

# Structural use of steelwork in building —

## Part 2: Specification for materials, fabrication and erection — Rolled and welded sections

ICS 91.080.10

## Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/521, Execution of steel structures, upon which the following bodies were represented:

British Constructional Steelwork Association

Cold Rolled Sections Association

DETR (Construction Directorate)

DETR (Highways Agency)

Health and Safety Executive

Institution of Civil Engineers

Institution of Structural Engineers

Steel Construction Institute

UK Steel Association

Welding Institute

This British Standard, having been prepared under the direction of the Sector Policy and Strategy Committee for Building and Civil Engineering, was published under the authority of the Standards Policy and Strategy Committee on  
24 August 2001

© BSI 24 August 2001

First published December 1985

Second edition March 1992

Third edition August 2001

The following BSI references relate to the work on this standard:

Committee reference B/521

Draft for comment 99/100269 DC

### Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 33304 3

# Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
Section 1. General	1
1.1 Scope	1
1.2 Normative references	1
1.3 Definitions	3
Section 2. Materials	5
2.1 Structural steel	5
2.2 Fasteners	5
2.3 Welding consumables	7
2.4 Steel castings and forgings	7
2.5 Bedding materials	7
Section 3. Fabrication	9
3.1 General	9
3.2 Identification	9
3.3 Cutting	9
3.4 Holing	9
3.5 Contact surfaces of preloaded friction grip connections	10
3.6 Direct contact bearing of cross-sections	10
3.7 Surface imperfections	10
Section 4. Assembly	11
4.1 General	11
4.2 Welding	11
4.3 Bolting	11
4.4 Movement joints	12
4.5 Marking for erection	12
4.6 Protective treatment	12
Section 5. Erection	15
5.1 Delivery, storage and handling	15
5.2 Erection methods	15
5.3 Accuracy of construction	15
Section 6. Supports and foundations	17
6.1 Installation and positioning of foundation bolts	17
6.2 Packings	17
6.3 Bedding of structures	17
Section 7. Tolerances	19
7.1 General	19
7.2 Fabrication tolerances	19
7.3 Erection tolerances	22
Annex A (normative) Final inspection of welds	23
A.1 Visual examination	23
A.2 Non-destructive testing	23
A.3 Stud shear connectors	23
A.4 Weld acceptance criteria and corrective actions	23
A.5 Structures subjected to cyclic loading	23

	Page
Annex B (informative) General recommendations for steelwork tenders and contracts	29
B.1 General	29
B.2 Exchange of information	29
B.3 Information needed by the steelwork designer	29
B.4 Information needed by the tenderer (if not also the steelwork designer)	30
B.5 Detailing	30
B.6 Time schedule	31
B.7 Inspection and testing	31
Annex C (informative) References to the phrase "Project Specification"	32
Bibliography	33
Figure 1 — Maximum punching distortion	10
Table 1 — Structural steel products	5
Table 2 — Matching bolts, nuts and washers	6
Table 3 — Clear threads	11
Table 4 — Tolerances on shape and dimensions	20
Table A.1 — Scope of inspection — Type of joints and thicknesses requiring non-destructive testing	24
Table A.2 — Scope of inspection — Frequency of testing of joints identified in Table A.1 as requiring non-destructive testing	25
Table A.3 — Acceptance requirements for production welds in steel structures	26
Table A.4 — Characteristic defects of production welds in steel structures	28

## Foreword

This part of BS 5950 is a revision of BS 5950-2:1992, which is superseded and withdrawn.

BS 5950 is a standard combining codes of practice covering the design, construction and fire protection of steel structures and specifications for materials, workmanship and erection. It comprises the following parts:

- *Part 1: Code of practice for design — Rolled and welded sections;*
- *Part 2: Specification for materials, fabrication and erection — Rolled and welded sections;*
- *Part 3: Design in composite construction;*
- *Section 3.1: Code of practice for design of simple and continuous composite beams;*
- *Part 4: Code of practice for design of composite slabs with profiled steel sheeting;*
- *Part 5: Code of practice for design of cold-formed thin gauge sections;*
- *Part 6: Code of practice for design of light gauge profiled steel sheeting;*
- *Part 7: Specification for materials and workmanship: cold-formed sections;*
- *Part 8: Code of practice for fire resistant design;*
- *Part 9: Code of practice for stressed skin design.*

Although the main purpose of this part of BS 5950 is to define the materials and workmanship needed for compatibility with the design assumptions of Part 1, its use with other design standards is not precluded.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A British Standard does not purport to include all necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 33 and a back cover.



# Section 1. General

## 1.1 Scope

This part of BS 5950 specifies requirements for the materials, fabrication and erection of structural steelwork in buildings subject primarily to static loading, using rolled and welded sections.

NOTE Although the requirements of this standard can be referred to in contractual documents, they might need to be modified, within the terms of contract, to align with specific contractual obligations. Special requirements will also have to be specified in the project specification. Annex B gives general recommendations for the exchange of information in steelworks tenders and contracts. Annex C identifies references to the project specification.

## 1.2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 4-1, *Structural steel sections — Part 1: Specification for hot-rolled sections.*

BS 29, *Specification for carbon steel forgings above 150 mm ruling section.*

BS 3100, *Specification for steel castings for general engineering purposes.*

BS 3923-1, *Methods for ultrasonic examination of welds — Part 1: Methods for manual examination of fusion welds in ferritic steels.*

BS 4190, *Specification for ISO metric black hexagon bolts, screws and nuts.*

BS 4320:1968, *Specification for metal washers for general engineering purposes: Metric series.*

BS 4395-1, *Specification for high strength friction grip bolts and associated nuts and washers for structural engineering — Part 1: General grade.*

BS 4395-2, *Specification for high strength friction grip bolts and associated nuts and washers for structural engineering — Part 2: Higher grade bolts and nuts and general grade washers.*

BS 4604, *Specification for the use of high strength friction grip bolts in structural steelwork — Metric series.*

BS 4933, *Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts.*

BS 5400-6, *Steel, concrete and composite bridges — Part 6: Specification for materials and workmanship, steel.*

BS 5950-1, *Structural use of steelwork in building — Part 1: Code of practice for design — Rolled and welded sections.*

BS 5964-1, *Building setting-out and measurement — Part 1: Methods of measuring, planning and organization and acceptance criteria.*

BS 5996, *Methods for ultrasonic testing and specifying quality grades of ferritic steel plate.*

BS 6072, *Method for magnetic particle flaw detection.*

BS 7079-A.1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Specification for rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.*

BS 7419, *Specification for holding down bolts.*

BS 7644, *Direct tension indicators.*

BS 7668, *Specification for weldable structural steels — Hot-finished structural hollow sections in weather resistant steels.*

BS EN 287, *Approval testing of welders for fusion welding — Steels.*

BS EN 288-1, *Specification and approval of welding procedures for metallic materials — Part 1: General rules for fusion welding.*

BS EN 288-2, *Specification and approval of welding procedures for metallic materials — Part 2: Welding procedures specification for arc welding.*

BS EN 288-3, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for the arc welding of steels.*

