AS/NZS 5131:2016

Australian/New Zealand Standard™

Structural steelwork—Fabrication and erection

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee BD-001, Steel Structures. It was approved on behalf of the Council of Standards Australia on 21 November 2016 and by the New Zealand Standards Approval Board on 17 November 2016.
This Standard was published on 8 Decmeber 2016.

The following are represented on Committee BD-001:

Australian Building Codes Board
Australian Chamber of Commerce and Industry
Australian Steel Association
Australian Steel Institute
Austroads
Bureau of Steel Manufacturers of Australia
Engineers Australia
New Zealand Heavy Engineering Research Association
Rail Industry Safety and Standards Board
Steel Construction New Zealand
University of New South Wales
University of Sydney
University of Western Sydney
Welding Technology Institute of Australia

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about joint Australian/New Zealand Standards can be found by visiting the Standards Australia Web Site at www.standards.org.au or Standards New Zealand web site at www.standards.govt.nz and looking up the relevant Standard in the on-line catalogue.

For more frequent listings or notification of revisions, amendments and withdrawals, Standards Australia and Standards New Zealand offer a number of update options. For information about these services, users should contact their respective national Standards organization.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Please address your comments to the Chief Executive of Standards Australia or the New Zealand Standards Executive at the address shown on the back cover.

This Standard was issued in draft form for comment as DR2 AS/NZS 5131:2016.

Australian/New Zealand Standard™

Structural steelwork—Fabrication and erection

First published as AS/NZS 5131:2016.

ISBN 978 1 76035 629 3

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-001, Steel Structures. The objective of this Standard is to provide best practice requirements for fabrication and erection of structural steel members, components and structural assemblies used for load-carrying purposes in buildings, bridges and other structures.

This Standard is based on the published joint Australian Steel Institute/Steel Construction New Zealand/Heavy Engineering Research Association (HERA) document '*Structural Steelwork Fabrication and Erection Code of Practice*', 1st edition, 2014. Reference was made to EN 1090-2:2008, *Execution of steel structures and aluminium structures*, Part 2: *Technical requirements for steel structures* in the development of this Standard.

The Standard introduces the fundamental concept of 'construction category' (CC), which is a risk-based fit-for-purpose categorization of a structure or parts thereof. It is expected the CC categorization will be implemented in other related Standards, such as AS 4100, *Steel structures*, in due course.

It is the intention of Committee BD-001 to revise AS 4100 to align with AS/NZS 5131, principally through removal of material that is covered in AS/NZS 5131 and inclusion of guidance on the assessment of the construction category in AS 4100.

In the interim development period for this Standard, the International Standards Organization (ISO) commenced development of ISO 17607, *Steel structures*, which also makes reference to EN 1090-2, *Execution of steel structures and aluminium structures*, Part 2: *Technical requirements for steel structures*. Committee BD-001 has worked to ensure alignment where possible with ISO/CD 17607.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

CONTENTS

Page

Page

Page

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Structural steelwork—Fabrication and erection

SECTION 1 SCOPE, INCLUSIONS AND EXCLUSIONS, AND SAFETY

1.1 SCOPE

This Standard sets out minimum requirements for the construction of structural steelwork involving fabrication, preparation of steel surfaces for corrosion protection, corrosion protection comprising painting and galvanizing, erection and modification of steelwork. It applies to complete structures, individual members and components, and manufactured components pre-fabricated for inclusion in a steel structure.

This Standard specifies requirements for the construction of structural steelwork produced from the following:

(a) Hot-rolled structural steel sections, flat bars and plates including those with a yield stress used in design of 690 MPa or less, which comply with one of the material Standards listed in Section 2 and which were designed using AS 4100 or AS 5100.6 or NZS 3404.1.

(b) Cold-formed structural hollow sections, including hollow sections manufactured by welding, which comply with AS/NZS 1163 and which were designed using AS 4100 or AS 5100.6 or NZS 3404.1.

(c) Weathering steel members and components complying with AS/NZS 3678 and AS/NZS 1594.

(d) Steel members in composite steel and concrete structures designed using AS 2327.1 or AS 5100.6 or NZS 3404.1, including beams, columns, composite slabs and decking.

(e) Cold-formed purlin and girt members and decking designed using AS/NZS 4600.

This Standard applies to all types of buildings, general structures, crane runway girders, monorails, roadway bridges, rail bridges and pedestrian bridges. Its application includes complete structures, individual members and manufactured components subject to seismic actions or to fatigue.

Some requirements are expressed in terms of construction categories.

NOTE: Guidance on construction categories is provided in Appendix C.

Provisions on inspection of welding and bolting applying to New Zealand only are covered in Appendix I.

1.2 STRUCTURAL ELEMENTS INCLUDED

This Standard applies to the elements of structural steelwork that are shown and sized on the structural design drawings, essential to support the design loads and described as follows:

(a) Structures and substructures—

(i) bins and bin support structures;

(ii) chimneys and stacks;

(iii) conveyor support structures;

(iv) door frames, if made up from standard rolled shapes or welded from plates and if part of the structural steel frame;

(v) structural steel frames generally;

(vi) floor opening frames, if made up from standard rolled shapes or welded from plates and if part of the structural steel frame;

(vii) bridges;

(viii) cranes;

(ix) gantries;

(x) wharves, jetties and piers;

(xi) lighting supports;

(xii) masts and poles, including flagpoles;

(xiii) roof and wall opening frames if made up from standard rolled shapes or welded from plates and if part of the structural steel frame;

(xiv) screen support frames if made up from standard rolled shapes or welded from plates;

(xv) sign supports;

(xvi) silos and silo supports;

(xvii) stairs;

(xviii) towers; and

(xix) walkways.

(b) Elements—

(i) base plates that are attached to columns;

(ii) anchor rods and footing bolts that will receive the base plates;

(iii) roof and wall battens attached to purlins and girts;

(iv) balustrading and handrailing;

(v) members made up from standard rolled shapes or welded from plates;

(vi) bearing plates, if part of the structural steel frame;

(vii) permanent and temporary bracing;

(viii) columns and posts made up from standard rolled shapes or welded from plates;

(ix) connection components manufactured from plate or flat bar, for framing structural steel to structural steel;

(x) crane runway girders and crane stops made up from standard rolled shapes or welded from plates;

(xi) embedded structural steel components that will receive structural steel;

(xii) fasteners, shop and field bolts, nuts and washers, screws and pins, levelling nuts and washers, and associated plates;

(xiii) floor plates, if attached to the structural steel frame;

(xiv) finger plate expansion joints cut from steel plate;

(xv) girts, if made up from standard rolled shapes or welded from plates or cold-formed C or Z or hat sections;

(xvi) grillage beams;

(xvii) hangers, if made up from standard rolled shapes or welded from plates and framing structural steel to structural steel;

(xviii) lintels that are part of the structural steel frame;

(xix) machinery supports, if made up from standard rolled shapes or welded from plates and if part of the structural steel frame;

(xx) mechanical and chemical anchors;

(xxi) monorail beams, if made up from standard rolled shapes or welded from plates and if part of the structural steel frame;

(xxii) purlins, if made up from standard rolled shapes or welded from plates or cold-formed C and Z or hat sections;

(xxiii) sag rods and tie rods, if part of the structural steel frame and connecting structural steel to structural steel;

(xxiv) stud connectors for composite steel-concrete action;

(xxv) shims and wedges, if permanent;

(xxvi) struts and stanchions, if permanent and part of the structural steel frame;

(xxvii) trusses, if made up from standard rolled shapes or welded from plates;

(xxviii) temporary works such as falsework but excluding scaffolding; and

(xxix) bridge barriers, including safety protection screens.

1.3 STRUCTURES AND ELEMENTS EXCLUDED

This Standard does not apply to the following structures and elements of structural steelwork:

(a) Stainless steel members, components and fasteners.

(b) Castings.

(c) Forgings.

(d) Wire and cable elements.

(e) Hot driven rivets.

(f) Proprietary structural bearings for girders, trusses or bridges.

(g) Proprietary expansion joints for bridges or building.

(h) Crane rails and crane rail fixings.

(i) Roof and wall sheeting.

(j) Frames manufactured from light-gauge cold-formed sections, other than hollow sections to AS/NZS 1163.

(k) Concrete formwork.

(l) Scaffolding.

(m) Steel storage racking.

(n) Steel-framed housing.

1.4 SAFETY

All risks and hazards from fabrication, welding, coating, mechanical fastening and erection shall be identified and managed to ensure that all work is carried out in a manner that does not endanger the health and safety of personnel.

NOTES:

1 Guidance on the management of risk is given in AS/NZS ISO 31000.

2 AS 1674.1 and AS 1674.2 provide requirements relating to welding activities, including the control of emitted fumes, especially when welding through paints, primers and other surface coatings.

3 Guidance on additional safety precautions is given in WTIA Technical Notes 7 and 22.

SECTION 2 NORMATIVE REFERENCED STANDARDS

2.1 GENERAL

This Section lists the normative documents referred to in this Standard. Normative referenced documents provide information that is essential to the application of the Standard.

NOTE: The construction specification is also considered to be a normative reference document for this Standard.

Some of these documents are considered to be 'primary' referenced documents, i.e. documents that will probably need to be readily available for repeated reference. These documents are indicated in the lists below by an asterix (*) against the document number.

NOTE: Documents referenced for informative purposes are listed in the Bibliography in Appendix A.

2.2 NORMATIVE REFERENCES

AS

1100 Technical drawing (series)
1100.101 Part 101: General principles
1100.501 Part 501: Structural engineering drawing

1110 ISO metric hexagon bolts and screws—Product grades A and B
1110.1* Part 1: Bolts
1110.2* Part 2: Screws

1111 ISO metric hexagon bolts and screws—Product grade C
1111.1* Part 1: Bolts
1111.2* Part 2: Screws

1112 ISO metric hexagon nuts
1112.1* Part 1: Style 1—Product grades A and B
1112.2* Part 2: Style 2—Product grades A and B
1112.3* Part 3: Product grade C
1112.4* Part 4: Chamfered thin nuts—Product grades A and B

1171 Non-destructive testing—Magnetic particle testing of ferromagnetic products, components and structures

1365 Tolerances for flat-rolled steel products

1397* Continuous hot-dip metallic coated steel sheet and strip—Coatings of zinc and zinc alloyed with aluminium and magnesium

1562 Design and installation of sheet roof and wall cladding
1562.1 Part 1: Metal

1627 Metal finishing—Preparation and pretreatment of surfaces
1627.1 Part 1: Removal of oil, grease and related contamination
1627.2 Part 2: Power tool cleaning
1627.4 Part 4: Abrasive blast cleaning of steel

1674 Safety in welding and allied processes
1674.1* Part 1: Fire precautions
1674.2* Part 2: Electrical

AS

2062 Non-destructive testing—Penetrant testing of products and components

2177 Non-destructive testing—Radiography of welded butt joints in metal

2207 Non-destructive testing—Ultrasonic testing of fusion welded joints in carbon and low alloy steels

2327 Composite structures
2327.1* Part 1: Simply supported beams

2331 Methods of test for metallic and related coatings
2331.1.4 Part 1.4: Local thickness tests—Magnetic induction and eddy current methods

2812 Welding, brazing and cutting of metals—Glossary of terms

2832 Cathodic protection of metals
2832.1 Part 1: Pipes and cables
2832.2 Part 2: Compact buried structures
2832.3 Part 3: Fixed immersion structures
2832.4 Part 4: Internal surfaces
2832.5 Part 5: Steel in concrete structures

3566 Self-drilling screws for the building and construction industries
3566.1 Part 1: General requirements and mechanical properties

3597* Structural and pressure vessel steel—Quenched and tempered plate

3894 Site testing of protective coatings
3894.1 Method 1: Non-conductive coatings—Continuity testing—High voltage (brush) method
3894.3 Method 3: Determination of dry film thickness
3894.4 Method 4: Assessment of degree of cure
3894.5 Method 5: Determination of surface profile
3894.6 Method 6: Determination of residual contaminants
3894.7 Method 7: Determination of surface temperature
3894.12 Method 12: Inspection report—Coating

4100* Steel structures

4291 Mechanical properties of fasteners made of carbon steel and alloy steel
4291.1 Part 1: Bolts, screws and studs
4291.2 Part 2: Nuts with specified property classes—Coarse thread and fine pitch thread

5100 Bridge design
5100.6* Part 6: Steel and composite construction

AS ISO

9712 Non-destructive testing—Qualification and certification of NDT personnel

13916 Welding—Guidance on the measurement of preheating temperature and preheat maintenance temperature

AS/NZS

1163* Cold-formed structural steel hollow sections

1170 Structural design actions
1170.0 Part 0: General principles

1214* Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series) (ISO 10684:2004, MOD)

AS/NZS		
1252		High-strength steel bolt assemblies comprising bolts, nuts and washers for structural engineering
1252.1*	Part 1:	Technical requirements
1554		Structural steel welding
1554.1*	Part 1:	Welding of steel structures
1554.2*	Part 2:	Stud welding (steel studs to steel)
1554.4*	Part 4:	Welding of high strength quenched and tempered steels
1554.5*	Part 5:	Welding of steel structures subject to high levels of fatigue loading
1554.7*	Part 7:	Welding of sheet steel structures
1559		Hot-dip galvanized steel bolts with associated nuts and washers for tower construction
1594*		Hot-rolled steel flat products
1873		Powder-actuated (PA) hand-held fastening tools (series)
2312		Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
2908		Cellulose-cement products (series)
2980*		Qualification of welders for fusion welding of steels
3678*		Structural steel—Hot-rolled plates, floorplates and slabs
3679		Structural steel
3679.1*	Part 1:	Hot-rolled bars and sections
3679.2*	Part 2:	Welded I sections
3750		Paints for steel structures (series)
4114		Spray painting booths, designated spray painting areas and paint mixing rooms
4114.1	Part 1:	Design, construction and testing
4114.2	Part 2:	Installation and maintenance
4600*		Cold-formed steel structures
4680*		Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS ISO		
3834		Quality requirements for fusion welding of metallic materials
3834.2*	Part 2:	Comprehensive quality requirements
3834.3*	Part 3:	Standard quality requirements
3834.4*	Part 4:	Elementary quality requirements
SA TS		
101		Design of post-installed and cast-in fasteners for use in concrete
ISO		
2859		Sampling procedures for inspection by attributes
2859-5	Part 5:	System of sequential sampling plans indexed by acceptance quality limits (AQL) for lot-by-lot inspection
7976		Tolerances for building—Methods of measurement of buildings and building products
7976-1	Part 1:	Methods and instruments
7976-2	Part 2:	Position of measuring points

ISO	
8501	Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness
8501-1	Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
9606	Qualification testing of welders—Fusion welding
9606-1	Part 1: Steels
11127	Preparation of steel substrates before application of paints and related products—Test methods for non-metallic blast-cleaning abrasives
11127-6	Part 6: Determination of water-soluble contaminants by conductivity measurement
14731	Welding coordination—Tasks and responsibilities
15976	Closed end blind rivets with break pull mandrel and protruding head—St/St
15979	Open end blind rivets with break pull mandrel and protruding head—St/St
15980	Open end blind rivets with break pull mandrel and countersunk head—St/St
15983	Open end blind rivets with break pull mandrel and protruding head—A2/A2
15984	Open end blind rivets with break pull mandrel and countersunk head—A2/A2
17123	Optics and optical instruments—Field procedures for testing geodetic and surveying instruments (series)
ASTM	
D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
F959	Standard specification for compressible-washer-type direct tension indicators for use with structural fasteners
BS	
1134	Assessment of surface texture: Guidance and general information
8539	Code of practice for the selection and installation of post-installed anchors in concrete and masonry
NZS	
3404*	Steel structures standard
3404.1	Part 1: Materials, fabrication, and construction
SSPC	
SP 1	Solvent cleaning
SP 7	Brush-off blast cleaning
SP 10	Near-white metal blast cleaning
WTIA	
Technical Note 3	Care and conditioning of arc welding consumables

SECTION 3 TERMS AND DEFINITIONS

3.1 GENERAL TERMS

For the purposes of this Standard, the following general terms and definitions apply.

3.1.1 Architecturally exposed structural steelwork (AESS)

Structural steelwork that is exposed to view and considered a fundamental component of the architectural intent of the structure.

3.1.2 Authority

A body having statutory powers to control the design and erection of a structure.

3.1.3 Coating quality level

The extent of required documentation, inspection and testing of protective coating work depending on the severity of the environment and complexity of the surface preparation and coating application.

3.1.4 Competent person

A person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the required task correctly and safely.

3.1.5 Component

An element of a structure, which may be a member, a cleat or plate or an assembly of several smaller members or plates.

3.1.6 Construction

All activities performed for the physical completion of the parts of the construction works that are structural steelwork. This comprises procurement, fabrication, welding, mechanical fastening, transportation, surface treatment, corrosion protection, erection and the inspection, certification and documentation thereof.

3.1.7 Construction category

Classified set of requirements specified for the construction of the works as whole, of an individual component or of a detail of a component.

NOTE: Both ISO 2394 and European Standards use the term ‘execution’ to describe all activities performed for the physical completion of the works (i.e. procurement, fabrication, welding, mechanical fastening, transportation, erection, surface treatment and the inspection and documentation) and this term may be considered equivalent to ‘fabrication and erection’. ‘Execution Class’ (EXC) is the term used in European Standards to refer to a risk-based categorization of a structure, similar in intent to the construction category adopted in this Standard. It should be noted, however, that the two categorizations are not based on the same risk matrix assessment and cannot be used interchangeably.

3.1.8 Construction specification

Set of documents covering technical data and other requirements for a particular steel structure, including those specified to supplement and qualify the provisions of this Standard.

3.1.9 Construction works

All things that are constructed or result from construction operations. This term covers both building and civil engineering works and refers to both structural and non-structural components.

3.1.10 Constructor

The person or organization undertaking the construction of the works or components thereof.

3.1.11 Designer

The person or organization responsible for defining the technical data and other requirements for a particular steel structure, as contained in the construction specification.

3.1.12 Direct tension indicator

A device that is capable of indicating the achievement of a specific minimum bolt tension in a structural bolt.

3.1.13 Erector

The person or organization assembling the works on-site as part of the overall construction works.

3.1.14 Fabrication

All activities required to produce and deliver a component. As relevant, this comprises procurement, preparation and assembly, welding, mechanical fastening, transportation, surface treatment, corrosion protection, inspection and documentation thereof.

3.1.15 Fabricator

The person or organization undertaking the fabrication of the complete works or components thereof. The fabricator may subcontract components of the works to another fabricator.

3.1.16 Firm contact

The condition that exists between plies in a bolted connection where the plies are solidly seated against each other, but not necessarily in continuous contact.

3.1.17 Importance level

A category that characterizes a structure in terms of the circumstances of its occupancy and its use, as defined in the National Construction Code (NCC) for Australia, and AS/NZS 1170.0, *Structural design actions*, Part 0: *General principles* for New Zealand and for structures in Australia not covered by the NCC.

3.1.18 Manufacturer

The person or organization producing the material and standard or proprietary components used in the works.

3.1.19 Material

A product used for fabricating a component and which remains as part of it, e.g. structural steel rolled steel members, mechanical fasteners and welding consumables.

3.1.20 Nonconformity

Failure to meet an expectation that is stated, implied or obligatory.

3.1.21 Non-slip fasteners

Mechanical fasteners or welds that do not allow slip to occur between connected plates of members at the serviceability limit state so that the original alignment and relative positions are maintained.

3.1.22 Preparation and assembly

All activities performed on the constituent steel products in order to produce the parts ready for assembly and inclusion in a fabricated item. As relevant, this comprises identification, handling and storage, cutting, shaping and holing.

3.1.23 Quality

Degree to which a set of inherent characteristics fulfils requirements.

NOTE: See AS/NZS ISO 9000 for further information and guidance.

3.1.24 Strength limit state

A limit state of collapse or loss of structural integrity.

3.1.25 Structural steelwork

Steel structures or manufactured steel components used in construction works.

3.1.26 Structure

Organized combination of connected parts designed to carry loads and provide adequate rigidity.

3.1.27 Supplier

The distributor, stockist or importer supplying the steel material or component.

3.1.28 Supplier declaration of conformity (SDoC)

A document issued by the supplier declaring that the products supplied comply with the requirements of the relevant Australian Standard and that the documentation required by the Standard is available for issue.

3.1.29 Tensile strength

The minimum ultimate strength in tension specified for the grade of steel in AS 4100, AS 5100.6 and NZS 3404.1 as appropriate.

3.1.30 Tolerance

The difference between the permissible maximum (or upper) limit of size or dimension and the permissible minimum (or lower) limit of size or dimension.

3.1.31 Works

Parts of construction works that are structural steelwork.

3.1.32 Yield stress

The minimum yield stress in tension specified for the grade of steel in AS 4100, AS 5100.6 and NZS 3404.1, as appropriate.

3.2 TYPES OF TOLERANCE

For the purposes of this Standard, the following terms and definitions relating to types of tolerance apply.

3.2.1 Erection tolerance

An essential tolerance checked during erection or a geometrical tolerance checked after erection, which might be required to meet a function other than those of an essential tolerance, such as for appearance or fit-up.

3.2.2 Essential tolerance

Basic limit for a geometrical tolerance necessary to satisfy the design assumptions for a structure in terms of design capacity and stability (see AS 4100, AS 5100.6 and NZS 3404.1).

3.2.3 Fabrication tolerance

An essential tolerance checked during fabrication or a geometrical tolerance checked during fabrication.

3.2.4 Functional tolerance

A tolerance which might be required to meet a function other than those of an essential tolerance, such as for appearance or fit-up.

3.2.5 Manufacturing tolerance

Permitted range in the size and dimensions of a steel product resulting from the manufacture of the product.

3.3 CONNECTION TYPES USING MECHANICAL FASTENERS

For the purposes of this Standard, the following general terms and definitions relating to types of connections using mechanical fasteners apply.

3.3.1 Bearing-type connection

Connection affected using either snug-tight mechanical fasteners, or high strength mechanical fasteners tightened to induce a specified minimum tension in the mechanical fastener, in which the design action is transferred by shear in the fasteners and bearing on the connected parts at the strength limit state.

3.3.2 Friction-type connection

Connection affected using high-strength mechanical fasteners tightened to induce a specific minimum tension in the mechanical fastener, such that the resulting clamping action is able to transfer the design shear forces at the serviceability limit state acting in the plane of the common contact surfaces by the friction developed between the contact surfaces.

3.3.3 Full tensioning

A method of installing and tensioning a mechanical fastener that induces a specific minimum tension in the mechanical fastener.

3.3.4 Snug tight

The tightness in the bolts in a bolted connection attained by a few impacts of an impact wrench or by the full effort of a person using a standard podger spanner to bring the plies into firm contact.

3.4 WELDED CONNECTIONS

For the purposes of this Standard, the definitions of weld types given in AS 2812 apply.

SECTION 4 DESIGN, SPECIFICATION, DOCUMENTATION AND TRACEABILITY

4.1 CONSTRUCTION SPECIFICATION

4.1.1 General

All necessary information and technical requirements for the construction of every element of the works shall be clearly set out in the construction specification. There shall be procedures in place for dealing with variations to the construction specification where variations are required. There shall be procedures in place for the resolution of any discrepancies or inconsistencies in the construction specification.

The construction specification shall include all of the following items that are relevant:

(a) The design data and design details to the extent nominated in AS 4100, AS 5100.6 (in Australia) and NZS 3404.1 (in New Zealand).

(b) The required additional information listed in Appendix B, Paragraph B1.

(c) The selection of relevant options listed in Appendix B, Paragraph B2.

(d) The assignment of responsibilities listed in Appendix B, Paragraph B3.

(e) Details of the construction category required (Clause 4.1.2).

(f) Any variations from or additions to the tolerances specified in Appendix F.

(g) Any requirements for architecturally exposed structural steelwork (AESS) (Section 10).

(h) Any special requirements for the fabrication and erection of the works.

(i) Responsibilities for managing compliance.

(j) For New Zealand only, additional information as detailed in Appendix I.

4.1.2 Construction category

Four construction categories denoted CC1, CC2, CC3, CC4 are nominated in this Standard, for which requirements increase in strictness from CC1 to CC4.

NOTE: The requirements for CC4 are additional to CC3. The additional requirements for CC4 are not fully defined in this Standard. CC4 applies to unusual or special structures for which it is expected that requirements additional to those for CC3 will be defined at a project specific level or by a particular organization, agency or business.

A construction category shall apply to either the whole structure or to parts of the structure or to specific details. A structure may therefore have multiple construction categories, provided that all parts of the structure are categorized. A detail or group of details will normally be ascribed one construction category. The choice of construction category does not necessarily have to be the same for all components.

The construction category shall be nominated in the construction specification. If no construction category is specified, then CC2 shall apply.

The list of requirements related to construction categories is specified in Appendix B, Paragraph B4.

NOTE: Guidance on the selection of construction category is given in Appendix C. The choice of construction category is related to the importance factor, the service category and the fabrication category as set out in Appendix C.

4.1.3 Treatment grades

The treatment grades are to make steel surfaces with imperfections, including welded and fabricated surfaces, suitable for the application of paints and related products.

Three treatment grades, denoted P1 to P3, are defined in Clause 9.8.4, for which the required strictness increases from P1 to P3.

Treatment grades may apply to the whole structure or to a part of the structure or to specific details. A structure can include several treatment grades. A detail or group of details will normally be ascribed one treatment grade.

NOTE: Treatment grades are related to the expected life of the corrosion protection and may be related to the type of corrosion protection system used in a particular area of a structure.

4.1.4 Geometrical tolerances

The following three types of geometrical tolerance are detailed in Appendix F:

(a) Manufacturing tolerances.

(b) Fabrication tolerances.

(c) Erection tolerances.

Some of these tolerances are also considered to be essential tolerances because the particular geometrical tolerance shall be complied with in order to satisfy the design assumptions for the structural element in terms of design capacity as defined in the design Standards AS 4100, AS 5100.6, AS 2327.1 or NZS 3404.1.

4.2 DESIGN STAGES

Two separate but related design stages are recognized in this Standard as follows:

(a) *The erection design stage*, which provides for the performance of the structure and elements during the erection (refer Section 11).

(b) *The in-service design stage*, which provides for the performance of the structure primarily in the final in-service condition. The construction specification is a usual deliverable from this stage.

4.3 USE OF BUILDING INFORMATION MODELLING

Where the construction specification requires the implementation of digital project models such as Building Information Models (BIM) to convey all or a defined portion of the project information between the relevant stakeholders, the specific requirements for process, hardware, software and competent personnel necessary shall be documented.

NOTE: The workflow and integration between project stakeholders necessary would usually be defined in the Project BIM Brief or the BIM Management Plan.

Where a digital model is utilized in the project, all references in this Standard to fabrication and erection documentation shall equally apply to the digital model.

The following issues shall be addressed:

(a) Production of a digital fabrication model consistent with the digital design model.

(b) Establishing the owner of the digital design model and ensuring the rights and obligations of ownership are clearly understood.

(c) Requirements and responsibilities for accuracy and maintenance of the digital design model.

(d) Preferably, utilization of an open Standard (see Note 1) for the exchange of digital steelwork data, depending on the exact nature of the use case.

NOTES:

1 CIS/2 and ISO 16739 are examples.

2 Comments attached to the individual elements as specified in the CIS/2 Standard should be used to annotate the digital fabrication model.

(e) Implementation of digital document management, version control and a system to record review, approval and final release of the digital fabrication model for preparation of shop detail documentation and fabrication of structural steel.

4.4 SHOP DETAILING DOCUMENTATION

4.4.1 Production

The production of the shop detail documentation and related responsibilities shall be defined in the construction specification.

4.4.2 Scope of documentation

The shop detailing documentation shall show, in standard engineering drawing manner, clear and complete information on each assembly, component and connection of the work.

The information shall include—

(a) identification;

(b) steel type and grade;

(c) dimensions of items;

(d) required camber, where applicable;

(e) fabrication methods including, where applicable, hot- or cold-forming and post-weld heat treatment;

(f) location, type and size of welds or bolts;

(g) weld categories and bolting categories;

(h) orientation of members;

(i) location of temporary connections;

(j) surface preparation methods, corrosion protection system and any detailing requirements specific to the selected coating system;

(k) procedures necessary for shop and site assembly;

(l) lifting and support points for handling and transport;

(m) temporary bracing, if required for handling and transport;

(n) required fixings for building elements;

(o) procedures for erection including temporary bracing;

(p) set out of items relative to project grid and rise level;

(q) all set out points as shown on structural and architectural drawings and their dimensions relative to grid;

(r) particular welding and material testing requirements as nominated by the engineer; and

(s) marking plans for all items including holding down bolts, shear studs and chemical anchors.

The shop detailing documentation shall be in accordance with the relevant parts of the AS 1100 series, including AS 1100.101 and AS 1100.501.

4.4.3 Production of shop detail documentation

The shop detail documentation shall—

(a) accurately and completely transfer the information from the construction specification; and

(b) provide for the development of accurate, detailed dimensional information which allows for the accurate fit-up of components during erection.

Each shop detail drawing shall be identified utilizing a numbering system allowing traceability throughout the duration of the works. Revisions shall be uniquely identified and dated, with the scope of each revision clearly identified.

Where requests for information (RFIs) are issued as part of the process of producing shop detail documentation, a written record of inquiries and responses shall be maintained.

NOTE: RFIs may be issued in order to seek an interpretation or a clarification of the construction specification or a resolution of discrepancies.

4.4.4 Approval of shop detail documentation

The construction specification shall nominate the competent person responsible for review and approval of the shop detail documentation. All such documentation shall be annotated as either approved or approved subject to corrections noted thereon.

4.5 DOCUMENTATION REQUIRED

4.5.1 Quality documentation

The following matters relating to quality shall be documented for all construction categories except CC1 and for Coating Quality level PC2:

(a) The allocation of tasks and authority during the various phases of the project.

(b) The procedures, methods and work instructions to be applied.

(c) An inspection and test plan specific to the works (see Clause 13.1).

(d) A procedure for handling changes and modifications.

(e) A procedure for handling nonconformities.

(f) A procedure for handling requests for concessions.

(g) A procedure for handling disputes related to quality.

(h) Any hold points or requirements to witness inspections or tests, and any consequent access requirements.

(i) A procedure for document control and control of records.

(j) A procedure for corrective and preventative actions.

(k) A procedure for quality audits.

(l) A review of contractual requirements (see Note 1).

(m) A technical review of contractual requirements (see Note 1).

NOTES:

1 Clause 5 in each of the AS/NZS ISO 3834 series of Standards addresses this topic and may be used in part or full to enable compliance with this requirement.

2 For CC1, the quality documentation should be consistent with the elements outlined in Appendix D.

4.5.2 Quality plan

For CC2, it shall be specified in the construction specification if a quality plan for the execution of the works is required. For CC3 and CC4 and for Coating Quality level PC2 a quality plan shall be prepared for execution of the works.

A quality plan shall include the following:

(a) A general management document which shall contain a review of the specification requirements against process capabilities.

(b) An organization chart and managerial staff responsible for each aspect of the construction.

(c) Arrangements for inspection including allocation of responsibility for each inspection task.

(d) Quality documentation prior to construction, as defined in Clause 4.5.1, which shall be produced before execution of the construction step to which they relate.

(e) Details of records of inspections and checks to be carried out or demonstration of qualification or certification of intended implemented resources. Include notification that execution records related to a hold-point that affect continuation of construction shall be produced before the hold-point is released.

NOTE: Appendix E provides guidance on the content of a quality plan recommended for the fabrication and erection of structural steelwork.

4.5.3 Safety of the works

All risks and hazards from fabrication, welding, coating, mechanical fastening and erection shall be identified and managed to ensure that all work is carried out in a manner that does not endanger the health and safety of personnel.

In particular, due consideration shall be given to the following:

(a) Requirements relating to welding activities (see AS 1674.1 and AS 1674.2), including the control of emitted fumes, especially when welding through paints, primers and other surface coatings.

(b) Requirements relating to the safety of the works as specified in various sections of this Standard.

NOTES:

1 Guidance on the management of risk is given in AS/NZS ISO 31000.

2 Guidance on additional safety precautions is given in WTIA Technical Notes 7 and 22.

4.5.4 As-built documentation

Sufficient documentation shall be prepared during construction as a record of the as-built structure in order to demonstrate that the works have been carried out according to the construction specification.

4.6 PURCHASING—COMPONENTS AND SUBCONTRACTED SERVICES

4.6.1 General

A documented purchasing procedure for both components and subcontracted services shall be maintained. The procedure shall be capable of monitoring trends in supplier performance. The procedure shall be operated by a named representative.

All purchases shall reflect the requirements of the construction specification and conform to the requirements specified in the order.

Purchasing information shall describe the product to be purchased, including the following where appropriate:

(a) Requirements for approval of product, procedures, processes and equipment.

(b) Requirements for qualification of personnel.

(c) Quality management system requirements.

(d) The required construction category.

(e) Requirements for verification of product, including where applicable, verification at the suppliers' premises.

A system shall be established to maintain and document inspection or other activities sufficient to ensure that purchased product meets specified purchase requirements.

NOTE: The verification of purchased product may be achieved through one or a combination of a number of processes, including assessment of supplier/subcontractor, maintenance of supplier/subcontractor purchasing history, receipt inspection and testing and maintenance of approved supplier lists.

4.6.2 Components

All necessary documentation shall be obtained at the time of purchase for all components utilized in the fabricated structure, including but not limited to raw material, steel members, plates and cleats, assemblies, bolts and consumables. The documentation shall be sufficient to meet the requirements of Clause 5.2 for the construction category applicable to the component or structure as a whole.

Preferably, a Supplier Declaration of Conformity (SDoC) should be obtained for all purchased components. Where an SDoC is not available, documentation sufficient to meet the requirements of this Standard shall be obtained.

