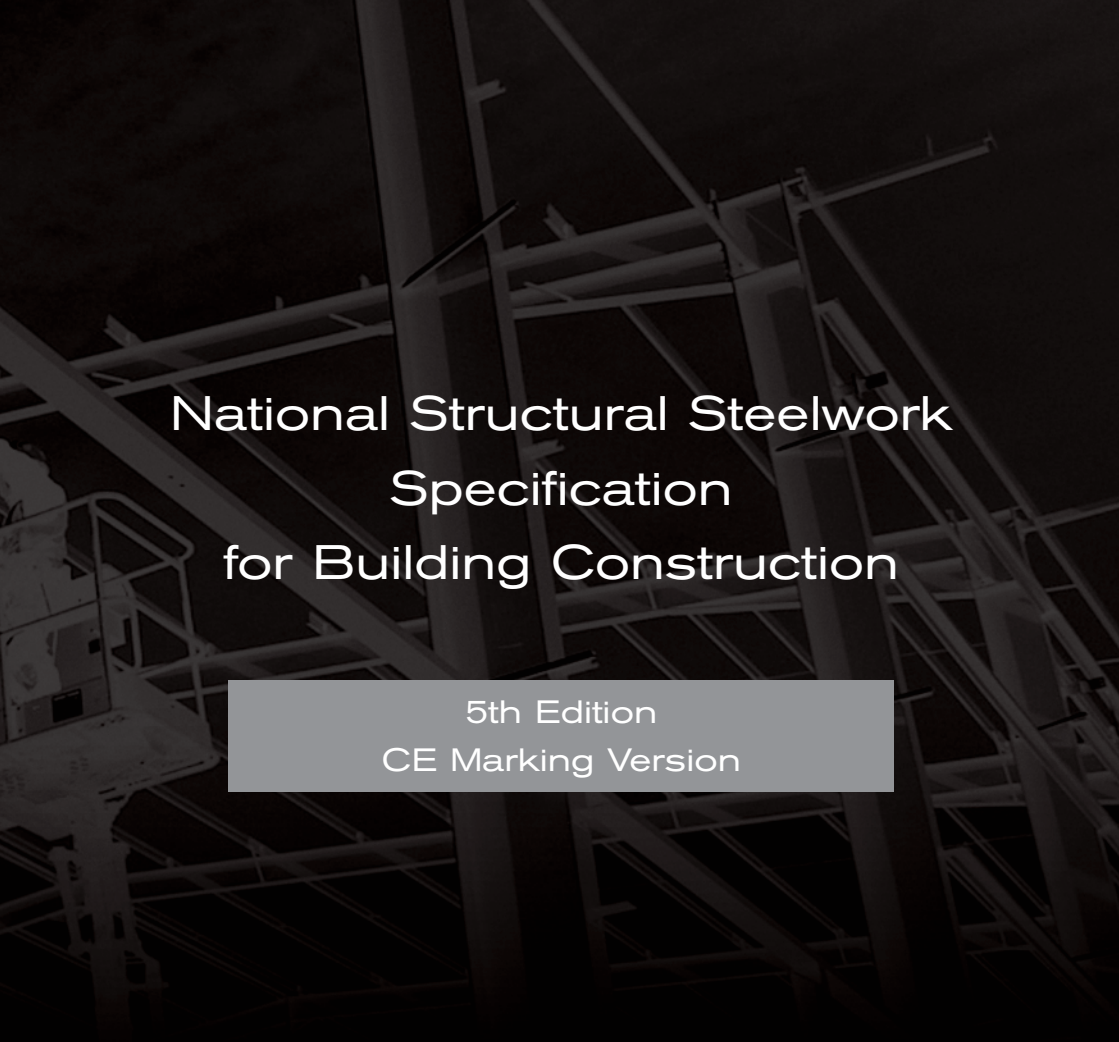

# National Structural Steelwork Specification for Building Construction

5th Edition
CE Marking Version

SCI
Steel Knowledge

TATA STEEL

BCSA

BCSA Publication No. 52/10

# National Structural Steelwork Specification for Building Construction

5th Edition

CE Marking Version

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**THE BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION LIMITED**

BCSA Limited is the national organisation for the steel construction industry: its Member companies undertake the design, fabrication and erection of steelwork for all forms of construction in building and civil engineering. Associate Members are those principal companies involved in the supply to all or some Members of components, materials or products. Corporate Members are clients, professional offices, educational establishments etc., which support the development of national specifications, quality, fabrication and erection techniques, overall industry efficiency and good practice.

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## FOREWORD

The National Structural Steelwork Specification for Building Construction is presented here in its 5th Edition CE Marking Version; issued some four years after the publication of the first version of the 5th Edition and more than twenty years after the 1st Edition in 1989. This version of the 5th Edition does not supersede the earlier version which remains current for applications where CE Marking is not required.

This Specification continues to meet its objective of achieving greater uniformity in steelwork contract specifications and is recognised as a document that can be incorporated readily into contract documentation to specify acceptable standards for the fabrication and erection of steelwork structures for buildings.

It is intended that this Specification should be invoked as part of the individual Project Specification and thus be part of the total building contract. It is essential that the Steelwork Contractor receives, on time, all information necessary for him to carry out the contract. Section 1 gives guidance on the items and information that should be included in the Project Specification. It is recognised that if the structure is unorthodox it may be appropriate to qualify and/or enlarge upon the provisions of this Specification; some guidance on such matters is given in the Commentary which is available on www.steelconstruction.org

It is considered that this Specification can be incorporated within the forms of contract normally employed in the steel construction industry.

Essentially the steel construction industry operates to the requirements of British Standards and increasingly to European Standards adopted as British Standards, and it is appropriate that all these standards are now referred to as British Standards. The British Constructional Steelwork Association Ltd and the Steel Construction Institute take a most active part in the preparation of these documents. Much of the information noted in this Specification is based upon that given in these standards, **but it must not be inferred that the full details of the standards are not relevant.**

Account is taken of the fact that information is increasingly exchanged in electronic form and the adoption of standard forms of steelwork connections allows the review of structural details to be streamlined.

Simplified procedures for weld inspection are introduced; tables for weld inspection and acceptance criteria, suitable for most welding generally used in steelwork building construction, are placed in an annex to the Specification. In Section 5 note is made that the Engineer should check that any additional project-specific requirements for non-destructive testing of welds are defined in the Project Specification.

References to British Standards (issued with BS, BS EN, BS EN ISO or BS ISO references) have been updated throughout the Specification.

All parties are reminded that under the Construction (Design and Management) Regulations 2007 they have a duty to cooperate with others involved with construction of The Works to demonstrate compliance with health and safety legislation. Compliance with this Specification will make that task easier.

Attention is drawn to Section 11 which requires that Steelwork Contractors should have all the necessary facilities, skills and effective quality management to ensure that their services and products conform to this Specification. It stipulates that the quality management system shall be open to assessment by the Employer or be certified by an approved certification body for compliance with BS EN ISO 9001. In addition it stipulates that the manufacturer's factory production control system shall be certified by a Notified Body for compliance with BS EN 1090-1.

It is intended to continue to update this Specification at regular intervals. BCSA would appreciate any observations, particularly on inaccuracies and ambiguities, or proposals on the clauses as printed here or on any other matters which should be included in future editions.

This issue of the Specification has been prepared under the guidance of a steering committee composed of the representatives and organisations listed below:

| | | |
|---|---|---|
| Mr A Pillinger (Chairman) | - | Bourne Construction Engineering Ltd. |
| Mr C Bakkala | - | Bakkala Consulting Engineers |
| Mr M Banfi | - | Arup |
| Mr D Brown | - | Steel Construction Institute |
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| Mr J Krancioch | - | Severfield-Rowen Plc. |
| Dr A Mann | - | Jacobs |
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| Mr J Parley | - | Tata Steel |
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| Mr R Reed | - | Consultant |
| Mr A Shepherd | - | Richard Lees Steel Decking Ltd. |
| Mr R Shipman | - | Department of Communities and Local Government |

The steering committee acknowledge further advice provided by:

| | | |
|---|---|---|
| Mr J French | - | Sandbergs |
| Mr G Mathers | - | The Welding Institute |
| Mr J Carmichael | - | Steel Construction Certification Scheme Ltd. |
| Dr M Ogle | - | The Welding Institute |
| Dr R Pargeter | - | The Welding Institute |

Care has been taken to obtain the views and comments of all sections of the industry including clients, government bodies, architects, surveyors, consulting engineers, general contractors, steelwork contractors and component suppliers. The BCSA acknowledges with thanks the helpful contributions made.

**Documents referred to in this Specification**

Copies of documents referred to in this Specification may be obtained from:

(a) British, European, American and ISO Standards
British Standards Institution
389 Chiswick High Road
London W4 4AL

(b) *The Construction (Design and Management Regulations) [L144]* and *Guidance Notes to Environmental Protection Act 1990 [PG6/23]*
Her Majesty's Stationery Office (HMSO) or its approved agents

(c) BCSA Publications
The Steel Construction Certification Scheme Ltd.
4 Whitehall Court
Westminster
London SWIA 2ES

(d) New paint systems for the protection of construction steelwork
CIRIA
Classic House
174-180 Old Street
London EC1V 9BP

(e) *National Structural Concrete Specification*
CONSTRUCT
Riverside House
4 Meadows Business Park
Camberley
Surrey GU17 9AB

**Commentary on the National Structural Steelwork Specification**

The Commentary on the National Structural Steelwork Specification for Building Construction is available on the BCSA website: www.steelconstruction.org

## CONTENTS

## SCOPE

This Specification deals with structural steelwork designed in accordance with:

| | |
|---|---|
| **BS 5950-1** | Structural use of steelwork in buildings: Code of practice for design: rolled and welded sections |
| **BS EN 1993-1-1** | Eurocode 3: Design of steel structures – Part 1.1: General rules and rules for buildings |
| **BS EN 1993-1-8** | Eurocode 3: Design of steel structures – Part 1.8: Design of joints |
| **BS EN 1993-1-10** | Eurocode 3: Design of steel structures – Part 1.10: Material toughness and through-thickness properties |

This Specification deals with structural steelwork executed in accordance with:

| | |
|---|---|
| **BS EN 1090-1** | Execution of steel structures and aluminimum structures – Part 1: Requirements for conformity assessment of structural components |
| **BS EN 1090-2** | Execution of steel structures and aluminimum structures – Part 2: Technical requirements for steel structures |

It can be used for all types of building construction designed for static loading. It is based on execution of structural steelwork in Execution Class 2 according to BS EN 1090-2. It is not intended to be used for steelwork in dynamically or seismically loaded structures or if fatigue is a factor unless appropriate amendments are made.

The Specification describes the information to be included in a Project Specification, and also covers materials, preparation of drawings, fabrication, erection and the requirements for protective treatment including standard paint coatings.

Specific requirements are placed on the Steelwork Contractor and the Employer. Other requirements are allocated to the Engineer, who may not be directly a party to the steelwork contract, but may be engaged by the Employer or by the Steelwork Contractor. It should also be noted that in certain design-build contracts design responsibility is shared and in these instances the role of Engineer will have to be redefined.

This Specification should be introduced into a steelwork contract by a Project Specification, the contents of which are described herein. The Project Specification should also include any additions or modifications that may be required to the National Structural Steelwork Specification by the Employer for a particular contract if the form of behaviour or other aspects of the structure are unorthodox.

## DEFINITIONS

Terms which are defined in this section are treated as Proper Nouns throughout the text of the Specification. The following definitions apply for the purposes of this Specification:

| | | |
|---|---|---|
| Connection Design | : | The design of bolts, welds, cleats, plates and fittings required to provide an adequate load path between the end of a member and the component it connects to. |
| Design Calculations | : | Calculations prepared by the Engineer showing the design and analysis of the structure. |
| Engineer | : | The Employer's, or the Steelwork Contractor's, designer who is responsible for the structural design and for reviewing and accepting the detail drawings and erection method statement. |
| Design Drawings | : | Fully dimensioned drawings or electronic equivalent prepared by the Engineer showing all members with their size and material grades, the forces to be developed in their connections, any cambers, eccentricities (offsets or levels) and other information necessary for the design of the connections and completion of Fabrication and Erection Drawings (see Table 1.3). |
| Electronic Data | : | Computer data and similar data transferred between parties providing essentially equivalent information to traditional drawings. |
| Employer | : | The individual, or company, placing the contract with the Steelwork Contractor.<br>*Note: This will usually be the main contractor, and is not necessarily the Employer as defined in JCT contracts.* |
| Erection Drawings | : | Drawings, prepared if necessary by the Steelwork Contractor, showing details to amplify the information given in the Steelwork Contractor's erection method statement and showing details of any temporary steelwork (see 8.1.1 and 8.4). |
| Examiner, Examining Body | : | A person or organisation respectively competent to verify compliance of welder tests to BS EN 287 or welding tests to BS EN ISO 15614.<br>*Note: These responsibilities are distinct from those of the Inspection Authority if appointed.* |
| Fabrication Data | : | Electronic means of communication for automatic or semi¬automatic methods of fabrication. |
| Fabrication Drawings | : | Drawings or electronic equivalent prepared by the Steelwork Contractor, showing all necessary information required to fabricate the structural steelwork.<br>*Note: These are often termed “detail drawings”.* |
| Fittings | : | Plates, flats or rolled sections which are welded or bolted to structural steel components. |
| Foundation Plan Drawings | : | Drawings, prepared by the Steelwork Contractor or the Engineer, indicating location of column bases and details of foundation connections to the steelwork. |
| General Arrangement Drawings | : | Drawings, prepared by the Steelwork Contractor, showing plans, cross sections and elevations, main dimensions and the erection marks of components. |
| Inspection Authority | : | A competent independent person or organisation which verifies compliance with this Specification and the Project Specification. |

| | | |
|---|---|---|
| | | *Note: Generally, the scope of an Inspection Authority's responsibility would necessitate it being competent to verify that welding procedure qualification records are suitable for the work being undertaken and that suitable welding procedure specifications are being used.* |
| Ordinary Bolt Assemblies | : | A bolt used in a non-preloaded bolt assembly which is designed to carry forces in shear and bearing or tension. |
| Production Test Plate | : | A plate used for testing purposes, which is made of the same material and using the same procedures as the joint in a component. |
| Programme | : | The programme of dates given in the Project Specification, or agreed with the Steelwork Contractor, for: the release of all necessary information for the progress of The Works; the preparation, submission and acceptance of fabrication drawings, calculations and information; the intended starting and completion dates for steelwork erection. |
| Project Specification | : | A specification prepared for a specific building project (see "The Works") which includes the latest version of the National Structural Steelwork Specification and qualifies it where necessary. The Project Specification includes the execution specification defined in BS EN 1090-2 and the individual component specifications defined in BS EN 1090-1. |
| Quality Assurance | : | Activities concerned with the provision of systems, equipment and personnel necessary to achieve the required level of quality. |
| Site | : | The area defined in the Project Specification within which The Works will be constructed. |
| Stiffener | : | A steel component, generally a plate, in a connection or attached to a member to increase the strength of a panel zone within the joint or member. |
| Steelwork Contractor | : | The company appointed to fabricate and/or erect the structural steelwork. If required by the Project Specification, the Steelwork Contractor may also be responsible for design. The Steelwork Contractor undertakes the role of constructor defined in BS EN 1090-2. |
| Works, the | : | Those parts of the construction works described in the Project Specification as structural steelwork. |
| Fillet Weld | : | A weld, other than a butt or edge weld, which is approximately triangular in transverse cross section and which is made without preparation of the parent material. |
| Full Penetration Weld | : | A weld between elements which may be in-line, in the form of a tee, or a corner in which the weld metal achieves full penetration throughout the joint thickness. |
| Partial Penetration Weld | : | A weld formed using a technique which ensures a specified penetration which is less than the depth of the joint and hence intentionally not full penetration.<br>*Note: This is distinct from "incomplete penetration" which is penetration that is less than that specified or required.* |
| Full Strength Weld | : | Any of the above welds designed to develop the full strength of the parts which it connects. |

Note: Terms and definitions given in BS EN 1090-1 and -2 also apply.

# SECTION 1

# INFORMATION REQUIRED BY THE STEELWORK CONTRACTOR

## 1.1 PROJECT SPECIFICATION FOR STRUCTURAL STEELWORK

### 1.1.1 Provision of information

It is the responsibility of the Employer to provide appropriate information for the intended works. The non-exhaustive checklists given in Tables 1.1 to 1.7 set out information that is to be shown on the Design Drawings or given in the Project Specification.

*Note: Greater detail is set out in the BCSA/ACE joint publication Allocation of Design Responsibilities in Constructional Steelwork Projects.*

### 1.1.2 Reference to National Structural Steelwork Specification

The Project Specification shall state that the National Structural Steelwork Specification for Building Construction 5th Edition CE Marking Version is incorporated into the contract along with any additions or modifications required by the Employer.

### 1.1.3 Precedence if there is a conflict

If there is a conflict in specified requirements the Project Specification takes precedence over other documents.

The full text of BS EN 1090-1 and -2 takes precedence over this Specification.

**TABLE 1.1 PROPOSED WORKS – CHECKLIST**

| **Information required by the Steelwork Contractor** |
|---|
| (i) A brief description of the structure. |
| (ii) The intended purpose of the structure. |
| (iii) Details of the Site within which the Works will be constructed. |
| (iv) The building class in accordance with the Building Regulations. |
| (v) Those parts of the structure (if any) that are external. |
| (vi) Those parts of the structure (if any) that may be manufactured to Execution Class 1. |

**TABLE 1.2A DESIGN – CHECKLIST**

**When the Steelwork Contractor carries out detailing of the steelwork and design and detailing of connections based on the member design prepared by the Engineer.**

**Information required by the Steelwork Contractor**

(i) A statement describing the design concept.

(ii) Design Drawings showing all dimensions relevant to the steelwork or, if agreed, equivalent electronic data.

(iii) The design standards to be used for connection design.

(iv) Information necessary to design the connections including forces, moments and their combination required to be transmitted at each joint. If connection design is to be in accordance with BS 5950-1 or BS EN 1993-1-8, the forces and moments should be the factored values as defined by the code.

(v) Particulars of any aesthetic, structural or clearance limits to be observed or environmental conditions which may affect detailing or protective treatment.

(vi) Details and locations of any temporary works assumed by the Engineer in the design.

(vii) A schedule of drawings, calculations and other information which the Steelwork Contractor must submit for acceptance.

(viii) Any part of the steelwork where the manufacturing processes must be restricted including locations where holes cannot be punched e.g. plastic hinge positions (see 4.6.1).

(ix) Details of any dynamic or vibrating forces and if fatigue is to be considered. Appropriate amendments to this Specification should be included since these factors are outside the intended scope.

(x) The designation of the steel to be used including the standard number, material grade, impact quality and any through-thickness requirements (see Tables 2.1 and 2.2).

(xi) Positions on the structure where additions and stiffeners are required to develop the strength of the member and where notching may affect member stability, including stiffeners required around service holes and in tubular joints.

(xii) Any property classes of bolt assemblies and their coatings which are specifically required.

(xiii) Details of the fixings or bolts to the foundations or walls designed by the Engineer, or a statement indicating that the Steelwork Contractor has to design these items and prepare a Foundation Plan Drawing (see 3.3).

(xiv) Any prescriptive requirements on thickness and type of bedding material (grout) to be used under column base plates.

