

04/20

# TECHNICAL BULLETIN 6

## Continuity Plates and the DuraFuse Frames Connection

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**Abstract:** Continuity plates are used in welded moment connections to transfer forces to the column web and to make the stress distribution at the beam-to-column welds more uniform. The DuraFuse Frames connection has a different load path that does not require standard continuity plates to transfer loads to the column. The cover plates in a DuraFuse Frames connection transmit the beam forces to the column and prevent local column flange deformations.

### Introduction

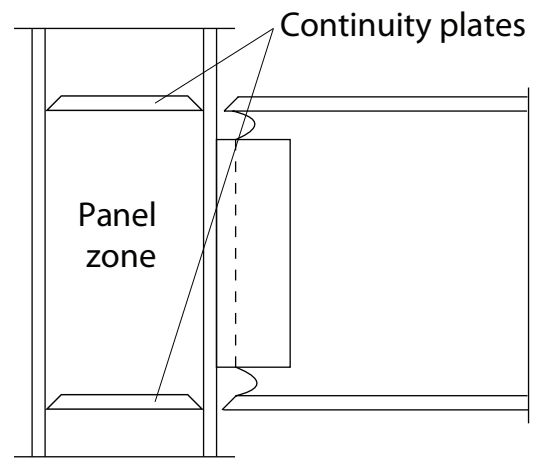
In steel moment frames, beam end moments are transferred into columns through the beam-to-column connection. Most welded moment connections require continuity plates, but the bolted DuraFuse Frames moment connection has a different load path for transmitting beam end moments into the column that does not require standard continuity plates. The purpose of this note is to explain why standard continuity plates are not required for the DuraFuse Frames connection.

### Welded Moment Connections

To begin, it is helpful to review the role that continuity plates play in welded moment connections.

Fig. 1 illustrates a welded moment connection with the continuity plates indicated. For most column and beam combinations, continuity plates are required in special moment frames by the Seismic Provisions for Structural Steel Buildings (ANSI/AISC 341). Mashayekh and Uang (2018) summarize the two main purposes for continuity plates:

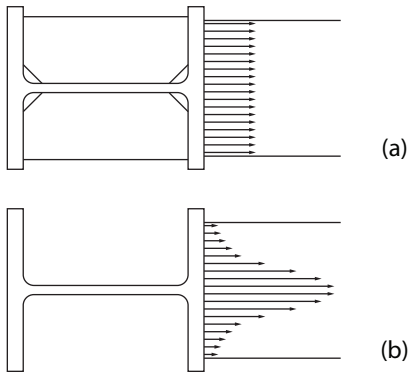
“When beam flanges are directly connected to the column flanges in the strong-axis direction, continuity plates (i.e., transverse stiffeners) in the column, at the beam flanges levels, are often need to transfer the large concentrated beam flange forces to the column. Continuity plates also play an important role in reducing the stress concentration that occurs at the beam flange complete-joint-penetration (CJP) groove welds.”



**Fig. 1** Welded moment connection with continuity plates

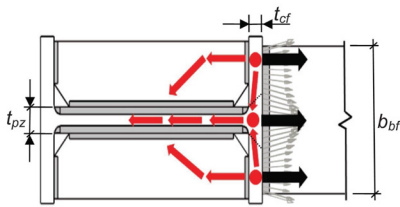
With regards to weld stress concentration, Fig. 2 illustrates the difference in weld stress distribution for a column with and without continuity plates. Fig. 2(a) shows an essentially uniform stress distribution in the beam-to-column flange weld when continuity plates are present. In contrast, Fig. 2(b) shows a concentration of stress in the middle of the weld when continuity plates are absent [Tran et. al. (2013)]. The prescriptive requirement in § E3.6f.1(b) of ANSI/AISC 341 addresses the general concern about force distribution across the weld beam-to-column welds and dictates the use of continuity plates unless the column flanges are relatively thick.

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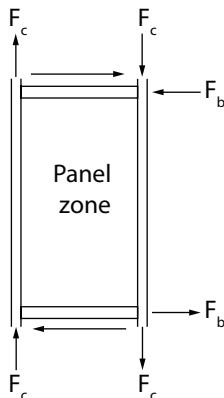
**Fig. 2** Beam flange stress distribution:  
 (a) with continuity plates; (b) without continuity plates

With regards to force transfer, Fig. 3 [from Tran et al. (2013)] illustrates how continuity plates distribute forces to the column. The continuity plates mitigate web local yielding of the column by allowing more of the column web to participate in the force transfer. The requirement in § E3.6f.1(a) of the ANSI/AISC 341 specifies when continuity plates are required for force transfer.



