DETAILED DRAWINGS:

BEFORE APPROVING THEM, WHAT SHOULD THE ENGINEER BE LOOKING FOR?

PART II

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In the second article in the series Spencer gives us some pointers related to the detailers interpretation of the engineers design specifically for trusses and bracings. We hope that these simple pointers will help both engineers and draughtsmen ensure that they get it right...

TRUSSES

Single angle construction trusses

The most common issue here is inadvertently building eccentricities into the construction that the engineer has not planned for. Please be reminded that typically trusses are designed to carry axial loads only and in order for this to occur, the centres of gravity of the various members framing into a node need to meet in a common centroid (Figure 1). Too many draughtsmen do not understand this and actually move members off the centroid (in their words to avoid welding on a toe plate to the angles) thus inadvertently creating an eccentricity with its associated moments and overstressing of the members (Figure 2).

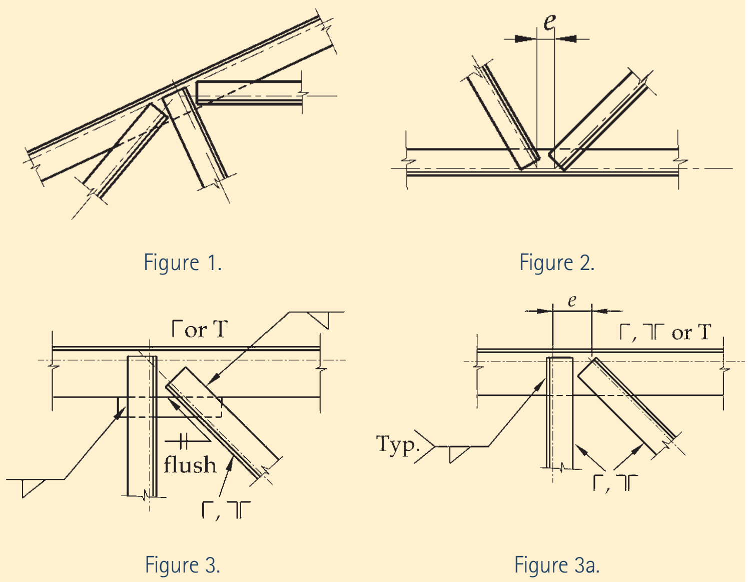

Figure 1: Centres of gravity meet in a common centroid.
Figure 2: Centres of gravity do not meet in a common centroid resulting in eccentricity.
Figure 3: The addition of a toe plate creates enough length for sufficient welding and at the same time ensures centres of gravities meet in the common centroid
Figure 3a: Poor detail.

The same applies to ensuring enough weld length on internal members to main chords. Once again a toe plate may be the answer (Figure 3). Please be reminded that latest theories now allow engineers to take the weld at the end of the member into account as well as those along the sides of the members (the old theory). When unequal angles are selected it is important to ensure that the long leg points the way the design engineer intended them to point.

For braced bays it is often advantageous for the fabricator to make either both braced trusses toe in or toe out (i.e. make one truss opposite hand or mirror image) thus allowing for layout of the opposite hand truss and assembly of all the as drawn trusses on the back of the opposite hand truss and at the same time keep all the bracing details symmetrical and thus the same.

Double angle construction trusses

Once again avoidance of eccentricities is important. The fact that connection plates are inserted between the double angles usually eliminates this problem if correctly laid out (Figure 4).

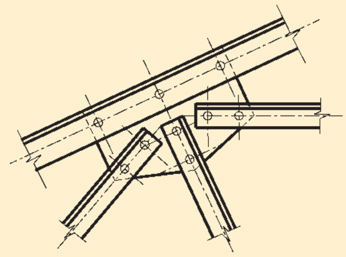

Figure 4: Example of double angle bolted detail. The welded detail would be similar.

Often overlooked are the need for batten plates for both compression and tension members. The spacing of such battens is covered by the design code SANS 10162:2005 and should be spaced to ensure that the slenderness ratio for compression members of the weak axis is the same or more than the strong axis when the lengths between the battens are taken into account. For tension members the slenderness ratio between battens should not exceed 300.

Tee bar construction trusses

Contractors often choose this form of construction believing it to be less labour consuming than double angle construction. But the cost assessment of which is cheaper to build is complicated by the fact that typically angles are considerably cheaper (price per ton) than the I beams from which T bars are cut. Tee bar construction also eliminates the problem of proper corrosion protection in the small gap between back-to-back members. Before finalising the design of this type of construction one should confirm with the appointed contractor which is his preferred method of construction. As with all trusses avoidance of eccentricity is essential. This may require the addition of toe plates to the web of the "tee" bars.

