

4TH EDITION

**NATIONAL STRUCTURAL
STEELWORK SPECIFICATION
for
BUILDING
CONSTRUCTION**

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FOREWORD

The National Structural Steelwork Specification for Building Construction is presented here in its 4th Edition; issued some eight years after the last publication and thirteen years after the 1st Edition in 1989. It has continued 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. With this in mind, Section 1, which gives guidance on the items and information that should be included in the Project Specification, has been rearranged to make its purpose more apparent. It is recognised that where 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 European Standards and to 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 and European standards have been updated throughout the specification.

The vertical line on the left of the page indicates a change to the text of the Third Edition. This vertical line has not been used where only clause renumbering was required.

All parties are reminded that under The Construction (Design and Management) Regulations 1994 they have a duty to cooperate with a Planning Supervisor 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 to with BS EN ISO 9000 series of standards.

Quality Schedules (CSQS Series) specifically applicable to this industry are available to all certification bodies.

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:-

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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 fabricators and component suppliers. 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)*
DETR's Guidance Notes to Environmental Protection Act 1990[PG6/23].
Her Majesty's Stationery Office (HMSO) or its
approved agents

- (c) *Quality Schedules (CSQS Series)*
The Steel Construction Certification Scheme Ltd.
4 Whitehall Court,
Westminster
London
SW1A 2ES

- (d) *Code of Practice for the Protective Coating of Structural Steel.*
Commentary on the Fourth Edition of the National Structural Steelwork
Specification for Building Construction.
British Constructional Steelwork Association Ltd.
4 Whitehall Court,
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Commentary on the National Structural Steelwork Specification

A Commentary on the National Structural Steelwork Specification for Building Construction is available on the BCSA website:

www.steelconstruction.org

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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'

Eurocode 3: Part 1.1 (DD ENV1993-1.1) 'General rules and rules for buildings' where the references to BS 5950 in the National Application Document are taken into account.

It can be used for all types of building construction designed for static loading. It is not intended to be used for steelwork in dynamically loaded structures or where 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 when the form 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 and eccentricities 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. This will usually be the main contractor, and is not necessarily the Employer as defined in JCT contracts.
- Erection Drawings : Drawings, prepared when 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)
- 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.
- 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 qualified independent body or association which verifies compliance with this Specification and the Project Specification. |
| 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 for steelwork erection. |
| Project Specification | : | A specification prepared for a specific building project (see “The Works”) which includes the National Structural Steelwork Specification and qualifies it where necessary. |
| 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. |
| Steelwork Contractor | : | The company appointed to fabricate and/or erect the structural steelwork. Where required by the Project Specification, the Steelwork Contractor may also be responsible for design. |
| The Works | : | As defined in the Project Specification, but limited in the context of this document to the 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. |
| Full Strength Weld | : | Any of the above welds designed to develop the full strength of the parts which it connects. |

SECTION 1

INFORMATION REQUIRED BY 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.

1.1.2 Reference to National Structural Steelwork Specification

The Project Specification shall state that the *National Structural Steelwork Specification for Building Construction 4th Edition* is incorporated into the contract along with any additions or modifications required by the Employer.

1.1.3 Precedence where there is a conflict

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

| TABLE 1.1 PROPOSED WORKS – CHECKLIST |
|--|
| <p>Information required by the steelwork contractor</p> <ul style="list-style-type: none"> (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. |

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, when 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. Where connection design is to be in accordance with BS 5950, 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 e.g. plastic hinge positions.
- (ix) Details of any dynamic or vibrating forces and where fatigue is to be considered. Appropriate amendments to this Specification should be included since these factors are outside the intended scope.
- (x) The material grade and designation of steel to be used, including any of the options noted in standards listed in Table 2.1.
- (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.
- (xii) Any grades 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 cutouts, holes or fittings required for use by others.
- (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.
- (xviii) Locations where holes cannot be punched (see 4.6.4).

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: standard 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) Areas on steelwork where the scope of weld inspection is to be greater than the minimum specified (see 5.5); such as whether final acceptance of welds according to Annex A of BS 5950-2: 2001 is to be applied instead.
- (vi) Any special requirements regarding weld acceptance criteria (see 5.5.6).

TABLE 1.4 ERECTION – CHECKLIST

Note: Information for some of these erection items may be 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) and 8.5(ii)).
- (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.
- (viii) A description of any temporary works and any special requirements for temporary bracing required by the Engineer; the stage when it is no longer necessary, or whether it is to be left in position after completion of the steelwork (see 8.4.1).
- (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) 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 (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.
- (vii) Any requirement for fire protective coating.

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 foundations prepared, free from obstruction, and accessible; with working surfaces, access roads and storage areas prepared and services available.
- (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 MATERIAL QUALITIES

Material shall be steel in ROLLED SECTIONS, STRUCTURAL HOLLOW SECTIONS, PLATES and BARS and shall comply with the appropriate standard shown in Table 2.1.

Note: Give full steel designation when ordering so that the correct properties for weldments is ensured.

2.2 MATERIAL TESTING

All steel shall have been specifically tested in accordance with the appropriate material quality standard shown in Table 2.1

2.3 DIMENSIONS AND TOLERANCES

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

TABLE 2.1 MATERIAL & DIMENSION STANDARDS

| Form | Material Quality ⁽¹⁾ | | | | Dimensions | Tolerances |
|---|---------------------------------|-------------------|------------------------------|--------------------------------|---------------|---------------|
| | Non-alloy steels | Fine grain steels | Q&T steels | Weathering steels | | |
| Universal Beams & Columns | BS EN 10025 ⁽²⁾ | BS EN 10113 | BS EN 10137-2 ⁽³⁾ | BS EN 10155 | BS 4 - 1 | BS EN 10034 |
| Joists | | | | | BS 4 - 1 | BS EN 10024 |
| Channels | | | | | BS 4 - 1 | BS EN 10279 |
| Rolled Asymmetric Beams | | | | | (4) | (4) |
| Angles | | | | | BS EN 10056-1 | BS EN 10056-2 |
| Rolled Tees | | | | | BS EN 10055 | BS EN 10055 |
| Split Tees | | | | | BS 4 - 1 | as UB & UC |
| Plates (Reversing Mill) | | | | | – | BS EN 10229 |
| Plates (Cut from Coil) | | | | | – | BS EN 10251 |
| Wide Flats | | | | | – | EU 91 |
| Hollow Sections (Hot Finished) ⁽⁵⁾ | BS EN 10210 – 1 | – | BS 7668 | BS EN 10210 – 2 | | |
| Hollow Sections (Cold Formed) ⁽⁵⁾ | BS EN 10219 – 1 | – | – | BS EN 10219 – 2 ⁽⁴⁾ | | |

(1) Certain product grades do not have a specified maximum manganese content or are not supplied with carbon equivalent value (CEV) options. Additional requirements may therefore need to be specified, e.g. options 5 and/or 6 of BS EN 10025.

(2) Grades S275 and S355 only. If the steel is to incorporate welded connections 'Option 5' must be ordered.

(3) Only plate and wide flats grade S460.

(4) See manufacturers information for rolled asymmetric beams and S235 Cold Formed hollow sections.

(5) Except where Cold Formed hollow sections to BS EN 10219–1 is specifically identified on drawings hollow section are to be Hot finished to BS EN 10210 -1.

2.4 TEST CERTIFICATES

The Steelwork Contractor shall have access to the manufacturer's test certificates to ensure compatibility with any welding processes being used.

2.5 SURFACE CONDITION

- (i) Steel surfaces when used shall not be more heavily pitted or rusted than Grade C of BS 7079 Part A1.
- (ii) 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.
- (iii) 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.

2.6 WELDING CONSUMABLES

2.6.1 Standards

Consumables for use in metal arc welding shall comply with BS EN 499, BS EN 440, BS EN 756 or BS EN 758 as appropriate.

2.6.2 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 2.6.1). Any drying or baking of consumables before issue shall be carried out in accordance with the manufacturer's recommendations.

2.7 STRUCTURAL FASTENERS

2.7.1 Ordinary Bolt Assemblies

Ordinary Bolt and nut (and washer if used) assemblies shall be as European Standards given in Table 2.2 or the British Standards given in Table 2.3.

2.7.2 Pre-loadable Bolt Assemblies

Pre-loadable HSFSG bolt assemblies shall be as given in Table 2.4.

2.7.3 Foundation Bolts Assemblies

Holding down bolt assemblies shall be as given in Table 2.5.
(see clause 3.4.6 for additional washers to holding down bolt assemblies)

2.7.4 Cup and Countersunk Bolts

Cup and countersunk bolts shall be as given in Table 2.6.

2.7.5 Lock Nuts for Bolt Assemblies

Lock nuts shall be in accordance with BS 4190.

2.7.6 Coatings for Bolt Assemblies

Where specific coatings are required, they shall be provided by the fastener manufacturer and shall comply with the appropriate part of BS 7371.

