

National Structural Steelwork
Specification
for Building Construction

5th Edition

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The British Constructional Steelwork Association Ltd.,
4, Whitehall Court, Westminster, London SW1A 2ES
Telephone: +44 (0)20 7839 8566 Fax: +44 (0)20 7976 1634
E-mail: postroom@steelconstruction.org
Website: www.steelconstruction.org

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The British Constructional Steelwork Association Limited,
4 Whitehall Court, Westminster, London SW1A 2ES.

Telephone: +44 (0)20 7839 8566, Fax: +44 (0)20 7976 1634.

Email: postroom@steelconstruction.org

Web site: www.steelconstruction.org



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The Steel Construction Institute, Silwood Park, Ascot, Berkshire, SL5 7QN,

Telephone: +44(0) 1344 623345, Fax: +44(0) 1344 622944

Email: reception@steel-sci.com

Web site: www.steel-sci.org

FOREWORD

The National Structural Steelwork Specification for Building Construction is presented here in its 5th Edition; issued some four years after the last publication and seventeen 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 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, is arranged to make its purpose more apparent. It is recognised that if the structure is unorthodox it may be appropriate to qualify and/or enlarge upon the provisions of this Specification; some guidance on such matters is given in the Commentary which is available on www.steelconstruction.org.

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

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

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

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

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

The vertical line on the left of the page indicates a change to the text of the 4th Edition. This vertical line has not been used where only clause renumbering or editorial corrections were required. All parties are reminded that under the Construction (Design and Management) Regulations 1994 they have a duty to cooperate with others involved with construction of The Works to demonstrate compliance with Health and Safety legislation. Compliance with this Specification will make that task easier.

Attention is drawn to Section 11 which requires that Steelwork Contractors should have all the necessary facilities, skills and effective quality management to ensure that their services and products conform to this Specification. It stipulates that the quality management system shall be open to assessment by the Employer or be certified by an approved certification body for compliance with BS EN ISO 9001: 2000.

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

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

Mr A Pillinger (Chairman)	-	Bourne Steel Ltd.
Mr G Andrews	-	Waterman Group Plc.
Mr C Bakkala	-	Buro Happold
Mr M Banfi	-	Arup
Mr E Boland	-	WS Britland & Company Ltd.
Mr J Brennan	-	Barrett Steel Buildings Ltd.
Mr D Brown	-	Steel Construction Institute
Mr G Charalambous	-	Corus Group Plc. (CC&I)
Mr J Garner	-	Mott MacDonald
Mr G Harding	-	ODPM
Mr E Hole	-	Corus Group Plc. (Tubes)
Mr A Hughes	-	Tube Lines Ltd.
Eur Ing J Krancioch	-	Severfield-Rowen Plc.
Dr A Mann	-	Jacobs Babbie
Dr D Moore	-	British Constructional Steelwork Association
Dr R Pope (Compiler)	-	BCSA Technical Consultant

The steering committee acknowledge further advice provided by:

Mr J French	-	Sandbergs
Mr G Mathers	-	The Welding Institute
Mr P Mould	-	Steel Construction Certification Scheme Ltd.
Dr M Ogle	-	The Welding Institute
Mr R Pargeter	-	The Welding Institute
Mr A Shepherd	-	Richard Lees Steel Decking Ltd.

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

Documents referred to in this Specification

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

- (a) British, European, American and ISO Standards
British Standards Institution
389 Chiswick High Road
London W4 4AL
- (b) *The Construction (Design and Management Regulations) and 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) *New paint systems for the protection of construction steelwork*
CIRIA
Classic House
174-180 Old Street
London EC1V 9BP
- (e) *National Structural Concrete Specification*
CONSTRUCT
Riverside House
4 Meadows Business Park
Camberley
Surrey GU17 9AB

Commentary on the National Structural Steelwork Specification

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

CONTENTS

SCOPE		10
DEFINITIONS		11
SECTION 1	INFORMATION REQUIRED BY THE STEELWORK CONTRACTOR	13
1.1	Project Specification for Structural Steelwork:	13
Table 1.1	Proposed Works - Checklist	13
Table 1.2A	Design - Checklist (Steelwork Contractor designing connections)	14
Table 1.2B	Design - Checklist (Steelwork Contractor designing members)	15
Table 1.2C	Design - Checklist (Steelwork Contractor arranging layout)	15
Table 1.3	Workmanship - Checklist	16
Table 1.4	Erection - Checklist	16
Table 1.5	Protective Treatment - Checklist	17
Table 1.6	Inspections and Tests - Checklist	17
Table 1.7	Programme - Checklist	17
SECTION 2	MATERIALS	19
2.1	Steel Products	19
Table 2.1	Material and Dimension Standards	20
2.2	Welding Consumables	21
2.3	Structural Fasteners	21
Table 2.2	Matching Ordinary Assemblies	23
Table 2.3	Matching Ordinary Assemblies	23
Table 2.4	Matching Preloaded Assemblies	24
Table 2.5	Holding Down Bolt Assemblies	24
Table 2.6	Cup and Countersunk Head Bolt Assemblies	24
2.4	Shear Studs	24
2.5	Protective Treatment Materials	25
2.6	Proprietary Items	25
2.7	Substitution of Material or Form	25
SECTION 3	INFORMATION PROVIDED BY THE STEELWORK CONTRACTOR	27
3.1	Information System	27
3.2	General Arrangement of Components	27
3.3	Foundation and Wall Interface Information	27
3.4	Fabrication Information for Components	28
3.5	Erection Information	29
3.6	Drawing or Information Review	29
3.7	"As Erected" Structure	31

SECTION 4	WORKMANSHIP - GENERAL	33
4.1	Identification	33
4.2	Handling	33
4.3	Cutting and Shaping	33
4.4	Machining	34
4.5	Dressing	34
4.6	Holing	34
4.7	Assembly	35
4.8	Curving and Straightening	36
4.9	Inspection	36
4.10	Storage	36
SECTION 5	WORKMANSHIP - WELDING	37
5.1	General	37
5.2	Welder Qualification	37
5.3	Welding Procedures	38
5.4	Assembly	38
5.5	Non-destructive Testing of Welds	39
5.6	Shear Stud Welding	42
SECTION 6	WORKMANSHIP - BOLTING	43
6.1	Ordinary (Non-preloaded) Assemblies	43
6.2	Fit-up if using Non-preloaded Bolt Assemblies	44
6.3	Preloaded Assemblies	44
6.4	Fit-up if using Preloaded Bolt Assemblies	45
SECTION 7	WORKMANSHIP - ACCURACY OF FABRICATION	47
7.1	Permitted Deviations	47
7.2	Permitted Deviations for Rolled Components after Fabrication	47
7.3	Permitted Deviations for Elements of Fabricated Components	48
7.4	Permitted Deviations for Plate Girder Sections	49
7.5	Permitted Deviations for Box Sections	51
SECTION 8	WORKMANSHIP – ERECTION	53
8.1	General	53
8.2	Site Conditions	54
8.3	Safety	54
8.4	Stability	55
8.5	Erection Loads	55
8.6	Lining and Levelling	55
8.7	Site Welding	56
8.8	Site Bolting	56
8.9	Certification of Completion	56

SECTION 9	WORKMANSHIP – ACCURACY OF ERECTED STEELWORK	57
9.1	Permitted Deviations for Foundations, Walls and Foundation Bolts	57
9.2	Foundation Inspection	58
9.3	Steelwork	58
9.4	Deviation	59
9.5	Information for Other Contractors	59
9.6	Permitted Deviations of Erected Components	59
SECTION 10	PROTECTIVE TREATMENT	64
10.1	General	64
10.2	Surface Preparation	64
10.3	Sprayed Metal Coatings	65
10.4	Hot Dip Galvanizing	65
Table 10.1	Post-Galvanizing Inspection	66
10.5	Paint Treatments	66
10.6	Coating of Surfaces to be Encased in Concrete	67
SECTION 11	QUALITY ASSURANCE	68
11.1	Quality System	68
11.2	Additional Inspections and Tests	68
11.3	Records	68
ANNEX A	Weld Testing – Hold Times	69
ANNEX B	Welds – Scope of Inspection	70
ANNEX C	Welds – Acceptance Requirements and Measurement Definitions	72
ANNEX D	Guidelines for Visual Inspection of Welds	75
ANNEX E	Specifications for Applied Coatings	76

SCOPE

This Specification deals with structural steelwork designed in accordance with:

BS 5950-1 Structural use of steelwork in buildings: Code of practice for design: rolled and welded sections

BS EN 1993-1-1 Eurocode 3: Design of steel structures – Part 1.1: General rules and rules for buildings

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 if fatigue is a factor unless appropriate amendments are made.

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

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

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

DEFINITIONS

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

- Connection Design : The design of bolts, welds, cleats, plates and fittings required to provide an adequate load path between the end of a member and the component it connects to.
- Design Calculations : Calculations prepared by the Engineer showing the design and analysis of the structure.
- Engineer : The Employer's, or the Steelwork Contractor's, designer who is responsible for the structural design and for reviewing and accepting the detail drawings and erection method statement.
- Design Drawings : Fully dimensioned drawings or electronic equivalent prepared by the Engineer showing all members with their size and material grades, the forces to be developed in their connections, any cambers, eccentricities (offsets or levels) and other information necessary for the design of the connections and completion of Fabrication and Erection Drawings.
- 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.
Note: This will usually be the main contractor, and is not necessarily the Employer as defined in JCT contracts.
- Erection Drawings : Drawings, prepared if necessary by the Steelwork Contractor, showing details to amplify the information given in the Steelwork Contractor's erection method statement and showing details of any temporary steelwork (see 8.1.1 and 8.4).
- Examiner, Examining Body : An independent person or organisation whose competence to verify compliance of welder tests to BS EN 287 or welding tests to BS EN ISO 15614 has been accepted by the Employer.
Note: These responsibilities are distinct from those of the Inspection Authority if appointed. UKAS accreditation of the Examiner / Examining Body is likely to ensure universal acceptance.
- 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.
Note: These are often termed "detail drawings".
- Fittings : Plates, flats or rolled sections which are welded or bolted to structural steel components.
- Foundation Plan Drawings : Drawings, prepared by the Steelwork Contractor or the Engineer, indicating location of column bases and details of foundation connections to the steelwork.

