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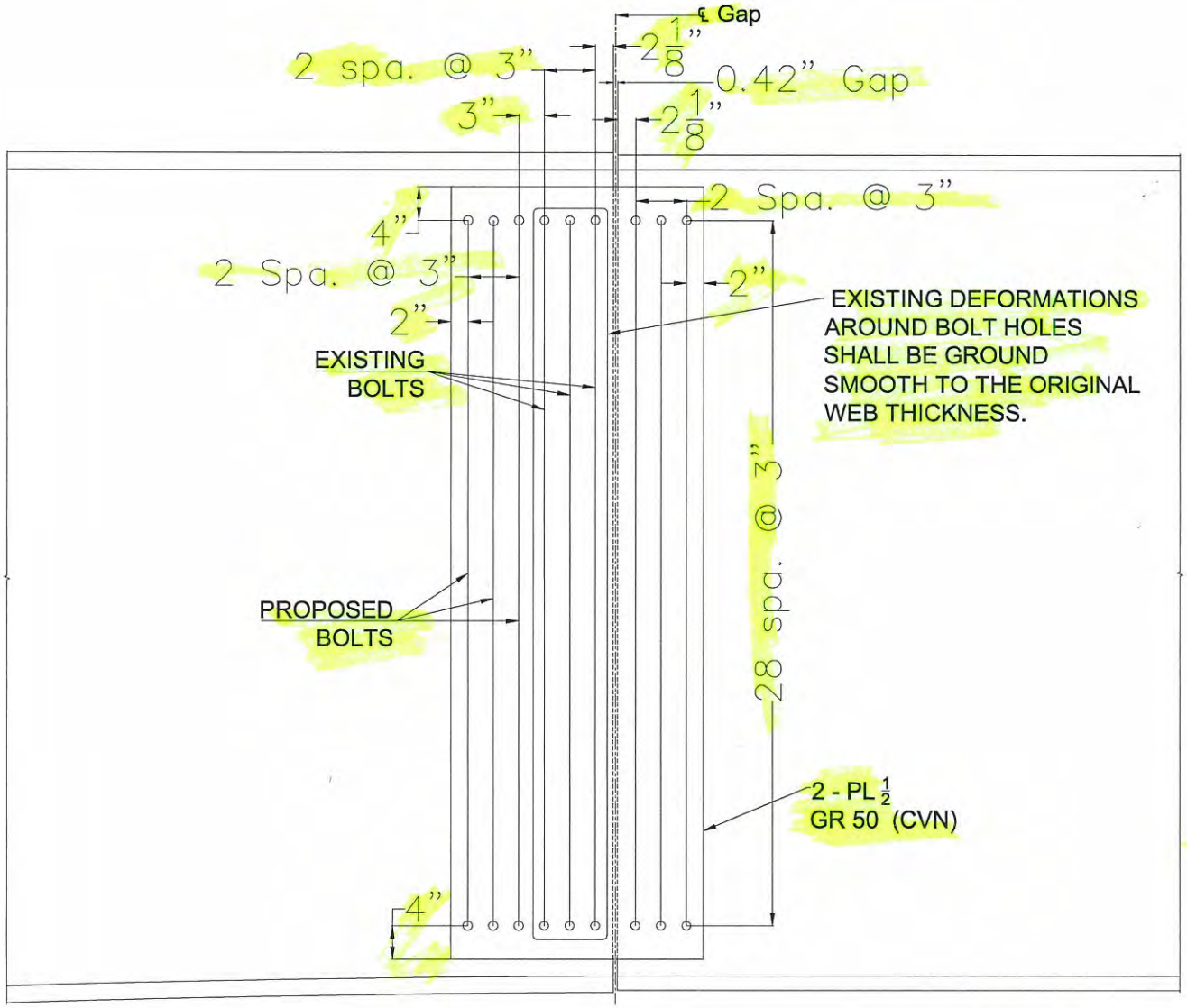
SJL 5-21-13

RFI 437
Girder 4, FS 17



NOTES:

1. FLANGE SPLICE NOT SHOWN FOR CLARITY.
2. ALL MATERIAL AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE RFC PLANS.
3. ALL BOLTS SHALL BE 1" DIAMETER.
4. ALL EXISTING HOLES SHALL BE DYE PENETRANT INSPECTED IN ACCORDANCE WITH ASTM E165 , TYPE 1 FLUORESCENT PENETRANT TESTING, METHOD C. THE INSIDE SURFACE OF THE HOLE SHALL BE INSPECTED. PRIOR TO INSPECTION, THE INSIDE SURFACE OF THE HOLE SHALL BE CLEANED OF ALL DIRT, GREASE AND OTHER SUBSTANCES IN ACCORDANCE WITH ASTM E165, A1.
5. PROPOSED BOLT HOLES IN WEB SHALL BE FIELD DRILLED $1\frac{1}{16}$" DIAMETER.

For CLEVELAND	Job no. 57048	Sheet no.
Made by SJL	Checked by MM	Backchecked by SJL
Date 5-21-13	Date 05/21/2013	Date 5-21-13

HNTB

RFI 437 - FS 17, G4

→ FS 17, G4 had several holes that incurred damage in the web during fit-up in the field.

→ New columns of bolts are proposed to remedy the damaged web splice.

→ To ensure the splice is adequate, 3 scenarios will be considered for design:

① Left side (damaged side) of the splice not considering any of the damaged holes.
e = ℄ of gap to ℄ of new holes.

② Left side (damaged side) of the splice considering all holes, both new and existing.
e = ℄ of gap to ℄ of all holes on left side.

③ Right side of the splice with existing, undamaged holes.
e = (℄ of right side holes to the ℄ of left side proposed, undamaged holes)/2

Edge distance to ℄ hole = 2⅛"

Gap = 0.42" (measured in the field)
→ use Gap = 0.5"

Eccentricities:

① $e_1 = 2\frac{1}{8}" + \frac{0.5"}{2} + (2)(3") + 3" + 3"$

$e_1 = 14.375"$

② $e_2 = 2\frac{1}{8}" + \frac{0.5"}{2} + (5)(3")/2$

$e_2 = 9.875"$

③ $e_3 = \frac{[(4)(3") + 2\frac{1}{8}" + 2\frac{1}{8}" + \frac{1}{2}" + 3"]}{2}$

$e_3 = 9.875"$

Note: In all 3 design scenarios, the eccentricity is taken as the worst of the distance from ℄ Gap to ℄ of bolt group under consideration or the distance from ℄ of active bolt groups on each side divided by 2.

Proposed Web Splice

Design Scenario 1

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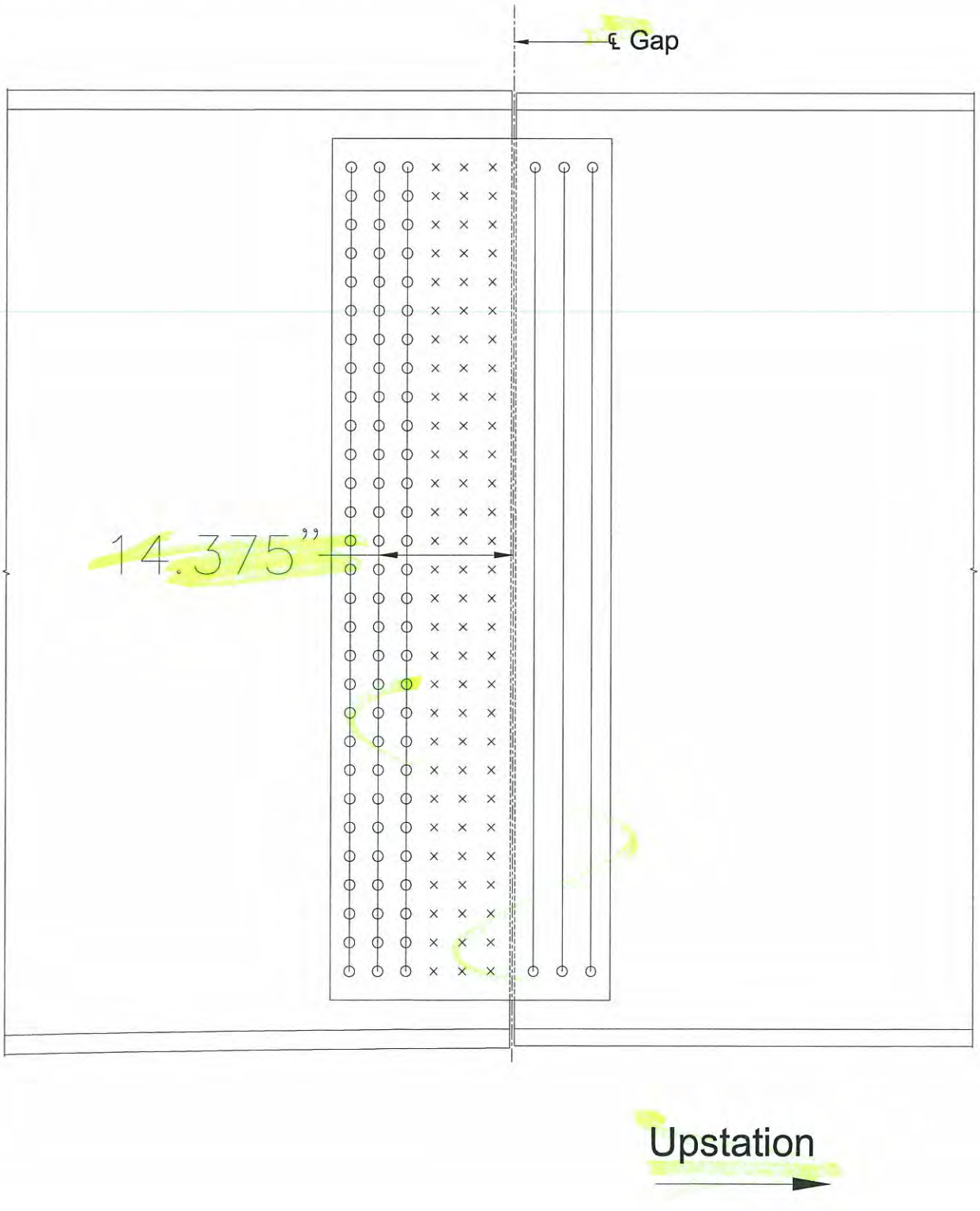
Note: Flange Splice not shown.