**TABLE 2.2 MATCHING BOLTS, NUTS and WASHERS
Manufactured to European Standards**

| GRADE | ORDINARY (NOT FOR PRE-LOADING) ASSEMBLIES FULL THREADED LENGTH BOLTS | | |
|-------|---|--|---------------------------|
| | BOLT | NUT ⁽²⁾ | WASHER |
| 4.6 | BS EN ISO 4018 | BS EN ISO 4034 (Class 4) ⁽³⁾ | BS EN ISO 7091 (100HV) |
| 8.8 | BS EN ISO 4017 ⁽¹⁾ | BS EN ISO 4032 ⁽¹⁾ (Class 8) ⁽⁴⁾ | BS EN ISO 7091 (100HV) |
| 10.9 | BS EN ISO 4017 ⁽¹⁾ | BS EN ISO 4032 ⁽¹⁾ (Class 10) ⁽⁵⁾ | BS EN ISO 7091 (100HV) |
| GRADE | ORDINARY (NOT FOR PRE-LOADING) ASSEMBLIES PART THREADED LENGTH BOLTS | | |
| | BOLT | NUT ⁽²⁾ | WASHER |
| 4.6 | BS EN ISO 4016 | BS EN ISO 4034 (Class 4) ⁽³⁾ | BS EN ISO 7091 (100HV) |
| 8.8 | BS EN ISO 4014 ⁽¹⁾ | BS EN ISO 4032 ⁽¹⁾ (Class 8) ⁽⁴⁾ | BS EN ISO 7091 (100HV) |
| 10.9 | BS EN ISO 4014 ⁽¹⁾ | BS EN ISO 4032 ⁽¹⁾ (Class 10) ⁽⁵⁾ | BS EN ISO 7091 (100HV) |

(1) Grade 8.8 and 10.9 bolts to the strength grades 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 strength classes of BS EN ISO 4032 (dimensions and tolerances of BS EN ISO 4034).

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

(3) Class 5 nuts for size M 16 and smaller.

(4) Nuts for galvanized or sherardized 8.8 bolts should be class 10

(5) Nuts for galvanized or sherardized 10.9 bolts should be class 12 to BS EN ISO 4033

**TABLE 2.3 MATCHING BOLT, NUT and WASHERS
Manufactured to British Standards**

| GRADE | ORDINARY BOLT ASSEMBLIES FULL THREADED AND PART THREADED LENGTH BOLTS | | |
|-------|--|-----------------------------------|------------------------|
| | BOLT | NUT | WASHER |
| 4.6 | BS 4190 | BS 4190 (Grade 4) | BS 4320 ⁽¹⁾ |
| 8.8 | BS 4190 | BS 4190 (Grade 8) ⁽²⁾ | BS 4320 ⁽¹⁾ |
| 10.9 | BS 4190 | BS 4190 (Grade 10) ⁽³⁾ | BS 4320 ⁽¹⁾ |

(1) Black steel washers to section 2 of BS 4320, normal diameter series.

(2) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to BS 4190

(3) Nuts for galvanized or sherardized 10.9 bolts should be grade 12 to BS 4190

TABLE 2.4 PRE-LOADED ASSEMBLIES ⁽¹⁾

| | BOLT | NUT | WASHER |
|----------------------|-------------|------------|---------------|
| General Grade | BS 4395 –1 | BS 4395 –1 | BS 4395 –1 |
| Higher Grade | BS 4395 –2 | BS 4395 –2 | BS 4395 –2 |

(1) Direct tension indicators to BS 7644 may also be included in the assembly.

TABLE 2.5 HOLDING DOWN BOLT ASSEMBLIES

| GRADE | BOLT | NUT | WASHER |
|--------------|-------------|-------------------------------------|------------------------|
| 4.6 | BS 7419 | BS 4190 (Grade 4) | BS 4320 ⁽¹⁾ |
| 8.8 | BS 7419 | BS 4190 ⁽²⁾ (Grade 8) | BS 4320 ⁽¹⁾ |

(1) Black steel washers to section 2 of BS 4320, normal diameter series.
(2) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to BS 4190

TABLE 2.6 CUP and COUNTERSUNK HEAD BOLT ASSEMBLIES

| GRADE | BOLT | NUT | WASHER |
|--------------|------------------------|-------------------------------------|------------------------|
| 4.6 | BS 4933 | BS 4190 (Grade 4) | BS 4320 ⁽¹⁾ |
| 8.8 | BS 4933 ⁽²⁾ | BS 4190 ⁽³⁾ (Grade 8) | BS 4320 ⁽¹⁾ |

(1) Black steel washers to section 2 of BS 4320, normal diameter series.
(2) Dimensions to BS 4933 and material to BS EN ISO 898-1.
(3) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to BS 4190.

2.8 SHEAR STUDS

Proprietary studs used in composite construction shall be the headed type with the following properties after being formed:

- (i) Minimum yield strength - 350 N/mm²
- (ii) Minimum ultimate tensile strength - 450 N/mm²
- (iii) Elongation of 15% on a gauge length of $5.65 \sqrt{A}$, where A is the area of the test specimen.

2.9 PROTECTIVE TREATMENT MATERIALS

2.9.1 Metallic Blast Cleaning Abrasives

Chilled iron grit shall be in accordance with BS 7079–E2, and cast steel grit shall be in accordance with BS 7079–E3.

2.9.2 Surface Coatings

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

2.9.3 Sherardized Coatings

Sherardized coatings shall be in accordance with BS 4921.

2.9.4 Galvanizing Materials

The composition of zinc in galvanizing baths shall be in accordance with BS 729.

2.10 PROPRIETARY ITEMS

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

2.11 SUBSTITUTION OF MATERIAL OR FORM

Material quality or form of components may, with the agreement of the Engineer, be substituted where 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.

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.

Members 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 members can be shown on them. Preferred scales are 1:100 or larger.

The drawings shall identify member size, material quality, location relative to other members and the grid, and the specified surface treatment. They may include a reference system to connections.

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

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 members 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 when so specified in the Project Specification or on request.

The system shall include full details of the date when component information is released for manufacture.

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

- (i) Any requirements for edge preparations for welds shall be indicated.
- (ii) Welding inspection requirements which differ from those specified in 5.5.5 shall be clearly indicated.

3.4.4 Packings, Clearances and Camber

The Steelwork Contractor shall make provision for:

- (i) Packings 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 (HSFG) bolts:
 - not exceeding 24mm diameter - 2mm greater than the bolt diameter
 - greater than 24mm diameter - 3mm greater than the bolt diameter
- (ii) For holding down bolts:

6mm greater than the 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

Where 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

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

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(ii)).

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. Where necessary drawings showing complex geometry shall also be submitted.

Note: Where 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 principle levels, dimensions and typical details shown on the General Arrangement Drawings are a correct interpretation of design requirements.
- (ii) the principles adopted for the Connection Design calculations are compatible with the design.

Acceptance does not relieve the Steelwork Contractor of the responsibility for accuracy of his 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

When 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) When 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

All steel to be used in The Works shall have a test certificate reference so that its properties are known and can be verified (see 2.4).

4.1.2 Material grade identification

The material grade shall be identifiable within the manufacturing system.

4.1.3 Marking steelwork

- (i) Individual pieces shall be capable of positive identification at all stages of fabrication.
- (ii) 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, 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.

4.3 CUTTING AND SHAPING

4.3.1 Cutting Operations

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

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

4.3.2 Flame-cut Edges

Flame-cut edges which are free from significant irregularities shall be accepted without further treatment except for the removal of dross, otherwise cut edges shall be dressed to remove irregularities.

4.3.3 Columns and Compression Members

- (i) Columns and compression members with ends not in direct bearing or intended to be erected on packs or shims, shall be fabricated to the accuracy given in 7.2.2.
- (ii) Columns and compression members intended to be in direct bearing shall be fabricated to the accuracy given in 7.2.3.
- (iii) 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 and the permitted gap in 9.6.5 are not exceeded.

4.4 MACHINING

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)).

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 members 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

Where 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

Full size punching of holes shall be permitted when all the following conditions are satisfied:

- (i) the tolerance on distortion of the punched hole does not exceed that shown in 7.3.3;
- (ii) the holes are free of burrs which would prevent solid seating of the parts when tightened;
- (iii) the thickness of the material is not greater than 30mm, nor greater than the diameter of the hole being punched;
- (iv) in spliced connections when the holes in mating surfaces are punched in the same direction and the splice plates marked to show the assembly faces, if packed separately.

Note: 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

Punching is permitted without the conditions in 4.6.3, 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, plasma 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 when the procedure used includes careful temperature control;

Note. 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 examination 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 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 together with other clauses contained in this section, unless otherwise specifically permitted by the Engineer.

Joints shall be prepared in accordance with BS EN 29692. Precautions shall be taken to ensure cleanliness of the connection prior to welding.

5.2 WELDER QUALIFICATION

5.2.1 Testing

Welders shall be tested to meet the requirements of BS EN 287-1.

As an alternative, when permitted by the Engineer, welders may be tested to meet the requirements of the American Society of Mechanical Engineers, ASME IX, or the American Welding Society, AWS D1.1.

5.2.2 Certification

Welder testing shall be witnessed and certificates endorsed by an independent Inspection Authority.

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 Procedure Specifications

Written welding procedure specifications (WPS) shall be available in accordance with BS EN 288-2, and tested in accordance with BS EN 288-3 by the Steelwork Contractor. They 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.

5.3.2 Approval of Procedures and Procedure Tests

Welding procedure approval records (WPAR) in accordance with BS EN 288-3, shall have been approved by an independent Inspection Authority.

5.3.3 Availability of Welding Procedure Specifications

Welding Procedure specifications shall be provided for the welder prior to the commencement of the works and shall be available to the Engineer and Inspection Authority on request.

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

- (i) Unless demonstrated by a satisfactory weld procedure test based on the length of tack weld used, they shall be made using the same procedure as the main weld (single run) or the root run of multi-run welds. The minimum length of the tack shall be the lesser of 4 times the thickness of the thicker part or 50 mm.
- (ii) Tack welds which are made by a welder qualified as in 5.2, and which are satisfactory by visual inspection, may be incorporated into main welds.
- (iii) Where tack welds are made in circumstances other than those identified above, they must be removed.

