AD 374
Design of gusset plate connections

Following a failure, in 2012, of a relatively long gusset plate connection, the SCI has looked into the performance of the behaviour of gusset plates subject to compression. The interim results from this investigation show that for bolted gusset plates connected on one edge only subject to compression (shown in Fig 1) the modelling assumptions are particularly crucial.

It should be noted that the advice given in the publication 'Joints in steel construction - Simple Joints to Eurocode 3' states:

'Preferably, gusset plates in compression should be supported on two edges and be reasonable compact.'

'Where the gusset plate is supported on one edge only, the detail is only recommended for light loads. For heavier loads, an extended end plate and gusset plate supported on two edges wherever possible is recommended.'

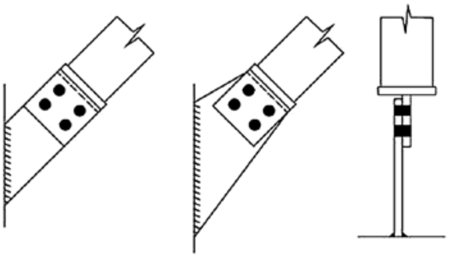

Figure 1 Gusset plates supported on one edge only

In the case of gusset plates as connections in a bracing system (which consists of a bracing member, spade end and gusset plate) the following issues may be important when deciding how to model the whole system:

- Is the connected bracing member stubby or slender and what are the implications for the likelihood of the gusset plate and spade end arrangements being subjected to a direct compression load (held in alignment by the stiffness of the brace) as opposed to bending from the brace moving out of alignment?
- Is the spade end on the brace itself stiffened (e.g. being made from an angle) or not?
- Even if the spade end on the brace itself is an unstiffened plate, is it relatively thicker, more compact and more securely welded than the gusset plate?
- Considering the bolt group connecting the gusset plate to the spade end of the brace, how effective is this in clamping the two elements together to restrain rotation?
- Considering the behaviour of the gusset plate itself, what is its likely mode of behaviour in terms of bending or buckling?
- Is the lapped connection to the gusset plate likely to fold with a hinge at each end of the connection?

As noted in the existing guidance for the gusset plate detail itself there are two specific issues to consider:

- What effective length should be used?
- Is the actual or equivalent eccentricity of the applied load significant?

If the gusset plate is connected by a bolt group that provides good clamping action to a relatively stubby brace with a relatively stiff spade end, then the simple model assumed in the existing guidance may be appropriate, provided a suitably conservative value is chosen for the effective length. For a gusset plate connected on the skew it is not conservative to take the shortest distance between the last bolt row and the nearest weld attachment point.

The existing guidance shows the effective length to be the same as the system length for the gusset plate itself. In simple structural mechanical terms, this is equivalent to a model with the plate being assumed as fully restrained in position and direction at one end and being fully restrained in direction but not held in position at the other end.

In practice, a gusset plate supported on one edge would be welded all round at one end and clamped by the bolt group at its other end. If the clamping action of the bolt group is considered to provide only partial restraint in direction, then the effective length would need to be increased above the system length. In case of doubt, the conservative value for the effective length would be twice the system length for the gusset plate itself unless a small value can be justified.

In addition, the spade end on the brace itself may lack stiffness or the brace itself may exhibit curvature under load that results in an imposed bending moment on the plate. The effect of these would be equivalent to an eccentrically-applied load such that the simple assumption to ignore the eccentricity would be invalid.

The designer would need to consider the points above in deciding whether the simple model is appropriate. Some designers may have been tempted to use overlong single-sided gusset plates with minimum thickness without looking at the system modelling issues such as the behaviour of the brace, the behaviour of the spade end, the behaviour of the gusset plate and the interaction between these components and the effect this may have on the propensity of the gusset plate to bend or buckle.

Further guidance funded by BCSA and Tata Steel is on its way. In the meantime designers are reminded that the use of single-sided gusset plates should only be used for light loads and stiffened if necessary if a double sided attachment is not possible. The length of the gusset plate should be kept to a minimum and the effective length should be chosen on the most conservative basis. Furthermore, the effect of ignoring the eccentricity of the connected plates should be reviewed against the modelling assumptions for the behaviour of the whole bracing system.

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AD 375
BS 2853:2011 Steel overhead runway beams

For over 50 years, steel overhead runway beams for hoists have been designed to BS 2853:1957, *Specification for the design and testing of steel overhead runway beams*. Last amended in 1970, BS 2853:1957 remained largely unchanged since 1967, when it was updated to take account of the replacement of RSJs by UBs. It remained in Imperial units and Allowable Stress format, whilst continuing to refer to numerous outdated British Standards.

The publication of BS EN 1993-6: 2007, *Eurocode 3: Design of steel structures. Crane supporting structures* has, since 2007, provided an alternative design standard for crane supporting structures. In April 2010 it came fully into force, along with the rest of the Eurocode Parts, when the former national structural design standards were withdrawn. However, BS 2853 has not been withdrawn – instead, a new version, BS 2853:2011 *Specification for the testing of steel overhead runway beams for hoist blocks* was published in October 2011. The Advisory Desk has been asked why, with the Eurocodes already in force, a new edition has been published and what its continued relevance is for structural designers.

There are two answers – test loads and serviceability criteria – and these are discussed below.