Field Splice - Node 7153
Design Scenario 1

Node 7153

For RFI 437

Updated	SJL	Date	5/21/2013
Checked	MM	Date	05/21/13
Backchk'd	SJL	Date	5-21-13

Note: For RFI 437, the web splice and pertinent web splice input was updated and verified. Flange splices were not re-evaluated.

Resisance 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 (in2)	0.79
Fub (ksi)	120
Hole (in)	1.06 (6.13.2.4.2-1)

	No. Bolt
TF	48
Web	87
BF	48

Determine Controlling Section

	Top Flange			Bottom Flange			Web		
Section	Area	ϕf Fnc	A*Fnc	Area	ϕf Fnc	A*Fnc	Area	Fyw	A*Fyw
7153 L	64.00	50.00	3200.00	64.00	47.22	3022.18	96.00	50.00	4800.00
7153 R	56.00	50.00	2800.00	56.00	50.00	2800.00	96.00	50.00	4800.00

Rh = 1.00

Controlling Section = 7153 R

Section and Material Properties

		b (in)	t (in)	L (in)	Ag (in2)	An (in2)	Ae (in2)	Fy (ksi)	Fu (ksi)
Girder Section	TF	32.00	1.75	---	56.00	41.13	45.02	50	65
	Web	96.00	1.00	---	96.00	65.19	---	50	65
	BF	32.00	1.75	---	56.00	41.13	45.02	50	65
Splice Plates	TF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	TF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	Web	92.00	0.500	20.75	92.00	61.19	---	50	65

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For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.		Backchk'd	DJG	Date	10/11/2011

Flange Design Forces Strength I-V (6.13.6.1.4c)

MJM 5-21-13 05/21/13

	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)	-10.59	4.26	14.86	-15.87	5.87	-12.58	-8.11	7.73	7.84	-9.43	-4.07	-3.51	20.36	-25.92	-9.42	13.33
ϕf Fnc (ksi)	50.00	50.00	50.00	47.09	50.00	46.78	50.00	50.00	50.00	47.03	50.00	42.35	50.00	47.00	50.00	50.00
f / ϕf Fnc	0.21	0.09	0.30	0.34	0.12	0.27	0.16	0.15	0.16	0.20	0.08	0.08	0.41	0.55	0.19	0.27
α	1.00	1.00	1.00	0.94	1.00	0.94	1.00	1.00	1.00	0.94	1.00	0.85	1.00	0.94	1.00	1.00
fcf (ksi)	-10.59			-15.87		-12.58	-8.11			-9.43		-3.51		-25.92		13.33
Fcf (ksi)	-37.50			-35.32		-35.08	-37.50			-35.27		-31.76		-36.46		37.50
Fcf (kip)	-2100.00			-1977.69		-1964.66	-2100.00			-1975.31		-1778.60		-2041.95		1688.29
fncf (ksi)		4.26	14.86		5.87			7.73	7.84		-4.07		20.36		-9.42	
Rcf		3.54	2.23		2.79			4.62	3.74		9.05		1.41		2.81	
Fncf (ksi)		37.50	37.50		37.50			37.50	37.50		-37.50		37.50		-37.50	
Fncf (kip)		1688.29	1688.29		1688.29			1688.29	1688.29		-2100.00		1688.29		-2100.00	

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)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (ksi)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (kip)	-325.31	122.68	546.64	-537.46	-85.79	-461.81	-267.56	351.36	-58.65	-239.27	-233.53	-154.02	840.86	-1107.32	-392.64	601.69

Max Flange Design Forces

	Strength I		Service II	
Pu	TF	BF	TF	BF
Tension	1688.29	1688.29	840.86	601.69
Comp	2100.00	2041.95	392.64	1107.32

ϕvVn (kip) = 1375.39

e_v (in) = 14.375

Web Design Forces (6.13.6.1.4b)

	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
Vu (kip)	575.70	455.11	720.25	230.64	442.77	532.07	558.31	362.80	417.41	330.11	519.53	171.52	321.39	386.58	405.12	264.89
Vuw (kip)	863.54	682.67	1047.82	345.97	664.16	798.11	837.47	544.20	---	---	---	---	---	---	---	---
Mv (k*ft)	1034.45	817.78	1255.20	414.44	795.61	956.07	1003.22	651.90	500.02	395.44	622.36	205.46	385.00	463.10	485.30	317.31
Huw (kip)	-1075.00	-108.10	-898.69	-84.92	-286.56	-3294.18	-375.78	528.55	-173.68	7.86	-469.37	71.83	-255.36	-332.19	-228.40	179.18
Muw (k*ft)	3366.67	4376.32	3292.39	4686.77	4132.93	326.87	4166.28	4095.26	511.99	1238.97	429.73	707.34	206.42	90.86	2226.49	1136.37
Mu (k*ft)	4401.12	5194.10	4547.59	5101.21	4928.54	1282.94	5169.49	4747.16	1012.01	1634.41	1052.08	912.80	591.42	553.96	2711.79	1453.69

Note: Mu = Muw + Mv

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For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date 8/5/2011	Sheet No.		Backchk'd	DJG	Date	10/11/2011

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Web Bolt Force

	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
PX1 (Huw)	12.36	1.24	10.33	0.98	3.29	37.86	4.32	6.08	2.00	0.09	5.40	0.83	2.94	3.82	2.63	2.06
PY1 (Vuw)	9.93	7.85	12.04	3.98	7.63	9.17	9.63	6.26	4.80	3.79	5.97	1.97	3.69	4.44	4.66	3.04
PX2 (Mu)	40.09	47.31	41.42	46.47	44.89	11.69	47.09	43.24	9.22	14.89	9.58	8.31	5.39	5.05	24.70	13.24
PY2 (Mu)	2.86	3.38	2.96	3.32	3.21	0.83	3.36	3.09	0.66	1.06	0.68	0.59	0.38	0.36	1.76	0.95
Pu (kip)	53.98	49.83	53.88	48.00	49.39	50.55	53.02	50.19	12.47	15.75	16.39	9.49	9.27	10.08	28.07	15.81

Note: $Pu = \sqrt{((PX1 + PX2)^2 + (PY1 + PY2)^2)}$

Splice Plate Design

Flange Splice Plates in Tension (6.13.5.2)

	Pu (kip)	Pry (kip)	Pru (kip)	Avg (in2)	Avn (in2)	Atn (in2)	Prbs (kip)	Rr (kip)	Check
TF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	OK
TF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	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	1020.76	1080.00	OK
TF Inside	1079.24	1141.88	OK
BF Inside	1049.41	1141.88	OK
BF Outside	992.54	1080.00	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)	49.12	45.36	48.45	44.32	45.04	46.72	48.06	46.13
Check	OK	OK	OK	OK	OK	OK	OK	OK

S (in3) = 1410.7

Web Splice Plates in Shear (6.13.5.3)

Vu (kip)	1047.82
Rr (kip)	1845.42
Check	OK

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE		8/5/2011	Job Number	49633	Revised	DJG	Date	10/11/2012
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Splice Bolt Design

Shear Resistance (6.13.2.7 & 6.13.6.1.5)

Ns = 1

	Fill Pl (in)	R	L Factor	Rr (kip)
TF	0.25	0.88	1.0	31.76
Web	0.00	1.00	1.0	36.19
BF	0.25	0.88	1.0	31.76

Slip Resistance (6.13.2.8)

Kh	1.00	
Ks	0.33	(Class A)
Ns	1.0	
Pt	51.0	
Rr	16.83	

Flange Bolt

	Shear Resistance			Slip Resistance		
	Pu (kip)	Pu/Bolt	Check	Ps	Ps/Bolt	Check
TF	1079.24	22.48	OK	432.14	9.00	OK
BF	1049.41	21.86	OK	569.08	11.86	OK

	Bearing Resistance (6.13.2.9)				
	Pu	Pu/Bolt	Lc	Rr (kip)	Check
TF Outside	1020.76	21.27	1.47	68.74	OK
TF	2100.00	43.75	1.47	160.39	OK
TF Inside	1079.24	22.48	1.47	80.19	OK
BF Inside	1049.41	21.86	1.47	80.19	OK
BF	2041.95	42.54	1.47	160.39	OK
BF Outside	992.54	20.68	1.47	68.74	OK

Web Bolt

Shear Resistance			Slip Resistance		
Pu (dbl)	Pu (sngl)	Check	Ps (dbl)	Ps (sngl)	Check
53.98	26.99	OK	28.07	14.04	OK

	Bearing Resistance (6.13.2.9)			
	Pu/Bolt	Lc	Rr (kip)	Check
Web	53.98	1.59	99.45	OK
Web SPL	26.99	1.47	45.83	OK

Design Factor of Safety Summary

Plate	Tension	Comp
TF Outside	1.12	1.06
TF Inside	1.08	1.06
BF Inside	1.08	1.09
BF Outside	1.12	1.09

