Main girder connections

No. 2.02

Scope

This Guidance Note, together with GN 2.03, covers a number of the typical connection details that occur in the fabrication and erection of a bridge made from steel I girders. The details are representative of those that have been used in practice, but are not the only details that are suitable in all cases. Some details are also appropriate to box girders.

The main girder make-up determines where connections within it are needed and also affects the details that are required. Make-up is covered in GN 2.01.

This Guidance Note covers the connections within the main girder, including the attachment of longitudinal web stiffeners.

Connections between the main girders and bracing or crossbeams are covered in GN 2.03.

The design and detailing of bearing stiffeners are covered in GN 2.04. The connection of intermediate transverse web stiffeners to the main girders is covered, along with their design aspects, in GN 2.05.

Detailing of bolted splices in main girders is covered in GN 2.06. Guidance on how to specify welds is given in GN 2.07.

Guidance on the attachment of bearings is covered in GN 2.08.

Shop connections in main girder

Splices in webs and flanges

Shop welded splices in flange and web plates will normally be full penetration butt welds. In most cases, they will be made before the pieces of the girder are put together.

*Flange to web welds*The designer specifies on the drawings the size of weld required between web and flange. Where the shear forces are modest this is often the minimum size that is practically acceptable (6 mm). Fillet welds, rather than butt welds, should be specified between web and flange in almost all situations. See Figure 1. Butt welds require more preparation and are more likely to distort the flange (creating a transverse curvature), as a result of weld shrinkage.

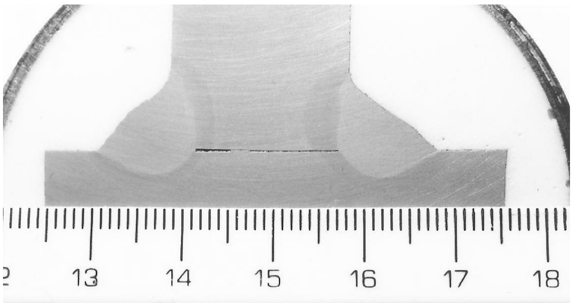

Figure 1 *Fillet welds to flange*

Only the minimum required size for the weld should be specified, except that a uniform size should be used as far as possible along the whole length of a girder.

Deep penetration fillet welds, as shown in Figure 2, are usually achieved with the submerged arc process using DC positive polarity. They give a greater effective throat than an ordinary fillet of the same measured leg length. The designer should continue to specify weld size in the usual way, but the actual leg length/throat size visible will be slightly less. Because the visible weld size does not indicate the full throat size for such welds, inspection procedures for this type of weld cannot rely on leg length measurements: **strict observance of the weld procedure specification is required.**

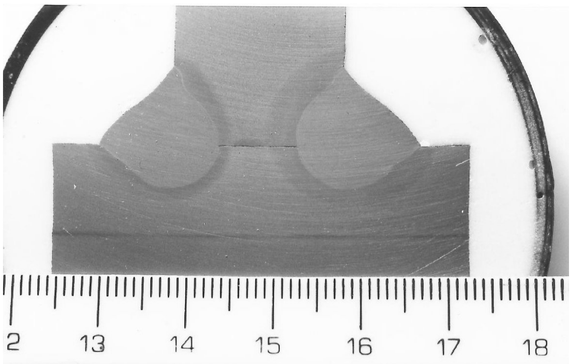

Figure 2 *Deep penetration fillet welds*

Changes in flange thickness

As noted in GN 2.01, changes in flange thickness will usually be made whilst keeping the overall girder depth constant and varying the web depth.

Intentional steps in flange faces at joints need to be treated in the same way as unintentional steps arising from distortions or rolling margins. At a butt welded joint, a better fatigue class can be used where the flange is tapered at 1:4

or less (see Figure 3). At a bolted joint, the step should normally be all on one side (and appropriate thickness packs used), unless the change of thickness is particularly large.

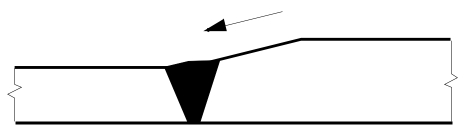

Figure 3 *Tapered change of flange thickness*

Doubler plates

Where a very thick flange is needed, doubler plates are sometimes used. The doubler plate is fillet welded onto the outer face of the primary flange plate (the plate that is attached to the web), and should therefore be narrower, to allow room for the weld. Where doubler plates are curtailed short of the girder ends, they are tapered in plan, radiused around the end, and tapered in elevation to smooth the stress flow (see Figure 4). (Note also that the tapered portion is not included in the effective section for stress analysis.) However, this is a very low class fatigue detail category and also a 'very severe' detail type for toughness verification. The toughness requirements become especially severe on tension flanges, which in many situations means that it is better to continue the doubler plate to near the girder end, rather than terminate it in the span.

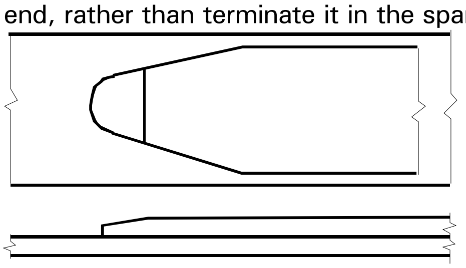

Figure 4 *Detail at end of a doubler plate*

Changes in web thickness

Webs should normally be dimensioned centrally on the flanges, without any attempt to keep one face aligned through changes in web thickness. Changes of thickness of up to 3 mm each side can be accommodated at a butt weld without any further precautions, as long as the centrelines are aligned. Greater steps should be tapered at 1:4 on each side.