All long span trusses and girders

Long span trusses and girders do deflect and so design engineers need to consider serviceability state for deflection. It is common practice to pre-camber the trusses so that after dead mass is all applied, the trusses would deflect back to the expected shape (preferably without sagging). The main issue in checking detailed drawings is to ensure that pre-cambers are built into the workshop details and that they are constructed into the fabrications. In the case of bolted construction this easily achieved by shortening the diagonal lacing members thus pulling the pre-cambered shape on assembly. In the case of welded latticed members the pre-camber is built in to the member during the assembly lay out on the workshop floor.

Design of splices should be a "non-slip" type splice to prevent the pre-camber being lost should slip occur. Alternatively, additional pre-camber can be added to the dead mass deflection, and then to allow slip to occur.

BRACING SYSTEMS

Vertical braces

Essentially eccentricity issues are the same as described above but because of the depth of the

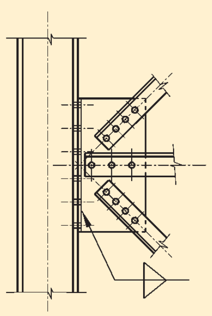

Figure 5.

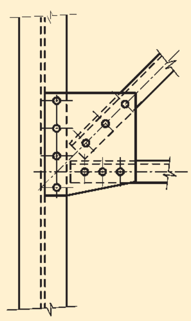

Figure 6.

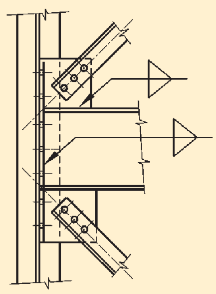

Figure 7.

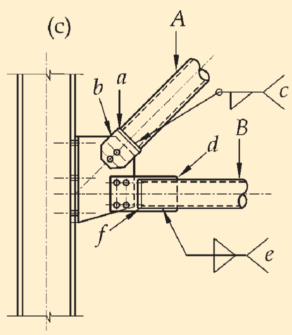

Figure 8.

Figure 5: Bracing SOP on the face of the column. The eccentricity is half the depth of the column and the resulting moment should be considered when designing the column.

Figure 6: Bracing with an SOP on centre line of the web should always meet in common centroid as the weak axis has little moment carrying capacity.

Figure 7: Bad detail building in moments about the weak axis.

Figure 8: Brace A with a Tee cutting connection. Brace B with a spade plate let into the tube.

members being framed into such as columns and or floor beams connections plates (gussets) can start to be excessively large. In addition because the bracing forces can be small relative to the axial forces in the column it is not unusual to design the eccentricity based moments into the design of the column and move the setting out point (SOP) to the face of a column (Figure 5) (or flange of the beam). In such a case the draughtsman should be advised that this is permitted. Unfortunately many draughtsmen now treat this as the rule rather than the exception.

A common detail popular with fabricators is to shop weld gussets at the ends of tie beams to the beams and the end plates that form a part of a vertical bracing system as shown in the example. Use of the "correct" SOP's to avoid eccentricity is important.

(Authors note: The desired methods of connection are driven by the authors experience of keeping the number of loose connection gussets to the minimum in an attempt to minimise the problem of logistics of small items. In addition to the welded solutions depicted loose connections are possible for most items referred to).

H or I beam braces

In order to accommodate the need for member centre lines to meet in the common centroid the connection of the beam type brace can be quite difficult, especially when it connects to the base plate of a column and or beams and needs to be thought through and carefully designed. One solution is to shop weld a starter section to the beam or column and then use cover splice plates to join the brace to the starter piece.

Star angle bracings

This form of construction is popular with design engineers and quantity surveyors because it is "light" when compared to other designs. It is unpopular with fabricators because it is time consuming and quite difficult for fabricators to make.

It is necessary to batten star angles as for any other double angle form of construction but there is an overriding clause in the design code regarding battens at the third points as it eliminates the need for other battens. Battens must face both directions at points of application (i.e. 2 battens required at each point).

Tubular braces

Once again "no eccentricity" is the watch word. Two main types of connections are common i.e. a "Tee" bar cutting or welded fabrication for relatively small forces and a "Spade" plate fitted into the tube for larger forces. The length of this plate insert must be correctly designed to accommodate enough welding (Figure 8).

For exceptionally high forces it is not unusual to call up full penetration welds between the spade plate and the body of the brace (brace B Fig 8). This must be reflected on the detail drawings. The detail of the connection plate at the middle a "cross" brace must get the same attention to detail.

Watch this space for Part III in the November/ December issue.