For CLEVELAND-RFI 431	Job no. 49633	Sheet no. 1
Made by SJL	Checked by JBT	Backchecked by SJL
Date 3-15-13	Date 3/21/13	Date 3-21-13

HNTB

RFI 437 - FIELD SPLICE 17

→ Girder 4 F.S. 17 did not fit-up correctly in the field. As a result of workers trying to fit-up the web connection, several holes in the Girder Web have been elongation and material around the hole has been damaged.

→ Per conversation with HRH, damaged material around hole is similar to that of a punched hole which changes the fatigue category from a B to a D.

→ As a remedy, the damaged web material should be removed by reaming the holes to a larger size and placing an appropriate-sized (larger) bolt in the reamed-out hole

→ This solution would not change the slip-critical capacity of the connection since oversized holes would not be used.

→ The minimum bolt spacing required in AASHTO would be violated, but this is a construction tolerance and is acceptable if the contractor is OK with it.

→ Since larger holes will be used, the following design checks need to be re-evaluated for the Web:

- Bearing Resistance

→ Note: Since the two splice plates are ½" thick and the web is 1" thick, only checks for the web need to be completed since the sum of splice plate thicknesses is equal to the web thickness

ME101-1204

For CLEVELAND	Job no.	Sheet no. 2
Made by SJL	Checked by UBT	Backchecked by SJL
Date 3-13-13	Date 3/21/13	Date 3-21-13

HNTB

→ RFI #437

→ Elongated web splice holes in web

→ Holes are elongated to ≈1 1/4" max near edge of plate

→ Approx. 80% of holes are elongated

→ Plan hole size was 1 1/16" Ø hole for 1" Ø bolts.

→ Design used 1/2" Gap between Girders ⇒ OK

→ Min. bolt spacing (AASHTO)

→ $3d_b$ = 3"

→ min clr. btwn. holes = $2d_b$

⇒ $2d_b$ + oversized hole Ø

⇒ 2" + 1.25" = 3.25"

* Min. bolt spacing is exceeded

→ Construction tolerance, OK if contractor is OK with it

→ Minimum Edge Distance = 1 3/4" for a sheared edge, 1 1/4" for a rolled edge

→ Plan edge distance = 2"

⇒ OK

SPLICE DATA:

→ Girder 4, FS 17

Web = 1" x 96" (both sides)

Flanges = 2" x 32" (back station)

Flanges = 1 3/4" x 32" (upstation)

(Grade 50)

→ Web Splice (1 side)

Columns: 3 col. @ 3"

Rows: 29 rows @ 3"

→ Assume All holes are reamed to 1 9/16" Ø hole and will have a 1 1/2" Ø bolt.

→ Splice plates (Each side)

1/2" x 20 1/2" wide x 89" deep

(Grade 50)

ME101-1204

For CLEVELAND	Job no. 49633	Sheet no. 3
Made by SJL	Checked by JBT	Backchecked by SJL
Date 3-15-13	Date 4/3/13	Date 4-3-13

HNTB

RFI #437

→ Check Bearing Resistance
(AASHTO 6.13.2.9)

$R_r = \phi R_n$ $\phi_{bb} = 0.80$

Assume ø hole = 1.5625"

Clr. btwn. holes = 3" − 1.5625" = 1.4375" < $2d_b$

Clr to end = 2" − 1.5625"/2 = 1.21875" < $2d_b$
⇒ $R_n = 1.2 L_c t F_u$

$L_c = 1.22"$

$\phi R_n = (1.2)(0.80)(1.22")(1")(65 ksi)$
$\phi R_n = 76.1 k/bolt$

From spreadsheet, (Tab "Type 3," cell C108),
max force on bolt = 48.08k

$\phi R_n = 76.1 k/bolt > 48.08k$ ⇒ OK

→ Since Σt splice plates = t_{web},
splice plates do not need checked
for Bearing Resistance

ME101-1204

6.13.6—Splices

6.13.6.1—Bolted Splices

6.13.6.1.1—General

Bolted splices shall be designed at the strength limit state to satisfy the requirements specified in Article 6.13.1. Where a section changes at a splice, the smaller of the two connected sections shall be used in the design.