General Arrangement Drawings	:	Drawings, prepared by the Steelwork Contractor, showing plans, cross sections and elevations, main dimensions and the erection marks of components.
Inspection Authority	:	<p>A competent independent person or organisation which verifies compliance with this Specification and the Project Specification.</p> <p><i>Note: Generally, the scope of an Inspection Authority's responsibility would necessitate it being competent to verify that welding procedure qualification records are suitable for the work being undertaken and that suitable welding procedure specifications are being used.</i></p>
Ordinary Assembly	:	A non-preloaded 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; and the intended starting and completion for steelwork erection.
Project Specification	:	A specification prepared for a specific building project (see "The Works") which includes the latest version of the National Structural Steelwork Specification and qualifies it where necessary.
Quality Assurance	:	Activities concerned with the provision of systems, equipment and personnel necessary to achieve the required level of quality.
Site	:	The area defined in the Project Specification within which The Works will be constructed.
Stiffener	:	A steel component, generally a plate, in a connection or attached to a member to increase the strength of a panel zone within the joint or member.
Steelwork Contractor	:	The company appointed to fabricate and/or erect the structural steelwork. If required by the Project Specification, the Steelwork Contractor may also be responsible for design.
Works, The	:	Those parts of the construction works described in the Project Specification as structural steelwork.
Fillet Weld	:	A weld, other than a butt or edge weld, which is approximately triangular in transverse cross section and which is made without preparation of the parent material.
Full Penetration Weld	:	A weld between elements which may be in-line, in the form of a tee, or a corner in which the weld metal achieves full penetration throughout the joint thickness.
Partial Penetration Weld	:	<p>A weld formed using a technique which ensures a specified penetration which is less than the depth of the joint and hence intentionally not full penetration.</p> <p><i>Note: This is distinct from "incomplete penetration" which is penetration that is less than that specified or required.</i></p>
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 THE STEELWORK CONTRACTOR

1.1 PROJECT SPECIFICATION FOR STRUCTURAL STEELWORK

1.1.1 Provision of information

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

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

1.1.2 Reference to National Structural Steelwork Specification

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

1.1.3 Precedence if there is a conflict

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

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. (iv) The building class in accordance with the Building Regulations.

TABLE 1.2A DESIGN – CHECKLIST

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

Information required by the Steelwork Contractor

- (i) A statement describing the design concept.
- (ii) Design Drawings showing all dimensions relevant to the steelwork or, if agreed, equivalent electronic data.
- (iii) The design standards to be used for connection design.
- (iv) Information necessary to design the connections including forces, moments and their combination required to be transmitted at each joint. If connection design is to be in accordance with BS 5950, the forces and moments should be the factored values as defined by the code.
- (v) Particulars of any aesthetic, structural or clearance limits to be observed or environmental conditions which may affect detailing or protective treatment.
- (vi) Details and locations of any temporary works assumed by the Engineer in the design.
- (vii) A schedule of drawings, calculations and other information which the Steelwork Contractor must submit for acceptance.
- (viii) Any part of the steelwork where the manufacturing processes must be restricted including locations where holes cannot be punched e.g. plastic hinge positions (see 4.6.1).
- (ix) Details of any dynamic or vibrating forces and if fatigue is to be considered. Appropriate amendments to this Specification should be included since these factors are outside the intended scope.
- (x) The designation of the steel to be used including the standard number, material grade and impact quality (see 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, including stiffeners required around service holes and in tubular joints.
- (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, or a statement clarifying the scope of coordination with others that the Steelwork Contractor has to undertake in this respect.
- (xvii) Camber and presets which have to be provided in fabrication so that continuous frames and other steelwork can be erected to the required geometry.

TABLE 1.2B DESIGN – CHECKLIST

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

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

Information required by the Steelwork Contractor

- (i) A statement describing the design requirements.
- (ii) Drawings showing the position of steel components.
- (iii) The design standards to be used.
- (iv) The loading data to be used.
- (v) Particulars of any aesthetic, structural or clearance limits to be observed or environmental conditions which may affect design and detailing or protective treatment.
- (vi) A schedule of drawings, calculations and other information which the Steelwork Contractor must submit for acceptance.
- (vii) Any restrictions on the material grade and designation of steel to be used, including any of the options noted in standards listed in Table 2.1.
- (viii) Specification of any other materials to be used in the Works.
- (ix) Any non-destructive testing required on the materials in addition to those specified in clause 5.5 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) 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 5.5.7).

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, access equipment 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 and 8.5).
- (iv) Any limitation on dimensions or weights of components to be delivered to the Site or ground capacity limits for heavy loads.
- (v) Any design features which would affect the construction sequence, or which may create an unusual hazard during construction.
- (vi) Details of any underground services, overhead cables or site obstructions.
- (vii) An outline of the method of erection envisaged by the Engineer, giving the sequence for erecting the structure taking into account any phasing of The Works, including positions on the structure where temporary bracing, metal decking or other restraints are needed to provide stability to individual members or the structure until walls, floors or other non-steel structures are in position (in accordance with 8.4.1).
- (viii) A description of any temporary works and any special requirements for temporary bracing required by the Engineer to comply with (vii) above; the stage when it is no longer necessary, or whether it is to be left in position after completion of the steelwork.
- (ix) A list of the responsibilities at the interface between the steelwork and other trades.
- (x) A Safe Site Handover Certificate and other information necessary so that the Steelwork Contractor can comply with Section 8 (see 8.3.1).

TABLE 1.5 PROTECTIVE TREATMENT – CHECKLIST**Information required by the Steelwork Contractor**

- (i) The grade of preparation in accordance with 10.2 or any requirement for surface preparation outside the provisions of 10.2.
- (ii) Thickness and composition of any sprayed metal coating (see 10.3).
- (iii) Any requirements for galvanizing including post-galvanizing inspection (see 10.4).
- (iv) Any requirements for paint treatment (see 10.5).
- (v) Responsibility for touch-up of damaged areas and cleaning of surface treatments on Site, and the specification for this work.
- (vi) Any requirement for fire protective coating.

TABLE 1.6 INSPECTIONS AND TESTS – CHECKLIST**Information required by the Steelwork Contractor**

- (i) Inspections or tests to be carried out or witnessed by the Employer, Engineer or Inspection Authority.
- (ii) The period of advance notice required for these additional requirements.

TABLE 1.7 PROGRAMME – CHECKLIST

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

Information required by the Steelwork Contractor

- (i) The date(s) of issue of the Design Drawings or data for construction and other information necessary for the progress of The Works.
- (ii) The period to be provided in the Steelwork Contractor's programme for acceptance of submitted information.
- (iii) The date(s) by which the Site is expected to be ready with prepared and cured foundations and compliant with the Safe Site Handover Certificate.
- (iv) The proposed starting and completion dates for erection of steelwork and the dates when other contractors' activities are expected to interface with the steelwork erection programme.

SECTION 2

MATERIALS

2.1 STEEL PRODUCTS

2.1.1 Qualities

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

Note: When specifying and ordering, full steel designation should be given including the standard number, strength grade and impact quality (e.g. BS EN 10025-2 S275J0) so that the correct properties for fracture toughness and weldability are ensured.

2.1.2 Testing

All steel products for use in The Works shall have been specifically tested in accordance with the appropriate material product standard shown in Table 2.1. The steel product manufacturer shall declare the results using an inspection certificate type 3.1 to BS EN 10204.

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

2.1.3 Dimensions and tolerances

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

TABLE 2.1 MATERIAL and DIMENSION STANDARDS

Form	Dimensions steels	Tolerances steels	Material Quality		
			Non-alloy steels	Fine grain	Weathering
Universal Beams & Columns	BS 4 - 1	BS EN 10034	BS EN 10025-2(1)	BS EN 10025-3(2) or BS EN 10025-4 (3)	BS EN 10025-5(4)
Joists	BS 4 - 1	BS EN 10024			
Channels	BS 4 - 1	BS EN 10279			
Rolled Asymmetric Beams	(7)	(7)			
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)(5)		BS EN 10029			
Plates (Cut from Coil)(5)	-	BS EN 10051			
Wide Flats	-	EU 91			
Hollow Sections (Hot Finished)(6)	BS EN 10210-2		BS EN 10210-1		BS 7668
Hollow Sections (Cold Formed)(6)	BS EN 10219-2(7)		BS EN 10219-1		

(1) Steel grades S275 and S355 in qualities JR, J0, J2 and K2.

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

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

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

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

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

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

2.1.4 Surface condition

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

Surface defects in hot rolled sections, plates and wide flats revealed during surface preparation which are not in accordance with the requirements of BS EN 10163 shall be rectified accordingly.

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

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

2.2 WELDING CONSUMABLES

2.2.1 Standards

Consumables for use in metal arc welding shall comply with BS EN ISO 2560, BS EN 440, BS EN 756 or BS EN 758 as appropriate.

2.2.2 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.

2.3 STRUCTURAL FASTENERS

2.3.1 Declaration of conformity

The Steelwork Contractor shall make declarations of conformity provided by suppliers of structural fasteners available to the Engineer or Inspection Authority, if requested.

If the fasteners are to be surface coated in accordance with 2.5 then this shall be included in the declaration of conformity.

Note: The BCSA issues a Model Specification for Structural Bolts and Holding Down Bolts to assist purchasers.

2.3.2 Ordinary (not for preloading) assemblies

Ordinary bolt and nut (and washer if used) assemblies for use without preloading shall be as given in Table 2.2 or Table 2.3.