- BS EN 440, *Welding consumables — Wire electrodes and deposits for gas shielded metal arc welding of non-alloy and fine grain steels — Classification.*
- BS EN 499, *Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification.*
- BS EN 571, *Non-destructive testing — Penetrant testing — General principles.*
- BS EN 756, *Welding consumables — Wire electrodes and wire-flux combinations for submerged arc welding of non-alloy and fine grain steels — Classification.*
- BS EN 758, *Welding consumables — Tubular cored electrodes for metal arc welding with and without a gas shield of non-alloy and fine grain steels — Classification.*
- BS EN 970, *Non-destructive examination of fusion welds — Visual examination.*
- BS EN 1011-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding.*
- BS EN 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels.*
- BS EN 1668, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine grain steels — Classification.*
- BS EN 10024, *Hot-rolled taper flange I sections — Tolerances on shape and dimensions.*
- BS EN 10025, *Hot-rolled products of non-alloy structural steels: Technical delivery conditions.*
- BS EN 10029, *Specification for tolerances on dimensions, shape and mass for hot-rolled steel plates 3 mm thick or above.*
- BS EN 10034, *Structural steel I and H sections — Tolerances on shape and dimensions.*
- BS EN 10051, *Specification for continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels — Tolerances on dimensions and shape.*
- BS EN 10055, *Hot-rolled steel equal flange tees with radiused root and toes — Dimensions and tolerances on shape and dimensions.*
- BS EN 10056-1, *Specification for structural steel equal and unequal angles — Part 1: Dimensions.*
- BS EN 10056-2, *Specification for structural steel equal and unequal angles — Part 2: Tolerances on shape and dimensions.*
- BS EN 10113, *Hot-rolled products in weldable fine grain structural steels.*
- BS EN 10137-2, *Plates and wide flats made of high yield strength structural steels in the quenched and tempered or precipitation hardened conditions — Part 2: Delivery conditions for quenched and tempered steels.*
- BS EN 10155, *Structural steels with improved atmospheric corrosion resistance — Technical delivery conditions.*
- BS EN 10163, *Specification for delivery requirements for surface conditions of hot-rolled steel plates, wide flats and sections.*
- BS EN 10164, *Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions.*
- BS EN 10204, *Metallic products — Types of inspection documents.*
- BS EN 10210-1, *Hot-finished structural hollow sections of non-alloy and fine grain structural steels — Part 1: Technical delivery requirements.*
- BS EN 10210-2, *Hot-finished structural hollow sections of non-alloy and fine grain structural steels — Part 2: Tolerances, dimensions and sectional properties.*
- BS EN 10219-1, *Cold-formed welded structural sections of non-alloy and fine grain steels — Part 1: Technical delivery requirements.*
- BS EN 10219-2, *Cold-formed welded structural sections of non-alloy and fine grain steels — Part 2: Tolerances, dimensions and sectional properties.*
- BS EN 10279, *Hot-rolled steel channels — Tolerances on shape, dimension and mass.*



BS EN ISO 4014, *Hexagon head bolts — Product grades A and B.*

BS EN ISO 4016, *Hexagon head bolts — Product grade C.*

BS EN ISO 4017, *Hexagon head screws — Product grades A and B.*

BS EN ISO 4018, *Hexagon head screws — Product grade C.*

BS EN ISO 4032, *Hexagon nuts, style 1 — Product grades A and B.*

BS EN ISO 4033, *Hexagon nuts, style 2 — Product grades A and B.*

BS EN ISO 4034, *Hexagon nuts — Product grade C.*

BS EN ISO 7091, *Plain washers — Normal series — Product grade C.*

BS EN ISO 8503-1, *Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast.*

BS EN ISO 12944-4, *Paints and varnishes. Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation.*

BS EN ISO 12944-7, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 7: Execution and supervision of paintwork.*

ISO 10721-2, *Steel structures — Part 2: Fabrication and erection.*

EU 91, *Hot-rolled wide flats — Tolerances on dimensions, shape and mass.*

### 1.3 Definitions

For the purposes of this part of BS 5950, the following definitions shall apply.

#### 1.3.1

##### **project specification**

documentation covering technical data and requirements for a particular project that need to be specified to supplement and qualify the requirements of this British Standard

NOTE This includes all documentation that specifies requirements for execution including fabrication and erection drawings.

#### 1.3.2

##### **thermal cutting**

flame cutting, plasma cutting and or laser cutting

#### 1.3.3

##### **fastener**

threaded bolt (possibly with a nut and/or one or more washers) or an alternative mechanical device capable of serving the same purpose



## Section 2. Materials

### 2.1 Structural steel

#### 2.1.1 General

Unless stated otherwise in the project specification all structural steel products shall conform to the relevant British Standards in Table 1.

**Table 1 — Structural steel products**

Product	Technical delivery requirements <sup>a</sup>				Dimensions	Tolerances			
	Non-alloy steels	Fine grain steels	Quenched and tempered steels	Weathering steels					
Universal beams and columns	BS EN 10025 <sup>b</sup>	BS EN 10113	BS EN 10137-2 <sup>c</sup>	BS EN 10155	BS 4-1	BS EN 10034			
Joists					BS 4-1	BS EN 10024			
Channels					BS 4-1	BS EN 10279			
Angles					BS EN 10056-1	BS EN 10056-2			
Rolled T sections					BS EN 10055	BS EN 10055			
Split T sections					BS 4-1	—			
Plates (reversing mill)					—	BS EN 10029			
Plates (cut from coil)					—	BS EN 10051			
Wide flats					—	EU 91			
Hot finished hollow sections					BS EN 10210-1	—	BS 7668	BS EN 10210-2	BS EN 10210-2
Cold-formed hollow sections					BS EN 10219-1	—	—	BS EN 10219-2	BS EN 10219-2

<sup>a</sup> Certain product grades do not have a specified maximum manganese content or are not supplied with carbon equivalent value (CEV) options. Additional requirements might therefore need to be specified and agreed at the time of order.

<sup>b</sup> Grades S235, S275 and S355 only, excluding rimming steel grades S235JR and S235JRG1.

<sup>c</sup> Only plates and wide flats grade S460.

In the areas shown on the project drawings, the material shall be tested for laminations to the specified acceptance level in accordance with BS 5996.

#### 2.1.2 Through thickness properties

In the areas shown on the project drawings, the material shall be tested for through thickness properties to the specified quality class in accordance with BS EN 10164.

#### 2.1.3 Inspection and testing

Structural steels for use in design conforming to BS 5950-1 shall receive specific inspection and testing in accordance with the relevant product standard.

A manufacturer's certificate of test and inspection shall be issued conforming to BS EN 10204, stating the process of manufacture and giving the product grade, the ladle analysis and the results of each of the mechanical tests applicable to the material supplied. The certificate shall indicate the numbers or identification marks of the product to which it applies, corresponding to those on the material supplied. In the case of sections with flanges, the certificate shall indicate whether the sample for test purposes was taken from the web or the flange.

NOTE Specific inspection and testing of certain grades of steel needs to be requested at the time of the enquiry and order.

## 2.2 Fasteners

Assemblies of bolts, nuts and washers shall correspond to one of the matching combinations in Table 2.

Preloaded fasteners shall generally be HSBG bolts, with associated nuts and washers. Direct tension indicators shall conform to BS 7644.

Other types of preloaded fasteners may be used provided that they can be reliably tightened to at least the minimum shank tensions specified in BS 4604.

Table 2 — Matching bolts, nuts and washers

Type of bolts		Nuts		Washers	
Grade	Standard	Class or grade <sup>c</sup>	Standard	Class	Standard
<i>Non-preloaded bolts</i>					
4.6	BS EN ISO 4016 BS EN ISO 4018	Class 4 <sup>d</sup>	BS EN ISO 4034	100 HV	BS EN ISO 7091
	BS 4190 BS 4933 <sup>a</sup>	Grade 4	BS 4190	—	BS 4320 <sup>i</sup>
8.8	BS EN ISO 4014 <sup>b</sup> BS EN ISO 4017 <sup>b</sup>	Class 8 <sup>e</sup>	BS EN ISO 4032 <sup>b</sup>	100 HV	BS EN ISO 7091
	BS 4190	Grade 8 <sup>f</sup>	BS 4190	—	BS 4320 <sup>i</sup>
10.9	BS EN ISO 4014 <sup>b</sup> BS EN ISO 4017 <sup>b</sup>	Class 10 <sup>g</sup>	BS EN ISO 4032 <sup>b</sup>	100 HV	BS EN ISO 7091
	BS 4190	Grade 10 <sup>h</sup>	BS 4190	—	BS 4320 <sup>i</sup>
<i>Non-preloaded HSFGB bolts</i>					
General grade	BS 4395-1	General grade	BS 4395-1	—	BS 4320 <sup>j</sup>
Higher grade	BS 4395-2	Higher grade	BS 4395-2	—	BS 4320 <sup>j</sup>
<i>Preloaded HSFGB bolts</i>					
General grade	BS 4395-1	General grade	BS 4395-1	—	BS 4395-1 <sup>k</sup>
Higher grade	BS 4395-2	Higher grade	BS 4395-2	—	BS 4395-2 <sup>k</sup>
<i>Holding down bolts</i>					
4.6	BS 7419	Grade 4	BS 4190	—	BS 4320 <sup>i</sup>
8.8	BS 7419	Grade 8 <sup>f</sup>	BS 4190	—	BS 4320 <sup>i</sup>
8.8 preloaded	BS 7419	General grade	BS 4395-1	—	BS 4395-1 <sup>k</sup>
<sup>a</sup> BS 4933 has been declared obsolescent, but should still be used for 90° countersunk head bolts and cup head bolts until corresponding BS EN standards are available. <sup>b</sup> Grade 8.8 and 10.9 bolts to the strength grades of BS EN ISO 4014 or BS EN ISO 4017 but with the dimensions and tolerances specified in BS EN ISO 4016 or BS EN ISO 4018 may also be used, with matching nuts to the strength classes of BS EN ISO 4032 but the dimensions and tolerances of BS EN ISO 4034. <sup>c</sup> Nuts of a higher class or grade may also be used. <sup>d</sup> Class 5 nuts for size M 16 and smaller. <sup>e</sup> Nuts for galvanized or sherardized 8.8 bolts shall be class 10. <sup>f</sup> Nuts for galvanized or sherardized 8.8 bolts shall be grade 10 to BS 4190. <sup>g</sup> Nuts for galvanized or sherardized 10.9 bolts shall be class 12 to BS EN ISO 4033. <sup>h</sup> Nuts for galvanized or sherardized 10.9 bolts shall be grade 12 to BS 4190. <sup>i</sup> Black steel washers to section 2 of BS 4320, normal diameter series. <sup>j</sup> Black steel washers to BS 4320:1968, Section 2, large diameter series. <sup>k</sup> Direct tension indicators to BS 7644 may also be used with preloaded HSFGB bolts.					