6.13.6.1.2—Tension Members

Splices for tension members shall satisfy the requirements specified in Article 6.13.5.2. Splices for tension members shall be designed using slip-critical connections as specified in Article 6.13.2.1.1.

6.13.6.1.3—Compression Members

Splices for compression members detailed with milled ends in full contact bearing at the splices and for which the contract documents specify inspection during fabrication and erection, may be proportioned for not less than 50 percent of the lower factored resistance of the sections spliced.

Splices in truss chords, arch members, and columns should be located as near to the panel points as practicable and usually on that side where the smaller force effect occurs. The arrangement of plates, angles, or other splice elements shall be such as to make proper provision for all force effects in the component parts of the members spliced.

C6.13.6.1.3

This is consistent with the provisions of past editions of the Standard Specifications which permitted up to 50 percent of the force in a compression member to be carried through a splice by bearing on milled ends of components.

6.13.6.1.4—Flexural Members

6.13.6.1.4a—General

In continuous spans, splices should be made at or near points of dead load contraflexure. Web and flange splices in areas of stress reversal shall be investigated for both positive and negative flexure.

In both web and flange splices, there shall not be less than two rows of bolts on each side of the joint. Oversize or slotted holes shall not be used in either the member or the splice plates at bolted splices.

Bolted splices for flexural members shall be designed using slip-critical connections as specified in Article 6.13.2.1.1. The connections shall also be proportioned to prevent slip during the erection of the steel and during the casting of the concrete deck.

The factored flexural resistance of the flanges at the point of splice at the strength limit state shall satisfy the applicable provisions of Article 6.10.6.2.

The flexural stresses due to the factored loads at the strength limit state and for checking slip of the bolted connections at the point of splice shall be determined using the gross section properties.

Bolted flange angle splices shall include two angles, one on each side of the flexural member.

C6.13.6.1.4a

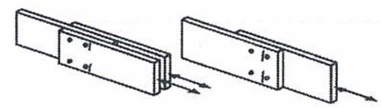
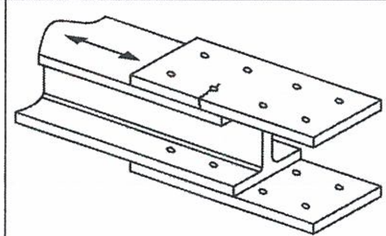
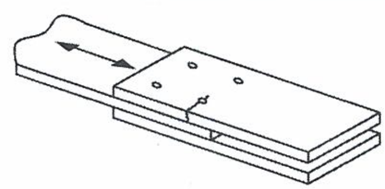
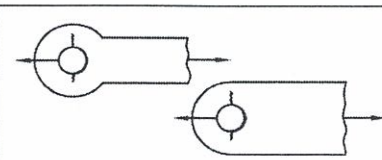
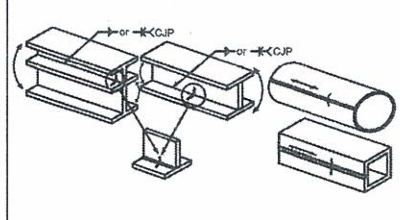
For a flexural member, it is recommended that the smaller section at the point of splice be taken as the side of the splice that has the smaller calculated moment of inertia for the noncomposite steel section.

Bolted splices located in regions of stress reversal near points of dead load contraflexure must be checked for both positive and negative flexure to determine the governing condition.

To ensure proper alignment and stability of the girder during construction, web and flange splices are not to have less than two rows of bolts on each side of the joint. Also, oversize or slotted holes are not permitted in either the member or the splice plates at bolted splices of flexural members for improved geometry control during erection and because a strength reduction may occur when oversize or slotted holes are used in eccentrically loaded bolted web connections.

Also, for improved geometry control, bolted connections for both web and flange splices are to be proportioned to prevent slip under the maximum actions induced during the erection of the steel and during the casting of the concrete deck.

