



STEEL INDUSTRY
GUIDANCE NOTES

Design Responsibility – Simple Connections

Accurate, timely and comprehensive design information leads to efficient and economic working for all parties involved in a construction project. This applies to the design and fabrication of structural steelwork connections. To achieve the correct information everyone throughout the supply chain (consulting engineer, main contractor and steelwork contractor) needs to understand exactly what they have to do and the level of detail required at each stage. Unfortunately on many projects the quality of information provided for connection design and fabrication varies enormously.

The purpose of this SIGNS is to identify the information required by the steelwork contractor to design and fabricate structural steelwork connections.

Design Loads

Design drawings are usually the best method of providing the steelwork contractor with information for connection design and are much preferred to design calculations sheets, computer output or descriptive clauses.

The loading information necessary for the design of connections includes the forces, moments and their combination required to be carried by each joint and end connections (including internal connections and joints in trusses etc). This information should be provided in a clear and easy to understand format as this will help avoid errors in the determination of the connection design parameters. If the design has been made using limit state methods (BS 5950 or BS EN 1993) the end reactions shown on the design drawings should be the ultimate limit state (factored) values. This should be stated in a note on the design drawings to avoid uncertainty: e.g. *Forces shown are ultimate limit state to BS 5950 (or BS EN 1993).*

The consulting engineer should ensure that loadings given for all load cases are compatible at node positions where several members meet. The connection design cannot be properly analysed if the forces in each member are not in equilibrium. Furthermore the forces at each, individual connection/node should be given rather than a global value to allow the steelwork contractor to economically size the connections.

The connection loading information should preferably be part of the tender enquiry documents to enable a proper allowance to be made in arriving at a tender price. If this is not the full loading information, connections

where loads are high or unusual as well as any moment connections should be identified. Where information is not provided the steelwork contractor will assume that the connection forces, etc are realistic.

The inclusion of comments such as **'Design the moment connection for the plastic moment capacity of the section'** should be avoided as they are not helpful. Often it is impossible to design efficient connections that are economic to fabricate and erect that comply with such statements.

It is good practice for the consulting engineer to provide on the design drawings typical details of the connections he/she envisaged when making his/her design particularly where there are geometrical constraints or the visual appearance of the connection is critical. The purpose of these details should be explained so that there is no misunderstanding of the design work to be carried out by the steelwork contractor. The consulting engineer is responsible for the design of the structure and this includes a responsibility for the compatibility of the type of connection used with the overall structural performance of the frame. The consulting engineer must also ensure the connection adopted is compatible with his design.

Base Plates

Base plate connections are one of the simplest to design but the steel, concrete interface makes the design responsibility complicated. The responsibility is usually split between the consulting engineer and the steelwork contractor. Sometimes the consulting engineer will design the anchorages while in other

cases he will provide an outline design of the holding down bolts and any shear keys. The consulting engineer is generally responsible for the design of both the frame and the foundation and will provide the steelwork contractor with the following information:

- Details of the foundation and grade of concrete (if required)
- The size, steel grade and sub-grade of the column
- Design loads (usually factored) at the base of the column

Once again design drawings are usually the best method of providing this information and it is recommended that indicative base details are provided to avoid interface problems.

The steelwork contractor will design the base plate for the design loads and will propose a suitable method of anchorage (holding down bolts) based on the loads, concrete strength, edge distance and foundation geometry. The consulting engineer will then confirm the adequacy of the anchorage. Generally, the steelwork contractor will quantify the load/s in the anchorage (i.e. holding down bolts) and the consulting engineer will confirm the proposed details and check the adequacy of the steel/concrete interface.

Where the holding down bolts are in tension the responsibility for providing a safe design is split between the consulting engineer, the main contractor and the steelwork contractor. Often the best approach is to have the following split of responsibilities:

- a. The consulting engineer will provide the foundation details, thickness, geometry and concrete strength
- b. The steelwork contractor will specify the design loads in the method of anchorage, design the base plate, propose an anchorage and manufacture and supply the anchorage system
- c. The consulting engineer will design and specify the anchorage system.
- d. The main contractor will install the anchorage system.

Simple Connections

The majority of steel beam to column and beam to beam connections are based on the recommendations given in '*Joint in Steel Construction – Simple Connections*' (Greenbook). The most popular connections are the flexible end plate and the fin plate. The steelwork contractor is normally responsible for the design of the connections based on the following information provided by the consulting engineer:

- Factored ultimate limit state design loads
- Where tying forces are not specified in the above loads. The proposed tying strategy, the class of the building in accordance with Approved Document A and the number of storeys. The tying force given in BS 5950-1 is dependent on the class of the building and the number of storeys.
- The value of the factor 'n' given in clause 2.4.5.3 of BS 5950-1.

For the standard cases the steelwork contractor will check the ultimate limit state and the tying capacity of the connection against the safe load tables given in the Greenbook.

For most connections the tie force condition will be the most critical loading condition and as a result the steelwork contractor will often extend the end plate to the flanges of the beam and use a weld on the inside profile of the beam to connect the end plate to the beam. On occasion the tying force is so large that it is impossible to design a connection to take the tie force and still be classified as a simple connection - bolt spacings and plate thicknesses are required that are outside the scope of the 'Greenbook' and invalidate the assumed flexibility of the connection. In these cases the steelwork contractor will need to seek advice from the consulting engineer and the consulting engineer will have to ensure that the connection design does not invalidate the design assumptions for the frame. This may require the consulting engineer to reconsider the design of the supporting column.

Key Points

1. Accurate and timely information is required to suit the project programme and sequence
2. Design drawings are the best method of providing the steelwork contractor with information in connection design
3. There should always be regular dialogue between all parties to ensure that the design information is clear and fully understood
4. If the design has been made using limit state methods (BS 5950 or BS EN 1993) the end reactions should be the ultimate limit state (factored) values on the design drawings
5. For base plate connections the responsibility is split between the steelwork contractor, the consulting engineer and the main contractor

Further sources of Information

Joints in Steel Construction – Simple Connections, The Steel Construction Institute and the British Constructional Steelwork Association, Publication P 212, 2002.

The Building Regulations, Approved Document A – Structure, Office of the Deputy Prime Minister, 2004.

National Structural Steelwork Specification for Building Construction, 5th Edition, The British Constructional Steelwork Association and the Steel Construction Institute, BCSA Publication 203/07.