Note: The standards in Table 2.2 are to be superseded when all parts of BS EN 15048 are published.

2.3.3 Preloaded assemblies

Preloaded assemblies shall be as given in Table 2.4.

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

Preloaded assemblies to BS EN 14399-1 tested to BS EN 14399-2 may also be used provided that the Project Specification specifies which system is to be used:

- HR assemblies to BS EN 14399-3, or
- HV assemblies to BS EN 14399-4.

Components from the two different systems shall not be mixed. Plain washers to BS EN 14399-5 and/or plain chamfered washers to BS EN 14399-6 may also be used with either of these assemblies.

Note: It is recommended that assemblies from only one of the two different systems are used exclusively on an individual project. Further parts of BS EN 14399 are in preparation.

2.3.4 Foundation bolt 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).

2.3.5 Cup and countersunk bolts

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

2.3.6 Lock nuts for bolt assemblies

Lock nuts shall be in accordance with BS 4190.

2.3.7 Coatings for bolt assemblies

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

TABLE 2.2 MATCHING ORDINARY ASSEMBLIES

Grade	Bolt	Nut (1)	Washer
Incorporating full threaded length bolts			
4.6	BS EN ISO 4018	BS EN ISO 4034 (Class 4) (3)	BS EN ISO 7091 (100HV)
8.8	BS EN ISO 4017 (2)	BS EN ISO 4032 (2) (Class 8) (4)	BS EN ISO 7091 (100HV)
10.9	BS EN ISO 4017 (2)	BS EN ISO 4032 (2) (Class 10) (5)	BS EN ISO 7091 (100HV)
Incorporating part threaded length bolts			
4.6	BS EN ISO 4016	BS EN ISO 4034 (Class 4) (3)	BS EN ISO 7091 (100HV)
8.8	BS EN ISO 4014 (2)	BS EN ISO 4032 (2) (Class 8) (4)	BS EN ISO 7091 (100HV)
10.9	BS EN ISO 4014 (2)	BS EN ISO 4032 (2) (Class 10) (5)	BS EN ISO 7091 (100HV)
<p>(1) Nuts of a higher class may also be used.</p> <p>(2) Grade 8.8 and 10.9 bolts to the strength grades of BS EN ISO 4014 or BS EN ISO 4017 with dimensions and tolerances to 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 with dimensions and tolerances to BS EN ISO 4034.</p> <p>(3) Class 5 nuts for size M 16 and smaller.</p> <p>(4) Nuts for galvanized or sherardized 8.8 bolts should be class 10.</p> <p>(5) Nuts for galvanized or sherardized 10.9 bolts should be class 12 to BS EN ISO 4033.</p>			

TABLE 2.3 MATCHING ORDINARY ASSEMBLIES

Grade	Bolt	Nut	Washer
Incorporating full or part threaded length bolts (1)			
4.6	BS 4190	BS 4190 (Grade 4) (3)	BS 4320 (2)
8.8	BS 4190	BS 4190 (Grade 8) (4)	BS 4320 (2)
10.9	BS 4190 (6)	BS 4190 (Grade 10) (5)	BS 4320 (2)
<p>(1) Full threaded bolts are also termed "screws" or "set screws".</p> <p>(2) Black steel washers to Section 2 of BS 4320, normal diameter series.</p> <p>(3) Nuts for galvanized or sherardized 4.6 bolts should be grade 8 to BS 4190.</p> <p>(4) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to BS 4190.</p> <p>(5) Nuts for galvanized or sherardized 10.9 bolts should be grade 12 to BS 4190.</p> <p>(6) For grade 10.9 bolts used other than in shear, thread lengths shall be selected to ensure that the minimum number of full threads (in addition to the thread run-out) that remain clear between the bearing surface of the nut and the unthreaded part of the shank is 5mm.</p>			

TABLE 2.4 MATCHING PRELOADED ASSEMBLIES (1)

Grade	Bolt	Nut	Washer
General Grade	BS 4395-1 (2)	BS 4395-1	BS 4395-1
Higher Grade	BS 4395-2 (2)	BS 4395-2	BS 4395-2

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

(2) Thread lengths shall be selected to ensure that the minimum numbers of full threads (in addition to the thread run-out) that remain clear between the bearing surface of the nut and the unthreaded part of the shank are as follows: 3mm for General Grade or 5mm for Higher Grade.

TABLE 2.5 HOLDING DOWN BOLT ASSEMBLIES (1)

Grade	Bolt	Nut	Washer
4.6	BS 7419	BS 4190 (3) (Grade 4)	BS 4320 (2)
8.8	BS 7419	BS 4190 (3) (Grade 8)	BS 4320 (2)

(1) If holding down bolts are to be preloaded, then assemblies to Table 2.4 should be used.

(2) Black steel washers to Section 2 of BS 4320, normal, large or extra large diameter series as appropriate.

(3) Nuts for galvanized or sherardized 4.6 or 8.8 bolts should be grade 8 or 10 to BS 4190 respectively

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.

2.4 SHEAR STUDS

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

2.5 PROTECTIVE TREATMENT MATERIALS

2.5.1 Metallic blast cleaning abrasives

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

2.5.2 Surface coatings

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

2.5.3 Sherardized coatings

Sherardized coatings shall be in accordance with BS 7371-8. The thickness of the coating needs to be specified.

2.5.4 Galvanizing Materials

The composition of zinc in galvanizing baths shall be in accordance with BS 7371-6.

2.5.5 Electrodeposited coatings

Electrodeposited coatings shall be in accordance with BS EN ISO 4042. The thickness of the coating needs to be specified.

2.6 PROPRIETARY ITEMS

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

2.7 SUBSTITUTION OF MATERIAL OR FORM

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

SECTION 3

INFORMATION PROVIDED BY THE STEELWORK CONTRACTOR

3.1 INFORMATION SYSTEM

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

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

The system shall be open to audit.

3.2 GENERAL ARRANGEMENT OF COMPONENTS

3.2.1 Marking system

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

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

3.2.2 General Arrangement Drawings (Marking Plans)

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

The drawings shall identify 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 components.

3.3 FOUNDATION AND WALL INTERFACE INFORMATION

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

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

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

3.4 FABRICATION INFORMATION FOR COMPONENTS

3.4.1 Fabrication drawings and fabrication data

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

The system shall include full details of the date when component information in the form of Fabrication Drawings and Data 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

Any requirements for edge preparations for welds shall be indicated.

Welding inspection requirements which differ from those specified in 5.5.5 shall be clearly indicated.

3.4.4 Packs, clearances and camber

The Steelwork Contractor shall make provision for:

- (i) Packs which may be necessary to ensure proper fit-up of joints (see 6.2.1 and 6.4.1);
- (ii) The need for clearances between the fabricated components so that the permitted deviations in fabrication and erection are not exceeded, (see Sections 7 and 9);
- (iii) The Engineer's requirements for pre-set or cambers (see Table 1.2A (xvii)).

3.4.5 Hole sizes

Holes in components shall be shown to the following nominal sizes:

- (i) For ordinary bolts and preloaded 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

If the connection is designed to allow movement, the 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.

3.5 ERECTION INFORMATION

3.5.1 Erection drawings

If necessary to amplify the information given in the 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).

3.6 DRAWING OR INFORMATION REVIEW

3.6.1 Submission to the Engineer

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

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

3.6.2 Extent of submissions

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

- (i) General Arrangement Drawings as defined in section 3.2.2. The Steelwork Contractor shall mark references on the General Arrangement Drawings or provide another suitable system such that a connection calculation or standard simple connection can be identified to a specific location on the structure.
- (ii) Connection Design calculations except for those where industry standard simple connections are used. Calculations shall include sketches or drawings showing the arrangement of the connection and shall be referenced to a location on the structure. If necessary drawings showing complex geometry shall also be submitted.

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

3.6.3 Acceptance of General Arrangement Drawings and Connection Design calculations

The review and acceptance by the Engineer means:

- (i) the principal levels, dimensions and typical details shown on the General Arrangement Drawings are a correct interpretation of design requirements;
- (ii) the 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 the calculations, detail dimensions on the drawings, nor the general fit-up of parts to be assembled on site.

3.6.4 Acceptance classification

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

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

3.6.5 Acceptance without comment

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

3.7 “AS ERECTED” STRUCTURE

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

either:

- (i) One set of paper prints of “As Erected” drawings comprising:
 - General Arrangement Drawings
 - Fabrication Drawings
 - Connection Design calculations or references to standard connections
 - Drawings made after fabrication showing revisions
 - The drawing register.

or:

- (ii) If it is agreed with the Employer, Electronic Data equivalent to that shown in (i).

SECTION 4

WORKMANSHIP - GENERAL

4.1 IDENTIFICATION

4.1.1 Traceability of steel products

All steel products to be used in The Works shall have a reference to a suitable declaration of conformity so that the properties are known and can be verified (see 2.1). Unless required by the Project Specification individual pieces do not need to be traceable to a particular inspection document.

Note: This is “type” as opposed to “unique” traceability.

4.1.2 Material identification

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

4.1.3 Marking steelwork

Individual pieces shall be capable of positive identification at all stages of fabrication. Completed components shall be marked with a durable and distinguishing erection mark in such a way as not to damage the material. Hard stamping may be used for steel grades up to and including S355, except where otherwise specified in the Project Specification.

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

4.2 HANDLING

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

4.3 CUTTING AND SHAPING

4.3.1 Cutting operations

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

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

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

4.3.2 Thermally-cut edges

Thermally-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

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

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

The butting surfaces of column sections which are one metre and over in width or depth and are to be in direct bearing shall be specially prepared so that after erection both the deviation in plumb in 9.6.4 and the permitted gap in 9.6.5 are not exceeded.

4.4 MACHINING

The thickness of machined parts 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).