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.

When 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. When parent metal thickness is greater than 20 mm it shall also be checked by magnetic particle inspection. 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

Where 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

Where 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 NON-DESTRUCTIVE TESTING OF WELDS

Note. The scope of inspection given here is intended to ensure that the Steelwork Contractor can maintain welding processes at an accepted standard which is generally suitable for structural steelwork. The Engineer should check that any additional project-specific requirements for non-destructive testing of welds are clearly specified in the Project Specification.

BS 5950-2 Annex A may be used as a reference for identifying critical welds which may require additional inspection.

5.5.1 Scope of Inspection

Visual inspection of all welds shall be carried out (see 5.5.3).

Where **ALL** of the following conditions apply, further non-destructive testing is **NOT** mandatory:

- (i) the "connection" is fillet welded,
- (ii) the leg length of the fillet weld is not greater than 10mm,
- (iii) the greatest member thickness is less than 20mm,
- (iv) the material grade is S275 or S355.

Where these conditions are not met, the scope of inspection shall be in accordance with Table B of Annex B.

Inspection requirements may be reduced at the Engineers discretion, based upon satisfactory performance in the initial production demonstrated against the requirements of BS EN 729.

Conversely, where testing indicates that weld quality problems have occurred (in similar materials, assembly methods or welding procedures) non-destructive testing requirements should be increased and should be extended to non-mandatory components.

5.5.2 Record of Testing

The results of visual inspection, surface flaw detection and ultrasonic examination shall be recorded and be available for inspection.

5.5.3 Visual Inspection of Welds

- (i) Visual inspection shall be made in accordance with guidance given in BS EN 970 over the full length of all welds. Such inspection shall be performed before any required NDT inspection.

Any welds which will be rendered inaccessible by subsequent work shall be examined in accordance with Tables A.1, B, C.1 and C.2 in Annexes prior to the loss of access.

- (ii) 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.

5.5.4 Hold Times before final NDT

Owing to the risk of delayed cracking, a period of at least 16 hours should generally be allowed before the final inspection is made of as-welded fabrications. This time may be reduced for thin materials whose yield strength is less than 500 N/mm² or should be increased for materials of thickness greater than 50 mm or of a yield strength over 500 N/mm². Typical hold times conforming with this requirement are illustrated in Table A.1 of Annex A.

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

5.5.5 Surface Flaw Detection

- (i) Where a closer examination of a weld surface is required in accordance with Table B in Annex B, magnetic particle inspection (MPI) shall be used in accordance with the recommendations given in BS EN 1290.

If magnetic particle inspection equipment is impractical, dye penetrant inspection (DPI) may be used in accordance with the recommendations given in BS EN 571.

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.1 in Annex A.

Note: Where 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.

- (ii) A suitably qualified person for surface flaw detection of welds may be a welding inspector or a welder who holds a current certificate of competence in surface flaw detection of the relevant types of work, from a nationally recognised authority (PCN, CSWIP or equivalent).

5.5.6 Ultrasonic Examination

- (i) Where ultrasonic examination (U/S) is required in accordance with Table B in Annex B, it shall be made in accordance with BS EN 1714 using reference level to Method 1, evaluation reference level -14dB (20% DAC) and examination level B unless specifically agreed otherwise by the Engineer.

Ultrasonic examination of a welded joint shall be carried out after completion of the weld in accordance with the hold times given in Table A.1 in Annex A

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

- (ii) Operators carrying out final ultrasonic examination of the weld shall hold a current certificate of competence from a nationally recognised authority (PCN, CSWIP or equivalent).

5.5.7 Acceptance Criteria and Corrective Action

Acceptance criteria, corrective action and re-testing shall be in accordance with Tables C.1 and C.2 in Annex C for components subject to static loading.

Note. 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 in accordance with the manufacturer's recommendations for materials, procedures and equipment. Adequate return earth connections shall be made local to the area being stud welded.

5.6.2 Trial Welding

- (i) When specified by the Engineer and before production welding of studs commences, procedure trials shall be carried out. The trials shall be made on samples of material and studs representative of those to be used in the work (see 1.3 (ii)).
- (ii) At the start of each shift when stud welding is in progress each welder shall perform the fixing of at least two trial studs.

5.6.3 Tests and Inspection

- (i) All studs are to be visually inspected. They shall show a full 360° collar.
- (ii) After a satisfactory visual inspection, bend tests shall be made at locations agreed with the Engineer. A minimum of 5% of the studs, but not less than two studs per beam shall be tested.

The bend test shall be made by bending the head of the stud towards the nearer end of the beam, by means of a steel tube placed over the stud, until it is displaced laterally a distance of one quarter of the height of the stud.

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

- (iii) Studs subjected to the bend test shall not be straightened.

5.6.4 Defective Studs

Studs with defective welding shall be replaced and re-tested as in 5.6.3.

If it is necessary to remove the defective stud it shall be detached and the surface checked as described in 5.4.5.

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 Tables 2.2, 2.3 and 2.4 of Section 2.

Galvanized or sherardized bolts in grades 8.8 or 10.9 shall be fitted with a higher grade nut; class 10 nuts with 8.8 bolts and class/grade 12 nuts with 10.9 bolts (all nuts to BS EN ISO 4032 or BS 4190 as appropriate).

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

6.1.2 Cup and Countersunk Head Bolt/Nut Assemblies

The combination of bolts and nuts which may be used are as tabulated in Table 2.6 of Section 2.

6.1.3 Differing Bolt Grades

Different bolt grades of the same diameter shall not be used in the same structure, except when 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 at least one clear thread shall show above the nut.

6.1.5 Washers

- (i) When the members 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.
- (ii) A suitable plate, or heavy duty washer shall be used under the head and nut when bolts are used to assemble components with oversize or slotted holes.

6.1.6 Taper Washers

When the bolt head or nut is in contact with a surface which is inclined at more than 3° 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

Nuts shall be checked after being galvanized for free running on the bolt and re-tapped if necessary to ensure a satisfactory tightening performance.

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 3692 may be used as fitted bolts when holes are drilled or reamed after assembly so that the clearance in the hole is not more than 0.3mm.

6.2 FIT-UP WHEN USING NON PRE-LOADED BOLT ASSEMBLIES

6.2.1 Fit-up

Connected parts shall be firmly drawn together. If there is a remaining gap which may affect the integrity of the joint, it shall be taken apart and a pack inserted.

6.2.2 Reaming

Where 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 PRE-LOADED BOLT ASSEMBLIES

6.3.1 Bolt/Nut/Washer Combinations

The combination of bolt and nut and washers may be used as specified in Table 2.4 of Section 2. The hardened washer is to be placed under the nut or head being turned.

6.3.2 Other Pre-Loaded Assemblies

The combination of pre-loaded assemblies other than those tabulated in Table 2.4 to be in accordance with manufacturer's recommendations.

6.3.3 Tightening

The use of friction grip bolts shall comply with BS 4604: Part 1 or 2.

Tightening which complies with BS4604: Part 1, may be by the torque control method, part-turn method, or direct tension indicators used in accordance with the manufacturer's recommendations.

6.3.4 Calibration of Torque Equipment

Torque spanners and other devices shall have a calibration check at least once per shift, and shall be re-calibrated where necessary in accordance with BS 4604.

6.3.5 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 WHEN USING PRE-LOADED 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 remaining gap which may affect the integrity of the joint, it shall be taken apart and a pack inserted before recommencing the tightening procedure.

6.4.2 Reaming

- (i) Where 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.
- (ii) 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 PERMITTED DEVIATIONS

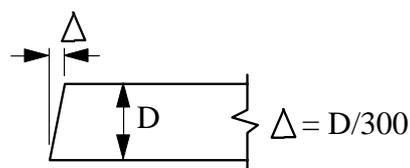
Permitted deviations in cross section, length, straightness, flatness, cutting, holing and position of fittings shall be as specified in 7.2 to 7.5 below.

7.2 PERMITTED DEVIATIONS IN 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
(Section 2)

7.2.2 Squareness of Ends Not Prepared for Bearing

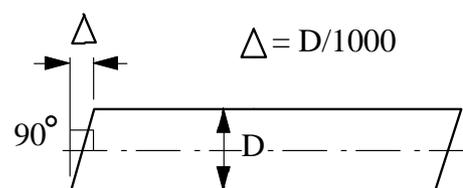


See also 4.3.3 (i).

Plan or Elevation of End

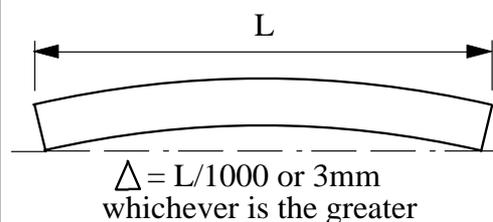
7.2.3 Squareness of Ends Prepared for Bearing

Prepare ends with respect to the longitudinal axis of the member.
See also 4.3.3 (ii) and (iii).