### 2.3 Welding consumables

Unless otherwise stated, all welding consumables including covered electrodes, wires, filler metals, flux and shielding gases for metal arc welding shall be selected from BS EN 440, BS EN 499, BS EN 756, BS EN 758, or BS EN 1668 as appropriate (see 4.2.2).

### 2.4 Steel castings and forgings

Steel castings and forgings shall conform to BS 3100 and BS 29 respectively.

### 2.5 Bedding materials

Bedding materials for steel bases or bearing plates on concrete foundations shall be of one of the following forms:

- a) neat cement of a thickness not exceeding 25 mm;
- b) fluid cement of a thickness between 25 mm and 50 mm;
- c) dry as possible cement mortar of thickness not less than 50 mm;
- d) special grouts:
  - i) mortar or fine concrete containing suitable admixtures, including the use of expanding additives to avoid shrinkage;
  - ii) expanding grout;
  - iii) resin based grout.



## Section 3. Fabrication

### 3.1 General

Fabricated structural steelwork shall be within the tolerances specified in Section 7. Steel may be bent, pressed or forged to the required shape either by the hot or the cold forming processes, provided the properties conform to those specified in the product standard for the material and the material has not been significantly defaced.

The following fabrication restrictions shall be applied in the relevant areas shown in the project drawings:

- a) hard stamping, see **3.2**;
- b) thermal cutting, see **3.3**;
- c) full size hole punching, see **3.4.2.3**.

NOTE Design considerations affecting these restrictions are given in BS 5950-1.

### 3.2 Identification

At all stages of fabrication, structural steel members shall be positively identified by a marking scheme. Every part shall be marked with a durable and distinguishing mark in such a way as not to damage the material.

Marking or hard stamping shall not be carried out on any areas of steelwork defined in the project drawings as areas to be kept free from marking or hard stamping.

### 3.3 Cutting

Cutting shall be by sawing, shearing, cropping, or thermal cutting (see **1.3.2**). Hand-held cutting shall be used only where it is impractical to use machine cutting, for notching, or for the completion of the formation of slotted holes.

Cut edges shall be true to profile and be free from major notches and cutting serrations and shall be dressed where necessary.

Thermal cutting shall not be carried out on areas defined in the project specification as areas where thermal cutting is not permitted.

### 3.4 Holing

#### 3.4.1 General

Round holes for fasteners or pins shall either be drilled, punched, plasma cut or laser cut.

Slotted holes (including kidney-shaped slots) shall either be punched in one operation, plasma cut, laser cut, or formed by drilling two holes and completed by cutting.

All matching holes for fasteners or pins shall register with each other so that fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact.

#### 3.4.2 Ordinary fasteners

##### 3.4.2.1 Drilling

Burrs shall be removed from holes before assembly except that, where holes are drilled in one operation through parts clamped together that would not otherwise be separated after drilling, they need not be separated to remove the burrs.

##### 3.4.2.2 Punching before reaming

Holes shall be punched at least 2 mm smaller in diameter than the required size and subsequently reamed to the full diameter.

##### 3.4.2.3 Full size hole punching

Holes shall not be punched full size in any areas specified in the project specification as areas where full size holes should not be punched, see **3.1**.

Where holes are punched full size all the following conditions shall be satisfied.

a) The appropriate steel quality (related to Charpy impact value) for punched unreamed holes shall be selected in accordance with BS 5950-1.

b) The punching operations shall not distort the material by more than 10 % of the diameter of the hole, see Figure 1.

$$\Delta \leq D \times 0.10$$

c) The holes shall be free from burrs, which would prevent solid seating of the parts when tightened.

d) The thickness of the material through which the hole is punched shall not exceed 30 mm nor shall it exceed the diameter of the hole.

e) In spliced connections, the holes in the mating surfaces shall be punched from the same direction and the splice plates marked to show the assembly faces, if packed separately.

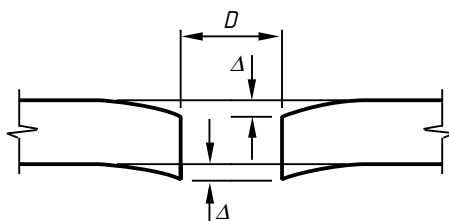


Figure 1 — Maximum punching distortion

#### 3.4.2.4 Hole size

The nominal size of bolt holes shall be greater than the bolt size by not more than 1 mm for bolt size M12, 2 mm for bolt sizes M16 to M24, and 3 mm for bolt sizes M27 and larger, except in steel baseplates and where otherwise specified in the project specification.

#### 3.4.3 Preloaded fasteners

Holes for preloaded fasteners shall be in accordance with BS 4604.

### 3.5 Contact surfaces of preloaded friction grip connections

All contact surfaces in friction grip connections shall be prepared to the condition given in the project specification (see BS 5950-1).

### 3.6 Direct contact bearing of cross-sections

Where the cross-section at the end of a member bears directly on another steel surface, and is required in the project specification to have full contact bearing, the steel surfaces transmitting the load shall be within the tolerances specified in clause 7.

### 3.7 Surface imperfections

Surface imperfections occurring from the fabrication process of steelwork to be subsequently painted shall be in accordance with the preparation grade specified in BS EN ISO 8501-3, in accordance with the project specification (see 4.2.5 and 4.6.7.4).



## Section 4. Assembly

### 4.1 General

The connected components shall be drawn together such that they achieve firm contact. At this stage residual gaps are permitted between contact faces except where full contact is required in the project specification. A gap shall not exceed 2 mm except in friction grip connections where a gap shall not exceed 1 mm. Shims may be used to adjust the fit.

Bolts, nuts and washers used to connect metal sprayed or galvanized steelwork shall be galvanized, sherardized or electroplated.

### 4.2 Welding

#### 4.2.1 General

Welding of structural steel shall be in accordance with BS EN 1011-1 and BS EN 1011-2 unless another process is specifically permitted in the project specification.

#### 4.2.2 Welding procedures

Welding of joints shall be undertaken using welding procedure specifications in accordance with BS EN 288-1 and BS EN 288-2, which shall have been qualified in accordance with BS EN 288-3.

Unless otherwise specified the welding consumables shall be such that the mechanical properties of deposited weld metal are not less than the specified minimum values in the product standard for the parent metal being welded.

#### 4.2.3 Welders

All welders shall be approved to BS EN 287-1 according to the welding conditions appropriate to the project.

#### 4.2.4 Inspection and testing

All welds shall be inspected and tested according to the requirements of Annex A. Any additional inspection and testing, specified in the project specification shall be carried out.

#### 4.2.5 Surface preparation

The surface preparation of welds to be subsequently painted shall be in accordance with the preparation grade selected from those specified in BS EN ISO 8503-1 in accordance with the project specification (see 3.7).

### 4.3 Bolting

#### 4.3.1 Length of fasteners

All bolt shanks shall protrude beyond the end of the nut by at least one thread pitch after tightening.