The Project Specification shall 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 components in a direction at right angles to the faces in contact. Drifts may be used but holes shall not be distorted.

4.6.3 Drilling through more than one thickness

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

4.6.4 Punching full size

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

- (i) the tolerance on distortion of the punched hole does not exceed that shown in 7.3.4;
- (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 for material up to S355, not greater than 10mm for higher grades, nor greater than the diameter of the hole being punched;
- (iv) the holes in mating surfaces in spliced connections are punched in the same direction and the splice plates marked to show the assembly faces, if packed separately.

4.6.5 Punching and reaming

Punching is permitted without the conditions in 4.6.4, provided that the holes are punched at least 2mm less in diameter than the required size and the hole is reamed to the full diameter after assembly.

4.6.6 Slotted holes

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

4.7 ASSEMBLY

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

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

4.8 CURVING AND STRAIGHTENING

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

- (i) mechanical means, taking care to minimise indentations, or change of cross-section;
- (ii) the local application of heat, ensuring that the temperature of the metal is carefully controlled, and does not exceed 650°C;
- (iii) the induction bending process if the procedure used includes careful temperature control and the procedure is validated beforehand in terms of its ability to retain suitable properties for the as-bent material.

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

4.9 INSPECTION

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

4.10 STORAGE

4.10.1 Stacking

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

4.10.2 Visible markings

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

SECTION 5

WORKMANSHIP - WELDING

5.1 GENERAL

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

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

If required by the Project Specification, the welding coordination personnel shall be subject to approval by the Employer.

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

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

Joints shall be prepared in accordance with BS EN ISO 9692-1 and -2.

Precautions shall be taken to ensure cleanliness of the joint 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, if 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 a competent Examiner or Examining Body.

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

5.3 WELDING PROCEDURES

5.3.1 Preparation of welding procedure specifications

Written welding procedure specifications (WPSs) shall be available in accordance with BS EN ISO 15609-1, and tested in accordance with BS EN ISO 15614-1 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 Verification of procedures

The Examiner or Examining Body shall verify that the welding procedure qualification records (WPQRs) are in accordance with BS EN ISO 15614-1.

5.3.3 Use of welding procedure specifications

Appropriate work instructions shall be produced from the WPQRs under the authority of the welding co-ordinator. The work instructions shall be either WPSs or contain all the relevant information required from the WPS in other formats suitable to the Steelwork Contractor's system. They shall be provided for the welder prior to the commencement of welding and shall be suitable for the joint configuration and material to be welded. These work instructions shall be made available to the Employer, Engineer or Inspection Authority on request, and shall include a cross-reference to the WPS upon which they are based.

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

5.4 ASSEMBLY

5.4.1 Fit-up

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

5.4.2 Jigs

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

5.4.3 Tack welds

Tacks may be used provided:

- (i) they are laid in an area to be welded and are thoroughly removed by grinding or gouging such that subsequent welding is unaffected; or
- (ii) they are undertaken by a welder qualified as in 5.2 as short length normal welds of a length at least four times the thickness of the thicker part being joined and at least 50mm long, and the procedure for welding complies with 5.3; or

- (iii) they are subsequently fully remelted using a welding procedure that complies with 5.3 and that demonstrates that the tack is fully re-melted during subsequent welding; or
- (iv) they are located away from zones where subsequent welding is to take place and in a zone where only compressive forces are present in service.

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

5.4.4 Distortion control

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

5.4.5 Fabrication or erection attachments

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

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

5.4.6 Extension pieces

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

5.4.7 Production test plates

If production test plates are required for testing purposes (see 1.3(iv)), they shall be clamped in line with the joint. The grade and quality 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).

If **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 component thickness is not greater than 20mm.

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

If a workshop is only producing work where all these conditions are met, then a monthly programme of further non-destructive testing shall be instituted by the person responsible for welding coordination such that a representative sample of each month’s output is subjected to appropriate non-destructive testing (NDT).

Note: With the exception of the frequency of testing in Table B, unless altered by the Project Specification these requirements make no distinction between shop and site welds.

Inspection requirements may be reduced at the Engineer’s discretion, based upon satisfactory performance in the initial production.

Conversely, if 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 testing shall be recorded and be available for inspection.

5.5.3 Visual inspection of welds

100% visual inspection shall be carried out during welding and on completion to determine the production quality is being maintained. Unless specified in the Project Specification, visual inspection shall be carried out in accordance with the guidelines given in Annex D.

A suitably qualified person for visual inspection of welds may be a welding inspector or a welder who can provide evidence of having been trained and assessed for competence in visual inspection of the relevant types of welds during and after welding.

The quality level shall be in accordance with the levels given in Annex C and the Project Specification. All imperfections identified shall be assessed in accordance with the required quality level to determine the need for corrective and preventive action.

Any welds which will be rendered inaccessible by subsequent work shall be examined in accordance with Annexes A to D prior to the loss of access.

5.5.4 Hold times before final NDT

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

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

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

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

5.5.5 Surface flaw detection

If a closer examination of a weld surface is required in accordance with Annex B, magnetic particle testing shall be used in accordance with the recommendations given in BS EN 1290 and this shall be preceded by visual inspection to BS EN 970 undertaken by the NDT technician.

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

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

Note: If a welding procedure requires an inspection after initial weld runs before further welding is performed, such inspections may be carried out when the weld metal has cooled to ambient temperature.

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 testing

If ultrasonic testing is required in accordance with 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 agreed otherwise by the Engineer.

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

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

Persons carrying out final ultrasonic testing 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 Annex C for components subject to static loading.

If non-conforming welds are identified the scope of inspection shall be increased until the source of the defects is established and rectified.

Note: The acceptance criteria shown in Annex C are not intended to apply to bridges, offshore structures, or other dynamically loaded structures.3

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.

If the studs are to be welded by other than drawn arc stud welding, then the size of the fillet weld used shall be checked for compliance with the Project Specification.

The local area around where the stud is to be welded shall be free of standing water before commencement of welding.

Note: See the BCSA Code of Practice for Metal Decking and Stud Welding for further guidance.

5.6.2 Trial welding

If 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 Table 1.3 (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. If either of these trial studs fails a bend test in accordance with 5.6.3, then further trials shall be conducted until satisfactory performance is established.

5.6.3 Tests and inspection

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

After satisfactory visual inspection and ring testing, bend tests shall be made at locations agreed with the Engineer. A minimum of 5% of the studs, but not less than two studs per beam shall be tested by bending the head of the stud towards the nearer end of the beam. In addition, the studs immediately adjacent to any stud found to be defective shall be subjected to bend testing.

The bend test shall be made by means of a steel tube placed over the stud and bending the head until it is displaced laterally a distance of one quarter of the height of the stud. The stud weld shall not show any signs of cracking or lack of fusion.

Studs subjected to the bend test shall not be straightened.

5.6.4 Defective studs

Studs with defective welding or that have failed the bend test shall be replaced with a new stud in an adjacent location. The replacement stud shall be inspected, ring tested and tested as in 5.6.3 by bending it towards the defective stud. The defective stud need not be removed.

SECTION 6

WORKMANSHIP - BOLTING

6.1 ORDINARY (NON-PRELOADED) ASSEMBLIES

6.1.1 Bolt/nut combinations

The combinations of bolts and nuts which may be used are as tabulated in Tables 2.2 and 2.3.

Note: The preloadable fasteners in Table 2.4 may also be used in non-preloaded applications.

Galvanized or sherardized bolts in grades 8.8 or 10.9 shall be fitted with higher grade/class nuts as tabulated in Section 2.

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

6.1.2 Cup and countersunk head bolt assemblies

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

6.1.3 Differing bolt grades

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

6.1.4 Bolt length

The bolt length shall be chosen such that, after tightening, at least one thread plus the thread run-out will be clear between the nut and the unthreaded shank of the bolt and at least one clear thread shall show above the nut.

6.1.5 Washers

If washers are used they shall be as tabulated in tables 2.2 and 2.3. If full bearing capacity is required when connecting thin-gauge sections of 4mm or less to each other, washers shall be used under both the bolt head and the nut.

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

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

A suitable plate, or heavy duty washer shall be used under the head and nut if bolts are used to assemble components with oversize or slotted holes.

6.1.6 Taper washers

If 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 if holes are drilled or reamed after assembly so that the clearance in the hole is not more than 0.3mm.

6.2 FIT-UP IF USING NON-PRELOADED BOLT ASSEMBLIES

6.2.1 Fit-up

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

6.2.2 Reaming

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

6.3 PRELOADED 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. The hardened washer is to be placed under the nut or head being turned.

6.3.2 Other preloaded assemblies

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

6.3.3 Tightening

The use of preloaded fasteners in friction grip applications shall comply with BS 4604-1 or -2.

Tightening which complies with BS 4604-1 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 if 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 IF USING PRELOADED BOLT ASSEMBLIES

6.4.1 Fit-up

Connected parts intended to transfer force in friction shall be firmly drawn together with all bolts partially tightened. The joint shall then be examined and if there is any 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

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

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

SECTION 7

WORKMANSHIP - ACCURACY OF FABRICATION

7.1 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 FOR ROLLED COMPONENTS AFTER FABRICATION (Δ) (including structural hollow sections)

7.2.1 Cross section after fabrication

7.2.2 Squareness of ends not prepared for bearing

Note: See also 4.3.3

7.2.3 Squareness of ends prepared for bearing

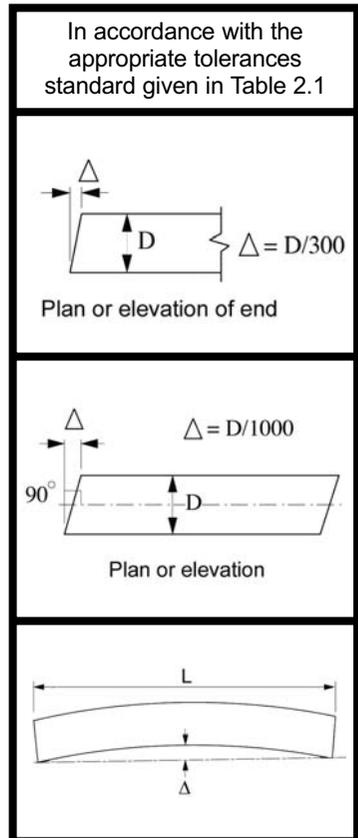
Prepare ends with respect to the longitudinal axis of the member.