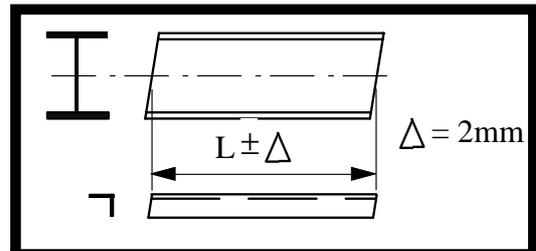
Plan or Elevation

7.2.4 Straightness on Both Axes



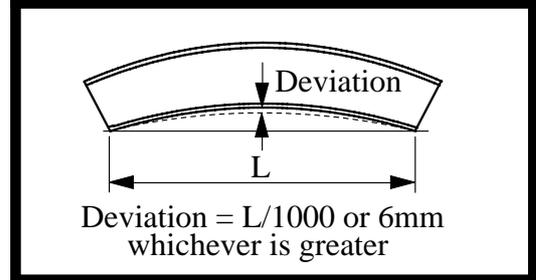
7.2.5 Length

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



7.2.6 Curved or Cambered

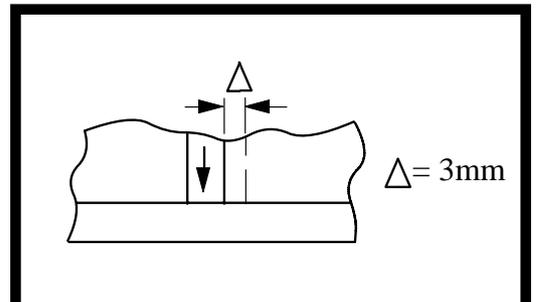
Deviation from intended curve or camber at mid-length of curved portion when measured with web horizontal.



7.3 PERMITTED DEVIATIONS FOR ELEMENTS OF FABRICATED MEMBERS (Δ)

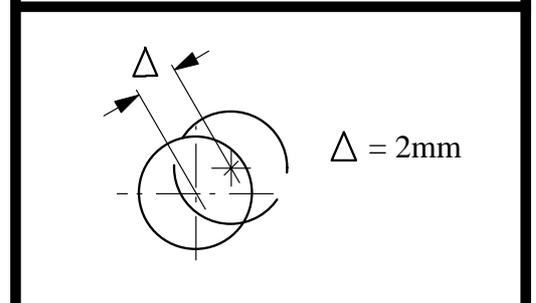
7.3.1 Position of Fittings

Fittings and components whose location is critical to the force path in the structure, the deviation from the intended position shall not exceed Δ .



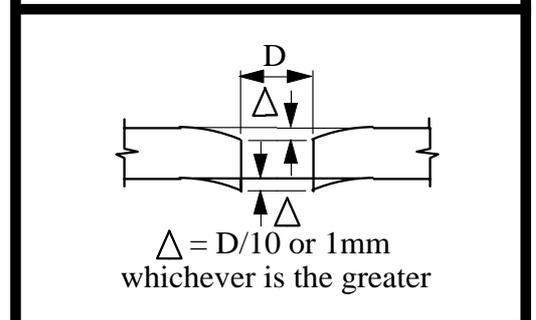
7.3.2 Position of Holes

The deviation from the intended position of an isolated hole, also a group of holes, relative to each other shall not exceed Δ .



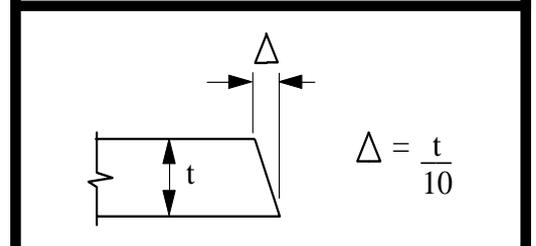
7.3.3 Punched Holes

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



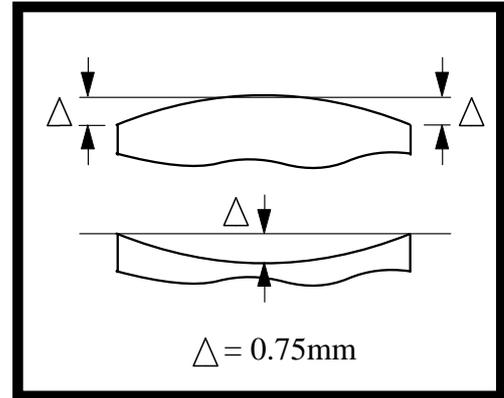
7.3.4 Sheared or Cropped Edges of Plates or Angles

The deviation from a 90° edge shall not exceed Δ .



7.3.5 Flatness

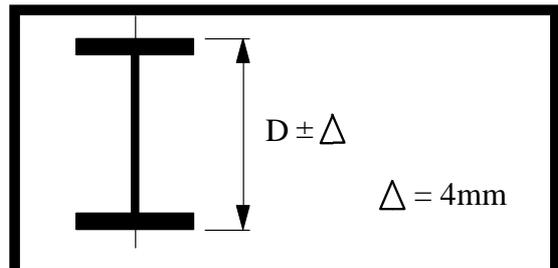
Where full contact bearing is specified, the flatness shall be such that when measured against a straight edge not exceeding one metre long, which is laid against the full bearing surface in any direction, the gap does not exceed Δ .



7.4 PERMITTED DEVIATIONS IN PLATE GIRDER SECTIONS (Δ)

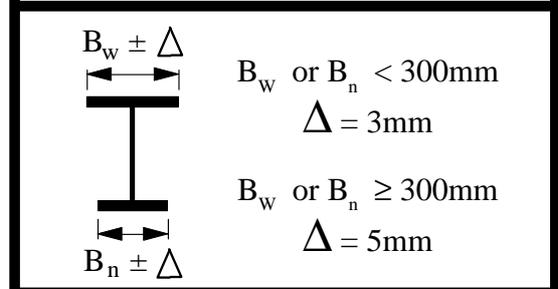
7.4.1 Depth

Depth on centre line.



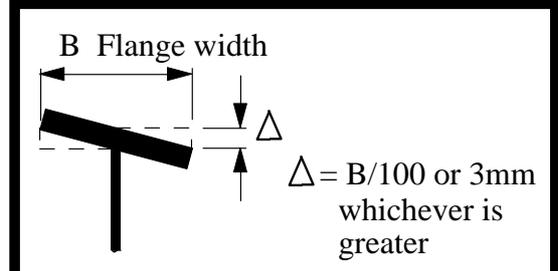
7.4.2 Flange Width

Width of B_w or B_n



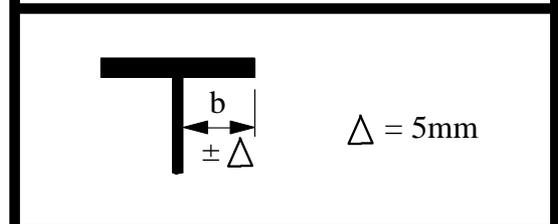
7.4.3 Squareness of Section

Out of Squareness of Flanges.



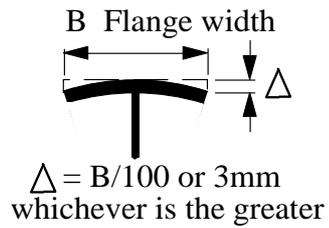
7.4.4 Web Eccentricity

Intended position of web from one edge of flange.



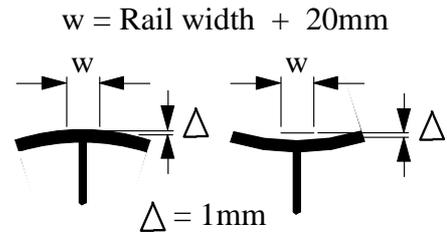
7.4.5 Flanges

Out of flatness.



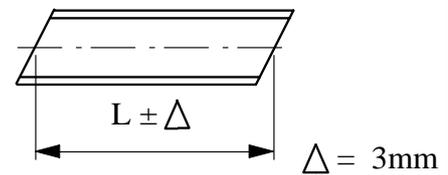
7.4.6 Top Flange of Crane Girder

Out of flatness where the rail seats.



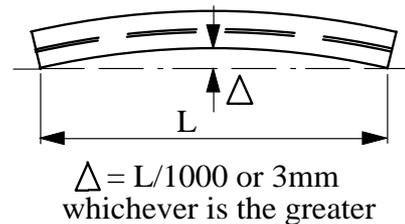
7.4.7 Length

Length on centre line.



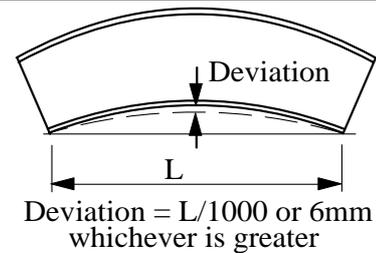
7.4.8 Flange Straightness

Straightness of individual flanges.



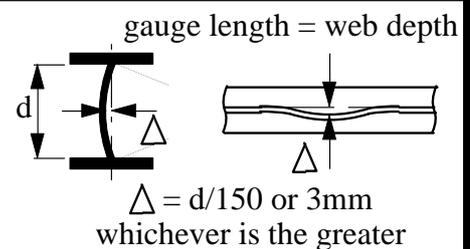
7.4.9 Curved or Cambered

Deviation from intended curve or camber at mid-length of curved portion, when measured with the web horizontal.



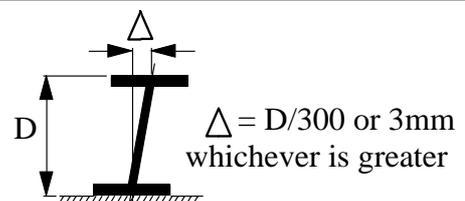
7.4.10 Web Distortion

Distortion on web depth or gauge length.