NOTE Using a bolt with at least one further full thread pitch in addition to the theoretical length required will normally ensure adequate allowance for tolerances.

The minimum number of full threads (in addition to the thread run-out) that shall remain clear between the bearing surface of the nut and the unthreaded part of the shank shall be in accordance with Table 3.

**Table 3 — Clear threads**

Type of bolts	Grade 4.6	Grade 8.8 <sup>a</sup>	Grade 10.9 <sup>b</sup>
Non-preloaded in shear only	1	1	1
Non-preloaded otherwise	1	1	5
Preloaded	—	3	5

<sup>a</sup> Including general grade bolts to BS 4395-1.  
<sup>b</sup> Including higher grade bolts to BS 4395-2.

#### 4.3.2 Washers

Washers need not be provided unless required in the project specification, except where over-size or slotted holes are used. For the use of direct tension indicating washers, reference should be made to BS 7644.

#### 4.3.3 Nuts

No measures beyond proper tightening need be taken to secure nuts unless otherwise specified in the project specification.

Where required in the project specification, nuts used on connections subject to vibration shall be secured to prevent loosening using a suitable method, i.e. self-locking nuts, locknuts, or upsetting of the threads of the bolts after assembly and tightening.

#### 4.3.4 Friction grip bolting

The use of fasteners conforming to BS 4395 in friction grip connections shall be in accordance with BS 4604.

For friction grip connections where the surfaces are not parallel, a suitably tapered washer shall be provided under the rotated head or nut. Such washers shall also be used under the non-rotated component except where the angle between bolt axis and contact surface is within the limits of 87° to 93°.

Where the use of other types of preloaded fasteners in friction grip connections is permitted by the project specification, the fasteners shall be installed in accordance with the manufacturer's recommendations and shall be tightened to at least the minimum preload specified in BS 4604.

### 4.4 Movement joints

Where movement joints are required, the assembly shall allow the connection to be free to move to its full extent.

### 4.5 Marking for erection

Components that are individually assembled or erected at the site shall be allocated an erection mark. Those that are identical in all respects may have the same erection mark.

A component shall be marked with its erected orientation if this is not clear from its shape.

Marks shall be placed, where possible, in positions where they will be visible in storage and after erection.

Marking methods shall conform to 3.2.

### 4.6 Protective treatment

#### 4.6.1 Specification

Any surface preparation, off-site and site protective treatments specified in the project specification shall be carried out.

NOTE Some advice and guidance on corrosion prevention coatings is given in BS EN ISO 12944 for painting systems and BS EN ISO 14713 for metallic coatings.

#### 4.6.2 Method statement

The steelwork contractor shall provide a written method statement, giving sequential details of the surface preparation and protective treatment procedure (including touching-in procedures) to be used in achieving the requirements of the project specification.

#### 4.6.3 Painting

Painting shall be carried out in accordance with the recommendations given in BS EN ISO 12944-7.

#### 4.6.4 Storage of materials

Protective treatment materials shall be stored in a clean, dry area that is protected from extreme temperatures, and used in accordance with the manufacturer's recommendations and within the shelf life recommended by the manufacturer.

#### 4.6.5 Application procedures

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

#### **4.6.6 Handling and storage of protected steelwork**

The procedures for handling and storage shall be so arranged that the protected surface is unlikely to be damaged.

#### **4.6.7 Surface preparation**

##### **4.6.7.1 General**

Work shall be carried out in accordance with the recommendations in BS EN ISO 12944-4.

##### **4.6.7.2 Wire brushing**

Surfaces that are not to be blast cleaned, but are to be coated, shall be wire brushed to remove loose mill scale, and cleaned to remove dust, oil and grease.

##### **4.6.7.3 Blast cleaning**

Blast cleaning shall conform to BS 7079-A.1.

The methods used shall be capable of cleaning all surfaces of the component.

The surface roughness and cleanliness levels shall be compatible with those recommended for the coating to be applied.

When abrasives are recycled in the blast cleaning system, the equipment shall be fitted with a dust removal system to remove fines and contaminants.

##### **4.6.7.4 Surface imperfections**

Surface imperfections revealed during surface preparation shall be rectified in accordance with the requirements of BS EN 10163, BS EN 10210-1, or BS EN 10219-1 as appropriate for the product (see 3.7).



## Section 5. Erection

### 5.1 Delivery, storage and handling

Fabricated parts shall be handled and stacked in such a way that permanent deformation does not occur and surface damage to the steel is minimized. Means shall also be provided to minimize damage to the protective treatment on the steelwork.

All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion, and adequately protect all machined surfaces. All bolts, nuts, washers, and small parts shall be suitably packed and identified.

### 5.2 Erection methods

The steelwork contractor shall prepare a written method statement consistent with the construction health and safety plan.

NOTE For guidance, BS 5531 should be followed.

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

Throughout the erection of the structure, the steelwork shall be securely bolted or fastened in order to ensure that it can adequately withstand all loading liable to be encountered during erection, including, where necessary, those from the erection plant and its operation. Any temporary bracing or temporary restraint shall be left in position until erection is sufficiently advanced to leave the remaining structure in a stable and safe condition.

### 5.3 Accuracy of construction

Unless otherwise required by the project specification, the accuracy with which the steelwork is assembled and erected shall be as required in Section 7.

When measurements are made for setting-out and erection, and for dimensional checks carried out subsequently, due account shall be taken of the effects of temperature on the structure and measuring instruments in accordance with BS 5964-1.



## Section 6. Supports and foundations

### 6.1 Installation and positioning of foundation bolts

Foundation bolts shall be set out within the limits for position and level specified in 7.3.1.

Foundation bolts shall be held firmly in position during all installation operations. Care shall be taken to ensure that the intended range of adjustment specified in 7.3.1.4 can be obtained.

Bolts, threads and nuts shall be fully protected against damage, cement grout, corrosion, etc. at all stages of construction.

Where tubes are to be concreted into foundations for grouting of bolt pockets at a later stage, they shall be securely fixed and effectively sealed to prevent ingress of grout from the surrounding concrete during placing operations.

Pockets formed around foundation bolts shall be kept clean and free from debris, water, or other harmful materials.

Proprietary bolting systems shall be used in accordance with the manufacturer's recommendations.

### 6.2 Packings

Packs, shims and other supporting devices shall be made of flat steel. Where packings are to be left in position and subsequently grouted they shall be placed such that they are totally enclosed by the grout.

### 6.3 Bedding of structures

#### 6.3.1 Preparation

No grouting shall be carried out until a sufficient portion of the structure (for multi-storey buildings, a sufficient number of bottom lengths of columns) has been aligned, levelled, plumbed and adequately braced by other structural components that have been levelled and are securely held by their permanent connections.

Immediately before grouting, the space under the steel shall be clear of all debris, water and other harmful materials.

#### 6.3.2 Grouting

Grouting shall be carried out as follows.

- a) Neat cement of a thickness not exceeding 25 mm. The grout shall be mixed as thickly as possible consistent with fluidity and shall be poured under a suitable head so that the space is completely filled.
- b) Fluid cement mortar of a thickness between 25 mm and 50 mm. The mortar shall not be leaner than 1:1 cement to fine aggregate and shall be mixed as thickly as possible consistent with fluidity. The mortar shall then be poured under a suitable head and tamped until the space has been completely filled.
- c) Dry as possible cement mortar of thickness not less than 50 mm. The mortar shall not be leaner than 1:2 cement to fine aggregate and shall be consolidated by thoroughly ramming with a suitable blunt rammer against properly fixed supports until the space has been completely filled.
- d) Special grouts. These shall be used in accordance with the manufacturer's recommendations.

#### 6.3.3 Bedding columns in pocket bases

Columns in pocket bases shall be grouted with fine dense concrete having a characteristic cube strength at 28 days not less than that of the surrounding concrete base nor less than 25 N/mm<sup>2</sup>, and with a maximum aggregate size of 10 mm. The pocket shall be filled initially with concrete up to a height of at least two-thirds of the embedded length of the column and shall then remain undisturbed for at least 48 h.





## Section 7. Tolerances

### 7.1 General

Notwithstanding the specified tolerances on fabricated components of the structure, it shall be erected to conform to the erection tolerances in 7.3.

Additional or different tolerances may be specified where necessitated by the nature of the particular building or structure under consideration. Such tolerances should be compatible with the design recommendations and product standards.