Note: See also 4.3.3

7.2.4 Straightness on both axes

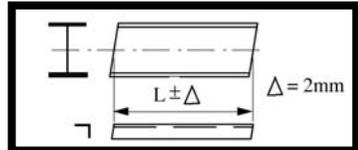
Generally $\Delta = L/1000$ or 3mm whichever is greater.

For components fabricated from structural hollow sections $\Delta = L/500$ or 3mm whichever is greater.



7.2.5 Length

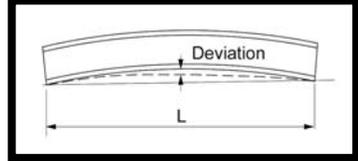
Length after cutting, measured on the centre line of the section or on the corner of angles.



7.2.6 Curved or cambered

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

Deviation = $L/1000$ or 6mm whichever is greater.



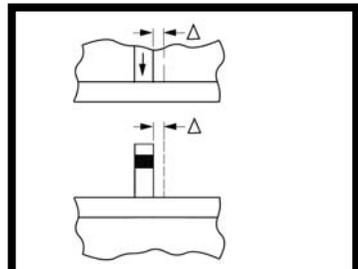
7.3 PERMITTED DEVIATIONS FOR ELEMENTS OF FABRICATED COMPONENTS (Δ)

7.3.1 Position of fittings

The deviation from the intended position relative to the setting-out point on the primary member shall not exceed Δ .

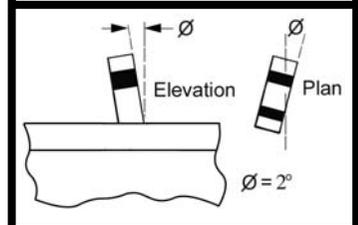
Fittings and attachments whose location is critical to the force path in the structure:
 $\Delta = 3\text{mm}$

Other fittings and attachments: $\Delta = 5\text{mm}$



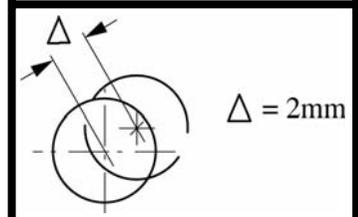
7.3.2 Alignment of fittings

Angular deviation \emptyset relative to intended local orientation.



7.3.3 Position of holes

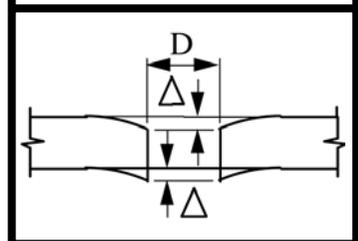
The deviation from the intended position of an isolated hole, also within a group of holes, the relative position to each other shall not exceed Δ



7.3.4 Punched holes

The distortion caused by a punched hole shall not exceed Δ

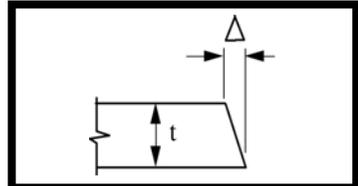
$\Delta = D/10$ or 1mm whichever is greater.



7.3.5 Sheared or cropped edges of plates or angles

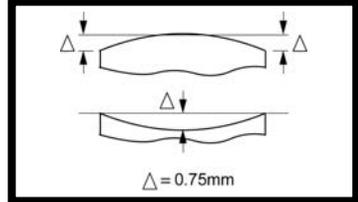
The deviation from a 90° edge shall not exceed Δ

$\Delta = t/10$ up to a maximum of 3mm.



7.3.6 Flatness

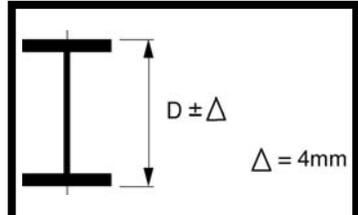
Where full contact bearing is specified, the flatness shall be such that when measured against a straight edge not exceeding one metre long, which is laid against the full bearing surface in any direction, the gap does not exceed Δ



7.4 PERMITTED DEVIATIONS FOR PLATE GIRDER SECTIONS (Δ)

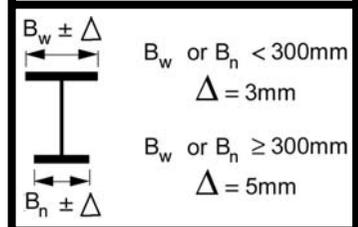
7.4.1 Depth

Depth on centre line.



7.4.2 Flange width

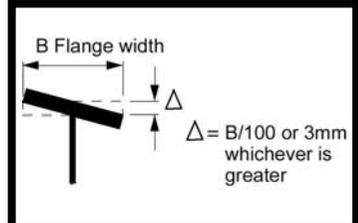
Width of B_w or B_n .



7.4.3 Squareness of section

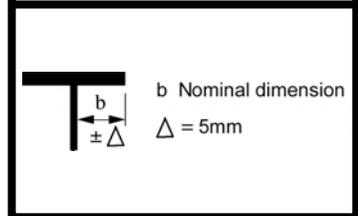
Out of squareness of flanges.

$\Delta = B/100$ or 3mm whichever is greater.



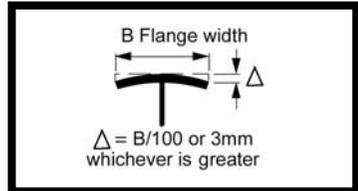
7.4.4 Web eccentricity

Position of web from edge of flange.



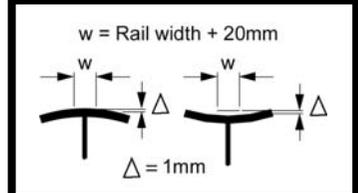
7.4.5 Flanges

Out of flatness.



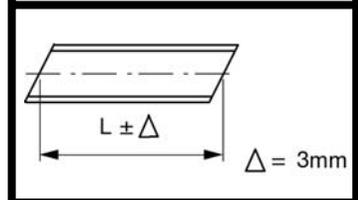
7.4.6 Top flange of crane girder

Out of flatness where the rail seats.



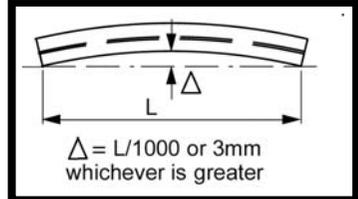
7.4.7 Length

Length on centre line.



7.4.8 Flange straightness

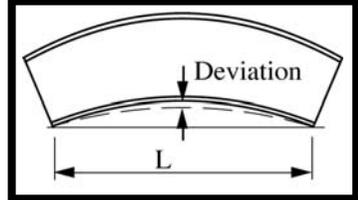
Straightness of individual flanges.



7.4.9 Curved or cambered

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

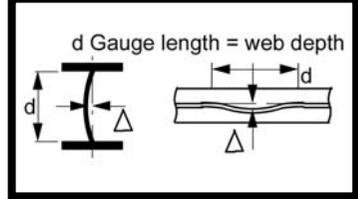
Deviation = $L/1000$ or 6mm whichever is greater.



7.4.10 Web distortion

Distortion on web depth or gauge length.

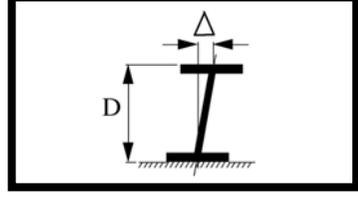
$\Delta = d/150$ or 3mm whichever is greater.



7.4.11 Cross section at bearings

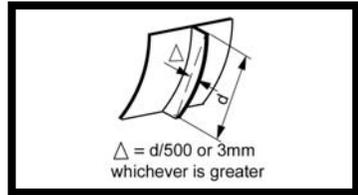
Squareness of flanges to web.

$\Delta = D/300$ or 3mm whichever is greater.



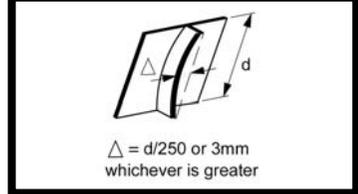
7.4.12 Web stiffeners

Straightness of stiffener out of plane with web after welding.



7.4.13 Web stiffeners

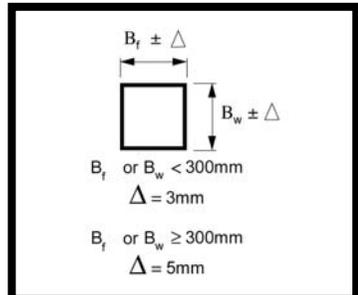
Straightness of stiffener in plane with web after welding.



7.5 PERMITTED DEVIATIONS FOR BOX SECTIONS (Δ)

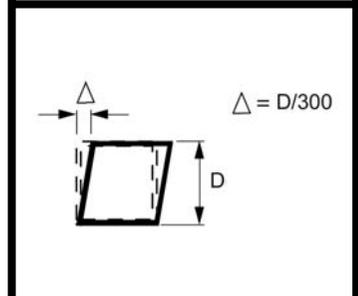
7.5.1 Plate widths

Width of B_f or B_w .



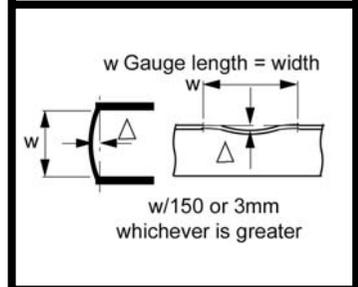
7.5.2 Squareness

Squareness at diaphragm positions.