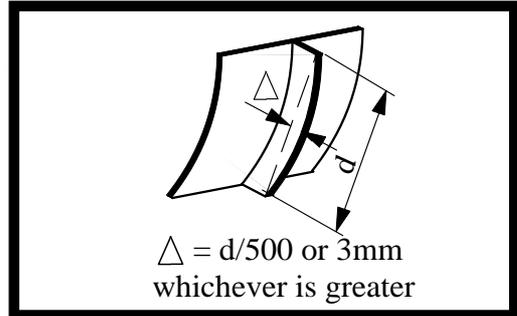
7.4.11 Cross Section at Bearings

Squareness of flanges to web.



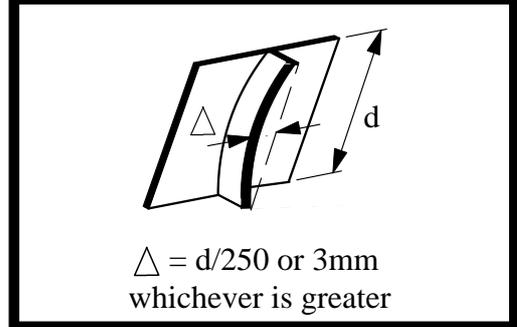
7.4.12 Web Stiffeners

Straightness of stiffener out of plane with web after welding.



7.4.13 Web Stiffeners

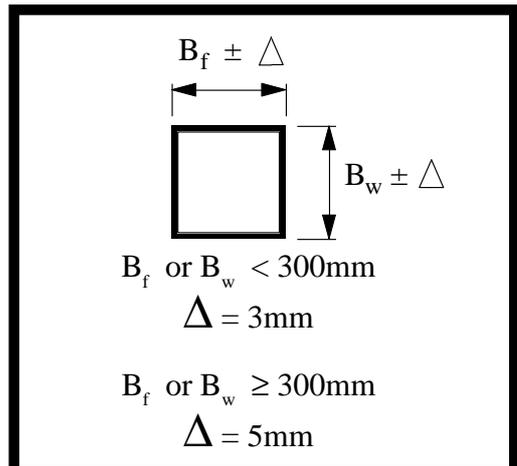
Straightness of stiffener in plane with web after welding.



7.5 PERMITTED DEVIATIONS IN BOX SECTIONS (Δ)

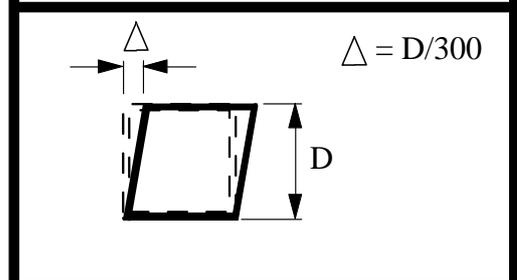
7.5.1 Plate Widths

Width of B_f or B_w



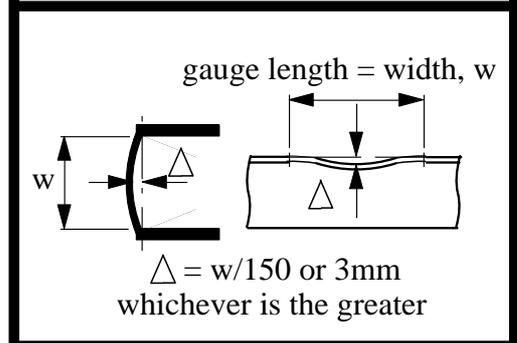
7.5.2 Squareness

Squareness at diaphragm positions.



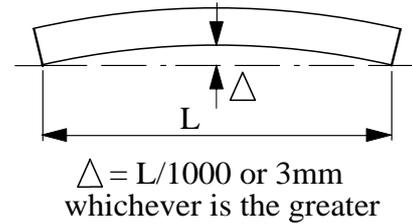
7.5.3 Plate Distortion

Distortion on width or gauge length.

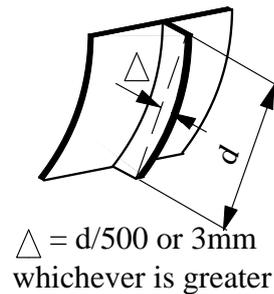


7.5.4 Web or Flange Straightness

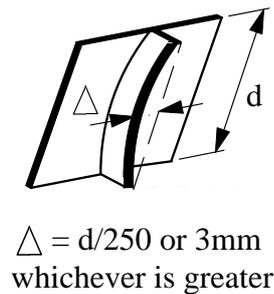
Straightness of individual web or flanges.

**7.5.5 Web Stiffeners**

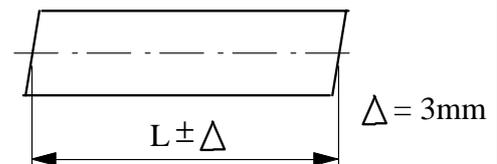
Straightness in plane with plate after welding.

**7.5.6 Web Stiffeners**

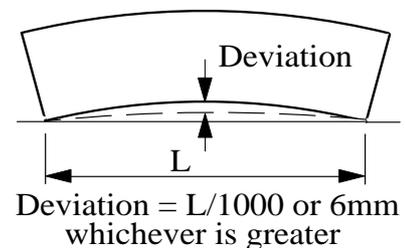
Straightness out of plane to plate after welding.

**7.5.7 Length**

Length on centre line.

**7.5.8 Curved or Cambered**

Deviation from intended curve or camber at mid-length of curved portion when measured with the uncambered side horizontal.



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, 1.5 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 provide and maintain until the steelwork is accepted, setting-out lines and datum levels within, or immediately adjacent to, the Works.

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

- (i) Steel packings shall be supplied to allow the structure to be properly lined and levelled and of sufficient size to avoid local crushing of the concrete.
- (ii) Base packings shall be placed so that they do not prevent subsequent grouting to completely fill all spaces directly under the base plates.
- (iii) Base packs may be left permanently in place.

8.1.7 Grouting

- (i) 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.
- (ii) 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 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) a Safe Site Handover certified checklist;
- (ii) the recommendations given in BS 5531;
- (iii) CDM Regulations.

8.3.2 Steelwork Contractor's Responsibility

The Steelwork Contractor shall:

- (i) ensure that his 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 his duties under current safety legislation.

8.4 STABILITY

8.4.1 Temporary Restraints until Permanent Features are Built

- (i) The Engineer shall advise the Steelwork Contractor of positions on the structure where temporary bracing, metal decking or other restraints must provide stability to individual members or the structure until walls, floors or other non-steel structures are in position. The Engineer shall also provide details of the forces and moments in these elements.
- (ii) The Steelwork Contractor shall design and provide the temporary bracing or restraints.

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

- (i) 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.
- (ii) 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 members until sufficient 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.

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

- (i) Site welding shall be carried out in accordance with Section 5.
- (ii) 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.
- (iii) 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.

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.

SECTION 9

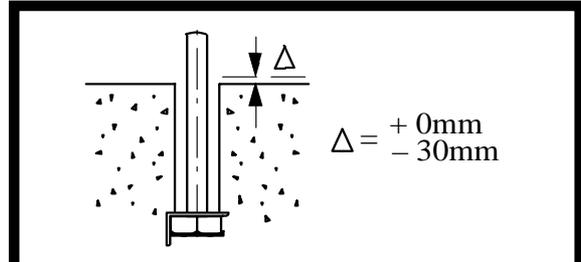
WORKMANSHIP

ACCURACY OF ERECTED STEELWORK

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

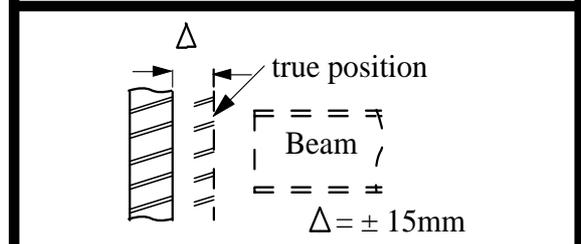
9.1.1 Foundation Level

Deviation from exact level.



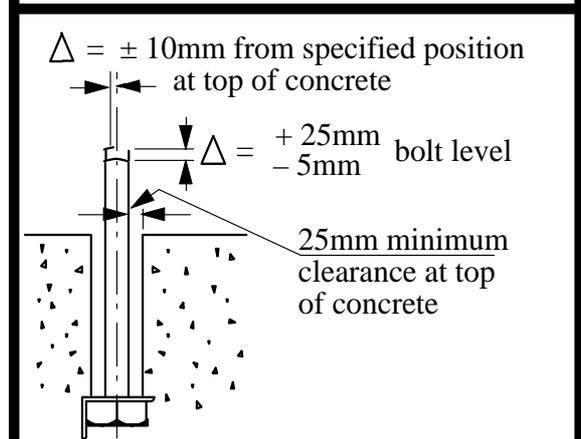
9.1.2 Vertical Wall

Deviation from exact position at steelwork support point.