NOTE Tolerances set out in this section are those required to conform to design assumptions in BS 5950-1 and therefore override the corresponding values given in BS 5606 clause 10.

### 7.2 Fabrication tolerances

#### 7.2.1 Rolled sections

After fabrication, the tolerances on cross-sections and straightness of rolled sections (including rolled sections used as components of built-up members) shall be as specified in the appropriate product standard, see Table 1.

#### 7.2.2 Built-up members

##### 7.2.2.1 Cross-section

For built-up I- or H-section members with an overall depth of less than 1m, the tolerances on the cross-section shall conform to those specified for rolled I- and H-sections in BS EN 10034.

For all other built-up sections and I- and H-sections with an overall depth greater than 1m, the deviations from the specified dimensions shall not exceed those specified in Table 4.

Built-up box sections shall not deviate from the specified shape at the diaphragm by more than that specified in Table 4.

##### 7.2.2.2 Straightness and curvature

Unless required to be any other shape, the deviation of a built-up member from a straight line drawn between adjacent points of subsequent effective lateral restraint shall not exceed 3 mm or  $l/1\ 000$  whichever is the greater, where  $l$  is the distance between restraints (in mm).

For members intended to be curved, the curvature shall not deviate from the specified curvature by more than the tolerance specified in Table 4.

##### 7.2.2.3 Length and squareness of ends

The length of members and squareness of the ends of members shall conform to the tolerances specified in Table 4.

#### 7.2.3 Flatness for full contact bearing

Where a surface is stated in the project specification to require full contact bearing, the flatness shall be such that when measured against a straight-edge laid against the full length of the bearing surface in any direction:

- a) over at least 50 % of the length measured the gap does not exceed 0.25 mm; and
- b) over 90 % of the length measured the gap does not exceed 0.75 mm.

Table 4 — Tolerances on shape and dimensions

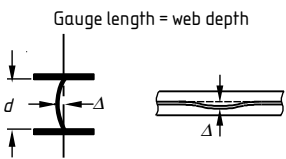
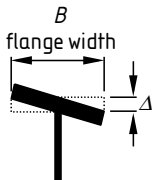
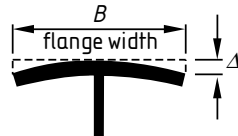
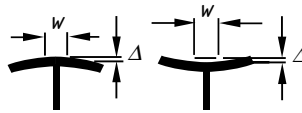
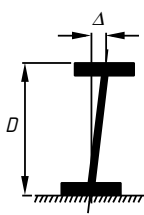
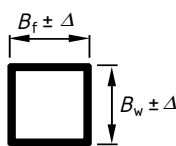
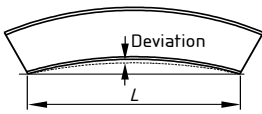
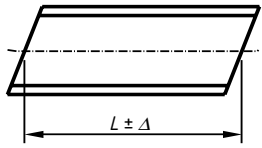
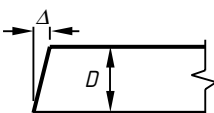
Dimension	Condition	Tolerance
a) Distortion of web on a gauge length in any direction equal to the web depth $d$ of the girder.  		$\Delta = d/150$ or 3 mm whichever is greater
b) Overall depth, $D$		$\pm 4$ mm
c) Width of flanges	$B < 300$ mm $B \geq 300$ mm	$\pm 3$ mm $\pm 5$ mm
d) Off-centre of web		$\pm 5$ mm
e) Out-of-squareness of flanges  		$\Delta = B/100$ or 3 mm whichever is greater
f) Out-of-flatness of flanges  		$\Delta = B/150$ or 3 mm whichever is greater
g) Top flange of crane girder, out-of-flatness where rail sits  		$W = \text{Rail width} + 20$ mm $\Delta = 1$ mm

Table 4 — Tolerances on shape and dimensions (concluded)

Dimension	Condition	Tolerance
h) Deviation from verticality of the web at its support points. 		$\Delta = D/300$ or 3mm whichever is greater.
i) Box section 	$B_f < 300$ mm $B_f \geq 300$ mm $B_w < 300$ mm $B_w \geq 300$ mm	$\Delta = \pm 3$ mm $\Delta = \pm 5$ mm $\Delta = \pm 3$ mm $\Delta = \pm 5$ mm
j) Curvature measured as the deviation from intended curve or camber at mid-length of curved portion when measured with the uncambered side horizontal. 		Deviation = $L/1000$ or 6 mm whichever is greater
k) Length measured on the centreline of the section or on the corner of an angle. 	Cut length  Length, $L$ of component with both ends finished for full contact bearing including end plates as applicable	$\Delta = \pm 3$ mm
l) Squareness of ends: 	Squareness to longitudinal axis:  — not finished for full contact bearing — finished for full contact bearing	$\Delta = \pm D/300$ $\Delta = \pm D/1000$

## 7.3 Erection tolerances

### 7.3.1 Connection to concrete elements

#### 7.3.1.1 Reference system

The position points, which mark the intended position for the erection of individual components, shall be in accordance with BS 5964-1.

Deviations of supports shall be measured relative to a secondary system set out in accordance with BS 5964-1.

Deviations of erected components shall be measured relative to their position points. If a position point is not established, deviations shall be measured relative to the secondary system.

#### 7.3.1.2 Position

The position of the centre of any bolt at the point where it connects to the steelwork shall not vary by more than  $\pm 3$  mm from its specified position for bolts rigidly cast in, and  $\pm 10$  mm for bolts in sleeves. The position of the other end of the bolt shall be set such that the resulting slope of the bolt can be accommodated by the clearance provided in the bolt holes.

#### 7.3.1.3 Projection of bolt end

The projection of the end of the bolt shall not deviate from that specified in the project specification by more than the following:

- a) for bolts set vertically  $+25$  mm or  $-5$  mm;
- b) for bolts set horizontally  $+45$  mm or  $-5$  mm.

#### 7.3.1.4 Adjustment clearance for bolts in sleeves

The sleeve provided shall allow the required adjustment, see 7.3.1.2.

NOTE A movement of  $\pm 25$  mm is normally sufficient.

### 7.3.2 Position in plan of column bases

The position in plan of a steel column at its base shall not deviate from the specified position by more than 5 mm along either of the principal setting-out axes.

### 7.3.3 Plumbing of columns

#### 7.3.3.1 Single storey columns

The deviation of the top of a single storey column (excluding in-plane deviations of portal frame columns) from its specified position relative to its base shall not exceed the greater of 5 mm or  $1/600$  of the height from base to top in any direction.

#### 7.3.3.2 Multi-storey columns (not exceeding 10 storeys)

The deviations of the columns at any level shall not exceed the greater of 5 mm or  $1/600$  of the storey height over the actual positions of the columns at the level immediately below.

The deviations of the columns at the topmost storey relative to required positions at the foundations shall not exceed 5 mm per storey.

NOTE 1 The in-plane plumb of columns for portal frames and the plumb of multi-storey buildings over 10 storeys should be as specified in the project specification. Guidance on the plumb of columns can be found in ISO 10721-2 and DD ENV 1090-1.

NOTE 2 Any special requirements for columns adjacent to the façade or the lifts etc. specified in the project specification should also be fulfilled.

### 7.3.4 Position in plan of members

Members other than columns shall not deviate from their specified position relative to the adjacent columns by more than 5 mm.

### 7.3.5 Levels

The level of the top of the beams at any storey shall be within  $\pm 10$  mm of the specified level at the supporting columns. The levels of the two ends of the same beam shall not vary by more than the lesser of  $\text{span}/500$  or 10 mm.

## **Annex A (normative)**

### **Final inspection of welds**

#### **A.1 Visual examination**

Unless otherwise specified in the project specification all welds shall be visually inspected in accordance with BS EN 970 before any non-destructive testing (NDT) is performed. Any welds that will be rendered inaccessible by subsequent work shall be examined prior to the loss of access.

#### **A.2 Non-destructive testing**

##### **A.2.1 Scope of testing**

Unless otherwise stated in the project specification, NDT methods shall be applied to the relevant joint types and thicknesses in accordance with Table A.1. The frequency of testing of joints requiring NDT according to Table A.1 shall be determined in accordance with Table A.2 unless otherwise stated in the project specification.