Bolt	Shear	Slip	Bearing
TF	1.41	1.87	3.23
Web	1.34	1.20	1.70
BF	1.45	1.42	3.32

Plate	Shear	Flexure
Web	1.76	1.02

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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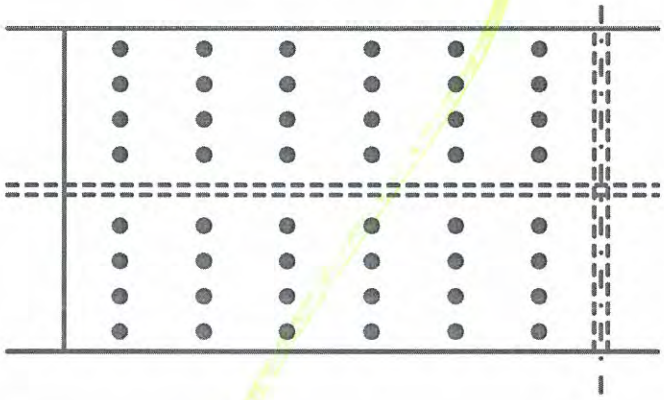
		Revised	DJG	Date	10/3/2012		
		Checked	SJL	Date	10/11/2012		
		Backchk'd	DJG	Date	10/11/2011		
		Revised	SJL	Date	5/9/2013		
		Checked	WM	Date	5/21/13		
		Backchk'd	SJL	Date	5-21-13		

Flange Bolt Pattern - Node 7153

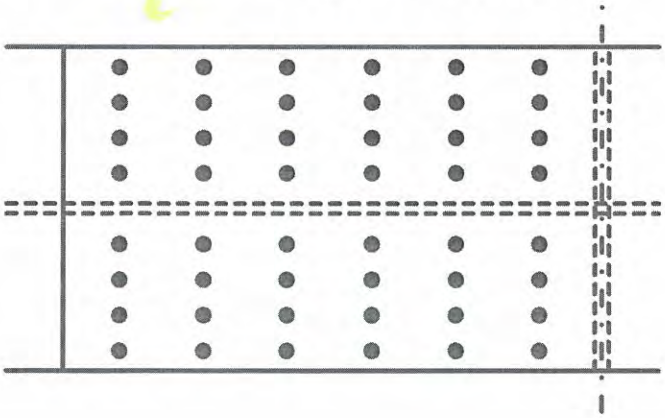
TF Bolt Coordinates (in)		BF Bolt Coordinates (in)	
x (long)	y (trans)	x (long)	y (trans)
0	0	0	0
0	3.5	0	3.5
0	7	0	7
0	10.5	0	10.5
0	17.5	0	17.5
0	21	0	21
0	24.5	0	24.5
0	28	0	28
3	0	3	0
3	3.5	3	3.5
3	7	3	7
3	10.5	3	10.5
3	17.5	3	17.5
3	21	3	21
3	24.5	3	24.5
3	28	3	28
6	0	6	0
6	3.5	6	3.5
6	7	6	7
6	10.5	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

	Top Flange		Bottom Flange	
No. Bolts =	48.0		48.0	
Splice Plate to First Column (in) =	2.000	OK	2.000	OK
No. Longitudinal Space =	5.0		5.0	
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	

Top Flange Field Splice



Bottom Flange Field Splice



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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Flange Bolt Pattern Cont. - Node 7153

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HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
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Web Bolt Pattern - Node 7153

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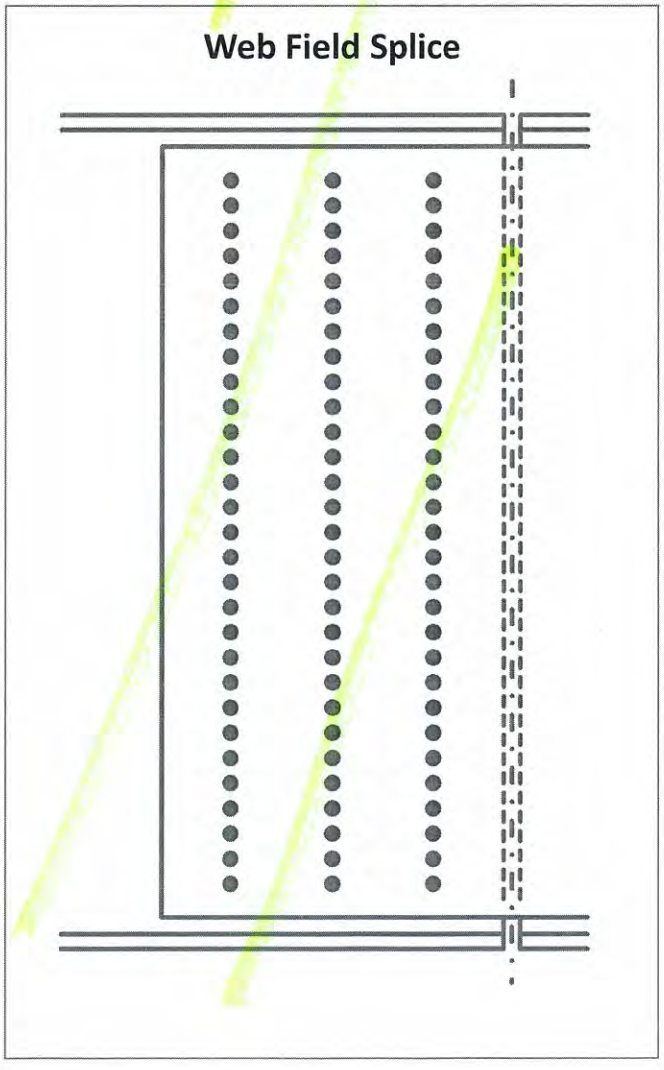
Bolt Coordinates (in)			
x (long)	y (vert)	$(x-x_{bar})^2$	$(y-y_{bar})^2$
0	0	9	1764
0	3	9	1521
0	6	9	1296
0	9	9	1089
0	12	9	900
0	15	9	729
0	18	9	576
0	21	9	441
0	24	9	324
0	27	9	225
0	30	9	144
0	33	9	81
0	36	9	36
0	39	9	9
0	42	9	0
0	45	9	9
0	48	9	36
0	51	9	81
0	54	9	144
0	57	9	225
0	60	9	324
0	63	9	441
0	66	9	576
0	69	9	729
0	72	9	900
0	75	9	1089
0	78	9	1296
0	81	9	1521
0	84	9	1764
3	0	0	1764
3	3	0	1521
3	6	0	1296
3	9	0	1089
3	12	0	900
3	15	0	729
3	18	0	576
3	21	0	441
3	24	0	324
3	27	0	225
3	30	0	144
3	33	0	81
3	36	0	36
3	39	0	9
3	42	0	0
3	45	0	9
3	48	0	36
3	51	0	81
3	54	0	144
3	57	0	225
3	60	0	324
3	63	0	441
3	66	0	576
3	69	0	729
3	72	0	900
3	75	0	1089
3	78	0	1296
3	81	0	1521
3	84	0	1764
6	0	9	1764

No. Bolts =	87.0	
Splice Plate to First Column (in) =	2.000	OK
No. Longitudinal Space =	2.0	
Longitudinal Spacing (in) =	3.000	OK
Last Column to End Girder (in) =	2.125	OK
Gap (in) =	0.500	
Top/Bot Web to First Row (in) =	6.000	OK
Splice Plate to First Row (in) =	4.000	OK
No. Vertical Space =	28.0	
Vertical Spacing (in) =	3.000	OK
Bolt Stagger =	NO	
x_{bar} (in) =	3	
y_{bar} (in) =	42	
$\Sigma(x-xbar)^2$ (in^2)=	522	
$\Sigma(y-ybar)^2$ (in^2) =	54810	
Σd^2 (in^2) =	55332.0	



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern Cont. - Node 7153

MH 05/24/13
SJL 5-21-13

6	3	9	1521
6	6	9	1296
6	9	9	1089
6	12	9	900
6	15	9	729
6	18	9	576
6	21	9	441
6	24	9	324
6	27	9	225
6	30	9	144
6	33	9	81
6	36	9	36
6	39	9	9
6	42	9	0
6	45	9	9
6	48	9	36
6	51	9	81
6	54	9	144
6	57	9	225
6	60	9	324
6	63	9	441
6	66	9	576
6	69	9	729
6	72	9	900
6	75	9	1089
6	78	9	1296
6	81	9	1521
6	84	9	1764