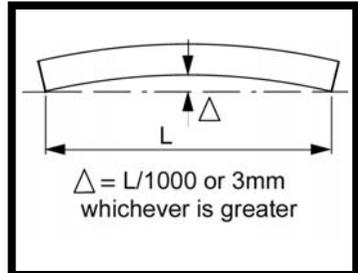
7.5.3 Plate distortion

Distortion on width or gauge length.



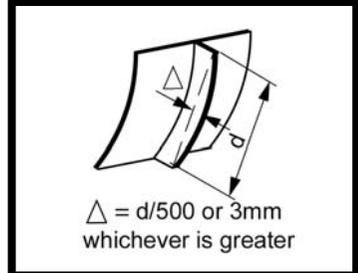
7.5.4 Web or flange straightness

Straightness of individual web or flanges.



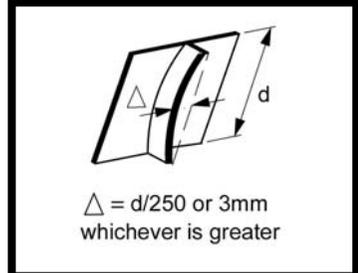
7.5.5 Web stiffeners

Straightness in plane with plate after welding.



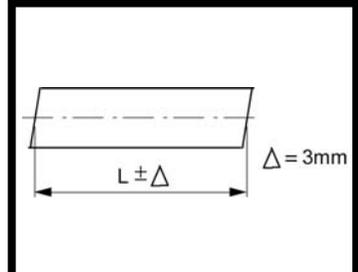
7.5.6 Web stiffeners

Straightness out of plane to plate after welding.



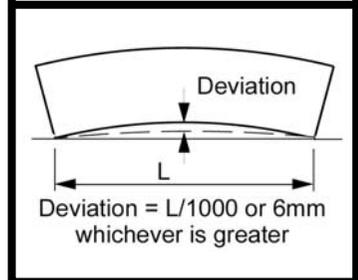
7.5.7 Length

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, 1.4 and 1.7).

Note: Further guidance is available in the BCSA Codes of Practice for Erection.

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

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

8.1.2 Meaning of acceptance

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

8.1.3 Provision of setting-out lines by the employer

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

8.1.4 Handling and storage

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

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

8.1.5 Damaged steelwork

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

8.1.6 Column base plates and slabs

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

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

Base packs may be left permanently in place.

8.1.7 Grouting

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

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

8.2 SITE CONDITIONS

8.2.1 Employer's responsibilities

The Employer shall:

- (i) maintain the working surfaces of the Site free from standing water and remove water from foundations;
- (ii) provide a firm, properly graded, working area and storage area; also maintain adequate access roads, into and through the site, for the safe delivery of plant and materials on normal road vehicles (see Table 1.4 (ii) and (iv));
- (iii) inform the Steelwork Contractor of the position of any underground services which may be considered liable to damage by the Steelwork Contractor's plant (see Table 1.4 (vi));
- (iv) be responsible for removing overhead obstructions.

8.2.2 Steelwork Contractor's responsibility

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

8.3 SAFETY

8.3.1 Responsibilities – all parties

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

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

8.3.2 Steelwork Contractor's responsibility

The Steelwork Contractor shall:

- (i) ensure that the operations comply with the Employer's rules for operating on site;
- (ii) ensure that appropriate safe systems of work are provided, installed and properly maintained to discharge the duties under current safety legislation.

8.4 STABILITY

8.4.1 Temporary restraints until permanent features are built

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

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

8.4.2 Other temporary restraints used by Steelwork Contractor

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

8.5 ERECTION LOADS

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

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

8.6 LINING AND LEVELLING

8.6.1 Alignment of part of the structure

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

8.6.2 Temperature effects

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

8.7 SITE WELDING

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

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

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

8.8 SITE BOLTING

Bolting shall be carried out in accordance with Section 6.

8.9 CERTIFICATION OF COMPLETION

When the steelwork, or a 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

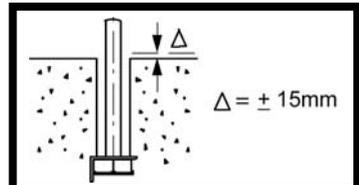
WORKMANSHIP - ACCURACY OF ERECTED STEELWORK

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

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

9.1.1 Foundation level

Deviation from specified level.

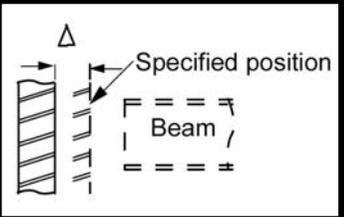


9.1.2 Vertical wall

Deviation from specified position at steelwork support point.

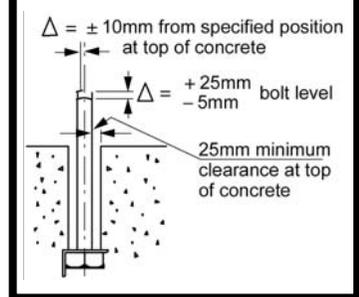
$\Delta = \pm 15\text{mm}$ up to 4m height

$\Delta = \pm 20\text{mm}$ above 4m plus 1mm for every metre above 8m height to $\pm 50\text{mm}$ maximum



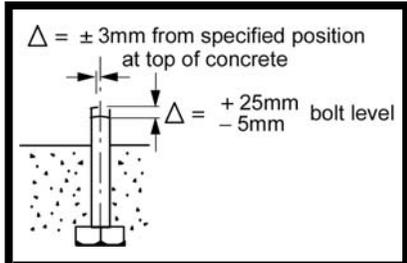
9.1.3 Pre-set foundation bolt or bolt groups if prepared for adjustment

Deviation from specified position.



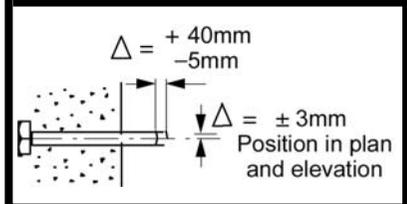
9.1.4 Pre-set foundation bolt or bolt groups if not prepared for adjustment

Deviation from specified position.

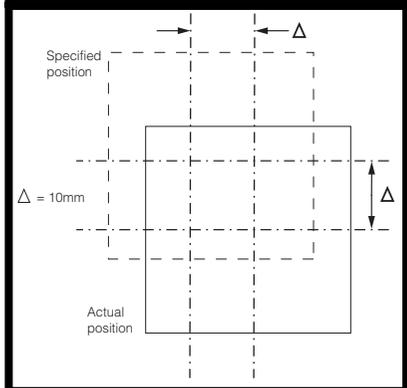
**9.1.5 Pre-set wall bolt or bolt groups if not prepared for adjustment**

Deviation from specified position.

Note: This is measured locally relative to the achieved verticality of the wall as specified in 9.1.2.

**9.1.6 Embedded cast-in fixing plates**

Deviation of centre lines from specified positions.

**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 to be taken in calm weather, and due note is to be taken of temperature effects on the structure (see 8.6.2).
- (ii) The deviations shown for open sections apply also to box and tubular sections.

9.4 DEVIATIONS

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

Note: The survey and assessment of deviations of erected steel frames is described in Annex A of the Commentary.

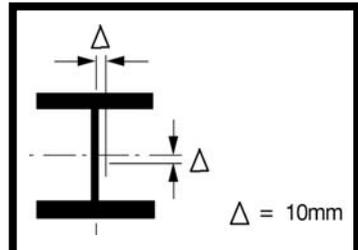
9.5 INFORMATION FOR OTHER CONTRACTORS

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)

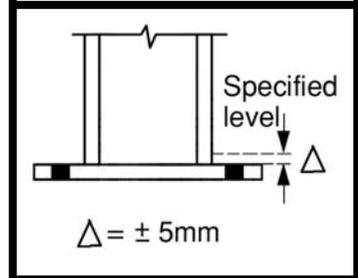
9.6.1 Position of columns at base

Deviation of section centre line from the specified position.



9.6.2 Level of columns at base

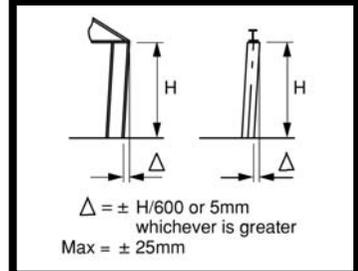
Deviation of the top of the base plate from the specified level.



9.6.3 Single storey columns plumb

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

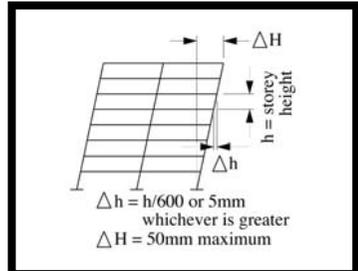
Note: See clause 1.2A(xvii) and 3.4.4(iii) regarding pre-setting portal frames.



9.6.4 Multi-storey columns plumb

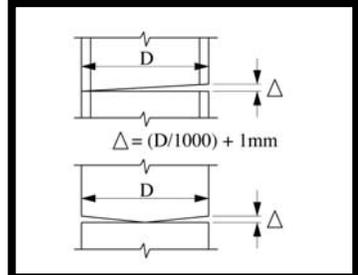
Deviation in each storey and maximum deviation relative to base for up to 10 storeys.

Note: Permitted deviations for columns over 10 storeys to be agreed with the Engineer.