(xv) Requirement for any particular type of fabrication detail and/or restriction on types of connection to be used.

(xvi) Details of cut-outs, holes or fittings required for use by others, or a statement clarifying the scope of coordination with others that the Steelwork Contractor has to undertake in this respect.

(xvii) Camber and presets which have to be provided in fabrication so that continuous frames and other steelwork can be erected to the required geometry.

**TABLE 1.2B DESIGN – CHECKLIST**

**When the Steelwork Contractor carries out design and detailing of the steelwork commencing with the design of the members after the conceptual layout has been prepared.**

*Note: The role of the Engineer will need to be clarified under this option, and terms may need to be redefined.*

**Information required by the Steelwork Contractor**

(i) A statement describing the design requirements.

(ii) Drawings showing the position of steel components.

(iii) The design standards to be used.

(iv) The loading data to be used.

(v) Particulars of any aesthetic, structural or clearance limits to be observed or environmental conditions which may affect design and detailing or protective treatment.

(vi) A schedule of drawings, calculations and other information which the Steelwork Contractor must submit for acceptance.

(vii) Any restrictions on the material grade and designation of steel to be used, including any of the options noted in standards listed in Table 2.1.

(viii) Specification of any other materials to be used in the Works.

(ix) Any non-destructive testing required on the materials in addition to those specified in clauses 5.5.3 and 5.5.4 on welds.

(x) The deflection limitations to be observed if the criteria are different from those given in the design standard.

**TABLE 1.2C DESIGN – CHECKLIST**

**When the Steelwork Contractor carries out design and detailing of the steelwork commencing with arranging the layout of members.**

*Note: In this option the Engineer acts for the Steelwork Contractor and the Engineer's approvals/agreements will be internal unless stated otherwise in the Project Specification*

**Information required by the Steelwork Contractor**

(i) Conceptual drawings of the project.

(ii) Particulars of any aesthetic, structural or clearance limits to be observed or environmental conditions which may affect design and detailing or protective treatment.

(iii) The parameters to be considered in preparing the design layout.

(iv) The design standards to be used.

(v) The loading data to be used.

(vi) A schedule of drawings, calculations and other information which the Steelwork Contractor must submit for acceptance.

**TABLE 1.3 WORKMANSHIP - CHECKLIST**

**Information required by the Steelwork Contractor**

(i) Areas on steelwork where hard stamping or other permanent forms of identification may not be used (see 4.1.3 (ii)).

(ii) Any special welding procedures (such as for non-standard joint types, or for restricted access situations) which have to be approved prior to the work commencing. (Note: Routine welding procedure requirements are in 5.3).

(iii) Any special requirements regarding fabrication or erection attachments (see 3.4.2 and 5.4.5).

(iv) Any production test plates which are required (see 5.4.7).

(v) Any project-specific supplementary NDT (see 5.5.7).

**TABLE 1.4 ERECTION – CHECKLIST**

*Note: Information for some of these erection items maybe provided separately by the Employer, or subject to negotiation.*

**Information required by the Steelwork Contractor**

(i) A Site plan showing position of datum level and setting-out lines.

(ii) Width and level of the prepared working area, for access of Site traffic and cranes, and areas available for storage (see 8.2).

(iii) Availability of site services and any prearranged procedures for cooperation with other contractors (see 8.3.1(i)).

(iv) Any limitation on dimensions or weights of components to be delivered to the Site or ground capacity limits for heavy loads.

(v) Any design features which would affect the construction sequence, or which may create an unusual hazard during construction.

(vi) Details of any underground services, overhead cables or site obstructions.

(vii) An outline of the method of erection envisaged by the Engineer, giving the sequence for erecting the structure taking into account any phasing of the Works, including positions on the structure where temporary bracing, metal decking or other restraints are needed to provide stability to individual members or the structure until walls, floors or other non-steel structures are in position (in accordance with 8.4.1).

(viii) A description of any temporary works and any special requirements for temporary bracing required by the Engineer to comply with (vii) above; the stage when it is no longer necessary, or whether it is to be left in position after completion of the steelwork.

(ix) A list of the responsibilities at the interface between the steelwork and other trades.

(x) A Safe Site Handover Certificate and other information necessary so that the Steelwork Contractor can comply with Section 8 (see 8.3.1).

**TABLE 1.5 PROTECTIVE TREATMENT – CHECKLIST**

**Information required by the Steelwork Contractor**

(i) The grade of preparation in accordance with 10.2 or any requirement for surface preparation outside the provisions of 10.2.

(ii) Thickness and composition of any sprayed metal coatings (see 10.3).

(iii) Any requirements for galvanizing including post-galvanizing inspection (see 10.4).

(iv) Any requirements for paint treatment (see 10.5).

(v) Responsibility for touch-up of damaged areas and cleaning of surface treatments on Site, and the specification for this work.

(vi) Any requirement for fire protective coating and/or the limiting fire temperatures to be observed.

**TABLE 1.6 INSPECTIONS AND TESTS – CHECKLIST**

**Information required by the Steelwork Contractor**

(i) Inspections or tests to be carried out or witnessed by the Employer, Engineer or Inspection Authority.

(ii) The period of advance notice required for these additional requirements.

**TABLE 1.7 PROGRAMME – CHECKLIST**

*Note: Programme dates may be those suggested by the Steelwork Contractor and accepted by the Employer.*

**Information required by the Steelwork Contractor**

(i) The date(s) of issue of the Design Drawings or data for construction and other information necessary for the progress of the Works.

(ii) The period to be provided in the Steelwork Contractor's programme for acceptance of submitted information.

(iii) The date(s) by which the Site is expected to be ready with prepared and cured foundations and compliant with the Safe Site Handover Certificate.

(iv) The proposed starting and completion dates for erection of steelwork and the dates when other contractors' activities are expected to interface with the steelwork erection programme.

# SECTION 2

# MATERIALS

## 2.1 CONSTITUENT PRODUCTS

Materials or products which are incorporated into completed structural components shall comply with the requirements of the component specification. Only products with a CE mark shall be used if a harmonised standard exists for that constituent product type.

*Note: This only refers to standards harmonised under the Construction Products Directive.*

## 2.2 STEEL PRODUCTS

### 2.2.1 Qualities

Material shall be steel in rolled sections, structural hollow sections, plates or bars and shall comply with the appropriate standard shown in Table 2.1.

*Note: When specifying and ordering, the full steel designation should be given including the standard number, strength grade and impact quality (e.g. BS EN 10025-2 S275J0) so that the correct properties for fracture toughness and weldability are ensured. When ordering, consideration should also be given to specifying particular options available in the steel product standards (e.g. option 5 of BS EN 10025-1 "Suitability for hot-dip zinc-coating").*

### 2.2.2 Testing

All steel products for use in the Works shall have been specifically tested and the steel product manufacturer shall declare the results using an inspection certificate type 3.1 to EN 10204.

*Note: This requirement is necessary to ensure that the weldability of the steel in terms of its CEV matches that required for the welding procedure specification, and it supersedes the testing requirements specified in BS EN 10025-1 which permits steel products of qualities S275JR, S275J0, S355JR or S355J0 to be supplied with non-specific test reports.*

The Steelwork Contractor shall have access to inspection documents to BS EN 10204 provided by manufacturers of all steel products used in the Works. If requested, the Steelwork Contractor shall make these inspection documents available to the Engineer or Inspection Authority.

Any further tests to establish whether the mechanical properties of steel products are appropriate for use in the Works shall be undertaken by a laboratory certified as competent to BS EN ISO IEC 17025.

### 2.2.3 Dimensions and tolerances

Dimensions and tolerances shall comply with the appropriate standard shown in Table 2.1.

**TABLE 2.1 MATERIAL and DIMENSION STANDARDS**

<table>
<tr><th rowspan="2">Form</th><th colspan="3">Material Quality</th><th rowspan="2">Dimensions</th><th rowspan="2">Tolerances</th></tr>
<tr><th>Non-alloy steels</th><th>Fine grain steels</th><th>Weathering steels</th></tr>
<tr><td>Universal Beams & Columns</td><td rowspan="9">BS EN 10025-2[1]</td><td rowspan="9">BS EN 10025-3[2] or BS EN 10025-4[3]</td><td rowspan="9">BS EN 10025-5[4]</td><td>BS 4 - 1</td><td>BS EN 10034</td></tr>
<tr><td>Joists</td><td>BS 4 - 1</td><td>BS EN 10024</td></tr>
<tr><td>Channels</td><td>BS 4 - 1</td><td>BS EN 10279</td></tr>
<tr><td>Rolled Asymmetric Beams</td><td>[7]</td><td>[7]</td></tr>
<tr><td>Angles</td><td>BS EN 10056-1</td><td>BS EN 10056-2</td></tr>
<tr><td>Rolled Tees</td><td>BS EN 10055</td><td>BS EN 10055</td></tr>
<tr><td>Split Tees</td><td>BS 4 -1</td><td>as UB & UC</td></tr>
<tr><td>Plates (Reversing Mill)[5]</td><td>-</td><td>BS EN 10029</td></tr>
<tr><td>Plates (Cut from Coil)[5]</td><td>-</td><td>BS EN 10051</td></tr>
<tr><td>Wide Flats</td><td>-</td><td>EU 91</td></tr>
<tr><td>Hollow Sections (Hot Finished)[6]</td><td colspan="2">BS EN 10210-1</td><td>BS 7668</td><td colspan="2">BS EN 10210-2</td></tr>
<tr><td>Hollow Sections (Cold Formed)[6]</td><td colspan="2">BS EN 10219-1</td><td>–</td><td colspan="2">BS EN 10219-2 [7]</td></tr>
</table>

(1) Steel grades S275 and S355 in qualities JR, J0 and J2, and S355K2.

(2) Steel grades S275, S355 and S420 in qualities N and NL.

(3) Steel grades S275, S355 and S420 in qualities M and ML.

(4) Steel grades S275J0W, S275 J2W, S355J0W, S355J2W and S355K2W.

(5) The scope of BS EN 10029 covers plates of 3mm up to 250mm rolled in a reversing mill process, whereas BS EN 10051 covers plates up to 25mm de-coiled from continuously hot-rolled uncoated flat products.

(6) Except if cold formed hollow sections to BS EN 10219-1 are specifically identified on drawings hollow sections are to be hot finished to BS EN 10210-1.

(7) See manufacturer's information for rolled asymmetric beams and grade S235 cold formed hollow sections.

### 2.2.4 Surface condition

At the time of order by the Steelwork Contractor subclass 2 to BS 10163-2 shall be specified for the manufacture of plates and wide flats. The Steelwork Contractor may permit subclass 1 to apply to the repair by welding of defects which cannot be repaired by grinding, provided that this has been agreed by the Steelwork Contractor's welding coordinator.

Steel surfaces when used shall not be more heavily pitted or rusted than Grade C of BS EN ISO 8501-1.

Surface defects in hot rolled sections, plates and wide flats revealed during surface preparation which are not in accordance with the requirements of BS EN 10163 shall be rectified accordingly. Plates and wide flats shall meet class A2 of BS EN 10163-2; sections shall meet class C1 of BS EN 10163-3.

Surface defects in hot rolled hollow sections revealed during surface preparation which are not in accordance with the requirements of BS EN 10210-1 shall be rectified accordingly.

Surface defects in cold formed hollow sections revealed during surface preparation which are not in accordance with the requirements of BS EN 10219-1 shall be rectified accordingly.

### 2.2.5 Toughness

Unless otherwise specified in the Project Specification, the steel qualities shall be in accordance with Table 2.2.

**TABLE 2.2 MAXIMUM THICKNESS in mm [(1) (2)]**

| | S275 | | | S355 | | |
|---|---|---|---|---|---|---|
| | **JR** | **J0** | **J2** | **JR** | **J0** | **J2** |
| **Internal steelwork** | 40 | 70 | 102.5 | 22.5 | 45 | 67.5 |
| **External steelwork** | 22.5 | 60 | 85 | 12.5 | 37.5 | 55 |

(1) Based on BS EN 1993-1-10 and PD 6695-1-10 assuming steelwork to be welded generally with details being "moderate" and the presence of tensile stress.

(2) For guidance the following factors may be applied to derive the approximate limiting thickness for other details or locations:

| **Compression (welded also)** | **Plain steel** | **Bolted (only)** | **Welded severe** | **Welded very severe (e.g. across ends of cover plates)** |
|---|---|---|---|---|
| 2.0 | 2.0 | 1.5 | 0.75 | 0.5 |

### 2.2.6 Curved or cambered components

In order to establish the impact strength of steel products after being curved or cambered by hot or cold forming, one of the following shall be provided:

(i) A report of specific testing by a suitably certified laboratory of the impact strength after forming; or

(ii) A specific inspection document to BS EN 10025-1 (type 3.1) for the original steel product accompanied by a certificate of conformity based on initial type testing in accordance with BS EN 1090-1 giving details of any effect that forming has.

### 2.2.7 Through-thickness properties

In the welded joint situations shown in Table 2.3 specific precautions shall be taken to avoid lamellar tearing of the "through" material stressed in the "Z" direction:

**TABLE 2.3 JOINTS WITH A HIGH RISK OF LAMELLAR TEARING**

| | Butt or deep penetration joints with "incoming" material thicker than: | Fillet welded joints with largest weld throat greater than: |
|---|---|---|
| Tee joints | 35mm | 35mm |
| Cruciform joints | 25mm | 25mm |
| Joints between columns and base plates are exempt unless the Project Specification identifies them as subject to significant tension. | | |

*Note: As explained in PD 6695-1-10, precautions may include purchasing the "through" material with improved deformation properties perpendicular to the surface of the product to BS EN 10164 (Z-quality) and/or specific ultrasonic inspection of the "through" material locally before and after welding of the "incoming" material. Z-quality is only available for qualities J2 or K2 for steel to BS EN 10025-2.*

## 2.3 WELDING CONSUMABLES

### 2.3.1 Standards

All welding consumables manufactured to harmonised BS EN 13479 standard shall be supplied complete with CE Marking.

Consumables for use in metal arc welding shall comply with BS EN 756, BS EN 760, BS EN ISO 2560, BS EN ISO 14341 or BS EN ISO 17632 as appropriate.

Consumables used for completing welding of steels to BS EN 10025-5 shall have a weather resistance at least equivalent to the parent metal.

### 2.3.2 Storage

Consumables in the Steelwork Contractor's works and on the Site, shall be stored and handled in the manner described in BS EN 1011-1 and in accordance with the relevant standard (See 2.3.1). Any drying or baking of consumables before issue shall be carried out in accordance with the manufacturer's recommendations.

## 2.4 STRUCTURAL FASTENERS

### 2.4.1 CE marking

All fastener assemblies manufactured to harmonised BS EN standards shall be supplied complete with CE marking as follows:

- Ordinary (non-preloaded) assemblies to BS EN 15048-1;
- Preloaded assemblies to BS EN 14399-1.

Fasteners supplied as proprietary items (see 2.7) shall either be CE marked as being in accordance with a European Technical Approval or be treated as special fasteners to BS EN 1090-2. Special fasteners shall only be used if the manufacturer publishes suitable product information in the form of a component specification and provides a certificate of conformity that the fasteners have been supplied in accordance with the component specification.

If provided, the Steelwork Contractor shall make certificates of conformity provided by manufacturers of structural fasteners available to the Engineer or Inspection Authority, if requested.

### 2.4.2 Service temperature

If bolts are intended for use at a service temperature below -20ºC, the purchase order shall specify the temperature at or below which the bolts shall have a minimum impact strength of 27J according to BS EN ISO 898-1.

*Note: The BCSA publishes a Model Specification for the Purchase of Structural Bolts*

### 2.4.3 Ordinary (not for preloading) bolt assemblies

Ordinary bolt and nut (and washer if used) assemblies for use without preloading shall conform to the requirements of BS EN 15048 and Table 2.4. The preloaded bolt assemblies in Table 2.5 may also be used without preloading in non-preloaded applications.

*Note: BS EN 15048 is not a complete product standard; it complements standards such as the BS EN ISO standards for fasteners by providing the testing and other requirements necessary for the manufacture of assemblies to be CE marked. Fasteners manufactured to previous BS and DIN standards are not suitable for CE marking as they do not achieve the test requirements for loadability specified in BS EN 15048-2.*

### 2.4.4 Preloaded bolt assemblies

Preloaded bolt assemblies shall be as given in Table 2.5.

*Note: The term "preloaded" refers to preloadable fasteners to be used in the preloaded condition. The previous usage "HSFG" referred to fasteners suitable for use as preloaded high strength bolts and nuts in friction grip connections.*

Preloaded HV assemblies to BS EN 14399-4 or -8 may only be used if the Project Specification permits this and provides a complete specification for their use.

*Note: It is recommended that assemblies from only one of the two different systems are used exclusively on an individual project.*

Bolts and nuts from the two different systems (HR and HV) shall not be mixed.

Plain washers to BS EN 14399-5 and/or plain chamfered washers to BS EN 14399-6 may be used as given in Table 2.5.

### 2.4.5 Foundation bolt assemblies

Holding down bolt assemblies shall be as given in Table 2.6. (See clause 3.4.6 for additional washers to holding down bolt assemblies).

### 2.4.6 Cup and countersunk bolts

Cup and countersunk bolts for use in non-preloaded applications shall be as given in Table 2.7.

### 2.4.7 Lock nuts for bolt assemblies

Lock nuts used with ordinary bolt assemblies shall be in accordance with BS EN ISO 4035 or 4036.

### 2.4.8 Coatings for bolt assemblies

If specific coatings are required, they shall be provided by the fastener manufacturer and shall comply with the appropriate part of BS 7371, BS EN ISO 4042 (electroplating) or BS EN ISO 10684 (hot dip galvanizing).

**TABLE 2.4 MATCHING ORDINARY ASSEMBLIES**

| Property Class | Bolt | Nut (1) | Washer |
|---|---|---|---|
| **Incorporating full threaded length bolts** | | | |
| 4.6 | BS EN ISO 4018 | BS EN ISO 4034 (Class 4) (3) (4) | BS EN ISO 7091 (100HV) |
| 8.8 | BS EN ISO 4017 (2) | BS EN ISO 4032 (2) (Class 8) (5) | BS EN ISO 7091 (100HV) |
| 10.9 | BS EN ISO 4017 (2) | BS EN ISO 4032 (2) (Class 10) (6) | BS EN ISO 7091 (100HV) |
| **Incorporating part threaded length bolts** | | | |
| 4.6 | BS EN ISO 4016 | BS EN ISO 4034 (Class 4) (3) (4) | BS EN ISO 7091 (100HV) |
| 8.8 | BS EN ISO 4014 (2) | BS EN ISO 4032 (2) (Class 8) (5) | BS EN ISO 7091 (100HV) |
| 10.9 | BS EN ISO 4014 (2) | BS EN ISO 4032 (2) (Class 10) (6) | BS EN ISO 7091 (100HV) |

(1) Nuts of a higher property class may also be used.

(2) Bolts to the property classes 8.8 and 10.9 of BS EN ISO 4014 or BS EN ISO 4017 (dimensions and tolerances of BS EN ISO 4016 or BS EN ISO 4018) may also be used, with matching nuts to the property classes of BS EN ISO 4032 (dimensions and tolerances of BS EN ISO 4034).

(3) Property class 5 nuts for size M16 and smaller.

