DETAILED DRAWINGS:

PART III

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In the third article in the series Spencer gives us further pointers for detailers to be able to correctly interpret the engineers design. We start with one of the more problematic areas where drawings are often not done well, read on...

FLOOR BRACING SYSTEMS

i. The most important feature of the floor bracing system is to get the forces to act axially, without eccentricity to reach the intended support point/ centroid or SOP.

ii. This can be complicated in the situation where there are numerous sizes of beams calculated and selected by the engineer that are required to be part of the floor bracing system. Figure 1 that follows illustrates the point. It further supports our suggestion to try to standardise secondary floor beam sizes.

iii. When there is no column involved at the node, a common solution that works well is to weld a gusset to the web, the flange or under the flange of the minor beam and its end plate as shown in the example in figure 2 (top flanges omitted for clarity).

iv. When the connection involves a column achieving this aim is more difficult and needs more attention. There are numerous ways of solving the problem correctly and many ways of getting it wrong, especially when the brace is intended to frame into the intersection of a column and a beam. One generic way, not often used in South Africa, almost always solving the problem is as shown.

v. A word of warning though: if the secondary beams are small and the chosen level for the floor brace system is in the middle of those small beams, welding gussets can become difficult to do well.

And now for the ubiquitous "simply supported floor beams", firstly some engineering issues:

Before going into detailing issues lets look at a few ways in which the engineer can contribute to productivity in the workshop and thereby influence the quoted rate for floor beams. The influence of standardisation has an important role to play, with tremendous productivity advantages, at very often small penalty of mass, resulting in an overall lower price whilst at all times satisfying the structural issues.

What standardisation possibilities are there and to what advantages?

Limit the number of profiles used for secondary beams. This has two advantages:

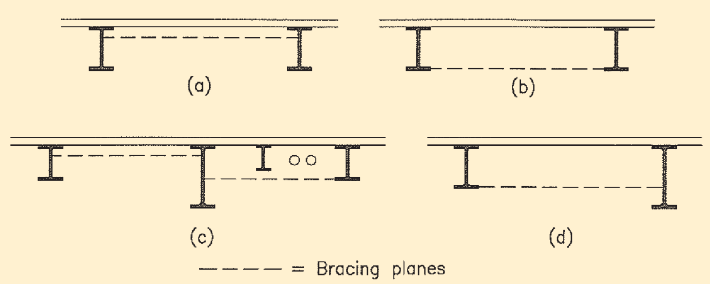

Figure 1.

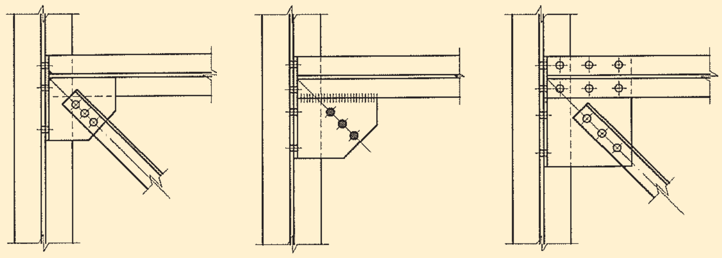

Figure 2: Main beams run up the page. Secondary beams run across the page. Bolted or welded construction can apply.

1. There can be advantages for the contractor to limit the number of profiles he has to purchase. The more beams there are from a profile the more optimally he can limit waste. (Bear in mind that as scrap the fabricator recovers about 10% of the new cost of steel so it is an expensive exercise to waste steel!)

2. If sufficient quantities of one profile can be ordered there can be additional discounts.

3. The major advantage will also come from standardising the end plate details. This implies that the fabricator will make all end connections to suit the worst load case. It is a simple logic that will bring home the message to readers: it is far more cost effective for an artisan to make 20 identical end plates and distribute them to 10 beams (say) than for 10 artisans to make 2 plates each for 10 beams (especially if the beams are all different.