##### **A.2.2 Methods of NDT**

###### **A.2.2.1 Surface flaw detection**

Magnetic particle inspection (MPI) shall be carried out in accordance with BS 6072.

Dye penetrant inspection (DPI) shall be carried out in accordance with BS EN 571. DPI may be used in place of MPI where specified by the project specification.

###### **A.2.2.2 Ultrasonic inspection**

Ultrasonic inspection shall be carried out in accordance with BS 3923-1 to Examination Level 2B.

###### **A.2.2.3 Other methods**

Radiographic examination shall not be used unless required by the project specification.

#### **A.3 Stud shear connectors**

Stud shear connectors shall be tested in accordance with BS 5400-6, unless otherwise required by the project specification.

#### **A.4 Weld acceptance criteria and corrective actions**

All welds shall conform to the quality requirements of Table A.3, which also provides requirements for corrective actions in the event of non-conformances.

#### **A.5 Structures subjected to cyclic loading**

For structures subjected to many cycles of loading, e.g. crane girders, vibrating machinery supports etc. the scope of inspection and weld acceptance criteria shall be reviewed. The guidance on this matter given in ISO 10721-2 shall be followed. For the purpose of comparison with the weld qualities given in that standard "normal quality" may be assumed to be equivalent to that given in this annex.

Table A.1 — Scope of inspection — Type of joints and thicknesses requiring non-destructive testing

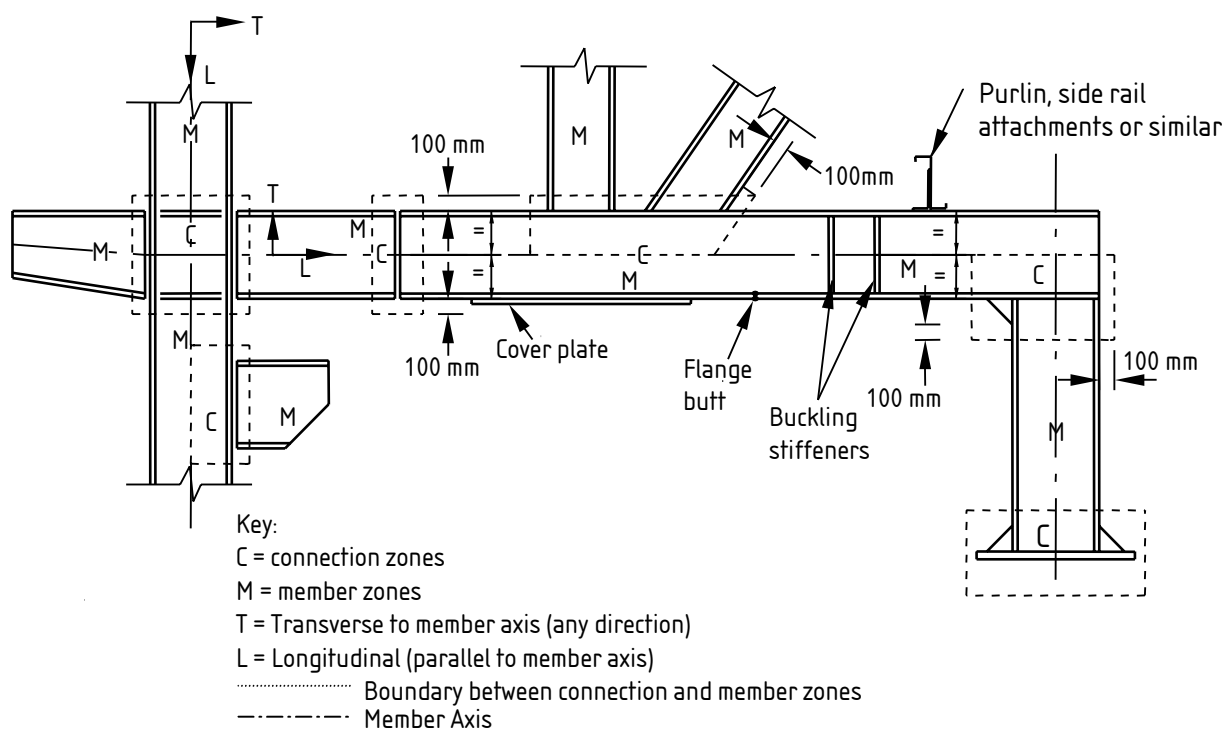
Weld type	Butts full and partial penetration (including butts with reinforcing fillets)						Fillet	
Joint type	In-line butt		Tee and cruciform		Corner	Lap	Tee, cruciform and corner	
Procedures	S/S	D/S and S/S+B	S/S	D/S and S/S+B	All	All	All	
Key	Examples							
$t$ = greatest $t$ at a joint $z$ = greatest $z$ at a joint S/S = single sided D/S = double sided +B = backing NM = not mandatory								
NDT Method	Grade	$t$ (mm)	$t$ (mm)	$t$ (mm)	$t$ (mm)	$t$ (mm)	$t$ (mm)	$z$ (mm)
Magnetic particle inspection	S275/S355	<10	<12	≥20	≥20	≥20	≥20	NM
	S460	<10	<10	≥15	≥15	≥15	≥15	≥15
Ultrasonic testing	S275/S355	≥10	≥12	≥12	≥20	≥30	NM	≥20
	S460	≥10	≥10	≥10	≥20	≥20	NM	≥15

NOTE The requirements of this table shall not preclude the use of non-destructive testing outside the limits shown should the results of visual inspection or non-destructive testing (NDT) indicate that a lapse in quality may have occurred in specific joints.

**Table A.2 — Scope of inspection — Frequency of testing of joints identified in Table A.1 as requiring non-destructive testing**

Categories of joint types according to location and orientation in structure (see figure below)		Frequency of testing <sup>a</sup>
<b>Connection zones</b>	Shop welds	First 5 identified joints of each type having the same basic dimensions, material grades and weld geometry and welded to the same procedures. Thereafter, 1 in 5 joints of each type (if the first 5 conform to Table A.3). <sup>b</sup>
	Site welds	All identified joints
<b>Member zones</b>	Built-up members	Transverse butts in web and flange plates before assembly
		Transverse fillet welds at ends of lap joints
	Longitudinal welds	0.5 m in each 10 m, or part thereof <sup>b</sup>
	Secondary attachment welds	e.g. for fixing purlins, side rails, buckling stiffeners etc.
		1 in 20 attachments <sup>b</sup>

**Definition of zones and weld orientation**



NOTE All welds in connection zones to be treated as transverse.

<sup>a</sup> Where only partial inspection is required, the joints for testing shall be selected on a random basis, but ensuring that sampling covers the following variables as widely as possible: joint type, material grade and welding equipment.

<sup>b</sup> In workshops where the same constructional details welded with the same welding procedures are being used on a regular basis, the first 5 identified joints may be inspected on a weekly basis. In the case of longitudinal joints and secondary attachment welds the specified inspection need only apply to 5 % of the weekly output of members. In the event that a non-conformance is detected by non-destructive testing, the full requirements of Table A.2 shall be implemented, for at least a full week following the rectification of the fault.