(4) Nuts for galvanized or sherardized 4.6 bolts shall be class 8.

(5) Nuts for galvanized or sherardized 8.8 bolts shall be class 10.

(6) Nuts for galvanized or sherardized 10.9 bolts shall be class 12 to BS EN ISO 4033.

**TABLE 2.5 MATCHING PRELOADED ASSEMBLIES [1] [2]**

| | System HR | | System HRC |
|---|---|---|---|
| | Hexagon bolt | Countersunk bolt | Tension control bolt [3] |
| **Bolt/nut assembly** | BS EN 14399-3 | BS EN 14399-7 | BS EN 14399-10 |
| Bolt marking | HR | HR | HRC |
| Nut marking | HR | HR | HR or HRD |
| Property classes | 8.8/8; 8.8/10 or 10.9/10 | 8.8/10; 8.8/10 or 10.9/10 | 10.9/10 |
| **Washers** | BE EN 14399-5 or BS EN 14399-6 | | |
| Washer marking | H | | |
| DTI, nut and bolt face washers [4] | BS EN 14399-9 | | At user's discretion |
| DTI marking | H8 or H10 | | |
| Nut face washer marking | HN | | |
| Bolt face washer marking | HB | Not applicable | |

(1) In terms of suitability for preloading, fasteners shall meet the test requirements of BS EN 14399-2 and any additional testing specified in the product standard.

(2) Bolt lengths shall be selected to ensure that a minimum number of four full threads (in addition to the thread run-out) remains clear between the bearing surface of the nut and the unthreaded part of the shank.

(3) Although known as a "tension control bolts", BS EN 14399-10 system HRC assemblies with calibrated preload depend on accurate control of the torque-tension characteristics to achieve the specified axial tensile loads as with other torque control methods.

(4) DTI = direct tension indicator.

**TABLE 2.6 HOLDING DOWN ASSEMBLIES**

| Property Class | Bolt | Nut [1] | Washer |
|---|---|---|---|
| **4.6** | BS 7419 | BS EN ISO 4032 [2] [3] (Class 4) | BS EN ISO 7091 (100HV) |
| **8.8** | BS 7419 | BS EN ISO 4032 [2] [3] (Class 8) | BS EN ISO 7091 (100HV) |

(1) Nuts of a higher property class may also be used.

(2) Nuts to the property classes of BS EN ISO 4032 with dimensions and tolerances to BS EN ISO 4034 may also be used.

(3) Nuts for galvanized or sherardized 4.6 bolts shall be class 8, and nuts for galvanized or sherardized 8.8 bolts shall be class 10.

**TABLE 2.7 CUP and COUNTERSUNK NON-PRELOADED ASSEMBLIES**

| Property Class | Bolt | Nut [1] | Washer |
|---|---|---|---|
| **4.6** | BS 4933 | BS EN ISO 4032 [2] [3] (Class 4) | BS EN ISO 7091 (100HV) |
| **8.8** | BS 4933 [2] | BS EN ISO 4032 [2] [3] (Class 8) | BS EN ISO 7091 (100HV) |

(1) Nuts of a higher property class may also be used.

(2) Nuts to the property classes of BS EN ISO 4032 with dimensions and tolerances to BS EN ISO 4034 may also be used.

(3) Dimensions to BS 4933 and property classes to BS EN ISO 898-1.

(4) Nuts for galvanized or sherardized 4.6 bolts shall be class 8, and nuts for galvanized or sherardized 8.8 bolts shall be class 10 to BS EN ISO 4032 or 4034.

## 2.5 SHEAR STUDS

Shear studs shall be in accordance with BS EN ISO 13918.

*Note: Shear studs should be treated as special fasteners to BS EN 1090-2 unless CE marked.*

## 2.6 PROTECTIVE TREATMENT MATERIALS

### 2.6.1 Metallic blast cleaning abrasives

Chilled iron grit shall be in accordance with BS EN ISO 11124-2, and cast steel grit shall be in accordance with BS EN ISO 11124-3.

### 2.6.2 Surface coatings

Paint materials and other coatings supplied shall be in accordance with the appropriate British Standard for the materials specified in the Project Specification (see Table 1.5).

*Note: For coatings for bolt assemblies see 2.4.8.*

### 2.6.3 Sherardized coatings

Sherardized coatings shall be in accordance with BS 7371-8.

### 2.6.4 Galvanizing materials

The composition of zinc in galvanizing baths shall be in accordance with BS EN ISO 1461 and, unless agreed otherwise, the following percentage weight limits:

- Tin (Sn) ≤ 0.1%;
- Lead (Pb) + 10*Bismuth (Bi) ≤ 1.5%.

*Note: These limits are to reduce the risk of occurrence of liquid metal assisted cracking. The galvanizer should measure and record the composition of the zinc in the bath.*

## 2.7 PROPRIETARY ITEMS

All proprietary items shall be used in accordance with the manufacturer's recommendations and instructions.

*Note: Proprietary items include threaded tie bars, connectors, couplers and turnbuckles.*

## 2.8 SUBSTITUTION OF MATERIAL OR FORM

Material quality or form of components may, with the agreement of the Engineer, be substituted if it can be demonstrated that the structural properties are not less suitable than the designed component and that compatibility with the intention of the design is maintained.

*Note: The availability of information on constituent products that have the required CE marking (see 2.1) facilitates the avoidance of unmonitored substitution with superficially similar products.*

# SECTION 3

# INFORMATION PROVIDED BY THE STEELWORK CONTRACTOR

## 3.1 INFORMATION SYSTEM

The information system used for manufacturing steelwork components may include drawings and calculations prepared manually or by computer modelling.

The system shall have means of identifying that the latest information provided by the Engineer is being used and that superseded information has been withdrawn.

The system shall be open to audit.

## 3.2 GENERAL ARRANGEMENT OF COMPONENTS

### 3.2.1 Marking system

Every component which is to be individually assembled or erected shall be allocated an erection mark.

Components which are identical in all respects may have the same erection mark.

### 3.2.2 General Arrangement drawings (Marking Plans)

Drawings shall be prepared by the Steelwork Contractor showing plans and elevations at a scale such that the erection marks for all components can be shown on them. Preferred scales are 1:100 or larger.

The drawings shall identify each component with respect to its component specification, its location relative to other components and the grid.

Details at an enlarged scale should also be made if these are necessary to show the assembly of components.

## 3.3 FOUNDATION AND WALL INTERFACE INFORMATION

Information showing holding down bolts and the interface of steelwork components to foundations shall include a Foundation Plan showing the base location, position and orientation of columns, the marks of all columns, any other components in direct contact with the foundations, their base location and level, and the datum level.

Similar information shall also be provided for components connecting to walls and other concrete surfaces (see Table 1.2A (xiii)).

Complete details of fixing steel and bolts to the foundations or walls, method of adjustment and packing space shall be provided.

## 3.4 FABRICATION INFORMATION FOR COMPONENTS

### 3.4.1 Fabrication shop drawings and fabrication data

Fabrication Shop Drawings or Fabrication Data used in the manufacturing system need only provide details and dimensions necessary for the manufacture of components. Such details shall be available to the Employer if so specified in the Project Specification or on request.

The system shall include all necessary information and technical requirements for the manufacture of each component together with full details of the date when component information is released for manufacture. The component specification shall specify the dimensions and quality of constituent products and the surface treatment. A reference system to connection types may be utilised.

### 3.4.2 Attachments to facilitate erection

Details of holes and fittings in components necessary for safety or to provide lifting and erection aids shall be included.

Unless specified otherwise by the Project Specification, such holes and fittings may remain on the permanent structure. Account shall be taken of 5.4.5 when detailing the welding of temporary attachments.

### 3.4.3 Welding

The component specification shall specify the requirements for edge preparations for welds.

*Note: This may be by reference to the typical edge preparations given in the BCSA's Typical Welding Procedure Specifications for Structural Steelwork.*

Welding inspection requirements which differ from those specified in 5.5 shall be clearly indicated.

### 3.4.4 Packs, clearances and camber

The Steelwork Contractor shall make provision for:

(i) Packs which may be necessary to ensure proper fit-up of joints (see 6.2.1 and 6.4.1);

(ii) The need for clearances between the fabricated components so that the permitted deviations in fabrication and erection are not exceeded, (see Sections 7 and 9);

(iii) The Engineer's requirements for pre-set or cambers, (see Table 1.2A (xvii)).

### 3.4.5 Hole sizes

Holes in components shall be shown to the following sizes

(i) For ordinary bolts and preloaded bolts:

not exceeding 14mm diameter – 1mm greater than the nominal bolt diameter;

from 16mm to 24mm diameter – 2mm greater than the nominal bolt diameter;

greater than 24mm diameter – 3mm greater than the nominal bolt diameter.

(ii) For holding down bolts:

6mm greater than the nominal bolt diameter, or with sufficient clearance to ensure that a bolt, whose adjustment may cause it to be out of perpendicular, can be accommodated through the base plate (see 9.1.3).

(iii) For fitted bolts:

in accordance with 6.1.9.

#### 3.4.6 Holding down bolt cover plates

Holding down bolt details shall include provision of loose cover plates or washers with hole diameter 3mm greater than the holding down bolts.

#### 3.4.7 Connections to allow movement

If the connection is designed to allow movement, the bolt assembly used shall remain secure without impeding the movement.

#### 3.4.8 Machining note

Any machining requirements shall be clearly indicated.

#### 3.4.9 Drilling note

The component information shall indicate those locations where holes are to be drilled but not punched or formed in another way (see also 4.6.4).

#### 3.4.10 Faying surfaces for friction grip connections

Faying surfaces which are to receive special treatment shall be identified in the production information system.

### 3.5 ERECTION INFORMATION

#### 3.5.1 Erection drawings

The Steelwork Contractor shall prepare Erection Drawings to amplify the information given in the erection method statement (see 8.1.1).

#### 3.5.2 Temporary steelwork drawings

Details and arrangements of temporary steelwork necessary for erection purposes shall be shown with the erection information (see 8.4.1).

### 3.6 DRAWING OR INFORMATION REVIEW

#### 3.6.1 Submission to the Engineer

Drawings or electronic data described in 3.6.2 shall be submitted for review by the Engineer in accordance with the Programme (see Table 1.7(ii)).

*Note: The programme should allow for a review of the computer model to be made in advance of the review of any calculations and any associated sketches and drawings.*

### 3.6.2 Extent of submissions

Unless stated otherwise in the Project Specification the following drawings, and connection calculations shall be submitted (see Tables 1.2A(vii), 1.2B(vi), 1.2C(vi)):

(i) General Arrangement Drawings as defined in section 3.2.2.

The Steelwork Contractor shall mark references on the General Arrangement drawings or provide another suitable system such that a connection calculation or standard simple connection can be identified to a specific location on the structure.

(ii) Connection Design Calculations except for those where industry standard simple connections are used.

Calculations shall include sketches or drawings showing the arrangement of the connection and shall be referenced to a location on the structure. If necessary drawings showing complex geometry shall also be submitted.

*Note: If industry standard connections are used, only a reference to the standard connection need be submitted.*

### 3.6.3 Acceptance of General Arrangement drawings and connection design calculations

The review and acceptance by the Engineer means:

(i) the principal levels, dimensions and typical details shown on the General Arrangement Drawings are a correct interpretation of design requirements.

(ii) the principle adopted for the Connection Design calculations are compatible with the design.

Acceptance does not relieve the Steelwork Contractor of the responsibility for accuracy of the calculations, detail dimensions on the drawings, nor the general fit-up of parts to be assembled on site

### 3.6.4 Acceptance classification

The following designations may be used by the Engineer when reviewing drawings or other information submitted in accordance with the Programme:

| Classification | | Meaning |
|---|---|---|
| **A** | "Accepted" | Information submitted may be released for construction. |
| **B** | "Accepted subject to comments" | Information submitted must be amended in line with the comments, but need not be re-submitted. |
| **C** | "Not Accepted" | Information must be amended in the way indicated and re-submitted for acceptance. |

### 3.6.5 Acceptance without comment

If the Steelwork Contractor submits information in accordance with the Programme but receives no comments, or other instruction concerning the submission, within the period given in the Project Specification, the information may be released for manufacturing after notifying the Engineer.

## 3.7 "AS ERECTED" STRUCTURE

On completion of the contract the Steelwork Contractor shall provide the Employer with either:

(i) One set of paper prints of "As Erected" drawings comprising:

General Arrangement Drawings

Fabrication Drawings

Connection calculations or references to standard connections

Drawings made after fabrication showing revisions

The drawing register.

or:

(ii) If it is agreed with the Employer, electronic information equivalent to that shown in (i).

# SECTION 4

# WORKMANSHIP - GENERAL

## 4.1 IDENTIFICATION

### 4.1.1 Traceability of steel products

All constituent steel products to be used in the Works shall have a reference to a suitable certificate of conformity so that the properties are known and can be verified (see 2.4). Unless required by the Project Specification individual pieces do not need to be traceable to a particular inspection document.

*Note: This is "type" as opposed to "unique" traceability.*

### 4.1.2 Material grade identification

The material grade and other relevant properties shall be identifiable within the manufacturing system.

### 4.1.3 Marking steelwork

Individual pieces shall be capable of positive identification at all stages of fabrication.

Completed components shall be marked with a durable and distinguishing erection mark in such a way as not to damage the material. Hard stamping may be used for steel grades up to and including S355, except where otherwise specified in the Project Specification.

Where areas of steelwork are indicated on the drawings, or fabrication information, as being unmarked, they shall be left free of all markings and hard stamping.

## 4.2 HANDLING

Steelwork shall be bundled, packed, handled and transported in a safe manner so that permanent distortion does not occur and surface damage is minimised. Particular care shall be taken to stiffen free ends and adequately protect any machined surfaces.

## 4.3 CUTTING AND SHAPING

### 4.3.1 Cutting operations

Cutting and shaping of steel may be carried out by sawing, shearing, cropping, thermal cutting, nibbling, planing or machining. Hand-held cutting shall only be used if it is impractical to use machine thermal cutting.

Any areas where thermal cutting is not permitted shall be so indicated in the Project Specification (see Table 1.2A (viii)).

*Note: Thermal cutting refers to plasma cutting, laser cutting or flame cutting.*

#### 4.3.2 Thermally-cut edges

Provided that the capability of the thermal cutting process used has been checked according to BS EN 1090-2 for the quality and hardness of the cut surfaces that the process produces, thermally-cut edges which are free from significant irregularities shall be accepted without further treatment except for the removal of dross; otherwise cut edges that are not to be melted during subsequent welding shall be dressed to remove irregularities and hardened surface material.

Thermally-cut re-entrant corners and notches (e.g. copes) shall be rounded off with a minimum radius of 5mm. Prior to galvanizing these locations shall be specifically inspected to verify conformity.

#### 4.3.3 Columns and compression members

Columns and compression members with ends not in direct bearing or intended to be erected on packs shall be fabricated to the accuracy given in 7.2.2.

Columns and compression members intended to be in direct bearing shall be fabricated to the accuracy given in 7.2.3.

The butting surfaces of column sections which are one metre and over in width or depth and are to be in direct bearing shall be specially prepared so that after erection both the deviation in plumb in 9.6.4.1 and 9.6.4.2 and the permitted gap in 9.6.5 are not exceeded.

### 4.4 MACHINING

#### 4.4.1 Thickness of machined parts

The thickness of elements shown on the drawings as requiring machining shall mean the minimum thickness after the machining operations.

### 4.5 DRESSING

#### 4.5.1 Removal of burrs

Cut edges shall be dressed to remove dross, burrs, and irregularities. Holes shall be dressed as required to remove burrs and protruding edges.

#### 4.5.2 Dressing of edges

Sharp edges shall be dressed, but a 90° rolled, cut, sheared or machined edge is acceptable without further treatment.

### 4.6 HOLING

#### 4.6.1 Holes

Round holes for fasteners or pins shall be drilled, punched or plasma cut (see 4.6.5).

*Note: The Project Specification should indicate any areas on components where due to design requirements thermal cutting or full size hole punching is not permitted (see Table 1.2A (viii)).*

The capability of holing processes shall be checked periodically in accordance with BS EN 1090-2.

*Note: Specific requirements for quality of cut surfaces, hardness of free edge surfaces and tolerances on diameter, taper and burring of holes are given in BS EN 1090-2. It is recommended that the checking of process equipment capability is undertaken in liaison with the equipment manufacturer or supplier.*

### 4.6.2 Matching

All matching holes for fasteners or pins shall register with each other so that fasteners can be inserted freely through the assembled components in a direction at right angles to the faces in contact. Drifts may be used but holes shall not be distorted.

### 4.6.3 Drilling through more than one thickness

If the separate parts are tightly clamped together drilling shall be permitted through more than one thickness. The parts shall be separated after drilling and any burrs removed.

### 4.6.4 Punching full size

Provided that the capability of the punching process used has been checked according to BS EN 1090-2, full size punching of holes shall be permitted unless otherwise specified in the Project Specification.

Any areas on components where holes are not to be punched full size shall be indicated in the Project Specification (see Table 1.2A (viii)).

### 4.6.5 Punching and reaming

In areas indicated in the Project Specification where holes are not to be punched full size punching is permitted provided that the holes are punched at least 2mm less in diameter than the required size and the hole is reamed to the full diameter after assembly.

### 4.6.6 Slotted holes

Slotted holes shall be punched, thermally cut or formed by drilling two holes and completed by cutting.

## 4.7 ASSEMBLY

Connected components shall be drawn together such that they achieve firm contact consistent with the requirements for fit-up or direct bearing (see 4.3.3, 5.4.1, 6.2.1 and 6.4.1).

Drifting of holes to align the components shall be permitted, but must not cause damage or distortion to the final assembly (see 6.2.2).

## 4.8 CURVING AND STRAIGHTENING

Curving or straightening components during fabrication, shall be performed by one of the following methods:

(i) mechanical means, taking care to minimise indentations, or change of cross-section;

(ii) the local application of heat, ensuring that the temperature of the metal is carefully controlled, and does not exceed 650°C;

(iii) the induction bending process if the procedure used includes careful temperature control and the procedure is validated beforehand in terms of its ability to retain suitable properties for the as-bent material.

The following restrictions shall be observed:

(i) for steel grades up to and including S355 bending in the heat range 250°C to 380°C is not permitted;

(ii) for steel grade S420 to BS EN 10025-3 the hot forming process shall take place in the temperature range 960°C to 750°C with subsequent cooling at air temperature;

(iii) hot forming is not permitted for steels to BS EN 10025-4;

(iv) shaping by cold forming, produced either by roll forming, pressing or folding shall conform to the requirements for cold formability given in the relevant product standard;

(v) hammering shall not be used.

*Note: BS EN 1090-2 and the BCSA Guide to the Use of Heat Straightening to Repair Impact Damaged Bridges (in preparation) include more detailed recommendations on shaping of components.*

After curving or straightening, welds within the area of curving or straightening shall be visually inspected. Welds which are to be subject to non-destructive testing shall have these tests carried out after curving or straightening.

## 4.9 INSPECTION

Sufficient components shall be checked for dimensional accuracy and conformity to drawing, to prove that the manufacturing process is working satisfactorily.

## 4.10 STORAGE

### 4.10.1 Stacking

Fabricated components which are stored prior to being transported or erected shall be safely stacked clear of the ground and arranged if possible so that water cannot accumulate. They shall be kept clean and supported in such a manner as to avoid permanent distortion.