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern Cont. - Node 7153

MM 05/21/13
SJL 5-21-13

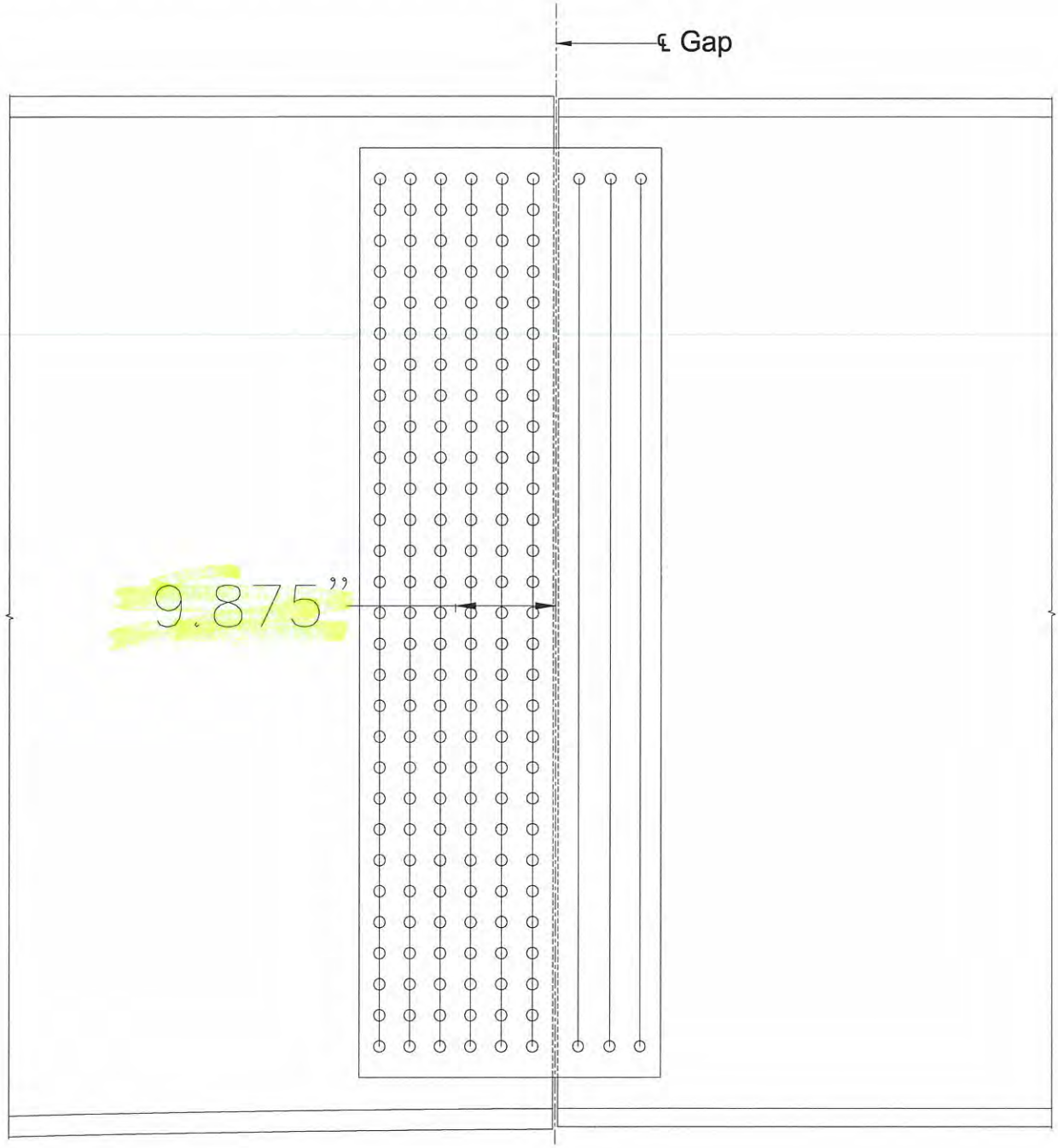
261	3654	522	54810

Proposed Web Splice

Design Scenario 2

SJL 5-21-13
MH 05/21/13
SJL 5-21-13

Note: Flange Splice not shown.



Field Splice - Node 7153
Design Scenario 2

Node 7153

For RFI 437

Updated	SJL	Date	5/21/2013
Checked	WM	Date	05/21/13
Backchk'd	SJL	Date	5-21-13

Note: For RFI 437, the web splice and pertinent web splice input was updated and verified. Flange splices were not re-evaluated.

Resisance 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 (in2)	0.79
Fub (ksi)	120
Hole (in)	1.06 (6.13.2.4.2-1)

	No. Bolt
TF	48
Web	174
BF	48

Determine Controlling Section

Rh = 1.00

	Top Flange			Bottom Flange			Web		
Section	Area	ϕf Fnc	A*Fnc	Area	ϕf Fnc	A*Fnc	Area	Fyw	A*Fyw
7153 L	64.00	50.00	3200.00	64.00	47.22	3022.18	96.00	50.00	4800.00
7153 R	56.00	50.00	2800.00	56.00	50.00	2800.00	96.00	50.00	4800.00

Controlling Section = 7153 R

Section and Material Properties

		b (in)	t (in)	L (in)	Ag (in2)	An (in2)	Ae (in2)	Fy (ksi)	Fu (ksi)
Girder Section	TF	32.00	1.75	---	56.00	41.13	45.02	50	65
	Web	96.00	1.00	---	96.00	65.19	---	50	65
	BF	32.00	1.75	---	56.00	41.13	45.02	50	65
Splice Plates	TF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	TF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	Web	92.00	0.500	38.75	92.00	61.19	---	50	65

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	8/5/2011	Job Number	49633	Revised	DJG	Date	1[illegible]012
		Checked	WME	Date 8/5/2011			Checked	SJL	Date	10/11/2012
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MM 05/21/13
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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)	-10.59	4.26	14.86	-15.87	5.87	-12.58	-8.11	7.73	7.84	-9.43	-4.07	-3.51	20.36	-25.92	-9.42	13.33
ϕf Fnc (ksi)	50.00	50.00	50.00	47.09	50.00	46.78	50.00	50.00	50.00	47.03	50.00	42.35	50.00	47.00	50.00	50.00
f / ϕf Fnc	0.21	0.09	0.30	0.34	0.12	0.27	0.16	0.15	0.16	0.20	0.08	0.08	0.41	0.55	0.19	0.27
α	1.00	1.00	1.00	0.94	1.00	0.94	1.00	1.00	1.00	0.94	1.00	0.85	1.00	0.94	1.00	1.00
fcf (ksi)	-10.59			-15.87		-12.58	-8.11			-9.43		-3.51		-25.92		13.33
Fcf (ksi)	-37.50			-35.32		-35.08	-37.50			-35.27		-31.76		-36.46		37.50
Fcf (kip)	-2100.00			-1977.69		-1964.66	-2100.00			-1975.31		-1778.60		-2041.95		1688.29
fncf (ksi)		4.26	14.86		5.87			7.73	7.84		-4.07		20.36		-9.42	
Rcf		3.54	2.23		2.79			4.62	3.74		9.05		1.41		2.81	
Fncf (ksi)		37.50	37.50		37.50			37.50	37.50		-37.50		37.50		-37.50	
Fncf (kip)		1688.29	1688.29		1688.29			1688.29	1688.29		-2100.00		1688.29		-2100.00	

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)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (ksi)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (kip)	-325.31	122.68	546.64	-537.46	-85.79	-461.81	-267.56	351.36	-58.65	-239.27	-233.53	-154.02	840.86	-1107.32	-392.64	601.69

Max Flange Design Forces

	Strength I		Service II	
Pu	TF	BF	TF	BF
Tension	1688.29	1688.29	840.86	601.69
Comp	2100.00	2041.95	392.64	1107.32

$\phi v V_n$ (kip) = 1375.39
e_v (in) = 9.875

Web Design Forces (6.13.6.1.4b)

	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
Vu (kip)	575.70	455.11	720.25	230.64	442.77	532.07	558.31	362.80	417.41	330.11	519.53	171.52	321.39	386.58	405.12	264.89
Vuw (kip)	863.54	682.67	1047.82	345.97	664.16	798.11	837.47	544.20	---	---	---	---	---	---	---	---
Mv (k*ft)	710.62	561.78	862.27	284.70	546.55	656.78	689.17	447.83	343.49	271.65	427.53	141.14	264.48	318.13	333.38	217.98
Huw (kip)	-1075.00	-108.10	-898.69	-84.92	-286.56	-3294.18	-375.78	528.55	-173.68	7.86	-469.37	71.83	-255.36	-332.19	-228.40	179.18
Muw (k*ft)	3366.67	4376.32	3292.39	4686.77	4132.93	326.87	4166.28	4095.26	511.99	1238.97	429.73	707.34	206.42	90.86	2226.49	1136.37
Mu (k*ft)	4077.29	4938.10	4154.66	4971.47	4679.48	983.65	4855.44	4543.09	855.48	1510.62	857.26	848.48	470.90	408.99	2559.87	1354.35

Note: Mu = Muw + Mv

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		Checked	WME	Date 8/5/2011		Checked	SJL	Date	10/11/2012
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date 8/5/2011	Sheet No.	Backchk'd	DJG	Date	10/11/2011

Web Bolt Force

MM 05/21/13 SJL 5-21-13

	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
PX1 (Huw)	6.18	0.62	5.16	0.49	1.65	18.93	2.16	3.04	1.00	0.05	2.70	0.41	1.47	1.91	1.31	1.03
PY1 (Vuw)	4.96	3.92	6.02	1.99	3.82	4.59	4.81	3.13	2.40	1.90	2.99	0.99	1.85	2.22	2.33	1.52
PX2 (Mu)	18.00	21.80	18.34	21.94	20.65	4.34	21.43	20.05	3.78	6.67	3.78	3.75	2.08	1.81	11.30	5.98
PY2 (Mu)	3.21	3.89	3.27	3.92	3.69	0.78	3.83	3.58	0.67	1.19	0.68	0.67	0.37	0.32	2.02	1.07
Pu (kip)	25.52	23.74	25.27	23.20	23.53	23.88	25.12	24.04	5.68	7.39	7.44	4.47	4.18	4.50	13.34	7.47

Note: $Pu = \sqrt{((PX1 + PX2)^2 + (PY1 + PY2)^2)}$

Splice Plate Design

Flange Splice Plates in Tension (6.13.5.2)

	Pu (kip)	Pry (kip)	Pru (kip)	Avg (in2)	Avn (in2)	Atn (in2)	Prbs (kip)	Rr (kip)	Check
TF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	OK
TF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	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	1020.76	1080.00	OK
TF Inside	1079.24	1141.88	OK
BF Inside	1049.41	1141.88	OK
BF Outside	992.54	1080.00	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)	46.37	43.18	45.11	43.21	42.92	44.17	45.39	44.39
Check	OK	OK	OK	OK	OK	OK	OK	OK

S (in3) = 1410.7

Web Splice Plates in Shear (6.13.5.3)

Vu (kip)	1047.82
Rr (kip)	1845.42
Check	OK

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		Checked	WME	Date 8/5/2011		Checked	SJL	Date 10/11/2012
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Splice Bolt Design

Shear Resistance (6.13.2.7 & 6.13.6.1.5)

Ns = 1

	Fill Pl (in)	R	L Factor	Rr (kip)
TF	0.25	0.88	1.0	31.76
Web	0.00	1.00	1.0	36.19
BF	0.25	0.88	1.0	31.76

Slip Resistance (6.13.2.8)

