AISC LRFD Specification (1993) Supplement No. 1

January 30, 1998

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1. **Section A3.1a**

   To approved structural steels add:

   "High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST), ASTM A913"

2. **Table B5.1**

   a. Delete the current footnote [e] and replace with the following:

   "For members with unequal flanges, use h_p instead of h when comparing to λ_p."

   b. Define h_p in paragraph B5.1(b) ("For webs of built-up sections ...") as follows:

   "h_p is twice the distance from the plastic neutral axis to the nearest line of fasteners at the compression flange or the inside face of the compression flange when welds are used."

   c. Attach footnotes [c, e] after all formulas in the λ_p column dealing with webs in flexure.

3. **Section B10**

   a. On the second line, replace "moment of inertia" with "flexural strength".

   b. On the line following Eq. B10-1, "net flange" should be "net tension flange".

   c. Immediately following Eq. B10-3 add:

   "and the maximum flexural strength shall be based on the elastic section modulus."

4.   Section I1

   a. Revise the paragraph on Elastic Analysis as follows:

   Elastic Analysis. For an elastic analysis of continuous composite beams without haunched ends, it is permissible to assume that the stiffness of a beam is uniform throughout the beam length. The stiffness is permitted to be computed using weighted average of the moments of inertia in the positive moment region and negative moment region.

   b. Add the following definitions at the end of the section:

   Encased Composite Column. A steel column fabricated from rolled or built-up shapes and encased in structural concrete.

   Filled composite column. Structural steel tubes or pipes that are filled with structural concrete.

5.   Section I2.1 (4)

Change "55 ksi" to "60 ksi".

6.   Section I3.3

Add the following paragraph to the end of the section:

If shear connectors are provided and concrete meets the requirements of Section I2.1(2), the design flexural strength $\phi_b M_n$ shall be computed based upon the plastic stress distribution on the composite section with $\phi_b = 0.85$.

7.   Section I4

In the last sentence, replace "required" with "used"

8.   Section I5.6

Revise the third sentence of the second paragraph as follows:

The minimum center-to-center spacing of stud connectors shall be six diameters along the longitudinal axis of the supporting composite beam and four diameters transverse to the longitudinal axis of the supporting composite beam, except that within ribs of formed steel decks, oriented perpendicular to the steel beam, the minimum center-to-center spacing shall be four diameters in any direction.

9.   Section J1.9

Add the following at the end of the first paragraph:

"These calculations shall be made at factored loads."

10. Sections J3.8 and J3.9 and Appendices J3.8 and J3.9

Move service-load provisions to the appendix and factored-load provisions to the main Chapter as follows:

J3.   BOLTS AND THREADED PARTS

8.   High-Strength Bolts in Slip-Critical Connections

The design for shear of high-strength bolts in slip-critical connections shall be in accordance with either Section J3.8a or J3.8b and checked for shear in accordance with J3.6 and J3.7 and bearing in accordance with J3.2 and J3.10.

8a.   Slip-Critical Connections Designed at Factored Loads

The design slip resistance per bolt ϕr_{str} for use at factored loads shall equal or exceed the required force per bolt due to factored loads, where:

$$R_{str} = 1.13\mu T_b N_s$$

where:

T_b = minimum fastener tension given in table J3.1, kips

N_s = number of slip panes

μ = mean slip coefficient for Class A, B, or C surfaces, as applicable, or as established by tests

(a) For Class A surfaces (unpainted clean mill scale steel surfaces or surfaces with Class A coatings on blast-cleaned steel), $\mu = 0.33$

(b) For Class B surfaces (unpainted blast-cleaned steel surfaces or surfaces with Class B coatings on blast-cleaned steel, $\mu = 0.50$

(c) For Class C surfaces (hot-dip galvanized and roughened surfaces), $\mu = 0.40$

ϕ = resistance factor

(a) For standard holes, $\phi = 1.0$

(b) For oversized and short-slotted holes, $\phi = 0.85$

(c) For long-slotted holes transverse to the direction of load, $\phi = 0.70$

(d) For long-slotted holes parallel to the direction of load, $\phi = 0.60$

Finger shims up to $\frac{1}{4}$-in. are permitted to be introduced into slip-critical connections designed on the basis of standard holes without reducing the design shear stress of the fastener to that specified for slotted holes.

8b.   Slip-Critical Connections Designed at Service Loads

See Appendix J3.8b.

9.   Combined Tension and Shear in Slip-Critical Connections

The design of slip-critical connections subject to tensile forces shall be in accordance with either Sections J3.9a and J3.8a or Sections J3.9b and J3.8b.

9a.   Slip-Critical Connections Designed at Factored Loads

When a slip-critical connection is subjected to an applied tension T_u that reduces the net clamping force, the slip resistance ϕR_{str} according to Section J3.8b shall be multiplied by the following factor:

$$1 - \frac{T_u}{(1.13T_bN_b)}$$

where

T_b = minimum fastener tension given in Table J3.1, kips
N_b = number of bolts carrying factored-load tension T_u

9b.   Slip-Critical Connections Designed at Service Loads

See Appendix J3.9b.