### 4.10.2 Visible markings

Individual components shall be stacked and marked in such a way as to ensure that they can be identified.

# SECTION 5

# WORKMANSHIP - WELDING

## 5.1 GENERAL

Welding shall be a metal arc process in accordance with BS EN 1011-1, the guidance given in BS EN 1011-2 as appropriate, together with other clauses contained in this section.

The Steelwork Contractor's system for the management of welding shall meet the standard quality requirements described in BS EN ISO 3834-3 (see 11.1).

All welding documentation (welder qualifications, welding procedure qualification records, welding procedure qualifications and associated work instructions) shall be reviewed for applicability by the person responsible for welding coordination. If requested, the documentation shall be made available to the Inspection Authority if appointed.

The Steelwork Contractor shall ensure that constituent product materials to be welded are compatible with the welding procedure being used.

Joints shall be prepared in accordance with BS EN ISO 9692-1 and -2. Precautions shall be taken to ensure cleanliness of the connection prior to welding.

## 5.2 WELDER QUALIFICATION

### 5.2.1 Testing

Welders and welding operators shall be tested to meet the requirements of BS EN 287 or BS EN 1418 as appropriate.

### 5.2.2 Certification

Testing of welders and welding operators shall be witnessed and certificates endorsed by a competent Examiner or Examining Body.

The certification shall remain valid providing it complies with the conditions for re-approval of certification specified in BS EN 287-1.

## 5.3 WELDING PROCEDURES

### 5.3.1 Preparation of Welding Procedure Specifications

Written welding procedure specifications (WPSs) shall be available in accordance with BS EN ISO 15609-1. In general each WPS shall be qualified by testing in accordance with BS EN ISO 15614-1, BS EN 15613 or BS EN ISO 14555 for stud welding. WPSs shall comply with the guidance of BS EN 1011-2 Annex C, Method A to avoid hydrogen cracking, and Annex D to provide adequate toughness in the heat affected zone.

*Note: Although, for restricted ranges of steel grades and welding processes, BS EN 1090-2 permits the use of standard welding procedures (qualified according to BS EN ISO 15612), previous welding experience (qualified according to BS EN ISO*

*15611) and tested welding consumables (qualified according to BS EN 15610), each manufacturer needs separately to qualify the WPSs used. To facilitate this, a suite of suitable model preliminary WPSs is published by the BCSA as Typical Welding Procedure Specifications for Structural Steelwork.*

If welding is to be undertaken on coated steel, the WPQR shall be qualified on the maximum nominal thickness of coating.

If specified in the Project Specification, WPSs for fillet welds shall be supported by a WPQR that includes a cruciform tensile test to BS EN ISO 9018.

*Note: This requirement may only be applied to qualification of procedures for fillet welds of leg length not above 12mm joining S355 material with thickness not above 17mm.*

### 5.3.2 Approval of procedures and procedure tests

Welding procedure qualification records (WPQRs) in accordance with BS EN ISO 15614-1 or BS EN 15613 shall have been verified by the Examiner or Examining Body.

### 5.3.3 Use of Welding Procedure Specifications (WPSs)

Appropriate work instructions shall be produced from the WPQRs. The work instructions shall be either WPSs or contain all information required within a WPS in other formats suitable to the Steelwork Contractor's system. They shall be provided for the welder prior to the commencement of the Works and shall be suitable for the joint configuration and material to be welded. These work instructions shall be made available to the Employer, Engineer or Inspection Authority on request.

*Note: The suitability of work instructions for the material to be welded includes consideration of the carbon equivalent of the actual material if this differs from the nominal value specified in the material product standard.*

## 5.4 ASSEMBLY

### 5.4.1 Fit-up

Joints shall be fitted up to the dimensional accuracy required by the welding procedure, depending on the process to be used, to ensure that the quality in Table C.1 and C.2 in Annex C of this Specification is achieved.

### 5.4.2 Jigs

Fabrications assembled in jigs may be completely welded in the jig, or may be removed from the jig after tack welding.

### 5.4.3 Tack welds

Tacks may be used provided:

(i) they are laid in an area to be welded and are thoroughly removed by grinding or gouging such that subsequent welding is unaffected;

(ii) they are undertaken by a welder qualified as in 5.2 as short length normal welds at least four times the thickness of the thicker part being joined and at least 50mm long, and the procedure for welding complies with 5.3;

(iii) they are undertaken by a welder qualified as in 5.2 to a welding procedure that complies with 5.3 and that demonstrates that the tack is fully re-melted during subsequent welding; or

(iv) they are located away from zones where subsequent welding is to take place and in a zone where only compressive forces are present in service.

*Note: Use of (iv) would be possible to secure column slab bases for transit.*

#### 5.4.4 Distortion control

The sequence of welding a joint or a sequence of joints shall be such that distortion is minimised (see Section 7).

#### 5.4.5 Fabrication or erection attachments

Welding of attachments required for fabrication or erection purposes shall be made in accordance with the requirements for a permanent weld.

If removal is necessary, they shall be flame cut or gouged at a point not less than 3 mm from the surface of the parent material. The residual material shall be ground flush and the affected area visually inspected. If parent metal thickness is greater than 20 mm it shall also be checked by penetrant or magnetic particle testing. Acceptance criteria are as set out in Table C.1 and C.2 in Annex C. Attachments shall not be removed by hammering (see 3.4.2).

#### 5.4.6 Extension pieces

If the profile of a weld is maintained to the free end of a run by the use of extension pieces they shall be of material of a similar composition, but not necessarily the same grade, as the component. They shall be arranged so as to provide continuity of preparation and shall be removed after completion of the weld and the end surface of the weld ground smooth.

#### 5.4.7 Production test plates

If production test plates are required for testing purposes (see 1.3(iv)), they shall be clamped in line with the joint. The grade of material, carbon equivalent, and rolling direction shall match the parent plate, but need not be cut from the same plates or cast.

### 5.5 TESTING OF WELDS

#### 5.5.1 Routine testing

Provided that it has been established that WPSs in use can produce conforming quality when implemented in production according to 5.5.2, ongoing control of welding quality shall be maintained by routine testing.

Routine testing includes 100% visual inspection to 5.5.3 and a supplementary programme of non-destructive testing (NDT) which shall be undertaken by the Steelwork Contractor to ensure that the welding processes and welders / welding operators are producing work of a quality that is consistent with Execution Class 2. The benchmark for the quality of work required for Execution Class 2 is generally quality level C to BS EN ISO 5817 with the following exceptions:

Incorrect toe (505) – not applicable;

Micro lack of fusion (401) – not applicable;

Undercut (5011, 5012) – quality level D permitted;

Overlap (506) – quality level D permitted;

Stray arc (601) – quality level D permitted;

End crater pipe (2025) – quality level D permitted.

Based on BS EN 12062, the supplementary programme of NDT shall be in accordance with Table B in Annex B.

The joints for routine supplementary NDT shall be selected to ensure that sampling covers the following variables as widely as possible:

(i) the joint type (single pass fillet, multi-pass fillet, PPBW, FPBW);

(ii) the constituent steel material grade;

(iii) the welding equipment;

(iv) the work of the welders; and

(v) the location of the work in the shop or on site.

If routine or project specific testing (see 5.5.7) within an inspection length discovers imperfections that exceed the acceptance criteria given in Tables C.1 and C.2 in Annex C, these shall be repaired or referred to the RWC as appropriate and further supplementary NDT shall be undertaken over two inspection lengths, one on each side of the length containing the imperfections. If further non-conforming imperfections are found an investigation shall be carried out to find the reason.

*Note: Further guidance is available in the BCSA Guide to Weld Inspection (in preparation).*

Records of the most recent three months of routine testing applicable to each WPS shall be maintained and made available on request to the Employer, the Engineer and the Inspection Authority if appointed.

If a workshop is only producing work where no supplementary NDT is required according to Table B, then a monthly programme of further NDT shall be instituted by the person responsible for welding coordination such that a representative sample of each month's output is subjected to appropriate NDT.

### 5.5.2 Initial type testing

Initial type testing includes 100% visual inspection to 5.5.3 and supplementary NDT which shall be undertaken by the Steelwork Contractor to establish that a WPS can produce conforming quality when implemented in production.

Initial type testing includes the process of qualifying a WPS and testing its initial introduction into production based on the first five joints made in production conditions to the same new WPS as follows:

(i) if the WPS is sometimes to be used on site, the production conditions shall include at least two joints welded on site, or all five joints welded on site if the WPS is only to be used on site;

(ii) the extent of testing shall be double the amount given in Table B;

(iii) the minimum length to be tested is 900mm;

(iv) the methods used for supplementary NDT shall be as Table B;

(v) the welds shall meet the acceptance criteria of quality level B in BS EN ISO 5817.

If initial type testing gives non-conforming results, investigation shall be carried out in order to find the reason and a further set of five joints shall be tested. The guidance in Annex C of BS EN 12062 should be followed.

Records of the initial type testing applicable to each WPS shall be maintained and made available on request to the Employer, the Engineer and the Inspection Authority if appointed.

### 5.5.3 Visual inspection of welds

100% visual inspection shall be carried out before welding, during welding and on completion to determine the production quality is being maintained. Visual inspection shall be carried out in accordance with the guidelines given in Annex D. Additional visual inspection shall be carried out as audit checking.

Any welds which will be rendered inaccessible by subsequent work shall be examined prior to the loss of access.

A suitably qualified person for visual inspection of welds may be a welding inspector or a welder who can provide evidence of having been trained and assessed for competence in visual inspection of the relevant types of welds during and after welding. Additional visual inspection as audit checking shall be carried out by an NDT technician qualified to the requirements of BS EN 473.

*Note: The initial 100% visual inspection is often undertaken by the welder and is aimed at verifying that the weld has been completed satisfactorily to allow the welder to progress. Defects visible at this stage can often be repaired immediately by the welder (see Table C.1 in Annex C). The need for additional visual inspection is often the prelude to deciding whether to investigate further using supplementary NDT (see 5.5.5).*

### 5.5.4 Hold times before final NDT

If there is a risk of delayed cracking, a period may be needed before the final inspection is made of as-welded fabrications. Recommended minimum hold times are given in Table A of Annex A.

Whatever hold time period is used shall be stated in the inspection records.

If it can be demonstrated by the Steelwork Contractor through records that delayed hydrogen cracking is not a risk, hold times may be reduced or waived at the discretion of the Steelwork Contractor's responsible welding coordinator.

*Note: Notwithstanding the use of waivers or hold times, whether in accordance with Annex A or otherwise, Annex C requires that all identified cracks shall be repaired.*

### 5.5.5 Surface flaw detection

If examination of a weld surface is required magnetic particle testing shall be used in accordance with the recommendations given in BS EN ISO 17638 and this shall be preceded by visual inspection to BS EN 970 undertaken by the NDT technician.

If magnetic particle testing is impractical, penetrant testing may be used in accordance with the recommendations given in BS EN 571-1.

Final surface flaw detection of a welded joint shall be carried out after completion of the weld in accordance with the hold times given in Table A in Annex A.

*Note: If a welding procedure requires an inspection after initial weld runs before further welding is performed, such inspections may be carried out when the weld*

*metal has cooled to ambient temperature.*

Operators carrying out final surface flaw detection of the weld shall hold a current certificate of competence to Level 2 according to BS EN 473 in surface flaw detection of the relevant types of work, from a recognised authority (PCN, CSWIP or equivalent).

### 5.5.6 Ultrasonic testing

If ultrasonic testing is required, it shall be made in accordance with BS EN 1714 using reference level to Method 1, evaluation reference level -14dB (20% DAC) and testing level B unless determined otherwise by the Steelwork Contractor's responsible welding coordinator.

Ultrasonic testing of a welded joint shall be carried out after completion of the weld in accordance with the hold times given in Table A in Annex A.

*Note: In addition to weld testing through-thickness ultrasonic testing of the parent material may also be necessary for weld geometries susceptible to lamellar tearing.*

Operators carrying out final ultrasonic testing of the weld shall hold a current certificate of competence to Level 2 according to BS EN 473 from a recognised authority (PCN, CSWIP or equivalent).

### 5.5.7 Project-specific testing

The Project Specification may identify specific joints for supplementary NDT together with the extent and method of testing. This testing may be counted within the extent of routine testing.

*Note: PD 6705-2 may be used as a reference for identifying critical welds for project-specific inspection. The scope of PD 6705-2 includes dynamically loaded structures but the acceptance criteria shown in Tables C.1 and C.2 in Annex C are not intended to apply to bridges, offshore structures, or other dynamically loaded structures.*

## 5.6 SHEAR STUD WELDING

### 5.6.1 Method

Shear studs shall be welded using a WPS qualified by welding procedure tests in accordance with the requirements of BS EN ISO 14555 and welders qualified in accordance with the requirements of BS EN 1418. If permitted by the Project Specification, the WPS may be based on previous welding experience in accordance with the manufacturer's recommendations for materials, procedures and equipment.

### 5.6.2 Production test welding

Before commencing welding of studs in production, a production weld test piece shall be carried out. This shall comprise at least 10 studs. The production weld test piece shall be inspected for acceptability using 100% visual examination and the bending of 5 studs through 60°. Additionally, if specified in the Project Specification, a macro examination shall be undertaken on two different studs (see Table 1.3 (ii)).

At the start of each shift, when stud welding is in progress, each welder shall perform a simplified production test. Using the first three studs in production, each stud shall

be visually examined, ring tested and bend tested in accordance with the test and inspection requirements given in 5.6.3. If any of the three studs fails, a further two studs shall be welded and tested. If one of these additional studs does not satisfy requirements, corrective action shall be taken and the production weld test piece repeated.

### 5.6.3 Tests and inspection

All studs are to be visually inspected and ring tested. Studs shall be replaced if they show less than a full 360° collar of weld or if they do not give a clear ring when struck by a metal club hammer.

After satisfactory visual inspection and ring testing, bend tests shall be made at locations determined by the Steelwork Contractor's responsible welding coordinator. A minimum of 5% of the studs, but not less than two studs per beam shall be tested by bending the head of the stud towards the nearer end of the beam. The bend test shall be made by means of a steel tube placed over the stud and bending the head until it is displaced laterally a distance of one quarter of the height of the stud (approximately 15º). In addition, the studs immediately adjacent to any stud found to be defective shall be subjected to bend testing.

The stud weld shall not show any signs of cracking or lack of fusion.

Studs subjected to the bend test shall not be straightened.

### 5.6.4 Defective studs

Studs with defective welding or that have failed the bend test shall be replaced with a new stud in an adjacent location. The replacement stud shall be inspected, ring tested and tested as in 5.6.3 by bending it towards the defective stud.

# SECTION 6

# WORKMANSHIP - BOLTING

## 6.1 ORDINARY BOLTED ASSEMBLIES

### 6.1.1 Hexagon bolt/nut combinations for ordinary (non-preloaded) assemblies

The combinations of bolts and nuts which may be used are as tabulated in Table 2.4 of Section 2.

Any bolt assemblies which seize when being tightened shall be replaced.

### 6.1.2 Cup and countersunk head bolt/nut assemblies

The combinations of bolts and nuts which may be used are as tabulated in Table 2.7 of Section 2.

### 6.1.3 Differing bolt property classes

Different bolt property classes of the same diameter shall not be used in the same structure, except if agreed otherwise by the Engineer.

### 6.1.4 Bolt length

The bolt length shall be chosen such that, after tightening, at least one thread plus the thread run-out will be clear between the nut and the unthreaded shank of the bolt and the length of protrusion shall be at least the length of one thread pitch measured from the outer face of the nut to the end of the bolt.

*Note: Due to the thread run-out permitted by the bolt product standards, this does not mean that a full thread form will necessarily be shown beyond the nut.*

### 6.1.5 Washers

Generally washers are not required for bolts in normal round holes. To achieve the full bearing capacity when connecting thin-gauge sections of 4mm or less to each other, washers shall be used under both the bolt head and the nut.

*Note: This requirement does not apply when connecting thin-gauge sections to another steel component that is not thin-gauge.*

If the components being connected have a finished surface protective treatment which may be damaged by the nut or bolt head being rotated, a washer shall be placed under the rotating part.

A suitable plate or heavy duty washer shall be used under the head and/or nut against plies that have oversize or slotted holes. Plate washers shall not be thinner than 4mm.

From one to three additional plate washers with a maximum combined thickness of 12mm may be used in order to adjust the grip length of bolt assemblies. For preloaded bolt assemblies tightened by the torque control method (including

system HRC) only a single additional washer may be used on the side that is turned, alternatively additional washers may be placed on the side that is not turned. Otherwise in preloaded and non-preloaded applications, the washers may be placed either on the side that is turned or on the side that is not turned.

#### 6.1.6 Taper washers

If the bolt head or nut is in contact with a surface which is inclined at more than 2° from a plane at right angles to the bolt axis, a taper washer shall be placed to achieve satisfactory bearing.

#### 6.1.7 Galvanized nuts

Nut blanks shall be tapped after being galvanized, galvanizing and re-tapping of nuts is not permitted.

#### 6.1.8 Bolt tightening

Bolts may be assembled using power tools or shall be fully tightened by hand using appropriate spanners in accordance with BS 2583.

#### 6.1.9 Fitted bolts

Precision bolts to BS EN ISO 4014 may be used as fitted bolts if holes are drilled or reamed after assembly so that the clearance in the hole is not more than 0.3mm.

### 6.2 FIT-UP IF USING NON-PRELOADED BOLT ASSEMBLIES

#### 6.2.1 Fit-up

Connected parts shall be firmly drawn together. If there is an unacceptable residual gap it shall be taken apart and a pack of not less than 2mm thickness inserted. Residual gaps are unacceptable in general if they exceed 2mm, but in connecting parts thicker than 8mm residual gaps of up to 4mm may be left at the edges provided that contact bearing is achieved at the central part of the connection unless otherwise specified in the Project Specification.

If plies of differing nominal thickness are being joined, no more than three packing plates shall be used.

#### 6.2.2 Reaming

If parts cannot be brought together by drifting without distorting the steelwork, rectification may be made by reaming, provided the design of the connection will allow the use of larger diameter holes and bolts.

### 6.3 PRELOADED BOLT ASSEMBLIES

#### 6.3.1 Bolt/nut/washer combinations

The combination of bolt and nut and washers may be used as specified in Table 2.5 of Section 2.

Washers shall be used under both the nut and the bolt head except that for 8.8 bolts only a single washer is necessary under the part to be rotated. If the bolt head or

nut is in contact with a surface which is inclined at more than 2° from a plane at right angles to the bolt axis, a taper washer to BS 4395 shall be placed to achieve satisfactory bearing. Plain washers to BS EN 14399-5 may only be used under the nut; otherwise plain chamfered washers to BS EN 14399-6 shall be used. The chamfer shall be placed towards the bolt head when fitted under the bolt head and towards the nut when fitted under the nut.

If permitted by the Project Specification, assemblies to BS EN 14399-10 (system HRC) may be used without a washer under the bolt head provided that the manufacturer's certificate of conformity confirms that this configuration has been used for the specified suitability tests.

Bolt lengths shall be selected such that a minimum of four complete lengths plus the thread run-out shall be between the end of the unthreaded shank of the bolt and the loaded face of the nut and the length of protrusion shall be at least the length of one thread pitch measured from the outer face of the nut to the end of the bolt.