Kh	1.00	
Ks	0.33	(Class A)
Ns	1.0	
Pt	51.0	
Rr	16.83	

Flange Bolt

	Shear Resistance			Slip Resistance		
	Pu (kip)	Pu/Bolt	Check	Ps	Ps/Bolt	Check
TF	1079.24	22.48	OK	432.14	9.00	OK
BF	1049.41	21.86	OK	569.08	11.86	OK

	Bearing Resistance (6.13.2.9)				
	Pu	Pu/Bolt	Lc	Rr (kip)	Check
TF Outside	1020.76	21.27	1.47	68.74	OK
TF	2100.00	43.75	1.47	160.39	OK
TF Inside	1079.24	22.48	1.47	80.19	OK
BF Inside	1049.41	21.86	1.47	80.19	OK
BF	2041.95	42.54	1.47	160.39	OK
BF Outside	992.54	20.68	1.47	68.74	OK

Web Bolt

Shear Resistance			Slip Resistance		
Pu (dbl)	Pu (sngl)	Check	Ps (dbl)	Ps (sngl)	Check
25.52	12.76	OK	13.34	6.67	OK

	Bearing Resistance (6.13.2.9)			
	Pu/Bolt	Lc	Rr (kip)	Check
Web	25.52	1.59	99.45	OK
Web SPL	12.76	1.47	45.83	OK

Design Factor of Safety Summary

Plate	Tension	Comp
TF Outside	1.12	1.06
TF Inside	1.08	1.06
BF Inside	1.08	1.09
BF Outside	1.12	1.09

Bolt	Shear	Slip	Bearing
TF	1.41	1.87	3.23
Web	2.84	2.52	3.59
BF	1.45	1.42	3.32

Plate	Shear	Flexure
Web	1.76	1.08

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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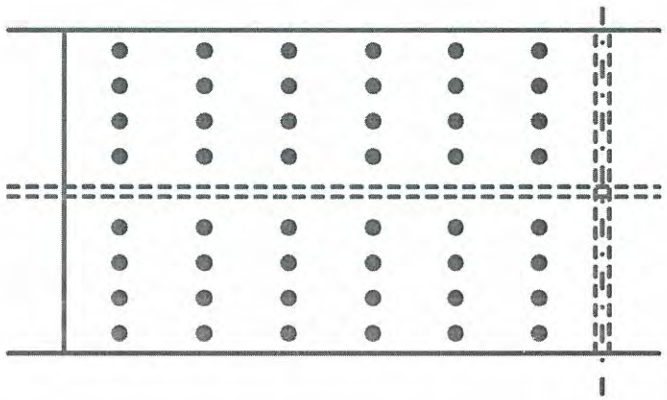
		Revised	DJG	Date	10/3/2012		
		Checked	SJL	Date	10/11/2012		
		Backchk'd	DJG	Date	10/11/2011		
		Revised	SJL	Date	5/9/2013		
		Checked	MM	Date	05/21/13		
		Backchk'd	SJL	Date	5-21-13		

Flange Bolt Pattern - Node 7153

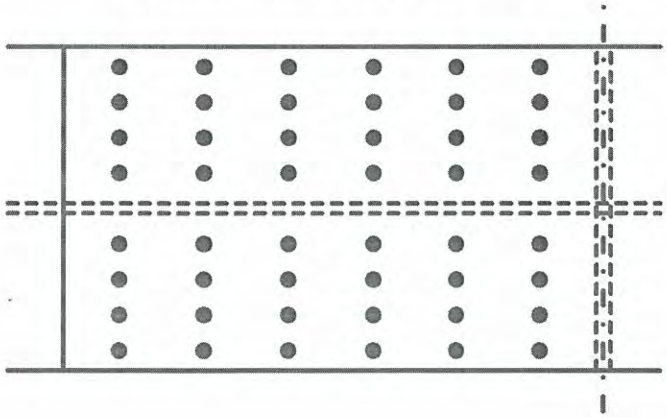
TF Bolt Coordinates (in)		BF Bolt Coordinates (in)	
x (long)	y (trans)	x (long)	y (trans)
0	0	0	0
0	3.5	0	3.5
0	7	0	7
0	10.5	0	10.5
0	17.5	0	17.5
0	21	0	21
0	24.5	0	24.5
0	28	0	28
3	0	3	0
3	3.5	3	3.5
3	7	3	7
3	10.5	3	10.5
3	17.5	3	17.5
3	21	3	21
3	24.5	3	24.5
3	28	3	28
6	0	6	0
6	3.5	6	3.5
6	7	6	7
6	10.5	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

	Top Flange		Bottom Flange	
No. Bolts =	48.0		48.0	
Splice Plate to First Column (in) =	2.000	OK	2.000	OK
No. Longitudinal Space =	5.0		5.0	
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	

Top Flange Field Splice



Bottom Flange Field Splice



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
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Flange Bolt Pattern Cont. - Node 7153

MM 05/21/13
SJL 5-21-13

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
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Web Bolt Pattern - Node 7153

MM 05/21/13
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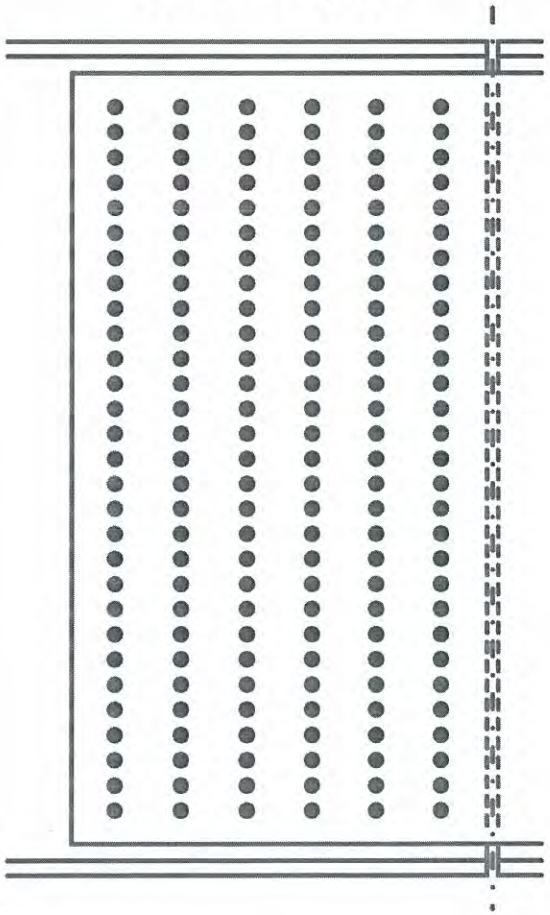
Bolt Coordinates (in)			
x (long)	y (vert)	$(x-x_{bar})^2$	$(y-y_{bar})^2$
0	0	56.25	1764
0	3	56.25	1521
0	6	56.25	1296
0	9	56.25	1089
0	12	56.25	900
0	15	56.25	729
0	18	56.25	576
0	21	56.25	441
0	24	56.25	324
0	27	56.25	225
0	30	56.25	144
0	33	56.25	81
0	36	56.25	36
0	39	56.25	9
0	42	56.25	0
0	45	56.25	9
0	48	56.25	36
0	51	56.25	81
0	54	56.25	144
0	57	56.25	225
0	60	56.25	324
0	63	56.25	441
0	66	56.25	576
0	69	56.25	729
0	72	56.25	900
0	75	56.25	1089
0	78	56.25	1296
0	81	56.25	1521
0	84	56.25	1764
3	0	20.25	1764
3	3	20.25	1521
3	6	20.25	1296
3	9	20.25	1089
3	12	20.25	900
3	15	20.25	729
3	18	20.25	576
3	21	20.25	441
3	24	20.25	324
3	27	20.25	225
3	30	20.25	144
3	33	20.25	81
3	36	20.25	36
3	39	20.25	9
3	42	20.25	0
3	45	20.25	9
3	48	20.25	36
3	51	20.25	81
3	54	20.25	144
3	57	20.25	225
3	60	20.25	324
3	63	20.25	441
3	66	20.25	576
3	69	20.25	729
3	72	20.25	900
3	75	20.25	1089
3	78	20.25	1296
3	81	20.25	1521
3	84	20.25	1764
6	0	2.25	1764

No. Bolts =	174.0	
Splice Plate to First Column (in) =	2.000	OK
No. Longitudinal Space =	5.0	
Longitudinal Spacing (in) =	3.000	OK
Last Column to End Girder (in) =	2.125	OK
Gap (in) =	0.500	
Top/Bot Web to First Row (in) =	6.000	OK
Splice Plate to First Row (in) =	4.000	OK
No. Vertical Space =	28.0	
Vertical Spacing (in) =	3.000	OK
Bolt Stagger =	NO	
x_{bar} (in) =	7.5	
y_{bar} (in) =	42	
$\Sigma(x-xbar)^2$ (in^2)=	4567.5	
$\Sigma(y-ybar)^2$ (in^2) =	109620	
Σd^2 (in^2) =	114187.5	