4.6.3 Subcontracted services

Where subcontracted services or activities are intended to be used, such as for drafting, cut and drill, forming, welding and fabrication, painting, galvanizing or erection, the procedure shall be as follows:

(a) Provide the subcontractor with all necessary information to meet the requirements of this Standard for the scope of work being undertaken by the subcontractor.

(b) Obtain from the subcontractor all necessary records and documentation to ensure the requirements of this Standard and the construction specification for the construction category designated for the scope of work undertaken by the subcontractor can be met.

The subcontractor shall fully comply with the relevant requirements of this Standard for the scope of work undertaken.

Full documentation sufficient to meet the requirements of this Standard shall be provided by the sub-contractor.

4.7 TRACEABILITY

4.7.1 General

There are three levels of traceability referenced in this Standard, as follows:

(a) Basic traceability (see Clause 4.7.2).

(b) Partial traceability (see Clause 4.7.3).

(c) Full traceability (see Clause 4.7.4).

4.7.2 Basic traceability

Test certificates are required for all steel material. Once issued from stock into the manufacturing/fabrication system, the grade of steel shall remain identifiable, but the direct link between the steel material and the relevant original test certificate need not be retained. Individual plate and section components shall be marked to correlate them directly with a fabrication drawing or data (see Clause 4.4.2) to ensure that when the fabricated component is finished, the grade of each piece part comprising the assembled component can be recorded.

A copy of the test certificates or supplier declaration of conformity (SDoC) with the purchasing information shall be maintained and if necessary, a copy provided to the relevant stakeholder(s).

In the case of partial and basic traceability sufficient quantities of the correct grade(s) and types of material procured for the purposes of the project and in accordance with the construction specification shall be demonstrable.

4.7.3 Partial traceability

Partial traceability requires the raw material for specific fabricated items to be traceable to the material test certificates at all stages through manufacture to incorporation into the works on-site.

Test certificates are required for all steel material. Main members and major plate components (for fabricated plate web girders, tanks and the like) shall be traceable back to the parent material test certificate. Raw material including all plate and section bought or allocated from stock for the work shall be correlated to the test certificates and incoming inspection records. Material identification shall be transferred when part material is returned to stock and before further being allocated to other jobs.

Partial traceability does not apply to minor components including cleats, connecting brackets and the like where basic traceability applies.

4.7.4 Full traceability

Full traceability requires the raw material or fabricated component to be traceable to the material test certificates at all stages through manufacture to incorporation into the works on-site.

Test certificates are required for all steel material. All items (including cleats, brackets, etc.) shall be traceable back to the parent material test certificate. Raw material including all plate and section bought or allocated from stock for the work shall be correlated to the test certificates and incoming inspection records. Material identification shall be transferred when part material is returned to stock and before further being allocated to other jobs.

SECTION 5 MATERIALS

5.1 GENERAL

5.1.1 Application

The properties of supplied materials shall be documented in a way that enables them to be compared to the properties specified in the construction specification and relevant Standards referred to in Clauses 5.3, 5.4, 5.5, 5.6, 5.7, 5.8 and 5.9.

5.1.2 Quality management system

The operations detailed in this Section shall be managed under a suitable quality management system.

NOTES:

1 An example of a suitable quality management system is set out in AS/NZS ISO 9001.

2 The level of documentation will generally increase with the construction category from CC1 to CC4. Guidance on the elements of a suitable quality management system aligned with the requirements of the construction categories is provided in Appendix D.

Quality documentation requirements are set out in Clause 4.5.1.

5.2 DESIGNATION, DOCUMENTATION AND TRACEABILITY

5.2.1 Designation

The designation of all materials used in the construction of the works shall be documented in the construction specification in a manner that is consistent with the designation requirements of the relevant Standard. The extent of identification of materials is covered in Clause 6.2 and in part is associated with traceability as defined in the construction specification and Clause 4.7.

For CC2, CC3 and CC4, if different grades and/or qualities of materials are in circulation together, each item shall be designated with a mark that identifies its grade.

Methods of marking of structural steel material as supplied shall be in accordance with the relevant Standards referred to in Clause 5.1.1. Methods of marking for material during and after fabrication shall comply with Clause 6.2.

Continuously hot-dip metallic coated steel shall be designated as specified in AS 1397.

If marking is required by this Standard, unmarked materials shall be treated as nonconforming product.

5.2.2 Documentation

Inspection documentation shall be provided in accordance with the relevant product specification.

5.2.3 Level of traceability

Levels of traceability are defined in Clause 4.7.

For Australia the level of traceability shall be as follows:

(a) Basic traceability for CC1.

(b) Partial traceability for CC2.

(c) Full traceability for CC3 and CC4. This traceability may be based on records for batches of product allocated to a common production process, unless traceability for each product separately is specified in the construction specification.

For New Zealand the level of traceability shall be as follows:

(i) No specific requirement on traceability for CC1.

(ii) Basic traceability for CC2.

(iii) Partial traceability for CC3 and CC4.

Full traceability is required if so designated in the construction specification.

5.3 STRUCTURAL STEELS

5.3.1 General

The construction specification shall specify the required grades, qualities and, if appropriate, coating thickness and finishes together with any required options permitted by the relevant Standard, including any requirements related to hot-dip galvanizing.

For Australia only, steel products and any coating shall conform to the requirements of the relevant product Standards specified in AS 4100 and AS 5100.6 as appropriate.

For New Zealand only, steel products and any coating shall conform to the requirements of the relevant product Standards specified in NZS 3404.1.

5.3.2 Thickness tolerances

Thickness tolerance shall be in accordance with AS/NZS 1365. The thickness tolerance, as defined in AS/NZS 1365, shall be Class A, except that the thickness tolerance for structural steel plates shall be Class B for CC4.

The dimensional tolerances of the base steel for continuously hot-dip metallic coated steel, including width, thickness, flatness and camber, shall be in accordance with the requirements of AS/NZS 1365.

5.3.3 Surface condition

The surface condition of the structural steel prior to coating, the repair of imperfections and the metallic coating on continuously hot-dip metallic coated steel shall conform to the requirements of the relevant Standard referenced in Clause 5.3.1. Any additional requirements for surface finish, restrictions on surface imperfections or repair of surface defects by grinding or welding shall be stated in the construction specification.

NOTE: Different metallic coated spangle finishes are generally aesthetic in nature and do not impact structural properties. Continuously hot-dip metallic coated steels used in structural application are typically not skin passed.

5.3.4 Additional requirements for particular applications

Additional requirements for seismic and fracture critical applications shall be included in the construction specification and shall be in accordance with AS/NZS 3678.

Any processing requirements before delivery, such as heat treatment, cambering and bending, shall be stated in the construction specification.

5.3.5 Lamellar tearing

The suitability of material for through-thickness requirements should be based on the through-thickness ductility quality criterion as specified in AS/NZS 3678, which is expressed in terms of quality classes identified by Z-values. The choice of material depends on requirements affected by the design of welded connections and the fabrication technique. Appendix H of AS/NZS 1554.1:2014 gives guidance for the choice of Z-qualities to avoid lamellar tearing in welded connections subject to tension stresses in through thickness direction.

If through-thickness tensile testing in accordance with AS/NZS 3678 is required, this shall be stated in the construction specification.

If ultrasonic examination of structural steel in the vicinity of critical welded details is required, such as cruciform joints transmitting tensile forces or bearing diaphragms or stiffeners, this shall be stated in the construction specification and the method of test to be used upon the parent metal shall comply with AS 2207 and AS/NZS 1554.1.

NOTE: Ultrasonic examination will not typically detect inclusions or internal discontinuities normally associated with lamellar tearing (e.g. manganese sulphides) and is therefore not an indicator of through-thickness ductility.

5.4 WELDING CONSUMABLES

All welding consumables shall conform to the requirements of the relevant Standard as listed in the relevant part of AS/NZS 1554.

5.5 MECHANICAL FASTENERS

5.5.1 Corrosion resistance

Coatings of all components of the fastener assembly shall be compatible and shall have similar corrosion resistance.

The corrosion resistance of fasteners and washers shall be comparable to that specified for the fastened components. The corrosion resistance of fasteners and washers shall be stated in the construction specification.

Protective coatings applied to mechanical fasteners shall comply with the requirements of the relevant product standard or, if not stated therein, with the manufacturer's specifications.

Hot-dip galvanized coatings on fasteners shall comply with AS/NZS 1214.

5.5.2 Terminology

In this clause, the following terms shall apply:

(a) *Washer* Plain or chamfered washer.

(b) *Assembly* Bolt with a nut and washer, as necessary.

5.5.3 Structural fasteners for other than tensioned applications

Bolts used for snug-tightened applications (/S categories in AS 4100 and AS 5100.6) shall comply with one of the following Standards:

AS 1110.1, AS 1111.1 and their mechanical properties shall comply with AS 4291.1.

Nuts used for snug-tightened applications shall comply with one of the following Standards:

AS 1112.1, AS 1112.2, AS 1112.3, AS 1112.4 and their mechanical properties shall comply with AS 4291.2.

Screws shall comply with one of the following Standards:

AS 1101.2, AS 1111.2 and their mechanical properties shall comply with AS 4291.1.

NOTE: The Australian Standards listed above are identical adoptions of ISO Standards, which may be used in place of their AS equivalents.

Fasteners for tower construction shall comply with AS/NZS 1559.

The grade of bolt or screw to be used and the relevant Standard shall be stated in the construction specification.

5.5.4 Structural bolt assemblies for tensioned applications

Bolts, nuts and washers used for tensioned applications (/T categories in AS 4100 and AS 5100.6) shall comply with AS/NZS 1252.1.

5.5.5 Direct tension indicators

Compressible-washer-type direct tension indicators and associated hardened nut face and bolt face washers shall be in accordance with ASTM F959. Direct tension indicators shall not be used with weathering steel.

If direct tension indicators are to be employed on tensioned bolts, their use shall be documented in the construction specification.

5.5.6 Weathering steel assemblies

Weathering steel assemblies shall be made of steel with improved atmospheric corrosion resistance, the chemical composition of which shall be as specified in AS/NZS 3678 or AS/NZS 1594.

NOTES:

1 Type 3 Grade A fasteners to ASTM A325 would be suitable.

2 It is recommended that HDG fasteners are not used with weathering steel. Appropriate weathering steel fasteners should be utilized.

5.5.7 Footing bolts

Chemical and mechanical properties of footing bolts shall be to AS/NZS 4291.1. Nuts shall be supplied as a minimum equivalent to the property class of the bolt material to AS/NZS 4291.2. Thread tolerance 6g shall be specified in the construction specification with dimensional tolerances to AS 1275. Galvanizing shall be to AS/NZS 1214. Plates for attachment shall be to AS/NZS 3678 or AS/NZS 1594.

Welding of materials of property class 8.8 and above shall not be permitted. Welding of nuts shall not be permitted unless they are specifically selected as a weldable product type.

NOTES:

1 The use of threaded rod for footing anchor bolts is not preferred. Threaded rod may not transfer load in the desired manner and may cause localised cracking through the interlocking effect of the threads in the concrete substrate. Threaded rod of any property class should not be bent to form shaped bolts as this may cause cracking of the material at the bend location. Threaded rods should not be welded as full penetration may not be achieved and thread roots can cause cracking in the heat affected zone.

2 The preferred fabrication method is a smooth shaft anchor bolt with either rolled or cut threads on one or both ends for attachment of plates and fittings. This fabrication method ensures direct load transfer through the bolt to the footing. Anchor bolts may be coated or sheathed to assist with bond breaking of the concrete to ensure elongation of the bolt and correct load transfer to the footing. Bolts with rolled threads may be manufactured from reduced diameter bars.

5.5.8 Locking devices

If required, locking devices such as nuts or bolt types which effectively prevent loosening of the assembly if subjected to impact or significant vibration shall be specified in the construction specification along with the relevant Standard.

Unless otherwise specified in the construction specification, products complying with ISO 2320, ISO 7040, ISO 7042, ISO 7719, ISO 10511, ISO 10512 and ISO 10513 may be used.

5.5.9 Tapered washers

Tapered washers shall comply with the relevant Standard cited in Clauses 5.5.3 and 5.5.4.

5.5.10 Fasteners for thin gauge components

Self-drilling screws shall comply with AS 3566.1. The grade and type of screw to be used should be specified in the construction specification.

Blind rivets shall comply with ISO 15976, ISO 15979, ISO 15980, ISO 15983 or ISO 15984. The grade of rivet, type and relevant Standard to be used should be specified in the construction specification.

Cartridge-fired pins and air-driven pins shall be classified as special fasteners (see Clause 5.5.11).

5.5.11 Special fasteners

Special fasteners are fasteners not covered by Australian, New Zealand or ISO Standards listed herein. They shall be fully specified in the construction specification, together with any tests required and installation instructions.

5.5.12 Delivery, identification and documentation

Fasteners complying with Clauses 5.5.3, 5.5.4 and 5.5.7 shall be delivered and identified in accordance with the requirements of the relevant Standard cited in the relevant clause.

5.5.13 Mechanical and chemical anchors

All mechanical and chemical fasteners shall be designed and specified in the construction specification in accordance with SA TS 101. Additional job specific requirements shall also be stated in the construction specification.

5.6 STUDS AND SHEAR CONNECTORS

Studs for arc stud welding, including shear studs for steel/concrete composite construction in accordance with AS 2327.1 and NZS 3404, shall comply with the requirements of AS/NZS 1554.2. Each stud shall be furnished with a ferrule and, if required, a deoxidizing and stabilizing flux each of which shall be suitable for the intended application. The grade, relevant material Standard, type and length of stud to be used shall be stated in the construction specification.

Shear connectors that comprise rolled sections shall comply with AS/NZS 3679.1.

Shear connectors that are mechanical fasteners shall comply with the relevant Standards listed in Clauses 5.5.3 and 5.5.4.

5.7 EXPLOSIVE FASTENERS

All explosive fasteners shall comply with, and shall be installed in accordance with AS/NZS 1873.

The grade, type and length of explosive fastener shall be stated in the construction specification.

5.8 GROUTING MATERIALS

Details of the grouting materials to be used shall be specified in the construction specification. Such materials shall be either: cement-based grout, special grout or concrete with small aggregate (10 mm or less).

Cement-based grout for use between steel base plates or bearing plates and concrete footings shall be as follows:

(a) For nominal thickness not exceeding 25 mm—Portland cement grout.

(b) For nominal thickness between 25 mm and 50 mm—fluid Portland cement grout that is not leaner than 1 part cement to 1 part fine aggregate.

(c) For nominal thickness of 50 mm and above—stiff Portland cement grout that is not leaner than 1 part cement to 2 parts fine aggregate.

Concrete with small aggregate shall only be used between steel base plates or bearing plates and concrete footings that have gaps with nominal thickness of 50 mm and above.

Special grouts include cement-based grouts with admixtures, expanding grout and resin-based grout. Those with low shrinkage characteristics are recommended. Special grout shall be supplied with detailed instructions for use that are provided by the manufacturer and shall be applied in accordance with the manufacturer's written instructions.

5.9 STORAGE OF MATERIALS

All material, including material supplied by the client, shall be stored according to the manufacturer's specifications such that the material will not be adversely affected. Identification shall be maintained during storage.

SECTION 6 PREPARATION, ASSEMBLY AND FABRICATION

6.1 GENERAL

6.1.1 Application

This Section specifies the requirements for identification, handling and storage, cutting, shaping, holing and assembly of steel materials into fabricated items.

Structural steelwork shall be fabricated to the relevant fabrication tolerances specified in Appendix F.

All equipment used during the fabrication process shall be suitably maintained to ensure that use, wear and failure do not cause significant inconsistency in the manufacturing process and the requirements of this Section are consistently met.

6.1.2 Quality management system

The operations detailed in this Section shall be managed under a suitable quality management system.

NOTES:

1 An example of a suitable quality management system is set out in AS/NZS ISO 9001.

2 The level of documentation will generally increase with the construction category from CC1 to CC4. Guidance on the elements of a suitable quality management system aligned with the requirements of the construction categories is provided in Appendix D.

Quality documentation requirements are set out in Clause 4.5.1.

6.1.3 Work method statements

A documented work method statement shall be prepared for each operation covered by this Section and for each stage of the work before any work is undertaken. The work method statements shall be made available to all relevant personnel involved in the works.

6.1.4 Steelwork to be painted or galvanized

Steelwork to be painted or galvanized shall also comply with the requirements of Clauses 9.3 and 9.8 in addition to the requirements of this Section.

6.1.5 Architecturally exposed structural steelwork

Steelwork identified in the construction specification as ‘Architecturally Exposed Structural Steelwork (AESS)’ shall comply with the requirements of Section 10 in addition to the requirements of this Section.

6.2 IDENTIFICATION AND TRACEABILITY

A record of test reports and test certificates supplied by the manufacturer for each item of steel supplied for fabrication shall be maintained.

A tracking system shall be established.

For Australia only, the tracking system shall support the following:

(a) Basic traceability for CC1.

(b) Partial traceability for CC2.

(c) Full traceability for CC3 and CC4.

For New Zealand only, the tracking system shall support the following:

(i) No specific requirement on traceability for CC1.

(ii) Basic traceability for CC2.

(iii) Partial traceability for CC3 and CC4. Full traceability is required for CC3 and CC4 if so designated in the construction specification.

(iv) Identification and traceability of welders for CC3 and CC4. Traceability of welders to individual welds shall be available either by documentation (e.g. weld plan) or welder ID stamp for primary connection welds.

(v) Identification and traceability of welding procedures for CC3 and CC4. Documentation allowing traceability of welding procedures (WPS) to individual welds shall be available.

Where full traceability is specified for CC3 and CC4, the following additional requirements apply:

(A) For primary connection welds, traceability of welders to individual welds shall be available by suitable methods, e.g. weld map, welder identification stamps, etc.

(B) Documentation showing traceability of welding procedures (WPS) to individual welds shall be available.

During fabrication any marking of steel members and components shall be such as to not damage the steel material. Hard stamping may be used for identification, except where specifically prohibited in the construction specification.

NOTE: Areas where hard stamping may be specifically prohibited include members or components subject to impact or fatigue or in locations where plastic hinges may occur.

The following requirements apply to hard stamped, punched or drilled marks for marking single components or packages of similar components unless otherwise specified in the construction specification:

(1) Shall be used only for grades of steel up to GR 350.

(2) Shall not be used on coated materials for cold-formed components.

(3) Shall only be used in the specified areas where the marking would not affect the fatigue life.

If the use of hard stamps, punched or drilled marks is not permitted, it shall be specified in the construction specification whether soft or low stress stamps may be used. Any areas where identification marks are not permitted or shall not be visible after completion shall be specified in the construction specification.

Any steel member or component which is not clearly identifiable shall be classed as unidentified steel and shall be treated in accordance with Clause 13.3.7.

6.3 HANDLING AND STORAGE

Members, components and fasteners shall be handled, stacked and stored in accordance with the relevant manufacturer's instructions in such a way that damage and permanent deformation is not caused to them during preparation, fabrication and assembly.

Storage, handling and transport of painted steel members and components shall comply with Clause 9.9.19. Storage, handling and transport of galvanized steel members and components shall comply with Clause 9.10.10.

6.4 CUSTOMER SUPPLIED PROPERTY

Customer supplied property provided for use or incorporation into the works shall be identified, verified, protected and safeguarded.

NOTE: Customer supplied property can include components, intellectual property and personal data.

Customer supplied property shall be verified in a similar manner to purchased components (see Clause 4.6). Any customer property lost, damaged or found to be unsuitable for use shall be reported and records maintained consistent with those required in Clause 4.6.

6.5 CUTTING

6.5.1 Methods of cutting

Steel material may be cut either by a sawing, shearing, cropping, machining, thermal cutting (including laser cutting and plasma cutting) or water cutting process, unless certain processes are otherwise excluded as identified in the construction specification or elsewhere in this Standard. Particular requirements for cut edges affecting coatings and corrosion protection are detailed in Clause 6.5.4.

Shearing of steel material over 16 mm thick shall not be carried out when the item is to be galvanized and subject to tension force or bending moment inducing tension, unless the resulting item is subsequently stress relieved. Shearing of edges shall not be undertaken in areas designated as yielding regions in seismic design to AS 4100 and AS 5100.6 earthquake design categories D and E or NZS 3404.1. In such applications, any material prepared by shearing shall be sheared 3 mm oversize with the excess material subsequently removed by machining.

All such material and regions shall be suitably identified in the construction specification.

6.5.2 Roughness of cut

Any cut surface not incorporated in a weld shall have a roughness not greater than the appropriate value given in Table 6.5. Roughness shall be measured using the Centre Line Average (CLA) method specified in BS 1134.

TABLE 6.5

MAXIMUM CUT SURFACE ROUGHNESS

Loading type	Maximum roughness CLA Method µm
Static loading	25
Fatigue loading	—
Fatigue detail category ≥ 80 MPa	12
Fatigue detail category < 80 MPa	25
Yielding regions of Category 1, 2, 3 members (New Zealand only)	12

Cut surfaces exceeding these values shall be repaired by grinding until the surface complies with the required value. Any grinding marks shall be parallel to the direction of the cut.

A cut surface to be incorporated in a weld shall comply with the requirements of Clause 7.5.1.

Notches and gouges in cut surfaces, not closer than $20t$ (where t is the component thickness) to one another and not exceeding 1% of the total surface area on an otherwise satisfactory surface, shall be acceptable, provided that imperfections greater than $t/5$ (where t = component thickness), but not exceeding 2 mm in depth, are removed by machining or grinding. Imperfections outside the above limits shall be repaired by welding in accordance with the requirements of Clause 13.6.2.5, except for rail bridges where repair by welding shall not be permitted.

6.5.3 Re-entrant corners

A re-entrant corner shall be shaped notch free to a radius of at least 10 mm by drilling a hole at the corner and cutting to the hole unless stated otherwise in the construction specification for fit-up purposes. A re-entrant corner shall be free of overcut.

NOTE: A re-entrant corner is a corner in which the open angle between the cut faces is less than 180°.

6.5.4 Cut edges to be painted

Cut edges which are to be painted shall comply with the requirements of Clauses 9.8.4 and 9.8.5.

NOTE: Clause 9.8.5 also covers rolled edges.

6.6 SHAPING

6.6.1 General

All steel material shall be straightened or formed or shaped where required to the configuration specified in the construction specification by methods that will not reduce the properties of the steel material below the values used in design (as defined in the construction specification) and specified in the relevant material Standard referenced in Clause 5.3.1.

Steel material may be bent or pressed to the required shape, including the introduction of camber by either hot or cold processes.

Where steel is to be bent to strains which cause permanent deformation, the design shall be checked to ensure allowance has been made for such permanent deformation in accordance with AS 4100 or AS 5100.6, as applicable.

NOTE: AS 4100 and NZS 3404.1 address steel material selection to minimize occurrence of brittle fracture, which is affected by temperature and the degree of bending strain the material may be subjected to during fabrication. Specific limits on bending strain are provided, above which material selection may be affected. The degree of bending stain due to a forming operation may be calculated using the guidance provided in AS 4100 Supp 1.

Shaped components or members that exhibit damage, cracking, tearing or damage to the protective coating shall be classified as nonconforming to the requirements of this Clause.

6.6.2 Hot forming

For hot processes, the temperature of heated areas shall not exceed 620°C. For hot-rolled sections to AS/NZS 3679.1, and plates to AS/NZS 3678, and welded sections to AS/NZS 3679.2, heating should be in the temperature range 580°C to 620°C.

NOTE: Heating hollow section members complying with AS/NZS 1163 above 620°C may adversely affect the material properties.

For quenched and tempered steel to AS 3597, the temperature during heating shall not exceed 570°C, or 30°C below the tempering temperature of the steel, whichever is lower.

Bending and forming in the blue heat range (250°C to 380°C) is not permitted.

6.6.3 Flame straightening

If distortion is to be corrected by flame straightening, this shall be undertaken by local application of heat, ensuring that the maximum steel temperature and cooling procedure are controlled. Maximum steel temperatures shall comply with Clause 6.6.2.

6.6.4 Cold forming

For cold bending of plate to AS/NZS 3678, minimum radii shall conform to the requirements of AS/NZS 3678. For cold bending of rolled sections to AS/NZS 3679.1, minimum radii shall conform to the requirements of AS/NZS 3679.1.

Members distorted by welding shall be straightened by mechanical means, by application of a limited amount of localized heat or by a combination of both methods.

6.6.5 Straightening, curving and cambering of fracture critical members (New Zealand only)

For fracture critical members (FCMs) in bridges mechanical cold working shall not be used. The temperature of heated areas shall not exceed 600°C. Finished FCMs constructed of as-rolled and normalized steels may be heated to produce slight reductions in excessive camber or to produce a curvature equivalent to a circular radius not less than 300 m.

NOTE: For FCMs in bridges, the use of heat above 600°C to assist working is prohibited, to further minimize the risk of such effects occurring and initiating fatigue crack development.

6.7 HOLING

6.7.1 Holing methods

A circular hole shall be either machine cut, or drilled full size, or punched full size or subpunched 3 mm undersize and reamed to size. Allowable cutting processes are defined in general in Clause 6.5.1.

Hand flame cutting of a bolt hole shall not be permitted except as a site rectification measure for holes in column base plates.

The holing requirements related to construction categories are as follows:

(a) For CC1 and CC2, a punched hole shall only be permitted in steel material whose yield stress (f_y) does not exceed 360 MPa and whose thickness does not exceed ($5600/f_y$) mm. Otherwise, punching shall be restricted to subpunching 3 mm undersize followed by reaming.

(b) For CC3 and CC4, punching shall be restricted to subpunching 3 mm undersize followed by reaming.

For New Zealand only, refer also to Clause 6.13 for holing requirements for yielding regions.

A slotted hole shall be either machine cut, or punched in one operation, or formed by drilling two adjacent holes and completed by hand cutting between the holes and subsequent grinding of the length of the hand cut.

All holes shall be free from burrs and rough edges.

Where holes are drilled in one operation through elements clamped together, which would not otherwise be separated after drilling, the elements need not be separated in order to remove burrs.

In areas designated as yielding regions in seismic design to AS 4100 or AS 5100.6 earthquake design categories D and E, fastener holes shall not be punched full sized. If punched, holes shall be punched undersize and reamed or drilled to remove all sheared surfaces.

All cutting shall conform to the requirements of Clause 6.5.1.

6.7.2 Circular hole diameters

For steel members designed to AS 4100, AS 5100.6 or NZS 3404.1, the nominal diameter of a completed bolt hole other than a hole in a base plate shall be 2 mm larger than the nominal bolt diameter for a bolt not exceeding 24 mm in diameter, and not more than 3 mm larger for a bolt exceeding 24 mm in diameter. For a hole in a base plate, the hole shall not be more than 6 mm greater than the anchor bolt diameter. A special plate washer of minimum thickness 4 mm shall be used under the nut if the hole diameter is 3 mm or larger than the anchor bolt diameter. The plate washer shall completely cover the hole such that the minimum distance from the edge of the hole to the edge of the plate washer shall be 0.5 times the hole's diameter.

NOTE: The hole diameter for baseplates intended to be used with mechanical or chemical anchors is given in SA TS 101.

For steel members designed to AS/NZS 4600, the nominal diameter of a completed bolt hole shall be 1 mm larger than the nominal bolt diameter for a bolt not exceeding 12 mm in diameter, and not more than 2 mm larger for a bolt exceeding 12 mm in diameter.

6.7.3 Oversize and slotted hole sizes

For steel members designed to AS 4100, AS 5100.6 or NZS 3404.1, an oversize hole shall not exceed $1.25d_f$ or $(d_f + 8)$ mm in diameter, whichever is the greater, where d_f is the nominal bolt diameter in millimetres.

For steel members designed to AS 4100, AS 5100.6 or NZS 3404.1, a short-slotted hole shall not exceed the diameter, in millimetres, specified in Clause 6.7.2 in width and $1.33(d_f + 10)$ in length, whichever is the greater.

For steel members designed to AS 4100, AS 5100.6 or NZS 3404.1, long-slotted hole shall not exceed the diameter specified in Clause 6.7.2 in width and 2.5 d_f in length, where the length of the slotted hole is taken as the total length from one hole edge to another edge along the longest dimension.

For steel members designed to AS/NZS 4600, the dimensions of oversize holes, short-slotted holes and long-slotted holes shall comply with AS/NZS 4600.

6.7.4 Limitations on use of oversize and slotted holes

The use of an oversize or slotted hole shall be limited so that the following requirements are satisfied:

(a) *Oversize hole* An oversize hole may be used in any or all plies of bearing-type or friction-type tensioned connections, provided hardened or plate washers are installed over the oversize holes under both the bolt head and the nut. The plate washer shall completely cover the hole such that the minimum distance from the edge of the hole to the edge of the plate washer shall be 0.5 times the hole's diameter.

(b) *Short-slotted hole* A short-slotted hole may be used in any or all plies of bearing-type or friction-type tensioned connections, provided hardened or plate washers are installed over the short-slotted holes under both the bolt head and the nut. The plate washer shall completely cover the hole such that the minimum distance from the edge of the hole to the edge of the plate washer shall be 0.5 times the hole's diameter.

(c) *Long-slotted hole* A long-slotted hole may be used only in alternate plies of bearing-type or friction-type tensioned connections, provided a plate washer not less than 8 mm thick is installed to completely cover the long-slotted hole under both the bolt head and the nut. The plate washer shall completely cover the hole such that the minimum distance from the edge of the hole to the edge of the plate washer shall be 0.5 times the hole's diameter.

Slotting of holes shall only be performed where indicated by the construction specification. Approval shall be sought where slotting of holes is required and not indicated in the construction specification.

NOTE: The construction specification should state which connections are friction-type and which are bearing-type. Where not stated, clarification should be sought. The use of short- and long-slotted holes is also restricted by the direction of loading in AS 4100 and AS 5100.6 and the construction specification should make it clear that the holes can be slotted and in which direction the slots may run.

6.7.5 Countersinking

Countersinking shall be carried out by drilling after holing is completed. The nominal depth of countersinking shall be at least 2 mm less than the nominal thickness of the outer ply.

Countersinking shall be such that the bolt or screw shall be flush with the outer face of the outer ply when installed.

6.7.6 Holes for pin connections

Holes for pin connections shall be bored smooth, straight and true to gauge at right-angles to the axis of the member.

Pins and holes at pinned connections shall be finished as required in the construction specification.

6.7.7 Weld access holes

The location and extent of weld access holes shall be subject to approval by a competent person. Where required, weld access holes shall have a length from the toe of the weld preparation not less than 1.5 times the thickness of the material in which the hole is made. The height of the access hole shall be not less than 1.5 times the thickness of the material, and not less than 25 mm nor greater than 50 mm. Cut surfaces of the access hole shall comply with Clause 6.5.2. No arc of the weld access hole shall have a radius less than 10 mm.

6.8 FULL CONTACT BEARING SURFACES

Full contact bearing surfaces shall be identified in the construction specification.

Full contact bearing surfaces in splices, at base plates and other connections shall be produced by either cold saw cutting or by machining.

The full contact bearing surfaces at such connections shall be such that, when the ends of the two members are abutted and the members comply with the alignment tolerances of Appendix F, the alignment of the members and the gap shall be within the following tolerances:

(a) The maximum clearance between the abutting surfaces shall not exceed 1 mm.

(b) The clearance shall not exceed 0.5 mm over at least 67% of the contact area.

6.9 ASSEMBLY

Assembly of components into fabricated items shall be executed in a manner such that the relevant fabrication and erection tolerances of Appendix F and the requirements of this Section are complied with.

All connections for temporary elements required for the fabrication process shall meet the requirements of this Section and Sections 7 and 8 and any special requirements in the construction specification. Repairs at locations of temporary attachments after their removal shall be carried out in accordance with Clause 7.5.6.

Any requirements for camber or pre-set in members shall be identified in the construction specification.

6.10 ASSEMBLY CHECK

The fit between fabricated members and components at more complex connection interfaces shall be checked and documented before dispatch to the site using either templates or accurate measurements or trial assembly or the method specified in the construction specification. Where required, trial assembly shall involve putting together (including bolting where required) sufficient fabricated members and components of the structure to check that a correct fit is achievable on-site.

6.11 TRANSIT TO SITE

All fabricated members and components shall be protected from damage in transit before they leave the fabrication shop. Particular care shall be taken to temporarily stiffen free ends, prevent permanent distortion during transit, and adequately protect all surfaces prepared for full contact connections. Means shall be provided to minimize damage to the corrosion protection on the steelwork. See Clause 9.9.19 for painted assemblies and Clause 9.10.10 for galvanized assemblies.

All nuts, bolts, washers, screws, small connection plates and steel articles generally shall be packed in containers and identified.

6.12 SUPERVISION

For CC2, CC3 and CC4, cutting, holing, shaping and assembly shall be supervised by a competent person.

NOTE: An example of suitable qualification would be a relevant trade qualification and 10 years' experience in the relevant trade.

6.13 REQUIREMENTS FOR YIELDING REGIONS (NEW ZEALAND ONLY)

6.13.1 Holing

All punched bolt holes in designated yielding regions of category 1, 2 and 3 members for seismic applications shall be punched 3 mm undersize and reamed to final size.

For railway bridges, holes shall not be machine flame-cut full size or punched full size on any members.

6.13.2 Roughness of cutting

Any cut surface not incorporated in a weld in yielding regions of Category 1, 2 or 3 members shall have a maximum roughness (CLA) of 12 μm.

A cut surface to be incorporated in a weld shall comply with AS/NZS 1554.1.

6.13.3 Transition of width and thickness

Members subject to earthquake loads or effects shall comply with the following:

(a) Transitions in thickness of members shall be undertaken in accordance with the requirements of AS/NZS 1554.1 for non-yielding regions in any category of member or for yielding regions in category 3 members.

