# Part I
# 4. WELDED JOINT DETAILS

## 4.1 Backing Bars

The use of backing bars shall be in accordance with *AWS D1.1-98*, Section 5.10. All tack welds attaching backing bars to the steel prior to the welding of the joint shall be made within the joint. Preheat for such tack welds as required by *AWS D1.1*, Table 3.2, or by the WPS, as applicable, shall be provided. Backing bars may remain in place unless required to be removed by Section 4.1.1 or 4.1.2 of this specification, by *AWS D1.1-98*, Section 5.10.4, or by *AISC Specification* Section J1.5.

### 4.1.1 Heavy Section Splices Requiring Removal of Backing Bars

All welded tension splices of Heavy Sections, as defined in Section 1.3.5, shall have the backing bars removed. Where fusible backing material is used, the root pass area shall be backgouged after backing bar removal, and backwelded until flush or with slight reinforcement. The surface shall then be ground smooth, to a surface roughness not to exceed 500 microinches. Notches and gouges shall be repaired to the requirements of *AWS D1.1-98*, Section 5.15.4.4.

### 4.1.2 Moment Connection Joints Requiring Removal of Backing Bars

Backing bars shall be removed from the joint when required on the design drawings. Following removal of backing, the root pass shall be backgouged to sound weld metal, and backwelded.

Backing bar removal may be performed by air carbon arc cutting (CAC-A), commonly referred to as air carbon arc gouging (ACAG), grinding, chipping, or thermal cutting. The process shall be controlled to minimize gouging and removal of base metal except for material immediately adjacent to the weld.

Following backgouging, the root shall be backwelded. A reinforcing fillet weld with a minimum leg size of 5/16 inch or the root opening plus 1/16 inch, whichever is larger, shall be provided. The reinforcing fillet weld need not be ground. Following completion of the reinforcing fillet weld, MT shall be performed on the fillet weld and the immediately adjacent area.

Should these joints be made with nonfusible backing, the backing material shall be removed, any unacceptable weld discontinuities removed by backgouging, the root backwelded as needed, the reinforcing fillet added as described above, and MT performed on the completed fillet weld and the immediately adjacent area. If visual inspection of the root shows no unacceptable discontinuities, no backgouging and backwelding is required.

*Commentary: Backing removal is required at the beam-bottom-flange-to-column joint of the following types of prequalified moment-resisting connections: Welded*

*Unreinforced Flange (WUF) connections, Reduced Beam Section (RBS) connections, and Free Flange (FF) connections, Welded Flange Plate (WFP) connections, Bolted Flange Plate (BFP) connections. In addition, backing should be removed from any connections subject to project-specific qualification testing, if the backing was removed from the qualification test specimens.*

## 4.2 Weld Tabs

### 4.2.1 Use of Weld Tabs

Welds shall be terminated at the end of a joint in a manner that will ensure sound welds. Whenever necessary, this shall be done by use of weld tabs, also called extension bars and run-off tabs. Weld tabs shall extend beyond the edge of the joint a distance equal to a minimum of the part thickness, but not less than one inch. Weld tabs shall be oriented parallel to the joint preparation and to the weld direction. No weld dams are allowed.

Except as noted in the following sections, weld tabs shall meet the requirements of *AWS D1.1-98*, Section 5.31. Fusible weld tabs may remain in place unless their removal is required by the following sections, by *AWS D1.1-98*, Section 5.31, or by *AISC Specification* Section J1.5. Nonfusible weld tabs may be used in applications and locations where qualified in accordance with *AWS D1.1*, Section 4.

### 4.2.2 Heavy Section Joint Weld Tab Removal and Finish

All welded tension splices in Heavy Sections, as defined in Section 1.3.5, shall have the weld tabs removed and ground smooth to a finish of 500 microinches or better. Gouges and notches shall satisfy the requirements of *AWS D1.1-98*, Section 5.15.4.4, or shall be repaired to the provisions of *AWS D1.1-98*, Section 5.15.4.4.

### 4.2.3 Moment Connection Weld Tab Removal and Finish

Weld tabs shall be removed when required by the design drawings. Weld tab removal may be performed by air carbon arc cutting (CAC-A), grinding, chipping, or thermal cutting to within 1/8 inch of the base metal surface. For weld tabs used on continuity plates, removal within ¼ inch of the plate edge is adequate. The process shall be controlled to minimize gouging and removal of base metal except for that material immediately adjacent to the weld.

The edges where the weld tabs have been removed shall be finished to a surface roughness value of 500 microinches or better. Grinding to a flush condition is not required. Gouges and notches are not permitted, and must be removed by grinding. The transitional slope of any area where gouges and notches have been removed shall not exceed 1:5. Material removed by grinding that extends more than 1/16 inch below the surface of the base metal shall be filled with weld metal using approved weld repair procedures.