Web Field Splice



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern Cont. - Node 7153

MM 05/21/13
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6	3	2.25	1521
6	6	2.25	1296
6	9	2.25	1089
6	12	2.25	900
6	15	2.25	729
6	18	2.25	576
6	21	2.25	441
6	24	2.25	324
6	27	2.25	225
6	30	2.25	144
6	33	2.25	81
6	36	2.25	36
6	39	2.25	9
6	42	2.25	0
6	45	2.25	9
6	48	2.25	36
6	51	2.25	81
6	54	2.25	144
6	57	2.25	225
6	60	2.25	324
6	63	2.25	441
6	66	2.25	576
6	69	2.25	729
6	72	2.25	900
6	75	2.25	1089
6	78	2.25	1296
6	81	2.25	1521
6	84	2.25	1764
9	0	2.25	1764
9	3	2.25	1521
9	6	2.25	1296
9	9	2.25	1089
9	12	2.25	900
9	15	2.25	729
9	18	2.25	576
9	21	2.25	441
9	24	2.25	324
9	27	2.25	225
9	30	2.25	144
9	33	2.25	81
9	36	2.25	36
9	39	2.25	9
9	42	2.25	0
9	45	2.25	9
9	48	2.25	36
9	51	2.25	81
9	54	2.25	144
9	57	2.25	225
9	60	2.25	324
9	63	2.25	441
9	66	2.25	576
9	69	2.25	729
9	72	2.25	900
9	75	2.25	1089
9	78	2.25	1296
9	81	2.25	1521
9	84	2.25	1764
12	0	20.25	1764
12	3	20.25	1521
12	6	20.25	1296
12	9	20.25	1089
12	12	20.25	900
12	15	20.25	729
12	18	20.25	576
12	21	20.25	441
12	24	20.25	324

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern Cont. - Node 7153

MM 05/21/13
SJL 5-21-13

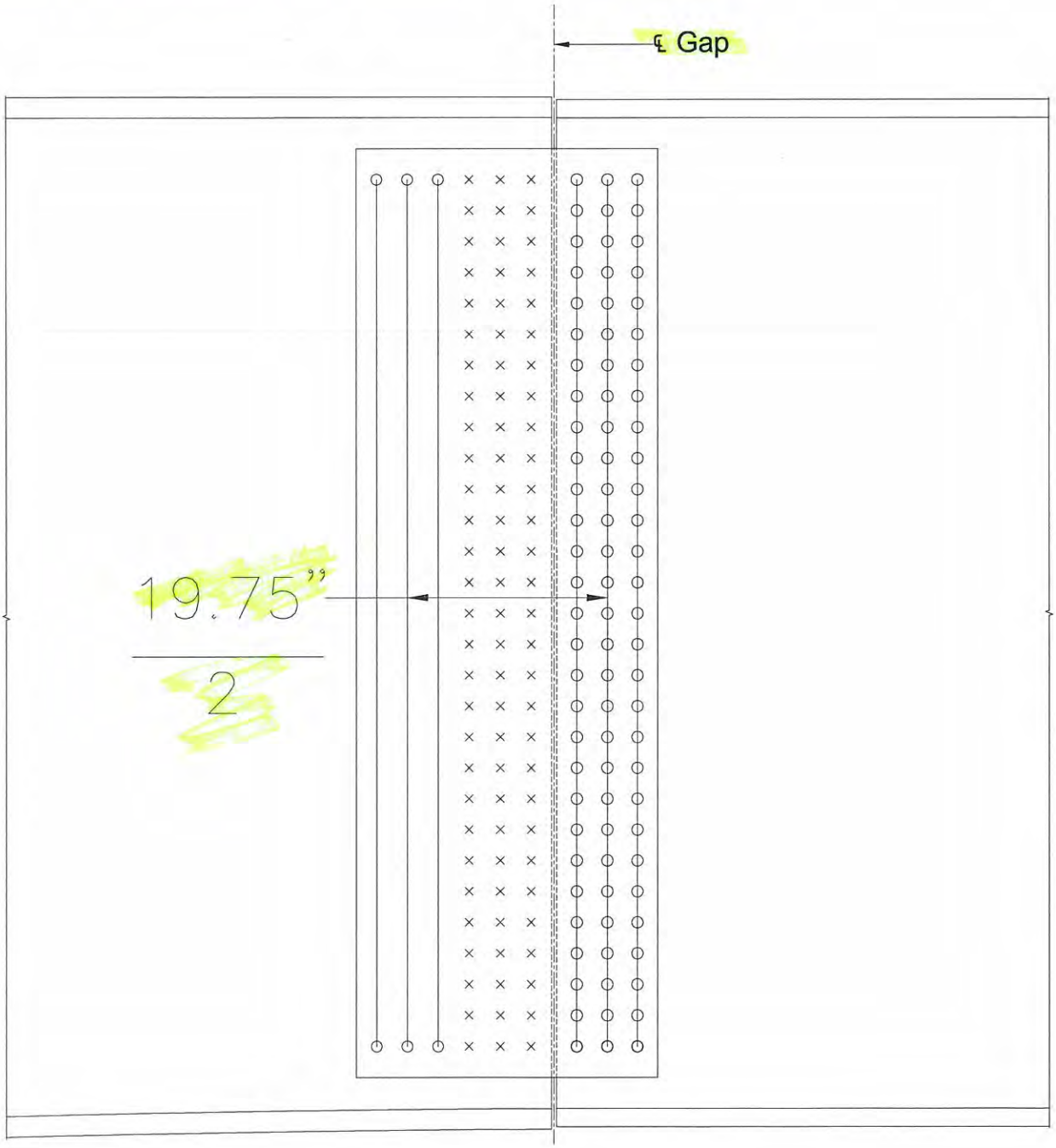
12	27	20.25	225
12	30	20.25	144
12	33	20.25	81
12	36	20.25	36
12	39	20.25	9
12	42	20.25	0
12	45	20.25	9
12	48	20.25	36
12	51	20.25	81
12	54	20.25	144
12	57	20.25	225
12	60	20.25	324
12	63	20.25	441
12	66	20.25	576
12	69	20.25	729
12	72	20.25	900
12	75	20.25	1089
12	78	20.25	1296
12	81	20.25	1521
12	84	20.25	1764
15	0	56.25	1764
15	3	56.25	1521
15	6	56.25	1296
15	9	56.25	1089
15	12	56.25	900
15	15	56.25	729
15	18	56.25	576
15	21	56.25	441
15	24	56.25	324
15	27	56.25	225
15	30	56.25	144
15	33	56.25	81
15	36	56.25	36
15	39	56.25	9
15	42	56.25	0
15	45	56.25	9
15	48	56.25	36
15	51	56.25	81
15	54	56.25	144
15	57	56.25	225
15	60	56.25	324
15	63	56.25	441
15	66	56.25	576
15	69	56.25	729
15	72	56.25	900
15	75	56.25	1089
15	78	56.25	1296
15	81	56.25	1521
15	84	56.25	1764
1305	7308	4567.5	109620

Proposed Web Splice

Design Scenario 3

SJL 5-21-13
MM 05/21/13
SJL 5-21-13

Note: Flange Splice not shown.



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	8/5/2011	Job Number	49633	Revised	DJG	Date	012
		Checked	WME	Date 8/5/2011			Checked	SJL	Date	10/11/2012
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date 8/5/2011	Sheet No.		Backchk'd	DJG	Date	10/11/2011

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Field Splice - Node 7153
Design Scenario 3

Node 7153

For RFI 437

Updated	SJL	Date	5/21/2013
Checked	MM	Date	05/21/2013
Backchk'd	SJL	Date	5-21-13

Resisance 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 (in2)	0.79
Fub (ksi)	120
Hole (in)	1.06 (6.13.2.4.2-1)

	No. Bolt
TF	48
Web	87
BF	48

Note: For RFI 437, the web splice and pertinent web splice input was updated and verified. Flange splices were not re-evaluated.

Determine Controlling Section

	Top Flange			Bottom Flange			Web		
Section	Area	ϕf Fnc	A*Fnc	Area	ϕf Fnc	A*Fnc	Area	Fyw	A*Fyw
7153 L	64.00	50.00	3200.00	64.00	47.22	3022.18	96.00	50.00	4800.00
7153 R	56.00	50.00	2800.00	56.00	50.00	2800.00	96.00	50.00	4800.00

Rh = 1.00

Controlling Section = 7153 R

Section and Material Properties

		b (in)	t (in)	L (in)	Ag (in2)	An (in2)	Ae (in2)	Fy (ksi)	Fu (ksi)
Girder Section	TF	32.00	1.75	---	56.00	41.13	45.02	50	65
	Web	96.00	1.00	---	96.00	65.19	---	50	65
	BF	32.00	1.75	---	56.00	41.13	45.02	50	65
Splice Plates	TF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	TF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Inside	14.50	0.875	38.50	25.38	17.94	---	50	65
	BF Outside	32.00	0.750	38.50	24.00	17.63	---	50	65
	Web	92.00	0.500	20.75	92.00	61.19	---	50	65

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	8/5/2011	Job Number	49633	Revised	DJG	Date	10/11/2012
		Checked	WME	Date 8/5/2011			Checked	SJL	Date	10/11/2012
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date 8/5/2011	Sheet No.		Backchk'd	DJG	Date	10/11/2011

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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)	-10.59	4.26	14.86	-15.87	5.87	-12.58	-8.11	7.73	7.84	-9.43	-4.07	-3.51	20.36	-25.92	-9.42	13.33
ϕf Fnc (ksi)	50.00	50.00	50.00	47.09	50.00	46.78	50.00	50.00	50.00	47.03	50.00	42.35	50.00	47.00	50.00	50.00
f / ϕf Fnc	0.21	0.09	0.30	0.34	0.12	0.27	0.16	0.15	0.16	0.20	0.08	0.08	0.41	0.55	0.19	0.27
α	1.00	1.00	1.00	0.94	1.00	0.94	1.00	1.00	1.00	0.94	1.00	0.85	1.00	0.94	1.00	1.00
fcf (ksi)	-10.59			-15.87		-12.58	-8.11			-9.43		-3.51		-25.92		13.33
Fcf (ksi)	-37.50			-35.32		-35.08	-37.50			-35.27		-31.76		-36.46		37.50
Fcf (kip)	-2100.00			-1977.69		-1964.66	-2100.00			-1975.31		-1778.60		-2041.95		1688.29
fncf (ksi)		4.26	14.86		5.87			7.73	7.84		-4.07		20.36		-9.42	
Rcf		3.54	2.23		2.79			4.62	3.74		9.05		1.41		2.81	
Fncf (ksi)		37.50	37.50		37.50			37.50	37.50		-37.50		37.50		-37.50	
Fncf (kip)		1688.29	1688.29		1688.29			1688.29	1688.29		-2100.00		1688.29		-2100.00	

