Tips for Designing Constructible Steel-Framed Structures

Part 2

By Clifford W. Schwinger, P.E., SECB and Todd R. Campbell, P.E.

This article is a continuation of a discussion of tips and suggestions for improving the constructability of steel-framed structures, the first part of which was in the August 2010 issue of STRUCTURE® magazine.

As readers may have observed in Part 1, seemingly small and innocuous changes in framing configurations can have a big impact on the ease and economy with which steel-structures can be erected.

As noted in the Part 1 article, these tips and suggestions may vary around the country and are dependent on local fabrication and erection practices. The best way for engineers to know for sure how to best enhance the constructability of the projects they design is to pick up the phone and call local steel fabricators. This is a topic that most fabricators have strong opinions about – and most are more than willing to share their opinions with you.

17) **The fewer the pieces the better.** In general, the fewer the pieces of steel there are to detail, fabricate, ship, erect and connect, the lower the cost of steel per ton. The easiest way to minimize the number of beams on a floor is to maximize the span of floor slabs and roof decks.

18) **Repetition = economy**

19) **Avoid framing more than one member to each side of a column.** Framing multiple members to one side of a column can complicate connections and lead to problems installing bolts and welds. (*Figure 5*)

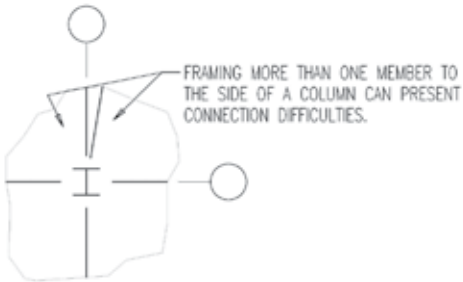

Figure 5: Avoid framing more than one member to any one side of a column.

20) **Modify workpoints on braced frames to simplify connections.** Orienting diagonal brace workpoints at the intersection of the faces of columns and beams may require upsizing members due to secondary moments, but doing so can simplify the connection design and reduce the number of bolts. (*Figure 6*)

21) **When using W Shape columns, do not use columns smaller than W10's.** W8 columns are too small to enable installation of single or double angle connections to the column web. W10 columns are the minimum size for which such connections can be used. Where space permits W12 columns are even better than W10's. (*Figure 7, page 34*)

22) **Check that braced frame connections will fit on the foundations, and that loads can be transferred from the braced frames to the foundations.** This may sound so obvious as to not warrant mention; however, a lack of attention to connection details between braced frames and foundations is not uncommon.

23) **Do not rely on anchor rods to transfer braced frame shear forces.** Anchor rods are usually installed through oversized holes in column base plates. Anchor bolts cannot resist shear until the base plate moves enough so that the anchor rods bear against the edges of the holes. Shear lugs welded to the underside of the base plate or embedded plates cast into the foundation (to which braced frame gusset plates are welded) are best for transferring lateral loads from braced frames into the foundation.

24) **Do not specify slip-critical (SC) bolted connections where slip-critical bolts are not required.** AISC 360-05 specifies where slip-critical bolts are required. The shear capacity of "SC" bolts is significantly less than bearing bolts. Requiring "SC" bolts where they are not truly required will add unnecessary cost and complexity to connections.

25) **Use R=3 for seismic design where possible.** Using R=3 avoids expensive "seismic" connection detailing requirements. In areas of low to moderate seismicity where seismic base shear is the same or less than base shear due to wind, there is usually no benefit to be gained by using a seismic response coefficient greater than R=3.

26) **Do not use beams with flanges less than 0.30-inch thick as composite beams.** ¾-inch diameter headed studs are most often used for composite beam design. The AISC specification requires that beam flanges have a thickness not less than the stud diameter divided by 2.5 unless the studs are aligned over the beam web. Headed studs are normally installed on beam flanges by welding through the metal deck. This usually makes precise alignment of studs over the beam web difficult to achieve. Accordingly, the use of very light beams (W8x10, W10x12, W12x14) as composite beams should

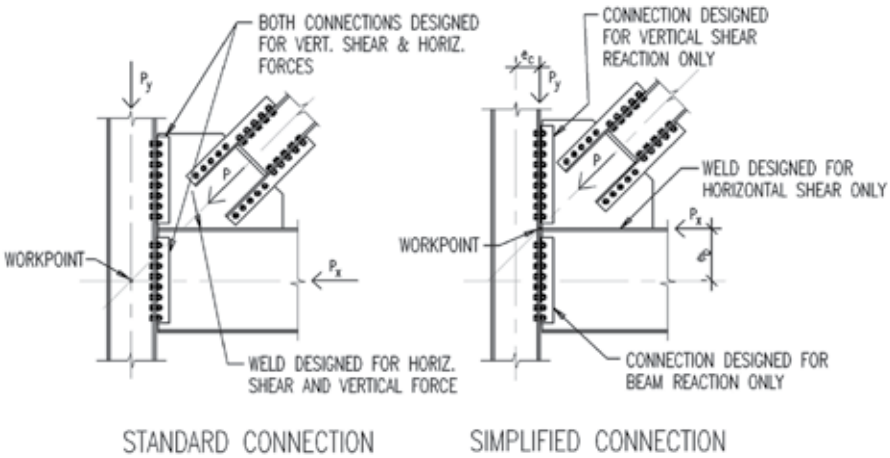

Figure 6: Adjust workpoint locations on braced frames to simplify connections.