APPENDIX

J3.   BOLTS AND THREADED PARTS

8.   High-Strength Bolts in Slip-Critical Connections

8b.   Slip-Critical Connections Designed at Service Loads

The design resistance to shear per bolt $\phi F_v A_b$ for use at service loads shall equal or exceed the shear per bolt due to service loads, where

ϕ = 1.0 for standard, oversized, and short-slotted holes and long-slotted holes when the long slot is perpendicular to the line of force

= 0.85 for long-slotted holes when the long slot is parallel to the line of force

F_v = nominal slip-critical shear resistance tabulated in Table J3.6, ksi. The values for F_v in Table J3.6 are based on Class A surfaces with slip coefficient $\mu = 0.33$. When specified by the designer, the nominal slip resistance for connections having special faying surface conditions are permitted to be adjusted to the applicable values in the RCSC Load and Resistance Factor Design Specification.

When the loading combination includes wind loads in addition to dead and live loads, the total shear on the bolt due to combined load effects, at service load, may be multiplied by 0.75.

9.   Combined Tension and Shear in Slip-Critical Connections

9b.   Slip-Critical Connections Designed at Service Loads

When a slip-critical connection is subjected to an applied tension T that reduces the net clamping force, the slip resistance $\phi F_v A_b$ according to Appendix J3.8b shall be multiplied by the following factor:

$$1 - \frac{T}{0.8T_bN_b}$$

where

T_b = minimum fastener tension from Table J3.1, kips
N_b = number of bolts carrying service-load tension T

11.   Section J3.10

To make this section consistent with the 1994 RCSC LRFD Specification, it is revised as follows:

J3.10 Bearing Strength at Bolt Holes

Bearing strength shall be checked for both bearing-type and slip-critical connections. The use of oversized holes and short- and long-slotted holes parallel to the line of force is restricted to slip-critical connections per section J3.2.

The design bearing strength at bolt holes is ϕR_n, where $\phi = 0.75$ and R_n is determined as follows:

(a)   For a bolt in connection with standard, oversized, and short-slotted holes independent of the direction of loading, or a long-slotted hole with the slot parallel to the direction of the bearing force; when deformation at the bolt hole at service load is a design consideration:

$$R_n = 1.2L_c tF_u \leq 2.4dtF_u$$

when deformation at the bolt hole at service load is not a design consideration:

$$R_n = 1.5L_c tF_u \leq 3.0dtF_u$$

For a bolt in a connection with long-slotted holes with the slot perpendicular to the direction of force:

$$R_n = 1.0L_c tF_u \leq 2.0dtF_u$$

In the foregoing,

R_n = nominal bearing strength of the connected material, kips
F_u = specified minimum tensile strength of the connected material, ksi
L_c = clear distance, in the direction of the force, between the edge of the hole
     and the edge of the adjacent hole or edge of the material, in.
d = nominal bolt diameter, in.
t = thickness of connected material, in.

For connections, the bearing resistance shall be taken as the sum of the bearing resistances of the individual bolts.

12.   Section J2.2b

In the provisions for lap joints, in Section J2.2b of the LRFD Specification, the current wording disallows the use of longitudinal welds (only) on lapped plates, which is not the intent. The second sentence of the paragraph "*In lapped joints ...*" should be modified to read "Lap joints joining plates or bars subjected to axial stress that utilize transverse fillet welds only shall be fillet welded ... <remainder unchanged>."

13.   Section J2.2b

Replace the paragraph beginning with the words, "*Fillet weld terminations ...*" with the following:

"Fillet weld terminations. Fillet weld terminations are permitted to extend to the ends or sides of parts or be stopped short or boxed except as limited by the following:

(a) For lap joints in which one part extends beyond an edge subject to calculated tensile stress, fillet welds shall terminate not less than the size of the weld from that edge.

(b) For connections and structural elements with cyclic forces normal to outstanding legs of frequency and magnitude that would tend to cause a progressive fatigue failure initiating from a point of maximum stress at the end of the weld, fillet welds shall be returned around the corner for a distance not less than the smaller of two times the weld size or the width of the part.

(c) For connections whose design requires flexibility of the outstanding legs, if end returns are used, their length shall not exceed four times the nominal size of the weld.

(d) Except where the ends of stiffeners are welded to the flange, fillet welds joining transverse stiffeners to plate girder webs shall end not less than four times nor more than six times the thickness of the web from the web toe of the web-to-flange welds.

(e) Fillet welds which occur on opposite sides of a common plane shall be interrupted at the corner common to both welds.

(f) The length and disposition of welds, including end returns shall be indicated on the design and detail drawings."

Commentary

Delete the last paragraph of Secton J2.2b ("There are numerous welded ...") and replace with the following:

J2. WELDS

2b. Limitations

Fillet weld terminations do not affect the strength or serviceability of connections in most cases. However, in certain cases, the disposition of welds affect the planned function of connections, and notches may affect the static strength and/or the resistance to crack initiation if cyclic loads of sufficient magnitude and frequency occur. For these cases, limitations are specified to assure desired performance.