If the web is spliced by bolting at a change of thickness, steps of no greater than 1 mm on each side can be accommodated without make-up packs.

Site splices in main girder

Connections made on site will either use full penetration butt welds or HSFG bolted joints. Weld procedures for site welds are usually similar to those for shop welds. However, because there will usually be greater limitations on weld positions (the pieces probably cannot be turned) and environmental conditions may be less favourable, the range of suitable procedure may be more restricted.

Cope holes in webs

Where there is to be a site weld across a flange, or where there is a step in the web to suit a tapered change of flange thickness, a semi-circular cope hole is usually provided. See Figure 5. If the web is spliced at the same position, the end of the weld (on the inside face of the cope hole) should be ground flush. Note that a stress concentration factor must be applied when verifying stress range at the open edge of a cope hole; it may be preferable to butt weld an infill piece

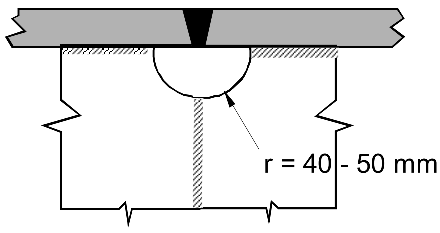

Figure 5 *Cope hole in web at a flange weld*

Longitudinal web stiffeners

Longitudinal stiffeners are usually only needed on the webs of I-beam girders when the girder is deep and the web is thin. This is most often the case with haunched girders where the web is deeper at the pier positions.

Stiffeners may be either flats or angles. Angles are often used in regions of significant compressive stress because they are efficient in resisting buckling, but it is very difficult to apply, inspect and maintain protective treatment to the inside face of the angle. Where angle stiffeners are used, they should be turned with one leg down, to avoid trapping water and debris.

Longitudinal stiffeners are normally attached by 'all-round' fillet welds. The welds on exposed faces (i.e. other than inside a box girder) need to be continuous, rather than intermittent, and on both faces, to avoid potential corrosion problems.

Continuous stiffeners

Longitudinal web stiffeners are usually provided primarily to enhance the shear capacity of thin webs. To participate also in carrying longitudinal stresses, the stiffeners must be structurally continuous. They will usually extend over several 'panels' between transverse web stiffeners.

Transverse stiffeners are usually notched to allow continuous longitudinal stiffeners to pass through (see Figure 6), except at bearing stiffeners, where the longitudinal stiffeners should be attached to the faces of the bearing stiffeners. Where a stiffener is notched, the loss of section should be taken into account in design. EN1993-1-5 limits the cut out to 0.6 of the depth of the stiffener.

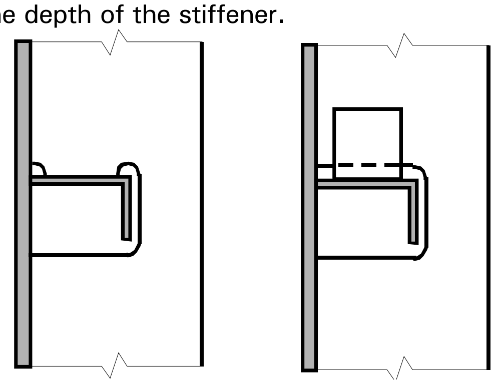

Figure 6 *Notches for longitudinal stiffener*

The gap between the stiffener tip and the face of the cutout is usually kept to a minimum for structural reasons, but it must be remembered that protective treatment has to be applied to the faces. A minimum gap of 12 mm (and not less than 1.5 times the stiffener thickness) should be provided, more if possible.

The direct attachment of the longitudinal stiffener to the transverse stiffener is a constraint during fabrication, since the longitudinal web stiffeners are usually attached before the transverse stiffeners. One way to avoid this is by using 'over-width' cut-outs in the transverse stiffener and welding tongue plates to make the connection (see right hand detail in Figure 6).

Welds between the longitudinal and transverse stiffeners are normally needed only on the back of the stiffener

Discontinuous stiffeners

If the longitudinal web stiffeners are only needed to stabilise the web they may be discontinuous. The use of discontinuous stiffeners avoids the extra fabrication work in attaching and welding the two types of stiffener where they meet, but the detail at the discontinuity needs to be considered carefully during design, particularly in regard to fatigue effects.

Where stiffeners are discontinuous, sufficient clearances should be allowed for completing welds and applying protective treatment. A typical arrangement is shown in Figure 7.

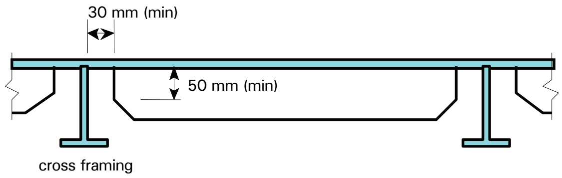

Figure 7 *Discontinuous stiffeners*

References

EN1993 Eurocode 3 Design of Steel Structures
Part 1-1-5 Plated Structural Elements
Part 1-1-9 Fatigue