*Note: Additional washers may be necessary to achieve these requirements (see 6.1.5). Due to the thread run-out permitted by the bolt product standards, this does not mean that a full thread form will necessarily be show beyond the nut.*

### 6.3.2 Tightening

The use of preloaded fasteners in friction grip applications shall comply with BS EN 1090-2.

Tightening which complies with BS EN 1090-2 and the relevant product standards may be by any of the torque control, combined, direct tension indicator (DTI), or HRC tightening methods.

The combined method specified in BS EN 1090-2 may be modified to be implemented with a lower initial torque and a larger subsequent part-turn provided that the values are calibrated in accordance with Annex H of BS EN 1090-2. Provided that the total nominal thickness of the parts to be connected (including all packs and washers) does not exceed 160mm, the values in Table 6.1 may be used for fastener assemblies using bolts to BS EN 14399-3 property class 8.8 and *k*-classes K0, K1 or K2 to BS EN 14399-1.

**TABLE 6.1: MODIFIED COMBINED METHOD**

| Bolt size | Torque for first tightening step (1) | Part-turn for final tightening step |
|---|---|---|
| **M24** | 270 Nm | 180 degrees, or |
| **M30** | 460 Nm | 1/2 turn |
| (1) Accuracy ±10% | | |

### 6.3.3 Inspection during and after tightening

Unless otherwise stated in the Project Specification, inspection shall comply with the requirements specified in BS EN 1090-2 for Execution Class 2. Unless prohibited by the Project Specification, the tightening of direct tension indicators to apparent full compression in more than 10% of cases shall not be a cause for rejection provided that the manufacturer's certificate of conformity confirms that this is acceptable in terms of the specified suitability tests.

### 6.3.4 Discarded bolt assemblies

If, after complete tightening, a bolt or nut has to be slackened off, the whole bolt assembly is to be scrapped.

## 6.4 FIT-UP IF USING PRELOADED BOLT ASSEMBLIES

### 6.4.1 Fit-up

Connected parts intended to transfer force in friction shall be firmly drawn together with all bolts partially tightened. The joint shall then be examined and if there is any residual gap that exceeds 1mm it shall be taken apart and a pack of not less than 2mm thickness inserted before recommencing the tightening procedure.

If plies of differing nominal thickness are being joined, no more than three packing plates shall be used.

### 6.4.2 Reaming

If parts cannot be brought together by drifting without distorting the steelwork, rectification can be made by reaming, provided that the design of the connection will allow the use of larger diameter bolts.

Calculations shall be made to demonstrate that the connection remains adequate for the forces in the connection.

# SECTION 7

# WORKMANSHIP - ACCURACY OF FABRICATION

## 7.1 GENERAL

Permitted deviations for manufacture of structural components are classified as essential tolerances or functional tolerances. Essential tolerances are indicated below with an "E" and components are warranted by the Steelwork Contractor as conforming to the requirements specified below the component is CE marked.

The permitted deviations given do not include elastic deformations induced by the self-weight of the components. The deviations shall be measured with respect to any specified camber or preset.

Methods and instruments used for dimensional measurement shall be selected, as appropriate, from those listed in ISO 7976-1 and -2 (BS 7307-1 and -2). Accuracy shall be assessed in accordance with the relevant part of ISO 17123.

*Note: ISO 17123 is not issued as a BS but it supersedes ISO 8322 which was issued as BS 7334.*

Constituent products used in the manufacture of structural components shall conform to the relevant product standard. These permitted deviations continue to apply to components manufactured from such products, unless superseded by more stringent criteria specified below.

Dimensional measurements of components shall always be taken. The location and frequency of measurements shall be specified in the plan for factory production control.

For press braked cold formed profiles refer to BS EN 1090-2 D.1.2 and D.2.2.

For stiffened plating refer to BS EN 1090-2 D.1.6 and D.2.11.

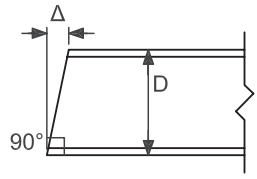
## 7.2 PERMITTED DEVIATIONS FOR ROLLED COMPONENTS AFTER FABRICATION (Δ) (Including structural hollow sections)

### 7.2.1 Cross section after fabrication

In accordance with the appropriate tolerances standard given in Table 2.1

### 7.2.2 Squareness of ends not prepared for bearing

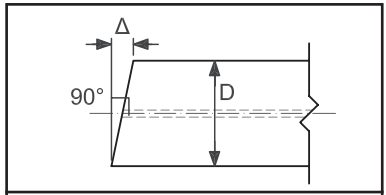
Plan or elevation of end.
*Note: See also 4.3.3.*
Δ = D/100



### 7.2.3 Squareness of ends prepared for bearing

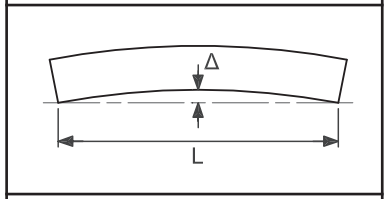
Ends prepared with respect to the longitudinal axis of the member. Plan or elevation of end. *Note: See also 4.3.3.*

Δ = D/1000




### 7.2.4 Straightness on both axes

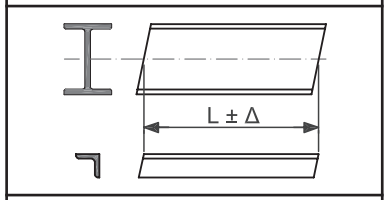
Δ = L/750.




### 7.2.5 Length

Length (L) after cutting, measured on the centre line of the section or on the corner of angles.

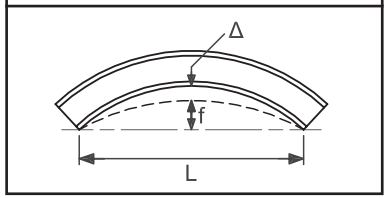
Δ = 2mm in general or 1mm if ends prepared for full contact bearing




### 7.2.6 Curve or camber

Deviation (Δ) from intended curve or camber (f) at middle of length (L) of curved portion when measured with web horizontal.

Δ = L/500 or 6mm whichever is greater.



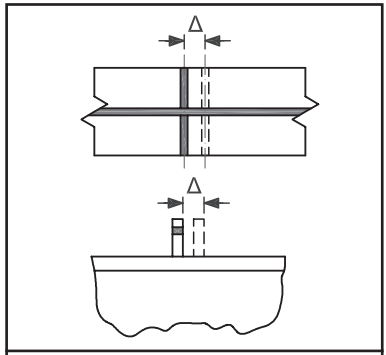

## 7.3 PERMITTED DEVIATIONS FOR ELEMENTS OF FABRICATED COMPONENTS (Δ)

### 7.3.1.1 Position of fittings E

Deviation (Δ) from the intended position, generally, relative to the setting-out point on the primary component.

Δ = 3mm.

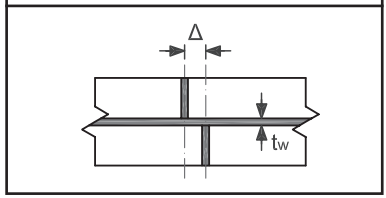
Fittings and attachments whose location is not critical to the force path (including non-bearing stiffeners): Δ = 5mm




### 7.3.1.2 Position of stiffeners E

Misalignment (Δ) between a pair of bearing stiffeners fixed to a web of thickness (tw).

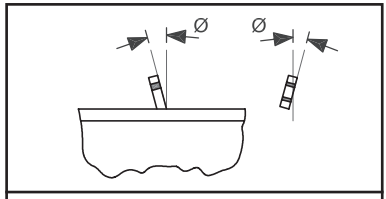
Δ = tw/2 generally but restricted to tw/3 at support positions.



**7.3.2 Alignment of fittings**

Angular deviation Φ relative to intended local orientation (assumed square in figure).

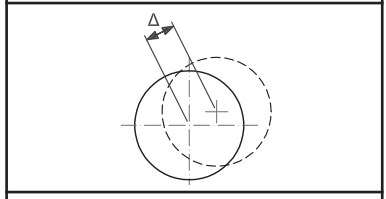
Φ = 1 in 60




**7.3.3 Position of holes E**

Deviation (Δ) from the intended position of an individual hole within a group of holes.

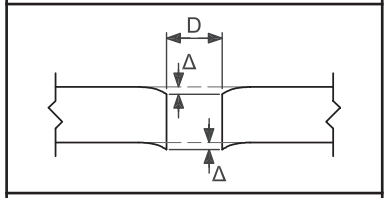
Δ = 2mm




**7.3.4 Punched holes**

Distortion caused by a punched hole shall not exceed Δ (see 4.6.4).

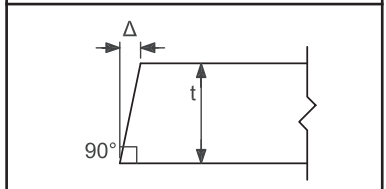
Δ = D/10 or 1mm whichever is greater.




**7.3.5 Sheared or cropped edges of plates or angles**

Deviation (Δ) from a 90° edge.

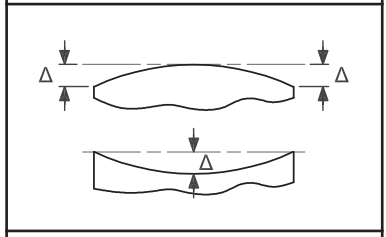
Δ = t/10 up to a maximum of 3mm.




**7.3.6 Flatness**

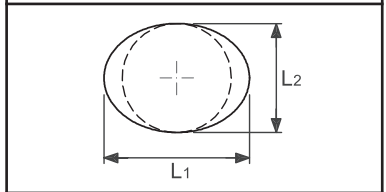
Maximum gap (Δ) between the surface and a straight edge laid in any direction for surfaces specified for full contact bearing in the Project Specification.

Generally Δ = 0.5mm with local high spots not be proud by more than 0.5mm.




**7.3.7 Ovalisation of holes**

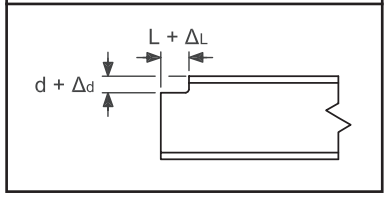
Δ = L1 – L2 = 1mm.




**7.3.8 Notches**

Δ = – 0mm / +3mm on depth (d) or length (L).

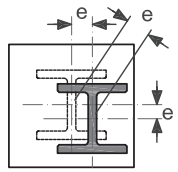
Note: See also 4.3.2.



**7.3.9 Baseplates**

Non-intended eccentricity (e) in either direction

Δ = 5mm.

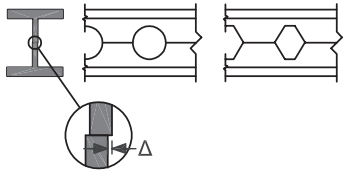



**7.3.10 Castellated and cellular beams**

Fabricated either from plate or from hot rolled sections with openings of inscribed nominal diameter D.

Misalignment of web post across thickness (as shown): Δ = 2mm.

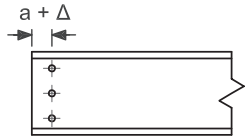
Misalignment of web post by overlap = D/200 or 2mm whichever is greater.




**7.3.11 Position of holes for fasteners E**

Deviation (Δ) in distance (a) between an individual hole and a cut end.

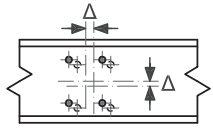
Δ = – 0mm / +2mm.




**7.3.12 Position of hole group E**

Deviation (Δ) of a hole group from its intended position.

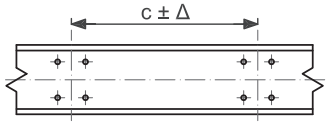
Δ = 2mm.




**7.3.13 Spacing of hole groups**

Deviation (Δ) in spacing (c) between centres of hole groups.

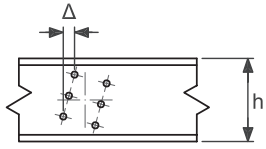
Δ = 5mm generally or 2mm if a single component is connected to another single component by two groups of fasteners.




**7.3.14 Twist of a hole group**

Δ = 2mm if h ≤ 1000mm.

Δ = 4mm if h > 1000mm.



## 7.4 PERMITTED DEVIATIONS FOR PLATE GIRDER SECTIONS (Δ)

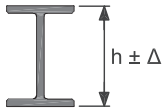
### 7.4.1 Depth E

Depth on centre line.

Δ = 3mm if h ≤ 900mm.

Δ = h/300 if 900mm < b < 1800mm.

Δ = 6mm if b ≥ 1800mm.




### 7.4.2 Flange width E

Width of b1 or b2.

Δ = 3mm if b < 300mm.

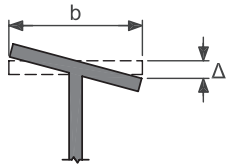
Δ = b/100 if b ≥ 300mm.


### 7.4.3 Squareness of section

Out of squareness of flange width (b).

Δ = 4mm.

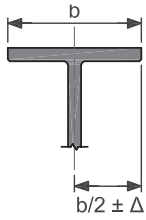
Generally Δ = b/100 or 5mm whichever is greater but limited to b/400 in locations identified in the Project Specification as in contact with structural bearings.




### 7.4.4 Web eccentricity

Position of web from one edge of flange width (b) relative to intended position.

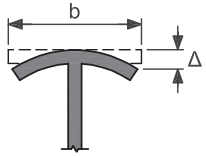
Generally Δ = 5mm but limited to 3mm in locations identified in the Project Specification as in contact with structural bearings.




### 7.4.5 Flanges

Out of flatness of flange width (b).

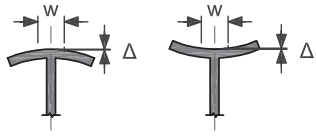
Generally Δ = b/150 or 3mm whichever is greater but limited to b/400 in locations identified in the Project Specification as in contact with structural bearings.




### 7.4.6 Top flange of crane girder

Out of flatness where the rail seats in zone (w) equal to rail width plus 10mm either side of rail in nominal position.

Δ = 1mm.

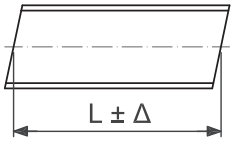


### 7.4.7 Length

Length on centre line.

Δ = 3mm.

Note: This may be increased up to a maximum of 50mm if sufficient clearance compensation with next adjacent component is possible.

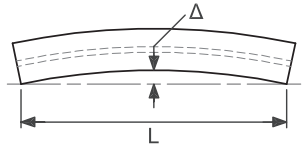



### 7.4.8 Flange straightness E

Straightness of individual flanges.

Δ = L/750.

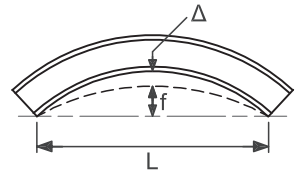
Note: At least 3mm allowable on beams shorter than 2250mm if specified as restrained in the Project Specification.




### 7.4.9 Curve or camber

Deviation (Δ) from intended curve or camber (f) at middle of length (L) of curved portion when measured with the web horizontal.

Δ = L/500 or 6mm whichever is greater.



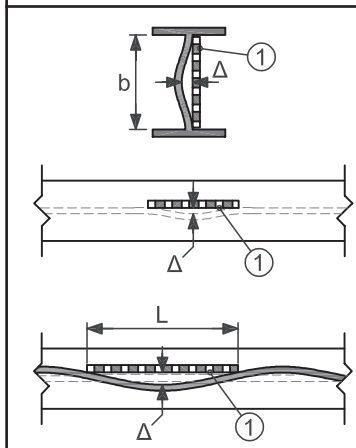

### 7.4.10 Web distortion E

Distortion (Δ) on web of thickness (t) over depth (b) or gauge [1] of length (b).

Δ = b/200 if b/t ≤ 80.

Δ = $b^2$/16000t if 80 < b/t ≤ 200.

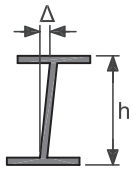
Δ = b/80 if b/t ≥ 200.




### 7.4.11 Cross section at bearings E

Squareness of flanges to web.

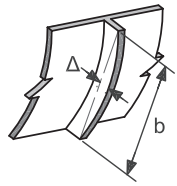
Δ = h/300 or 3mm whichever is greater.



**7.4.12 Web stiffeners E**

Straightness of stiffener out of plane with web after welding.

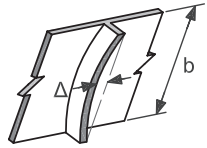
Δ = b/250 or 4mm whichever is greater.




**7.4.13 Web stiffeners E**

Straightness of stiffener in plane with web after welding.

Δ = b/500 or 4mm whichever is greater.

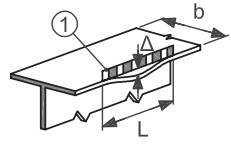


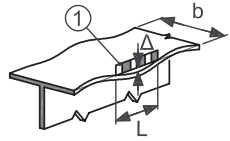

**7.4.14 Flange distortion or undulation E**

Distortion (Δ) or undulation over gauge [1] of length (L) equal to flange width (b) of thickness (t).

Δ = b/150 if b/t ≤ 20.

Δ = $b^2$/3000t if b/t > 20.

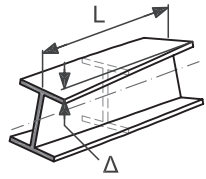



**7.4.15 Twist**

Overall twist in a component of length (L).

Δ = L/700 of 4mm whichever is the greater up to a maximum of 20mm.



## 7.5 PERMITTED DEVIATIONS FOR BOX SECTIONS (Δ)

### 7.5.1 Plate widths E

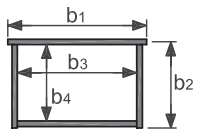
Deviation (Δ) in internal or external dimension b = $b_1$, $b_2$, $b_3$ or $b_4$.

Δ = – (b/100) / +3mm if b ≤ 300mm.

Δ = 3mm if 300mm < b ≤ 900mm.

Δ = b/300 if 900mm < b < 1800mm.

Δ = 6mm if b ≥ 1800mm.




### 7.5.2 Squareness

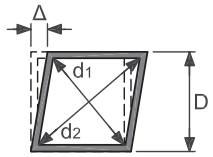
Squareness at diaphragm positions.

Δ = D/300.

Difference Δ = ($d_1$ – $d_2$) between diagonal dimensions $d_1$ and $d_2$.

Δ = ($d_1$ + $d_2$)/400 or 6mm whichever is greater.

*Note: Δ is the difference between actual and intended values of ($d_1$ – $d_2$) if $d_1$ and $d_2$ are significantly different.*




### 7.5.3 Plate distortion E

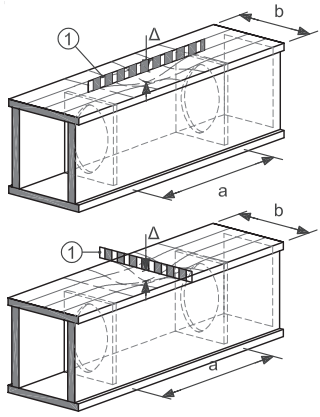
For a panel of width (b) with distance (a) between stiffener diaphragms.

Distortion perpendicular to the plate transversely over whole width relative to straight edge [1] or longitudinally with respect to a gauge [1] of length (b).

General case: Δ = b/125 unless a ≤ 2b in which case Δ = a/250.