(b) For yielding regions in category 1 or 2 members, the requirements of AS/NZS 1554.1 shall also apply, except that the thickness transition slope shall not exceed 1:2.5, where the former dimension is perpendicular to the line of applied force and the latter dimension is parallel to the line of applied force.

(c) An abrupt transition of width is permitted where it occurs outside a yielding region.

SECTION 7 WELDING

7.1 GENERAL

7.1.1 Quality requirements

Welding shall be carried out and managed under a suitable quality management system (QMS).

NOTE: An example of a suitable quality management system would be the relevant part of AS/NZS ISO 3834 or other Standards that provide equivalent technical conditions and be related to the construction category as set out below.

The following are recommended to apply to the construction categories:

(a) CC1: AS/NZS 1554 or AS/NZS ISO 3834.4 ‘Elementary quality requirements’.

(b) CC2: AS/NZS ISO 3834.3 ‘Standard quality requirements’.

(c) CC3 and CC4: AS/NZS ISO 3834.2 ‘Comprehensive quality requirements’.

NOTES:

1 For CC1, fabricators complying with AS/NZS ISO 3834.4 should note that the normative requirements of the relevant part of AS/NZS 1554 exceed those of AS/NZS ISO 3834.4.

2 Guidelines for the implementation of a QMS in accordance with AS/NZS ISO 3834 for fusion welding of steel may be found in ISO/TR 3834-6.

7.1.2 Welding requirements

The welding of structural steels shall comply with all the requirements of the relevant Part of AS/NZS 1554 as follows:

Part 1: Welding of steel structures
Part 2: Stud welding (steel studs to steel)
Part 4: Welding of high strength quenched and tempered steels
Part 5: Welding of steel structures subject to high levels of fatigue loading
Part 7: Welding of sheet steel structures

The welding of structural steels shall also comply with any additional requirements contained in the construction specification and this Standard.

7.1.3 Requirements of construction specification

Before any welding commences, the construction specification shall be checked for consistency with Clause 4.1 and, in particular, the following information relevant to welding is contained therein, and is shown within the shop detail drawing set:

(a) Weld category for each weld.

(b) Weld size for each weld.

(c) Weld type (butt, fillet, lap, partial penetration, etc.) for each weld.

(d) Extent of each weld.

(e) Extent of non-destructive examination required for each weld.

(f) Construction category (for each weld if different between welds).

7.2 WELDING PLAN

7.2.1 Requirements for a welding plan

A welding plan should be provided as part of the production planning process (see Table 7.4).

7.2.2 Content of a welding plan

For CC2, CC3 and CC4 or where required in the construction specification, the welding plan shall include as relevant—

(a) the welding procedure specifications including welding consumable, any preheating, interpass temperature and post weld heat treatment requirements;

(b) measures to be taken to avoid distortion during and after welding;

(c) the sequence of welding with any restrictions or acceptable locations for start and stop positions, including intermediate stop and start positions where joint geometry is such that welding cannot be executed continuously;

NOTE: Guidance for joints of hollow sections is given in AS/NZS 1554.1.

(d) requirements for intermediate checking;

(e) turning of components in the welding process, in connection with the sequence of welding;

(f) details of restraints to be applied;

(g) measures to be taken to avoid lamellar tearing;

(h) special equipment for welding consumables (low hydrogen, conditioning, etc.);

(i) weld category (GP, SP, FP) and associated acceptance criteria for the welds including any specified in the construction specification in accordance with Clause 7.6;

(j) cross reference to the requirements of the inspection and test plan (see Clause 13.6);

(k) requirements for weld identification;

(l) requirements for surface treatment in accordance with Section 9; and

(m) requirements for welding through coatings.

If welding or assembly overlaps or masks previous welds special consideration is needed concerning which welds are to be executed first and the possible need to inspect/test a weld before the second weld is executed or before masking components are assembled.

Welding requirements related to fatigue or seismic detail categories shall be included in the construction specification.

7.3 WELDING PROCESSES

Welding may be performed by any of the welding processes permitted by the relevant Part of the AS/NZS 1554 series of Standards (see Clause 7.1.2), as appropriate.

Other welding processes shall only be used if permitted by the construction specification.

7.4 QUALIFICATION OF WELDING PROCEDURES AND WELDING PERSONNEL

7.4.1 Qualification of welding procedures

7.4.1.1 *General*

Welding shall be carried out using qualified procedures using a welding procedure specification (WPS) complying with the relevant provisions in the application Standard (see Clause 7.1.2) and Clause 7.2.

If specified, special deposition conditions for tack welds shall be included in the WPS (see also Clause 7.5.7). For joints in hollow section lattice structures the WPS shall define the start and stop zones and the method to be used in order to cope with locations where the welds change from a fillet weld to butt around a joint.

If impact tests, as defined in the relevant Part of the AS/NZS 1554 series of Standards cited in Clause 7.1.2, are specified in the construction specification or the WPS, such tests shall be carried out at the lowest of—

(a) the design service temperature;

(b) the actual test temperature specified in the construction specification; or

(c) the lowest temperature for which the relevant Standard for the steel grade involved requires impact properties.

If welding on shop primers, weld qualification tests shall be carried out using the maximum (nominal + tolerance) accepted film thickness.

For welding processes not included in a Part of the AS/NZS 1554 series of Standards, the qualification of the welding procedure shall be in accordance with Table 7.4

7.4.1.2 *Validity of a welding procedure qualification*

The validity of a welding procedure depends on the requirements of the Standard used for the qualification.

The extension of qualification and any required requalification due to a change in an essential variable of any welding procedure shall be that specified in the relevant Standard.

If specified in the construction specification, for CC3 and CC4 production tests shall be carried out in accordance with the provisions of the construction specification.

For CC3 and CC4, weld procedure traceability is required.

7.4.2 Qualification of welders

For CC1 and CC2, welders shall be qualified in accordance with the requirements of the application Standard (see Clause 7.1.2, as appropriate).

For CC3 and CC4, welders shall be qualified in accordance with the requirements of AS/NZS 2980 or ISO 9606-1.

For CC3 and CC4, identification and traceability of welders is required.

The role of the examiner or examining body shall be fulfilled by the welding coordinator unless otherwise specified in the construction specification.

Records of all welder qualification tests shall be available for perusal by the welding inspector (see Section 13).

7.4.3 Welding coordination

For all construction categories, welding coordination shall be maintained during the execution of welding by welding coordination personnel suitably qualified for, and experienced in the welding operations they supervise (see Table 7.4).

With respect to the welding operations being supervised, welding coordination personnel shall have technical knowledge of the welding processes and equipment, materials and their behaviour during welding.

NOTE: Guidance on the minimum technical knowledge of welding required in order to provide adequate supervision is provided in AS 2214 and ISO 14731.

TABLE 7.4

TECHNICAL REQUIREMENTS RELATED TO CONSTRUCTION CATEGORY (STRUCTURAL STEELS)

Description	Construction category			
	CC1	CC2	CC3	CC4
Quality	Clause 7.1.1	Clause 7.1.1	Clause 7.1.1	Clause 7.1.1
Qualification of weld procedures	AS/NZS 1554	AS/NZS 1554	AS/NZS 1554	AS/NZS 1554
Weld category	GP	GP, SP	GP, SP, FP	GP, SP, FP
Welder qualifications	AS/NZS 1554	AS/NZS 1554	AS/NZS 2980	AS/NZS 2980
Welding supervisor or coordinator qualifications	AS/NZS 1554	AS/NZS 1554	ISO 14731	ISO 14731
Identification and traceability of welders	Not specified	Not specified	Required	Required
Traceability of weld procedures	Not specified	Not specified	Required	Required

NOTES:

1 Fabricators complying with AS/NZS ISO 3834.2 and AS/NZS ISO 3834.3 should note that welders should be qualified to AS/NZS 2980. Compliance with ISO 9606-1 is also acceptable (see also Clause 7.4.2).

2 For CC2, the competence of the welding supervisor (or welding coordinator) without formal qualifications to supervise or coordinate work undertaken by the fabricator should be assessed by professional interview.

3 For CC3, depending on work undertaken by the fabricator, the welding supervisor or coordinator may require specific technical knowledge (Clause 7.4.3). The construction specification should specify any additional requirements.

4 When welding steels from steel groups 8Q to 12Q (see AS/NZS 1554.4), welding supervisors and coordinators are recommended to have specific technical knowledge on the welding of quench and tempered steels.

5 Identification and traceability of welds and welders to individual welds is required when specified by either the quality plan or within the contract documents. Identification of the welder can be by welder ID stamps or weld map. Stamping shall not be used on welds subject to high levels of dynamic loading or fatigue.

6 For CC3 and CC4, examples of qualifications that would satisfy the requirements of ISO 14731 for the purposes of this Standard include:

(a) *Basic knowledge*—qualifications compliant with AS 2214, AS 1796 certificate 10, New Zealand Institute of Welding Supervisors Certificate, International Institute of Welding qualifications at the level of International Welding Specialist (IWS).

(b) *Specific knowledge*—New Zealand Institute of Welding certificate in Welding Engineering, International Institute of Welding qualifications at the level of International Welding Technologist (IWT).

(c) *Comprehensive knowledge*—International Institute of Welding qualifications at the level of International Welding Engineer (IWE).

7.5 PREPARATION AND EXECUTION OF WELDING

7.5.1 Joint preparation

7.5.1.1 *General*

Joint preparation shall be appropriate for the welding process being used and shall be identical to the type of preparation used in the relevant welding procedure test.

Tolerances for joint preparations and fit-up shall comply with the workmanship requirements of the application Standard (see Clause 7.1.2, as appropriate).

The joint preparation shall be uniform and free from fins, tears, cracks and other defects that would adversely affect the quality or strength of the weld.

If large notches or other errors in joint preparation or joint geometry are corrected by welding, a qualified welding procedure shall be used and the area shall be subsequently ground smooth and blended into the adjacent surface. All surfaces to be welded and surfaces adjacent to the weld shall be dry and free from material that would adversely affect the quality of the welds or impede the process of welding (e.g. rust, grease paint organic material, galvanizing, etc.). Mill scale that withstands vigorous hand wire brushing or power wire brushing, rust-inhibiting coatings and anti-spatter compounds that do not interfere with weld quality or the welding process itself may remain.

Prefabrication primers (shop primers) may be left on the fusion faces only if they do not adversely affect the weld quality or the welding process. They shall not be left on fusion faces unless the welding procedure tests were completed with the weld-through primer in place.

7.5.1.2 *Hollow sections*

For circular hollow sections being used as branch components in fillet welded joints, the fit-up of the joint geometry shall suit the requirements of the WPS.

For branch connections in hollow section trusses, any adjustment for lack of fit by a welded surface deposit shall be in accordance with a suitable welding procedure.

7.5.2 Storage and handling of welding consumables

7.5.2.1 *General*

Welding consumables shall be stored, handled and used in accordance with the manufacturer's specifications. See also Clause 7.5.2.2.

After consumables have been removed from their original packages, they shall be protected or stored in accordance with the manufacturer's specifications so that their specified properties and welding characteristics are not adversely affected.

Consumables that have not been stored in dry conditions, kept free from rust, oil, grease or other foreign materials shall be discarded.

Welding consumables showing signs of damage or deterioration shall be discarded.

NOTE: Examples of damage or deterioration include cracked or flaked coatings on covered electrodes, rusty or dirty electrode wires and electrode wires with flaked or damaged copper coatings.

7.5.2.2 *Electrodes and fluxes with specific controlled hydrogen properties*

Coated electrodes and fluxes with specific controlled hydrogen properties shall be stored in accordance with the manufacturer's specifications.

If no manufacturer's specifications are available, then welding consumables shall be reconditioned in accordance with WTIA Technical Note 3.

Immediately after being removed from their original packages, coated electrodes shall be stored in ovens in accordance with the manufacturer's specifications.

If the original packaging shows evidence of damage, electrodes shall be redried in accordance with the manufacturer's specifications.

Consumables remaining unused at the end of the welding shift shall be redried in accordance with the manufacturer's specifications.

7.5.3 Weather protection

The welder, the consumables and the working area shall be adequately protected against the effects of wind, rain and snow.

Welding processes requiring an external gas shield shall not be carried out in a draught or wind with a wind speed of more than 10 km/h, unless the welding area is suitable shielded so as to reduce wind speed below 10 km/h, or unless the welding procedure including wind at the actual wind speed or higher is qualified in accordance with Clause 7.4.

Surfaces to be welded shall be maintained dry and free from condensation.

When the base metal temperature is below 0°C, the base metal shall be preheated to at least the higher of 10°C or the specified minimum preheat temperature shown on the WPS, and this minimum temperature maintained during welding.

Welding and thermal cutting shall not be carried out when the metal temperature is colder than 0°C unless the welding procedure is qualified in accordance with Clause 7.4 for the actual metal temperature below the value of 0°C.

7.5.4 Assembly for welding

Assembly shall be in accordance with the relevant clause in the application Standard cited in Clause 7.1.2, as appropriate.

The alignment of parts to be welded shall be made having regard to the normal tolerances associated with the fabrication and erection procedures to be used. Ends of parts that are to be joined shall be aligned consistent with the requirements of the welding procedure being employed. Suitable allowances shall be made for distortion and shrinkage such that the relevant fabrication tolerances in Appendix F are complied with for the fabricated assembly.

The components to be welded shall be assembled and held in position such that joints to be welded are readily accessible and easily visible to the welder.

Additional welds shall not be introduced and the location of specified welds shall not be changed from what is specified in the construction specification.

Changes to the welding details or additional welds than originally shown on the fabrication drawing shall be approved prior to welding.

7.5.5 Preheating

The need for preheating shall be determined in accordance with the relevant clause in the relevant Part of the AS/NZS 1554 series, as appropriate, and shall be carried out in accordance with AS ISO 13916.

Preheating shall be undertaken in accordance with the applicable WPS and shall be applied during welding, including tack welding and the welding of temporary attachments.

7.5.6 Temporary attachments

If the assembly or erection procedure requires the use of components temporarily attached by welds, they shall be positioned such that they can easily be removed without damage to the permanent steelwork. All welds for temporary attachments shall be made in accordance with an established WPS. Any areas where welding of temporary attachments is not permitted shall be specified in the construction specification.

Temporary attachments shall not be placed in areas not permitted in the construction specification for CC2, CC3 and CC4. Where temporary attachments are permitted in the construction specification, they shall comply with the requirements of the relevant clause in the relevant Part of the AS/NZS 1554 series, as appropriate.

Welds joining temporary attachments to the steel structure shall be made to the same standards as final welds. All temporary attachments shall be removed unless otherwise specified in the construction specification. Temporary welds and attachments shall not be allowed on the tension flanges of beams, girders and similar members.

When temporary welds or attachments are removed, the surface at the location shall be—

(a) reinstated to a reasonably smooth condition by grinding or a combination of welding and grinding;

(b) checked by magnetic particle examination or other suitable method in order to ensure soundness; and

(c) finished to the requirements of the relevant clause in the relevant Part of the AS/NZS 1554 series.

After removal of the temporary attachment, removal of the weld metal or portions of the base metal shall be effected by machining, grinding, chipping, oxygen gouging, air-arc-gouging or plasma gouging in such a manner that the remaining weld metal or base metal is not nicked or undercut and so that the surface of the parent metal can subsequently be carefully ground smooth. Unacceptable portions of the weld shall be removed without substantial removal of the parent metal. The surfaces shall be cleaned thoroughly before welding.

Oxygen-gouged and air-arc-gouged surfaces shall be cleaned by grinding or machining in order to remove all carbon absorption or contamination.

NOTE: The relevant parts of AS/NZS 1554 have limits on the depth of grinding allowed.

7.5.7 Tack welds

For CC2, CC3 and CC4, tack welds shall be made using a qualified welding procedure and comply with the requirements of the relevant clause in the relevant Part of the AS/NZS 1554 series of Standards (see Clause 7.1.2).

All tack welds not incorporated into the final weld shall be removed. Tack welds that are to be incorporated into the final weld shall have a suitable shape and be carried out by qualified welders. Tack welds shall be free from deposition faults and shall be cleaned thoroughly before final welding. Cracked tack welds shall be removed.

7.5.8 Fillet welds

Fillet welds shall comply with the relevant clause of the relevant Part of the AS/NZS 1554 series cited in Clause 7.1.2, as appropriate.

The size of a fillet weld shall be the leg length as defined in AS 2812. The fillet weld size as deposited shall not be less than the specified leg length. Where there is a root gap, the size shall be given by the lengths of the legs of the inscribed triangle reduced by the root gap amount, in accordance with the relevant clause of the relevant Part of the AS/NZS 1554 series.

7.5.9 Butt welds

7.5.9.1 *General*

The construction specification (shop drawings) shall specify the location of butt welds used as splices to accommodate available lengths of constituent products.

Butt welds shall comply with the relevant clause of the relevant Part of the AS/NZS 1554 series, as appropriate.

The ends of butt welds shall be terminated in a manner that ensures sound welds with full throat thickness.

When specified in the construction specification, run-on/run-off tabs shall be used to ensure full throat thickness at the ends. The weldability of the run-on/run-off tabs shall not be less than that of the parent metal.

After completion of the welds, any run-on/run-off tabs or other supplementary material shall be removed and their removal shall comply with Clause 7.5.6.

If a flush surface is specified, the excess weld metal shall be removed to satisfy the quality requirements (see also Clause 7.5.6).

7.5.9.2 *Single sided welds*

Complete penetration welds welded from one side may be produced with or without metallic or non-metallic backing material.

Unless otherwise specified in the construction specification, permanent steel backing material may be used. The requirements for its use shall be included in the WPS.

If steel backing is used, it shall have a weldability not less than that of the parent metal to be joined by the weld.

Backing materials shall be fitted tightly to the parent metal and should generally be continuous for the full length of the joint. For CC3 and CC4, permanent backing metal shall be made continuous by means of complete penetration butt welds. Tack welds shall be included in the butt welds.

Flush grinding of single-sided butt welds in joints between hollow sections executed without backing is not permitted, unless otherwise specified. If those welds are fully backed they may be ground off flush with the general surface profile of the parent metal.

7.5.9.3 *Back gouging*

Back gouging shall comply with the requirements of the relevant clause in the relevant Part of the AS/NZS 1554 series, as appropriate.

Back gouging shall be carried out to a sufficient depth to ensure full penetration into the previously deposited weld metal.

Back gouging shall produce a contour of a single U-shaped groove and a have a root radius of not less than 5 mm with its fusion faces readily accessible to allow the welder reasonable access to reinstate the weld.

7.5.10 Welds on weathering steel

Welds on weathering steel shall be carried out using appropriate welding consumables as specified in either AS/NZS 1554.1 or AS/NZS 1554.5 as appropriate.

When C-Mn consumables are used for the body of a multi-run fillet or butt weld, consideration shall be given to the atmospheric resistance of the exposed ends of multi-pass welds after removal runon/run-off pieces.

7.5.11 Stud welding

Stud welding of steel studs to steel shall be carried out in accordance with AS/NZS 1554.2. Stud welding operators shall be qualified to AS/NZS 1554.2 for all construction categories.

7.5.12 Seal, slot and plug welds

Seal, slot and plug welds shall comply with the relevant clause of the relevant Part of the AS/NZS 1554 series, as appropriate.

7.5.13 Arc spot welds for light gauge components

Arc spot welds used to weld sheet steel to thicker supporting members shall be in accordance with AS/NZS 1554.7. Arc spot welds shall not be made where the thinnest connected steel material is greater than 3 mm thick, nor through a combination of steel sheets having a total thickness greater than 3 mm.

Weld washers shall have a thickness of between 1 mm and 2 mm with a pre-punched hole of 10 mm minimum diameter.

7.5.14 Post weld heat treatment

If post-weld heat treatment of welded components is necessary or specified in the construction specification, it shall comply with the requirements of AS 4458.

7.5.15 Execution of welding

7.5.15.1 *General*

Arc strikes outside the area of permanent welds shall be avoided. If stray arc strikes do occur the surface of the steel shall be visually inspected.

Cracks or blemishes resulting from arc strikes on members, other than those members or components identified in the construction specification as not required to be so treated, shall be ground to a smooth contour and checked by magnetic particle examination.

Precautions shall be taken to avoid weld spatter. Weld spatter shall be removed for CC2, CC3 and CC4.

Visible imperfections such as cracks, cavities and other imperfections shall be removed from each run before the deposition of additional runs.

NOTE: Where cracks are noticed during welding, the welding process should be stopped and the reason for cracking investigated.

All slag shall be removed from the surface of the finished weld. Particular attention shall be paid to the junction between the finished weld and the parent metal.

Cleaning of finished welds shall comply with the appropriate clause in the relevant Part of the AS/NZS 1554 series, as appropriate.

Dressing of finished butt welds shall comply with the appropriate clause in the relevant Part of the AS/NZS 1554 series, as appropriate. Any dressing in addition to these requirements shall be specified in the construction specification.

7.5.15.2 *Welds on steel to be painted or galvanized*

Welds on steelwork to be subsequently painted or galvanized shall also comply with the requirements of Clauses 9.8.2 and 9.8.4 in addition to the requirements of Clause 7.6.

NOTE: The use of anti-spatter sprays and compounds should be avoided on steelwork to be painted or galvanized unless it can be established that such use does not interfere with coating adhesion.

7.5.15.3 *Welds on architecturally exposed structural steelwork*

Welds on steelwork identified in the construction specification as architecturally exposed structural steelwork (AESS) shall also comply with the requirements of Section 10 in addition to the requirements of this Section.

7.5.16 Welding of continuity stiffeners in earthquake resisting members (New Zealand only)

Corners of continuity stiffener plates placed in the webs of rolled sections with elements greater than 32 mm thick shall be clipped to avoid the k-areas (see Figure 7.5.16) as follows. Along the web, the clip shall extend a distance of 35 mm beyond the tangent of the web-to-flange radius. Along the flange, the clip shall extend 12 mm beyond the tangent of the web-to-flange radius. The welds to the continuity stiffener shall be terminated 5 mm back from the clipped corners.

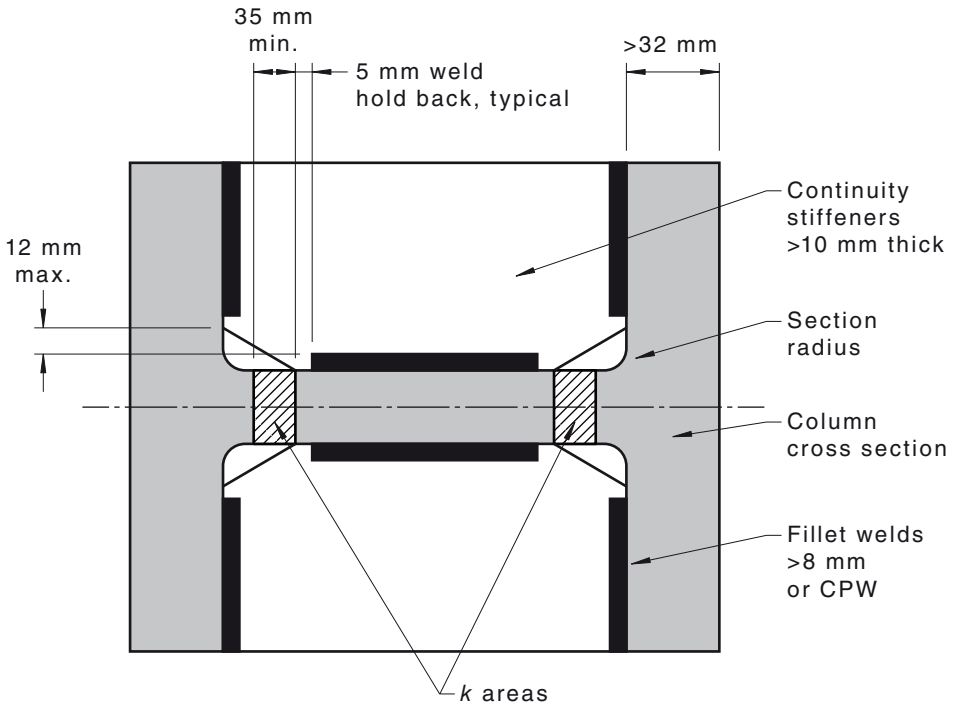


FIGURE 7.5.16 WELDING OF CONTINUITY STIFFENERS IN SEISMIC MEMBERS

7.5.17 Welds subject to earthquake loads or effects (New Zealand only)

7.5.17.1 *General*

For welds subject to earthquake loads or effects, the following shall apply:

(a) For steel types 2S, 5S, 3 and 6, the welding consumables shall have a Ships' Classification Societies Grade 3 approval as required.

(b) The heat input in a run of deposited weld metal shall not exceed 2.5 kJ/mm.

7.5.17.2 *Removable weld backing (New Zealand only)*

In the situation where removable weld backing was used for beam flange to column weld, a reinforcing fillet weld with a minimum of 6 mm leg should be welded on the column flange. The fillet weld size should be such to completely cover the weld root area. The fillet weld may have unequal leg sizes, with the horizontal leg being larger.

7.5.17.3 *Permanent steel backing (New Zealand only)*

In situations where backing is permitted to remain, the backing bar should be welded to the column with continuous fillet weld as shown in the Figure 7.5.17. No weld should be placed at the interface of the backing and column flange.

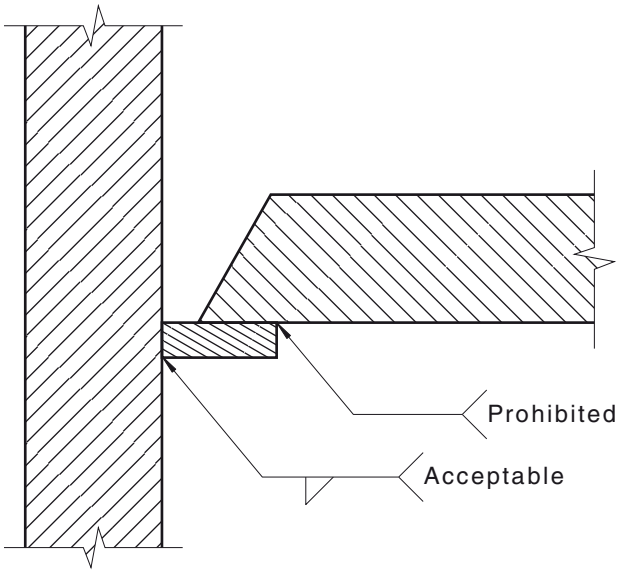


FIGURE 7.5.17 WELDED CONNECTION FOR BEAM FLANGE TO COLUMN WITH PERMANENT STEEL BACKING.

7.6 ACCEPTANCE CRITERIA

7.6.1 Routine requirements

Welded components shall comply with the requirements specified in the relevant Part of the AS/NZS 1554 series, as appropriate, unless specified otherwise in the construction specification.

In the case of a nonconformity with the requirements of this Standard, each weld defect shall be assessed in accordance with the appropriate clause in the relevant Part of the AS/NZS 1554 series cited in Clause 7.1.2, as appropriate, unless specified otherwise in the construction specification. The evaluation should be based on the function of the component in which the defect occurs and on the characteristics of the imperfection (type, size, location) in deciding if the weld is to be accepted or repaired.

Where it can be demonstrated by the use of fracture mechanics or other suitable method of assessment, that a specific defect will not be injurious to the performance of the structure, that specific defect need not be repaired or re-welded, provided that for that specific defect, such methods are acceptable to the principal and the fabricator.

NOTE: WTIA Technical Note 10 gives guidance on the use of fracture mechanics analyses in the assessment of the effects of imperfections. WTIA Technical Note 10 or BS 7910 may be used to evaluate the acceptability of imperfections.

Repaired welds shall be reinspected to the same level as that specified for the original weld.

7.6.2 Seismic requirements

For Australia only, unless otherwise specified, the routine requirements given in Clause 7.6.1 shall apply to welds subject to seismic actions.

For New Zealand only, the requirements of Appendix I should also apply to welds subject to seismic actions.

7.6.3 Fatigue requirements

For welds subject to dynamic loading where category SP is selected (see AS/NZS 1554.1 and AS/NZS 1554.4 as appropriate), the routine requirements of Clause 7.6.1 shall apply.

For welds subject to high levels of dynamic loading where category FP is selected, the routine requirements of Clause 7.6.1 and the additional requirements of AS/NZS 1554.5 and AS/NZS 1554.4 (as appropriate) shall apply.

The construction specification shall specify any additional execution requirements that are necessary to comply with the assumptions of design for fatigue resistance.

7.6.4 Welding dissimilar steels

The welding coordinator shall take into account the appropriate welding techniques, welding processes and welding consumables. Issues associated with contamination and galvanic corrosion should be considered carefully.

SECTION 8 MECHANICAL FASTENING

8.1 GENERAL

8.1.1 Application

This Section specifies the requirements for the installation of mechanical fasteners specified in Clauses 5.5 and 5.6 in both the fabrication shop and during erection on-site.

8.1.2 Quality management system

The operations detailed in this Section shall be managed under a suitable quality management system.

NOTES:

1 An example of a suitable quality management system is set out in AS/NZS ISO 9001.

2 The level of documentation will generally increase with the construction category from CC1 to CC4. Guidance on the elements of a suitable quality management system aligned with the requirements of the construction categories is provided in Appendix D.

Quality documentation requirements are set out in Clause 4.5.1.

8.1.3 Work method statements

A documented work method statement (WMS) shall be prepared for each operation covered by this Section and for each stage of the work before any work is undertaken. The work method statement shall be made available to all relevant personnel involved in the works.

8.1.4 Architecturally exposed structural steelwork

Steelwork identified in the construction specification as ‘Architecturally Exposed Structural Steelwork (AESS)’ shall comply with the requirements of Section 10 in addition to the requirements of this Section.

8.2 BOLTS, NUTS AND WASHERS

8.2.1 General

All material within the grip of the fastener shall be steel and no compressible material shall be permitted within the grip.

NOTE: This does not include load indicating washers.

The final gap between plies (after snug tightening but before any tensioning) shall be as follows:

(a) For snug tight connections, less than or equal to 2 mm.

(b) For tensioned connections, less than or equal to 1 mm.

Where required, steel packer plates or shims shall be a minimum thickness of 2 mm. This requirement shall also apply to local dishing of end plates where tapered shims may be required. A maximum of three packer plates or shims shall be used. Smaller gaps should be considered for packing or shimming where severe corrosion is likely to occur.

NOTE: AS/NZS 2312.1 and AS/NZS 2312.2 contain guidance on classification of corrosion environments and corrosion protection using paint systems and galvanizing respectively.

Packer plates, where required, shall meet the requirements of Clause 11.5.7. Coatings of all components of an assembly shall be compatible and have similar corrosion resistance. Full consideration shall be given to the risk and implication of galvanic corrosion resulting from dissimilar metals being in contact.

Bolts and nuts shall not be welded, except for stud bolts that are stud welded to steel material in accordance with AS/NZS 1554.2.

Where bolt assemblies, comprising bolt plus nut plus washer, are supplied, the assemblies shall be kept intact until installation.

8.2.2 Bolts

The nominal diameter of a bolt used for structural bolting shall be at least M12.

The length of a bolt shall be such that at least one clear thread shows above the nut and at least one thread plus the thread run out is clear beneath the nut after snug-tightening.

For New Zealand only, the minimum number of clear thread run out beneath the nut after tensioning shall be:

(a) Five threads for a bolt length up to and including 4 diameters.

(b) Seven threads for a bolt length over 4 diameters but not exceeding 8 diameters.

(c) Ten threads for a bolt length over 8 diameters.

8.2.3 Nuts

Nuts shall run freely when part of a bolt/nut assembly and shall be checked by running the nut along the bolts threads by hand before being used in a connection.

Nuts shall be installed so that any markings required by the relevant Standard are visible for inspection after installation. The construction specification shall specify any means other than tightening (snug-tight or full tensioning) that are required in order to secure the nuts, especially for connections subject to vibration. Tensioned bolt/nut assemblies do not require additional locking devices.

All locking devices for nuts shall comply with Clause 5.5.8.

A lock nut when used shall be used together with a standard nut and installed in accordance with Clause 8.3.

8.2.4 Washers

Where uncoated steel is used, one washer shall be provided under the part (nut or bolt head) rotated during tightening.

For painted or galvanized surfaces, one washer shall be provided under the part (nut or bolt head) rotated during tightening.

NOTE: The construction specification may specify one washer to be placed under both the nut and head where it is desired to limit the potential for touch-up painting from paint damage caused by the tightening process.

Where oversize or slotted holes are used, plate washers complying with Clause 6.7.4 shall be used. Plate washers shall have similar mechanical properties to other components of the connection. Coatings of all components of an assembly shall be compatible and have similar corrosion resistance. Full consideration shall be given to the risk and implication of galvanic corrosion resulting from dissimilar metals being in contact.

One additional plate washer or up to three complying washers with a maximum total thickness of 12 mm may be used where the bolt grip and supplied bolt length requires such additional washer material. All such additional washers shall be placed under the bolt head or nut, according to which is the non-rotated element.

Where the slope of the surfaces of the parts in contact with the bolt head or nut exceeds 1:20 with respect to a plane normal to the bolt axis, a suitable tapered washer shall be provided against the tapered surface and the non-rotating part shall be placed against the tapered washer.

8.2.5 Storage

Fastener components shall be protected from dirt and moisture in closed containers at the location where the bolts are to be installed. Only the required number of fastener components to be installed shall be taken from protected storage at any one time. Fastener components not used shall be returned to protected storage. Fastener components shall not be modified from the as-delivered condition except for removal of dirt or moisture with a soft brush.