The contour of the weld at the ends shall provide a smooth transition, free of notches and sharp corners. A minimum radius at the corner need not be provided.

Following removal and finishing to the required smoothness and contour, and the completion of any necessary repairs, the exposed ends of the weld shall be inspected using magnetic particle testing (MT).

*Commentary: Weld tabs should be specified to be removed from each end of both the top and bottom beam flanges for the following prequalified beam-to-column connections: Welded Unreinforced Flange (WUF) connections, Reduced Beam Section (RBS) connections, Welded Flange Plate (WFP) connections, Free Flange (FF) connections, Bolted Flange Plate (BFP) connections, Welded Bottom Haunch (WBH) connections, Welded Top and Bottom Haunch (WTBH) connections, Welded Cover Plated Flange (WCPF) connections, and Improved Welded Unreinforced Flange (IWURF) connections. Weld tabs should also be removed from connections subject to project specific qualification if the tabs were removed from the qualification test specimens.*

## 4.3 Weld Toes

Weld toes, whether for groove welds or fillet welds, shall provide a smooth transition between the weld and base metal. The as-welded profile is adequate provided it satisfies the criteria of *AWS D1.1*, Section 5.24. No grinding is required.

## 4.4 Weld Access Holes

Weld access holes shall meet the dimensional, surface finish, and testing requirements of *AISC LRFD Specification Section J1.6* and *AWS D1.1-98*, Section 5.17.1 and Figure 5.2, except as otherwise required by the Contract Documents. The provisions in *AWS D1.1* Section 5.17.2 and Figure 5.2, Note 1 shall apply to all Heavy Sections as defined in this document.

The access hole shall be ground smooth to a surface roughness value not to exceed 500 microinches, and shall be free of notches and gouges. For this purpose, a notch or gouge is any depression deeper than the overall surface roughness.

Notches or gouges present from thermal cutting shall be removed by grinding, faired to a slope of not more than 1:5 against a straight cut surface, or to a radius of not less than 3/8 inch if in the curved portion of the cut surface. The depth of notches and gouges that may be repaired by grinding is not limited, provided the required dimensions, including tolerances, of the access hole are maintained.

Notches deeper than can be repaired by grinding (as above) may be repaired by welding. Prior to welding, the notch or gouge shall be ground to provide a smooth contour with a radius not less than 3/8 inch. The repair area shall be preheated to a temperature between 400°F and 550°F, measured at the point of welding immediately prior to welding. Filler metal meeting the

requirements for Seismic Weld Demand Categories A and B shall be used. A written repair WPS for the application shall be followed. Following completion of welding, the area shall be ground smooth and flush to meet the contour and finish requirements for the access holes, with fairing of the welded surface to adjoining surfaces.

Prior to acceptance, the weld access hole shall be inspected using magnetic particle testing (MT) or liquid penetrant testing (PT) and shall be free of cracks. If a welded repair has been performed, magnetic particle testing (MT) shall be performed.

## 4.5 Web Weld Details

Unless otherwise shown on the drawings, shear tabs may be welded to the column using fillet welds, partial joint penetration (PJP) groove welds with reinforcing fillet welds, a combination of fillet weld and PJP groove weld, or a CJP groove weld.

When required by the design drawings, the beam web shall be welded to the shear tab using fillet welds. A minimum clear distance of ½ inch shall be provided between the weld access hole and the toe of the fillet weld connecting the shear tab and beam web.

Fillet welds should terminate a distance equal to or greater than the leg size from the beam end.

## 4.6 Doubler Plate Details

Web doubler plates, if required, may be welded using any of the three details of the *AISC Seismic Provisions*, Figure C-9.3.

When Figure C-9.3(a) is used, the edges of the doubler plate shall be chamfered to an adequate bevel to facilitate access to the root of the weld. A square-edge plate and square groove weld between doubler plate and column is not acceptable. No grinding of the completed weld is required.

When Figure C-9.3(b) is used, the plate shall be chamfered to miss the radius of the column. The fillet weld, in both throat and leg size, as a minimum, shall be equal to or larger than the chamfer dimensions used for the doubler plate. No grinding of the completed weld is required.

## 4.7 Column Continuity Plate Details

Continuity plates, also referred to as stiffeners, shall have clips, sized to avoid interference with the radius of the column. Against the column flange, the size of the clip may exceed the radius ($k_1$ dimension) by no more than 1/2 inch. Along the web, the clip shall extend a distance of approximately 1-1/2 inches beyond the published *k* dimension. The clip shall be detailed to facilitate suitable weld terminations for both the flange weld and the web weld, with a minimum radius of ½ inch.