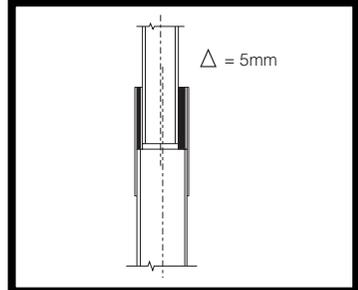
9.6.5 Gap between bearing surfaces

Note: See also clauses 4.3.3, 6.2.1 and 7.2.3



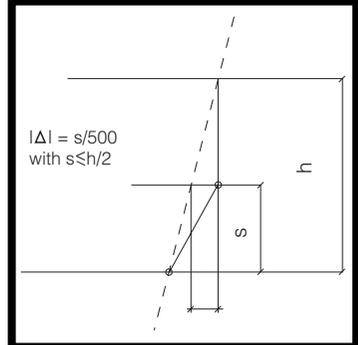
9.6.6 Eccentricity at column splice

Non-intended eccentricity about either axis.



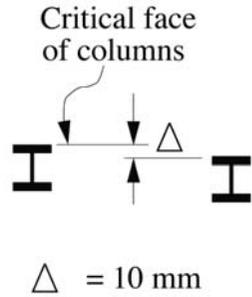
9.6.7 Alignment at column splice

Straightness of a spliced column between adjacent storey levels.

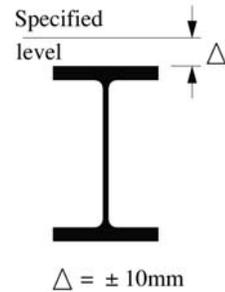


9.6.8 Alignment of adjacent perimeter columns

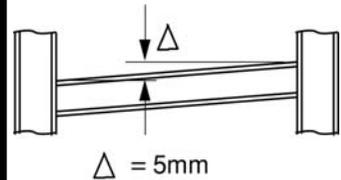
Deviation relative to next column on a line parallel to the grid line when measured at base or splice level.

**9.6.9 Beam level**

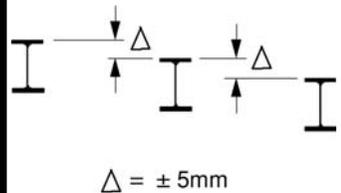
Deviation from specified level at supporting column.

**9.6.10 Level at each end of same beam**

Relative deviation in level at ends.

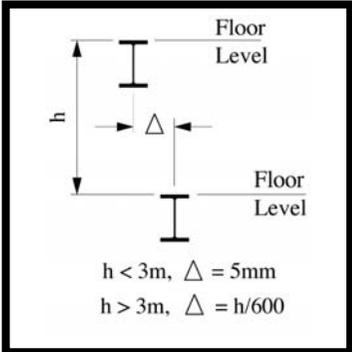
**9.6.11 Level of adjacent beams within a distance of 5 metres**

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



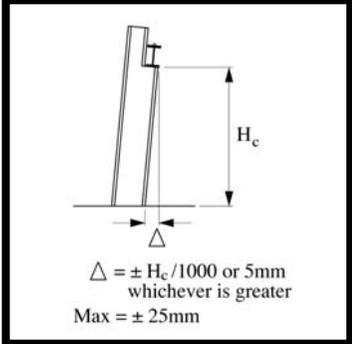
9.6.12 Beam alignment

Horizontal deviation relative to an adjacent beam above and below.



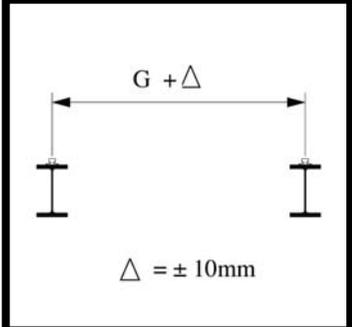
9.6.13 Crane gantry columns plumb

Deviation of cap relative to base.



9.6.14 Crane gantries gauge of rail tracks

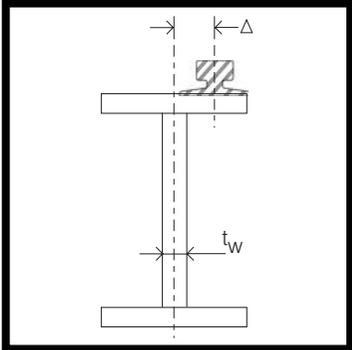
Deviation from nominal gauge.



9.6.15 Eccentricity of rail relative to web

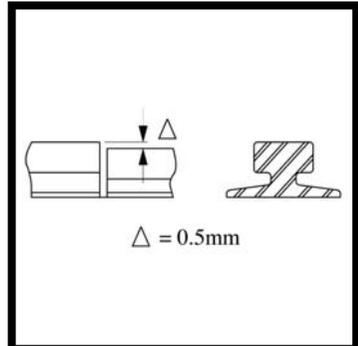
$\Delta = 5mm$ for $t_w < 10mm$

$\Delta = t_w/2$ for $t_w > 10mm$

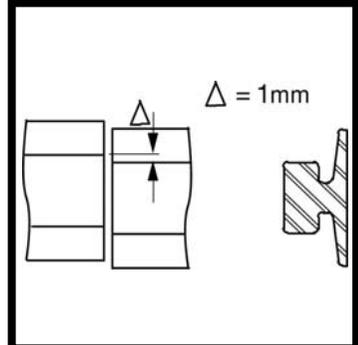


9.6.16 Rail surface at joints in gantry crane rails

Deviation in level at rail joint.

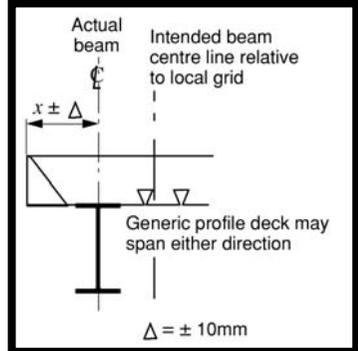
**9.6.17 Rail edge at joints in gantry crane rails**

Deviation in line at rail joint.

**9.6.18 Profiled steel floor decking**

Deviation of dimension between decking edge trim prior to concrete placement and perimeter beam.

Note: The deviation (as shown) between actual beam centre line and intended beam centre line relative to local grid arises from other permitted tolerances (e.g. 9.6.4).



SECTION 10

PROTECTIVE TREATMENT

10.1 GENERAL

10.1.1 Specification

The coatings and associated surface preparation required for structural steelwork shall be as specified on the Design Drawings or in the Project Specification (see Table 1.5). If possible, the system should be chosen from those listed in Annex E. The system shall be in accordance with the latest edition of DEFRA's *Guidance Notes to Environmental Protection Act 1990 [PG6/23]*.

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

10.1.2 Method statement

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

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

10.1.3 Coating procedures

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

10.1.4 Transportation, handling and storage of coated steelwork

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

10.2 SURFACE PREPARATION

10.2.1 Surface cleanliness

At the time of coating the surface cleanliness of the steelwork to be coated shall be in accordance with BS EN ISO 8501-1.

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 EN 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 EN ISO 8503.

10.2.4 Surface defects

Surface defects revealed during surface preparation shall be dealt with in accordance with 2.1.4.

10.3 SPRAYED METAL COATING

10.3.1 Procedures

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

10.3.2 Reinstatement of damaged coating

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

10.3.3 Sealing before painting

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

10.4 HOT DIP GALVANIZING

10.4.1 Procedures

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

All galvanized components shall be subjected to 100% post-galvanizing inspection in accordance with procedure PGI-1 in Table 10.1 unless otherwise specified in the Project Specification.

The Project Specification shall identify:

- (i) any components for which post-galvanizing inspection is not required (PGI-0);
- (ii) any components that shall be subjected to procedure PGI-2A in addition;
- (iii) any specific locations that shall be subjected to procedure PGI-2B in addition.

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

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

TABLE 10.1 POST-GALVANIZING INSPECTION		
Reference	Visual Inspection	Magnetic Particle Testing
PGI-0	Not required	Not required
PGI-1	100% of all surfaces with special attention to areas around welded connections and joints	Not required
PGI-2A	Already required by PGI-1	On 10% of welded connections or node points of welded joints
PGI-2B	Already required by PGI-1	On specified areas
PGI-3	Already undertaken	Sufficient to establish the scope and origin of the problem(1)
Personnel	Inspection to be undertaken by a suitably experienced person	Non-destructive testing to be undertaken by a person suitably qualified on the technique to be used
(1) Eddy current and alternating current field measurement tests may be used to assist diagnosis.		

Note: Further guidance is available in the BCSA publication Galvanizing Structural Steelwork - An approach to the management of Liquid Metal Assisted Cracking.

10.4.2 Vent holes

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

10.5 PAINT TREATMENT

10.5.1 Specification

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

10.5.2 Surface preparation prior to painting

Steelwork shall be prepared for coating in accordance with 10.2.

10.5.3 Painting of site weld areas and fasteners

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

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

10.5.4 Inspection of site applied coatings

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

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

10.6 COATING OF SURFACES TO BE ENCASED IN CONCRETE

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

SECTION 11

QUALITY MANAGEMENT

11.1 QUALITY SYSTEM

11.1.1 System requirements

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

The Steelwork Contractor shall review the requirements of the Project Specification prior to commencing work, and shall provide a project-specific quality plan to supplement the quality management system if the work is not covered by a generic plan.

11.1.2 System acceptance

The system shall be

either:

(i) assessed and certified as complying to the requirements of BS EN ISO 9001 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 BS EN ISO 3834-3.

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 Inspection Authority to examine during the contract period.

ANNEX A - WELD TESTING - HOLD TIMES

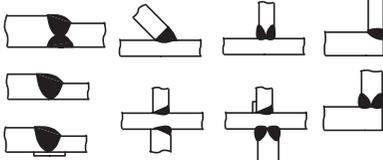
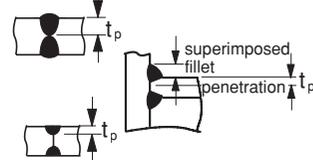
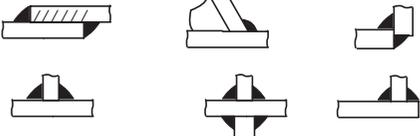
The requirements for hold time (the period to be allowed after completion of welding before commencement of final ultrasonic, magnetic particle and/or penetrant testing) are set out in 5.5.4.