Table 6.6.1.2.3-1 (continued)—Detail Categories for Load-Induced Fatigue

Description	Category	Constant A (ksi^3)	Threshold $(\Delta F)_{TH}$ ksi	Potential Crack Initiation Point	Illustrative Examples
Section 2—Connected Material in Mechanically Fastened Joints					
2.1 Base metal at the gross section of high-strength bolted joints designed as slip-critical connections with pre-tensioned high-strength bolts installed in holes drilled full size or subpunched and reamed to size—e.g., bolted flange and web splices and bolted stiffeners. (Note: see Condition 2.3 for bolt holes punched full size.)	B	120×10^8	16	Through the gross section near the hole	
2.2 Base metal at the net section of high-strength bolted joints designed as bearing-type connections, but fabricated and installed to all requirements for slip-critical connections with pre-tensioned high strength bolts installed in holes drilled full size or subpunched and reamed to size. (Note: see Condition 2.3 for bolt holes punched full size.)	B	120×10^8	16	In the net section originating at the side of the hole	
2.3 Base metal at the net section of all bolted connections in hot dipped galvanized members (Huhn and Valtinat, 2004); base metal at the appropriate section defined in Condition 2.1 or 2.2, as applicable, of high-strength bolted joints with pretensioned bolts installed in holes punched full size (Brown et al., 2007), and base metal at the net section of other mechanically fastened joints, except for eyebars and pin plates; e.g., joints using ASTM A307 bolts or non pretensioned high strength bolts.	D	22×10^8	7	In the net section originating at the side of the hole or through the gross section near the hole, as applicable	
2.4 Base metal at the net section of eyebar heads or pin plates (Note: for base metal in the shank of eyebars or through the gross section of pin plates, see Condition 1.1 or 1.2, as applicable).	E	11×10^8	4.5	In the net section originating at the side of the hole	
Section 3—Welded Joints Joining Components of Built-Up Members					
3.1 Base metal and weld metal in members without attachments built-up of plates or shapes connected by continuous longitudinal complete joint penetration groove welds back-gouged and welded from the second side, or by continuous fillet welds parallel to the direction of applied stress.	B	120×10^8	16	From surface or internal discontinuities in the weld away from the end of the weld	

Damaged material due to fit-up is similar to a punched hole

continued on next page

Table 11.4.7-1—Maximum Straightening Temperature

AASHTO M 270M/M 270 (ASTM A709/A709M) Grades	Temperature
HPS 70W	1100°F
HPS 100W	1100°F

In all other steels, the temperature of the heated area shall not exceed 1200°F as controlled by temperature indicating crayons, liquids, or bimetal thermometers. Heating in excess of the limits shown shall be cause for rejection, unless the Engineer allows testing to verify material integrity.

Parts to be heat-straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

11.4.8—Bolt Holes

11.4.8.1—Holes for High-Strength Bolts and Unfinished Bolts

11.4.8.1.1—General

All holes for bolts shall be either punched or drilled, except as noted herein. The width of each standard hole shall be the nominal diameter of the bolt plus 0.0625 in. The standard hole diameter for metric bolts M24 and smaller shall be the nominal diameter of the bolt plus 2 mm. For metric bolts M27 and larger, the standard hole diameter shall be the nominal diameter of the bolt plus 3 mm.

Except as noted in the articles below, material forming parts of a member composed of not more than five thicknesses of metal may be punched full-size.

When more than five thicknesses of material are joined or, as required by Article 11.4.8.5, material shall be subdrilled or subpunched and then reamed full-size, or drilled full-size while in assembly.

When required, all holes shall be either subpunched or subdrilled 0.1875 in. smaller and, after assembling, reamed or drilled to full size.

Holes in cross frames, lateral bracing components, and the corresponding holes in connection plates between girders and cross frames or lateral components may be punched full size. Holes in longitudinal main load-carrying members, transverse floorbeams, and any components designated as fracture critical (FCMs) shall not be punched full-size.

When shown in the contract documents, enlarged or slotted holes are allowed with high-strength bolts.

C11.4.8.1.1

Previous punching restrictions whenever the thickness of the material was not greater than 0.75 in. for structural steel, 0.625 in. for high strength steel, or 0.5 in. for quenched-and-tempered alloy steel, are upper limits but punching equipment may be more restrictive.