The weld between the continuity plate and the column flange, unless otherwise shown, shall be a CJP groove weld for the full length of the groove preparation. The joint may use backing

bars, or may be made without backing provided the root is backgouged and backwelded. If backing bars are used and remain in place, they shall receive a reinforcing fillet weld between the backing bar and column flange. No fillet weld should be placed between backing bar and continuity plate. The fillet weld size need not exceed the minimum size requirements of *AWS D1.1*, Table 5.8.

Weld terminations near the end of the column flange tips may be completed using weld tabs. Weld tabs, if used, may be steel or nonfusible material. After welding completion, weld tabs shall be removed to within ¼ inch of the continuity plate edge and the surface finished to a surface roughness not to exceed 500 microinches. Removal or grinding to the flush condition is not required. Following finishing, the edge shall be inspected using magnetic particle testing.

For column flange to continuity plate welds, weld terminations near the radius of the column need not be made using weld tabs. The use of small nonfusible weld tabs to assist in weld terminations is permitted. Weld tabs shall be removed following completion of welding, but no grinding is required.

The weld between the continuity plate and column web may be made with groove welds, fillet welds, or a combination of the two. The weld termination should be held back from the end of the joint at each end a distance of approximately ¼ inch.

## 4.8 Welding Sequence for Moment Connection of Bottom Beam Flange

When welding the bottom flange to the column flange of welded moment-resisting connections, the following sequence shall be followed:

1. When welding from Side A (one side of the beam), the root pass shall begin beyond the center of the joint on Side B, reaching past the beam web (or web plate, for FF connections) through the weld access hole (or opening, for FF connections). After the arc is initiated, travel shall progress toward the edge of the Side A beam flange, and the weld shall be terminated on the Side A weld tab.
2. The Side A root pass, and the root pass deposit on Side B, shall be thoroughly cleaned and visually inspected by the welder to ensure fusion, soundness, and freedom from cracks, slag inclusions and excessive porosity. The resulting bead profile shall be suitable for obtaining good fusion by the subsequent root pass to be initiated from Side B. If the profile is not conducive to good fusion, the start of the first root pass shall be ground, gouged, chipped, or otherwise prepared to ensure adequate profile to achieve fusion.
3. The second half of the weld joint, from Side B, shall have the root pass applied before any other weld passes are performed. The arc shall be initiated in the area of the start of the first Side A root pass, and travel shall progress to the end of the joint, terminating on the Side B weld tab.
4. The above sequence shall be repeated for subsequent weld layers, and each weld layer shall be completed on both sides of the joint before a new layer is deposited. The order of

operations (Side A, then Side B, or vice versa) is not restricted and may vary for each weld layer.

Weld passes shall be placed in horizontal layers. Each pass shall be thoroughly cleaned of slag and wire brushed. Each pass shall be visually inspected by the welder, as described above in Step 2.

Both top and bottom beam flanges should be completely welded prior to any supplemental welding to the beam web or shear tab, unless otherwise detailed in the approved erection plan and the WPS.

*Commentary: The above welding sequence is recommended for the following types of joints: Welded Unreinforced Flange (WUF) connections, Reduced Beam Section (RBS) connections, Welded Free Flange (FF) connections, Welded Bottom Haunch (WBH) connections, and Welded Top and Bottom Haunch (WTBH) connections.*

## 4.9 Improved Welded Unreinforced Flange Connection Details

The following provisions are applicable to upgrading existing connections using improvements to the existing beam flange welds only.

### 4.9.1 Existing Web Connection Materials and Details

The existing web connection and web access holes may remain as constructed.

### 4.9.2 Replacement of Beam Flange Welds

Where required on the design drawings, the existing beam-to-column flange welds shall be removed by air carbon arc cutting (CAC-A), chipping or grinding until only base metal remains. The joint shall be prepared for new groove welding, using a joint detail that uses a backing bar. The actual root opening is permitted to exceed the prequalified root opening of *AWS D1.1*, Figure 3.4, provided a split-layer technique is used for the placement of the root pass. The groove angle of the joint shall satisfy the prequalified groove angles of *AWS D1.1* Figure 3.4, unless otherwise qualified under the provisions of *AWS D1.1*, Section 4.

At the top flange, if the backing bar is left in place, a 5/16 inch reinforcing fillet shall be placed between the backing bar and the column. No weld should be placed between the backing bar and beam flange. At the bottom flange, following the provisions of Section 4.1.2 of this specification, the backing bar shall be removed, the weld root backgouged to solid weld metal, and the area backwelded until at least flush. A 5/16 inch reinforcing fillet shall be placed between the weld root and the column at the bottom of the bottom flange.

Continuity plates, if added, shall conform to the requirements of Section 4.8 of this specification.

### 4.9.3 New Welding Material

All new welding filler metals shall meet the requirements of Section 2.4 of this specification. Weld tab removal shall be as required in Section 4.2.