8.3 SNUG-TIGHTENING OF BOLTS

All bolt holes shall be aligned so as to permit insertion of the bolts without damage to the thread. All matching holes shall align with each other so that a drift pin equal in diameter to the bolts to be installed shall pass freely through the assembled contact faces at right angles to them. Drifting to align holes shall be done in a manner that does not distort the steel or enlarge the holes. Once each bolt is inserted, the washer and nut shall be installed to that bolt.

Snug-tightening should only be carried out by competent personnel.

Snug-tightening of the bolts in the connection should proceed systematically from the most rigid part of the connection towards the free edges. More than one cycle of snug-tightening may be required.

Re-use of snug-tightened bolts is permitted provided the threads are undamaged and the nuts run freely in accordance with Clause 8.2.3.

Where lock nuts are used together with a standard nut, the lock nut shall be the bottom nut closest to the material being connected, and should be installed first on the thread and snug-tightened before the standard nut is installed. The standard nut should then be installed and tightened so that the threads in the lock nut bear on the bolt thread. The two nuts should bear in opposite directions on the bolt thread in order to effectively jam the nuts.

8.4 PREPARATION OF CONTACT SURFACES ON CONNECTED PLIES

8.4.1 General

All oil, dirt, loose scale, loose rust, burrs, foreign material and any other defects on the surfaces to be in contact in the completed connection and which will prevent solid seating of the plies when snug-tightening is completed shall be removed. A clean ‘as rolled’ surface with tight mill scale adhering is acceptable.

Burrs less than or equal to 1.5 mm are permitted to remain on contact surfaces for all joint types. Burrs larger than 1.5 mm shall be removed by grinding or reduced to 1.5 mm or less by grinding.

Any cleaning of contact surfaces shall be in accordance with AS 1627.2.

Any applied finish for corrosion protection shall be permitted on contact surfaces, except for friction-type connections (see Clause 8.4.2).

Where the steelwork is to be painted or galvanized, refer to Clause 9.3 for overall surface preparation requirements and Clause 9.9.9 for masking requirements.

8.4.2 Friction-type connection

For a friction-type connection, the contact surfaces in the connection shall be clean ‘as rolled’ surfaces or equivalent, and in addition to satisfying Clause 8.4.1, shall be free from paint, lacquer, galvanizing or other applied finish unless the applied finish has been tested to establish the friction coefficient. The construction specification shall state if friction-type connection surfaces are to be coated and the type of coating to end of first paragraph.

NOTE: AS/NZS 2312.1 contains information on the effect of paint coating systems on the friction coefficient. Generally, all systems will require testing.

A method of testing to determine the friction coefficient of an applied coating shall be one of the following methods:

(a) The method detailed in Appendix G.

(b) The method detailed in Research Council on Structural Connections, 'Specification for Structural Joints Using High-Strength Bolts'.

(c) The method detailed in EN 1090-2.

Where an applied coating is to be kept out of the contact surface area, the coating including overspray shall be excluded from areas closer than one bolt diameter to any holes but not less than 25 mm from the edge of any hole and from all areas in the bolt group.

Galvanized contact surfaces shall be roughened by means of hand wire brushing if the testing for the friction coefficient involved roughening of the galvanized surface in order to improve the friction coefficient. The extent and degree of roughening should match that carried out in the actual testing.

NOTE: It is not necessary to completely remove hot-dip galvanized coatings in order to obtain an adequate friction coefficient. However, the testing specified above should reflect as accurately as possible the actual treatment to be given to the galvanized surface. Consideration also has to be given to the possibility of long-term slip or creep occurring. Further information is available from the Galvanizers Association of Australia or the Galvanizing Association of New Zealand.

8.5 TENSIONING OF HIGH STRENGTH BOLTS

8.5.1 Competent personnel

Tensioning of high strength bolts in accordance with this Clause shall only be undertaken by competent personnel.

8.5.2 Snug-tightening

All bolts to be tensioned shall be first tightened to the snug-tight condition, and shall comply with the requirements of Clause 8.3 for that condition.

High strength structural bolts that are to be tensioned may be used temporarily during erection in order to facilitate assembly of a connection. If so used, they shall not be fully tensioned until all the bolts in the connection have been snug-tightened in the correct sequence.

8.5.3 Tensioning pattern

Tensioning of the bolts in the connection should proceed systematically from the most rigid part of the connection towards the free edges. More than one cycle of tensioning may be required.

8.5.4 Re-tensioning

Re-tensioning of bolts, which have been fully tensioned, is not permitted except as set out below.

Re-tensioning shall only be permitted once, and only where the bolt remains in the same hole in which it was originally tensioned and with the same grip. Under no circumstances shall a bolt that has been previously tensioned in one hole be reused and tensioned in another hole.

Touching up or re-tensioning of previously tensioned bolts that have been loosened by the tensioning of adjacent bolts shall not be considered as re-tensioning and is permitted.

8.5.5 Minimum bolt tension

In the completed connection, all bolts shall have at least the minimum bolt tension specified in Table 8.5.5 when all the bolts in the connection have been tightened.

The minimum bolt tension shall be achieved using either the part-turn method of tensioning (Clause 8.5.6) or by the use of a direct-tension indication device (Clause 8.5.7).

TABLE 8.5.5

MINIMUM BOLT TENSION

Nominal diameter of bolt	Minimum bolt tension kN
M16	95
M20	145
M24	210
M30	335
M36	490

NOTE: The minimum bolt tensions given in this Table are approximately equivalent to the minimum proof loads derived from a proof load stress of 600 MPa as specified in AS 4291.1 (ISO 898-1). They are applicable for bolt assemblies to AS/NZS 1252.1 which are Grade 8.8.

8.5.6 Part-turn method of tensioning

Tensioning of bolts by the part-turn method shall be in accordance with the following procedure:

(a) After completing snug-tightening in accordance with Clause 8.3, location marks shall be established to mark the relative positions of the bolt and the nut in order to control the amount of final nut rotation. Location marks shall be permanent when required in the construction specification for later inspection, but may be temporary when not so required in the construction specification.

NOTE: Observation of the amount of final rotation of the nut may also be achieved by using marked wrench sockets.

(b) Bolts shall be tensioned by rotating the nut by the amount given in Table 8.5.6. During final tensioning, the component not turned by the wrench shall not rotate. The tightening pattern shall comply with Clause 8.5.3. Where it is impractical to turn the nut for reasons of access, tensioning by turning the bolt head is permitted provided rotation of the nut is prevented and provided that a washer is used under the bolt head.

TABLE 8.5.6

NUT ROTATION FROM THE SNUG-TIGHT CONDITION

Bolt length (underside of head to end of bolt)	Disposition of outer face of bolted parts (see Notes 1, 2, 3 and 4)		
	Both faces normal to bolt axis	One face normal to bolt axis and other sloped	Both faces sloped
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters (see Note 5)	2/3 turn	5/6 turn	1 turn

NOTES:

1 Tolerance on rotation: for 1/2 turn or less, 1/12 of a turn (30°) over and nil under tolerance; for 2/3 turn or more, 1/8 of a turn (45°) over and nil under tolerance.

2 The bolt tension achieved with the amount of nut rotation specified in Table 8.5.6 will be at least equal to the minimum bolt tension specified in Table 8.5.5.

3 Nut rotation is the rotation relative to the bolt, regardless of the component turned.

4 Nut rotations specified are only applicable to connections in which all material within the grip of the bolt is steel.

5 No research has been performed to establish the turn-of-nut procedure for bolt lengths exceeding 12 diameters. Therefore, the required rotation should be determined by actual test in a suitable tension measuring device which simulates conditions of solidly fitted steel. The 'assembly test' specified in AS/NZS 1252.1 is a suitable test.

8.5.7 Tensioning by the use of direct-tension indication device

Tensioning of bolts using a direct-tension indication device shall be in accordance with the following procedure:

(a) The suitability of the device shall be demonstrated by testing a representative sample of not less than three bolts for each diameter times bolt length combination and for each grade of bolt to be used. This testing shall be carried out in a calibration device such as a load cell which is capable of indicating bolt tension. The calibration test shall demonstrate that the device indicates a tension of not less than 1.05 times the minimum bolt tension specified in Table 8.5.5. The bolt assemblies used for testing shall be taken from the same assembly lot being used on the works.

(b) On assembly, all bolts shall be snug-tightened in accordance with Clause 8.3.

(c) The bolts shall be tensioned to provide the minimum bolt tension specified in Table 8.5.5. This shall be indicated by the tension indication device. Tensioning shall also be in accordance with the tension-indication device manufacturer's specification and should only be carried out by competent personnel.

Where compressible washer-type direct tension indicating devices are used, they shall comply with Clause 8.5.8.

8.5.8 Use of compressible washer-type direct tension indicators

Compressible washer-type direct tension indicators shall meet the requirements of ASTM F959, and their use shall comply with Clause 8.5.7. The use of alternative washer-type indicating devices that differ from those that meet the requirements of ASTM F959 is permitted, provided that detailed installation instructions are provided by the manufacturer in a supplementary installation specification and provided that the requirements of Clause 8.5.7 are fully complied with.

The compressible washer protrusions shall be compressed to the gap specified by the manufacturer. If over compression of the gap has occurred, the bolt/nut/washer assembly and the compressible washer shall be removed and a new bolt/nut/washer assembly and compressible washer installed.

Compressible washer-type indicators should generally be fitted under the bolt head when the bolt is tensioned by rotation of the nut. If limited access results in the bolt head being rotated, the washer-type indicator should be located under the nut and a nut face washer should be fitted between the washer-type indicator and the nut.

8.6 FASTENING OF THIN GAUGE COMPONENTS

Sheeting supporting members shall be installed in accordance with AS 1562.1.

Fasteners shall comply with AS 1562.1.

Installation of fasteners shall only be carried out by competent personnel.

8.7 USE OF SPECIALIZED FASTENERS AND FASTENING METHODS

Specialized fasteners may include twist-off-type tension-control bolt assemblies, swage-lock fasteners, hexagon injection bolts, blind bolts and threaded studs stud welded to supporting members.

Special fastening methods may include the use of tapped holes, adhesive bonding or clinching of plates to effect a connection using local deformations.

All specialized fasteners and fastening methods shall be fully detailed in the construction specification and shall conform to the manufacturer's specifications. Any procedure testing required by the manufacturer shall be specified in the construction specification as well as all inspection procedures.

Installation of specialized fasteners shall only be carried out by competent personnel.

NOTE: Persons installing specialized fasteners should be trained by the supplier in correct and safe installation.

8.8 INSTALLATION OF MECHANICAL AND CHEMICAL ANCHORS

8.8.1 Construction specification

The construction specification shall state either—

(a) details of the mechanical or chemical anchor to be used by identifying the manufacturer, the anchor designation and the embedment length. No substitution of specified anchor shall be permitted without written authorization; or

(b) the design actions on the anchors, in which case the appropriate anchors shall be selected in consultation with the supplier.

Documentation shall be made available which confirms that the mechanical or chemical anchor complies with the requirements of the construction specification in all respects.

NOTE: The AEFAC *Guideline for the specification of fastenings to concrete—Engineering technical notes* provides suitable guidance on what information should be included in the construction specification.

8.8.2 General requirements

Mechanical and chemical anchors shall be installed to the manufacturer's detailed installation instructions. The setting tool and any cleaning accessories (blow-out pump, cleaning brushes and the like) shall be used as specified by the manufacturer.

NOTE: Incorrect installation, particularly poor hole cleaning, may prevent the anchors from functioning as intended. Resin bonded anchors are sensitive to poor installation methods.

8.8.3 Competent personnel

Installation of mechanical or chemical anchors shall only be carried out by competent personnel.

NOTE: Examples of qualifications of competent personnel are:

(a) A certification through the AEFAC Installer Certification Program.

(b) Specific training from the supplier of the product being installed.

8.8.4 Installation

Installation shall be in accordance with the manufacturer's written instructions for the type of anchor being used, which take precedence over any other instructions available. A typical installation procedure should include the following steps:

(a) Check that the concrete or masonry substrate into which the anchor is to be installed has reached the nominated strength specified.

(b) Drill the hole perpendicular to the surface using a suitable drill containing a drill bit whose diameter is that specified in the manufacturer's written instructions, together with a depth gauge reflecting the depth specified in the manufacturer's written instructions.

(c) Clean the hole in accordance with the manufacturer's written instructions (see also Clause 8.8.5) and check the condition of the hole.

(d) Use the setting tools recommended by the manufacturer and which are appropriate to the size and type of anchor being used.

(e) For bonded fasteners, the full curing time specified by the manufacturer should be observed without any disturbance to the fastener, before tightening or loading (see Clause 8.8.6).

(f) Tighten the anchor to the recommended tightening torque as stated in the manufacturer's written instructions (see Clause 8.8.7).

Products of similar type but different manufacturers may have different installation procedures. The installation procedure used shall only be that of the actual manufacturer of the product used. Setting equipment shall be specific to the anchor used.

The temperature at the time of installation shall be within the manufacturer's nominated temperature range at the time of installation.

NOTE: Temperature is particularly critical with resin chemical anchor systems for which anchors should only be installed within the installation temperature range stated on the packaging. The temperature measured should match that specified on the packaging and would normally be that of the steel material, not the ambient temperature.

8.8.5 Holes

Templates should be used for drilling holes in order to ensure correct location. Tolerance on hole location shall be ±1.5 mm and tolerance on depth shall be –0, +5 mm.

Holes shall be drilled with drill bits and diameters recommended in the manufacturer's written instructions. If diamond drilling is used, manufacturer written requirements shall be checked to ascertain if roughening of the hole sides is required after drilling.

NOTE: Some chemical anchors do not function in diamond drilled holes due to the smooth sides of the holes.

Hole depths shall be such as to achieve the effective embedment depth or design load capacity nominated in the construction specification. Depth gauges shall be used when drilling.

The holes shall be cleaned in accordance with the manufacturer's written instructions. Where compressed air is used, no oil contamination shall exist in the air flow.

NOTE: For most mechanical anchors, it should be possible to clean the hole with a blow-out pump in order to remove dust and fragments from the hole. If this does not achieve a clean hole, brushes need to be used. For chemical anchors, a brush should be used in addition to the blow-out pump.

Anchors shall not be installed in wet holes unless specifically permitted in the manufacturer's written instructions. Any special requirements by the manufacturer in relation to use in wet holes shall be complied with.

8.8.6 Curing of chemical anchors

Tightening and subsequent loading shall only occur after the curing time noted on the packaging has been achieved.

The full curing time relating to the temperature quoted on the packaging shall be allowed and not reduced.

NOTE: The curing time is the time from mixing until the time when the anchor may be torqued, during which the anchor should be left undisturbed.

8.8.7 Tightening

A calibrated torque wrench shall be used to apply the installation torque specified by the manufacturer. The wrench shall be set to the torque specified by the manufacturer and tightening shall not continue beyond this value. Under-tightening shall be avoided.

Torque wrenches shall be recalibrated at intervals not exceeding 12 months.

8.8.8 Substitution and alteration

The anchors used shall have the correct length as specified in the construction specification in order to achieve the nominated embedment length or design load capacity, as appropriate. Anchors shall not be shortened for any reason. Anchors shall not be adapted, altered or modified in any way without written authorization from the manufacturer.

The thickness of any shims, packers or grout shall be used in determining the overall fixture thickness.

Fasteners shall not be adapted, altered or modified in any way without written authorisation from a competent person. Mixing of products from different manufacturers (e.g. anchor type from one manufacturer, resin type from another manufacturer) shall not be permitted.

NOTE: Alteration of fasteners, in particular shortening of embedment length, can significantly reduce fastener performance.

8.8.9 Storage and handling

Storage and handling shall be in accordance with the manufacturer's written instructions.

Resin materials have a shelf life as declared on the packaging. If the resin in a capsule is not liquid or will not flow at normal room temperature, it shall not be used. If resin packaging shows any signs of leaking, they shall not be used.

NOTE: Elevated temperature has a deleterious effect on chemical anchors. When elevated temperature occurs beyond the temperature specified by the manufacturer, advice should be sought from the manufacturer.

8.8.10 Hitting reinforcement in concrete elements

Drilling through reinforcement shall not be permitted without authorization. If steel reinforcement is encountered when drilling any hole, drilling shall cease immediately.

The hole diameter shall not be enlarged or the drill forced past the reinforcement.

Solutions to the problem may involve one or more of the following:

(a) Permission may be given to drill through the reinforcement.

(b) Moving the anchor.

(c) Permission may be given to drill at an angle in order to miss the reinforcement.

An anchor shall not be cut short or replaced with a shorter anchor that is set into the hole whose depth is limited by the depth to the reinforcement.

Any new hole shall be located away from the aborted hole by at least the depth of the aborted hole, although a lesser distance may be permitted if the aborted hole is filled with high strength non-shrink mortar.

NOTE: BS 8539 permits a lesser distance for a new hole from an aborted hole subject to detailed instructions being complied with. BS 8539 should be consulted for details.

8.8.11 Anchors in masonry

Drilling into softer types of masonry may result in holes that become oversized. The drilling technique shall be selected in order to minimize hole oversizing.

Care should be taken to ensure that no damage is done to mortar joints or masonry units by expansion anchors, or during drilling or setting of any anchor type.

NOTE: Correctly installed chemical anchors avoid damage to masonry since they do not exert expansive pressure on the masonry. Chemical fasteners used in hollow masonry require the use of a sieve to properly engage with the substrate.

The guidance of the anchor manufacturer shall be sought as to any reduction in the performance of the anchor as a result of oversize holes or damage in masonry.

The suitability of the anchor system for use with hollow bricks, blocks or aerated concrete products shall be checked with the manufacturer before being used. Additional special components may be required

NOTE: In general, anchor manufacturers advise against the installation of anchors of either type in the mortar. BS 8539 provides detailed guidance on where anchors should be set in masonry and should be consulted for details.

8.9 SUPERVISION

For CC2, CC3 and CC4, installation of mechanical fasteners and mechanical and chemical anchors shall be supervised by a competent person.

NOTE: Examples of qualifications of competent personnel are:

(a) Certification through the AEFAC Installer Certification Program.

(b) Specific training from the supplier of the product being installed.

SECTION 9 SURFACE TREATMENT AND CORROSION PROTECTION

9.1 GENERAL

9.1.1 Application

This Section specifies requirements for the preparation of steel surfaces for the subsequent application of corrosion protection. It also specifies the requirements for corrosion protection systems, including painting and galvanizing.

The construction specification may contain additional requirements to those of this Section. The additional information contained in Appendix B, Table B1 should also be addressed in the construction specification.

This Section applies specifically to the structural steels in accordance with Clause 5.3.1. For light gauge steels designed using AS/NZS 4600, the provisions of AS/NZS 4600 are applicable.

Any coating to be applied over a corrosion protection system (such as fire protection) shall be compatible with the corrosion protection system.

9.1.2 Architecturally exposed structural steelwork

Steelwork identified in the construction specification as ‘Architecturally Exposed Structural Steelwork’ (AESS) shall comply with Section 10 in addition to the requirements of this Section.

9.2 PLANNING

9.2.1 Quality documentation

The level of quality documentation and inspection required for surface preparation and paint coating application depends on the service environment and quality of surface preparation, rather than the construction category. Guidance on the elements of a suitable quality management system aligned with the requirements of the quality level is provided in Appendix D, Paragraph D2. Two levels are given:

(a) Coating Quality Level PC 1: For coatings applied in atmospheric corrosivity category C1 or less critical C2 environments or where surface preparation is by hand or power tool cleaning or abrasive blast cleaning to Sa1. This level requires less documentation than the higher level.

(b) Coating Quality Level PC 2: For coatings applied in any other atmospheric corrosivity category or for systems where abrasive blasting is required. This quality level shall require:

(i) A Quality Management System as set out in Clause 4.5.1.

NOTE: An example of a suitable quality management system is set out in AS/NZS ISO 9001.

(ii) A Quality Plan as set out in Clause 4.5.2.

(iii) An Inspection and Test Plan as set out in Clauses 13.8.1 and 13.8.2.

9.2.2 Work method statements

A documented work method statement (WMS) shall be prepared for each stage of the work before any work involving surface preparation, painting or galvanizing is undertaken. The WMS shall be made available to all relevant personnel involved in the works.

9.2.3 Painting and galvanizing specification details

9.2.3.1 *Painting*

The construction specification shall include the following:

(a) Scope of work including all areas designated to be coated and the coating requirements.

(b) Colour and gloss requirements and paint Standards.

NOTE: Where a proprietary system is specified, the manufacturer and brand identifier and manufacturer's requirements for application should be included.

(c) Specifications for special areas such as bolted connections, concrete to steel interfaces and wet areas.

(d) Specifications for on-site repair of handling damage to the coating system.

Any changes to the environmental requirements during surface preparation and paint application and curing if different from requirements in Clauses 9.4.3 and 9.9.10 and any special paint manufacturer's instructions.

(e) Surface preparation and surface cleanliness inspection requirements (in accordance with AS 1627.4).

(f) Specification for limits of fabrication defects, intermittent welds or weld surface quality.

(g) Need and method for sealing intermittent welds.

(h) Surface profile measurement requirements (in accordance with AS 3894.5).

(i) Checks for the presence of, measurement of and removal of soluble salts or non-visible contaminants (in accordance with AS 3894.6).

(j) Dry film thickness requirements (in accordance with AS 3894.3).

(k) Curing requirements (in accordance with AS 3894.4).

(l) Specification for limits of pin holes, misses and other paint defects.

(m) The level of inspection required (see Clauses 13.8 and 13.9).

(n) The record keeping required.

NOTE: The use of the relevant inspection forms contained in AS 3894.10 to AS 3894.14 is recommended. Records kept should include a requirement to maintain batch details for each discrete section of the work.

9.2.3.2 *Galvanizing*

The construction specification shall contain the following details:

(a) Reference to the hot dip galvanizing Standard, AS/NZS 4680, and any special coating thickness or repair requirements.

(b) The nature, chemical composition and mechanical properties of the product to be galvanized, and its end use, including the location of any significant surfaces.

NOTE: Material test certificates and product drawings should be provided.

(c) Any special or supplementary requirement of the coating, e.g. for a special finish such as painting, powder coating, or requirements for pre-treatment or post-treatment.

(d) The level of inspection required (see Clauses 13.8 and 13.10).

9.2.4 Traceability

Clause 6.2 requires a suitable system to allow identification of each steel member, component and fastener.

Where surface preparation and/or corrosion protection by means of painting or galvanizing is sub-contracted, systems shall be put in place to ensure traceability is maintained.

NOTE: The requirements of Clause 6.2 apply for all identification systems.

Traceability consistent with the fabrication methods used shall be maintained for every steel member, component or fastener throughout surface preparation and the application of the corrosion protection. The identification system shall be such that, where required, the identification of each item is visible after surface preparation and after painting or galvanizing.

NOTE: Heat resistant tags are available that are compatible with the galvanizing process.

Items to be galvanized that are batch processed (e.g. bolts or bundles of reinforcing bars) shall be galvanized in such a way that the individual batch or bundle identification is maintained.

9.3 PREPARATION OF STEEL SURFACES

9.3.1 Competent personnel

Surface preparation involving high pressure water cleaning, abrasive blast cleaning and mechanical cleaning shall be performed by competent personnel.

9.3.2 Preparation of surfaces intended to be painted

A documented inspection and test plan (ITP) in accordance with Clause 13.8.1 shall be prepared prior to surface preparation commencing.

Weld spatter, slag deposits and flux residues shall be removed from welding and sharp edges prepared prior to surface preparation to the specified treatment grade (see Clause 9.8.4).

Surface contamination such as soluble chloride salts, bird droppings, algal or fungal growth, soot, dirt, loose scale and any other products that may reduce adhesion of the applied coating shall be removed by high-pressure water cleaning.

Oil and grease shall be removed by solvent cleaning in accordance with AS 1627.1 or SSPC-SP 1.

NOTE: Methods of test to determine whether a surface is free of oil, grease and salt contamination are provided in AS 3894.6.

Abrasive blast cleaning shall comply with Clause 9.4. If abrasive blasting is specified in the construction specification, but is not permitted or practicable, written approval shall be required from a competent person to use alternative methods. This may require selection of a new coating system and subsequent specification.

All interior steelwork shall have surface preparation by mechanical cleaning, as a minimum to St2 or by abrasive blast cleaning to Sa1 as specified in ISO 8501-1 or by brush-off blasting to SSPC-SP 7.

All exterior steelwork shall have surface preparation by abrasive blast cleaning to Sa2.5 as specified in ISO 8501-1 or by abrasive blast cleaning to SSPC-SP 10, unless otherwise specified in the construction specification.

NOTE: Four grades of blast clean surfaces are given in ISO 8501-1, namely classes Sa1, Sa2, Sa2.5 and Sa3. Class Sa2.5 is ‘very thorough’ or ‘near white’ which has mill scale, rust and foreign particles removed to the extent that only traces remain in the form of spots or stripes, and the surface shows varying shades of grey. Class Sa1 is ‘light’ blast cleaning which removes only loose mill scale, rust and foreign matter.

The actual standard of surface cleanliness achieved shall conform to the specified photograph and description standard in ISO 8505-1.

Where surfaces to be painted are required by the construction specification to be tested for the presence of soluble salts such as chlorides, sulphates and nitrates, the Bresle Patch or swab test of AS 3894.6 shall be used. Salts shall be removed from the surface to a maximum level, as specified in the construction specification.

NOTE: Soluble salts may be removed with the use of hot water, high pressure water cleaning (see ISO 8501-4), wet abrasive blasting (see Clause 9.4) or proprietary treatments to lower soluble salt concentration (see AS/NZS 2312.1).

9.3.3 Surfaces intended to be galvanized

The articles to be hot dip galvanized shall be cleaned and fluxed to the requirements of AS/NZS 4680 to a condition that will allow the galvanizing reaction to take place.

NOTE: The surface preparation of steel to be galvanized is integral to the galvanizing process and it is not usually necessary to separately specify the surface preparation required.

9.3.4 Steel surfaces intended for other coating systems

For other coating systems, steel surface preparation shall be in accordance with recognized Standards or manufacturer's specifications and shall be carried out by competent personnel.

9.3.5 Weathering steel surfaces

Any requirements for blast cleaning of exposed areas or requirements intended to ensure that the surfaces of uncoated weather resistant steels is acceptable visually shall be specified in the construction specification and shall be complied with.

NOTE: In order to assist in the formation of the protective patina and provide a uniform finish, it is recommended that after fabrication and prior to erection, all weathering steel components should be abrasive blast cleaned to SSPC-SP 6/NACE No 3 or ISO 8501-1 Sa2 to remove mill scale and other contaminants. This should be immediately followed by a minimum of three cycles of wetting using potable water and drying.

Any procedures intended to prevent contamination of the surface from oil, grease paint, concrete or asphalt and to prevent the surface from being constantly immersed in water shall be specified in the construction specification.

Any treatment for weather resistant surfaces in contact with non-weather resistant steels or other metals, either coated or not, shall be specified in the construction specification.

9.3.6 Contact surfaces in connections using mechanical fasteners

The preparation of contact surfaces on connected plies in connections using mechanical fasteners shall comply with Clause 8.4.1.

For friction-type bolted connections, the additional requirements of Clause 8.4.2 shall be complied with.

9.3.7 Surfaces in contact with concrete

Surfaces of structural steel that are to be in contact with concrete, including the underside of base plates, shall have surface preparation and corrosion protection identical to that on the adjacent structural steelwork, excluding any finish coat that is purely aesthetic.

For painted structural steel members that are embedded in concrete, the preparation and corrosion protection shall extend for the first 50 mm of the embedded length and the deeper lengths of section need not have corrosion protection applied, unless specified otherwise in the construction specification.

Any uncoated embedded steelwork shall be blast cleaned or wire brushed in order to remove loose mill scale and to remove dust, oil and grease. Immediately before being embedded in the concrete, any loose rust, dust and other loose debris that has accumulated since cleaning shall be removed.

NOTE: Structural steel members that are to be galvanized will normally be coated for the full length of the member. It is usually not possible to specify for only part of a member length to be galvanized while the remainder remains ungalvanized. However, there are situations, such as where shear studs are intended to be welded post-galvanizing, where a heat-resistant paint or other masking system may be applied prior to galvanizing to inhibit adherence of the galvanized coating and ensure the surface remains essentially zinc free.

9.4 ABRASIVE BLASTING

9.4.1 General

Abrasive blasting shall comply with the requirements of AS 1627.4 except where over-ruled in the construction specification.

NOTE: For hot-dip galvanized systems, abrasive blasting is generally only carried out when extra galvanizing thickness is desired. Guidance is provided in AS/NZS 2312.2. Abrasive blasting should not be carried out without first consulting the galvanizer.

The abrasive blast media shall be angular, clean, dry and free from extraneous matter such as dirt, gravel and organic matter.

Where media used in dry abrasive blasting needs to be cleaned and recycled, the cleaning shall be carried out on-site and all waste extracted shall be contained for later disposal.

The construction specification shall state if there are any limitations on acceptable media and if recycling of abrasive is acceptable.

9.4.2 Equipment

The compressed air supply used for abrasive blasting shall be free of water and oil as determined by ASTM D4285. Adequate separators and traps shall be provided and these shall be regularly emptied of water and oil. Accumulations of oil and moisture shall be removed from the air receiver by regular purging.

9.4.3 Restrictions

No abrasive blasting shall be carried out on areas of black rust, unless such areas have been thoroughly washed within the previous 48 hours in order to remove any salt contamination.

Abrasive blast cleaning shall not be carried out—

(a) where damage or contamination of nearby newly or partially completed painting will occur;

(b) within 40 m of any unprotected personnel;

(c) when surfaces are less than 3°C above dew point;

(d) when the relative humidity of the air is above 85%; or

(e) in conditions of poor visibility with light below 200 lx.

9.4.4 Surface finish

Unless otherwise specified in the construction specification, surfaces shall be abrasive blast cleaned to achieve a minimum angular profile of 40 µm and a maximum of 75 µm as measured by AS 3894.5.

The visual cleanliness of the surface finish shall comply with Clause 9.3.2 for surfaces to be painted.

9.4.5 Precautions after preparation

No contamination by windborne salts or dust or deterioration in the condition of the cleaned surface shall be permitted.

All prepared areas shall be cleaned of all residual dust and other loose material before painting by using dry compressed air or vacuum brushing. Visible oil and grease remaining on the surface shall be completely removed by a method described in AS 1627.1.

Priming shall be carried out as soon as practicable after preparation but the delay shall not be in excess of 4 h. If the quality has degraded, the surface of the steel shall be re-prepared.

9.5 MECHANICAL CLEANING

9.5.1 Surface requirements

Where areas of rust exist and abrasive blasting or similar tools is not permitted or practicable, power disc sanders or 'bristle blasters' shall be used to remove contamination back to clean steel equivalent to ISO 8501-1 Sa2.

Any areas inaccessible for such treatment may be cleaned by needle guns or by other power tools to a St3 finish. Manual cleaning to St2 shall only be used where other methods are not practicable. Wire brushes shall not be used.

NOTES:

1 Photographic pictorial representation of the surface finish 'St3' is illustrated in ISO 8501-1.

2 These lower standards of cleaning will require the use of a surface tolerant primer.

Power tool and hand tool cleaning shall comply with AS 1627.2.

9.5.2 Procedure

Power tools should be operated in such a manner that burrs or sharp edges are minimized on the surface and no gouges are made in the steel surface.

Edges of any existing paint shall be feathered back to tightly adhering paint by sanding if necessary.

Power cleaning operations shall be programmed and performed in such a manner that nearby newly or partially completed paintwork is not contaminated or damaged.

Prepared areas shall be treated as per Clause 9.4.5.

9.6 SEALING OF ENCLOSED SPACES

9.6.1 General

Any surface preparation and corrosion protection system required for enclosed spaces shall be specified in the construction specification and shall be executed in accordance with this Section and the construction specification.

If a space is to be fully enclosed by welding, the construction specification shall state the quality of the welding permitted, and if any application of filler material or sealant is required to prevent the ingress of moisture.

NOTE: Cracks in seal welds which are not detectable by visual examination may allow moisture to penetrate through a seal weld.

If closed sections are to be galvanized, they shall not be sealed before galvanizing (see Clause 9.6.3).

9.6.2 Overlapping surfaces

Where intended to be painted, overlapping surfaces shall be detailed to minimize the potential for corrosion through capillary action of water.

NOTE: AS/NZS 2312.1 provides guidance on minimizing the potential for corrosion through capillary action of water.

Where intended to be hot-dip galvanized, overlapping surfaces involving closed sections and continuous welds shall be provided with adequate venting and draining.

NOTE: Where overlapping surfaces are intended to be galvanized, a galvanizing contractor should be consulted prior to fabrication to assess the provisions made for venting.

9.6.3 Closed sections and closed end hollow sections

For structures intended to be galvanized, vent holes and drainage holes shall be provided. Every hollow section shall have at least one vent and one drain hole. Vent and drain holes shall be a minimum of 25% of the largest internal diagonal dimension and no smaller than the steel thickness.

NOTES:

1 Multiple holes can be provided to make up the cross-sectional area equivalent to 25% of the largest cross-section dimension, so long as no hole is smaller than Ø10 mm.

2 As the location and number of vent and drain holes can significantly alter the quality and cost of a galvanized structure, a galvanizing contractor should be consulted prior to fabrication to assess the provisions made for venting and draining in order to ensure that the provisions are adequate.

3 Guidance on the extent of vent and drain holes for hollow sections is provided in AS/NZS 2312.2.

Box, hollow and tubular connections that have access or inspection holes or ports during painting, shall have these holes or ports temporarily closed off during surface preparation. All such holes or ports shall be fully sealed off once painting is completed.

9.7 INACCESSIBLE SURFACES

Areas and surfaces that are difficult to access, or cannot be accessed at all after assembly, shall be provided with the corrosion protection system specified in the construction specification before assembly.