Test loads

The original 1957 edition of BS 2853 covered both design and testing. With the requirement for BSI to withdraw all national standards conflicting with Eurocodes, structural design has been removed from the scope of BS 2853. However, in design to BS EN 1993-6: 2007, runway beams need to be checked under test loading if the hoist they support needs to be tested. Details of the relevant test loads are specified in BS 2853:2011 and these will govern the design of the bottom flange of the runway beam to resist local wheel loads. BS 2853:2011 is thus "non-contradictory complementary information" (NCCI) that should be used in association with BS EN 1993-6: 2007.

Serviceability criteria

The 2011 edition of BS 2853 has retained and amplified general serviceability requirements for the design of runway beams. The criteria now include:

- deflection;
- slope;
- suitability.

Deflection

The wording now clarifies that the deflection of a runway beam due to the safe working load is to be measured relative to its supports. In the past, some inspectors erroneously measured the absolute deflection. The deflection limit in BS 2853:2011 now corresponds with the design requirement in BS EN 1993-6.

Requiring a loaded runway beam to have a sufficiently large "moment of inertia" (second moment of area) to limit its deflection relative to its supports, also limits its slope due to the loaded trolley. This is an indirect way to avoid subjecting a trolley to an excessive slope. The deflections of the supports are not relevant unless they increase the maximum slope to which the trolley is subjected.

Slope

A new requirement has also been added, limiting the unintended slope of an unloaded runway beam, again to avoid subjecting a trolley to an excessive slope.

Unintended differences in the levels of runway beam supports can arise from three sources:

- Erection tolerances;
- Differences between the deflections of each support due to static loads on the supporting structure;
- Differences between the deflections of each support due to other moving loads on the supporting structure.

Some design modification will be needed if the deflections of the supporting structure are such that the total slope of an unloaded runway beam from these three causes could exceed the limiting value. As an alternative to modifying the supporting structure, the runway beam could be treated as intentionally sloping and the trolley designed accordingly.

Suitability

The retained non-contradictory wording on general aspects of runway beam design requires the design and layout of the supporting structure to be appropriate.

Provided that the supporting structure doesn't oscillate, its deflections due to the load on a simply supported runway beam are not normally a problem, even if some supports deflect more than others. With a simply supported beam, the slope at the trolley location will reach its maximum when the trolley is closer to one of its supports than to the other. At this point, the slope of a runway beam due to the load from the trolley is relatively insensitive to the deflection of the other support, so it is sufficient to limit the deflection of the runway beam under the load from the trolley, relative to the mean of the deflections of its supports, with the trolley at mid-span. The same is true in the case of a continuous runway beam.

However, in the case of a load on a cantilevered runway beam, it is necessary to allow for the resulting deflections of its supports, because when the trolley is on a cantilever, the remote support of the anchor arm will deflect upwards. The deflection of the cantilever relative to the mean of the deflections at its supports will thus be more than its deflection relative to the adjacent support, because the resulting slope of the anchor arm will increase the slope of the cantilever. (This is in addition to the downward deflection of the cantilever due to the upward curvature of the anchor arm.)

Accordingly, the calculated deflection of the cantilever at the trolley location needs to include its deflection due to the relative deflections of its supports.

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New and revised codes & standards

From BSI Updates April and May 2013

BS IMPLEMENTATIONS

BS ISO 14346:2013
Static design procedure for welded hollow-section joints. Recommendations
No current standard is superseded

CORRIGENDA TO BRITISH STANDARDS

BS EN 1991-1-2:2002
Eurocode 1: Actions on structures. General actions. Actions on structures exposed to fire
CORRIGENDUM 3

BS EN 1991-1-6:2005
Eurocode 1. Actions on structures. General actions. Actions during execution
CORRIGENDUM 3

BS EN 1991-3:2006
Eurocode 1. Actions on structures. Actions induced by cranes and machinery
CORRIGENDUM 1

BS EN 1991-3:2006
Eurocode 1. Actions on structures. Actions induced by cranes and machinery
CORRIGENDUM 2

BS EN 1991-4:2006
Eurocode 1. Actions on structures. Silos and tanks
CORRIGENDUM 1

PD 6695-2:2008+A1:2012
Recommendations for the design of bridges to BS EN 1993
CORRIGENDUM 1

BRITISH STANDARDS UNDER REVIEW

BS EN ISO 10684:2004
Fasteners. Hot dip galvanized coatings

BS EN ISO 13918:2008
Welding. Studs and ceramic ferrules for arc stud welding

BS EN 24015:1992
(ISO 4015:1979)
Hexagon head bolts. Product grade 8. Reduced shank (shank diameter pitch diameter)

NEW WORK STARTED

EN 10338
Hot rolled and cold rolled non-coated flat products of multiphase steels for cold forming. Technical delivery conditions

EN 10346
Continuously hot-dip coated steel flat products. Technical delivery conditions
Will supersede BS EN 10346:2009

EN ISO 9934-1
Non-destructive testing. Magnetic particle testing. General principles
Will supersede BS EN ISO 9934-1:2001

EN ISO 16810
Non-destructive testing. Ultrasonic testing. General principles

ISO 4759-3
Tolerances for fasteners. Plain washers for bolts, screws and nuts. Product grades A and C
Will supersede BS EN ISO 4759-3:2000

ISO 4998
Continuous hot-dip zinc-coated carbon steel sheet of structural quality
Will supersede BS ISO 4998:2011

ISO 16228
Fasteners. Certificates. Test reports

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