## 4.10 Haunched Connection Welding Details

The following provisions are applicable to upgrading existing connections with either a bottom haunch or a top and bottom haunch, as shown on the design drawings.

### 4.10.1 Existing Web Connection Materials and Details

The existing web connection and web access holes may remain as constructed.

### 4.10.2 Flange Weld Details

Where shown on the design drawings, the existing beam-to-column flange welds shall be removed by air carbon arc cutting (CAC-A), chipping or grinding until only base metal remains. The joint shall be prepared for new groove welding, using a joint detail that uses a backing bar. The actual root opening is permitted to exceed the prequalified root opening of *AWS D1.1*, Figure 3.4, provided a split-layer technique is used for the placement of the root pass. The groove angle of the joint shall satisfy the prequalified groove angles of *AWS D1.1* Figure 3.4, unless otherwise qualified under the provisions of *AWS D1.1*, Section 4.

At the top flange, if the backing bar is left in place, a 5/16 inch reinforcing fillet shall be placed between the backing bar and the column. No weld should be placed between the backing bar and beam flange. At the bottom flange, following the provisions of Section 4.1.2 of this specification, the backing bar shall be removed, the weld root backgouged to solid weld metal, and the area backwelded until at least flush. A 5/16 inch reinforcing fillet shall be placed between the weld root and the column at the bottom of the bottom flange. No fillet weld should be placed between the backing bar and beam flange.

### 4.10.3 New Welding Material

All new welding filler metals shall meet the requirements of Section 2.4 of this specification. Welding shall be executed in conformance with the requirements of Chapter 3 of this specification. Weld tab removal shall be as required in Section 4.2 of this specification.

### 4.10.4 Haunch Welding Requirements

The groove welds between column and WT haunch may be made with or without backing, but if backing is used, an access hole meeting the minimum dimensional requirements of *AWS D1.1*, Section 5.17.1 and *AWS D1.1* Figure 5.2 shall be used. Backing bars, if used, may remain in place, but if left in place, shall receive a reinforcing fillet. The weld between the WT stem and the beam flange shall be a CJP groove weld. Backing bars, if used, may remain in place, and no reinforcing fillet is required.

The weld between the WT stem and the column flange shall be a CJP groove weld. Backing bars, if used, may remain in place, but if left in place, a reinforcing fillet is required.

### 4.10.5 Continuity Plates and Stiffener Welding Requirements

New continuity plates added to the column shall meet the requirements of Section 4.7 of this specification. Stiffeners added to the beam web shall meet the requirements of Section 4.7 of this specification, except that the welds between the stiffener and the beam web may be fillet welds of minimum 5/16 inch leg size.

## 4.11 Cover-Plated Moment-Connection Details

The following provisions are applicable to upgrading existing connections with cover plates when shown on the design drawings.

### 4.11.1 Existing Web Connection Materials and Details

The existing web connection and web access holes may remain as constructed.

### 4.11.2 Flange Weld Details

Where shown on the design drawings, the existing beam-to-column flange welds shall be removed by air carbon arc cutting (CAC-A), chipping or grinding until only base metal remains. The joint shall be prepared for new groove welding, using a joint detail that uses a backing bar. The actual root opening is permitted to exceed the prequalified root opening of *AWS D1.1*, Figure 3.4, provided a split-layer technique is used for the placement of the root pass. The groove angle of the joint shall satisfy the prequalified groove angles of *AWS D1.1* Figure 3.4, unless otherwise qualified under the provisions of *AWS D1.1*, Section 4.

### 4.11.3 New Welding Material

All new welding filler metals shall meet the requirements of Section 2.4 of this specification. Welding shall be executed in conformance with the requirements of Chapter 3 of this specification. Weld tab removal shall be as required in Section 4.2 of this specification.

### 4.11.4 Sequence of Assembly

Following completion of the replacement groove welds between the existing beam flanges and the column flange, the top flange groove welds shall have the cap pass surface of the weld ground flush with the surface of the beam flange to enable the cover plate to fit flat against the beam flange. At the bottom flange, the backing bar shall be removed, the weld root backgouged to solid weld metal, and the area backwelded until at least flush. The weld at the bottom of the bottom flange shall then be ground flush with the surface of the beam flange to enable the cover plate to fit flat against the beam flange. Care should be used to avoid over-grinding the existing weld below the surface of the beam flange and creating a void between cover plate and flange. The weld shall be tested using UT, using the percentage testing required for Seismic Weld Demand Category BH/T joints, prior to placement of the cover plate. MT of the cap pass of this

weld is not required. After acceptance of the beam flange-to-column flange weld, the cover plate shall be placed and welded. The cover plate to column flange weld shall then be inspected by UT and MT, using the percentage testing required for Seismic Weld Demand Category BH/T joints.