For other dimensional criteria assumed in the design of bolted details, e.g., oversize holes, slotted holes, edge distances, and end distances, see Article 6.13.2, "Bolted Connections," of the *AASHTO LRFD Bridge Design Specifications.*

With the owner's approval, round or slotted holes for non-main members in thin plate may be thermally cut by plasma, laser, or oxygen-acetylene methods subject to the requirements herein.

With the owner's approval, round or slotted holes for non-main members in thin plate may successfully be thermally cut by plasma, laser, or oxygen-acetylene means. The maximum surface roughness of ANSI 1000 μin. and the conical taper of the hole must be maintained within tolerance. See references AISC *Steel Construction Manual*, 13th Edition, Section M2.5; RCSC *Specification for Structural Joints Using ASTM A325 or A490 Bolts*, Section 3.3; and NSBA *Steel Bridge Fabrication*, S2.1.

11.4.8.1.2—Punched Holes

If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean-cut without torn or ragged edges. The slightly conical hole that naturally results from punching operations shall be considered acceptable.

11.4.8.1.3—Reamed or Drilled Holes

Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall comply with the requirements of Article 11.4.8.1.1 as to size. Where practical, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Reaming and drilling shall be done with twist drills, twist reamers, or rotobroach cutters. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match-marked before disassembling.

11.4.8.1.4—Accuracy of Holes

Holes not more than 0.03125 in. larger in diameter than the true decimal equivalent of the nominal diameter that may result from a drill or reamer of the nominal diameter shall be considered acceptable. The width of slotted holes which are produced by thermal cutting or a combination of drilling or punching and thermal cutting should be not more than 0.03125 in. greater than the nominal width. The thermally-cut surface shall be ground smooth to obtain a maximum surface roughness of ANSI 1000 μin.

11.4.8.2—Accuracy of Hole Group

11.4.8.2.1—Accuracy before Reaming

All holes punched full-size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 0.125 in. smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces shall be rejected. If any hole will not pass a pin 0.1875 in. smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection.

11.5.5.3—Ribbed Bolts

The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 0.078125 in. greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B18.5 (ANSI B18.5.2.2M or B18.5.2.3M) as specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not distort to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

11.5.6—Connections Using High-Strength Bolts

11.5.6.1—General

This Article covers the assembly of structural joints using AASHTO M 164 (ASTM A325) or AASHTO M 253 (ASTM A490) high-strength bolts or equivalent fasteners, installed so as to develop the minimum required bolt tension specified in Table 11.5.6.4.1-1. The bolts are used in holes conforming to the requirements of Article 11.4.8, "Bolt Holes."

C11.5.6.1

Information is found in the *Structural Bolting Handbook*, SBH-1 (1996).

11.5.6.2—Bolted Parts

All material within the grip of the bolt shall be steel; there shall be no compressible material such as gaskets or insulation within the grip. Bolted steel parts shall fit solidly together after the bolts are snugged and may be coated or uncoated. The slope of the surfaces of parts in contact with the bolt head or nut shall not exceed 1:20 with respect to a plane normal to the bolt axis.

11.5.6.3—Surface Conditions

At the time of assembly, all joint surfaces, including surfaces adjacent to the bolt head and nut, shall be free of scale, except tight mill scale, and shall be free of dirt or other foreign material. Burrs that would prevent solid seating of the connected parts in the snug condition shall be removed.

Paint is permitted on the faying surface including slip-critical joints when designed in accordance with Article 6.13.2, "Bolted Connections," of the *AASHTO LRFD Bridge Design Specifications*.

The faying surfaces of slip-critical connections shall meet the requirements of the following paragraphs, as applicable:

- In noncoated joints, paint, including any inadvertent overspray, shall be excluded from areas closer than one bolt diameter but not less than 1.0 in. from the edge of any hole and all areas within the bolt pattern.

C11.5.6.3

Surface conditions refers to Article 6.13.2, "Bolted Connections," and Article 6.13.2.8, "Slip Resistance," of the *AASHTO LRFD Bridge Design Specifications*.