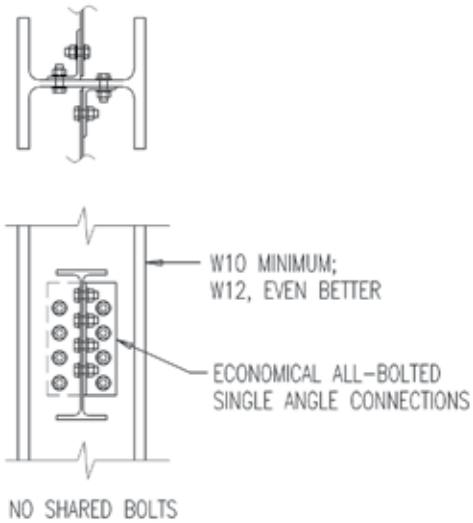

Figure 7: Columns should be at least W10's to permit bolted connections to the web.

be avoided. There is nothing wrong, however, in using these beams as non-composite members.

27) **Do not specify 105 ksi anchor rods unless absolutely required.** Grade 105 material is difficult to bend and weld if anchor rod repairs are required.

28) **Check that column baseplate anchor rods can be installed in piers, columns and footings.** Failure to coordinate if anchor rods will fit can lead to RFI's and potentially costly field modifications.

29) **Do not use flange plate moment connections on beams with flanges less than 5 inches for ¾-inch bolts or 6.5 inches for ⅞-inch diameter bolts.** Bolts are difficult to install on beams with narrow flanges.

30) **Avoid using W shapes to resist torsion.** Use rectangular or square HSS sections when torsion cannot be avoided.

31) **Increase beam depth to avoid web reinforcing.** Beams with large copes at connections should be increased in depth when required, to eliminate the need for web reinforcement or special connections. (*Figure 8*)

32) **Understand local fabricator preferences with regards to preferred connection details.** Designers should know the preferred practices of the steel fabricators in their area. Do local fabricators prefer to use ¾-inch or ⅞-inch diameter bolts for standard connections? Do local erectors have any issues with regards to field-welded versus field-bolted moment connections?

33) **Permit (and anticipate) that fabricators will want to use to use Short Slotted (SSL) or Oversized (OVS) holes to facilitate steel erection.**

34) **Use "tension only" bracing in lightly loaded braced frames.** Cross bracing using single angle braces designed for tension are easy to design, detail and erect.

35) **Favor double angle diagonal bracing over HSS and W shape bracing where feasible in braced frames.** The sizes of double angle bracing may be heavier than similar strength HSS or W shape bracing; however, the bolts at the ends of double angle bracing members are in double shear and the connections are easy to detail, fabricate and erect.

36) **Do not use camber beams in braced frames.** Cambering beams in braced frames can cause fit-up problems with the connections.

37) **Do not use camber beams that have moment connections.** Cambering beams with moment connections can cause fit-up problems with the connections.

38) **Consider gravity moments induced by fixity created by drag strut connections.** Drag struts are often required to transfer axial loads through floor framing members. Drag strut connections often provide rotational restraint at the ends of members similar to the restraint from moment connections. If drag strut connections provide such rotational restraint, then

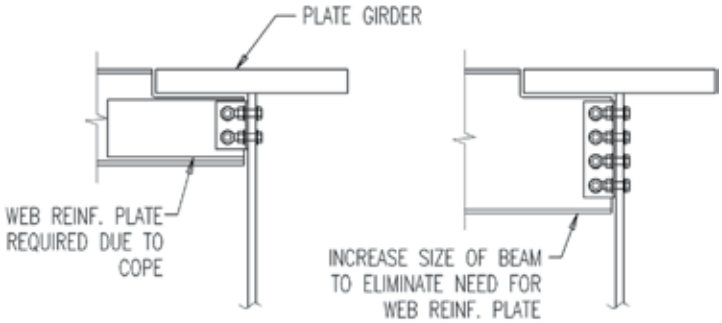

Figure 8: Increase beam depth to avoid reinforcing webs at connections.

the gravity moment occurring due to connection fixity must be considered in the drag strut connection and element design.

39) **Consider implications of structural steel erection sequence for projects with unusual geometry or framing configurations.** Whereas the contractor is responsible for temporary framing or shoring to support the steel while it's being erected, designers should consider the implication of temporary loads on the framing during construction in order to minimize the likelihood that the steel erector will encounter difficulty in configuring an erection sequence using the framing members required for the final structure.

40) **Avoid beam web penetrations where possible.** Where unavoidable, try to keep web openings in beams within the middle third of the beam span, centered at mid-depth and no deeper than half the beam depth.

41) **Use pipe columns to avoid complexities of skewed connections.** Most connections to pipe columns are square connections. Pipe columns are ideal for short columns (no splices) with reasonably small loads.

Please note: the numbering of graphics in this article begins with Figure 5, and is a continuation of the graphics numbering in the Part 1 article, August 2010 issue of STRUCTURE magazine.

42) **Avoid using W shape columns oriented in the weak axis in moment frames.** When more frame stiffness is required, it is better to increase the sizes of those columns in the moment frame that are oriented in the strong axis rather than spending money on costly moment connections to columns bending about their weak axis. Most W14 columns are about three times stiffer in their strong axis than about their weak axis.

This list is but a sampling of the ways that engineers can improve the constructability of steel-framed structures. There are many other ways to enhance constructability. One of the enjoyable aspects of structural engineering is that we are always learning. Do you have any constructability tips that were not mentioned or do you take issue with anything mentioned in this article? If so, email the authors.▪

Clifford Schwinger, P.E., SECB is a Vice President and Quality Assurance Manager at The Harman Group. He may be reached at ***cschwinger@harmangroup.com****.*

Todd R. Campbell, P.E. is an Associate and Project Manager at The Harman Group. He may be reached at ***tcampbell@harmangroup.com****.*