Special case: Δ = a/125 unless a ≥ b/2 in which case Δ = b/250.

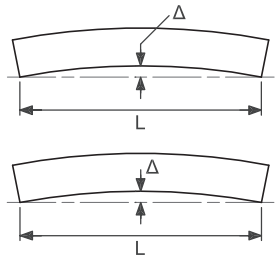
*Note: The special case only applies if specified in the Project Specification for compression of the box section is in the transverse direction.*




### 7.5.4 Web or flange straightness E

Straightness of individual web or flanges.

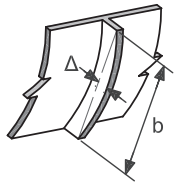
Generally Δ = L/500 or 3mm but limited to L/750 for components identified in the Project Specification as struts or columns.



**7.5.5 Web stiffeners E**

Straightness of stiffener of length (b) in plane with plate after welding.

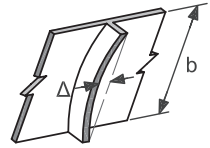
Δ = b/400.




**7.5.6 Web stiffeners E**

Straightness of stiffener of length (b) out of plane to plate after welding.

Δ = b/400.

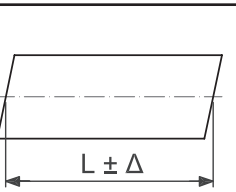



**7.5.7 Length**

Length (L) on centre line.

Δ = 3mm.

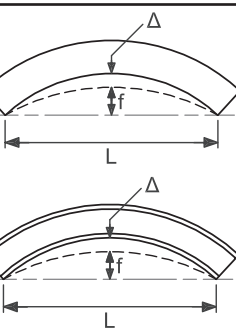
*Note: This may be increased up to a maximum of 50mm if sufficient clearance compensation with next adjacent component is possible.*




**7.5.8 Curve or camber**

Deviation (Δ) from intended curve or camber (f) at middle of length (L) of curved portion when measured with the uncambered side horizontal.

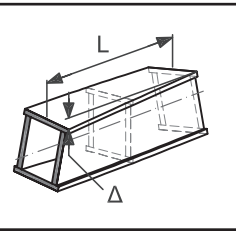
Δ = L/500 or 6mm whichever is greater.




**7.5.9 Twist**

Overall twist in a component of length (L).

Δ = L/700 of 4mm whichever is the greater up to a maximum of 10mm.

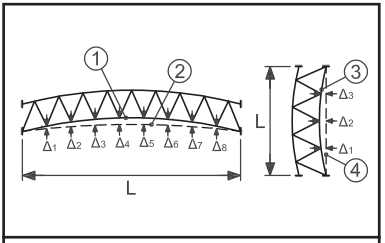


## 7.6 PERMITTED DEVIATIONS FOR LATTICE COMPONENTS (Δ)

### 7.6.1 Straightness and camber E

Deviations (Δi) of the actual positions [3] or [1] at each panel point relative to a straight line [4] or to the intended camber [2] when measured after welding with the component lying flat on its side.

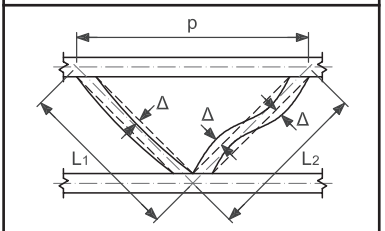
Δ = L/500 or 12mm whichever is greater.




### 7.6.2 Panel dimensions

Deviation (Δ) of individual distances (p, $L_1$ or $L_2$) between intersections of centre lines at panel points.

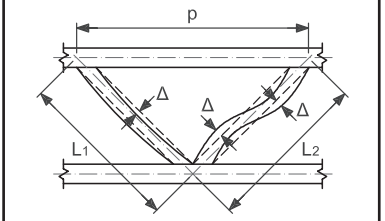
Δ = 5mm but limited longitudinally to a cumulative value (∑p) of 10mm.




### 7.6.3 Straightness of bracings

Straightness of bracings of length L = $L_1$ or $L_2$.

Δ = L/750 or 6mm whichever is greater.



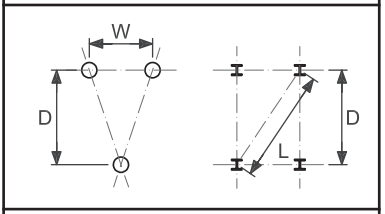

### 7.6.4 Cross-sectional dimensions

Deviation (Δ) of distance s = D, W or L as appropriate.

Δ = 3mm if s ≤ 300mm.

Δ = 5mm if 300mm < s < 1000mm.

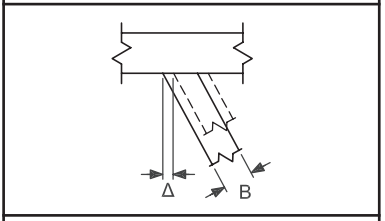
Δ = 10mm if s ≥ 1000mm.




### 7.6.5 Intersecting joints

Eccentricity of bracing of dimension (B) relative to intended eccentricity.

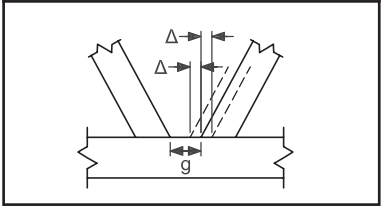
Δ = ± (B/20 + 5mm).




### 7.6.6 Gap joints

Gap (g) and deviation (Δ) in gap between bracings of thicknesses $t_1$ and $t_2$.

g ≥ ($t_1$ + $t_2$) and Δ = 5mm.



# SECTION 8

# WORKMANSHIP - ERECTION

## 8.1 GENERAL

### 8.1.1 Erection method statement

The Steelwork Contractor shall prepare a written method statement in accordance with the Construction (Design and Management) (CDM) Regulations. It should take account of the information provided by the Employer on design, erection and programme (see Table 1.2, 1.4 and 1.7).

The Steelwork Contractor shall submit the method statement to the Engineer for acceptance at least two weeks before erection commences.

Erection shall not commence before the method statement has been accepted by the Engineer.

### 8.1.2 Meaning of acceptance

Acceptance by the Engineer of the Erection Statement means that the Engineer's design concept for safe erection has not been invalidated.

### 8.1.3 Provision of setting-out lines by the Employer

The Employer shall establish and maintain a system for setting out the building in accordance with ISO 4463-1 (BS 5964-1). Deviations in the position of foundation supports for the Works shall be measured relative to this system.

### 8.1.4 Handling and storage

Components shall be handled and safely stacked in such a manner as to minimise the risk of surface abrasion and damage.

Fasteners and small fittings shall be stored under cover in dry conditions.

### 8.1.5 Damaged steelwork

Any steelwork damaged during off-loading, transportation, storage or erection shall be restored to conform to the standards of manufacture as given in this Specification

### 8.1.6 Column base plates and slabs

Steel packs shall be supplied to allow the structure to be properly lined and levelled and of sufficient size to avoid local crushing of the concrete.

Base packs shall be placed so that they do not prevent subsequent grouting to completely fill all spaces directly under the base plates.

Base packs may be left permanently in place.

### 8.1.7 Grouting

Grouting shall not be carried out under column base plates until a sufficient portion of the structure has been aligned, levelled, plumbed and adequately braced.

Immediately before grouting, the space under column base plates shall be clean and free of all extraneous matter.

## 8.2 SITE CONDITIONS

### 8.2.1 Employer's responsibilities

The Employer shall:

(i) maintain the working surfaces of the Site free from standing water and remove water from foundations;

(ii) provide a firm, properly graded, working area and storage area; also maintain adequate access roads, into and through the site, for the safe delivery of plant and materials on normal road vehicles (see Table 1.4 (ii) and (iv));

(iii) inform the Steelwork Contractor of the position of any underground services which may be considered liable to damage by the Steelwork Contractor's plant; (see 1.4 (vi));

(iv) be responsible for removing overhead obstructions.

### 8.2.2 Steelwork Contractor's responsibility

The Steelwork Contractor shall ensure that the load spread under cranes and lifting plant is commensurate with the strength of firm standing provided by the Employer.

## 8.3 SAFETY

### 8.3.1 Responsibilities – all parties

The initial planning, design, site management and procedures adopted for safe erection of the structure shall be in accordance with:

(i) use of the checklist given in the *BCSA Safe Site Handover Certificate*;

(ii) the recommendations given in the *BCSA Codes of Practice for Erection of Low Rise and Multi-Storey Buildings* and the *BCSA Guide to Steel Erection in Windy Conditions*;

(iii) CDM Regulations.

### 8.3.2 Steelwork Contractor's responsibility

The Steelwork Contractor shall:

(i) ensure that the operations comply with the Employer's rules for operating on site;

(ii) ensure that appropriate safe systems of work are provided, installed and properly maintained to discharge the duties under current safety legislation.

## 8.4 STABILITY

### 8.4.1 Temporary restraints until permanent features are built

The Engineer shall advise the Steelwork Contractor of positions on the structure where temporary bracing, metal decking or other restraints are needed to provide stability to individual components or the structure until walls, floors or other non-steel structures are in position.

The Steelwork Contractor shall design and provide the temporary bracing or restraints. The Engineer shall provide sufficient information to enable the Steelwork Contractor to design the necessary temporary works.

### 8.4.2 Other temporary restraints used by Steelwork Contractor

If the Steelwork Contractor uses temporary restraints during erection which do not substitute for permanent features, they may be removed after the structure has been lined, levelled and plumbed provided that sufficient steelwork and/or permanent bracing has been erected to ensure the stability of the structure under the worst expected conditions of dead, imposed and wind loading.

## 8.5 ERECTION LOADS

The Steelwork Contractor shall ensure that no part of the structure is permanently distorted by stacking of materials or temporary erection loads during the erection process.

The Employer shall ensure that no other contractor shall place loads on the partly erected structure without the permission of the Steelwork Contractor.

## 8.6 LINING AND LEVELLING

### 8.6.1 Alignment of part of the structure

Each part of the structure shall be aligned as soon as practicable after it has been erected. Permanent connections shall not be made between components until sufficient of the structure has been aligned, levelled, plumbed and temporarily connected to ensure that components will not be displaced during subsequent erection or alignment of the remainder of the structure.

Alignment of the structure and lack of fit in connections may be adjusted by the use of shims. Shims shall be secured if they are in danger of coming loose.

### 8.6.2 Temperature effects

Due account shall be taken of the effects of temperature on the structure and on tapes and instruments when measurements are made for setting out, during erection, and for subsequent dimensional checks. The reference temperature shall be 20°C

## 8.7 SITE WELDING

Site welding shall be carried out in accordance with Section 5.

In all cases precautions are to be taken so that the welding current does not damage components it passes through and adequate return earth connections are made local to the area being welded.

Welding shall not be permitted during inclement weather, unless adequate protective measures are taken.

## 8.8 SITE BOLTING

Bolting shall be carried out in accordance with Section 6.

All bolted connections shall be visually checked after they are bolted up with the structure aligned locally. Connections identified during snagging that do not have the full complement of bolts shall be checked for fit up after the missing bolts have been installed.

## 8.9 CERTIFICATION OF COMPLETION

When the steelwork, or portion of the steelwork, has been completed, the Steelwork Contractor shall present a certificate for the Employer and the Steelwork Contractor to sign. The completion of the certificate means the following:

(i) The Steelwork Contractor's signature signifies that an inspection has been made to ensure that all connections are completed and that the steelwork is erected in accordance with this Specification and contract requirements.

(ii) The Employer's signature signifies acceptance that the structure, or part of the structure, has been built in accordance with this Specification and the contract requirements.

If a record of the dimensional checks at acceptance is required, the requirements shall be given in the Project Specification.

# SECTION 9

# WORKMANSHIP - ACCURACY OF ERECTED STEELWORK

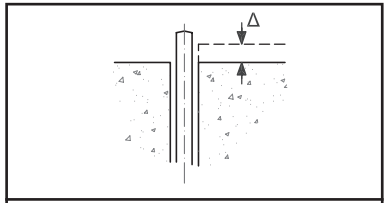
## 9.1 PERMITTED DEVIATIONS FOR FOUNDATIONS, WALLS AND FOUNDATION BOLTS (Δ)

*Note: The permitted deviations in 9.1.1 to 9.1.5 are in accordance with the National Structural Concrete Specification.*

### 9.1.1 Foundation level

Deviation (Δ) from specified level.

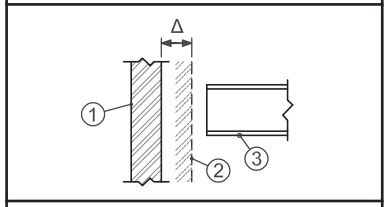
Δ = – 15mm below / + 5mm above.




### 9.1.2 Vertical wall

Deviation (Δ) of actual position [1] from specified position [2] at steelwork [3] support point.

Δ = ± 25mm.




### 9.1.3 Pre-set foundation bolt or bolt groups if prepared for adjustment

Deviation ($\Delta_p$) of bolt protrusion relative to intended position.

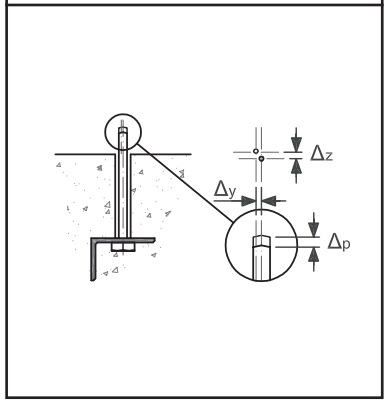
$\Delta_p$ = – 5mm (low) / + 25mm (high).

Deviation ($\Delta_y$ or $\Delta_z$) from specified position at top of concrete.

$\Delta_y$ or $\Delta_z$ = ± 10mm.

A minimum clearance of 25mm around the bolt is required for adjustment.

*Note: The permitted deviation for the location of the centre of the foundation bolt group is 6mm.*



**9.1.4 Pre-set foundation bolt or bolt groups if not prepared for adjustment**

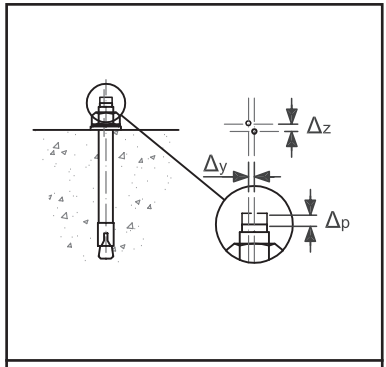
Deviation ($\Delta_p$) of bolt protrusion relative to intended position.

$\Delta_p$ = – 5mm (low) / + 25mm (high).

Deviation ($\Delta y$ or $\Delta z$) from specified position at top of concrete.

$\Delta_y$ or $\Delta_z$ = ± 3mm.

*Note: The permitted deviation for the location of the centre of the foundation bolt group is also ± 3mm.*




**9.1.5 Pre-set wall bolt or bolt groups if not prepared for adjustment**

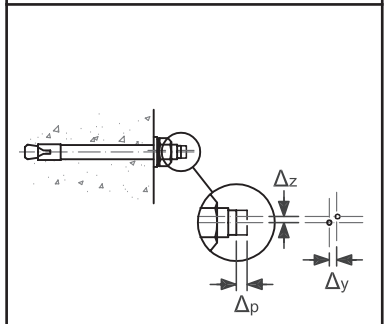
Deviation ($\Delta_p$) of bolt protrusion relative to intended position.

$\Delta_p$ = – 5mm (inward) / + 25mm (outward).

Deviation ($\Delta_y$ or $\Delta_z$) from specified position at face of concrete.

$\Delta_y$ or $\Delta_z$ = ± 3mm.

*Note: The permitted deviation for the location of the centre of the foundation bolt group is also ± 3mm. These measurements are measured locally relative to the achieved verticality of the wall as specified in 9.1.2.*

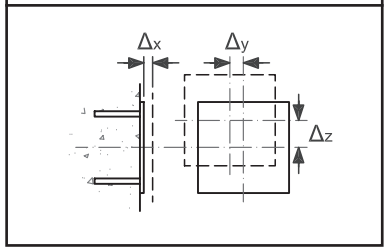



**9.1.6 Embedded cast-in fixing plates**

Deviations ($\Delta_x$, $\Delta_y$ or $\Delta_z$) of centre lines of the plate relative to the specified positions.

$\Delta_x$, $\Delta_y$ or $\Delta_z$ = ± 10mm.

*Note: These measurements are measured locally relative to the achieved verticality of the wall as specified in 9.1.2.*




## 9.2 FOUNDATION INSPECTION

The Steelwork Contractor shall inspect the prepared foundations and holding down bolts for position and level not less than seven days before erection of steelwork starts. He shall then inform the Employer if he finds any discrepancies which are outside the deviations specified in clause 9.1 requesting that remedial work be carried out before erection commences.

The compliance survey used to check the position of the foundation supports shall be documented.

## 9.3 STEELWORK

Methods and instruments used for dimensional measurement shall be selected, as appropriate, from those listed in ISO 7976-1 and -2 (BS 7307-1 and -2). Accuracy shall be assessed in accordance with the relevant part of ISO 17123.

*Note: ISO 17123 is not issued as a BS but it supersedes ISO 8322 which was issued as BS 7334.*

A survey of the completed structure shall be made. This survey shall be related to the system for setting out the building established in accordance with 8.1.3.

Measurements will only be taken of the position of components adjacent to site interconnection nodes as set out below, unless otherwise specified in the Project Specification. The location and frequency of measurements shall be specified in the Steelwork Contractor's erection method statement or quality plan.

The positional accuracy of the erected steelwork shall be measured under self-weight of steelwork only unless otherwise specified in the Project Specification.

Permitted maximum deviations in erected steelwork shall be as specified in 9.6 taking account of the following:

(i) All measurements to be taken in calm weather, and due note is to be taken of temperature effects on the structure (see 8.6.2).

(ii) The deviations shown for I sections apply also to box and tubular sections.

*Note: Components supplied as an erected kit that is CE marked by the Steelwork Contractor are warranted as conforming to the permitted deviations for the erection of structural components that are indicated below with an "E" as essential tolerances.*

## 9.4 DEVIATIONS

The Steelwork Contractor shall as soon as possible inform the Engineer of any deviation position of erected steelwork which is greater than the permitted deviation in 9.6 so that the effect can be evaluated and a decision reached on whether remedial work is needed.

Assessment of whether a nonconformity exists shall take into account the inevitable variability in methods of measurement. Accuracy of construction shall be interpreted in relation to the expected deflections, cambers, presets, elastic movements ad thermal expansion of components.

*Note: The survey and assessment of deviations of erected steel frames is described in Annex A of the Commentary. ISO 6954-1 to -3 (BS 6954-1 to -3) give guidance on tolerances for buildings and the implications of variabilities (including manufacturing, setting-out and erection deviations) on the fit between components.*

## 9.5 INFORMATION FOR OTHER CONTRACTORS

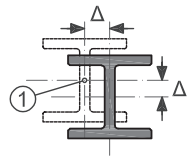
The Engineer shall advise contractors engaged in operations following steel erection of the deviations acceptable in this document in fabrication and erection, so that they can provide the necessary clearances and adjustments.

## 9.6 PERMITTED DEVIATIONS OF ERECTED COMPONENTS (Δ)

### 9.6.1 Position of columns at base

Deviations (Δ) of section centre lines from the specified position [1].

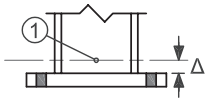
Δ = ± 10mm.