**Fig. 3** Flow of beam flange force to column,  
 from Tran et al. (2013)

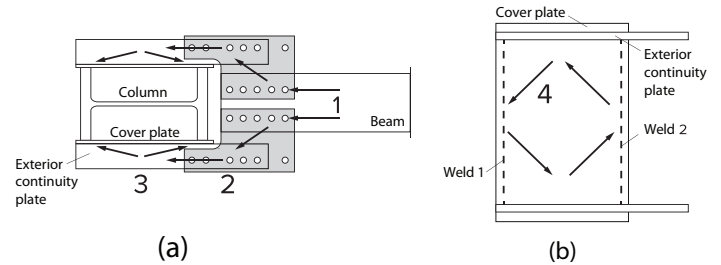
In welded moment connections, after the beam forces are transmitted to the column web (often with the help of continuity plates), the panel zone resolves the forces into column moments outside the panel zone. Fig. 4 shows idealized point forces from the beam flanges ( $F_b$ ) that are resolved in the panel zone to idealized resultants in the column flanges ( $F_c$ ). In this load path, the continuity plates are important for transmitting the beam flange forces,  $F_b$ , into the column panel zone where they are resolved.



**Fig. 4** Column web panel zone resolves forces in welded moment connection

## DuraFuse Frames Connection

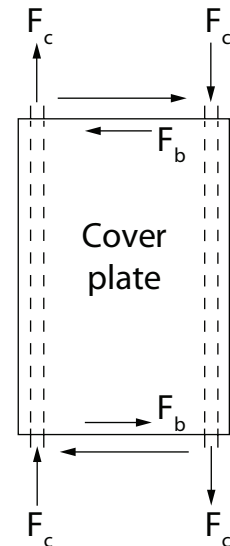
The force transfer mechanism through a DuraFuse Frames connection differs from that of a welded moment connection. The beam is not attached directly to the column, rather beam forces are transferred to the column via various plates. Fig. 5 illustrates the load path for forces from the beam to the column. In 1 [Fig. 5(a)], the forces flow from the beam to the top plates (or fuse plate on the bottom flange). In 2, the forces are transferred from the top plates (or fuse plate) to the external continuity plates. In 3, the forces are transferred from the external continuity plate to the cover plates. In 4 [Fig. 5(b)] the forces are transferred from the cover plates to “Weld 1” and “Weld 2”, and from there they enter into the column flanges.



**Fig. 5** Load path for forces from the beam to the column in DuraFuse Frames connection: (a) beam to cover plates; (b) cover plates to column

The cover plates in a DuraFuse Frames connection function in a similar way as the column web in a traditional connection. Fig. 6 shows how the cover plates resolve point loads from the beam flanges ( $F_b$ ) into resultants acting at the column flanges ( $F_c$ ). Since the cover plates are resolving the forces, it is not necessary for the forces to be transferred to the column web for resolution.

This different force transfer mechanism for DuraFuse Frames,



**Fig. 6** Cover plate resolves forces from beam to column in DuraFuse Frames connection

as show in Fig. 5 and Fig. 6, eliminates the two purposes of standard continuity plates:

1. The cover plates deliver the loads to the column flanges directly over a distributed area so, there is no need for continuity plates to deliver forces to the column web.

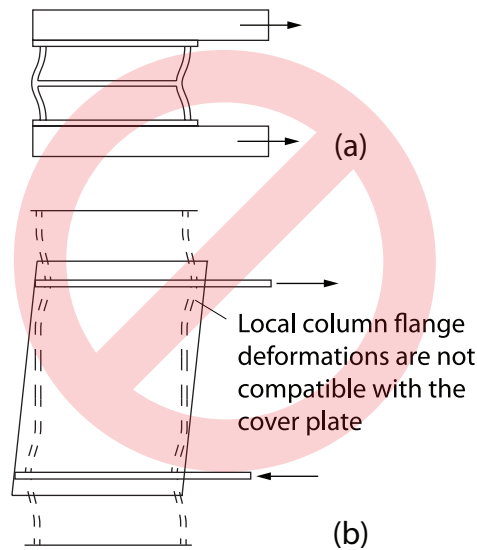
2. There is no beam-to-column weld, so there is no need to ensure uniform stress distribution across the weld.