- Joints specified to have painted faying surfaces shall be blast cleaned and coated with a paint which has been qualified in accordance with requirements of Article 6.13.2.8, "Slip Resistance," of the *AASHTO LRFD Bridge Design Specifications.*

- Coated joints shall not be assembled before the coating has cured for the minimum time used in the qualifying test.

- Faying surfaces specified to be galvanized shall be hot-dip galvanized in accordance with AASHTO M 111M/M 111 (ASTM A123/A123M) and shall subsequently be roughened by means of hand wire brushing. Power wire brushing is not permitted.

"Surface conditions" refers to Article 6.13.2, "Bolted Connections," and Article 6.13.2.8, "Slip Resistance," of the *AASHTO LRFD Bridge Design Specifications*, 2007.

11.5.6.4—Installation

11.5.6.4.1—General

C11.5.6.4.1

Fastener components shall be assigned lot numbers, including rotational-capacity lot numbers, prior to shipping and components shall be assembled when installed. Such components shall be protected from dirt and moisture at the job site. Only the number of anticipated components to be installed and tensioned during a work shift shall be removed from protective storage. Components not used shall be returned to protective storage at the end of the shift. Assemblies for slip-critical connections which accumulate rust or dirt resulting from job site conditions shall be cleaned, relubricated, and tested for rotational capacity prior to installation. All galvanized nuts shall be lubricated with a lubricant containing a visible dye. Plain bolts must be oily to touch when delivered and installed. Lubricant on exposed surfaces shall be removed prior to painting.

A bolt-tension measuring device (a Skidmore-Wilhelm Calibrator or other acceptable bolt-tension indicating device) shall be at all job sites where high-strength bolts are being installed and tensioned. The tension-measuring device shall be used to perform the rotational-capacity test and to confirm:

- the suitability to satisfy the requirements of Table 11.5.6.4.1-1 of the complete fastener assembly, including lubrication if required to be used in the work,

- calibration of the wrenches, if applicable, and

- the understanding and proper use by the bolting crew of the installation method.

Field Splice - Node 7153

For RFI 437

Updated	SJL	Date	3/20/2013
Checked	UBT	Date	3/26/2013
Backchk'd	SJL	Date	3-26-13

This calculation was checked using a previously checked version of this spreadsheet. Only the updated design parameters and resulting design checks were verified. Equations not re-checked.

Node 7153

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)	1.56	(6.13.2.4.2-1)

	No. Bolt
TF	48
Web	87
BF	48

Note: Hole diameter changed to 1 9/16" dia. hole to conservatively check connection for RFI 437. Changing the hole diameter here changes all flange and web holes. OK

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	34.13	37.36	50	65
	Web	96.00	1.00	---	96.00	50.69	---	50	65
	BF	32.00	1.75	---	56.00	34.13	37.36	50	65
Splice Plates	TF Outside	32.00	0.750	38.50	24.00	14.63	---	50	65
	TF Inside	14.50	0.875	38.50	25.38	14.44	---	50	65
	BF Inside	14.50	0.875	38.50	25.38	14.44	---	50	65
	BF Outside	32.00	0.750	38.50	24.00	14.63	---	50	65
	Web	89.00	0.500	20.50	89.00	43.69	---	50	65

NOTE: The capacity shown in this calculation for Girder 4, FS 17 is valid for only the Girder 4 FS 17 location and cannot be assumed for other locations or field splices. Other locations must be evaluated separately.