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)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (ksi)	-5.81	2.19	9.76	-9.60	-1.53	-8.25	-4.78	6.27	-1.05	-4.27	-4.17	-2.75	15.02	-19.77	-7.01	10.74
Fs (kip)	-325.31	122.68	546.64	-537.46	-85.79	-461.81	-267.56	351.36	-58.65	-239.27	-233.53	-154.02	840.86	-1107.32	-392.64	601.69

Max Flange Design Forces

	Strength I		Service II	
Pu	TF	BF	TF	BF
Tension	1688.29	1688.29	840.86	601.69
Comp	2100.00	2041.95	392.64	1107.32

ϕvVn (kip) = 1375.39

e_v (in) = 9.875

Web Design Forces (6.13.6.1.4b)

	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
Vu (kip)	575.70	455.11	720.25	230.64	442.77	532.07	558.31	362.80	417.41	330.11	519.53	171.52	321.39	386.58	405.12	264.89
Vuw (kip)	863.54	682.67	1047.82	345.97	664.16	798.11	837.47	544.20	---	---	---	---	---	---	---	---
Mv (k*ft)	710.62	561.78	862.27	284.70	546.55	656.78	689.17	447.83	343.49	271.65	427.53	141.14	264.48	318.13	333.38	217.98
Huw (kip)	-1075.00	-108.10	-898.69	-84.92	-286.56	-3294.18	-375.78	528.55	-173.68	7.86	-469.37	71.83	-255.36	-332.19	-228.40	179.18
Muw (k*ft)	3366.67	4376.32	3292.39	4686.77	4132.93	326.87	4166.28	4095.26	511.99	1238.97	429.73	707.34	206.42	90.86	2226.49	1136.37
Mu (k*ft)	4077.29	4938.10	4154.66	4971.47	4679.48	983.65	4855.44	4543.09	855.48	1510.62	857.26	848.48	470.90	408.99	2559.87	1354.35

Note: Mu = Muw + Mv

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	8/5/2011	Job Number	49633	Revised	DJG	Date	10/11/2012
		Checked	WME	Date 8/5/2011			Checked	SJL	Date	10/11/2012
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date 8/5/2011	Sheet No.		Backchk'd	DJG	Date	10/11/2011

Web Bolt Force

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	Strength I								Service II							
	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ	MAX FX	MIN FX	MAX FY	MIN FY	MAX MY	MIN MY	MAX MZ	MIN MZ
PX1 (Huw)	12.36	1.24	10.33	0.98	3.29	37.86	4.32	6.08	2.00	0.09	5.40	0.83	2.94	3.82	2.63	2.06
PY1 (Vuw)	9.93	7.85	12.04	3.98	7.63	9.17	9.63	6.26	4.80	3.79	5.97	1.97	3.69	4.44	4.66	3.04
PX2 (Mu)	37.14	44.98	37.84	45.28	42.62	8.96	44.23	41.38	7.79	13.76	7.81	7.73	4.29	3.73	23.32	12.34
PY2 (Mu)	2.65	3.21	2.70	3.23	3.04	0.64	3.16	2.96	0.56	0.98	0.56	0.55	0.31	0.27	1.67	0.88
Pu (kip)	51.07	47.53	50.38	46.82	47.14	47.84	50.20	48.34	11.16	14.65	14.73	8.92	8.26	8.89	26.70	14.92

Note: $Pu = \sqrt{((PX1 + PX2)^2 + (PY1 + PY2)^2)}$

Splice Plate Design

Flange Splice Plates in Tension (6.13.5.2)

	Pu (kip)	Pry (kip)	Pru (kip)	Avg (in2)	Avn (in2)	Atn (in2)	Prbs (kip)	Rr (kip)	Check
TF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	OK
TF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Inside	867.65	1205.31	932.75	59.50	39.05	12.80	1843.09	932.75	OK
BF Outside	820.64	1140.00	916.50	25.50	16.73	15.42	1306.65	916.50	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	1020.76	1080.00	OK
TF Inside	1079.24	1141.88	OK
BF Inside	1049.41	1141.88	OK
BF Outside	992.54	1080.00	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)	46.37	43.18	45.11	43.21	42.92	44.17	45.39	44.39
Check	OK	OK	OK	OK	OK	OK	OK	OK

S (in3) = 1410.7

Web Splice Plates in Shear (6.13.5.3)

Vu (kip)	1047.82
Rr (kip)	1845.42
Check	OK

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE		8/5/2011	Job Number	49633	Revised	DJG	Date	1 012
		Checked	WME	Date	8/5/2011			Checked	SJL	Date	10/11/2012
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Splice Bolt Design

Shear Resistance (6.13.2.7 & 6.13.6.1.5)

Ns = 1

	Fill Pl (in)	R	L Factor	Rr (kip)
TF	0.25	0.88	1.0	31.76
Web	0.00	1.00	1.0	36.19
BF	0.25	0.88	1.0	31.76

Slip Resistance (6.13.2.8)

Kh	1.00	
Ks	0.33	(Class A)
Ns	1.0	
Pt	51.0	
Rr	16.83	

Flange Bolt

	Shear Resistance			Slip Resistance		
	Pu (kip)	Pu/Bolt	Check	Ps	Ps/Bolt	Check
TF	1079.24	22.48	OK	432.14	9.00	OK
BF	1049.41	21.86	OK	569.08	11.86	OK

	Bearing Resistance (6.13.2.9)				
	Pu	Pu/Bolt	Lc	Rr (kip)	Check
TF Outside	1020.76	21.27	1.47	68.74	OK
TF	2100.00	43.75	1.47	160.39	OK
TF Inside	1079.24	22.48	1.47	80.19	OK
BF Inside	1049.41	21.86	1.47	80.19	OK
BF	2041.95	42.54	1.47	160.39	OK
BF Outside	992.54	20.68	1.47	68.74	OK

Web Bolt

	Shear Resistance			Slip Resistance		
	Pu (dbl)	Pu (sngl)	Check	Ps (dbl)	Ps (sngl)	Check
	51.07	25.53	OK	26.70	13.35	OK

	Bearing Resistance (6.13.2.9)			
	Pu/Bolt	Lc	Rr (kip)	Check
Web	51.07	1.59	99.45	OK
Web SPL	25.53	1.47	45.83	OK

Design Factor of Safety Summary

Plate	Tension	Comp
TF Outside	1.12	1.06
TF Inside	1.08	1.06
BF Inside	1.08	1.09
BF Outside	1.12	1.09

Bolt	Shear	Slip	Bearing
TF	1.41	1.87	3.23
Web	1.42	1.26	1.79
BF	1.45	1.42	3.32

Plate	Shear	Flexure
Web	1.76	1.08

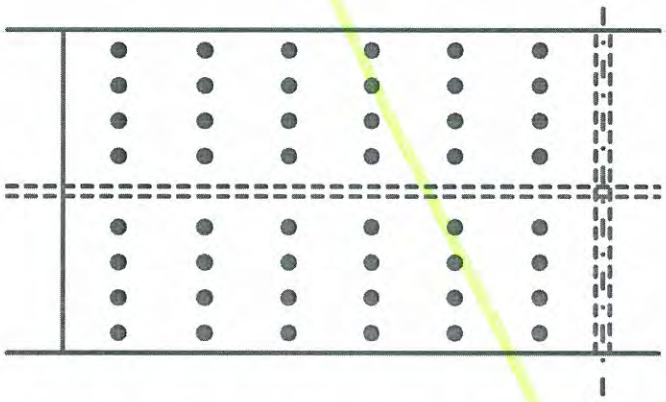
HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	
		Revised	DJG	Date	10/3/2012		
		Checked	SJL	Date	10/11/2012		
		Backchk'd	DJG	Date	10/11/2011		
		Revised	SJL	Date	5/9/2013		
		Checked	MM	Date	05/21/13		
		Backchk'd	STL	Date	5-21-13		

Flange Bolt Pattern - Node 7153

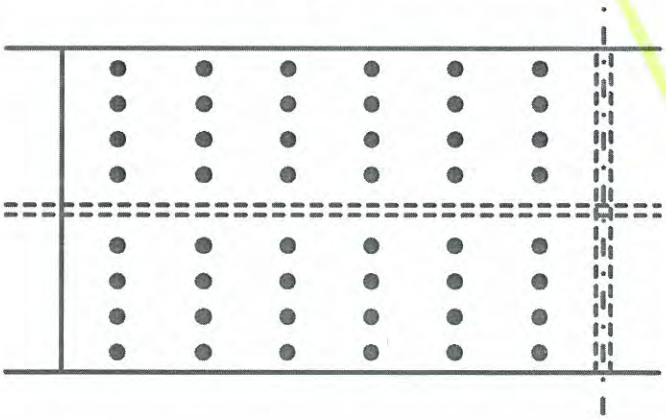
TF Bolt Coordinates (in)		BF Bolt Coordinates (in)	
x (long)	y (trans)	x (long)	y (trans)
0	0	0	0
0	3.5	0	3.5
0	7	0	7
0	10.5	0	10.5
0	17.5	0	17.5
0	21	0	21
0	24.5	0	24.5
0	28	0	28
3	0	3	0
3	3.5	3	3.5
3	7	3	7
3	10.5	3	10.5
3	17.5	3	17.5
3	21	3	21
3	24.5	3	24.5
3	28	3	28
6	0	6	0
6	3.5	6	3.5
6	7	6	7
6	10.5	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

	Top Flange		Bottom Flange	
No. Bolts =	48.0		48.0	
Splice Plate to First Column (in) =	2.000	OK	2.000	OK
No. Longitudinal Space =	5.0		5.0	
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	