## Preventing Local Column Flange Deformations

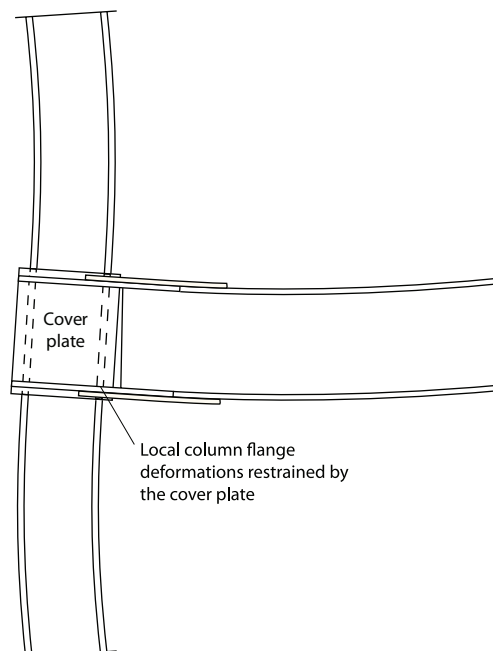
Some engineers inquire whether the absence of continuity plates results in deformations at column flange tips. From the top view shown in Fig. 7(a), this type of deformation may seem possible, however Fig. 7(b) shows the same deformation from another view, and it is clearly not compatible with the deformation of the cover plate, to which the column flange is welded. The deformation envisioned in Fig. 7(a) and (b) violates

deformation compatibility between the column flange and the cover plates and does not occur. Fig. 8 illustrates the deformation mode that satisfies deformation compatibility and is observed in testing.

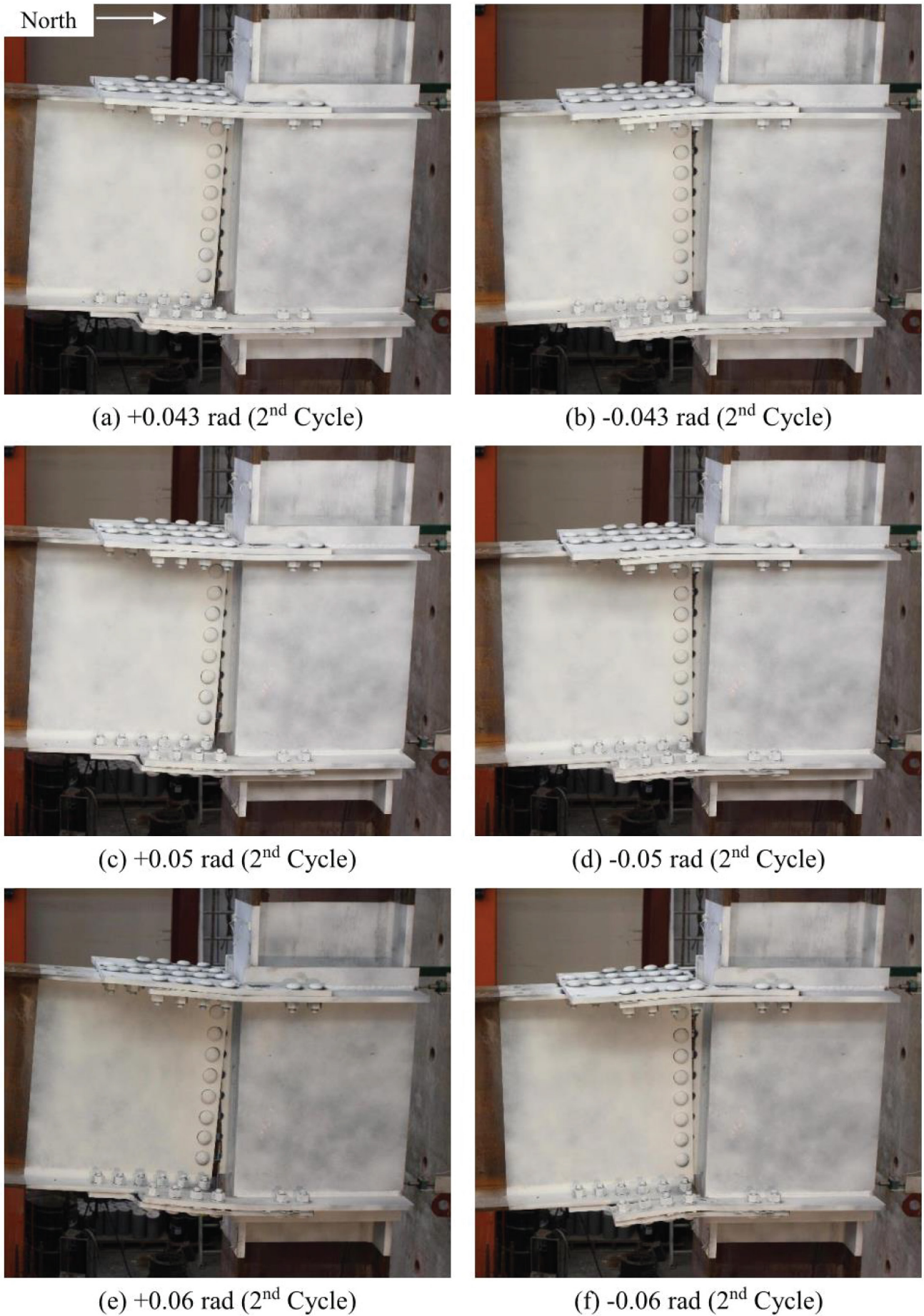
More than twenty full-scale DuraFuse Frames connections have demonstrated excellent performance without standard continuity plates. Fig. 9 shows a test specimen with a W30x99 beam and a W21x132 column at large drifts (4%-6%). No localized column deformation was observed even at ultimate drifts because the cover plates prevent it. The deformations that have been observed in testing are consistent with principles of deformation compatibility as illustrated in Fig. 8.