### 9.6.2.1 Level of columns at base

Deviation (Δ) of the top of the base plate from the specified level [1].

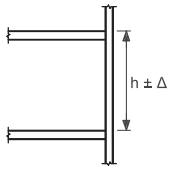
Δ = ± 5mm.




### 9.6.2.2 Storey height

Deviation (Δ) of storey height (h) measured relative to adjacent levels.

Δ = 10mm.




### 9.6.2.3 Overall height

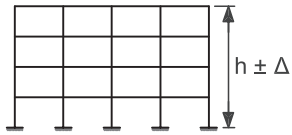
Deviation (Δ) of overall height (h).

Δ = 20mm if h ≤ 20m.

Δ = 0.5 (h+20) if 20m < h < 100m.

Δ = 0.2 (h+200) if h ≥ 100m.

*Note: Value in metres for h in formulae.*

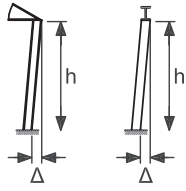



### 9.6.3.1 Inclination of single storey columns generally E

Inclination (Δ) of top relative to base on main axes.

Δ = ± h/300.

*Note: Excluding portal frames, see 9.6.3.2 and 9.6.3.3, and columns supporting crane gantries, see 9.6.13.*

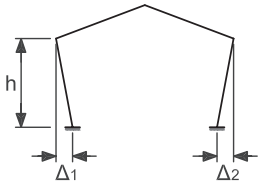



### 9.6.3.2 Inclination of individual columns in single storey portal frames

Inclination ($\Delta_i$) of each column.

$\Delta_1$ or $\Delta_2$ = ± h/150.

*Note: See 1.2A(xvii) and 3.4.4(iii) regarding pre-setting portal frames.*

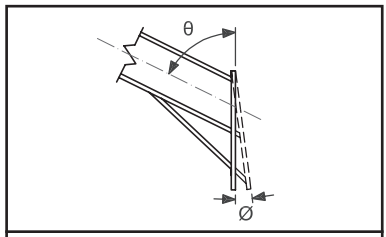


**9.6.3.3 Inclination of single storey portal frames E**

Mean inclination (Δ) of all the columns in the same frame.

$\Delta = \pm h/500$ (e.g $\Delta = (\Delta_1 + \Delta_2)/2$ for two columns)

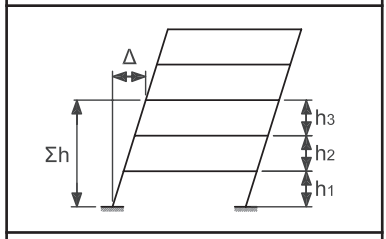
Note: See 1.2A(xvii) and 3.4.4(iii) regarding pre-setting portal frames.




**9.6.4.1 Multi-storey columns overall plumb E**

Location (Δ) of a column centre line in plan at each storey relative to a vertical line through column centre at its base.

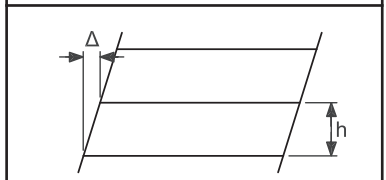
$\Delta = \sum h / (300\sqrt{n})$ where $\sum h = h_1 + h_2 + h_3$ etc.




**9.6.4.2 Multi-storey columns plumb over storey E**

Location (Δ) of a column centre line in plan relative to a vertical line through its centre at the next lower level.

$\Delta = h/500$.



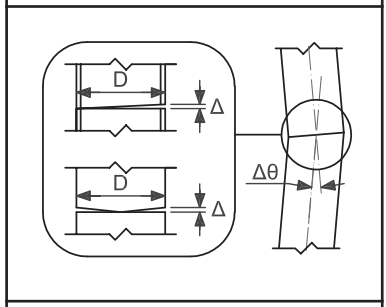

**9.6.5 Column splice alignment and gap between bearing surfaces E**

Local angular misalignment (ΔΘ) occurring at same time as gap (Δ).

ΔΘ = 1/500 radians.

Δ = 0.5mm over at least two thirds of the area with a maximum of 1.0mm locally.

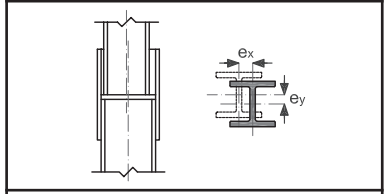
*Note: See also clauses 4.3.3, 7.2.3 and 9.6.7.1.*




**9.6.6 Eccentricity at column splice**

Non-intended eccentricity (e = ex or ey) about either axis.

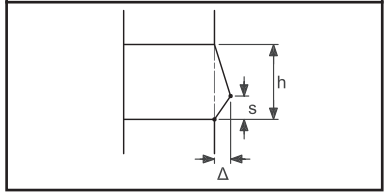
e = 5mm.




**9.6.7.1 Straightness of a spliced column between adjacent storey levels E**

Location (Δ) of the column in plan relative to a straight line between position points at adjacent storey levels.

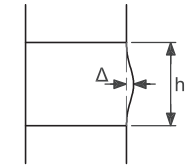
$\Delta = s/750$ with $s \leq h/2$.



**9.6.7.2 Location of a continuous column between adjacent storey levels E**

Location (Δ) of the column in plan relative to a straight line between position points at adjacent storey levels.

Δ = h/750.




**9.6.8.1 Overall length of building**

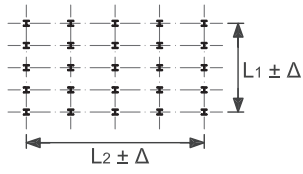
Deviation (Δ) in distance (L = $L_1$ or $L_2$) between end columns in each line at base level.

Δ = 20mm if L ≤ 30m.

Δ = 0.25 (L+50) if 30m < L < 250m.

Δ = 0.1 (L+500) if L ≥ 250m.

*Note: Value in metres for L in formulae.*



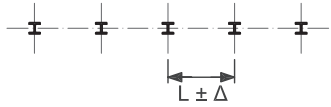

**9.6.8.2 Column spacing**

Deviation (Δ) in distance (L) between centres of columns at base level.

Δ = 10mm if L ≤ 5m.

Δ = 0.2 (L+45) L > 5m.

*Note: Value in metres for L in formulae.*

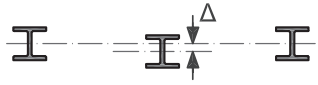



**9.6.8.3 Column alignment generally**

Location (Δ) of the centre of the column at base level relative to the established column line.

Δ = 10mm.

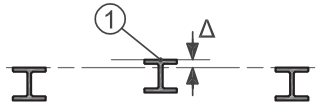
*Note: See 9.6.8.4 for perimeter columns. The established column line is the alignment representing a series of columns in one line.*




**9.6.8.4 Perimeter column alignment**

Location (Δ) of the outer face [1] of a perimeter column at base level relative to the line joining the faces of adjacent columns.

Δ = 10mm.

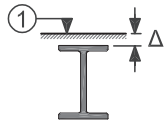


**9.6.9 Beam level**

Level of the beam (Δ) at a beam-to-column connection measured relative to the established floor level [1].

Δ = 10mm.

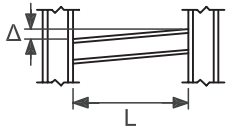
*Note: The established floor level is the level representing a series of beams at one storey level.*




**9.6.10.1 Beam slope**

Height (Δ) relative to the other end of a beam of length (L).

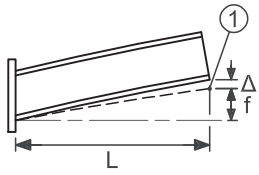
Δ = L/500 but not greater than 10mm.




**9.6.10.2 Pre-set of cantilever**

Deviation (Δ) from intended pre-set (f) at end of an erected cantilever of length (L) relative to nominal position [1] measured locally.

Δ = L/200.

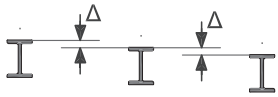



**9.6.11 Relative beam level**

Relative level (Δ) of adjacent beams measured at corresponding ends.

Δ = 10mm.

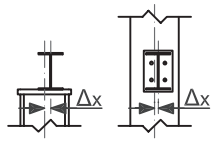
*Note: Actual camber of the primary beam needs to be taken into account in assessing the relative level of attached secondary beams.*




**9.6.12.1 Beam location**

Deviation in line (Δx) from intended location at a beam-to-column connection measured relative to the column.

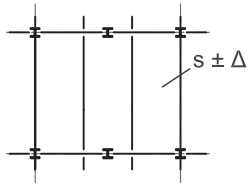
Δx = 5mm.




**9.6.12.2 Beam spacing**

Deviation (Δ) from intended distance (s) between adjacent erected beams measured at corresponding ends.

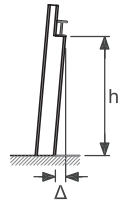
Δ = 10mm.



**9.6.13 Inclination of a column supporting crane gantry E**

Inclination (Δ) from floor level to bearing of crane beam.

Δ = ± h/1000 up to a maximum of 25mm.

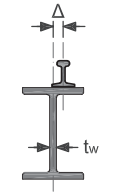



**9.6.14 Eccentricity of rail relative to web**

Eccentricity (Δ) of rail relative to web of thickness ($t_w$).

Δ = 5mm for $t_w \leq 10$mm.

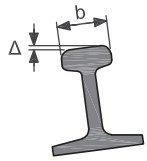
Δ = $t_w/2$ for $t_w > 10$mm.




**9.6.15 Slope of rail surface**

Slope (Δ) of top surface of cross-section of crane rail of width (b).

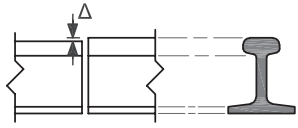
Δ = b/100.




**9.6.16 Level of rail**

Step (Δ) in top of rail at joint.

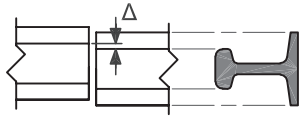
Δ = 1mm.




**9.6.17 Edge of rail**

Step (Δ) in edge of rail at joint.

Δ = 1mm.

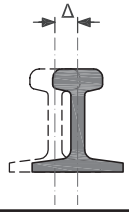



**9.6.18 Relative location of rail in plan**

Deviation (Δ) in location of rail in plan relative to the intended location.

Δ = 10mm.

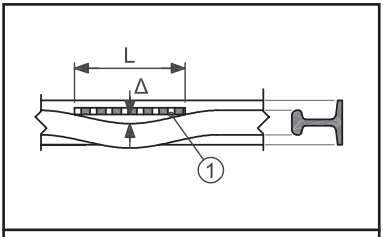
*Note: Location is relative to supporting steelwork.*



**9.6.19 Local alignment of rail**

Misalignment in plan of rail over gauge [1] of length (L) equal to 2m.

Δ = 1.5mm.

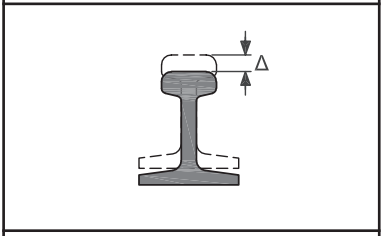



**9.6.20 Relative level of rail**

Deviation (Δ) in level of rail relative to the intended level.

Δ = 15mm.

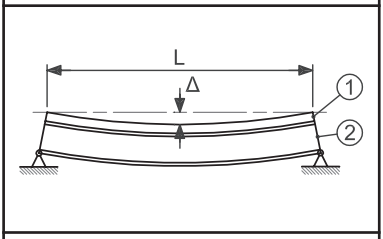
Note: Location is relative to supporting steelwork.




**9.6.21 Level of rail over crane beam**

Variation on level of rail [1] over crane beam [2] of span (L).

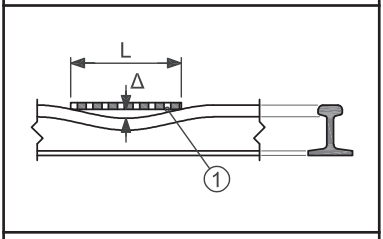
Δ = L/500 or 10mm whichever is the greater.




**9.6.22 Local level of rail**

Misalignment in elevation of rail over gauge [1] of length (L) equal to 2m.

Δ = 3mm.

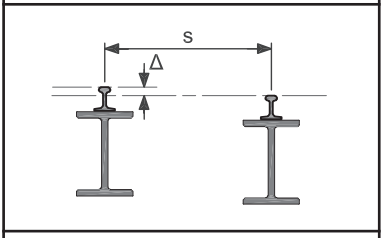



**9.6.23 Relative level of two rails**

Deviation (Δ) in levels of two rails on the two sides of a crane gantry of span (s).

Δ = 20mm if s ≤ 10m.

Δ = s/500 if s > 10m.



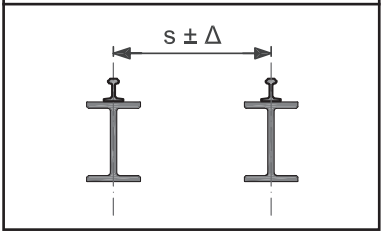

**9.6.24 Crane gantries gauge of rail tracks**

Deviation (Δ) in spacing from nominal gauge (s).

Δ = 10mm if s ≤ 16m.

Δ = 10 + (s – 16)/3 if s > 16m.

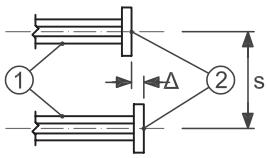
Note: Value in metres for s in formula.



### 9.6.25 Structural end stops

Relative location (Δ) of the end stops [2] at the same end measured in the direction of travel on the gantry [1].

Δ = s/1000 but limited to a maximum of 10mm.



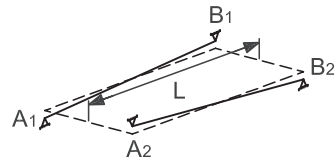

### 9.6.26 Inclination of opposite rails

Relative inclination (Δ) of rails on opposite sides of a gantry of length (L) between adjacent supports.

Inclination of rail $A_1B_1$ is $N_1$. Inclination of rail $A_2B_2$ is $N_2$.

Relative inclination Δ = is ($N_1 – N_2$) is limited to L/500.

*Note: In example $N_2$ will be a negative slope.*

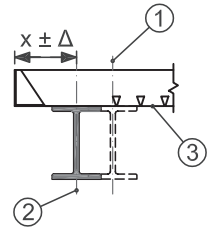



### 9.6.27 Profiled steel floor decking

Deviation (Δ) from nominal dimension (x) between decking edge trim prior to concrete placement and actual position of perimeter beam.

Δ = 10mm.

*Note: The deviation (as shown) between actual beam centre line [2] and intended beam centre line [1] relative to local grid arises from other permitted tolerances (e.g. 9.6.12.1). Decking [3] is a generic profile and may span in either direction.*



# SECTION 10

# PROTECTIVE TREATMENT

## 10.1 GENERAL

### 10.1.1 Specification

The coatings and associated surface preparation required for structural steelwork shall be as specified on the Design Drawings or in the Project Specification (see Table 1.5). If possible, the system should be chosen from those listed in Annex E. The system shall be in accordance with the latest edition of DEFRA's Process Guidance Note [PG6/23(04)].

A single source of coating supply shall be used unless otherwise agreed with the Employer.

### 10.1.2 Method statement

Before any work commences for the application or reapplication of protective coating, a detailed method statement shall be prepared and given to the Employer for approval. The method statement shall distinguish and identify the inspection to be undertaken.

A copy of the approved method statement shall be available where the work is being carried out.

### 10.1.3 Coating procedures

Coating materials shall be prepared, and coatings applied to surfaces, in accordance with the manufacturer's recommendations.

### 10.1.4 Transportation, handling and storage of coated steelwork

The procedures for the transportation, handling and storage of coated steelwork shall be so arranged as to minimise the risk of damage to the coating.

## 10.2 SURFACE PREPARATION

### 10.2.1 Surface cleanliness

At the time of coating the surface cleanliness of the steelwork to be coated shall be in accordance with BS EN ISO 8501-1. The preparation grade according to ISO 8501-3 (BS 7079-A3) shall be specified.

### 10.2.2 Surface profile

The surface profile of the steelwork to be coated shall be compatible with the coating to be applied when compared in accordance with the procedure BS EN ISO 8503-2 (BS 7079-C2).

### 10.2.3 Measurement of surface profile

Measurement of the surface profile of steelwork to be coated shall be made using the methods given in BS EN ISO 8503 (BS 7079-C).

### 10.2.4 Surface defects

Surface defects revealed during surface preparation shall be dealt with in accordance with 2.2.4.

## 10.3 SPRAYED METAL COATINGS

### 10.3.1 Procedures

Zinc or aluminium sprayed coatings shall be applied to the surface as required by BS EN ISO 2063 to a thickness given in the Project Specification or on the Design Drawings.

### 10.3.2 Reinstatement of damaged coating

All reinstatement of damaged coatings shall be made good to the standard of the original work.

### 10.3.3 Sealing before painting

If a sprayed metal coating is to be overcoated subsequently, it shall be sealed before the application of the overcoating.

## 10.4 HOT DIP GALVANIZING

### 10.4.1 Procedures

Galvanizing shall be carried out in accordance with BS EN ISO 1461.

Unless otherwise specified in the Project Specification, all galvanized components shall be subjected to post-galvanizing inspection in accordance with procedure PGI-1 in Table 10.1.

The Project Specification shall identify:

(i) any components for which post-galvanizing inspection is not required (PGI-0);

(ii) any components that shall be subjected to procedure PGI-2A in addition;

(iii) any specific locations that shall be subjected to procedure PGI-2B in addition.

The results of post-galvanizing inspection shall be recorded. These records shall be made available to the Engineer on request.

If evidence of cracking is identified, then the component and all similarly shaped components fabricated with similar materials and weld details shall be identified and quarantined as non-conforming products. A photographic record of the cracking shall be made and procedure PGI-3 shall then be used to establish the scope and origin of the problem. The results shall be submitted to the Engineer. Quarantined components may only be repaired for use in the Works with the agreement of the Engineer.

**TABLE 10.1 POST-GALVANIZING INSPECTION**

| Reference | Visual Inspection | Magnetic Particle Testing |
|---|---|---|
| **PGI-0** | Not required | Not required |
| **PGI-1** | 100% of all surfaces with special attention to areas around copes, welded connections and joints | Not required |
| **PGI-2A** | Already required by PGI-1 | On 10% of welded connections or node points of welded joints |
| **PGI-2B** | Already required by PGI-1 | On specified areas |
| **PGI-3** | Already undertaken | Sufficient to establish the scope and origin of the problem (1) |
| **Personnel** | Inspection to be undertaken by a suitably experienced person (2) | Non-destructive testing to be undertaken by a person suitably qualified on the technique to be used |
| (1) Eddy current and alternating current field measurement tests may be used to assist diagnosis | | |
| (2) The BCSA and the Galvanizers Association train and assess inspectors | | |

*Note: Further guidance is available in the BCSA publication Galvanizing Structural Steelwork – An Approach to the Management of Liquid Metal Assisted Cracking.*

#### 10.4.2 Vent holes

The Steelwork Contractor shall agree with the Engineer the position of vent and drainage holes in hollow components as laid down in BS EN ISO 14713, and any requirements for subsequent sealing.