Table A.3 — Acceptance requirements for production welds in steel structures

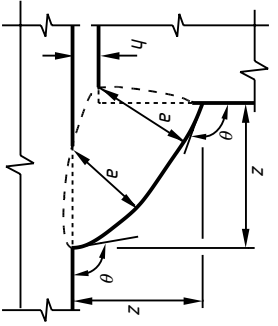
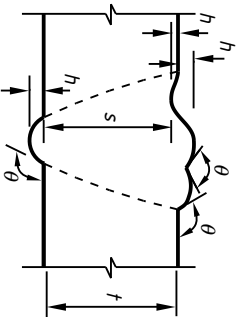
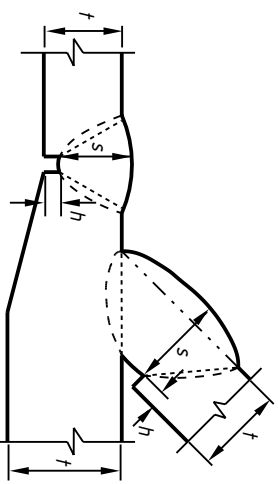
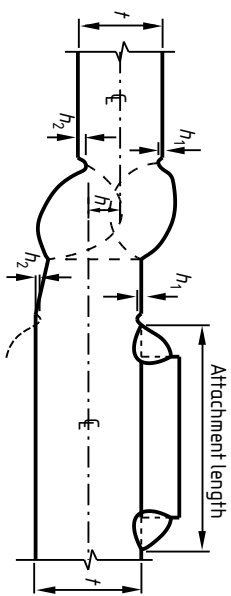
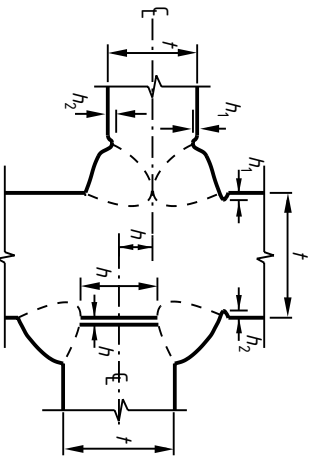
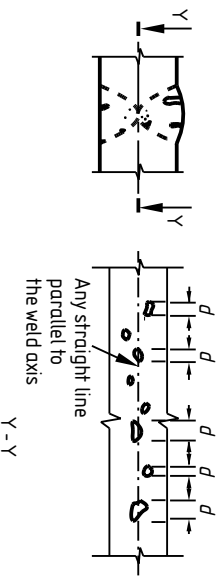
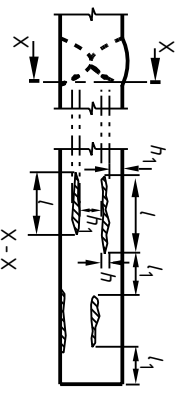
Feature	Parameter	Weld type	Particular conditions <sup>a</sup>	Figure reference in Table A.4	Acceptance criteria for normal quality <sup>b c</sup> (All dimensions in mm)	Remedial action for non-conforming welds <sup>d</sup>
Overall weld geometry	Location <sup>e</sup>	All	—	—	$D \pm 10$	E
	Weld type	All	—	—	$D$	E
	Extent (length)	All	—	—	$D + 10 - 0$	E
Profile discontinuities	Actual throat thickness	All	—	i, ii, iii	$a, s \geq D$ (50) $a, s \leq D + 5$	R DS
	Leg length	Fillet	—	i	$z \geq D$ (50)	E
	Toe angle (interface and inter-run)	All	Transverse Longitudinal	i, ii i, ii	$\theta \geq 90^\circ$ $\theta \geq 90^\circ$	DS/R DS/R
	Excess weld metal	Butt	Transverse Longitudinal	ii ii	$h \leq 6$ $h \leq 6$	DS DS
	Incomplete groove or concave root	Butt	Transverse Longitudinal	ii ii	$h \leq 0$ (50) $h \leq 0.1t$	R E
	Linear misalignment	Butt All All	Transverse butt Transverse cruciform Longitudinal	iv v iv, v	$h \leq D + 0.2t$ $h \leq D + 0.4t$ $h \leq D + 0.4t$	E E E
Surface breaking discontinuities	Undercut <sup>f</sup>	All	Transverse (not lap joint)	iv, v	$h_1 + h_2 \leq 0.05t$ $l - NL$	R R
		Fillet	Transverse (lap joint)	v	$h_1 + h_2 \leq 0.03t$ $l \leq 10$	R R
		All	Longitudinal	iv, v	$h_1 + h_2 \leq 0.1t$	R
	Lack of root penetration	S/S Butt	Transverse Longitudinal	iii iii	$h \leq D + 0.05t$ (50) $h \leq D + 0.01t$ (50)	R R
		Porosity	All	Transverse	vi	$d \leq 2$ $\Sigma d \leq 10$ [100]
	Longitudinal			vi	$d \leq 2$ $\Sigma d \leq 20$ [100]	R R
Lack of fusion	All	—	vii	NP	R	
Cracks	All	At crater Not at crater	vii	NP NP	R R	
<b>Abbreviated terms</b>			<p>D As specified on drawings</p> <p>DS Dress smoothly</p> <p>E Refer to engineer</p> <p>NL No limit</p> <p>NP Not permitted (applies to discontinuities which are detectable by NDT methods in Table A.1)</p> <p>R Repair by welding to approved procedure</p> <p><math>\geq</math> Greater than or equal to (i.e. not less than)</p> <p><math>\leq</math> Less than or equal to (i.e. not greater than)</p> <p><math>\Sigma</math> Sum of</p> <p>( ) Length of weld over which measurement may be averaged (mm)</p> <p>[ ] Length of weld over which the summation is made (mm)</p> <p><math>l</math> Length parallel to the weld axis</p>			
			<p><sup>a</sup> For definition of orientation see Table A.2.</p> <p><sup>b</sup> Thickness applies to minimum member thickness at weld in question. For thicknesses greater than 20 mm “<math>t</math>” shall be taken as 20 mm. Where permitted size “<math>h</math>” of a discontinuity is related to “<math>t</math>” the maximum permitted value shall be not less than 0.3 mm in any case.</p> <p><sup>c</sup> Where more than one requirement is given both shall apply.</p> <p><sup>d</sup> 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.</p> <p><sup>e</sup> Subject to any other locational requirements.</p> <p><sup>f</sup> “Lap” shall apply to any fillet welded attachment whose length in the longitudinal direction exceeds 50 mm.</p> <p><sup>g</sup> Lamellar tears may only be accepted in the longitudinal welds if the extent does not exceed limits for lack of fusion in transverse welds.</p>			



Table A.3 — Acceptance requirements for production welds in steel structures (concluded)

Feature	Parameter	Weld type	Particular conditions <sup>a</sup>	Figure reference in Table A.4	Acceptance criteria for normal quality <sup>b c</sup> (All dimensions in mm)	Remedial action for non-conforming welds <sup>d</sup>	
Sub-surface discontinuities	Lack of fusion/root penetration, slag lines	Butt	All	vii	$h \leq 3$	R	
			Transverse	Full depth	vii	$\Sigma l \leq 1.5t$ [100]	R
					vii	$l \leq 10$ $l_1 \geq 10$	R R
			Longitudinal	Full depth	vii	$l - NL$ $l_1 - NL$	R R
					vii	$\Sigma l \leq 3t$ [100]	R
			vii	$l - NL$ $l_1 - NL$	R R		
vii	$l - NL$ $l_1 - NL$	R R					
—	Root gap	Fillet P/P Butt	—	i, v	$h \leq 2$ (100), 3	R	
—	Cracks	All	—	—	NP	R	
—	Lamellar tears	All	Transverse Longitudinal	—	NP <sup>g</sup>	E	
<b>Abbreviated terms</b>							
E Refer to engineer				<sup>a</sup> For definition of orientation see Table A.2.			
NL No limit				<sup>b</sup> Thickness applies to minimum member thickness at weld in question. For thicknesses greater than 20 mm “ $t$ ” shall be taken as 20 mm. Where permitted size “ $h$ ” of a discontinuity is related to “ $t$ ” the maximum permitted value shall be not less than 0.3 mm in any case.			
NP Not permitted (applies to discontinuities which are detectable by NDT methods in Table A.1)				<sup>c</sup> Where more than one requirement is given both shall apply.			
P/P Partial penetration				<sup>d</sup> 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.			
R Repair by welding to approved procedure				<sup>e</sup> Subject to any other locational requirements.			
$\geq$ Greater than or equal to (i.e. not less than)				<sup>f</sup> “Lap” shall apply to any fillet welded attachment whose length in the longitudinal direction exceeds 50 mm.			
$\leq$ Less than or equal to (i.e. not greater than)				<sup>g</sup> Lamellar tears may only be accepted in the longitudinal welds if the extent does not exceed limits for lack of fusion in transverse welds.			
$\Sigma$ Sum of							
( ) Length of weld over which measurement may be averaged (mm)							
[ ] Length of weld over which the summation is made (mm)							
$l$ Length parallel to the weld axis							

Table A.4 — Characteristic defects of production welds in steel structures

<p>Figure (i)</p> 	<p>Figure (ii)</p> 	<p>Figure (iii)</p> 
<p>a and s are minimum distances</p>		
<p>Figure (iv)</p> 	<p>Figure (v)</p> 	
<p>Figure (vi)</p>  <p>Any straight line parallel to the weld axis Y - Y</p>	<p>Figure (vii)</p> 	

## Annex B (informative)

### General recommendations for steelwork tenders and contracts

#### B.1 General

The following recommendations, and the terms used to refer to the various parties to the contract are those generally adopted for steelwork construction.