The HNTB Companies Engineers Architects Planners	Made	SAE	Date	8/5/2011	Job Number	49633	Revised	DJG	Date	10[illegible]2
	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

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		1400.92
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)		1400.92	1400.92		1400.92			1400.92	1400.92		-2100.00		1400.92		-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	1400.92	1400.92	840.86	601.69
Comp	2100.00	2041.95	392.64	1107.32

$\phi_v V_n$ (kip) = 1375.39

e_v (in) = 5.25

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)	377.80	298.67	458.42	151.36	290.57	349.17	366.39	238.09	182.61	144.42	227.30	75.04	140.61	169.13	177.24	115.89
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)	3744.47	4674.98	3750.81	4838.13	4423.50	676.04	4532.67	4333.35	694.60	1383.39	657.02	782.38	347.03	260.00	2403.73	1252.26

Note: Mu = Muw + Mv

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)	34.11	42.58	34.16	44.07	40.29	6.16	41.29	39.47	6.33	12.60	5.98	7.13	3.16	2.37	21.89	11.41
PY2 (Mu)	2.44	3.04	2.44	3.15	2.88	0.44	2.95	2.82	0.45	0.90	0.43	0.51	0.23	0.17	1.56	0.81
Pu (kip)	48.08	45.16	46.79	45.60	44.84	45.06	47.31	46.44	9.84	13.53	13.06	8.33	7.25	7.72	25.30	14.01

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	680.95	1140.00	760.50	25.50	12.61	12.80	1045.74	760.50	OK
TF Inside	719.97	1205.31	750.75	59.50	29.42	10.17	1416.30	750.75	OK
BF Inside	719.97	1205.31	750.75	59.50	29.42	10.17	1416.30	750.75	OK
BF Outside	680.95	1140.00	760.50	25.50	12.61	12.80	1045.74	760.50	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)	46.11	43.71	44.19	44.93	43.43	43.16	45.42	45.33
Check	OK	OK	OK	OK	OK	OK	OK	OK

S (in3) = 1320.2

Web Splice Plates in Shear (6.13.5.3)

Vu (kip)	1047.82
Rr (kip)	1317.62
Check	OK

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	1.0	
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	1.22	57.04	OK
TF	2100.00	43.75	1.22	133.09	OK
TF Inside	1079.24	22.48	1.22	66.54	OK
BF Inside	1049.41	21.86	1.22	66.54	OK
BF	2041.95	42.54	1.22	133.09	OK
BF Outside	992.54	20.68	1.22	57.04	OK

Web Bolt

Shear Resistance			Slip Resistance		
Pu (dbl)	Pu (sngl)	Check	Ps (dbl)	Ps (sngl)	Check
48.08	24.04	OK	25.30	12.65	OK

	Bearing Resistance (6.13.2.9)			
	Pu/Bolt	Lc	Rr (kip)	Check
Web	48.08	1.22	76.05	OK
Web SPL	24.04	1.22	38.03	OK

Design Factor of Safety Summary

Plate	Tension	Comp
TF Outside	1.12	1.06
TF Inside	1.04	1.06
BF Inside	1.04	1.09
BF Outside	1.12	1.09

Plate	Shear	Flexure
Web	1.26	1.08

Bolt	Shear	Slip	Bearing
TF	1.41	1.87	2.68
Web	1.51	1.33	1.58
BF	1.45	1.42	2.76

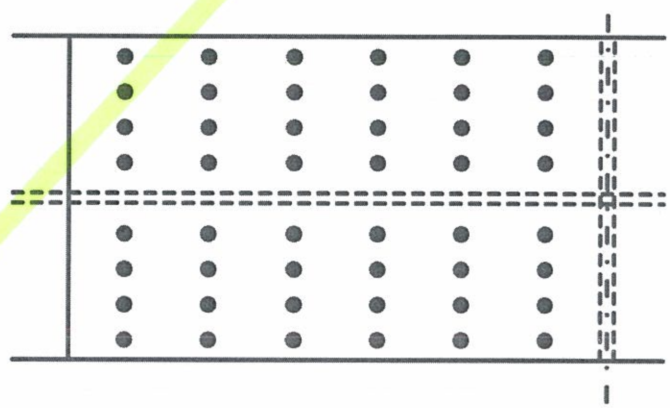
HNTB — The HNTB Companies, Engineers Architects Planners	Made: SAE	Date: 8/5/2011	Job Number: 49633
	Checked: WME	Date: 8/5/2011	
For: Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd: SAE	Date: 8/5/2011	Sheet No.
	Revised: DJG	Date: 10/3/2012	
	Checked: SJL	Date: 10/11/2012	
	Backchk'd: DJG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