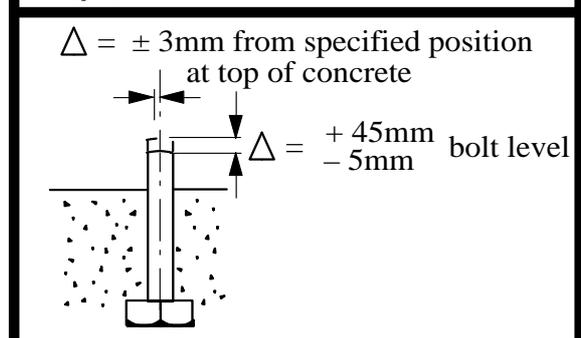
9.1.3 Pre-set Foundation Bolt or Bolt Groups when Prepared for Adjustment

Deviation from specified position



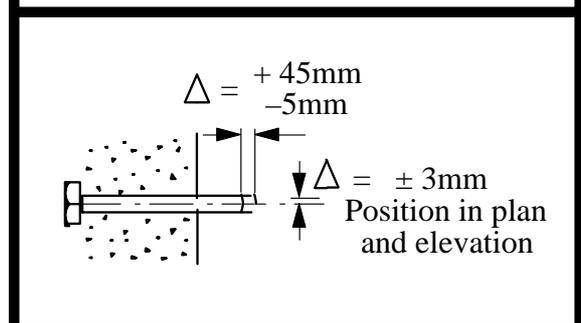
9.1.4 Pre-set Foundation Bolt or Bolt Groups when Not Prepared for Adjustment

Deviation from specified position



9.1.5 Pre-set Wall Bolt or Bolt Groups when Not Prepared for Adjustment

Deviation from specified position



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.

9.3 STEELWORK

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

- (i) All measurements 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.
- (iii) Where deviations are shown relative to nominal centrelines of the section, the permitted deviation on cross-section and straightness, given in Section 7, may be added.

9.4 DEVIATIONS

The Steelwork Contractor shall as soon as possible inform the Engineer of any deviation in 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.

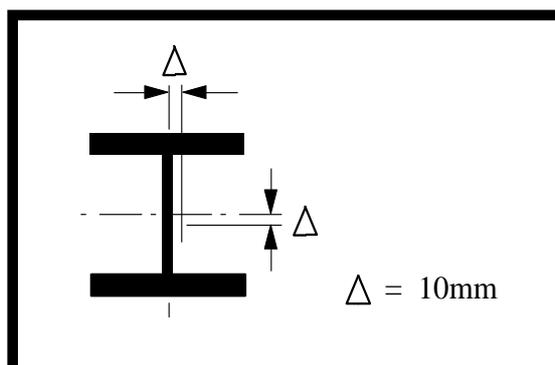
9.5 INFORMATION FOR OTHER CONTRACTORS

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

Deviation of section centreline from the specified position.



9.6.2 Overall Plan Dimensions

Deviation in length or width.

True overall dimension $L < 30$ metres

$$\Delta = 20\text{mm}$$

True overall dimension $L > 30$ metres

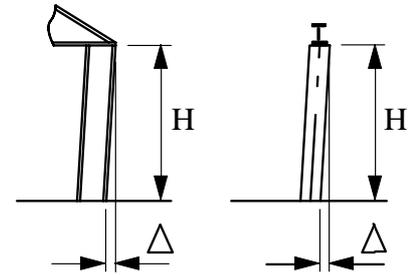
$$\Delta = 20\text{mm} + 0.25(L - 30)\text{mm}$$

L is the maximum dimension in metres

9.6.3 Single Storey Columns Plumb

Deviation of top relative to base, excluding portal frame columns, on main axes.

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



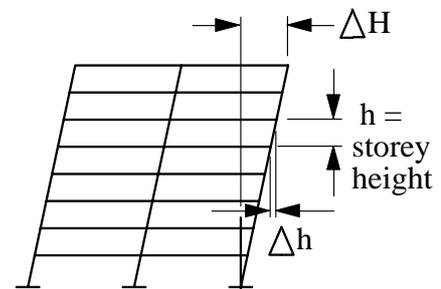
$$\Delta = \pm H/600 \text{ or } 5\text{mm}$$

whichever is greater

$$\text{Max} = \pm 25\text{mm}$$

9.6.4 Multi-storey Columns Plumb

Deviation in each storey and maximum deviation relative to base.



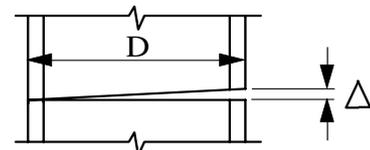
$$\Delta h = h/600 \text{ or } 5\text{mm}$$

whichever is greater

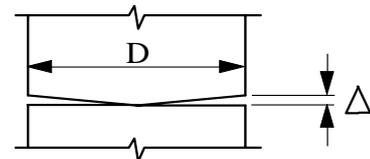
$$\Delta H = 50\text{mm maximum}$$

9.6.5 Gap Between Bearing Surfaces

(See clauses 4.3.3 (iii), 6.2.1 and 7.2.3.)

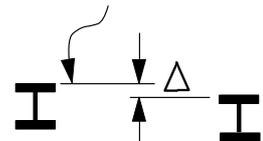


$$\Delta = (D/1000) + 1\text{mm}$$

**9.6.6 Alignment of Adjacent Perimeter Columns**

Deviation relative to next column on a line parallel to the grid line when measured at base or splice level.

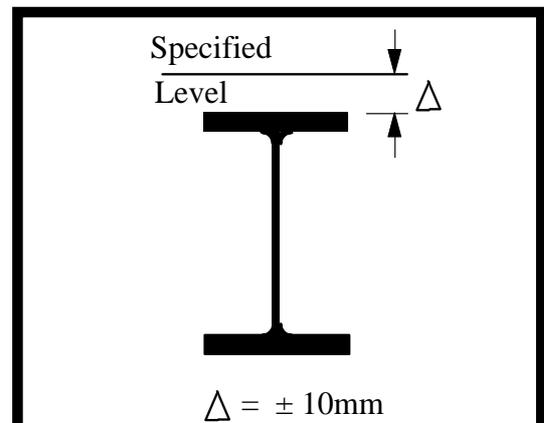
critical face of columns



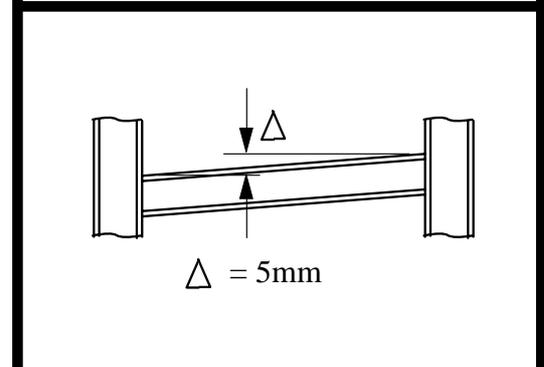
$$\Delta = 10 \text{ mm}$$

9.6.7 Beam Level

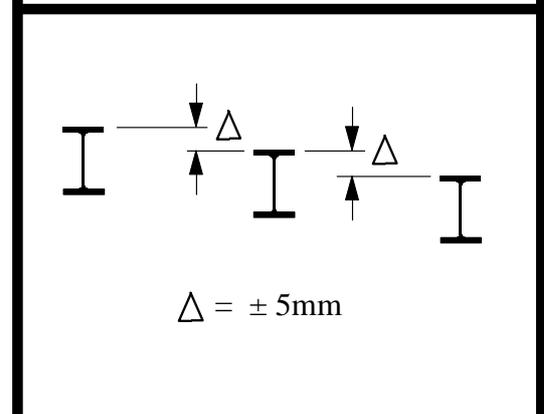
Deviation from specified level at supporting column.

**9.6.8 Level at Each End of Same Beam**

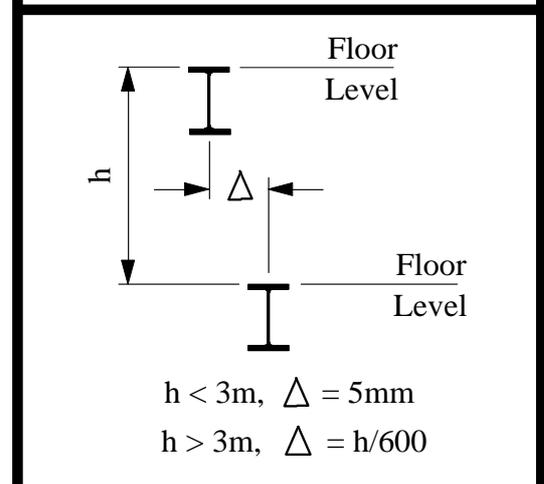
Relative deviation in level at ends.

**9.6.9 Level of Adjacent Beams within a distance of 5 metres**

Deviation from relative horizontal levels (measured on centreline of top flange).

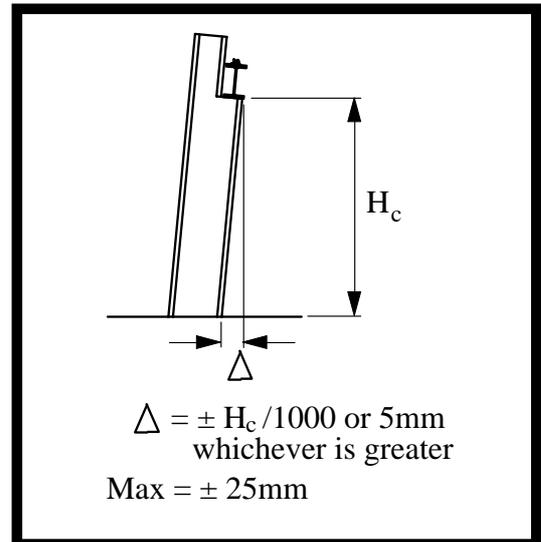
**9.6.10 Beam Alignment**

Horizontal deviation relative to an adjacent beam above or below.