These recommendations are unsuitable for inclusion as a block requirement in a contract, but in drawing up a contract the points mentioned should be considered.

#### B.2 Exchange of information

Before the steelwork design is commenced, the building designer should be satisfied that the planning of the building, its dimensions and other principal factors, meet the requirements of the building owner and conform to the regulations of all authorities concerned. Collaboration of building designer and steelwork designer should begin at the outset of the project by joint consideration of the planning, the structural layout and materials to be used.

#### B.3 Information needed by the steelwork designer

The following information is needed by the steelwork designer.

##### a) *General*

- 1) Site plans showing in plan and elevation the proposed location and main dimensions of the building or structure and its orientation to the north.
- 2) Ground levels, existing and proposed, relative to mean sea level.
- 3) Particulars of building or other obstructions which may have to remain on the actual site of the new building or structure during the erection of the steelwork.
- 4) Particulars of adjacent buildings affecting, or affected by, the new work.
- 5) Requirements regarding the erection sequence of time schedule.
- 6) Conditions affecting the position or continuity of members.
- 7) Limits of length and weight of steel members in transit and erection.
- 8) Drawings of the substructure, proposed or existing, showing:
  - i) levels of column foundations, if already determined;
  - ii) any details affecting the column bases or anchor bolts;
  - iii) permissible bearing pressure on the foundation;
  - iv) provisions for grouting, see **6.3**.

In the case of new work, the substructure should be designed in accordance with the relevant codes dealing with foundations and substructure.

- 9) Climatic conditions on site including seasonal variations of temperatures, humidity, and maximum wind loading (speed, direction etc., see BS 6399-2 or as otherwise required).
- 10) Reference to bylaws and regulations affecting the steelwork design and construction.

##### b) *Further information relating to buildings*

- 1) Plans of the floors and roof with principal dimensions, elevations and cross-sections showing heights between floor levels.
- 2) The occupancy of the floors and the positions of any special loads should be given.
- 3) The building drawings, which should be fully dimensioned, should preferably be to scale of 1 to 100 or larger and should show all stairs, fire escapes, lifts, etc., suspended ceilings, flues, and ducts for heating and ventilating. Doors, windows and other openings should be shown.

Requirements should be given in respect of any maximum depth of beams or minimum head room.

Large-scale details should be given of any special features affecting the steelwork.

4) The inclusive weight per square metre of walls, floors, roofs, suspended ceilings, stairs and partitions, or particulars of their construction and finish for the computation of dead load.

The plans should indicate the floors which are to be designed to carry partitions. Where the layout of partitions is not known, or a given layout is liable to alteration, these facts should be specially noted so that allowance can be made for partitions in any position (see BS 6399-1).

5) The imposed loads on the floor (See BS 6399-1 or as otherwise required in terms of blanket loads, services loads etc.). Details of special loads from cranes, runways, tips, lifts, bunkers, tanks, plant and equipment.

6) The grade of fire resistance appropriate to the occupancy as given in BS 5588 or as otherwise required.

#### **B.4 Information needed by the tenderer (if not also the steelwork designer)**

The following information is needed by the tenderer.

##### *a) General*

- 1) All information listed under **B.3(a)**.
- 2) Results of the investigation of subsoils at site of building or structure.
- 3) Accessibility of site and details of power supply.
- 4) Whether the steelwork contractor will be required to survey the site and set out or check the building or structure lines, foundations and levels.
- 5) Setting-out plan of foundations columns and levels of bases.
- 6) Cross-sections and elevations of the steel structure, as necessary, with large-scale details of special features.
- 7) Assumed erection sequence including any requirements for temporary measures for stability.
- 8) The use of bolted or welded connections. Particular attention should be drawn to connections of a special nature such as overhead welds, HSFG bolts and site welding.
- 9) Grade of steel (see **2.1**) and provisions for identification.
- 10) Requirements in respect of surface treatment at works and on site.
- 11) Approximate dates for commencement and completion of erection.
- 12) Details of any tests that have to be made during the course of fabrication, erection or upon completion.
- 13) Where the tenderer is required to take off quantities, a list should be given of the principal items to be included in the schedule.

##### *b) Further information relating to buildings*

- 1) Schedule of columns giving sizes, lengths and typical details of brackets, joints, etc.
- 2) Plans of floor beams showing sizes, levels and eccentricities. The beam reactions and end moments together with details of the type of connection required should be shown on the plans with a statement identifying whether the quoted forces and moments are factored or un-factored.
- 3) Plan of roof steelwork. For a flat roof the plan should give particulars similar to those of a floor plan. Where the roof is sloping, details should be given of trusses, portals, purlins, bracing, etc.
- 4) The steelwork drawings should preferably be to a scale of 1 to 100 and should give identification marks against all members.
- 5) Particulars of holes required for services, pipes, machinery fixings, etc. Such holes should preferably be formed at works.

#### **B.5 Detailing**

In addition to the number of copies of the approved drawings or details required under the contract, dimensioned shop drawings or details should be submitted in duplicate to the steelwork designer who should retain one copy and return the other to the steel suppliers or steelwork contractor with any comments.

**B.6 Time schedule**

As the dates on which subsequent trades can commence depend on the progress of erection of the steel framing, the time schedule for the latter should be carefully drawn up and agreed by the parties concerned at a joint meeting.

**B.7 Inspection and testing****B.7.1 General**

Provision should be made for inspectors or independent inspection and testing agencies as may be appointed to have access at all reasonable times to all places where work, both on site and at the contractor's premises, is being carried out. Facilities for inspection and testing of the work should be provided in accordance with the agreed procedure.

**B.7.2 Acceptance criteria for welds**

Acceptance levels of parameters for inspection and testing of welds should be specified. This should normally be done by adopting those given in **A.4**. If special circumstances prevail (e.g. see for example **A.5**) the acceptance criteria may need to be modified by consideration of values appropriate to the particular structure.

**B.7.3 Qualification and testing of welders**

For welding of any particular type of joint, welders should give evidence acceptable to the engineer of having satisfactorily completed appropriate tests as specified in BS EN 287.

## Annex C (informative)

### References to the phrase “Project Specification”

The clauses listed as follows include reference to the project specification that identifies information needed to supplement the requirements of this British Standard.

Clause	Subject
1.1	Special requirements
1.3.1	Definition
2.1.1	Steel specifications
3.3	Thermal cutting
3.4.2.3	Full size hole punching
3.4.2.4	Hole size
3.5	Contact bearing
3.6	Contact imperfections
3.7	Surface finishes
4.1	Full contact
4.2.1	Welding processes
4.2.4	Weld testing and inspection
4.2.5	Surface preparation of welds
4.3.2	Use of washers
4.3.3	Tightening of nuts
4.3.4	Preloaded fasteners
4.6.1	Protective treatment specification
4.6.2	Protective treatment method statement
5.3	Accuracy of construction
7.2.3	Flatness for full contact bearing
7.3.1.3	Projection of bolt end
7.3.3.2	Multi-storey columns
A.1	Visual examination of welds
A.2.1	Non-destructive testing
A.2.2.1	Use of DPI
A.2.2.3	Other methods of inspection
A.3	Stud shear connectors

---

## Bibliography

### Standards publications

BS 5531, *Code of practice for safety in erecting structural frames.*

BS 5588, *Fire precautions in the design, construction and use of buildings.*

BS 5606, *Guide to accuracy in building.*

BS 6399-1, *Loading for buildings — Part 1: Code of practice for dead and imposed loads.*

BS 6399-2, *Loading for buildings — Part 2: Code of practice for wind loads.*

DD ENV 1090-1, *Execution of steel structures — Part 1: General rules and rules for buildings (together with United Kingdom national application document).*

BS EN ISO 14713, *Protection against corrosion of iron and steel in structures — Zinc and aluminium coatings — Guidelines.*

---

---

## BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

### Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

### Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001. Standards are also available from the BSI website at <http://www.bsi-global.com>.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

### Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001. Further information about BSI is available on the BSI website at <http://www.bsi-global.com>.

### Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

If permission is granted, the terms may include royalty payments or a licensing agreement. Details and advice can be obtained from the Copyright Manager. Tel: 020 8996 7070.