## 10.5 PAINT TREATMENTS

#### 10.5.1 Specification

Paint coatings shall be to a system designated on the Design Drawings or in the Project Specification (see Table 1.5 (iv)).

#### 10.5.2 Surface preparation prior to painting

Steelwork shall be prepared for coating in accordance with 10.2.

#### 10.5.3 Painting of site weld areas and fasteners

Site weld areas and fasteners which are not suitably protected shall be painted with an approved paint system to ensure similar properties, performance and compatibility with the protective treatment system being used on the surrounding surfaces.

Fasteners and bolt assemblies which are supplied with a protective treatment which is equivalent to the protective treatment on the steelwork need not be painted.

### 10.5.4 Inspection of site applied coatings

If the Project Specification permits or requires coatings, other than those covered by 10.5.3, to be applied on site, then an inspection plan for the site application work shall be included in the project quality plan.

The inspection plan shall include steps to monitor the quality of the materials being used, the thickness of the applied coatings, and that the process of application is in accordance with the product manufacturer's recommendations.

## 10.6 COATING OF SURFACES TO BE ENCASED IN CONCRETE

Structural steel surfaces to be encased in concrete may be left unpainted and need not be blast cleaned unless required by the Project Specification.

# SECTION 11

# QUALITY MANAGEMENT

## 11.1 COMPETENCE OF STEELWORK CONTRACTOR

### 11.1.1 General

Prior to undertaking the Works, the competence of the Steelwork Contractor shall be demonstrated by an assessment that evaluates whether the Steelwork Contractor has the resources and capability to undertake the Works.

*Note: The BCSA undertakes mandatory independent assessment of the competence of all its Steelwork Contractor members in terms of recommended maximum contract values and categories of structural steelwork.*

### 11.1.2 Sustainability

If required by the Project Specification, the Steelwork Contractor shall demonstrate that the management of its operations address the sustainability issues relevant to structural steelwork.

*Note: The BCSA has published a Sustainability Charter for structural steelwork that allows its members to volunteer for independent assessment of their commitment to sustainability. The scheme may be used to identify Steelwork Contractors that implement responsible sourcing and carbon footprinting measures.*

## 11.2 QUALITY SYSTEM

### 11.2.1 System requirements

The Steelwork Contractor shall maintain and operate a management system to ensure that the procedures for design, detailing, purchasing, fabrication and erection of steel components and structures can provide completed work that conforms to the requirements of this Specification.

The Steelwork Contractor shall review the requirements of the Project Specification prior to commencing work, and shall provide a project-specific quality plan to supplement the quality management system if necessary.

### 11.2.2 System acceptance

The factory production control (FPC) system for controlling the conformity of manufactured components shall be certified as complying with the requirements of BS EN 1090-1.

*Note: The application of BS EN 1090-1 is explained in the BCSA Guide to the CE Marking of Structural Steelwork.*

The other elements of the system shall be either:

(i) assessed and certified as complying with the requirements of BS EN ISO 9001 by an accredited certification body; or

(ii) open to audit and approval by the Employer.

### 11.2.3 Scope

The system shall cover all procedures as detailed in BS EN ISO 9001 and BS EN ISO 3834-3. With respect to an FPC system for the manufacture of welded components, the welding certificate shall explicitly identify the scope as including:

Execution Class 2 or higher; the list of metal arc processes in use; and qualities and thicknesses of constituent steel products being used as parent metals.

*Note: The scope of welding operations should align with the coverage of the Steelwork Contractor's qualified welding procedure specifications and qualified welders or welding operators.*

### 11.2.4 Welding coordination

Welding coordination shall be undertaken according to a welding plan which shall be supplemented by a project-specific welding plan if necessary.

*Note: A management system in accordance with BS EN 3834-3 would fulfil the need for the general welding plan.*

With respect to the scope of welding operations being supervised as defined in 11.2.3, welding shall be coordinated by suitably qualified and experienced personnel with suitable technical knowledge.

*Note: Welding coordinators should have the ability to detect and assess defects, to instruct repairs and know how to avoid defects, as well as knowledge about the relevant standards, regulations and specifications to be observed.*

The Steelwork Contractor's management system shall identify the person with overall responsibility for welding coordination. The certification of the FPC system for the manufacture of welded components shall include the verification of the competence of the responsible welding coordinator (RWC).

The technical knowledge of the RWC shall be assessed with respect to the scope of welding operations being supervised as itemised in the relevant welding certificate(s) and the levels defined in BS EN ISO 14731 according to Table 11.1.

**TABLE 11.1: TECHNICAL KNOWLEDGE OF RWC**

| Scope (of welding operations being supervised) | Maximum parent metal thickness t (in mm) | | |
|---|---|---|---|
| | t ≤ 25 (1) | 25 < t ≤ 50 (2) | t > 50 |
| Welding of S275 or S355 steel products using only processes 111, 131 or 135 (i.e. MMA, MIG or MAG) | Basic (3) | Specific (3) | Specific (3) |
| Welding of S275 steel products otherwise | Basic | Specific | Specific |
| Welding of S355 steel products otherwise | Basic | Specific | Comprehensive |
| Welding of S420 steel products | Specific | Specific | Comprehensive |

(1) Column base plates and endplates ≤ 50mm.

(2) Column base plates and endplates ≤ 75mm.

(3) The technical knowledge of the RWC may be verified in a technical discussion during the FPC certification process. Otherwise independent certification of the RWC's technical knowledge by a recognised authority is required. Up to the Specific level, the RWC's technical knowledge may be verified as part of a competence assessment of the RWC undertaken by the BCSA.

If the Employer wishes to establish the competence of the RWC on a project-specific basis, the Project Specification should specify a suitable pre-production welding test to BS EN ISO 15613 for the RWC to organise.

## 11.3 ADDITIONAL INSPECTIONS AND TESTS

The Steelwork Contractor shall provide the necessary facilities for any tests and inspections required by the Project Specification (see 1.6).

## 11.4 RECORDS

All records made in accordance with the system described in clause 11.1 shall be available for the Employer and the accredited certification body to examine during the contract period.

## ANNEX A – WELD TESTING – HOLD TIMES

The requirements for hold time (the period to be allowed after completion of welding before commencement of final ultrasonic, magnetic particle and/or penetrant testing) are set out in 5.5.4.

Table A illustrates how these requirements may be met for typical structural steelwork components.

### TABLE A RECOMMENDED MINIMUM HOLD TIMES

| Weld Size (mm) (1) (2) | Heat Input (kJ/mm) (3) | Hold Time (hours) (4) |
|---|---|---|
| a or s ≤ 6 | All | Cooling period only |
| 6 < a or s ≤ 12 | ≤ 3 | 8 |
| | > 3 | 16 |
| a or s > 12 | ≤ 3 | 16 |
| | > 3 | 40 |

(1) Size applies to the nominal throat thickness (a) of a fillet weld, the nominal weld depth (s) of a partial penetration butt weld, or the nominal material thickness (s) of a full penetration weld.

(2) If two fillet welds are separated by an unfused root face of less than 10mm then the governing weld size (a) shall be taken as the sum of their individual weld sizes.

(3) Heat input to be calculated in accordance with clause 19 of BS EN 1011-1.

(4) The time between weld completion and commencement of NDT shall be stated in the NDT report. In the case of “cooling period only” this will last until the weld is cool enough for NDT to commence.

## ANNEX B – WELDS – EXTENT OF ROUTINE SUPPLEMENTARY NDT

### TABLE B EXTENT OF ROUTINE SUPPLEMENTARY NDT

| Weld Type (1) | Extent (2) |
|---|---|
| Full or partial penetration butt welds (other than welds to stiffeners or longitudinal welds) | 10% magnetic particle testing (MT) |
| Full or partial penetration butt welds in material being joined with a maximum nominal thickness >10mm | 10% ultrasonic testing (UT) |
| Fillet welds with nominal throat thickness > 12mm, nominal leg length > 17mm or in material being joined with a maximum nominal thickness > 20mm | 10% MT and 5% UT (3) |

(1) Provided that site welding is undertaken under the control of a suitably competent welding coordinator on site and appointed by the RWC, these requirements generally make no distinction between shop and site welds. However, the extent of testing for the weld types above shall be 100% for site welds on a new project until the RWC is satisfied that suitable quality levels can be maintained.

*Note: This applies the principles in 5.5.2 for initial type testing to the supplementary NDT for welds on the site of a new project.*

(2) The percentages are subject to a minimum length of 900mm in any inspection lot and apply to the cumulative amount of weld length in joints welded according to the same WPS treated as a single continuing inspection lot. An inspection lot is a group of welds expected to show a uniform quality. See also 5.5.1 for workshops where no supplementary NDT is required by this Table.

(3) Ultrasonic testing of fillet welds shall be carried out using 0° probes to determine the absence of defects in the parent material.

# ANNEX C - WELDS - ACCEPTANCE REQUIREMENTS AND MEASUREMENT DEFINITIONS

## TABLE C.1 ACCEPTANCE REQUIREMENTS for production welds in steel structures

| | Parameter | Weld type | Weld Orientation | | Figure reference in Table C2 | Acceptance criteria for normal quality (all dimensions in mm) | Remedial action for non-conforming welds See Note (6) |
|---|---|---|---|---|---|---|---|
| Weld geometry | Location | All | | | | D ± 10 | Repair |
| | Weld type | All | | | | D | Refer to RWC |
| | Length | All | | | | D +10 – 0 | Repair |
| Profile discontinuities | Throat thickness | All | | | (i),(ii),(iii) | a,s ≥ D (Av. 50)<br>a,s ≤ D +5 | Repair and dress smooth |
| | Leg length | Fillet | | | (i) | z ≥ D (Av. 50) | Repair |
| | Toe angle | All | Transverse or Longitudinal | | (i),(ii) | θ ≥ 90° | Repair and dress smooth |
| | Excess weld metal | Butt | Transverse or Longitudinal | | (ii) | h ≤ 6 | Repair and dress smooth |
| | Incomplete groove or concave root | Butt | Transverse | | (ii) | h ≤ 0 (Av. 50) | Repair |
| | | | Longitudinal | | (ii) | h ≤ 0.1t | |
| | Linear misalignment | Butt | Butt Joint | | (iv) | h ≤ D + 0.2t | Refer to RWC |
| | | All | Transverse cruciform | | (v) | h ≤ D + 0.4t | |
| | | | Longitudinal | | (iv),(v) | h ≤ D + 0.4t | |
| Surface breaking discontinuities | Undercut | All | Transverse (not lap joint) | | (iv),(v) | $h_1 + h_2 \leq 0.05t$<br>$l$ - No limit | Repair |
| | | Fillet | Transverse (lap joint) | | (iv) | $h_1 + h_2 \leq 0.03t$<br>$l \leq 10$ | |
| | | All | Longitudinal | | (iv),(v) | $h_1 + h_2 \leq 0.1t$ | |
| | Lack of root penetration | S/S Butt | Transverse | | (iii) | h ≤ D + 0.05t (Av. 50) | Repair |
| | | | Longitudinal | | (iii) | h ≤ D + 0.1t (Av. 50) | |
| | Porosity | All | Transverse | | (vi) | d ≤ 2<br>Σ d ≤ 10 [100] | Repair |
| | | | Longitudinal | | (vi) | d ≤ 2<br>Σ d ≤ 20 [100] | |
| | Lack of fusion | All | | | | Not permitted | Repair |
| | Cracks | All | | | | Not permitted | Repair |
| Sub-surface discontinuities | Lack of fusion/root penetration, slag lines | Butt | Transverse | Full depth | (vii) | h ≤ 3 and Σ $l$ ≤ 1.5t [100] | Repair |
| | | | | Zone O | (vii) | $l \leq 10$<br>$l' \geq 10$ | |
| | | | | Zone I | (vii) | $l \leq$ 1.5t [100]<br>h' ≥ 6 | |
| | | | Longitudinal | Full depth | (vii) | h ≤ 3 and Σ $l$ ≤ 3t [100]<br>No individual limits on $l$ or $l'$ | |
| | Root Gap | Fillet, P/P Butt | | | | (i),(v) | h ≤ 2 (Av.100)<br>h ≤ 3 Repair |
| | Cracks | All | | | | Not permitted | Repair |
| | Lamellar Tears | All | Transverse<br>Longitudinal | | | Not permitted | Refer to RWC |

*Note: Further guidance on the application of these tables is available in the BCSA Guide to Weld Inspection (in preparation).*

**Abbreviated terms and notes applicable to Table C.1**

**Abbreviated terms:**

| | |
|---|---|
| D | As specified on drawing |
| P/P | Partial Penetration |
| Repair | Repair by welding to approved procedure |
| S/S | Single sided (including butt weld in hollow section) |
| (Av. 50) | Length of weld over which measurement may be averaged (mm) |
| [100] | Length of weld over which summation is made (mm) |
| *1* | Length of discontinuity - parallel to the weld axis |
| *1'* | Gap between ends of discontinuities - parallel to the weld axis. If non-conforming, 1 becomes the overall length of the discontinuities plus the gaps(s) between them. |
| h | Height of discontinuity - in thickness direction |
| h' | Gap between discontinuity - in the thickness direction |
| I | Inner zone |
| O | Outer zone |

**Notes:**

(1) For definition of orientation see Annex B.

(2) Thickness applies to minimum member thickness at weld in question. For thickness greater than 20mm 't' shall be taken as 20mm. The limiting value 'h' for any discontinuity, where related to member thickness 't', is the greater of this calculated figure or 0.3mm.

(3) "Lap" shall apply to any fillet welded attachment whose length in the longitudinal direction exceeds 50mm.

(4) Subject to any other locational requirements.

(5) Where more than one requirement is given both shall apply.

(6) Where a repair is necessary an approved procedure shall be used. If on increasing the scope of inspection, further non-conformances are found, the scope shall be increased to 100% for the joint type in question.

(7) Lamellar tears may be accepted in the longitudinal welds only if extent does not exceed limits for lack of fusion in transverse welds.

**TABLE C.2 MEASUREMENT DEFINITIONS for production welds in steel structures**

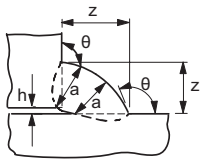



Figure (i)

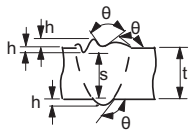



Figure (ii)

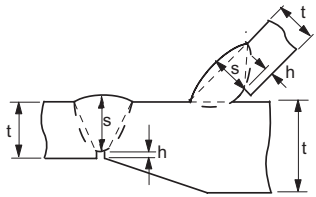



Figure (iii)

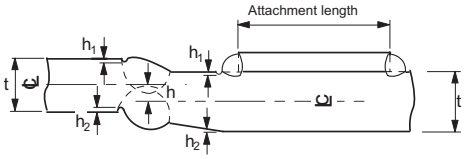



Figure (iv)

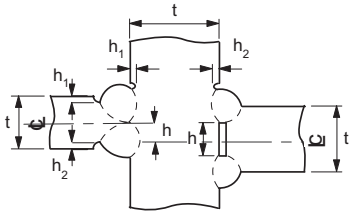



Figure (v)

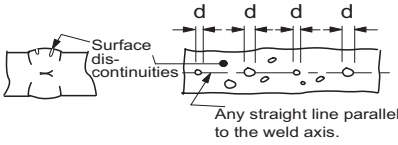



Figure (vi)

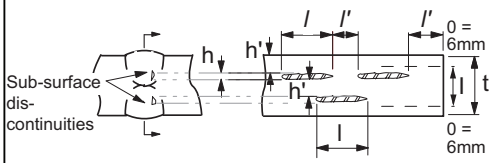



Figure (vii)

Sub-surface discontinuities may be in Zones I (as shown) or O

# ANNEX D – GUIDELINES FOR VISUAL INSPECTION OF WELDS

## Prior to welding or between weld passes

(i) Check that the weld preparation is correct in accordance with the welding work instruction. Items to be checked include preparation angles, root gap, root face condition, depth of preparation for part penetration welds, minimal gap for fillet welds.

(ii) Check that the area to be welded is not contaminated with grease, oil, dirt, paint or moisture.

(iii) Check that any tacks welds have been removed or are suitable for welding over as required by 5.4.3.

(iv) For multi-pass welds, check the suitability of the surface of previously deposited weld metal. In addition to checking any re-preparation to (i) and cleanliness to (ii), the area to be welded shall be de-slagged, free of weld spatter and be of a suitable profile for deposition of the subsequent pass.

(v) Check that the relative position of parts to be joined is in accordance with the Fabrication Drawings and that the joint fit-up is satisfactory.

(vi) Check the shape and depth of any back gouging to ensure the complete removal of the second side back to sound metal. Also check whether supplementary NDT is needed at this stage before proceeding.

**After deposition of each weld pass or at final completion**

(i) Check the weld size. Visual estimation may be used to assess acceptability, but, if in doubt, check by measurement. Confirm by measurement periodically anyhow.

(ii) Check that welds are complete. Items to be checked include whether the weld extends fully to the end of the preparation or run-on/run-off plates if used for butt welds, and that return welds are completed.

(iii) Check that any craters have been filled and that no crater cracks are evident visually.

(iv) Check for undercut, and measure for evaluation if identified.

(v) Check that the weld beads are of even appearance and that fillets present a mitre or slightly convex profile and butt welds are not under-flush with incomplete grooves. Measure any concave profiles to ensure that the specified throat thickness has not been compromised.

(vi) Check for absence of any cracking or significant porosity.

(vii) Check for absence of overlapping.

(viii) Check for absence of any mechanical damage from tool marks (e.g. chisels, hammers).

**Corrective action**

Corrective action on minor defects capable of immediate rectification may be taken under the authority of the visual inspector. More significant defects shall be reported using a non-conformance procedure, and corrective action undertaken before further NDT including additional visual inspection. A record shall be kept that visual inspection has been carried out and any non-conformities identified.

## ANNEX E – SPECIFICATIONS FOR APPLIED COATINGS

| Location (1) | Primer (Max VOC 250 g/l) | | Intermediate (Max VOC 250 g/l) | | Finish (Max VOC 420 g/l) | |
|---|---|---|---|---|---|---|
| **CIRIA Spec** | **Type (3)** | **DFT µ (2)** | **Type** | **DFT µ (2)** | **Type (4)** | **DFT µ (2)** |
| **External steel** | | | | | | |
| E-1 | Epoxy Zinc Rich | 75 | Epoxy MIO | 100 - 125 | Acrylic/Urethane | 50 |
| E-2 | Epoxy Zinc Phosphate | 75 | Epoxy MIO | 100 - 125 | Acrylic/Urethane | 50 |
| **Internal steel** | | | | | | |
| I-1 | None | | None | | None | |
| I-2 | Epoxy Zinc Phosphate | 50 | None | | Acrylic/Urethane | 50 |
| I-3 | Epoxy Zinc Rich | 50 | None | | None | |
| I-4 | Epoxy Primer / Finish | 125 | None | | None | |
| E-2 | Epoxy Zinc Phosphate | 75 | Epoxy MIO | 125 | Acrylic/Urethane | 50 |

(1) See CIRIA publication 174 “New paint systems for the protection of construction steelwork” for link between environmental classification according to BS EN ISO 12944-2 and the predicted durability of the coating system in terms of life to first maintenance.

(2) Nominal dry film thickness in microns.

(3) Surface preparation required – blast clean to Sa2½ of BS EN ISO 8501-1 except for Spec I-1 which requires no surface preparation.

(4) Applied on site.

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