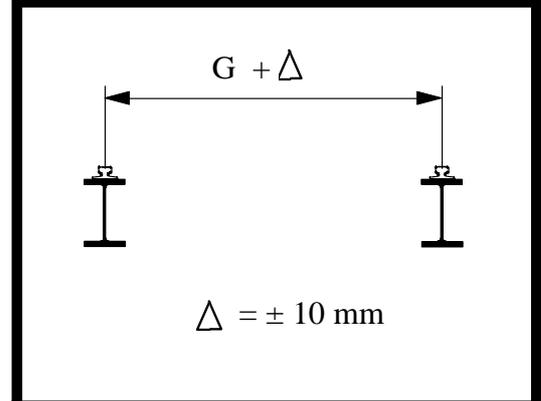
9.6.11 Crane Gantry Columns Plumb

Deviation of cap relative to base.



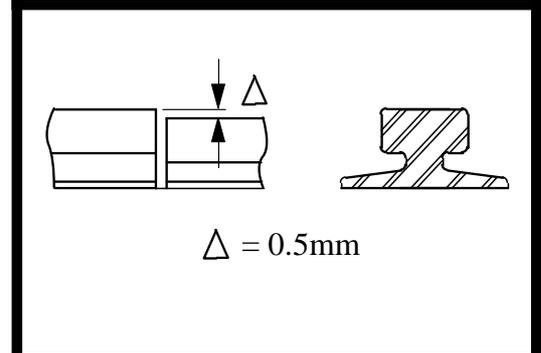
9.6.12 Crane Gantries Gauge of Rail Tracks

Deviation from true gauge.



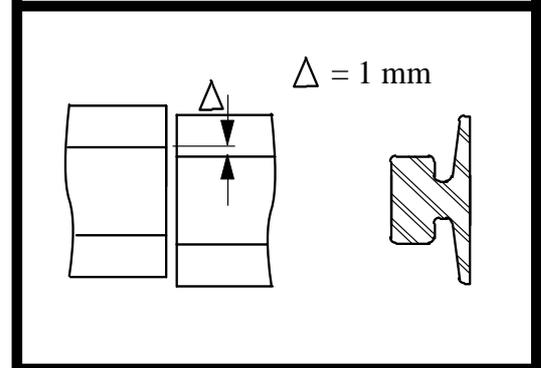
**9.6.13 Joints in Gantry Crane Rails
Rail surface**

Deviation in level at rail joint.



**9.6.14 Joints in Gantry Crane Rails
Rail edge**

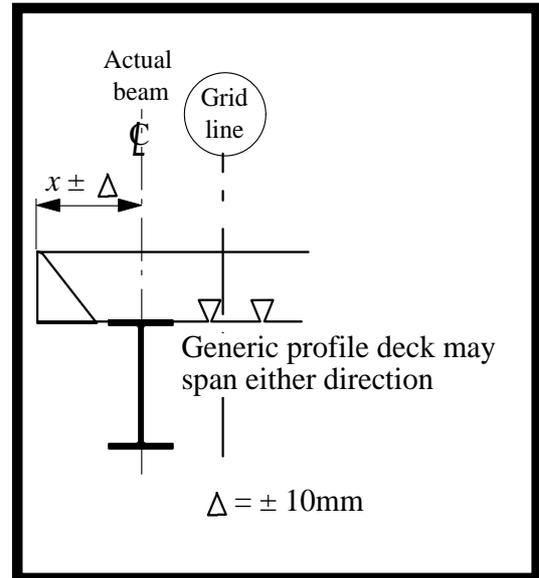
Deviation in line at rail joint.



9.6.15 Profile Steel Floor Decking

Deviation of dimension between deck edge trim and perimeter beam

Note : Deviation (as shown) between actual beam centre line and intended beam centre line arises from other permitted tolerances (e.g. 9.6.4)



SECTION 10

PROTECTIVE TREATMENT

10.1 GENERAL

10.1.1 Specification

- (i) The coatings required for structural steelwork shall be as specified on the Design Drawings or in the Project Specification (see Table 1.5). The system shall be in accordance with the latest edition of DETR's *Guidance Notes to Environmental Protection Act 1990*[PG6/23].
- (ii) A single source of coating supply shall be used unless otherwise agreed with the Employer.

10.1.2 Method Statement

- (i) 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.
- (ii) 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 7079: Part A1 and ISO 8501.1.

10.2.2 Surface Profile

The surface profile of the steelwork to be coated shall be compatible with the coating to be applied in accordance with BS 7079: Part C2 and ISO 8503.2.

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 7079: Group C.

10.2.4 Surface Defects

Surface defects revealed during surface preparation shall be dealt with in accordance with 2.5 (ii) and (iii).

10.3 SPRAYED METAL COATINGS

10.3.1 Procedures

Zinc or aluminium sprayed coatings shall be applied to the surface as required by BSEN 22063 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

Where a sprayed metal coating is to be overcoated subsequently, it shall be sealed before the application of the overcoating in accordance with BS 5493 Table 4C Part 2.

10.4 HOT-DIP GALVANIZING

Note. Where higher strength steels are to be galvanized, advice on good practice to minimise the risk of cracking should be sought from the Galvanizers Association.

10.4.1 Procedures

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

10.4.2 Vent Holes

The Steelwork Contractor shall agree with the Engineer the position of vent and drainage holes in hollow members 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

- (i) 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.
- (ii) 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.

10.6 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 ASSURANCE

11.1 QUALITY SYSTEM

11.1.1 System Requirements

The Steelwork Contractor shall have a management system to ensure that the procedures for design, detailing, purchasing, fabrication and erection of steel components and structures conform to the requirements of the Contract and of this Specification.

11.1.2 System Acceptance

The system shall be either:

(i) assessed and certified as complying to the requirements of BSEN ISO9001 by an accredited certification body.

or

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

11.1.3 Scope

The system shall cover all procedures as detailed in BS EN ISO 9001 and 9002

11.2 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).

11.3 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 MPI, DPI, U/S examination) are set out in 5.5.4.

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

TABLE A Illustrative Hold Times ⁽¹⁾

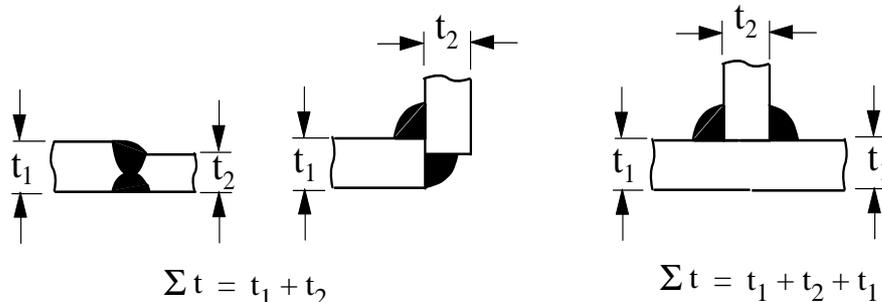
| Nominal Carbon Equivalent Value (CEV) ⁽²⁾ | $\Sigma t^{(3)} \leq 30\text{mm}$ | $\Sigma t^{(3)} \leq 60\text{mm}$ | $\Sigma t^{(3)} \leq 90\text{mm}$ | $\Sigma t^{(3)} > 90\text{mm}$ |
|--|-----------------------------------|-----------------------------------|-----------------------------------|--------------------------------|
| ≤ 0.40 | None | 8 hours | 16 hours | 40 hours |
| ≤ 0.45 | 8 hours | 16 hours | 40 hours | 40 hours |
| ≤ 0.5 | 16 hours | 40 hours | 40 hours | 40 hours |
| > 0.5 | 40 hours | 40 hours | 40 hours | 40 hours |

Notes (1) Hold times are the waiting times normally required after completion of welding. In high restraint situations (e.g. cruciform welds) the hold time might need to be increased; with evidence of continual satisfactory production hold times might be reduced. The shaded area highlights those situations where, generally, the advice of a welding engineer should be sought.

(2) Carbon Equivalent Value is that of the parent material and is calculated as follows:

$$\text{CEV} = C + \frac{\text{Mn}}{6} + \frac{\text{Cr} + \text{Mo} + \text{V}}{5} + \frac{\text{Ni} + \text{Cu}}{15}$$

(3) Σt is the combined thickness (see below):



Annex B Welds - Scope of Inspection

TABLE B WELDS - SCOPE OF INSPECTION

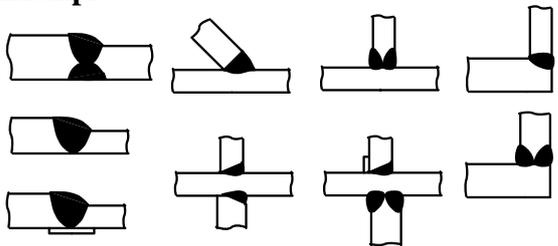
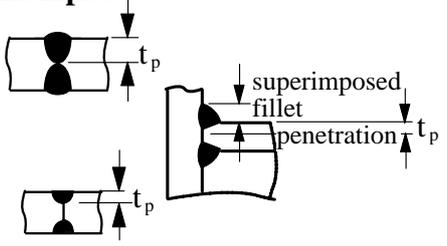
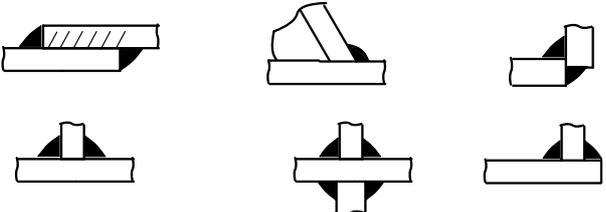
| | | | |
|--------------------------------|------------------|--|--|
| PART A | | VISUAL INSPECTION Prior to non-destructive testing ALL welds to be visually inspected by a suitably qualified person. (See 5.5.2) | |
| PART B | | MANDATORY NON-DESTRUCTIVE TESTING AND FREQUENCY of TESTING | |
| | | Full Penetration Butt Welds | Partial Penetration Butt Welds |
| | | Examples:  | Examples:  |
| MPI (see 5.5.3) | Thickness | All thicknesses | All thicknesses |
| | Frequency | 50% (Site Welds 100%) | 20% (Site Welds 100%) |
| U/S (see 5.5.4) | Thickness | $t_{max} \geq 10 \text{ mm}$ | $t_p \geq 8 \text{ mm}$ |
| | Frequency | 50% (Site Welds 100%) | 20% (Site Welds 100%) |
| | | Fillet Welds | |
| | | Examples:  | |
| MPI (see 5.5.3) | Thickness | Leg length > 10 mm | |
| | Frequency | 10% (Site Welds 100% but longitudinal welds 0,5 m in each 10m or part thereof) | |
| U/S (see 5.5.4) | Thickness | Leg length $\geq 20 \text{ mm}$ | |
| | Frequency | 10% (Site Welds 100%) | |
| See Notes (Facing Page) | | | |