4. As noted above floor bracing systems can be simplified. Floor bracings, due to their small nature of components and numerous connections can be a very expensive part of all steel work construction. Any method of simplifying these systems will impact on costs.

Draughting issues

I guess most of our readers are wondering what can go wrong in detailing the “simplest of items” our floor beams? Once again let’s go back to some basics. Simply supported beams are designed with flexible end-plates to ensure that rotation can occur (see below item viii). Our

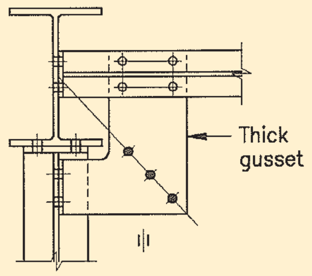

Figure 3:

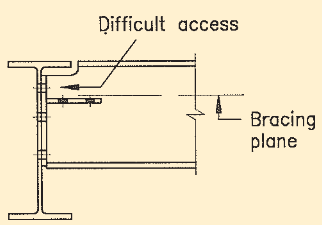

Figure 4:

usual requirement is that the tops of floor beams should be at the same level to support the flooring system. In detailing floors we need to seriously consider the fabricators equipment and favoured methods before just mindlessly detailing floors.

There are 2 main types of end connections for beams: end plates and bolted end cleats. There are many issues that apply to beams irrespective of welded end plate details or bolted cleats.

i. The notch details should be shown and there should be emphasis on a curved cut in the corner of the notch. (In addition nicks in the cutting will not be accepted but can be repaired by welding). Standardising the level of the cut makes the artisans life easier.

ii. That the top holes should all be 70mm down and that the vertical spacing of holes should be 100mm for Class grade 8.8 M20 bolts (should the depth of the beam permit the number of rows of bolts required failing which the spacing can be reduced to 70mm)

iii. The SAISC strongly recommends that only class grade 8.8 bolts be used for connecting beams and thus, as described in other publications, should be 20mm diameter bolts minimum. (Class grade 4.8 bolts should only be used for secondary connections and in order to prevent the possibility of using the wrong class grade we recommend that they only be 16mm diameter bolts be used in this grade).

iv. That the draughtsman has allowed for construction gaps when calculating the length of the beams (2mm each end is common).

v. That pre-camber information is shown when required.

vi. That tops of beams and directional marks (north say) are given for the works to include on the beam.

vii. That final part mark (i.e. the assembly part mark) will be the only mark that will be visible after the works has completed the item.

Let's look at end-plates specifics:

viii. The end-plates should not normally exceed 8mm thick to still be "flexible"

ix. Calculation show that in most situations, the end plate does not have to be welded to either of the flanges (if the beam is not notched) or to the bottom flange if the top flange is notched. The standard end plates shown in table 7.24 of the "Red Book" are all based on this approach and the capacity of the various end plates are clearly defined in the table.

x. But there are definitely two schools of thought in this regard and some engineers/ fabricators do still (in my opinion conservatively) insist on welding the end plates to the flanges of the beams. Unfortunately this conservatism results in a doubling of the length of welding to these end plates which just has to increase the cost of manufacture.

xi. The weld size should be called up (6mm CFW for standard end plates) and there should be an emphasis of the need to return the weld around the top and bottom of the plate. As mentioned previously the welding consumables (as expected by the Red Book) will be E70xx type and should be called up on the drawing.

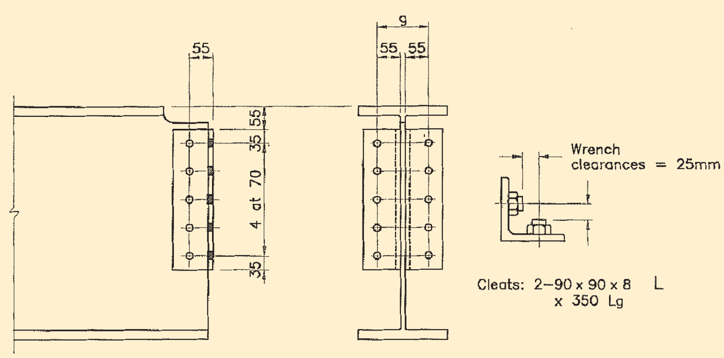

Figure 5.