9.8 FABRICATION AND WELDING CONSIDERATIONS

9.8.1 General

The quality plan shall include inspection procedures for checking the condition of the steel after fabrication and after surface cleaning.

NOTES:

1 Defects should be detected and repaired before transport to the coating applicator. However, some defects may not be detected until the steel has been abrasive blast cleaned.

2 The painting contractor or galvanizing contractor should point out visible fabrication defects to the fabricator before commencing the application of paint or commencement of galvanizing.

9.8.2 Welds

All welds shall comply with the requirements of Section 7 and Clauses 9.3.2 and 9.3.3 in respect of requirements before surface preparation commences.

Before any weld areas are abrasive blast cleaned, all weld spatter, sharp corners and hardened cut edges shall be removed and then scrubbed with clean water in order to remove all traces of weld fluxes.

NOTE: AS/NZS 1554.1:2014, Table 6.2.2, Note 3 contains a warning that where allowance for overlap and surface pores are detrimental to any surface treatment, they may not be acceptable for that surface treatment. Such imperfections may either need to be filled (in the case of a painted finish (see Clause 9.8.3) or may need to be repaired by being ground out and repair welded (in the case of galvanized finish and possibly for a paint finish).

9.8.3 Rectification

For surfaces to be painted, rectification may be carried out before or after priming by filling with a suitable solventless epoxy compound. Filling crevices with an elastomeric sealant shall only occur after all paint coats have been applied. Responsibility for such rectification shall be stated in the construction specification.

9.8.4 Treatment grades

For surfaces intended to be painted, a treatment grade shall be specified in the construction specification. Treatment grades may vary across an individual project and may be related to the corrosion protection system used in a particular area of a project.

For surfaces intended to be galvanized, the requirements of AS/NZS 4680 shall apply unless otherwise specified in the construction specification.

NOTE: Unless the galvanized surface is to be subsequently painted after galvanizing, or AESS is required (see Section 10), surface preparation to treatment grades is not necessary for galvanized products. Advice on the effect of the surface condition on the quality of hot dip galvanizing is provided in AS/NZS 2312.2.

Treatment grades shall be selected from and identified by one of the following:

(a) *P1: Light treatment*—involves the removal of burrs, fins and weld defects that could cause injury or prevent proper paint adherence. Also involves the removal of weld spatter, welding slag, rolled in matter and mill scale. Pits and craters shall be opened to allow the penetration of paint or galvanizing.

(b) *P2: Thorough treatment*—in addition to P1 requirements, cut edges shall have a chamfer of at least 1 mm in width. Welds shall be dressed to remove irregular and sharp weld profiles. Undercut, porosity and craters acceptable under Section 7 shall be sufficiently open to allow penetration of paint or galvanizing. All visible laminations, pits, grooves and indentations shall be ground smooth.

(c) *P3: Very thorough treatment*—in addition to P1 and P2 requirements, all edges shall be rounded with a minimum radius of not less than 2 mm. Welds shall be dressed smooth, and shall be free from undercut, visible porosity, pits craters, shelling and laminations. Any indentations, craters or gouges shall have a minimum radius of 2 mm along their edges.

NOTES:

1 These ‘treatment grades’ follow equivalent ‘preparation grade’ requirements in ISO 8501-3 except that Grade P2 has a requirement for a chamfer which is not included in ISO 8501-3.

2 It should not be necessary to measure the radii specified with these ‘treatment grades’ but reliance on visual examination alone is assumed. To achieve a 2 mm radius a minimum of three passes of grinding is usually required.

3 Rolled edges include edges of universal sections and channels.

Unless otherwise specified in the construction specification, Treatment Grade P2 shall apply for painting. Where the steelwork is designated as AESS (see Section 10), Treatment Grade P3 shall apply for painting.

For all treatment grades, any re-entrant corners shall be radiused in accordance with Clause 6.5.3. Cut edges in re-entrant corners shall comply with Clause 9.8.5.

NOTE: Cut edges that are to be galvanized are generally not required to be chamfered or radiused unless they have been cut by thermal process (see AS/NZS 2312.2).

9.8.5 Cut edges

The construction specification should state the extent of the treatment of edges required and if any repair or additional protective treatment is required to cut edges or adjacent surfaces after cutting is completed, in addition to the requirements of Clause 6.5.

In order to obtain the required coating thickness more reliably and to ensure adequate cohesion/adhesion of the coating, flame cut, laser cut and plasma cut surfaces shall be ground off and sharp edges treated to the specified treatment grade.

NOTE: Flame-cutting, laser-cutting and plasma-cutting changes the steel composition and structure in the zone on and around the cut surface. The required surface profile and the minimum coating thickness may be more difficult to obtain and the coating so formed may exhibit a decreased cohesion/adhesion to the steel substrate.

9.8.6 Pre-coated steel

If pre-coated material is to be welded, the construction specification should state the methods and extent of repair or other treatment required to the coating adjacent to the weld. The requirements of the construction specification should be based on manufacturer's written instructions, where available. Where no requirements are contained in the construction specification, manufacturer's written instructions shall be followed.

If power tool surface preparation is specified for welds, power wire brushing should not polish the weld surface (see AS 1627.2 for suitable methods). Weld spatter shall be removed by chipping or grinding and any residual flux removed by chipping or abrasive blasting. Rough weld beads shall be ground flush or stripe-coated with a brush.

If a galvanized coating has been removed or damaged by subsequent welding, the affected area shall be cleaned, prepared and repaired in accordance with the requirements of AS/NZS 4680.

9.9 APPLICATION OF PAINT COATINGS

9.9.1 Competent personnel

Application of paint coatings shall be undertaken by competent personnel.

NOTE: Examples of qualifications of competent personnel include the following:

(a) An appropriate trade qualification in Australia at Certificate Level 3 or higher.

(b) An Australasian Corrosion Association approved trade specific certification.

(c) Painting contractors registered with the Painting Contractor's Certification Programme (PCCP).

9.9.2 Safety

In addition to the provisions of this Clause, the provisions of Clause 9.2.2 shall be complied with.

Pigments shall be used that are not hazardous to workers or the environment.

NOTE: A number of pigments are considered hazardous to workers and the environment, including lead chromate based, zinc chromate, asbestos, red lead, white lead and calcium plumbate.

Spray booths shall comply with AS/NZS 4114.1 and AS/NZS 4114.2.

Previous experience with the processes and materials selected and familiarity with all regulations that apply to the handling and storage of paint shall be demonstrable.

The coating manufacturer's Safety Data Sheets (SDS) covering all materials to be used in the work, including thinners and solvents, shall be readily available on request.

9.9.3 Paint material

Paint shall comply with the requirements of the Standards in Table 9.9.

NOTE: To ensure compatibility of the paints used, all paint in any one system used on an individual project should be manufactured by the same company.

TABLE 9.9

STANDARDS FOR PAINT MATERIAL

Standard	Description	APAS approval number
AS/NZS 3750.16	Acrylic latex	APAS 0280
AS/NZS 3750.19	Alkyd metal primer	APAS 0162
AS/NZS 3750.5	Epoxy mastic	APAS 2919
AS/NZS 3750.14	High build epoxy	APAS 2973
AS/NZS 3750.15	Inorganic zinc	APAS 2908
	Polysiloxane	APAS 2920
AS/NZS 3560.6	Polyurethane	APAS 2911
AS/NZS 3750.19	Zinc phosphate alkyd primer	APAS 0162
AS/NZS 3750.9.2	Zinc rich epoxy	APAS 2916
AS/NZS 3750.5	2-pack acrylic	APAS 2919

NOTES:

1 Certification to the Australian Paint Approval Scheme (APAS) is an indicator of compliance with the relevant Standard in Table 9.9. Certification to APAS is not a requirement of this Standard.

2 Paint products complying with ISO 12944-5, for the applicable corrosion environment, may be used subject to the requirements of the construction specification.

9.9.4 Quality control of paint material

The paint material used shall be within its specified shelf life and shall not be used after the date of expiry. Any deteriorated or contaminated material shall not be used, shall be quarantined and shall be removed from the site as soon as practicable.

Paint material shall be transported and stored under the conditions specified by the paint manufacturer. On removal from storage, all containers should be examined for signs of damage which might be indicative of degradation of the paint.

All paint material and thinners to be used shall be stored as supplied in unopened identifiable containers with the label intact. All paints, thinners, solvents and other liquids shall be stored and mixed within bunded areas.

NOTE: Paint should normally be stored at temperatures above 3°C and below 30°C in a secure area.

9.9.5 Information required

The following information shall be recorded:

(a) The name or registered mark of the paint manufacturer.

(b) The paint or thinner type.

(c) The colour identification.

(d) The product identification together with a description of each component.

(e) The production or batch numbers on packs of 4 L capacity and above.

The following information shall be available on-site:

(i) The manufacturer's Product Data Sheet (PDS) with instructions for use including (where relevant) the mixing ratio of components, the induction time, pot life, recommended methods of storage, mixing and application.

(ii) The manufacturer's Safety Data Sheets (SDS).

9.9.6 Mixing of paint

All paints shall be thoroughly mixed by manual or machine stirring in bunded areas so that all pigment is in suspension before being used. If required, zinc rich paint shall be agitated during application in order to keep the paint homogeneous. Any pigment that has settled in the bottom of its container shall be reincorporated by stirring.

Curing agents or hardeners that are separately packaged shall be added and mixed in bunded areas with the base paint in accordance with the manufacturer's specification.

All two-part material shall be folded in from the outer edge of the container with a flat spatula during mixing to ensure that it is fully integrated.

Only sufficient paint for use shall be mixed at one time.

Unused portions of mixed convertible coatings shall be discarded at the end of the manufacturer's specified pot life and shall not be added to freshly mixed paint.

9.9.7 Use of thinners

Thinning of paint and cleaning of equipment shall be carried out in bunded areas and strictly in accordance with the paint manufacturer's specifications.

No more thinner shall be used than is strictly necessary for satisfactory brushing or spraying and in no case shall the paint manufacturer's specifications be exceeded.

Re-refined solvent (such as 'gunwash') shall not be used unless in a cleaning procedure specifically approved by the paint manufacturer. Cleaning solvents shall be thoroughly flushed from all lines and equipment with the recommended thinner prior to application of any paint.

9.9.8 Tinting

Where successive coats of the same product have been specified, alternate coats shall be tinted off-shade sufficiently so as to produce enough contrast to indicate complete coverage of the surface.

No site tinting of the finish coat shall be permitted.

9.9.9 Masking

Bearing surfaces under bolt heads and nuts should be masked before application of build and top coats. A primer coat around bolted connections can be used consisting of a single coat of no more than 125 μm of inorganic zinc silicate, zinc rich epoxy or zinc phosphate. Masking should be applied for subsequent coats.

Crevices between mechanically fastened plates on external steelwork shall be neatly filled with a clear neutral cure silicone sealant after the topcoat has cured.

Machined surfaces shall be left uncoated and shall be protected by suitable masking.

A weld margin of 75 mm width shall be left uncoated in the vicinity of the locations of site welds and the weld margin shall be masked appropriately.

NOTE: See also Clause 8.4.2 for requirements for contact surfaces in friction-type connections.

9.9.10 Painting conditions

Unless otherwise permitted by the paint manufacturer's data sheet, paint shall not be applied when any one of the following conditions exists:

(a) The substrate temperature is less than 3°C above the dew point.

(b) The ambient air temperature is below 5°C.

(c) The relative humidity exceeds 85%, unless a moisture-cured coating is being applied or special precautions are taken to ensure that the steel surface is at least 3°C above the temperature of the surrounding air. Some coatings have a minimum relative humidity limit.

(d) There is moisture or ice visible on the surface of the steel.

(e) In conditions of poor visibility (minimum of 200 lx is required).

(f) When the steel surface is in direct strong sunlight.

(g) When the weather is deteriorating or is unfavourable for application or curing (such as wind, dust or air pollution).

(h) If the pot life of the paint has been exceeded.

Air and surface temperatures, relative humidity and dew point shall be regularly monitored and recorded throughout the work when required by the construction specification.

NOTES:

1 AS 3894.7 covers measurement or surface temperature and ISO 8502-4 provides guidance on the probability of condensation.

2 AS/NZS 2312.1 contains a discussion of painting conditions.

The paint manufacturer's written instructions for recoating times and time between the application of the final coat and time for handling shall be strictly observed.

9.9.11 Priming

Abrasive blast cleaned or mechanically cleaned areas shall be primed with a coat of primer before re-rusting or recontamination occurs, but within a maximum of 4 h if outdoors.

On surfaces that are not cleaned by abrasive blasting, or where pit depths exceed 2 mm, the first coat of priming paint shall be applied by brush and shall be well worked into the steel surface. Subsequent coats may be applied by brush, roller or spray.

All welds, bolts, laps, edges, external corners of the section, and any other areas that are difficult to spray shall be stripe coated by brush with primer prior to spray application.

9.9.12 Spray painting equipment

All spray painting equipment shall comply with the instructions of the paint manufacturer for the specific paint being applied.

All spray painting equipment shall have adequate pressure regulating and monitoring devices, effective strainers, moisture traps, separators and earthing devices, suitable sized hoses and shall be maintained in good order.

During the work, the equipment shall be checked daily for defects and any defects found shall be remedied before further application of paint.

9.9.13 Spray application

Paint for spray application shall be thoroughly strained before use, in accordance with the specifications of the paint manufacturer.

Lines and pots shall be thoroughly cleaned before the addition of new materials. Compressed air shall be free from oil or water as determined using ASTM D4285. All equipment should be thoroughly cleaned after use.

A supply of tips with varying spray angles and orifice sizes shall be available. These shall comply with the specifications of the paint manufacturer for each specific steel configuration to be painted.

Each coat shall be applied uniformly and completely over the entire surface to be painted. All runs and sags shall be brushed out immediately or the paint shall be removed and the surface resprayed.

Before spraying each coat, all areas such as corners, edges, welds, small brackets bolts, nuts, crevices, shadow areas, and difficult to spray areas shall be re-coated by brush in a contrasting colour in order to ensure that these areas have at least the minimum specified film thickness.

Surrounding areas shall be properly protected from overspray and paint droplets by suitable masking.

The paint film shall have a smooth, even finish, free from sagging, stickiness, floating and any other defects. Paint shall not be applied in uneven layers. All equipment and work areas should be kept clean.

All particle pick-up and protrusions on primed and undercoated surfaces shall be lightly abraded and all resulting dust removed prior to application of the next coat.

9.9.14 Brush and roller application

Guidance on brush and roller application is provided in AS/NZS 2312.1.

Brushing shall be done such that a smooth coat, as nearly uniform in thickness as possible, is obtained. Paint shall be worked into all pits, welds, crevices and corners. Runs or sags shall be brushed out.

Surfaces not accessible to brushes shall be painted by other suitable means to ensure a uniform paint film of adequate thickness.

9.9.15 Testing equipment

Equipment shall be available to accurately measure the environmental and other variables described in the construction specification (see Clause 9.2.4). Wet film gauges shall be used to ensure that the specific film thickness is being achieved. All measuring and inspection equipment shall be calibrated and maintained to manufacturer’s specifications. All personnel using this equipment shall be competent.

Dry film thickness shall be checked on each coat using the method described in AS 3894.3 and using a dry film thickness gauge which has been calibrated in accordance with AS 3894.3.

9.9.16 Measurement of film continuity

Where required in the construction specification, a fully cured coating shall be tested for film continuity and for defects such as pinholes, misses and damage in accordance with the method described in AS 3894.1, AS 3894.2 or using a method specified by the paint manufacturer.

9.9.17 Other tests

Where required in the construction specification, the degree of cure of the coating shall be tested using methods given in AS 3894.4. Acceptance levels for each stage shall be obtained from the paint manufacturer.

9.9.18 Corrosion protection of fasteners

Coatings of all components of an assembly, including fasteners shall be compatible and shall have similar corrosion resistance.

Unless otherwise detailed in the construction specification, fasteners shall be protected from corrosion and hot dip galvanized in accordance with AS/NZS 1214. Painting of bolts, nut and washers is not recommended due to the likelihood of installation damage.

Additional corrosion protection may be provided by the use of proprietary PVC caps or equivalent placed snugly over the bolt heads and nuts.

NOTES:

1 AS/NZS 2312.1 recommends the use of hot-dip galvanized fasteners, since this coating will provide all-over protection and will withstand installation procedures. If required, additional corrosion protection can be provided by the use of proprietary PVC caps or equivalent placed snugly over the bolt heads and nuts.

2 In some applications alternative coatings for corrosion protection may be suitable.

3 In aggressive environments stainless steel fasteners may be more suitable, especially where maintenance is difficult.

9.9.19 Storage, handling and transport

Once painted, all items shall be stored, handled and transported in such a manner that damage to the paint system is minimized. Any slings used for lifting shall have softeners to minimize damage.

Particular care shall be taken with structural steelwork identified in the construction specification as architecturally exposed structural steelwork (AESS) (See Section 10).

Soft packing shall be used between painted items and stacking should be avoided where possible.

Any damage to painted surfaces shall be repaired in accordance with Clause 9.12.1.

9.9.20 Supervision of painting

A documented ITP in accordance with Clause 13.9.1 shall be prepared prior to painting commencing.

All surface preparation and painting shall be undertaken under the supervision of a competent person.

NOTE: Examples of qualifications of competent personnel include:

(a) An ACA or NACE Level One Certified Coatings Inspector.

(b) A supervisor with at least seven years' experience of supervising coatings installation, inspection and maintenance as appropriate to the standard of work being undertaken.

9.10 APPLICATION OF GALVANIZED COATINGS

9.10.1 General

This Clause covers the after-fabrication hot-dip galvanized coating applied to general steel articles, structural steel sections, beams and columns, fabricated steel assemblies, castings, threaded fasteners, steel reinforcement and miscellaneous steel components.

Galvanizing shall be carried out to AS/NZS 4680 and this Standard (see Clause 9.2.4.2), except threaded fasteners which shall be galvanized to AS/NZS 1214 (see Clause 9.10.5).

NOTES:

1 Preferred design of articles suitable for hot dip galvanizing may be found in AS/NZS 2312.2.

2 See also Clause 9.10.5.

3 This Standard does not include hot-dip galvanizing of continuous sheet coil and cold-formed shapes covered by AS/NZS 4792, nor electro-galvanized zinc coatings applied to hollow and open sections covered by AS/NZS 4750.

The information supplied with the articles to be galvanized shall conform to the information listed in AS/NZS 4680.

NOTE: Any design features of the articles to be galvanized which create difficulties in galvanizing should be resolved between the relevant parties prior to galvanizing being undertaken.

9.10.2 Surface preparation

Surface preparation shall be in accordance with Clause 9.3.3. For further guidance refer to AS/NZS 2312.2.

9.10.3 Steel material

Materials that will be adversely affected by the heat of the hot-dip galvanizing bath shall not be hot-dip galvanized.

NOTES:

1 AS/NZS 2312.2 contains information relating to steel composition and suitability for galvanizing. Different steel compositions affect the coating thickness and the initial surface finish.

2 In general the mechanical properties of steel are not affected by the hot-dip galvanizing process. Heat-treated or cold-worked steels may be tempered by the heat in the hot-dip galvanizing bath and lose some of any increased strength obtained by heat treatment or cold working.

Clause 6.2 requires that a record of test reports and test certificates for the steel supplied for fabrication is maintained and that a tracking system be established to allow assemblies of members, individual members and individual components to be traceable back to these reports and certificates. This information shall be made available prior to galvanizing.

9.10.4 Fabrication considerations for galvanizing

The construction specification should include provision for stress relieving where fabrication is expected to result in internal stresses such that distortion may occur during galvanizing.

NOTES:

1 Guidance on fabrication issues affecting galvanizing may be found in ‘Australian steelwork corrosion and coatings guide’ and AS/NZS 2312.2. Specialist advice may need to be sought in relation to these issues.

2 Where intermittent welds are present, guidance should be sought in order to determine if the resultant component can be galvanized in accordance with this Clause.

Where surface imperfections such as porosity are present, the affected weld length shall be ground out and repair welded prior to galvanizing, unless agreed otherwise.

Soft soldered assemblies cannot be batch hot-dip galvanized and brazing should be avoided (see AS/NZS 2312.2).

9.10.5 Galvanizing method

The hot-dip bath and associated plant shall be of adequate capacity to process the items to be hot-dip galvanized. Preferably, items should be coated in a single dipping operation but partial dipping and then dipping for a second time is acceptable if permitted by the construction specification and the galvanizing bath dimensions allow this process to occur.

All items shall be secured during immersion in the zinc bath. Acceptable methods include use of existing bolt holes, lugs, racks or jigs. Holes and lifting lugs may be provided at agreed positions in order to facilitate handling of the galvanized items. Any areas where any contact marks from jigs or racks are not acceptable shall be identified prior to galvanizing.

Threaded fasteners shall be galvanized in accordance with AS/NZS 1214. However, if threaded components are attached to fabricated articles, surplus zinc shall be removed in accordance with AS/NZS 4680.

The process parameters shall be recorded at all stages of the galvanizing process in accordance with the relevant QMS. If requested in the construction specification, tests may be performed on a small initial test lot in order to assess the suitability of the proposed galvanizing procedure.

9.10.6 Appearance of coating and freedom from defects

The galvanizing coating shall comply with the requirements of AS/NZS 4680.

Any special requirements relating to the end use of the component shall be identified prior to the galvanizing process commencing.

The integrity of the coating shall be determined by visual examination (see Clause 13.10).

9.10.7 Coating mass and thickness

Coating mass and thickness of the galvanized coating shall comply with AS/NZS 4680.

Coating mass and thickness shall be determined using one of the methods detailed in AS/NZS 4680.

9.10.8 Adherence of coating

Adherence of the galvanized coating shall comply with AS/NZS 4680. The adherence shall be sufficient to withstand normal handling during transport and erection without flaking and any additional requirements of the construction specification.

NOTE: The adhesion between zinc and the base metal generally does not need to be tested, as adequate bond is a feature of the galvanizing process.

9.10.9 Repair after galvanizing

The extent of repairable damaged or uncoated areas shall comply with AS/NZS 4680.

The method of repair shall comply with AS/NZS 4680.

9.10.10 Storage handling and transport

Hot-dip galvanized work shall be stacked securely and in a manner that allows it to be handled, stored and transported safely. Hot-dip galvanized items should be stored and transported under clean, dry well ventilated conditions. Where possible, stored material should be covered and raised clear of the ground on dunnage or spacers.

Where shelter is not possible, galvanized items should be stacked in a manner that allows drainage of rainwater. The storage of galvanized articles under covers which restrict ventilation such as tarpaulins is not recommended.

Galvanized articles should not be stored in contact with cardboard or paper products, cinders, clinkers, unseasoned or treated timber or harmful chemicals.

Any wet storage staining, which is formed at the galvanizing plant, shall be removed prior to the affected item leaving the plant, unless permitted otherwise in the construction specification. The underlying thickness after removal treatment shall exceed the specified minimum value in AS 4680.

NOTES:

1 Passivation treatment after galvanizing may be used in order to minimize wet-storage staining and is normal practice in Australia and New Zealand. Other control measures to minimize wet storage staining might include storage such that free air movement is allowed across the surfaces of the work, the use of spacers to minimize contact areas between items, or the avoiding of close nesting of the work.

2 If passivation is not required, this should be identified in the construction specification.

3 The development of wet-storage staining is not to be a cause for rejection (see AS/NZS 4680) provided that the zinc coating thickness remains above the specified minimum requirements.

4 Guidance on the issue of wet-storage stain may be found in AS/NZS 2312.2.

Repair after handling and installation or repair at site shall comply with AS/NZS 4680.

9.10.11 Supervision of galvanizing

All operations shall be undertaken under the supervision of a competent person.

9.11 PAINTING OF GALVANIZED COATINGS

9.11.1 Treatment of galvanized surface

The preparation and treatment of galvanized surfaces prior to paint application shall be to the manufacturer's instructions.

NOTE: Degreasing followed by abrasive sweep (brush) blasting or by abrading with wet or dry sandpaper would usually be used to prepare a galvanized surface prior to the application of a paint coating, in order to achieve the removal of the oxide film from the zinc surface.

9.11.2 Procedure for sweep blasting

Guidance on sweep blasting is provided in AS/NZS 2312.2.

All spikes shall be removed and all edges shall be left free from lumps and bumps.

The sweep blasting shall be performed carefully to ensure that no more than 10 μm of zinc coating is removed (measured according to AS 2331.1.4). The paint coating shall be applied within 6 hours of sweep blasting.

9.11.3 Painting

Painting shall be in accordance with Clause 9.9.

NOTE: Examples of suitable paint systems for galvanized steel may be found in AS/NZS 2312.2.

9.12 REPAIRS TO CORROSION PROTECTION

9.12.1 Painted surfaces

Generally, repairs to an existing coating or repainting of existing coatings shall be in accordance with the paint manufacturer's specifications.

Before application of any further coat of paint material, all defects or damage to previous coats and the substrate where necessary shall be repaired.

Areas with an inadequate coating thickness shall be thoroughly cleaned and where necessary, additional coats applied until the specified film thickness for each layer or area is achieved.

Areas with excessive thickness shall have the overbuilt paint material removed. The substrate shall then be re-prepared and the correct film thickness reapplied.

Surfaces to be overcoated that become contaminated shall be thoroughly cleaned to remove soluble contaminants (e.g. salt), or washing with solvent or detergent in order to remove organic material (e.g. oil or amine bloom), and/or hand sanding or light brush blasting as necessary, before overcoating.

After cleaning, the coating around any damaged area shall be feathered to ensure continuity of the patch coating and the full system reinstated.

9.12.2 Paint affected by on-site welding

Where the paint coating is affected by subsequent on-site welding, the following steps shall be followed:

(a) Remove weld spatter.

(b) Power tool clean welds to remove scale, spatter, roughness and entrapped slag. For a high integrity coating, abrasive blasting is preferred, or bristle blasting or disc grinding where not practical. Take care not to damage nearby sound paint or equipment but ensure the edge of the sound paint is 'feathered' and smooth. Wire brushing or other processes which burnish the surface shall not be used with high integrity coating systems.

(c) Remove any steel filings and dust by vacuuming or compressed air.

(d) Prime weld immediately with specified primer. Ensure that the primer overlaps the adjacent sound unaffected coating by not less than 25 mm and not more than 50 mm.

(e) Apply intermediate and top coats over the primed area to match the surrounding coating system. Ensure that the subsequent coats overlap the adjacent sound unaffected coating by not less than 25 mm and not more than 50 mm.

9.12.3 Galvanized surfaces

Repair after site handling and installation and site repair generally shall comply with AS/NZS 4680.

9.13 CATHODIC PROTECTION

Cathodic protection shall comply with the provisions of AS 2832.1 to AS 2832.5 in respect of the selection of coatings and resistance to cathodic disbondment.

NOTE: Cathodic protection for the corrosion protection of metals applies to buried or immersed structures or parts of structures. For effective operation of the protection, electrical continuity is essential and that the protection system is applied in coordination with any other adjacent buried or submerged metallic structures.

9.14 GALVANIC COUPLING

Contact between different metals, such as between stainless steel and structural steel, or between zinc coated steel and other metals such as copper, lead and stainless steel should be avoided.

If stainless steel is welded to structural steel, the corrosion protection system (including surface preparation and corrosion protection) shall continue from the structural steel element across the weld and on to the stainless steel for a minimum distance of 50 mm.

NOTE: A discussion of bimetallic contact is contained in AS 4036, AS/NZS 2312.1 and AS/NZS 2312.2.

SECTION 10 ARCHITECTURALLY EXPOSED STRUCTURAL STEELWORK

10.1 GENERAL

Where members are specifically designated in the construction specification as 'architecturally exposed structural steelwork' (AESS), the additional requirements of this Section shall apply.

10.2 CATEGORIES OF AESS

Categories of AESS are listed in the AESS Matrix shown in Table 10.2 where each category is represented by a set of characteristics. The following categories shall be used when referring to AESS:

(a) AESS 1—Basic elements which require enhanced workmanship.

(b) AESS 2—Feature elements viewed at a distance greater than 6 m requiring good fabrication practices with enhanced treatment of weld, connection, fabrication detail, tolerances for gaps and copes.

(c) AESS 3—Feature elements viewed at a distance of less than 6 m requiring welds that are generally smooth but visible, some grind marks are acceptable. Tolerances are tighter than normal standards.

(d) AESS 4—Showcase or dominant elements used where the designer intends that the form is the only feature showing in an element. All welds which have ground and filled edges are ground smooth and true. All surfaces are sanded and filled to be 'glove smooth'. Tolerances of fabricated items are more stringent.

(e) AESS C—Custom elements.

TABLE 10.2

ARCHITECTURALLY EXPOSED STRUCTURAL STEEL MATRIX

Category	AESS C Custom elements	AESS 4 Showcase elements	AESS 3 Feature elements	AESS 2 Feature elements	AESS 1 Basic elements	Notes
Viewing distance			Viewed at a distance ≤6 m	Viewed at a distance >6 m		
Characteristics						
1.1 Surface preparation		✓	✓	✓	✓	At least Sa2
1.2 Sharp edges ground smooth		✓	✓	✓	✓	
1.3 Continuous weld appearance		✓	✓	✓	✓	Intermittent welds are made continuous, either with additional welding, caulking or body filler.
1.4 Standard structural bolts		✓	✓	✓	✓	See Clause 10.5(g).
1.5 Weld spatters removed		✓	✓	✓	✓	
2.1 Visual samples		Optional	Optional	Optional	Optional	Visual samples are a 3D rendering, a physical sample, a first off inspection, a scaled mock-up or a full-scale mock-up, as specified in the construction specification.
2.2 One-half standard fabrication tolerances		✓	✓	✓		These tolerances are required to be one-half of those for standard structural steel as specified in Appendix F.
2.3 Fabrication marks not apparent		✓	✓	✓		Specific numbers marked on members during the fabrication and erection process are to be made not visible.
2.4 Welds uniform and smooth		✓	✓	✓		See Clauses 10.4(j) and 10.4(m).
3.1 Mill marks removed		✓	✓			All mill marks are not to be visible in the finished product.
3.2 Butt and plug welds ground smooth and filled		✓	✓			Caulking or body filler is acceptable.

(*continued*)

TABLE 10.2 (*continued*)

Category	AESS C Custom elements	AESS 4 Showcase elements	AESS 3 Feature elements	AESS 2 Feature elements	AESS 1 Basic elements	Notes
3.3 RHS/CHS weld seam oriented for reduced visibility		✓	✓			
3.4 Cross-sectional abutting surface aligned		✓	✓			See Clause 10.4(f).
3.5 Joint gap tolerances minimized		✓	✓			This characteristic is similar to 2.2 above. A clear distance between abutting members of 3 mm is required.
3.6 All welded connections		Optional	Optional			Hidden bolts may be considered.
4.1 RHS/CHS seam not apparent		✓				RHS/CHS seams are to be treated so they are not visible.
4.2 Welds contoured and blended		✓				In addition to a contoured and blended appearance, welded transitions between members are also required to be contoured and blended.
4.3 Surfaces filled and sanded		✓				Steel surface imperfections shall be filled and sanded.
4.4 Weld show-through minimized		✓				Weld show-through on the back face of the welded element caused by the welding process can be minimized by hand grinding the back face.
C1						Custom elements as required.

10.3 CONSTRUCTION SPECIFICATION INFORMATION

The AESS category for specific members and components and detailed requirements shall be provided in the construction specification (see Appendix B). Any specific requirements in relation to machined surfaces or locally abraded surfaces shall be identified in all shop detail drawings and erection drawings. In addition, the following shall be identified:

(a) If distinction is to be made between different surfaces or parts of members the transition line/plane.

(b) Tack welds, temporary braces, or fixtures used in fabrication.

(c) Fabrication and erection tolerances that are more restrictive than provided for in Appendix F.

(d) All architecturally sensitive connection details.

(e) Any specific requirements for Category AESS C.

Any requirements for a visual sample of a first-off component for inspection and acceptance standards prior to the start of fabrication shall be nominated in the construction specification.

10.4 ADDITIONAL FABRICATION REQUIRMENTS FOR AESS

Additional requirements during fabrication for AESS shall be as follows:

(a) Special care shall be taken in handling the steel in order to avoid marking or distorting the steel members.

(b) All slings shall be nylon type or chains with softeners or wire rope with softeners and all tie downs on loads shall be either nylon strap or chains with softeners.

(c) Care shall be taken to minimize damage to any corrosion protection coating.

(d) Tack welds shall be ground smooth.

(e) Any temporary braces or fixtures required for fabrication and transport shall have any blemishes or unsightly surfaces resulting from their removal repaired.

(f) For categories AESS 3 and 4, the matching of abutting cross-sections is required, unless specified otherwise in the construction specification.

(g) For categories AESS 2, 3 and 4 the as-fabricated straightness tolerance shall be one-half of that specified in Appendix F.

(h) For categories AESS 3 and 4, all copes, mitres and butt cuts in surfaces exposed to view shall be made with uniform gaps, if shown to be open jointed, or in uniform contact if shown without a gap.

(i) For corrosive environments, all joints shall be seal welded.

(j) A smooth uniform weld is acceptable for categories AESS 1, 2 and 3 but for category AESS 4 the weld shall be contoured and blended.

(k) All weld spatter, slivers and surface discontinuities shall be removed for all categories of AESS.

(l) In addition to the above Items (j) and (k), treatment grade shall be P3 (see Clause 9.8.4).

(m) A weld projection of up to 2 mm is acceptable for butt and plug welded joints for categories AESS 1 and 2 but for categories AESS 3 and 4 welds shall be ground smooth.

(n) Weld show-through is acceptable for categories AESS 1, 2 and 3 while for AESS 4 the fabricator shall attempt to minimize weld show-through.