TABLE B WELDS - SCOPE OF INSPECTION NOTES

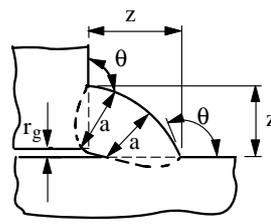
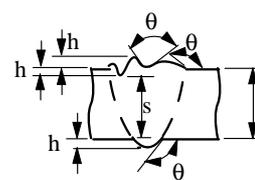
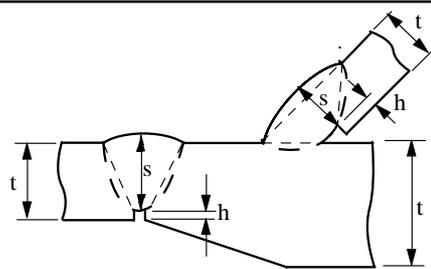
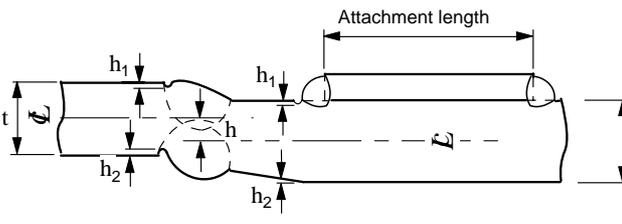
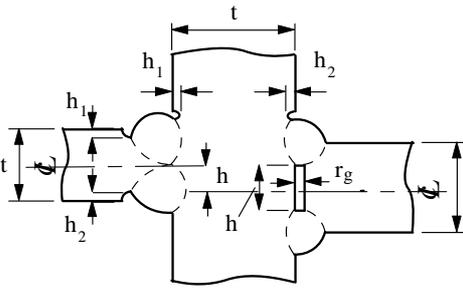
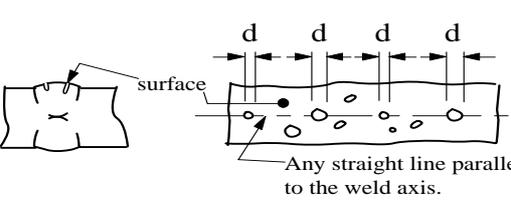
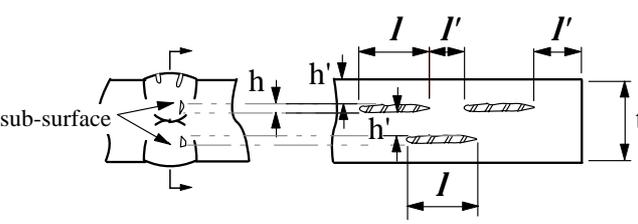
- (i) The requirements of this table shall not preclude the use of Non-Destructive Testing outside the limits shown should the results of visual inspection or NDT indicate that a lapse in quality may have occurred in specific joints.
- (ii) Where only partial inspection is required the joints for testing shall be selected on a random basis, but ensuring that sampling covers the following variables as widely as possible: Joint Type, Material Grade & Welding Equipment.
- (iii) The scope of inspection, subsequent to initial production, may be reduced at the Engineer's discretion (See 5.5.1).
- (iv) In workshops where the same constructional details welded with the same welding procedures are being used on a regular basis, the first 5 joints of each type having the same basic dimensions, material grades, weld geometry and welded to the same procedures, 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 this table shall be implemented, for at least a full week following the rectification of the fault.

Three months of weekly weld testing records showing satisfactory performance, applicable to each constructional detail, should be maintained and made available for inspection.
- (v) Longitudinal welds are those made parallel to the member axis and whereas transverse welds are orientated otherwise.
- (vi) The size of fillet welds is identified in this table by leg length; this differs from recently issued BS EN welding standards which use throat thickness to identify the size.

Annex C - Welds – Acceptance requirements & measurement definitions

| Table C.1 Acceptance requirements for production welds in steel structures | | | | | | | |
|--|---|-----------------------------------|-----------------------------------|------------------------------|--|--|-----------------------------|
| | Parameter | Weld type | Particular conditions | Figure reference in Table C2 | Acceptance criteria for normal quality (all dimensions in mm) (Note 1 & 5) | Remedial action for non-conforming welds Table C2 (Note 2) | |
| Weld geometry | Location | All | | | $D \pm 10$ | Repair | |
| | Weld Type | All | | | D | Refer to Engineer | |
| | Length | All | | | $D + 10 - 0$ | Repair | |
| Profile discontinuities | Throat thickness | All | | (i),(ii),(iii) | $a, s \geq D$ (Av. 50) $a, s \leq D + 5$ | Repair and dress smooth | |
| | Leg length | Fillet | | (i) | $z \geq D$ (Av. 50) | Repair | |
| | Toe Angle | All | Transverse or Longitudinal | (i),(ii) | $\theta \geq 90^\circ$ | Repair and dress smooth | |
| | Excess weld metal | Butt | Transverse or Longitudinal | (ii) | $h \leq 6$ | Repair and dress smooth | |
| | Incomplete groove or concave root | Butt | Transverse | (ii) | $h \leq 0$ (Av. 50) | Repair | |
| | | | Longitudinal | (ii) | $h \leq 0.1t$ | | |
| Linear misalignment | Butt | Butt Joint | (iv) | $h \leq D + 0.2t$ | Refer to Engineer | | |
| | | Transverse cruciform | (v) | $h \leq D + 0.4t$ | | | |
| | | Longitudinal | (iv),(v) | $h \leq D + 0.4t$ | | | |
| Surface breaking discontinuities | Undercut | All | Transverse (not lap joint) | (iv),(v) | $h_1 + h_2 \leq 0.05t$ I - No limit | Repair | |
| | | Fillet | Transverse (lap joint) | (v) | $h_1 + h_2 \leq 0.03t$ $I \leq 10$ | | |
| | | All | Longitudinal | (iv),(v) | $h_1 + h_2 \leq 0.1t$ | | |
| | Lack of root penetration | S/S Butt | Transverse | (iii) | $h \leq D + 0.05t$ (Av. 50) | Repair | |
| | | | Longitudinal | (iii) | $h \leq D + 0.1t$ (Av. 50) | | |
| | Porosity | All | Transverse | (vi) | $d \leq 2$ $\Sigma d \leq 10$ [100] | Repair | |
| | | | Longitudinal | (vi) | $d \leq 2$ $\Sigma d \leq 20$ [100] | | |
| Lack of fusion | All | | | | Not permitted | Repair | |
| Cracks | All | | | | Not permitted | Repair | |
| Sub-surface discontinuities | Lack of fusion/root penetration, slag lines | Butt | All | (vii) | $h \leq 3$ | Repair | |
| | | | Transverse | Full depth | (vii) | | $\Sigma I \leq 1.5t$ [100] |
| | | | | $h' < 6$ | (vii) | | $I \leq 10$ $I' \geq 10$ |
| | | | $h' > 6$ | (vii) | I - No limit I' - No limit | | |
| Longitudinal | Full depth | (vii) | $\Sigma I \leq 3t$ [100] | | | | |
| | $h' < 6$ | (vii) | I - No limit I' - No limit | | | | |
| $h' > 6$ | (vii) | I - No limit I' - No limit | | | | | |
| Root Gap | Fillet, P/P Butt | | | (i),(v) | $r_g \leq 2$ (Av.100) $r_g \leq 3$ | Repair | |
| Cracks | All | | | | Not permitted | Repair | |
| Lamellar Tears | All | Transverse Longitudinal | | | Not permitted | Refer to Engineer | |

Table C.2 Measurement definitions for production welds in steel structures

| | | |
|--|--|---|
|  <p>Figure (i)</p> |  <p>Figure (ii)</p> |  <p>Figure (iii)</p> |
|  <p>Figure (iv)</p> |  <p>Figure (v)</p> | |
|  <p>Figure (vi)</p> |  <p>Figure (vii)</p> | |

Abbreviated terms and notes applicable to Table C1

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) |
| ≥ | Greater than or equal to (ie Not less than) |
| ≤ | Less than or equal to (ie Not greater than) |
| Σ | Sum of |
| (Av50) | Length of weld over which measurement may be averaged (mm) |
| [100] | Length of weld over which summation is made (mm) |
| <i>l</i> | length parallel to the weld axis- |

Note 1. For definition of orientation see Table B

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

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

Note 4. Subject to any other locational requirements.

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

Note 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.

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