(a) At lapped joints where one part extends beyond the end or edge of the part to which it is welded and if the parts are subject to calculated tensile stress at the start of the overlap, it is important that the weld terminate a short distance from the stressed edge. For one typical example, the lap joint between the Tee chord and the web members of a truss, the weld should not extend to the edge of the Tee stem. See Fig. CJ2b(1). The best technique to avoid inadvertent notches at this critical location is to strike the welding arc at a point slightly back from the edge and proceed with welding in the direction away from the edge. See Fig. CJ2b(2). On the other hand, where framing angles extend beyond the end of the beam web to which they are welded, the free end of the beam web is subject to zero stress; thus, it is permissible for the fillet weld to extend

continuously across the top end, along the side and along the bottom end of the angle to the extreme end of the beam. See Fig. CJ2b(3).

(b) For connections which are subject to maximum stress at the weld termination due to cyclic forces and/or moments of sufficient magnitude and frequency to initiate cracks emanating from unfilled start or stop craters or other discontinuities, at the end of the weld must be protected by boxing or returns. If the bracket is a plate projecting from the face of a support, extra care must be exercised in the deposition of the boxing weld across the thickness of the plate to assure that a fillet free of notches is provided.

(c) For connections such a framing angles and simple end plates which are assumed in design of the structure to be flexible connections, the top and bottom edges of the outstanding legs must be left unwelded over a substantial portion of their length in order to assure flexibility of the connection. Research tests (Johnston and Green 1940) have shown that the static strength of the connection is the same with or without end returns; therefore the use of returns is optional, but if used, their length must be restricted to not more than four times the weld size, see Fig. CJ2b(4).

(d) Experience has shown that when ends of intermediate transverse stiffeners on the webs of plate girders are not welded to the flanges (the usual practice), small torsional distortions of the flange which occur near shipping bearing points in the normal course of shipping by rail or truck may cause high out-of-plane bending stresses (yield point) and fatigue cracking at the toe of the web-to-fillet welds. This has been observed even with closely fitted stiffeners. The intensity of these out-of-plane stresses may be effectively limited and cracking prevented if "breathing room" is provided by terminating web-to-stiffener welds four times the web thickness from the toe of the web-to-flange welds. The unwelded distance should not exceed six times the web thickness to assure that the column buckling of the web within the unwelded length does not occur.

(e) For fillet welds which occur on opposite sides of a common plane, it is not possible to desposit a weld continuously around the corner from one side to the other without causing a gouge in the corner of the parts joined; therefore the welds must be interrupted at the corner. See Fig. CJ2b(5).
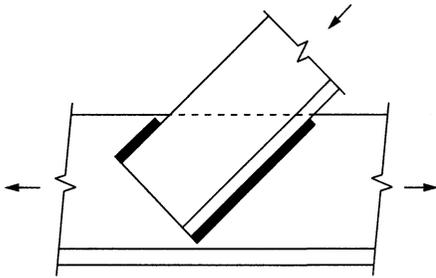
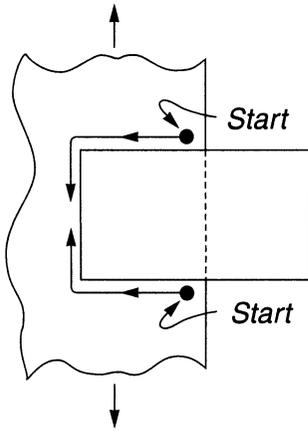*Fig. CJ2b(1). Fillet welds
near tension edges.*

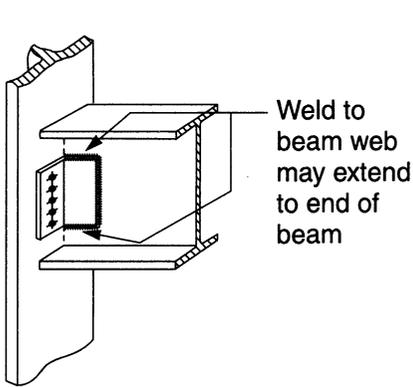*Fig. CJ2b(2). Suggested direction of
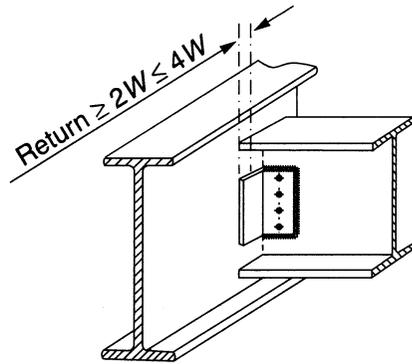welding travel to avoid notches.*

Figure CJ2b(3).

*Fig. CJ2b(4). Flexible connection returns
optional unless subject to fatigue.*

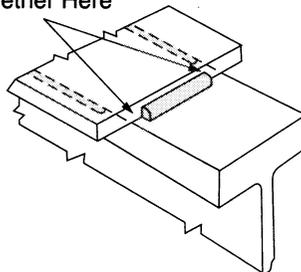*Figure CJ2b(5).*