(o) Sharp edges resulting from flame cutting, grinding and shearing shall be softened.

(p) Unless specified otherwise in the construction specification or this Standard, the surface cleaning shall meet at least Sa2 to AS 1627.4.

(q) For hollow sections seams as produced shall be acceptable for categories AESS 1 and 2, for AESS 3 seams shall be oriented away from view, and for AESS 4 seams shall be treated so that they are not apparent.

10.5 ADDITIONAL ERECTION REQUIREMENTS FOR AESS

Special care shall be used when unloading, handling and erecting the AESS in order to avoid marking or distorting the steelwork. The erection process shall be planned and executed in such a manner that allows the architectural appearance of the steelwork to be maintained.

Additional requirements during erection for AESS shall be as follows:

(a) All slings shall be nylon strap or chains with softeners.

(b) Care shall be taken to minimize damage to any corrosion protection.

(c) Any temporary braces or fixtures required for transport or erection shall have any blemishes or unsightly surfaces resulting from their removal repaired.

(d) Tack welds shall be ground smooth.

(e) Holes shall be ground smooth and filled with weld metal or body filler and smoothed by grinding or filling to the same standard as the fabrication originally.

(f) All backing bars for site welds shall be removed and the area around ground smooth and the corrosion protection repaired in accordance with Clause 9.12.

(g) All bolt heads shall be on the same side in a connection and consistent from one connection to another.

(h) Unless otherwise specified in the construction specification, members and components shall comply with the tolerances specified in Appendix F.

SECTION 11 ERECTION

11.1 GENERAL

This Section contains requirements for erection of structural steelwork and associated work on-site.

Work carried out on-site which involves cutting, shaping, holing, welding, mechanical fastening, surface preparation and painting shall comply with the relevant Clauses of Sections 6, 7, 8 and 9 respectively.

Erection tolerances shall comply with Appendix F.

Inspection and testing of the erected structure shall be undertaken in accordance with Section 13.

Any site modifications made during erection shall comply with Sections 6, 7, 8, 9 and 14 as appropriate.

Modifications to any element, in particular damaged elements, shall be assessed and repaired to meet in-service requirements. Approval of repair shall be obtained from a competent person.

11.2 SITE PLANNING

11.2.1 Safety plan

High risk construction work (see Clause 11.2.4) shall include an erection plan.

Steel structures that have unusual or atypical features which present special hazards or risks during the construction phase, or are outside the type of structures which are typically erected, shall include an erection plan.

During the erection of the structural steelwork, the steelwork shall be made safe against erection loading, including loading due to erection equipment and stacked materials, the operation of erection equipment and wind.

11.2.2 Quality management system

The operations detailed in this section shall be managed under a suitable quality management system.

NOTES:

1 An example of a suitable quality management system is set out in AS/NZS ISO 9001.

2 The level of documentation will generally increase with the construction category from CC1 to CC4. Guidance on the elements of a suitable quality management system aligned with the requirements of the construction categories is provided in Appendix D.

Quality documentation requirements are set out in Clause 4.5.1.

11.2.3 Work method statement

A documented work method statement (WMS) shall be prepared before any erection work commences. This shall be made available to all personnel involved in the works.

The WMS should include erection specific drawings (see Clause 11.6) and details of any temporary bracing or temporary restraint required and the time period for which each temporary item is required.

11.2.4 Risk assessment

Hazard identification and risk assessment shall be carried out and shall be done before any erection work commences. The outcome of this assessment should be documented and made available to all personnel involved in the works.

11.2.5 Lifting equipment and associated personnel

Erection work involving large or complex lifts should have a documented safe operation procedure, associated lift studies, lifting maps and sequencing diagrams for such lifts available, in addition to the requirements in Clauses 11.2.1 to 11.2.4.

Where required by the construction specification, all registrable lifting equipment to be used on the site shall have its proof of registration available for inspection by a competent person. Documented maintenance and inspection records for the lifting equipment to be used on the site shall be available for inspection by a competent person.

Lifting equipment shall be installed and commissioned by a competent person in accordance with the manufacturer's written documentation and industry accepted best practice.

Where personnel associated with operation of the lifting equipment are required to hold a current relevant high risk licence applicable to the type of lifting being undertaken, such licences shall be available for inspection when required.

11.3 SITE SURVEY

A system shall be established and maintained for the setting out and measurement of the construction works. The set out for the structural steelwork and site measurements of the steelwork set out shall be related to this system.

All setting out of the structural steelwork shall be done by competent personnel. All surveys carried out in relation to this set out shall be documented and verified.

A reference temperature of 20°C shall be used for setting out and measuring the structural steelwork.

Any deviation in position or level of the footings or structure to which steel members are to be connected, shall be measured relative to the system used for setting out. Any rectification required due to a deviation in position shall be documented in a detailed written procedure, and shall be complied with.

11.4 ERECTION DESIGN

The stability design of the whole structure shall be checked for each stage during erection, up to completion. Special care shall be taken in design and construction to guard against progressive collapse during construction.

11.5 ERECTION PROCESS

11.5.1 Erection sequence methodology (ESM)

For high risk construction work, or work that is unusual or atypical, an erection sequence methodology shall be prepared addressing any unusual or atypical requirements and at least the information required in Clauses 11.5.2, 11.5.3 and 11.5.4. The erection sequence methodology shall be reviewed by a competent person.

NOTE: The ESM describes the step-by step-procedures, with all associated technical and supporting documents, required to safely erect a multi-element structural steel structure. The ESM is an outcome of all risk planning workshops held with respect to the structural steel scope of work.

11.5.2 Equipment support

Equipment supported on partly or fully erected steelwork shall not induce actions or deflections in the steel greater than the design capacity calculated in accordance with the provisions of AS 4100, AS 5100.6 or NZS 3404.1 as applicable.

Equipment supported on suspended structures or concrete slabs on ground shall have the capacity of the supporting structure to support the equipment at various stages of the erection process and at all probable locations of the equipment reviewed and documented by a competent person. If a system of propping of suspended structures is required, this shall be designed and documented by a competent person.

11.5.3 Installation of temporary supports

No part of the structural steelwork shall be permanently distorted by stacking of materials or by temporary erection loads during the erection process.

Throughout the erection process, the structural steelwork shall be securely fastened to ensure that it can adequately withstand all loadings liable to be encountered during erection, including those from erection equipment, stacked materials, the operation of erection equipment and wind acting on the already erected members.

A review of the erection method and any transient loading due to the erection method shall be undertaken by a competent person.

11.5.4 Temporary members

Bracing and propping shall be installed in accordance with the ESM unless prior written approval for variation has been obtained from a competent person.

Temporary supports shall not be moved, removed or modified without prior written approval from a competent person. Any installed temporary supports that are damaged shall be reported.

Any temporary bracing or temporary restraint shall be left in position until such time as the erection process is sufficiently advanced to allow its safe removal in accordance with the WMS (see Clause 11.2.3).

All connections for temporary bracing and restraints provided for erection purposes shall be made in accordance with Section 6 or 7, as appropriate, and shall not weaken the completed structure nor impair its serviceability.

If welding backing bars and pull-in cleats are used to support a member or the structure itself during site welding, they and the connecting welds shall comply with AS 4100, AS 5100.6 or NZS 3404.1 as appropriate for the erection loads involved.

11.5.5 Inspection and removal of temporary supports

Prior to the removal of braces, props, frames and other items providing temporary support, the structure shall be inspected by a competent person to ensure that all permanent structural elements affecting stability are in place and securely fixed in accordance with the structural drawings.

Where projects are staged, such inspections and approvals can be undertaken progressively.

The removal of temporary support from an element shall be planned and conducted in a controlled manner to prevent risk of injury to people, or damage to the equipment and the structure. Prior to the removal of temporary supports, a written approval shall be obtained.

11.5.6 Handling and storage

Members, components and fasteners shall be stacked and handled in such a way that they are safely stored and so that no surface abrasion, damage nor permanent deformation is caused to them on-site.

Fasteners and small components shall be kept in the packages they are supplied in and shall be stored in accordance with the manufacturer's specifications and Clause 8.2.5.

Means shall be provided so as to minimize damage to the corrosion protection on the steelwork in accordance with Clause 9.9.19 (painted surfaces) and 9.10.10 (galvanized surfaces).

Surfaces prepared for full contact shall be suitably protected.

Any steel members or components damaged during off-loading, site storage or erection shall be restored to the requirements of this Standard using methods complying with Section 14.

Any damage to painted or galvanized surfaces shall be repaired in accordance with Section 13.

11.5.7 Assembly and alignment

All matching holes shall align with each other so that a drift pin, equal in diameter to that of the matching holes, shall pass freely through the assembled contact faces perpendicular to them. Any necessary drifting shall be done in such a manner that no distortion of the holes surrounds or enlargement of the holes occurs.

Correction of misalignment of holes shall be by reaming or by using a hollow milling cutter. The internal finish of the reamed or milled holes shall be checked for compliance with the requirements of Clause 6.7. Holes may only be made oversize or slotted if not originally so, provided all the requirements of Clause 6.7 are complied with.

Assembly of bolted connections shall comply with the provisions of Clause 8.3 for snug-tightened connections and tensioning shall comply with the provisions of Clause 8.5.

Each part of the structure shall be aligned as soon as possible after it has been erected and final assembly should be completed as soon as practicable thereafter. Permanent connections shall not be made between members until sufficient of the structure has been aligned, plumbed and temporarily connected so as to ensure that members will not be displaced during the erection of subsequent members or affect the alignment of the remainder of the structure.

Alignment of the structure and lack of fit in connections may be corrected by the use of packers or shims (see Clause 11.5.7) which shall be secured if they could come loose. Any welding to them shall be in accordance with Section 7.

Hand flame cutting of a bolt hole shall not be permitted except as a site rectification measure for holes in column base plates.

Site welding shall comply with the provisions of Section 7. Precautions shall be taken so that any welding current does not damage any members or connections that it passes through. Precaution shall be taken so that return earth connections are made local to the area being welded.

11.5.8 Packing

Refer to Clause 8.2.1 for details of packing.

11.5.9 Architecturally exposed structural steelwork

Steelwork identified in the construction specification as architecturally exposed structural steelwork (AESS) shall comply with the requirements of Section 10 in addition to the requirements of this Section.

11.5.10 Temporary erection

Where required in the construction specification, steelwork shall be temporarily erected at the fabrication works and reviewed by a competent person.

11.5.11 Assembly of weathering steel components

Weathering steel assemblies can give rise to a risk of crevice corrosion as rust is not protective within the crevice. To minimize such risk, plates should be assembled with proper fit-up and bolt spacing should be minimized. Sealants should be used to protect the joint if crevices still occur.

11.6 SUPPORTS

11.6.1 Suitability of permanent supports

The suitability of the supports to receive the steel structure and the location of the supports and any anchor bolts or bearings shall have been checked by a documented survey and by a documented visual examination before the start of the erection process.

Erection shall not commence until the location, levels and condition of the supports, anchor bolts and bearings have all been checked against the construction specification.

While erection is proceeding, the supports for the steelwork shall be maintained in an equivalent condition to that at the start of erection. Compensation for any settlement of supports shall be done using grouting or packing between the steelwork and the support in accordance with written instructions.

11.6.2 Bearings, anchor bolts and anchoring devices

Installation of bearings shall be in accordance with the manufacturer's written procedure or with the construction specification, as applicable.

Cast-in anchor bolts intended to be able to be adjusted in sleeves should be provided with sleeves that have a diameter three times that of the bolt with a minimum of 75 mm, and should have a depth no more than half the embedment depth of the anchor bolt.

If the anchor bolts are to be post-tensioned, the upper 100 mm as a minimum of the bolts should have no adhesion to the concrete support.

Anchoring devices in a concrete support shall be set in place in accordance with the construction specification. Suitable measures shall be taken to avoid damage to the concrete support. Mechanical and chemical anchors shall be installed in accordance with Clause 8.8.

Anchor bolt threads and nuts shall be adequately protected against mechanical damage, accretion of concrete or cement or grout and against corrosion at all stages of the erection process. Nuts shall be run up on threads to check that they will run freely before erection of the incoming steel member commences. If the nut does not run freely, any deleterious material shall be removed or if the tread is damaged it shall be repaired.

11.6.3 Temporary supports

Shims packers and other supporting devices used as temporary supports under base plates shall present a flat surface to the steel and shall be of adequate size, strength and rigidity to avoid local crushing of the supporting concrete or masonry. They shall be placed so that they do not prevent the spaces being filled during subsequent grouting or mortaring.

Shims and packers may be left in place once erection is completed only if allowed by the construction specification. If left in place, they shall be made from the same materials with the same corrosion protection as the adjacent steel components, and are to be grouted in place and shall be so located that the grout encloses them with a minimum cover of 25 mm unless additional cover is specified in the construction specification.

If adjustment to the level of the base plate is achieved using levelling nuts on the anchor bolts under the base plate, these nuts should be left in position. The nuts shall be suitable for the corrosion environment and suitable to maintain the stability of the part-erected structure and shall not adversely affect the performance of the footing bolt in service.

11.6.4 Grouting or mortaring at supports

Bedding under a base plate or a bearing sitting on concrete or masonry shall be provided by grout or mortar and shall comply with Clause 5.8. The grout or mortar shall completely fill the space to be grouted. Grout shall be placed either under pressure or by ramming against fixed supports. Mortar shall be rammed against fixed supports. Vent holes shall be provided in the base plate or bearing as necessary.

Grouting or mortaring shall not be carried out until a sufficient portion of the structure has been aligned, levelled, plumbed and adequately braced by other structural members or supports which themselves have been levelled and are securely held by their permanent fastenings.

The space between the base plate and the support shall be thoroughly cleaned and shall be free from moisture, pooled water, debris and any contaminants immediately before grouting or mortaring. The space shall be completely filled by the grout or mortar.

Grout material shall be mixed and used in accordance with the product manufacturer's specifications, in particular in relation to the consistency to be used. Grout material shall not be used below 0°C unless permitted in the manufacturer's specifications.

If any treatment of the steelwork, base plates, bearings or concrete surfaces is required before grouting or mortaring, this treatment shall be specified in the construction specification.

Hold down fasteners shall not be released to facilitate grout installation without approval from a competent person.

11.7 ERECTION DRAWINGS

The construction specification should specify if erection drawings are to be prepared and who should prepare them. If not stated in the construction specification, shop detail drawings complying with the requirements of this Clause should be used as erection drawings.

Erection drawings shall be prepared showing plans and elevations and at such a scale that the erection marks for all members and components can be shown on them. Erection drawings shall show grid locations, bearing or support positions together with tolerance requirements.

Footing plans shall show the footing location and level, base plate or bearing location and level, orientation of the steelwork, any other components in direct contact with the footing, and the relevant datum for the levels. Elevations shall show the same levels and the required levels of structure and floors.

Footing drawings shall show all necessary details for fixing the steel to anchor bolts or bearings in the footings, including details of the anchor bolts or bearings, the method of adjustment by packing or shimming and the grout or mortar requirements.

Erection drawings shall show details and arrangements of any steelwork or temporary work necessary for erection purposes.

Erection drawings shall state the weight of all components or assemblies over 5 t and the centre of gravity of all large or irregular items.

Erection drawings shall state the identification mark to be used for erection. Marks should be placed where they will be visible in storage and after erection. Marks shall comply with Clause 6.2.

Erection drawings shall show any required sequencing in the erection of members, bracing and temporary members.

NOTE: For larger or more complex projects, erection sequence diagrams are recommended to display in a clear pictorial manner the planned sequence of erection and would usually be included as part of the ESM.

11.8 ERECTION WORK AT SITE

The erection of the structural steelwork shall be carried out in conformity with the following:

(a) The site safety plan.

(b) The QMS.

(c) The WMS.

(d) This Section.

(e) The ESM.

The stability of the partially erected structure shall be maintained at all times.

If the erection procedure involves rolling or otherwise moving a part or all of the structure into its final erected position, provision shall be made for controlled braking of the moving mass and provision may also need to be made for reversing the direction of movement and for any temporary works should the process need to be halted part way through.

All temporary anchoring devices shall be made secure against unintentional release. Only jacks that can be locked in position under load shall be used.

Any site modifications shall comply with Section 14.

11.9 SUPERVISION

For CC2, CC3 and CC4, erection shall be supervised by competent personnel.

NOTE: An example of qualification of competent personnel is a rigging or advanced rigging qualification and 10 years' experience in the erection of structural steelwork.

SECTION 12 GEOMETRICAL TOLERANCES

12.1 GENERAL

This Section defines the geometrical deviations permitted in fabricated and erected structural steelwork. Two types of permitted deviations are defined:

(a) *Essential tolerances*—applicable to a range of criteria that are essential for the mechanical resistance and stability of the completed structure. In many cases these are compatible with assumptions made in formulating the expressions for design capacity in AS 4100, AS 5100.6, AS/NZS 4600, AS 2327 and NZS 3404.1, as appropriate.

(b) *Functional tolerances*—required to fulfil other criteria, such as fit-up and appearance. Functional tolerances have two classes defined, Class 1 and Class 2, for which requirement strictness increases from Class 1 to Class 2.

Quantitative values for both essential tolerances and functional tolerances are provided in Appendix F. Essential and functional tolerances shall be complied with. Functional tolerances and the appropriate class may be specified in the construction specification or the relevant application Standard (AS 5100.6 for example). Where not specified, Class 1 shall apply.

NOTE: For Construction category 3 and 4, Class 2 should be considered.

The permitted geometrical deviations are independent of elastic deformations induced by the self-weight of members, which shall be separately assessed.

The tolerances specified for fabricated components shall be met in addition to those for manufactured components supplied by a manufacturer upon which fabrication takes place.

The tolerances specified for the final checking of the erected structure shall be met in addition to those for fabricated components.

Modifications to the tolerances contained in Appendix F and special or additional tolerances may also be separately specified in the construction specification. If modifications to tolerances or special or additional tolerances are specified in the construction specification, the following information shall be contained within the construction specification:

(i) Details of any amendment to tolerances specified in this Standard.

(ii) Defined parameters and permissible values for any special or additional geometrical tolerances required to be controlled.

(iii) Whether the special or additional tolerances apply to all affected components or particular components.

12.2 MEASUREMENT

The measurement of fabricated and erected components shall be in accordance with Clauses 13.4 and 13.11.

12.3 NONCONFORMANCE OF ESSENTIAL TOLERANCES

For essential tolerances, the values specified are permissible deviations. If the actual deviation exceeds the permissible value, the essential tolerance shall be corrected such that the actual deviation is within the permissible value.

The deviation of an essential tolerance above the specified value may be acceptable, when the excessive deviation is included explicitly in a revised calculation of design capacity using the relevant design provisions of AS 4100, AS 5100.6, AS/NZS 4600, AS 2327 or NZS 3404.1 as appropriate.

12.4 NONCONFORMANCE OF OTHER THAN ESSENTIAL TOLERANCES

For other than essential tolerances, the values specified are permissible deviations. If the actual deviation exceeds the permissible value, the deviation shall be corrected such that the actual deviation is within the permissible value.

SECTION 13 INSPECTION, TESTING AND CORRECTION

13.1 GENERAL

This Section specifies the requirements for inspection, testing and correction with respect to the requirements included in this Standard, the requirements in the construction specification, the quality documentation (see Clause 4.5.1) and the quality plan (see Clause 4.5.2), as relevant.

NOTE: Inspection requirements may be carried out by first, second or third parties.

All inspection and testing at each stage shall be undertaken in accordance with a documented inspection and test plan (ITP) for that stage using documented procedures. The ITPs for each stage shall be documented in or attached to the quality plan, where a quality plan is required by this Standard or the construction specification.

The inspection and testing requirements at each stage are set out in Clauses 13.3 to 13.12 inclusive, and the ITP shall include at least these requirements, and any additional requirements contained in the construction specification. The ITP shall also include any options relating to inspection and testing from Appendix B, Tables B1 and B2 that are included in the construction specification.

All results of inspections and testing, and any resultant actions arising from the inspections and details of any corrections (if required) shall be documented.

13.2 INSPECTION

Inspection shall be undertaken at each stage of the overall process of material and component procurement, fabrication, surface preparation, painting, galvanizing and erecting the structural steel.

The competency of the personnel inspecting shall be, as a minimum, as set out in this Section. The construction specification may specify additional requirements.

13.3 INSPECTION OF MATERIALS AND COMPONENTS

13.3.1 General

Documents supplied with materials, in accordance with the requirements of Section 5, shall be checked to verify that the information on the products supplied matches those ordered.

13.3.2 Inspection and test plan

For all construction categories except CC1, an ITP should be prepared covering the inspection against the relevant Standards for materials and components.

The ITPs shall include for incoming inspection of all raw materials, products, parts and consumables.

Where the relevant Standard contains specific inspection and testing requirements covering the same subject, these shall take precedence over requirements in this Standard.

13.3.3 Competency of the inspection personnel

Inspection of materials shall be undertaken by a competent person.

NOTE: An example of qualification of competent personnel is experience in application of the relevant Standards and over 10 years' experience in structural steel fabrication.

13.3.4 Structural steels

Documentation complying with Clause 5.2 shall be inspected and checked to verify that the information contained therein complies with—

(a) structural steel requirements that were specified in the construction specification;

(b) documentation for the structural steel that was ordered;

(c) requirements of Clause 5.3 in all respects; and

(d) requirements for documentation in the relevant Standard.

Marking of the structural steel supplied shall be checked against the relevant Standard.

13.3.5 Metallic coated steels

Documentation in respect of all metallic coated steel supplied to AS 1397 shall be inspected and checked. Such documentation shall comply with Clauses 5.2 and 5.3.

Marking of the metallic coated steels shall be checked against the requirements of the relevant Standard.

13.3.6 Pre-fabricated components

Documentation complying with Clause 5.2 shall be inspected and checked to verify that the information contained therein complies with the construction specification and with the details of the component that was ordered, and that all properties of the material incorporated into the component comply with the requirements of Clauses 5.3, 5.4 and 5.5, as applicable.

Marking of each component supplied shall be checked against the requirements of Clause 5.2.

Documentation of ITPs and results of inspections carried out in manufacturing the pre-fabricated component shall be inspected and checked against the requirements in the following Clauses:

(a) Clause 13.3—Materials.

(b) Clause 13.5—Preparation and assembly.

(c) Clause 13.6—Welding.

(d) Clause 13.7—Mechanical fasteners where such fasteners are installed in the pre-fabricated component.

(e) Clause 13.8—Surface preparation where carried out on the pre-fabricated component.

(f) Clause 13.9—Paint coatings where the pre-fabricated component is painted.

(g) Clause 13.10—Galvanized coatings where the pre-fabricated component is galvanized.

NOTE: This Clause applies to all part-fabricated components delivered to the fabricator's works for inclusion in a fabricated item and to pre-fabricated components delivered directly to site for erection, if these components are not fabricated by the fabricator.

13.3.7 Nonconforming steel or components

If the documentation supplied does not meet the requirements of Clauses 13.3.4, 13.3.5 and 13.3.6 as applicable, or is inadequate or incomplete such that compliance with Clause 5.3 cannot be reliably established, the steel material or component shall be treated as nonconforming and treated as unidentified steel in terms of AS 4100, AS/NZS 4600, AS 5100.6 and NZS 3404.1 as applicable, until such time as it can be reliably established that the steel material meets the above requirements.

NOTE: AS 4100, AS/NZS 4600, AS 5100.6 and NZS 3404.1 require that unidentified steel be assumed to have a yield stress of 170 MPa.

If testing of nonconforming material or components is undertaken, the results of all testing shall be in accordance with Clause 13.3.8 and the results of such testing shall be fully documented.

13.3.8 Testing of nonconforming steel or components

The type of testing shall be consistent with the type of testing specified in the relevant product Standard cited in Clause 5.3, and shall be sufficient to establish a proper statistical basis. Single or limited test results shall not be acceptable. Appropriate statistical processes shall be applied to multiple samples in order to establish confidence in the properties of the product.

NOTE: AS 5104—2005, Appendix D, Design based on experimental models, provides guidance on assessment of design values based on statistical sampling.

13.3.9 Offcuts or unused material

Plate or section not fully utilized and returned to stock for use on other projects or elsewhere in the current project, shall have the heat and serial number transferred in accordance with a documented procedure by a competent person on an inspection record sheet.

13.4 MEASUREMENT OF FABRICATED AND ERECTED COMPONENTS

Appropriate dimensions of members, components, fabricated assemblies and erected structures shall be inspected and checked against the tolerance requirements of Appendix F.

Appropriate methods of measurement and instruments to be used shall be selected from those listed in ISO 7976-1 and ISO 7976-2. Accuracy of measurement shall be assessed in accordance with the requirements of the relevant Part of ISO 17123. The location of and frequency of any measurements shall be specified in the ITP.

If inspection results in the identification of nonconformity, the action on such nonconformity shall be as follows:

(a) If practical, the nonconformity shall be corrected using methods that are in accordance with this Standard and checked again.

(b) If correction is not practicable, modifications to the steel structure may be made to compensate for the nonconformity provided that this is in accordance with a written procedure for handling nonconformities.

13.5 INSPECTION OF PREPARATION AND ASSEMBLY

13.5.1 Inspection and test plan

For all construction categories except CC1, an ITP for preparation and assembly shall cover the inspection of the following:

(a) Identification (see Clause 6.2).

(b) Handling and storage (see Clause 6.3).

(c) Cutting (see Clause 6.5).

(d) Shaping (see Clause 6.6).

(e) Holing (see Clause 6.7).

(f) Full contact bearing surfaces (see Clause 6.8).

(g) Assembly and assembly check (see Clauses 6.9 and 6.10).

(h) Any requirements for packing plates (see Clause 11.5.7).

(i) Pinned connections (see Clause 6.7.6).

(j) Arrangements for transit to site (see Clause 6.11).

(k) Any special requirements of the construction specification.

(l) Any options from Appendix B, Tables B1 and B2 included in the construction specification in relation to preparation and assembly.

The ITP shall include for an inspection of the surface of all steel material for defects before any fabrication commences. If surface defects are detected during this inspection and are repaired using methods that are in accordance with this Standard, the repaired product may be used provided that its mechanical properties comply with those specified in the relevant product Standard.

Inspection shall be by visual means and measurement in the case of member and component dimensions, cut surface roughness, hole dimensions, full contact bearing surfaces and assembly. All measurement shall comply with Clause 13.4.

The ITP shall nominate who is to carry out the inspections and the stage at which the inspections are to be carried out.

13.5.2 Competency of inspection personnel

Inspection of preparation and assembly shall be undertaken by a competent person.

NOTE: An example of qualification of competent personnel is a relevant trade qualification and over 10 years' experience in structural steel fabrication.

13.5.3 Inspection report

The results of all inspections shall be documented and the documentation shall include the name of the competent person inspecting, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected against and the result of the inspection.

13.6 INSPECTION OF WELDING

13.6.1 Inspection of weldments—General requirements

13.6.1.1 *General*

Inspection before, during and after welding shall be included in the inspection plan (also referred to as the inspection and test plan or ITP) in accordance with the requirements given in Clause 13.6.1.2 and Table 13.6.

The extent and method of non-destructive examination (NDE) shall be specified in the construction specification, and, shall specify the weld category applicable to each weld, which welded connections are to be inspected, and the extent of inspection to be carried out using each method of inspection. Any special inspection requirements shall be specified in the construction specification.

NDE including visual examination, shall be performed by suitably qualified personnel (see Clause 13.6.1.3).

Inspection requirements throughout the fabrication process are summarized in Table 13.6.

TABLE 13.6

INSPECTION REQUIREMENTS RELATED TO CONSTRUCTION CATEGORY FOR WELDING

Description	Construction category			
	CC1	CC2	CC3	CC4
Review of NDE and visual examination requirements (Note 1)	Not specified	Required	Required	Required
Review of extent of non-destructive examination after non-compliance	Not specified	Required	Required	Required
Qualification of the inspection personnel	Clause 13.6.1.3	Clause 13.6.1.3	Clause 13.6.1.3	Clause 13.6.1.3
Inspection and test plan	Clause 13.6.1.2	Clause 13.6.1.2	Clause 13.6.1.2	Clause 13.6.1.2
Inspection before, during and after welding	AS/NZS 1554	AS/NZS 1554	AS/NZS 1554, Clause 13.6.1.2	AS/NZS 1554, Clause 13.6.1.2

NOTES:

1 The minimum extent of non-destructive examination shall be specified on the engineering drawings or within the contract documentation.

2 AS/NZS ISO 3834.2 and AS/NZS ISO 3834.3 requires documented inspection as a minimum throughout the fabrication process.

13.6.1.2 *Inspection and test plan for welding*

For CC1 and CC2, an ITP shall be prepared—

(a) when required by the construction specification;

(b) where welding is subcontracted; or

(c) when the work is required to be inspected by an inspection authority or the principal (see AS/NZS 1554.1).

For CC3 and CC4, and where specified in the construction specification, an ITP shall be prepared covering the inspection of the following:

(i) Compliance with welding plan (see Clause 7.2).

(ii) Suitability and qualification of welding procedures (see Clause 7.4).

(iii) Qualification of welding personnel (see Clause 7.4.2).

(iv) Identity of parent material (see Clauses 5.2 and 5.3).

(v) Identity and compliance of welding consumables with relevant Standard (see Clause 5.4).

(vi) Joint preparation (see Clause 7.5.1).

(vii) Correct use and handling of welding consumables (see Clause 7.5.2).

(viii) Assembly for welding (including fit-up, jigging and tacking) (see Clause 7.5.4).

(ix) Monitoring of essential welding parameters (e.g. welding current, arc voltage and travel speed).

(x) Preheating and interpass temperature where applicable (see Clause 7.5.5).

(xi) Tack welds (see Clause 7.5.7).

(xii) Back gouging (see Clause 7.5.9.3).

(xiii) Temporary attachments (see Clause 7.5.6).

(xiv) Presence of arc strikes (see Clause 7.5.15.1).

(xv) Presence of weld spatter (see Clause 7.5.15.1).

(xvi) Interrun cleaning and shape of runs and layers of weld metal (see Clause 7.5.15.1).

(xvii) Cleaning of finished welds (see Clause 7.5.15.1).

(xviii) Dressing of butt welds where specified (see Clause 7.5.15.1).

(xix) Post weld heat treatment where specified (see Clause 7.5.14).

(xx) Visual examination of finished welds.

(xxi) Non-destructive examination of finished welds.

(xxii) Inspection of welds on weathering steel (see Clause 7.5.10).

(xxiii) Inspection of welds to be painted or galvanized (see Clause 7.5.15.2).

(xxiv) Inspection of welds on architecturally exposed structural steelwork (see Clause 7.5.15.3).

(xxv) Inspection of stud welds (see Clause 7.5.11).

(xxvi) Assessment against acceptance criteria (see Clause 7.6).

(xxvii) Any special requirements of the construction specification.

(xxviii) Any options from Appendix B, Tables B1 and B2 included in the construction specification in relation to preparation and assembly (see Section 6).

Inspection before, during and after welding shall be included in the ITP in accordance with the requirements of Clause 7.2.2, the construction specification and the QMS.

Inspection shall ensure that the provisions of the relevant clause quoted above, any additional provisions of the construction specification and any options from Appendix B, Tables B1 and B2 are complied with in all respects.

The ITP shall nominate who is to carry out the inspections and the stages at which the inspections are to be carried out.

The ITP shall identify the welds to be inspected and the method and extent of inspection to be used. Any special inspection requirements shall also be identified. This information shall reflect the requirements of the construction specification (see also Clause 13.6.1.4).

If the ITP requires a check of the fit-up before the welding of hollow section members prepared for branch welding, the following locations shall be given particular attention:

(A) For circular hollow sections—the mid-toe, mid-heel and two mid-flank positions.

(B) For square or rectangular hollow sections—the four corner positions.

For New Zealand only, the welding inspection should also comply with the requirements of Appendix I.

13.6.1.3 *Qualifications of inspection personnel*

Inspection personnel engaged in welding related inspection shall be suitably qualified to deal with the technical issues of this Standard and the relevant part(s) of AS/NZS 1554. The following apply:

(a) Inspection shall be carried out by personnel qualified in accordance with the requirements of the relevant clause in the application Standard (see Clause 7.1.2).

(b) Non-destructive examination (NDE) other than visual examination shall be carried out by personnel qualified according to Level 2 as defined in AS ISO 9712 or by personnel qualified according to Level 1 as defined in AS ISO 9712 under the supervision of a Level 2 qualified person.

13.6.1.4 *Inspection report*

The results of all inspections shall be documented and the documentation shall include the name of the inspector, the identification of the welded item and specific weld that was inspected, the date of the inspection, the requirements that were inspected against and the result of the inspection.

Any nonconformity shall be dealt with under the provisions of Clause 13.6.2.5.

13.6.2 Inspection after welding

13.6.2.1 *Timing*

The NDE of a weld (other than visual scanning and examination) shall not be completed until after the minimum hold time after welding shown in Table 13.6.2.1.

TABLE 13.6.2.1

MINIMUM HOLD TIMES

Weld size (see Note 1) mm	Heat input Q (see Note 2) kJ/mm	Hold time (hours) (see Note 3)	
		Steel types 1 to 8 (see Note 4)	Steel type 8Q and above
S ≤ 6	All	Cooling period only	24
6 < S ≤ 12	≤3	8	24
	>3	16	40
S > 12	≤3	16	40
	>3	40	48

NOTES:

1 Size applies to the design throat thickness DTT of a fillet weld or the nominal material thickness t of a complete penetration weld. For partial penetration butt welds the governing criterion is the design throat thickness, as specified in AS/NZS 1554.1.

2 Heat input Q to be calculated in accordance with AS/NZS 1554.1.

3 The time between weld completion and commencement of NDE shall be stated in the NDE report. In the case of 'cooling period only' this will last until the weld is cool enough for NDE to commence.