Flange Bolt Pattern - Node 7153

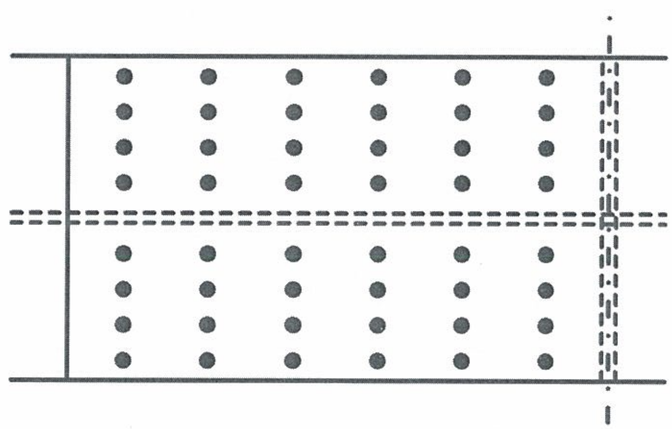
TF Bolt Coordinates (in)		BF Bolt Coordinates (in)	
x (long)	y (trans)	x (long)	y (trans)
0	0	0	0
0	3.5	0	3.5
0	7	0	7
0	10.5	0	10.5
0	17.5	0	17.5
0	21	0	21
0	24.5	0	24.5
0	28	0	28
3	0	3	0
3	3.5	3	3.5
3	7	3	7
3	10.5	3	10.5
3	17.5	3	17.5
3	21	3	21
3	24.5	3	24.5
3	28	3	28
6	0	6	0
6	3.5	6	3.5
6	7	6	7
6	10.5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



Flange Bolt Pattern Cont. - Node 7153

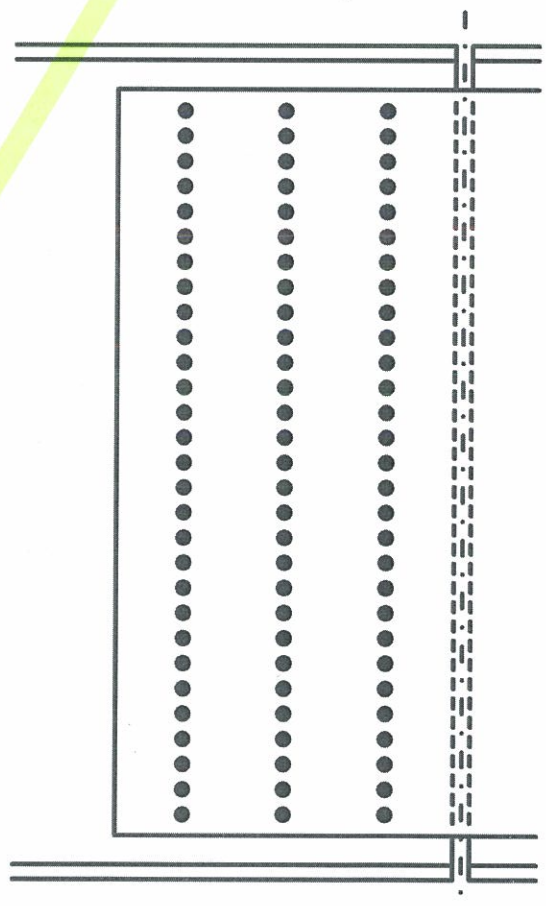
HNTB — The HNTB Companies, Engineers Architects Planners	Made: SAE	Date: 8/5/2011	Job Number: 49633
	Checked: WME	Date: 8/5/2011	
For: Cleveland InnerBelt : Field Splice - Node 7153	Backchk'd: SAE	Date: 8/5/2011	Sheet No.

Web Bolt Pattern - Node 7153

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) =	2.000	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) =	3	
y_{bar} (in) =	42	
$\Sigma(x\text{-}xbar)^2$ (in^2)=	522	
$\Sigma(y\text{-}ybar)^2$ (in^2) =	54810	
Σd^2 (in^2) =	55332	

Web Field Splice



Web Bolt Pattern Cont. - Node 7153

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

261	3654	522	54810