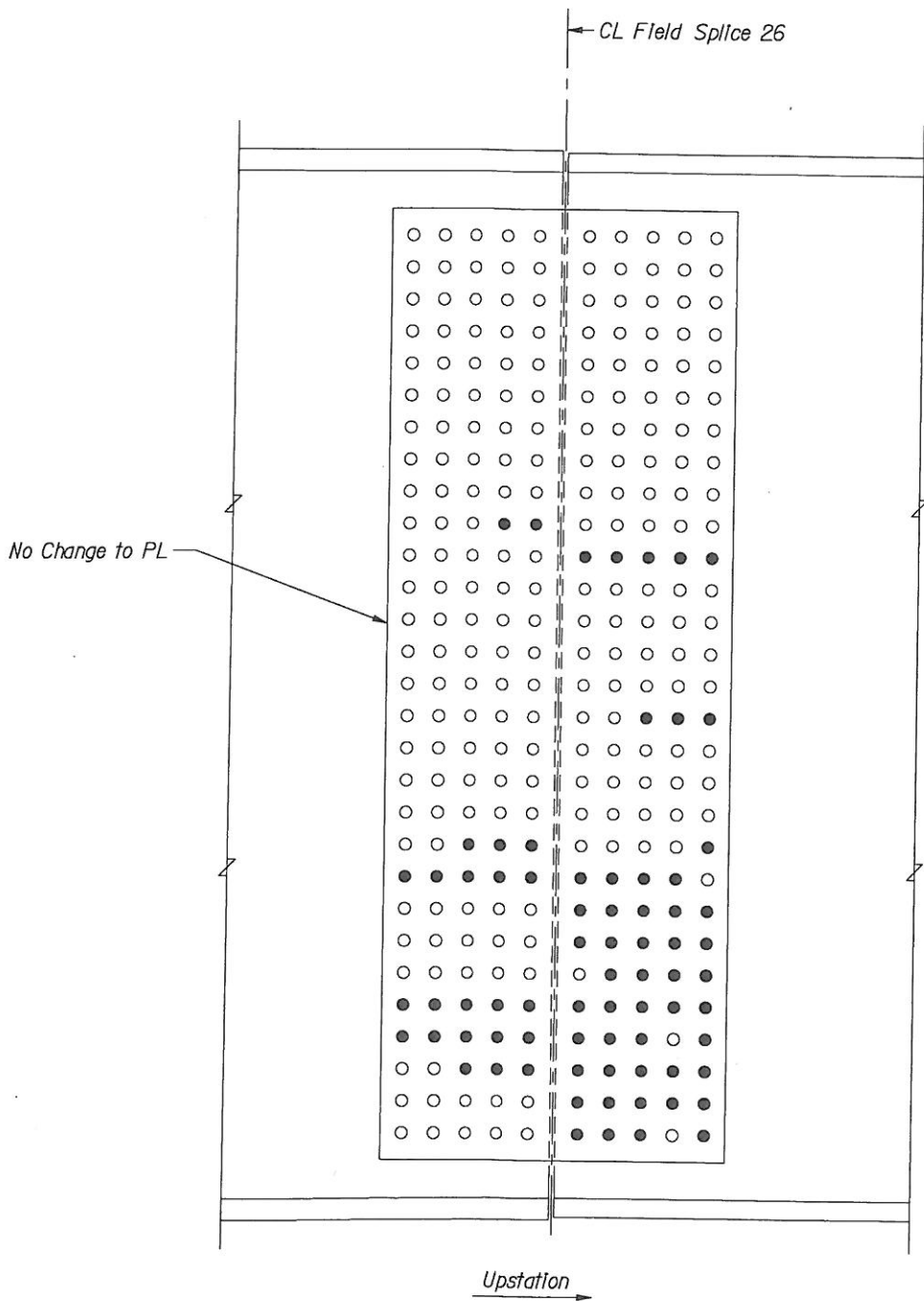
For **Cleveland InnerBelt : Field Splice - Node 5233**

Web Bolt Pattern Cont. - Node 5233

12	27.0000	36	225
12	30.0000	36	144
12	33.0000	36	81
12	36.0000	36	36
12	39.0000	36	9
12	42.0000	36	0
12	45.0000	36	9
12	48.0000	36	36
12	51.0000	36	81
12	54.0000	36	144
12	57.0000	36	225
12	60.0000	36	324
12	63.0000	36	441
12	66.0000	36	576
12	69.0000	36	729
12	72.0000	36	900
12	75.0000	36	1089
12	78.0000	36	1296
12	81.0000	36	1521
12	84.0000	36	1764

870 6090 2610 91350

PROJECT Cleveland Innerbelt	MADE VWR	DATE 07-22-13	HNTB
STRUCTURE I-90 WB - Unit 2	CHECKED HRH	DATE 08-02-13	
FOR RFI 450-1: FS 26, Girder 3	BACK CHECKED VWR	DATE 08-02-13	PROJECT NUMBER 49633



LEGEND:

- No reaming of 1/16" diameter hole. 1" diameter bolt used (i.e. no change to existing design).
- Hole reamed to 3/16" diameter. 1 1/8" diameter bolt used. No noticeable shift in hole center.

NOTES:

1. Flange splice not shown for clarity.
2. Bolts are high strength A325 galvanized Type 1 bolts.
3. 73 holes reamed total (23 downstation, 50 upstation).