4 Steel types 7 and 8 includes variants A, B and C.

For welds requiring preheat, the periods in Table 13.6.2.1 may be reduced, if the weldment is post-heated for a period after welding is complete in accordance with Annex C of ISO/TR 17671-2:2002.

If a weld will become inaccessible through subsequent work, it shall be inspected prior to subsequent work being carried out.

Any weld located in a zone where unacceptable distortion has been corrected shall be inspected again.

13.6.2.2 *Scope of inspection*

All welds shall be visually examined throughout their full length. If surface imperfections are detected on a weld, surface testing by penetrant examination or magnetic particle examination should be carried out on the inspected weld.

The degree of welding inspection (visual and NDE) selected should be varied in a controlled manner throughout. The recommended degree of inspection is as follows:

(a) Examine the first five welded connections made with a new welding procedure specification (WPS) or at a rate double the rate specified in the construction specification.

(b) If the examination yields a weld imperfection within the inspection length in excess of the permissible levels, further examination shall be undertaken over two additional inspection lengths, one on each side of the length that includes the defect.

(c) If the examination yields a nonconforming weld, conduct an investigation and determine the reason for the nonconformance. Implement corrective action and examine a new set of connections made with the amended welding procedure specification.

(d) The minimum length of weld examined for each WPS should be 1.0 m.

(e) Once the results from the examination for the WPS are conforming, reduce the level of examination carried out to random spot checks if the weld quality remains complying.

(f) Further welds tested, which have been welded according to the same WPS, can be treated as a single continuing inspection lot. The percentage to be inspected visually or by supplementary NDE [see Tables 13.6.2.2 (A) and (B)] may be treated as the cumulative amount within each inspection lot.

(g) If imperfections in excess of permissible levels are encountered, the level of inspection shall be increased until confidence in the weld quality is re-established.

NOTE: For example, if an overall requirement of 10% of welds are to be examined ultrasonically, 20% of the initial welds including a minimum of one weld of each welder should be tested until it is established that the welding is being done satisfactorily. The amount of inspection can then be dropped off to random spot checking if the welding remains satisfactory. An overall inspected weld length of 10% approximately can be achieved by suitable manipulation of the extent of spot checking.

If not specified otherwise, the welded connections for inspection shall be selected at random with preference given to the examination of butt welds on tension flanges, and welded connections likely to be highly restrained such as T-butt and cruciform joints, particularly near plate edges.

Selected welded connections for inspection shall cover the following variables as widely as possible:

(i) The type of connection.

(ii) The steel grade.

(iii) The welding process and equipment used.

(iv) Different welders.

Nonconforming welds shall be corrected in accordance with Clause 13.6.2.5.

TABLE 13.6.2.2(A)

RECOMMENDED EXTENT AND TYPE OF NDE

Category	Visual	Other
CC1	100% visual scanning	Not required
CC2	100% visual scanning, 10% visual examination to AS/NZS 1554	5% ultrasonic examination (UT) on butt welds for SC2: • In tension flanges. • Cruciform joints. • Restrained joints at or near plate edges.
CC3	100% visual scanning, plus: • For weld category SP—20% visual examination to AS/NZS 1554. • For weld category FP—100% visual examination to AS/NZS 1554.	For weld category SP joints for SC2—10% UT of butt welds: • In tension flanges. • Cruciform joints. • Restrained joints at or near plate edges. Weld category FP joints for SC2: • See AS/NZS 1554 Part 4 or 5 (as appropriate).
CC4	As per client specification	

NOTES:

1 Ultrasonic examination should be supplemented by magnetic particle examination of the same welds.

2 Ultrasonic examination is not generally suited to steels thinner than 10 mm. Specialist advice should be sought if UT examination is required on thinner steels.

3 Percentage specified is of the weld length consistent with the philosophy adopted in AS/NZS 1554.

4 The use of magnetic particle is unusual except for supplementary inspection after visual examination for the types of structures and applications for which this Standard is intended, and their use is usually restricted to repairs (see Clause 6.1.1).

For Australia only, for structures designed and detailed to AS 4100 or AS 5100.6 earthquake design categories D and E, the extent and type of NDE shall be at least that given in Tables 13.6.2.2(A) or (B), whichever is the greater.

TABLE 13.6.2.2(B)

RECOMMENDED EXTENT AND TYPE OF NDE—EARTHQUAKE DESIGN CATEGORIES D AND E

Weld type	Visual scanning, %	Visual examination, %	Magnetic particle or dye penetrant, %
Butt welds in members or connections in tension	100	100	100
Butt welds in members or connections other than those in tension	100	50	10
All other welds in members or connections	100	20	5

For New Zealand only, for structures designed and detailed to NZS 3404.1, the recommended extent and type of NDE is defined in Appendix I.

13.6.2.3 *Visual examination*

The visual examination shall be performed after completion of welding in an area and before any other NDE is carried out.

NOTE: Visual examination is also commonly known as visual testing (VT).

Visual examination shall include the following:

(a) The presence and location of all welds and that the welds are in accordance with the construction specification.

(b) Examination of the welds in accordance with AS 3978.

(c) Checking for stray arcs and areas of weld spatter.

The examination of the shape and surface of welds of welded branch joints using hollow sections shall pay careful attention to the following locations:

(i) For circular hollow sections—the mid-toe, mid-heel and two mid-flank positions.

(ii) For square or rectangular hollow sections—the four corner positions.

13.6.2.4 *Non-destructive examination (NDE) of welds*

The extent of NDE covers both testing for surface and internal imperfections.

The following NDE methods shall be carried out in accordance with the requirements of AS/NZS 1554 (see Clause 7.1.2) and with the requirements of the Standard particular to each method:

(a) Visual examination (VT).

(b) Penetrant examination (PT) according to AS 2062.

(c) Magnetic particle examination (MT) according to AS 1171.

(d) Ultrasonic examination (UT) according to AS 2207.

(e) Radiographic examination (RT) according to AS 2177.

If an NDE method not referenced above is specified for use within the construction specification, it shall be carried out in accordance with a written procedure with specified acceptance levels (e.g. phased array UT in accordance with ISO 13588).

Permissible levels of imperfection shall be in accordance with the application Standard (see Clause 7.1.2) and the weld category nominated in the construction specification.

13.6.2.5 *Correction of welds*

Weld imperfections that exceed the levels given in the application Standard (Clause 7.1.2), shall be classed as defects.

However, where it can be demonstrated, by the use of fracture mechanics or other suitable methods of assessment, that the defects will not be injurious to the performance of the structure, such defects need not be repaired or re-welded, provided that, for any such defect, such methods of assessment are permitted by the construction specification and are acceptable to both the principal and the fabricator.

NOTE: For methods of fracture assessment and guidance on the effects of imperfections, see BS 7910 and WTIA Technical Note 10.

Imperfections of parent metal origin are not normally considered to be a cause for rejection of the weld. Parent metal discontinuities, which interfere with the examination, shall be reported to the principal and included in the test report.

Repairs of a defect by welding shall be carried out in accordance with a qualified welding procedure complying with Clause 7.4.

Corrected welds shall be reinspected to the same level as that originally specified and shall meet the requirements of the original welds.

13.6.3 Inspection and testing of welded shear studs for composite steel and concrete structures

Inspection and testing of welded shear studs for composite steel and concrete structures shall be carried out in accordance with AS/NZS 1554.2.

The inspection shall include checking the length of the studs after welding.

Nonconforming studs shall be replaced. Replacement studs to be welded in an adjacent new position.

The proper operation of welding equipment used on-site should be rechecked after it has been moved and at the commencement of each shift or other period of work by using tests on studs welded with the equipment in accordance with AS/NZS 1554.2.

13.6.4 Inspection of welds on enclosed spaces

If the construction specification does not call for additional non-destructive examination, seal welds shall be visually inspected.

13.7 INSPECTION OF MECHANICAL FASTENING

13.7.1 Inspection and test plan

For all construction categories except CC1, an ITP shall be prepared covering the inspection of the following:

(a) Identification and documentation (see Clauses 5.5.12 and 13.7.4).

(b) Tightness of snug-tight bolts (see Clause 8.3).

(c) Preparation of contact surfaces (see Clause 8.4).

(d) Installation of packing, if required (see Clause 11.5.7).

(e) Tension in tensioned high strength bolts achieved by part-turn method (see Clause 8.5.6).

(f) Tension in tensioned high strength bolts using direct-tension indication devices (see Clause 8.5.7).

(g) Installation of thin gauge fasteners (see Clause 8.6).

(h) Installation of specialized fasteners or fastening methods (see Clause 8.7).

(i) Installation of mechanical or chemical anchors (see Clause 8.8).

(j) Any special requirements of the construction specification.

(k) Any options from Appendix B, Tables B1 and B2 included in the construction specification in relation to mechanical fastening (Section 8).

The ITP shall nominate who is to carry out the inspections and the stages at which the inspections are to be carried out.

The ITP shall identify the bolted connections to be inspected and the method and extent of inspection to be used. Any special inspection requirements nominated in the construction specification shall also be identified.

13.7.2 Competency of inspection personnel

Inspection of mechanical fastening shall be undertaken by a competent person.

NOTES:

1 For mechanical fasteners, an example of qualification of competent personnel is a relevant trade qualification and over 10 years' experience in installation of mechanical fasteners.

2 For mechanical and chemical anchors, examples of qualifications of competent personnel are:

(a) A certification through the AEFAC Installer Certification Program.

(b) Specific training from the supplier of the product being installed.

13.7.3 Inspection report

The results of all inspections shall be documented and the documentation shall include the name of the inspector, the identification of the mechanically fastened item or mechanical fasteners or anchors that were inspected, the date of the inspection, the requirement that was inspected against and the result of the inspection.

13.7.4 Inspection prior to erection of steelwork

The documentation and packaging shall be inspected and checked against the requirements for the mechanical fastener or mechanical or chemical anchor that was specified in the construction specification and the requirements of Clauses 5.5 and 5.6 (as appropriate).

Where the relevant Standard contains specific inspection and testing requirements, these shall take precedence over equivalent requirements in this Standard.

Marking of the mechanical fasteners supplied shall be checked against the relevant Standard.

If the documentation or packaging supplied does not meet the requirements of Clauses 5.5 or 5.6, as appropriate, or is inadequate or incomplete such that compliance with Clauses 5.3, 5.5 or 5.6 as appropriate cannot be reliably established, the mechanical fastener or mechanical or chemical anchor shall be treated as nonconforming, until such time as it can be reliably established that the mechanical fastener or mechanical or chemical anchor meets the requirements in this Standard.

All testing of mechanical fasteners shall comply with Clause 13.7.5. The results of such testing shall be fully documented.

13.7.5 Testing of mechanical fasteners

Testing of mechanical fasteners shall be undertaken to the relevant product Standard.

For mechanical or chemical anchors, the type and rate of testing shall be in accordance with SA TS 101.

Testing shall be sufficient to establish a proper statistical basis consistent with the product Standard or manufacturer's specification (as appropriate). Single or limited test results shall not be acceptable. Statistical processes shall be applied to multiple samples in order to establish confidence in the properties of the product.

13.7.6 Inspection prior to installation of fasteners

Prior to installation, bolts, nuts and washers shall be visually inspected for gross physical defects, including cracks, thread damage and loss of lubrication.

All contact surfaces shall be inspected and checked against the requirements of Clause 8.4 before the connection is assembled.

13.7.7 Inspection after snug-tightening of fasteners

All connections which are initially snug tightened shall be inspected after the connection is snug tightened with the structure aligned locally, for the following:

(a) All bolts correctly in position.

(b) Bolts not of the prescribed grade or size.

(c) Bolts with insufficient or excessive thread extending beyond the nut.

(d) Nuts with no prescribed locking device, if a locking device has been prescribed.

(e) All plies are the correct thickness and dimensions.

All connections shall be inspected to ensure they are properly packed (if required) in accordance with Clause 11.5.7 and that the plies of the connection have been brought into firm contact (see Clause 3.1.15). It shall be determined visually that all of the bolts in the joint have been tightened sufficiently to prevent the turning of the nuts without the use of a spanner. Where visual examination indicates the fastener may not have been sufficiently tightened to prevent the removal of the nut by hand, a physical check for the condition shall be undertaken.

If there is any lack of fit up or if any mechanical fastener is damaged, the connection shall be disassembled, corrected and then reassembled correctly and re-inspected. Where inspection has resulted in correction, the complete connection shall be re-inspected.

13.7.8 Inspection of tensioned high strength bolted connections

The connection shall have been inspected at the snug-tight stage in accordance with Clause 13.7.7 before tensioning commences.

For friction-type connections, the contact surfaces shall be visually inspected before assembly against the requirements of the construction specification and Clause 8.4.2. Assembly of the connection shall not proceed until the contact surfaces meet the requirements and are re-inspected.

Tensioning of bolts shall be periodically observed during installation to ascertain that the proper procedures are employed.

For CC2, CC3 and CC4, the connection shall be inspected after tensioning as follows:

(a) For part-turn tensioning—the correct part-turn in accordance with Table 8.5.6 from the snug-tight position shall be either measured (in the case of permanent location marks being used) or observed otherwise.

(b) Where a direct-tension indicating device is used—the minimum tension developed in the bolt shall be indicated by the device, and the value shall exceed the value given in Table 8.5.5.

NOTES:

1 The manufacturer's inspection procedures should be followed when using a direct-tension indicating device.

2 The use of a torque wrench for inspection is considered suitable only to detect gross under-tensioning. A procedure for such use is contained in Appendix H.

Unless otherwise specified in the construction specification, the inspection of tensioned bolts shall be undertaken using a sampling plan complying with the principles contained in ISO 2859-5.

NOTE: ISO 2859-5 gives two methods for establishing sequential sampling plans, the numerical method and the graphical method. The graphical method should be applied for fastener inspection.

If the high strength bolts have not been tensioned in accordance with the provisions of Clause 8.5, the affected bolts shall either be re-tensioned in the same hole or a new high strength bolt installed and tensioned. Connections containing all such fasteners shall be re-inspected.

For compressible washer-type direct tension indicators, the visual examination shall include a check to identify any indicators that exhibit full compression of the protrusions. No more than 10% of the indicators shall exhibit full compression of the protrusions.

For New Zealand only, additional recommendations for inspection of tensioned bolts are included in Appendix I.

13.7.9 Inspection of fasteners in thin-gauge components

The inspection of fasteners in thin-gauge components shall address the following issues:

(a) The fastener make, type, material, grade, diameter and length are all in accordance with the construction specification.

(b) The fastener coating type and durability is equivalent to the light gauge product it is fastening or as stated in the construction specification. Where differences exist, this shall be clearly identified.

(c) The washer type, size and material are in accordance with the construction specification.

(d) The fastener is correctly installed as per the manufacturer's specifications. Particular attention shall be paid to the angle of the fastener, the sealing of any washers and the correct installation tightness (torque or washer compression or other indication as noted by the manufacturer).

(e) The location and frequency of the fasteners are in accordance with the construction specification.

For self-tapping screws and blind rivets, sample holes shall be measured periodically by spot checks on-site in order to ensure that the holes are in accordance with manufacturer's specifications.

For self-drilling and self-tapping screws, samples of screws shall be spot checked periodically in order to ensure the integrity of the thread after setting. This method should be used for each different application. Screws which exhibit a deformation of the thread form which exceeds the limits specified by the screw manufacturer shall be replaced with new screws.

NOTE: Replacement screws may need to be of a larger diameter in order to ensure secure fixing in the pre-formed hole and the advice of the screw manufacturer should be sought in this regard.

For blind rivets, holes with burred edges that would adversely affect the drawing together of the connected parts shall be rectified.

Connections with blind rivets shall be inspected to check that the upset at the blind end of the rivet is not formed between the overlapping material. If it is so formed, the blind rivet shall be removed and replaced. If the rivet is removed with a drill of a larger size than that used to drill the original hole, the replacement blind rivet shall be suitable for the hole size so created.

13.7.10 Inspection of specialized fasteners and fastening methods

Inspection of specialized fasteners and fastening methods shall be in accordance with the manufacturer's specifications.

13.7.11 Inspection of mechanical and chemical anchors

The inspection of mechanical and chemical anchors shall address the following issues:

(a) The anchor make, anchor type, anchor material, anchor diameter and anchor length are all in accordance with the construction specification.

(b) The anchor position is in accordance with the construction specification in respect of the distance between anchors, the anchor embedment lengths and the anchor locations from any edges.

(c) The base material into which the anchors are set is as specified in the construction specification.

(d) Holes are of correct diameter and depth and spacing and have been cleaned out.

(e) The steel to which the anchor is fixed is in accordance with the construction specification in terms of material type and thickness.

(f) The anchors have been installed using the correct equipment and in accordance with manufacturer's specifications in respect of drill bit diameter used, hole cleaning method used, setting tools used, correct installation torque has been used, correct curing times have been allowed.

Prior to loads being applied to the connection in which mechanical or chemical anchors are used, the installation shall be inspected so that any rotation, movement, deformation, cracking or other damage of the base material or the connected steel component can be detected. All such observations shall be documented.

Where required by the construction specification, or where there are doubts as to the quality of the installation of anchors, a sample of anchors shall be proof tested in order to validate the quality of the installation of the mechanical or chemical anchors. Testing requirements should be specified in the construction specification. If no requirements are so specified, testing shall be in accordance with BS 8539.

13.8 INSPECTION OF SURFACE TREATMENT

13.8.1 Inspection and test plan

For Coating Quality Level PC2, an ITP shall be prepared covering the inspection of the following:

(a) For surfaces to be painted, compliance with the requirements of Clause 9.3.2.

(b) For weathering steel, compliance with the requirements of Clause 9.3.5.

(c) For contact surfaces in connections using mechanical fasteners, compliance with the requirements of Clause 9.3.6.

(d) For surfaces in contact with concrete, compliance with the requirements of Clause 9.3.7.

(e) After abrasive blast cleaning, compliance with the requirements of Clause 9.4.

(f) After mechanical cleaning, compliance with the requirements of Clause 9.5.

(g) Compliance with the requirements of Clause 9.8, including treatment grade.

(h) Any special requirements of the construction specification.

(i) Any options from Appendix B, Tables B1 and B2 included in the construction specification in relation to surface treatment (Section 9).

The ITP shall include a list of any inspection equipment to be used and details of any calibration carried out on the equipment. Sample report forms should be included in the ITP.

The ITP shall identify acceptable methods of identifying non-complying areas by marking.

The ITP shall nominate who is to carry out the inspections and the stages at which the inspections are to be carried out.

The ITP shall identify the surfaces to be inspected and the method and extent of inspection to be used. Any special inspection requirements shall also be identified. This information should reflect the requirements of the construction specification.

13.8.2 Competency of the inspection personnel

Inspection of surface treatment shall be undertaken by a competent person.

NOTE: Examples of qualifications of competent personnel are:

(a) A Certified Coatings Inspector qualification available through NACE International or the Australasian Corrosion Association.

(b) Equivalent international qualifications.

13.8.3 Inspection report

The results of all inspections shall be documented and the documentation shall include the name of the inspector, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected against and the result of the inspection.

For components intended to be painted, reference may be made to pictorial representations in ISO 8501-1 or SSPC-VIS 3 in assessing the quality of the surface preparation. The method used to determine surface profile shall be that contained in AS 3894.5.

13.8.4 Pre-painting condition reports

Prior to any painting commencing, documentation shall be prepared regarding the condition of the steel surface, the blast surface finish grade and the treatment grade. Any correction shall be undertaken before any further surface treatment is carried out.

13.9 INSPECTION OF PAINT COATINGS

13.9.1 Inspection and test plan

For Coating Quality Level PC2, an ITP shall be prepared covering the inspection of the following:

(a) Paint material complies with Clause 9.9.3.

(b) Quality control of paint material complies with Clause 9.9.4.

(c) Masking complies with Clause 9.9.9.

(d) Painting condition complies with Clause 9.9.10 according to records maintained by the painting contractor.

(e) Priming complies with Clause 9.9.11.

(f) Spray application complies with Clause 9.9.13.

(g) Brush and roller application complies with Clause 9.9.14.

(h) Dry film thickness complies with Clause 9.9.15.

(i) Film continuity complies with Clause 9.9.16.

(j) Any special requirements of the construction specification, such as measurement of adhesion.

(k) Any information from Tables B1 and B2 of Appendix B to be included in the construction specification in relation to paint coatings (see Section 8).

The supervisor shall be named in the ITP together with their qualifications.

The ITP shall include a list of any inspection equipment to be used and details of any calibration carried out on the equipment and sample report forms. The ITP shall identify acceptable methods of identifying non-complying areas.

The ITP shall nominate the inspector who is to carry out the inspections and the stage at which the inspections are to be carried out.

The ITP shall identify the areas to be inspected and the method and extent of inspection to be used. Any special inspection requirements shall also be identified. This information shall align with the requirements of the construction specification.

13.9.2 Competency of the inspection personnel

Inspection of paint coatings shall be undertaken by a competent person.

NOTE: Examples of qualifications of competent personnel are:

(a) A Certified Coatings Inspector qualification available through NACE International or the Australasian Corrosion Association.

(b) Equivalent international qualifications.

13.9.3 Inspection report

The results of all inspections shall be documented and the documentation shall include the name of the competent person inspecting, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected against and the result of the inspection.

13.9.4 Daily inspection report

A daily inspection report shall be provided in an approved format (e.g. that contained in AS 3894.12) for each work area. The report shall also record paint batch numbers, paint system and paint quantities used.

13.9.5 Inspection after priming

After priming, no further coats shall be applied until the prime coat has been inspected and any defects have been corrected and have been re-inspected.

13.9.6 Measurement of dry film thickness

Measurement of dry film thickness during inspection shall comply with Clause 9.9.15.

13.10 INSPECTION OF GALVANIZED COATINGS

13.10.1 Inspection

Inspection shall be undertaken according to the requirements of AS/NZS 4680, which sets out a number of approaches to address the requirement for inspection. The approach to be used shall be nominated. Inspection documentation shall be provided sufficient to allow checking against the requirements of AS/NZS 4680.

Any additional or special inspection requirements shall be documented in the construction specification, especially in relation to defects that may affect the stated use of the article. In this case, the construction specification should address requirements for acceptance inspection, sampling requirements, and acceptance criteria in relation to the measurement of the coating thickness and repair to damaged or uncoated areas.

Unless specifically mandated in the construction specification, variation in hue across a component or components inspected shall not be reason for rejection.

NOTE: Inspectors should expect variations in initial hue across components galvanized to AS/NZS 4680. Reference to AS/NZS 4680 is particularly important when inspecting the initial appearance of galvanized surfaces.

13.10.2 Inspection report

The results of any inspections undertaken as required by the construction specification shall be documented, and the documentation shall include the name of the competent person, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected against and the result of the inspection.

13.11 INSPECTION OF ERECTION

13.11.1 Inspection and test plan

For all construction categories except CC1, an ITP shall be prepared covering the following matters which shall be checked before erection commences:

(a) Locations of anchor bolts and compliance with tolerances on their location.

(b) Locations where connections are to be made to existing structure or previously erected structure.

(c) Trial erection if undertaken.

(d) Positions of all survey points and grids.

(e) Levels at all anchor bolt locations.

For all construction categories except CC1, an ITP shall be prepared covering the following matters, which shall be checked after erection is completed:

(i) Assembly is in accordance with the erection drawings and the relevant tolerances of Appendix F.

(ii) General condition and alignment of the erected structure.

(iii) Any components or members that have been distorted.

(iv) All temporary attachments and temporary supports have been removed and the affected areas repaired (see Clause 7.5.6).

(v) Installation of mechanical fasteners has been inspected in accordance with Clause 13.7.

(vi) All site welds have been inspected in accordance with Clause 13.6.

(vii) The overall dimensions of the erected structure comply with the relevant tolerances in Appendix F.

(viii) Condition of the corrosion protection and whether any repairs are required.

(ix) Grouting under base plates (see Clause 11.6.4).

(x) All anchor bolts and bearings have been installed satisfactorily (see Clause 11.6.2).

(xi) Any special tolerances nominated in the construction specification.

(xii) Locations where measurements are to be made in order to assess tolerances specified in Appendix F.

(xiii) Any special requirements of the construction specification, including any options from Tables B1 and B2 of Appendix B that are included in the construction specification.

The ITP shall nominate who is to carry out the inspections and the stage at which the inspections are to be carried out.

The ITP shall identify the members that are to be inspected and the method and extent of inspection to be used. Any special inspection requirements shall also be identified.

NOTE: The ITP should reflect the requirements of the construction specification.

13.11.2 Competency of the inspection personnel

Inspection of steelwork erection shall be undertaken by a competent person.

NOTE: An example of qualification of competent personnel is a relevant trade qualifications and over 10 years experience in structural steel erection.

13.11.3 Inspection report

The results of all inspections shall be documented, such documentation to include the name of the competent person, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected and the result of the inspection.

13.11.4 Survey methods and accuracy

For all construction categories except CC1, a survey of the completed structure shall be made which shall be related to the site survey marks and site grid system. The survey shall comply with Clause 11.3.

Methods used and instruments used shall be selected from those listed in ISO 7976-1 and ISO 7976-2. The selection shall take into account the capability of the survey process in terms of accuracy relative to the acceptance criteria of Appendix F.

If appropriate, the survey shall be corrected for the effects of temperature using the relevant parts of ISO 17123. A reference temperature of 20°C shall be used when measuring the structural steelwork.

Accuracy of measurement shall be assessed in accordance with the requirements of the relevant Part of ISO 17123.

NOTE: When comparing measurements against specified tolerances, the following should be considered:

(a) Inherent tolerances exist in optical and electronic equipment.

(b) Steel tapes require corrections for sag, tension, slope and temperature.

(c) Axial shrinkage of columns will occur due to dead loads and construction loads and should be considered when comparing floor levels with external benchmarks.

(d) The effect of permissible rolling and fabrication tolerances should be considered as to their effect on erection tolerances.

13.11.5 System of measurement

For buildings, the system of permissible deviations is built up from position points at base level, an envelope for column verticality and a series of intermediate and roof levels referred to as-built floor levels. Position points mark the location of individual members such as columns (see ISO 4463-1).

For other structures and bridges, the system of permissible deviations is built up from position points at base level, an envelope for structural elements and a series of levels where relevant. Position points mark the location of individual members (see ISO 4463-1).

Each individual value measured shall have a deviation from nominal less than the relevant deviation permitted in Appendix F. The algebraic sum of the discrete values measured shall not be greater than the permissible deviations for the overall structure.

A system shall be established that sets out requirements for connection positions. Between the connection positions, the fabrication tolerances define the permissible deviations.

NOTES:

1 Any system does not need to set out explicit requirements for secondary structural members such as door posts, purlins and girts, unless called for in the construction specification.

2 As an alternative to assessing the permissible deviations for the overall structure based on Appendix F, for large or unusual structures, an alternative approach, such as the square root of the sum of the squares (SRSS) method specified in BS 5606, may be used.

Special attention shall be given to establishing survey lines and levels when connecting a new steel structure to existing construction.

13.11.6 Reference points and levels

Deviations from nominal due to erection shall generally be specified relative to the following reference points on each member or component:

(a) For members within 10° of vertical: the centre of the component at each end.

(b) For members within 45° of the horizontal (including the tops of trusses): the centre of the top surface at each end.

(c) For internal components in built-up girders and trusses: the centre of the component at each end.

(d) For other members and components, the erection drawings shall indicate the reference points to be used. These shall generally be the top or outside surfaces of components that are mainly subject to bending, and the centre lines of members and components that are mainly subject to axial tension and compression.

Alternative reference points may be substituted for ease of survey reference provided they have a similar effect to the reference points specified above.

13.11.7 Location and frequency of measurements

Measurements should only be taken of the position of members and components adjacent to site connection nodes.

The location and frequency of measurements shall be as specified in the ITP. Critical dimensional checks of the as-built structure in relation to any special tolerances shall be identified and incorporated into the ITP.

The positional accuracy of the erected steelwork should be measured under the self-weight of the steelwork only, unless specified otherwise in the construction specification. Where the construction specification nominates other conditions under which the measurements are to be taken, the construction specification shall also specify the permissible deviations and movements due to the imposed loads (other than those due to self-weight), if these can affect the dimensional checks.

13.12 INSPECTION OF SECONDARY STRUCTURAL ELEMENTS

13.12.1 Scope

Secondary structural elements include roof purlins and wall girts manufactured from light gauge materials as defined in AS/NZS 4600.

13.12.2 Installation

For roof purlins and wall girts, the following shall be checked:

(a) Profile type, manufacturer, and size are consistent with the construction specification.

(b) Dimensions—overall profile depth and base metal thickness is consistent with the Product Specification.

(c) Steel grade and metallic coating class (via product marking as per AS 1397).

(d) Location, layout, spacing, lap length is consistent with the construction specification.

(e) Quantity and location of bridging is consistent with the construction specification.

(f) Overall alignment of the finished connected flange surface to the intended roof or wall plane.

(g) Rotational orientation to the intended roof or wall plane (to be substantially perpendicular to the intended roof or wall plane).

(h) Overall straightness of purlin or girt line.

(i) Gauge line and hole size and number at connection locations.

(j) Gauge line and hole size and number at lap locations.

(k) Connection integrity of bridging.

(l) Size, grade, head marking and washer configuration of connection bolts is consistent with the construction specification.

(m) Bolts in connections are snug tight.

13.12.3 Inspection report

The results of all inspections shall be documented, such documentation to include the name of the competent person, the identification of the item that was inspected, the date of the inspection, the requirement that was inspected and the result of the inspection.

SECTION 14 SITE MODIFICATIONS DURING ERECTION AND MODIFICATION AND REPAIR OF EXISTING STRUCTURES

14.1 GENERAL

This Section applies to modifications made on-site to fabricated items during erection, and to modifications or repairs to existing structures or structural elements made on-site.

All provisions in Sections 6 through 13 shall apply equally to any such modifications or repairs, in addition to the provisions of this Section.

14.2 SITE MODIFICATION OF FABRICATED STEELWORK

No site modification to any steel member, connection component, mechanical fastener, weld or corrosion protection shall be made without a detailed written procedure to be followed, which shall be contained in the construction specification in the case of modification and repair of existing structures or provided by a competent person in the case of site modification during erection.

Particular attention shall be paid to the following clauses of this Standard in carrying out all modifications and repairs:

(a) Cutting (Clause 6.5).

(b) Shaping (Clause 6.6).

(c) Holing (Clause 6.7).

(d) Welding (Section 7).

(e) Mechanical fastening (Section 8).

(f) Repairs to corrosion protection (Section 9).

(g) Clauses 14.3 to 14.8.

14.3 MATERIALS

In the case of modification and repair of existing structures, the types of steel material, mechanical fasteners, welds and corrosion protection shall be determined and documented in the construction specification, before any modification is made to an existing structure.

In the case of modification and repair of existing structures, representative tests of the base metal may be required if the provenance of the steel is uncertain. The suitability of the base metal for welding shall be established if site welding is to be employed, and the selection of suitable electrodes for site welding shall be in accordance with Section 7.

NOTE: The identification of all elements should be determined from existing drawings or specifications where possible and should be confirmed by site inspection.

In the case of site modification during erection, a detailed written procedure shall be established for the treatment of any areas of steel which are observed to be corroded, including how such areas are to be restored or replaced.

In the case of modification and repair of an existing structure, a detailed procedure shall be contained within the construction specification for the treatment of any areas of steel which are observed to be corroded, including how such areas are to be restored or replaced.

Structural members shall not be removed or reduced in size unless so documented in either the construction specification or detailed written procedure, as appropriate.

14.4 LOADING DURING OPERATIONS

The detailed written procedure or construction specification (as appropriate) should identify the extent to which each member is able to carry load during repair or modification operations and whether additional temporary members or propping are required. The detailed written procedure or construction specification (as appropriate) shall be followed in its entirety.

Consideration shall be given to the effect of local heating due to heating or welding on the local strength of the member at the expected temperature of such operations.

14.5 CLEANING

Surfaces of existing steel which are to be modified, strengthened, repaired or welded shall be cleaned of dirt, rust and any foreign material, except adherent corrosion protection that is clear of any area to be welded.

The areas of surfaces to be welded shall be cleaned thoroughly as above and cleaned of coatings for a distance of 50 mm each side of the outside lines of the welds.

14.6 WELDING

If weld repairs are required, they shall be made in accordance with all requirements of Section 7.

Where welded connections are to be made to existing steelwork, the type and grade of the steel to be welded shall be verified and welded in accordance with the relevant part of AS/NZS 1554. Verification can be based on review of fabrication records for the original structure, or by positive material identification (PMI). PMI may be by way of sampling and laboratory analysis or equivalent on-site analysis of the material.

The welding sequence to be used shall be chosen to result in a balanced heat input so as to minimize residual stresses and distortion of the member and to ensure that its straightness complies with the appropriate straightness limits of Appendix F.

14.7 HEAT STRAIGHTENING

When heat straightening or heat curving methods are used, the maximum temperature of heated areas as measured by approved methods shall not exceed 590°C, or 20°C below the tempering temperature of the steel, whichever is the lower for quenched and tempered steel or 620°C for other steel. Accelerated cooling shall not be used.

14.8 TESTING AND INSPECTION

Testing and inspection shall comply with the requirements of the written documentation or construction specification (as appropriate) and relevant requirements of Section 13.

14.9 REPLACEMENT OF RIVETS

Existing rivets in an existing structure that are to be removed in order to effect a repair or strengthening, shall be replaced in accordance with the construction specification.

14.10 REPLACEMENT OF MECHANICAL FASTENERS

Existing bolts that are to be removed in order to effect a site modification, repair or strengthening shall be replaced by the method specified by the construction specification and complying with Section 8.