Bolted end cleats

xii. Standardisation of end cleats is well covered in the Red Book section. This is essential for cleats to be cost effective for all players in the structural team. It is almost certain that the cost of bolted cleat from a workshop and probably over labour point of view will be cheaper than a welded end plate especially for those companies who have NC drill lines and angle punching machines.

xiii. There is however an issue with the cross centres of the holes where the secondary beam connects to the web of the primary beam. The thickness of the web varies as the mass of the serial size of the beams goes up. So in Figure 4 the dimension g increases by increases in the web size. If each and every web thickness were to be accommodated this way the number of variations in cleat size would be horrendous and totally impractical.

It is common knowledge that we allow for a 2mm oversize hole compared to the diameter of the bolt. Despite the apparent 4mm of tolerance this is still not sufficient to allow for one single standard cross centre to suit the full range. This then leaves two options to solve this problem:

a. Use non standard cleats with different back marks to the holes. This leads to a large number of variations to each cleat.

b. Instead of using a round hole +2mm bigger in diameter by using a slightly elongated hole (say 26 x 22 slot) the problem goes away. It is necessary to clear this approach with the design engineer.

xiv. One last issue with bolted cleats is the need to paint the interface with the full paint specification before bolting on the cleats can create logistic and timing problems.

Haunched floor and rafter beams

The haunch welded to a member is to assist in the transfer of the bending forces from one member to the next. Common applications are for a framing system that does not use cross

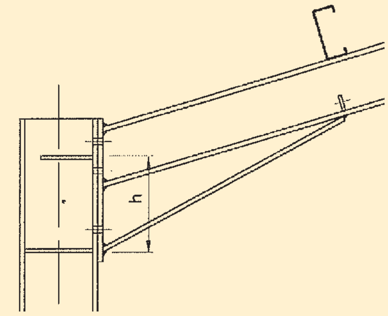

Figure 6.

bracings or for portal rafters to columns. To make connection design readily understandable for all parties, the moments are assumed to be carried by the flanges and are connected through the end plates to the receiving (column say) member. The shear would be carried by the web (bolts).

What should the team be allowing for and looking for?

i. At the extreme end of the member it is necessary to check that the end plate extends past the thickness of the flange/haunch flange to permit welding to take place. (For large members with big bending moments this extension could be to allow for additional bolts outside the width of the members). This could either be a fillet weld all the way around the flange (as shown in the figure ?) or a full penetration weld between the flange and the end plate. The full pen weld would be cheaper to do than 2 fillets welds the length of a thin flange and in the case of thick flanges 2 quite large fillet welds could be necessary. So the SAISC advises a full pen weld for these connections.

ii. At the inner end of the haunch the weld between the end of the haunch flange and the beam flange is still quite important and the one successful way of achieving a good quality fillet is to stop the tapering of the haunch when it reaches the flange of the haunch and to cut "square" through the flange allowing for a "corner to corner weld" as shown.

iii. The weld between the bottom flange of the beam (not the haunch) is more important than the weld between the web of the haunch and end plate/ underside of the beam flange. To allow the important weld to be properly done a mouse hole should be detailed as shown in the corner of the haunch web.

iv. Since the forces can be quite large in these flange connections it is important that the haunched connection is properly designed and that the information is carried through to the detailed drawing. SAISC strongly advises that only the design engineer should be responsible to design moment carrying connections as he should understand the implications best. Prying action needs to be considered. The design requirements can often mean that web stiffeners be strategically placed to transfer the forces (To the flange of the columns, to the webs of the columns, at the inner end of the haunch into the main rafter body all as shown in the example). It is necessary to check that all of these details are incorporated into the detail drawings.

v. Fly bracing and its connection is often overlooked by the inexperienced draughtsman.

The last part of the 'Detailed Drawings' series will be published in the January/ February issue of Steel Construction.