**Fig. 7** Local column flange deformation that does not occur because such deformation is incompatible with the cover plates: (a) top view; (b) elevation view



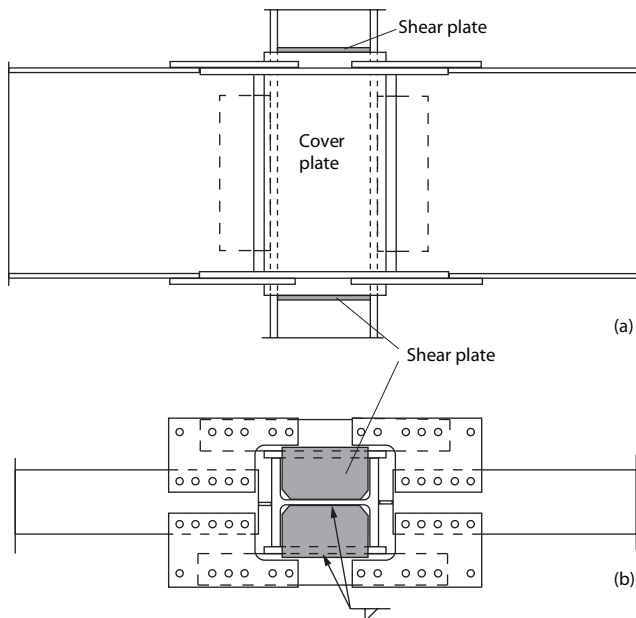
**Fig. 8** Joint deformations with DuraFuse Frames connection (deformations exaggerated for illustration purposes)



**Fig. 9** DuraFuse Frames connection at large deformations [from Reynolds and Uang (2019)]

## Shear Plates

For some DuraFuse Frames connections, shear plates may be added help transmit shear out of the cover plates and reduce the demands on weld 1 [Fig. 10(a)]. Shear plates tend to be used when columns are shallow and two beams are being connected to the column. Shear plates are not necessary to prevent column local flange deformations (the cover plates do that) and do not have to be welded to the column flange [Fig. 10(b)]. Shear plate welds to the column flange are also omitted in other connections that use similar plates (Chapter 11, AISC, 2016b)



**Fig. 10** Using shear plates to help transfer force from the cover plates: (a) side view; (b) top view

## Conclusions

The purpose of this bulletin was to explain why standard continuity plates are not required for the DuraFuse Frames connection. The following points were established:

1. In traditional welded moment frame connections, continuity plates are used to transmit beam forces into the column web and to minimize stress concentrations in the beam-to-column flange welds.
2. DuraFuse Frames connections use cover plates, rather than continuity plates, to transfer beam forces into the column.
3. DuraFuse Frames connections use cover plates, rather than continuity plates, to prevent local column flange deformations.
4. Experimental testing of DuraFuse Frames connections has demonstrated that it is not necessary to have continuity plates that are welded to the column flange. No local column flange deformations have been observed in more than 20 full-scale tests.

## References

- American Institute of Steel Construction (2016a). "Seismic Provisions for Structural Steel Buildings," AISC 341, Chicago, IL.
- American Institute of Steel Construction (2016b). "Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications," AISC 358, Chicago, IL.
- Mashayekh, A., and Uang, C.M. (2018). "Experimental evaluation of a Procedure for SMF Continuity Plate and Weld Design," *Engineering Journal*, 55(2), 109-122.
- Reynolds, M., and Uang, C.M. (2019) "Cyclic Testing of DuraFuse (DF) Moment Frame Connections for SMF and IMF applications: Series E, F, and G Specimens." Report No. TR-19/01, Department of Structural Engineering, University of California, San Diego, CA.
- Tran, A., Hassett, P., and Uang, C.M. (2013). "A Flexibility-Based Formulation for the Design of Continuity Plates in Steel Special Moment Frames." *Engineering Journal*, 50(3), 181-200.



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