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

TABLE A RECOMMENDED MINIMUM HOLD TIMES		
Weld Size (mm)	Heat Input (kJ/mm)	Hold Time (hours)
a or s ≤ 6	All	Cooling period only
6 < a or s ≤ 12	≤ 3	8
	> 3	16
a or s > 12	≤ 3	16
	> 3	40
(i) Size applies to the nominal throat thickness (a) of a fillet weld, the nominal weld depth (s) of a partial penetration butt weld, or the nominal material thickness (s) of a full penetration weld. (ii) If two fillet welds are separated an unfused root face of less than 10mm then the governing weld size (a) shall be taken as the sum of their individual weld sizes. (iii) Heat input to be calculated in accordance with clause 19 of BS EN 1011-1. (iv) The time between weld completion and commencement of NDT shall be stated in the NDT report. In the case of "cooling period only" this will last until the weld is cool enough for NDT to commence.		

ANNEX B - WELDS - 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 5.5.3)	
PART B	MANDATORY NON-DESTRUCTIVE TESTING AND FREQUENCY of TESTING	
	Full Penetration Butt Welds	Partial Penetration Butt Welds
	<p>Examples:</p> 	<p>Examples:</p> 
Surface flaw detection (see 5.5.5)	All thicknesses	All thicknesses
	50% (site welds 100%)	20% (site welds 100%)
Ultrasonic testing (see 5.5.6)	Max thickness ≥ 10 mm	Penetration $t_p \geq 8$ mm
	50% (site welds 100%)	20% (site welds 100%)
	Fillet Welds	
	<p>Examples:</p> 	
Surface flaw detection (see 5.5.5)	Leg length > 10 mm or thickness of thickest element > 20 mm	
	Shop welds: 10% of weekly production output sampling welders and types Site welds: 100% but longitudinal welds 0.5m in each 10m or part thereof	
Ultrasonic testing (see 5.5.6)	Leg length ≥ 20 mm	
	10%(Site Welds 100%)	

- (i) The requirements of this Table shall not preclude the use of NDT 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) If 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 (single pass fillet, multi-pass fillet, PPBW, FPBW), material grade, and 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, under the authority of the welding co-ordinator the first five joints of each type having the same basic dimensions, material grades, weld geometry and welded to the same procedure, may be inspected on a weekly basis. In the case of longitudinal welds and secondary attachment welds the specified inspection need only apply to 5% of the weekly output of components. In the event that a non-conformance is detected by NDT, the full requirements of this Table shall be implemented for at least a full week following 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 AND MEASUREMENT DEFINITIONS

TABLE C1 ACCEPTANCE REQUIREMENTS for production welds in steel structures

	Parameter	Weld type	Weld Orientation	Figure reference in Table C2	Acceptance criteria for normal quality (all dimensions in mm)	Remedial action for non-conforming welds See Note (6)	
Weld geometry	Location	All			$D \pm 10$	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	
All		Transverse cruciform Longitudinal	(v) (iv),(v)	$h \leq D + 0.4t$ $h \leq D + 0.4t$			
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	(vi),(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	Transverse	Full depth	(vii)	$h \leq 3$ and $\Sigma I \leq 1.5t$ [100]	Repair
				Zone 0	(vii)	$I \leq 10$ $I' \geq 10$	
				Zone 1	(vii)	$I \leq 1.5t$ [100] $h' \geq 6$	
		Longitudinal	Full depth	(vii)	$h \leq 3$ and $\Sigma I \leq 3t$ [100] No individual limits on I or I'		
	Root Gap	Fillet, P/P Butt				(i),(v)	$h \leq 2$ (Av.100) $h \leq 3$ Repair
Cracks	All				Not permitted	Repair	
Lamellar Tears	All	Transverse Longitudinal			Not permitted	Refer to Engineer	

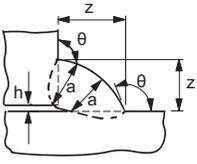
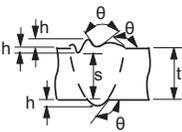
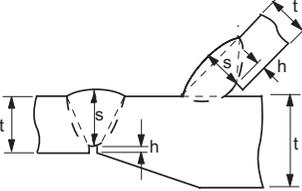
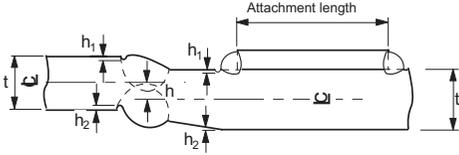
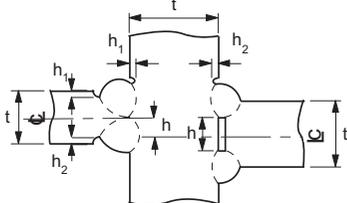
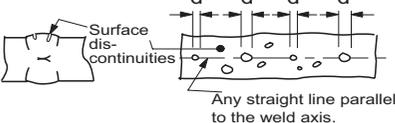
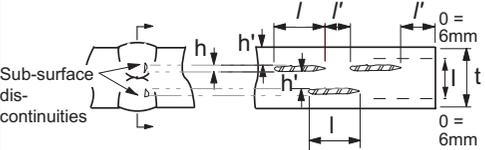
Abbreviated terms and notes applicable to Table C1**Abbreviated terms:**

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)
(Av. 50)	Length of weld over which measurement may be averaged (mm)
[100]	Length of weld over which summation is made (mm)
1	Length of discontinuity - parallel to the weld axis
1'	Gap between ends of discontinuities - parallel to the weld axis. If non-conforming, 1 becomes the overall length of the discontinuities plus the gaps(s) between them.
h	Height of discontinuity - in thickness direction
h'	Gap between discontinuity - in the thickness direction
I	Inner zone
O	Outer zone

Notes:

- (1) For definition of orientation see Annex B.
- (2) Thickness applies to minimum member thickness at weld in question. For thickness greater than 20mm 't' shall be taken as 20mm. The limiting value 'h' for any discontinuity, where related to member thickness 't', is the greater of this calculated figure or 0.3mm.
- (3) "Lap" shall apply to any fillet welded attachment whose length in the longitudinal direction exceeds 50mm.
- (4) Subject to any other locational requirements.
- (5) Where more than one requirement is given both shall apply.
- (6) Where a repair is necessary an approved procedure shall be used. If on increasing the scope of inspection, further non-conformances are found, the scope shall be increased to 100% for the joint type in question.
- (7) Lamellar tears may be accepted in the longitudinal welds only if extent does not exceed limits for lack of fusion in transverse welds.

Table C2 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> <p>Sub-surface discontinuities may be in Zones I (as shown) or O</p>	

ANNEX D - GUIDELINES FOR VISUAL INSPECTION OF WELDS

Prior to welding or between weld passes

- (i) Check that the weld preparation is correct in accordance with the welding work instruction. Items to be checked include preparation angles, root gap, root face condition, depth of preparation for part penetration welds, minimal gap for fillet welds.
- (ii) Check that the area to be welded is not contaminated with grease, oil, dirt, paint or moisture.
- (iii) Check that any tack welds have been removed or are suitable for welding over as required by 5.4.3.
- (iv) For multi-pass welds, check the suitability of the surface of previously deposited weld metal. In addition to checking any re-preparation to (i) and cleanliness to (ii), the area to be welded should be de-slugged and free of weld spatter.

After deposition of each weld pass or at final completion

- (i) Check the weld size. Visual estimation may be used to assess acceptability, but, if in doubt, check by measurement. Confirm by measurement periodically anyhow.
- (ii) Check that welds are complete. Items to be checked include whether the weld extends fully to the end of the preparation (or run-on/run-off plates if used for butt welds), and that return welds are completed.
- (iii) Check that any craters have been filled and that no crater cracks are evident visually.
- (iv) Check for undercut, and measure for evaluation if identified.
- (v) Check that the weld beads are of even appearance and that fillets present a mitre or slightly convex profile. Measure any concave profiles to ensure that the specified throat thickness has not been compromised.
- (vi) Check for absence of any cracking or significant porosity.
- (vii) Check for absence of cold-lapping.

Corrective action

Corrective action on minor defects capable of immediate rectification may be taken under the authority of the visual inspector. More significant defects should be reported using a non-conformance procedure, and corrective action undertaken before further non-destructive testing.

A record should be kept that visual inspection has been carried out and any problems identified.

ANNEX E – SPECIFICATIONS FOR APPLIED COATINGS

Location (1)	Primer (Max VOC 250 g/l)		Intermediate (Max VOC 250 g/l)		Finish (Max VOC 420 g/l)	
CIRIA Spec	Type (3)	DFT μ (2)	Type	DFT μ (2)	Type (4)	DFT μ (2)
External steel						
E-1	Epoxy Zinc Rich	75	Epoxy MIO	100 - 125	Acrylic/Urethane	50
E-2	Epoxy Zinc Phosphate	75	Epoxy MIO	100 - 125	Acrylic/Urethane	50
Internal steel						
I-1	None		None		None	
I-2	Epoxy Zinc Phosphate	50	None		Acrylic/Urethane	50
I-3	Epoxy Zinc Rich	50	None		None	
I-4	Epoxy Primer / Finish	125	None		None	
E-2	Epoxy Zinc Phosphate	75	Epoxy MIO	125	Acrylic/Urethane	50
(1)	See CIRIA publication 174 “New paint systems for the protection of construction steelwork” for link between environmental classification according to BS EN ISO 12944-2 and the predicted durability of the coating system in terms of life to first maintenance.					
(2)	Nominal dry film thickness in microns.					
(3)	Surface preparation required - blast clean to Sa2½ of BS EN ISO 8501-1 except for Spec I-1 which requires no surface preparation.					
(4)	Applied on site.					