Top Flange Field Splice



Bottom Flange Field Splice



HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

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Flange Bolt Pattern Cont. - Node 7153

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern - Node 7153

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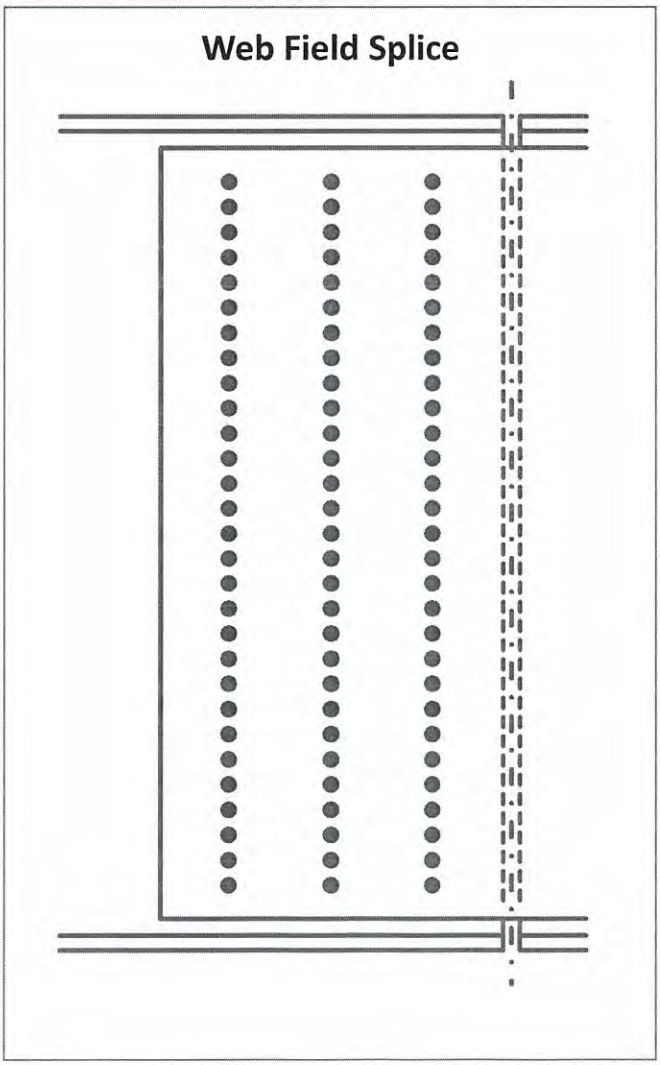
Bolt Coordinates (in)			
x (long)	y (vert)	$(x-x_{bar})^2$	$(y-y_{bar})^2$
0	0	9	1764
0	3	9	1521
0	6	9	1296
0	9	9	1089
0	12	9	900
0	15	9	729
0	18	9	576
0	21	9	441
0	24	9	324
0	27	9	225
0	30	9	144
0	33	9	81
0	36	9	36
0	39	9	9
0	42	9	0
0	45	9	9
0	48	9	36
0	51	9	81
0	54	9	144
0	57	9	225
0	60	9	324
0	63	9	441
0	66	9	576
0	69	9	729
0	72	9	900
0	75	9	1089
0	78	9	1296
0	81	9	1521
0	84	9	1764
3	0	0	1764
3	3	0	1521
3	6	0	1296
3	9	0	1089
3	12	0	900
3	15	0	729
3	18	0	576
3	21	0	441
3	24	0	324
3	27	0	225
3	30	0	144
3	33	0	81
3	36	0	36
3	39	0	9
3	42	0	0
3	45	0	9
3	48	0	36
3	51	0	81
3	54	0	144
3	57	0	225
3	60	0	324
3	63	0	441
3	66	0	576
3	69	0	729
3	72	0	900
3	75	0	1089
3	78	0	1296
3	81	0	1521
3	84	0	1764
6	0	9	1764

No. Bolts =	87.0	
Splice Plate to First Column (in) =	2.000	OK
No. Longitudinal Space =	2.0	
Longitudinal Spacing (in) =	3.000	OK
Last Column to End Girder (in) =	2.125	OK
Gap (in) =	0.500	
Top/Bot Web to First Row (in) =	6.000	OK
Splice Plate to First Row (in) =	4.000	OK
No. Vertical Space =	28.0	
Vertical Spacing (in) =	3.000	OK
Bolt Stagger =	NO	
x_{bar} (in) =	3	
y_{bar} (in) =	42	
$\Sigma(x-xbar)^2$ (in^2)=	522	
$\Sigma(y-ybar)^2$ (in^2) =	54810	
Σd^2 (in^2) =	55332.0	



6	3	9	1521
6	6	9	1296
6	9	9	1089
6	12	9	900
6	15	9	729
6	18	9	576
6	21	9	441
6	24	9	324
6	27	9	225
6	30	9	144
6	33	9	81
6	36	9	36
6	39	9	9
6	42	9	0
6	45	9	9
6	48	9	36
6	51	9	81
6	54	9	144
6	57	9	225
6	60	9	324
6	63	9	441
6	66	9	576
6	69	9	729
6	72	9	900
6	75	9	1089
6	78	9	1296
6	81	9	1521
6	84	9	1764

Web Bolt Pattern Cont. - Node 7153

MM 05/21/13
SJL 5-21-13

HNTB	The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633
		Checked	WME	Date	8/5/2011		
For	Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd	SAE	Date	8/5/2011	Sheet No.	

Web Bolt Pattern Cont. - Node 7153

MM 05/21/13
SJL 5-21-13

261	3654	522	54810

Sarah Larson

From: Hans Hutton
Sent: Thursday, May 09, 2013 10:17 AM
To: Sarah Larson
Subject: FW: Girder Splices

fyi

Regards,

Hans

From: Mike Grubb [mailto:mgrubb@zoominternet.net]
Sent: Thursday, May 09, 2013 10:13 AM
To: Hans Hutton
Cc: Karl Frank
Subject: Re: Girder Splices

Hans,

I will give it my best shot to answer your question first...and then let Karl add anything (or possibly *correct*) what I say.

In web splice design, we typically design the bolts on one side of the splice for the actions at the splice assumed applied at the centroid of the bolt group on one side. We design the bolts for the shear at the splice, a moment due to the eccentricity of the shear at the splice (with the eccentricity measured from the center of the splice to the centroid of the bolts on one side), and the portion of the flexural moment at the splice that is assumed resisted by the web. The splice may also be designed for a horizontal force resultant to ensure equilibrium if the girder is not doubly symmetric. This allows us to conveniently and conservatively use the same number of bolts on the other side of the splice, even though the moment acting at the centroid of the bolt group on the other side of the splice is slightly different that at the centroid on the other side of the splice. For practical reasons in new designs, it is also probably a good idea to keep the splice symmetrical to avoid any possible confusion in the fab shop, in the field, etc. and to perhaps better help maintain girder alignment. In your special case, I suppose you could check the bolt group on each side separately to make sure all is ok, or if there is still concern, add to the splice on the other side to make it symmetrical.

Those are my thoughts anyway...hopefully Karl will be able to chime in...

Mike

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Phone: 724-799-8286
Cell: 724-272-9749
Fax: 724-799-8287
E-mail: mgrubb@zoominternet.net

----- Original Message -----
From: Hans Hutton
To: 'mgrubb@zoominternet.net' ; Karl Frank (karl.frank@hirschfeld.com)
Sent: Thursday, May 09, 2013 10:32 AM
Subject: Girder Splices

Mike and Karl,

I am hoping that you might be able to provide me with some insight into the AASHTO Specifications regarding splices. We have an unusual situation that has developed due to some damage that occurred during construction. What we are considering is shown in the attached file. The concern by the client is that there is a provision in the Specifications that requires splices to be symmetrical. Can you tell me the basis of this provision? As you can see from the attached sketch the proposed splice would not be symmetrical. Your insight would be appreciated.

Best Regards,

Hans

Hans R. Hutton, P.E., S.E.
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Sarah Larson

From: Hans Hutton
Sent: Thursday, May 09, 2013 10:49 AM
To: Sarah Larson
Subject: FW: Girder Splices

See comment regarding proper eccentricity.

Regards,

Hans

From: Karl Frank [mailto:karl.frank@hirschfeld.com]
Sent: Thursday, May 09, 2013 10:46 AM
To: Hans Hutton; 'mgrubb@zoominternet.net'
Subject: RE: Girder Splices

Hans,

I think the requirement the connection be symmetrical is just simply a statement flowing the consequence that the forces should be the same each side of the splice and consequently they should be symmetrical. Often flange splices at width transitions are not symmetrical. I think a properly designed unsymmetrical connection is OK.

You should fill the holes in the original connection with tightened bolts to bring their fatigue strength to category B and they also serve to insure that the splice plate does not buckle between the bolt groups which could occur if left the bolts out of those holes. These bolts will also insure you meet the maximum edge distances to prevent corrosion built up between the plates. You need to consider the added eccentricity of the shear force which produces a larger moment in the connection. The eccentricity is the equal to the distance between the active bolt groups divided by 2.

Karl H. Frank
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Cell 512-633-7544
karl.frank@hirschfeld.com

HIRSCHFELD INDUSTRIES
BRIDGE

From: Hans Hutton [mailto:HHutton@HNTB.com]
Sent: Thursday, May 09, 2013 9:33 AM
To: 'mgrubb@zoominternet.net'; Karl Frank
Subject: Girder Splices

Mike and Karl,

I am hoping that you might be able to provide me with some insight into the AASHTO Specifications regarding splices. We have an unusual situation that has developed due to some damage that occurred during construction. What we are considering is shown in the attached file. The concern by the client is that there is a provision in the Specifications that requires splices to be symmetrical. Can you tell me the basis of this provision? As you can see from the attached sketch the proposed splice would not be symmetrical. Your insight would be appreciated.

Best Regards,

Hans

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