Existing mechanical or chemical anchors that are to be removed in order to effect a site modification, repair or strengthening shall be replaced by the method specified by the construction specification and complying with Clause 8.8.

APPENDIX A

BIBLIOGRAPHY

(Informative)

A1 GENERAL

This Appendix lists the documents referenced in this Standard for informative purposes.

Documents considered to be 'primary' referenced documents, i.e. documents that will probably need to be readily available for repeated reference, are indicated in the lists below by an asterix (*) against the document number.

A2 INFORMATIVE REFERENCED DOCUMENTS

The following documents are referred to for informative purposes in this Standard:

AS	
1796*	Certification of welders and welding supervisors
2214*	Certification of welding supervisors—Structural steel welding
3828*	Guidelines for the erection of building steelwork
3894	Site testing of protective coatings
3894.10	Method 10: Inspection report—Daily surface and ambient conditions
3894.14	Method 14: Inspection report—Daily painting
4036	Corrosion of metals—Dissimilar metals in contact in seawater
4100 Supp 1	Steel structures—Commentary (Supplement to AS 4100—1998)
5104	General principles on reliability for structures
AS/NZS	
1252	High-strength steel bolts with associated nuts and washers for structural engineering
2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
2312.1*	Part 1: Paint coatings
2312.2*	Part 2: Hot dip galvanizing
4750	Electrogalvanized (zinc) coatings on ferrous hollow and open sections
4792	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or specialized process
AS/NZS ISO	
3834	Quality requirements for fusion welding of metallic materials
3834.2	Part 2: Comprehensive quality requirements
9000	Quality management systems—Fundamentals and vocabulary
9001	Quality management systems—Requirements
31000	Risk management—Principles and guidelines
ISO	
898	Mechanical properties of fasteners made of carbon steel and alloy steel
898-1	Part 1: Bolts, screws and studs with specified property classes—Coarse thread and fine pitch thread

ISO	
2320	Prevailing torque type steel nuts—Mechanical and performance properties
4463	Measurement methods for building—Setting out and measurement
4463-1	Part 1: Planning and organization, measuring procedures, acceptance criteria
7040	Prevailing torque type hexagon regular nuts (with non-metallic insert)—Property classes 5, 8 and 10
7042	Prevailing torque type all-metal hexagon high nuts—Property classes 5, 8, 10 and 12
7719	Prevailing torque type all-metal hexagon regular nuts—Property classes 5, 8 and 10
8501	Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness
8501-3	Part 3: Preparation grades of welds, edges and other areas with surface imperfections
8501-4	Part 4: Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting
8502	Preparation of steel substrates before application of paints and related products—Tests for the assessment of surface cleanliness
8502-4	Part 4: Guidance on the estimation of the probability of condensation prior to paint application
9606	Qualification testing of welders—Fusion welding
9606-1	Part 1: Steels
10511	Prevailing torque type hexagon thin nuts (with non-metallic insert)
10512	Prevailing torque type hexagon regular nuts (with non-metallic insert) with metric fine pitch thread—Property classes 6, 8 and 10
10513	Prevailing torque type all-metal hexagon high nuts with metric fine pitch thread—Property classes 8, 10 and 12
12944	Paints and varnishes—Corrosion protection of steel structures by protective paint systems
12944-5	Part 5: Protective paint systems
13588	Non-destructive testing of welds—Ultrasonic testing—Use of automated phased array technology
16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries
ISO/TR	
3834	Quality requirements for fusion welding of metallic materials
3834-6	Part 6: Guidelines on implementing ISO 3834
17671	Welding—Recommendations for welding of metallic materials
17671-2	Part 2: Arc welding of ferritic steels
ASTM	
A325	Standard specification for structural bolts, steel, heat treated, 120/105 ksi minimum tensile strength

BS	
5606	Guide to accuracy in building
7910	Guide to assessing the acceptability of flaws in metallic structures
8539	Code of practice for the selection and installation of post-installed anchors in concrete and masonry
EN	
1090	Execution of steel structures and aluminium structures
1090-2	Part 2: Technical requirements for steel structures
1990	Eurocode—Basis of structural design
AEFAC	Guideline for the specification of fastenings to concrete—Engineering technical notes
SSPC	
SP 6/NACE No.3	Commercial blast cleaning
VIS 3	Guide and reference photographs for steel surfaces prepared by hand and power tool cleaning
CIS/2	The CIM Steel Integration Standard See http://www.aisc.org/content.aspx?id=26044 (accessed 4/8/2016)
WTIA	
Technical Note 7	Health and safety in welding
Technical Note 10	Fracture mechanics
Technical Note 22	Welding electrical safety

APPENDIX B

INFORMATION TO BE INCLUDED IN THE CONSTRUCTION SPECIFICATION

(Normative)

B1 REQUIRED ADDITIONAL INFORMATION

The construction specification (CS) includes information (relating to design, manufacturing or contractual considerations, etc.) required for fabrication and erection of steel structures in accordance with this Standard. Extensive reference is made to the CS by this Standard. This Appendix lists subjects and clause references where this Standard requires the CS to provide information that is needed to fully define the provisions of this Standard.

TABLE B1

REQUIRED ADDITIONAL INFORMATION

Clause	Additional information required
4 Design, specification, documentation and traceability	
4.1 Construction specification	
4.1.1	Design data and design details as per AS 4100 , AS 5100.6 or NZS 3404 as relevant
4.1.2	Construction category for the structure or parts thereof
4.1.3	Treatment grade for the structure or parts thereof
4.4 Shop detailing documentation	
4.4.1	Responsibility for production of shop detail documentation
4.4.4	Responsibility for review and approval of shop detail documentation
4.5 Documentation required	
4.5.1	Various matters to be addressed in the quality documentation
5 Materials	
5.3 Structural steels	
5.3.1	Grades, qualities and, if appropriate, coating weights and finishes for steel products. Include any required options
5.5 Mechanical fasteners	
5.5.1	Corrosion protection of fasteners and washers required
5.5.3	Property classes of bolts and nuts for other than tensioned applications
5.5.7	Grade or property class for foundation bolts
5.5.10	Grade and type of fasteners for thin gauge components
5.5.11	Grade, type and installation instructions for special fasteners
5.5.13	Grade, type and tests required for mechanical or chemical anchors
5.6	Grade, type and length for studs and shear connectors
5.7	Grade, type and length for explosive fasteners
5.8	Grade and type for grouting materials

(*continued*)

TABLE B1 (*continued*)

Clause	Additional information required
6 Preparation, assembly and fabrication	
6.1 General	
6.1.5	Identify steelwork that is to be treated as ‘architecturally exposed structural steelwork’ (AESS)
6.5 Cutting	
6.5.1	Identify areas designated as yielding regions in seismic design categories D and E
6.5.2	Identify details with a fatigue detail category ≥ 80 MPa, for the purposes of defining maximum cut surface roughness
6.6 Shaping	
6.6.5	Identify fracture critical members (FCMs)
6.7 Holing	
6.7.1	Identify yielding regions
6.7.4	Friction-type and bearing type tensioned connections to be identified Slotting of holes to be identified
6.7.6	Required finishing for pins and holes at pinned connections
6.8	Full contact bearing surfaces to be identified
6.9	Any special requirements for connections for temporary elements Any camber or preset requirements to be identified
7 Welding	
7.1 General	
7.1.3	Required specification of weld parameters
7.2 Welding plan	
7.2.2	Welding requirements related to fatigue or seismic detailing categories
7.5 Preparation and execution of welding	
7.5.6	Areas where welding of temporary attachments is permitted
7.6 Acceptance criteria	
7.6.3	Any additional execution requirements necessary to comply with the assumptions of design for fatigue resistance
8 Mechanical fastening	
8.7	Requirements, any tests required and inspection procedures for use of specialized fasteners and fastening methods
8.8 Installation of mechanical and chemical anchors	
8.8.1	Requirements for type and embedment length, or required load capacity and load type
9 Surface treatment and corrosion protection	
9.2 Planning	
9.2.3.1	Key technical requirements to be specified for painting
9.2.3.2	Key technical requirements to be specified for galvanizing
9.3 Preparation of steel surfaces	
9.3.2	The maximum level of salt removal from the surface as part of surface preparation
9.8 Fabrication and welding considerations	
9.8.3	Responsibility for rectification

(*continued*)

TABLE B1 (*continued*)

Clause	Additional information required
9.8.4	Specification of treatment grades for surfaces intended to be painted
9.8.5	Extent of treatment of edges required
9.8.6	Method for repair of damage to pre-coated steel
9.9.3	If paints complying with ISO 12944-5 are acceptable
10 Architecturally exposed structural steelwork	
10.3	Identify steelwork that is to be treated as 'Architecturally exposed structural steelwork' Where AESS C nominated, the custom requirements shall be specified
13 Inspection, testing and correction	
13.6	Inspection of welding
13.6.1.1	The extent and method of non-destructive examination (NDE)
13.6.2.5	Whether assessment of weld defects by fracture mechanics or other suitable methods is allowed
14 Site modifications during erection and modification and repair of existing structures	
14.2	Detailed written procedure for modification and repair of existing structures
14.3	For existing structures, details of the types of steel material, mechanical fasteners, welds and corrosion protection
14.4	Details of the relevant member load capacities and whether propping or strengthening is required

B2 INFORMATION FOR OPTIONAL OR PARTICULAR APPLICATIONS

Information in the CS may be required for subjects that are optional or relate to particular applications under the scope of this Standard. Table B2 lists the subjects and clause references for this information.

NOTE: The information provided in Table B2 is intended to form a checklist of items for review and, where appropriate, inclusion in the construction specification for the project.

TABLE B2

LIST OF OPTIONS TO BE SELECTED

Clause	Option(s) to be selected
4 Design, specification, documentation and traceability	
4.1 Construction specification	
4.1.1	Any special requirements for the fabrication or erection of the works
4.3 Use of building information modelling	
4.3	If implementation of digital project models is required
4.5 Documentation required	
4.5.2	For CC2, if a quality plan for execution of the works is required
5 Materials	
5.3 Structural steels	
5.3.3	Additional requirements for surface finish, restrictions on surface imperfections or repair of surface defects by grinding
5.3.4	Additional requirements for seismic and fracture critical applications. If any special processing is required prior to delivery

(*continued*)

TABLE B2 (*continued*)

Clause	Option(s) to be selected
5.3.5	If through thickness tensile testing is required. If ultrasonic examination in the vicinity of critical welded details is required.
5.5 Mechanical fasteners	
5.5.5	If direct tension indicators are to be used
5.5.8	If locking devices are to be used
5.5.11	If special fasteners are required, installation instructions and any tests
5.5.13	If any tests are required for mechanical or chemical anchors
6 Preparation, assembly and fabrication	
6.2 Identification and traceability	
6.2	Areas where hard stamping is prohibited Alternative requirements for hard-stamped, punched or drilled marks Areas where identification marks are not permitted or shall not be visible after completion If the use of hard stamps, punched or drilled marks is not permitted, whether soft or low stress stamps may be used.
6.5 Cutting	
6.5.1	If certain cutting processes are excluded
6.5.3	Alternative treatment of re-entrant corners
6.10	If a method for the assembly check is specified
7 Welding	
7.1.2	If additional requirements for welding are specified
7.2 Welding plan	
7.2.2	If additional items are included in the welding plan
7.3	Whether alternative welding processes are permitted
7.4 Qualification of welding procedures and welding personnel	
7.4.1.1	If impact tests are required.
7.4.1.2	Requirement for and details of welding production testing, is required
7.4.2	Alternative nomination of the role of examiner or examining body
7.4.3	Any additional requirements for the technical knowledge of the welding supervisor or coordinator for CC3
7.5 Preparation and execution of welding	
7.5.9.1	If run-on/run-off tabs shall be used
7.5.9.2	If permanent steel backing plates may be used
7.5.14	If post-weld heat treatment is required
7.5.15.1	If certain members do not require treatment for arc strikes. Any additional dressing of finished butt welds
7.6 Acceptance criteria	
7.6.1	If there are requirements other than those in the AS/NZS 1554 series Alternative evaluation of nonconformity
7.6.3	Any additional execution requirements necessary to comply with the assumptions of design for fatigue resistance

(*continued*)

TABLE B2 (*continued*)

Clause	Option(s) to be selected
8 Mechanical fastening	
8.2 Bolts, nuts and washers	
8.2.3	If alternative means other than tightening is required in order to secure nuts against loosening from vibration
8.2.4	If washers are required under both the bolt head and nut
8.4.2	Whether friction-type connection surfaces are to be coated and the type of coating
8.5 Tensioning of high strength bolts	
8.5.6	Whether location marks to measure part-turn method need to be permanent
9 Surface treatment and corrosion protection	
9.3 Preparation of steel surfaces	
9.3.2	Whether testing of surfaces to be painted for the presence of soluble salts is required If any alternative surface preparation by blast cleaning is required
9.3.5	Any specific requirements for blast cleaning of weathering steel. Any procedures to prevent contamination. If there are any procedures for treatment of weathering steel surfaces in contact with other steels
9.3.7	Any alternative corrosion protection for steel members embedded in concrete
9.4 Abrasive blasting	
9.4.1	If there are requirements other than those in AS 1627.4 Any limitations on acceptable media and if recycling of abrasive is acceptable
9.4.4	If an alternative surface finish is required
9.5 Mechanical cleaning	
9.5.2	Alternative treatment of sharp edges
9.6 Sealing of enclosed spaces	
9.6.1	If there are any requirements for surface preparation and corrosion protection of surfaces in enclosed spaces. Quality of weld used to seal spaces
9.8 Fabrication and welding considerations	
9.8.4	If treatment other than that required by AS/NZS 4680 is required for surfaces to be galvanized. If a treatment grade other than P2 is required for surfaces to be painted
9.8.5	Extent of treatment of cut edges
9.9 Application of paint coatings	
9.9.8	Whether site tinting of finish coat is allowed
9.9.10	Whether regular monitoring and recording of air and surface temperatures, relative humidity and dew point is required
9.9.16	Whether testing of film continuity is required
9.9.17	Whether testing of degree of cure is required
9.10 Application of galvanized coatings	
9.10.4	Provision for stress relieving where it is expected distortion may occur during galvanizing
9.10.5	If double dipping is permitted. If an initial test lot for galvanizing is required

(*continued*)

TABLE B2 (*continued*)

Clause	Option(s) to be selected
9.10.6	Any special provisions relating to end use of the component to be galvanized
9.10.8	Any additional requirements for adherence of galvanized coating
9.10.10	If removal of wet storage staining is not required
10 Architecturally exposed structural steelwork (AESS)	
10.3	Particular requirements for each AESS category. Where AESS C is nominated, the custom requirements shall be specified Any requirements for a visual sample
10.5	If tolerances different to those provided in Appendix F are required
11 Erection	
11.2 Site planning	
11.2.5	Whether registered lifting equipment has proof of registration available on site
11.5 Erection methods	
11.5.10	Whether steelwork is temporarily erected at the fabrication works
11.6 Supports	
11.6.3	If temporary shims and packers may be left in place after erection, and required minimum grout cover
11.6.4	If there is any special treatment of steelwork, baseplates, bearings or concrete surfaces prior to grouting or mortaring required
11.7 Erection drawings	
11.7	Whether erection drawings are required
12 Geometrical tolerances	
12.1	If there are special or additional tolerances beyond those in Appendix F
13 Inspection, testing and correction	
13.1	If there are additional requirements for inspection and testing to be included in the ITP
13.2	Additional requirements for competency of personnel
13.5 Inspection of preparation and assembly	
13.5.1	Whether there are any special requirements to be included in the ITP
13.6 Inspection of welding	
13.6.1.1	Any special inspection requirements before and during welding
13.6.1.2	Whether there are any special requirements to be included in the ITP Whether an inspection and test plan is required for CC1 and CC2
13.7 Inspection of mechanical fastening	
13.7.1	Whether there are any special requirements to be included in the ITP
13.7.8	Any special requirements for the sampling plan for tensioned high strength bolted connections
13.7.11	Whether proof testing of mechanical or chemical anchor installation is required
13.8 Inspection of surface treatment	
13.8.1	Whether there are any special requirements to be included in the ITP
13.9 Inspection of paint coatings	
13.9.1	Whether there are any special requirements to be included in the ITP

(*continued*)

TABLE B2 (*continued*)

Clause	Option(s) to be selected
13.10 Inspection of galvanized coatings	
13.10.1	Any additional or special inspection requirements for galvanized coatings
13.11 Inspection of erection	
13.11.1	If there are any special tolerances that are to be checked. If there are any special requirements for inspection of the structure after erection
13.11.7	Whether positional accuracy of erected steelwork is measured under dead weight or an alternative scenario
14 Site modifications during erection and modification and repair of existing structures	
14.8	Requirements for testing and inspection
14.9	Method for replacement of rivets
14.10	Method for replacement of mechanical fasteners

B3 RESPONSIBILITIES TO BE ASSIGNED

The Standard outlines several requirements where the responsibility for actioning on a project basis is not defined and will depend on the contractual arrangement. Table B3 lists those areas where assignment of responsibilities may need to be clarified in the contractual documentation. The list does not represent the only areas of responsibility that need to be addressed, only those where current construction practice may vary between projects.

TABLE B3

LIST OF RESPONSIBILITIES TO BE ASSIGNED

Clause	Responsibility to be assigned
4 Design, specification, documentation and traceability	
4.1 Construction specification	
4.1.1	Preparation of the construction specification, including the individual parts of the specification.
4.3 Use of Building Information Modelling (BIM)	
4.3	Where required, preparation of the ‘Project BIM Brief’ or ‘BIM Management Plan’
4.4 Shop detailing documentation	
4.4.1	Preparation of the shop detail documentation
4.4.4	Approval of shop detail documentation
4.5 Documentation required	
4.5.1	Preparation of quality documentation
4.5.2	Preparation of quality plan
4.5.4	Preparation of as-build documentation
4.6 Purchasing—Components and subcontracted services	
4.6.1	Preparation of purchasing procedure Responsibility for operating the purchasing procedure
5 Materials	
5.1 General	
5.1.2	Responsibility for operation of quality management system

(*continued*)

TABLE B3 (*continued*)

Clause	Responsibility to be assigned
6 Preparation, assembly and fabrication	
6.1 General	
6.1.2	Responsibility for operation of quality management system
6.1.3	Preparation of work method statements
6.12 Supervision	
6.12	Responsibility for supervision
7 Welding	
7.1 General	
7.1.1	Responsibility for operation of quality management system
7.2.1	Preparation of welding plan
7.4.3	Responsibility for welding coordination
8 Mechanical fastening	
8.1 General	
8.1.2	Responsibility for operation of quality management system
8.1.3	Preparation of work method statements
8.9	Responsibility for supervision
9 Surface treatment and corrosion protection	
9.2 Planning	
9.2.3	Preparation of work method statements
9.9 Application of paint coatings	
9.9.20	Responsibility for supervision
9.10 Application of galvanized coatings	
9.10.11	Responsibility for supervision
11 Erection	
11.2 Site planning	
11.2.1	Preparation of safety plan
11.2.2	Responsibility for operation of quality management system
11.2.3	Preparation of work method statements
11.5 Erection process	
11.5	Preparation of Erection Sequence Methodology (ESM) Review of ESM
11.7 Erection drawings	
11.7	Preparation of erection drawings
11.9 Supervision	
11.9	Responsibility for supervision
13 Inspection, testing and correction	
13.2 Inspection	
13.2	Responsibility for inspection and testing at each stage of the project
14 Site modifications during erection and modification and repair of existing structures	
14.2 Site modification of fabricated steelwork	
14.2	Preparation of detailed written procedure

B4 REQUIREMENTS RELATED TO THE CONSTRUCTION CATEGORIES

This Paragraph specifies the requirements that are specific to each of the construction categories covered in this Standard.

NOTES:

1 Which requirements fall into each construction category are typically, though not always, already documented in the relevant section of the main body of the Standard.

2 The Table documents requirements that may vary between construction categories only, not the full set of requirements, which are defined in the relevant sections of the main body of the Standard.

The entries in Table B4 typically define only the requirements that may vary between construction categories and are therefore particular to a construction category. The full set of requirements for the construction categories is defined in the relevant clauses in the body of this Standard.

TABLE B4

PARTICULAR REQUIREMENTS RELATING TO EACH CONSTRUCTION CATEGORY

Clause	CC1	CC2	CC3	CC4
4 Design, specification, documentation and traceability				
4.5 Documentation required				
4.5.1 Quality documentation	See Note 3	Yes, as listed	Yes, as listed	Yes, as listed
4.5.2 Quality plan	NPR	If required in construction specification	Required	Required
5 Materials				
5.1 General				
5.1.2 Quality management system	Required. See Note 4			
5.2 Designation, documentation and traceability				
5.2.1 Designation	NPR	Grade identification if different grades in circulation	Grade identification if different grades in circulation	Grade identification if different grades in circulation
5.2.3 Level of traceability	Australia: Basic New Zealand: NPR	Australia: Partial New Zealand: Basic	Australia: Full New Zealand: Partial	Australia: Full New Zealand: Partial
5.3 Steels				
5.3.2 Thickness tolerances	Class A	Class A	Class A	Class A generally Class B for structural steel plate
6 Preparation, assembly and fabrication				
6.1 General				
6.1.2 Quality management system	Required. See Note 4			

(*continued*)

TABLE B4 (*continued*)

Clause	CC1	CC2	CC3	CC4
6.2 Identification and traceability (of components)	Australia: Basic New Zealand: NPR	Australia: Partial New Zealand: Partial	Australia: Full New Zealand: Full	Australia: Full New Zealand: Full
6.2 Identification and traceability (of welders and weld procedures)	Australia: NPR New Zealand: NPR	Australia: NPR New Zealand: NPR	Australia: NPR New Zealand: Required	Australia: NPR New Zealand: Required
6.7 Holing				
6.7.1 Holing methods	Punching	Punching	Punching + reaming	Punching + reaming
6.12 Supervision	NPR	Competent person	Competent person	Competent person
7 Welding				
7.1 General				
7.1.1 Recommended quality requirements	AS/NZS 1554 or AS/NZS ISO 3834.4 'Elementary quality requirements' recommended	AS/NZS ISO 3834.3 'Standard quality requirements' recommended	AS/NZS ISO 3834.2 'Comprehensive quality requirements' recommended	AS/NZS ISO 3834.2 'Comprehensive quality requirements' recommended
7.2 Welding plan				
7.2.1 Requirement for a welding plan	If required	If required Content defined in Clause 7.2.2 Cross reference ITP	If required Content defined in Clause 7.2.2 Cross reference ITP	If required Content defined in Clause 7.2.2 Cross reference ITP
7.4 Qualification of welding procedures and welding personnel				
7.4.1.1 General (Qualification of weld procedures)	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4
7.4.1.2 Validity of a welding procedure qualification	To AS/NZS 1554 requirements	To AS/NZS 1554 requirements	Production tests required if specified in the construction specification	Production tests required if specified in the construction specification
7.4.1.2 Validity of a welding procedure qualification: (Traceability of weld procedures)	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4
7.4.2 Qualification of welders	To AS/NZS 1554 requirements	To AS/NZS 1554 requirements	To AS/NZS 2980 or ISO 9606.1	To AS/NZS 2980 or ISO 9606.1
7.4.2 Qualification of welders: (Identification and traceability of welders)	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4
7.4.3 Welding coordination	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4	Refer Table 7.4

(*continued*)

TABLE B4 (*continued*)

Clause	CC1	CC2	CC3	CC4
7.5 Preparation and execution of welding				
7.5.6 Temporary attachments	NPR	As per location exclusion zones given in construction specification	As per location exclusion zones given in construction specification	As per location exclusion zones given in construction specification
7.5.7 Tack welds	NPR	Comply with relevant part of AS/NZS 1554 series	Comply with relevant part of AS/NZS 1554 series	Comply with relevant part of AS/NZS 1554 series
7.5.9.2 Single sided welds	NPR	NPR	Permanent backing metal made continuous	Permanent backing metal made continuous
7.5.15.1 General	NPR	Remove weld spatter	Remove weld spatter	Remove weld spatter
8 Mechanical fastening				
8.1 General				
8.1.2 Quality management system	Required. See Note 4.			
8.9 Supervision	NPR	Competent person	Competent person	Competent person
11 Erection				
11.2 Site planning				
11.2.2 Quality management system	Required. See Note 4.			
11.9 Supervision	NPR	Competent person	Competent person	Competent person
12 Tolerances				
12.1 General				
Class for functional tolerances	Class 1 recommended	Class 1 recommended	Class 2 recommended	Class 2 recommended
13 Inspection, testing and correction				
13.3 Inspection of materials and components				
13.3.2 Inspection and test plan	NPR	Documented inspection and test plan recommended	Documented inspection and test plan recommended	Documented inspection and test plan recommended
13.5 Inspection of preparation and assembly				
13.5.1 Inspection and test plan	NPR	Documented inspection and test plan required	Documented inspection and test plan required	Documented inspection and test plan required
13.6 Inspection of welding				
13.6.1.1 General	Inspection requirements as per Table 13.6	Inspection requirements as per Table 13.6	Inspection requirements as per Table 13.6	Inspection requirements as per Table 13.6
13.6.1.2 Inspection and test plan for welding	Required when specified Details as listed		Required Details as listed	
13.6.2.2 Scope of inspection	Extent and type of NDE as per Tables 13.6.2.2(A) and (B)	Extent and type of NDE as per Tables 13.6.2.2(A) and (B)	Extent and type of NDE as per Tables 13.6.2.2(A) and (B)	Extent and type of NDE as per Tables 13.6.2.2(A) and (B)

(*continued*)

TABLE B4 (*continued*)

Clause	CC1	CC2	CC3	CC4
13.7 Inspection of mechanical fastening				
13.7.1 Inspection and test plan	NPR	Documented inspection and test plan required	Documented inspection and test plan required	Documented inspection and test plan required
13.7.8 Inspection of tensioned high-strength bolted connection	NPR	Required	Required	Required
13.11 Inspection of erection				
13.11.1 Inspection and test plan	NPR	Documented inspection and test plan required	Documented inspection and test plan required	Documented inspection and test plan required

NOTES:

1 'NPR' = No particular requirement. However, general requirements specified in the relevant Clause in the Standard and any requirements required by the construction specification are still applicable.

2 The requirements for CC4 are additional to CC3 but not fully defined in this Standard. CC4 applies to unusual or special structures for which it is expected that requirements additional to those for CC3 will be defined at a project specific level or by a particular organization, agency or business.

3 Quality documentation for CC1 should be consistent with Appendix D.

4 Recommended elements of a quality management system are provided in Appendix D.

APPENDIX C

GUIDANCE ON DETERMINATION OF THE CONSTRUCTION CATEGORY

(Informative)

C1 BACKGROUND

The selection of a 'Construction Category', as applicable to a steel structure or components thereof, is a risk based approach intended to provide consistency with the reliability based philosophy and principles on which the fundamental load assessment (AS/NZS 1170 series) and structural design (AS 4100 and AS 5100.6) is based. The approach translates into a fit-for-purpose assessment that ensures the fabrication and erection of steel structures is based on a rational risk assessment, recognizing the importance of the structure, what maintenance and inspection measures will be in place, the consequences of failure and the complexity of the fabrication and erection.

AS/NZS 1170 series is based on the philosophy and principles set out in ISO 2394, *General principles on reliability for structures*, which provides a common basis for defining design rules relevant to the construction and use of a wide variety of buildings, bridges and civil engineering works. It includes methods for establishing and calibrating limit states design Standards. The required reliability is related to the expected social and economic consequences from a design failure. Significantly, the required reliability may be achieved through suitable combinations of the following measures:

(a) Measures related to design, such as choice of values of action variables, reliability of design calculations, accuracy of mechanical models used and the like.

(b) Measures relating to quality assurance, to reduce the risk of hazards from gross human errors, design and execution (fabrication and erection).

The construction category classification provides a fit-for-purpose level of quality assurance to reduce risks associated with fabrication and erection. It achieves this through reliability differentiation from inspection and supervision levels.

AS/NZS 1170.0 references the 'importance level' for the building or structure as the primary indicator of the relative risk to life in extreme events (consequences of failure), and is based on the philosophy and principles set out in AS 5104 (ISO 2394). For Australia, the importance level is defined in the National Construction Code (NCC). For New Zealand, or for structures in Australia not covered by the NCC, AS/NZS 1170.0, Section 3 is utilized.

The importance level is one component of the risk assessment that provides the basis for the calculation of the construction category. Other components reflect the type of loading the structure is subjected to and the complexity of the fabrication. Taken together, these components formalize the reliability differentiation that is included in AS 5104 and is implicit within AS/NZS 1170.0.

C2 INTRODUCTION

This Appendix provides guidance on the choice of the construction category relevant to the building or structure as a whole or to components of the structure where it is appropriate to assign different construction categories.

NOTE: The process outlined for defining a construction category is consistent with the philosophy and principles on which AS/NZS 1170.0 is based and intended to provide a level of consistency between the basis for the design assumptions and those for the ensuing fabrication and erection of the building or structure.

The determination of the construction category is undertaken in the design phase, based on the known loading for the building, the intended function, what maintenance and inspection measures will be in place, the elements that comprise the structure and the expected complexity of fabrication or erection for the structure. The construction specification should embody the specifics of these decisions and the additional and optional information necessary to fully define the necessary requirements for the chosen construction category or categories.

C3 INPUT FACTORS DETERMINING THE CHOICE OF CONSTRUCTION CATEGORY

C3.1 General

The selection of the construction category defined in Paragraph C4 is based on three input variables:

(a) The 'importance factor', which reflects the risk to life and consequences of failure (see Paragraph C3.2).

(b) The 'service category', which reflects the actions to which the structure and its parts are likely to be exposed, such as earthquake or fatigue (see Paragraph C3.3).

(c) The 'fabrication category', which reflects the complexity of the fabrication of the structure and its components (see Paragraph C3.4).

C3.2 Importance factor

The National Construction Code (for Australia) or AS/NZS 1170.0, Section 3 (for New Zealand) defines the importance levels for different structure types. Importance levels are designated from 1 (representing the lowest risk to life) up to 4 (representing the highest risk to life and/or post disaster recover functions). An additional importance level of 5 is designated for New Zealand only, representing special structures outside the scope of the Standard.

Where the structure type falls outside the scope of the NCC, AS/NZS 1170.0, Section 3 should be referred to.

NOTE: There is no provision in the NCC or in AS/NZS 1170.0 for designating parts of a structure with different importance factors.

C3.3 Service category

The selected service category reflects the uncertainty in the exposure of the structure to actions that may expose flaws in the structure during use. The service category may be selected based on Table C1.

TABLE C1
SUGGESTED CRITERIA FOR SERVICE CATEGORIES

Service category	Criteria
SC1	• Structures or components designed for predominantly quasi-static actions only. Examples include typical multi-level buildings, warehouses and storage facilities. *or* • Structures and components subject to low seismic demand (Categories 3, 4 systems in New Zealand and earthquake design Categories I and II in Australia). *or* • Structures and components designed for low level fatigue actions where fatigue assessment is not required (e.g. for applications that satisfy AS 4100, Clause 11.4 , AS 5100.6 Clause 13.4 (for Australia) or NZS 3404, Clause 10.4 (for New Zealand) or cranes classified S1-3 according to AS 1418.1)
SC2	• Structures and components with members and connections subject to fatigue assessment in accordance with AS 4100, AS 5100.6 or NZS 3404.1. Examples include road and railway bridges, cranes and immediate supporting structure (where supported off the building or structure) and structures susceptible to vibrations produced by wind, crowds or vibrating machinery. *or* • Structures and connections subject to medium to high seismic demand (Categories 1, 2 systems in New Zealand and earthquake design Category III in Australia).

The structure or part of the structure can contain components or structural details that are categorized under different service categories.

NOTE: The service category is also used to assess the recommended extent of non-destructive examination (NDE) of welds (see Clause 12.6.10) and therefore should be nominated in the construction specification.

C3.4 Fabrication category

The selected fabrication category reflects the complexity of the fabrication inherent in the structure or parts of the structure. The fabrication category is selected based on Table C2.

TABLE C2
SUGGESTED CRITERIA FOR FABRICATION CATEGORIES

Fabrication category	Criteria
FC1	• Non-welded components manufactured from any steel grade products • Welded components manufactured from steel grade components less than or equal to Grade 450
FC2	• Welded components manufactured from steel above Grade 450 • Site welded components essential for structural integrity • Components receiving thermic treatment during manufacturing • Components of CHS trusses requiring end profile cuts

The structure or part of the structure can contain components or structural details that are categorized under different fabrication categories.

C4 DETERMINATION OF THE CONSTRUCTION CATEGORY

The construction category may be determined by the following process:

(a) Selection of the building or structure importance level, from the National Construction Code (for projects in Australia covered by the NCC) or AS/NZS 1170.0, Section 3 (for projects in New Zealand or projects in Australia not covered by the NCC).

(b) Selection of the service category (see Table C1).

(c) Selection of the fabrication category (see Table C2).

(d) Determination of the construction category from Table C3 (for Australia) or Table C4 (for New Zealand).

TABLE C3

RISK MATRIX FOR DETERMINATION OF THE CONSTRUCTION CATEGORY (FOR AUSTRALIA)

Importance level		**1**		**2**		**3**		**4**	
Service categories		**SC1**	**SC2**	**SC1**	**SC2**	**SC1**	**SC2**	**SC1**	**SC2**
Fabrication categories	FC1	CC1	CC3	CC2	CC3	CC3	CC3	CC3	CC3
	FC2	CC2	CC3	CC2	CC3	CC3	CC3	CC3	CC4

NOTES:

1 The determination of the construction category is the responsibility of the designer, taking national provisions, published guidance from industry associations and the relevant Work, Health and Safety regulations and Codes of Practice into account.

2 The requirements for CC4 are additional to CC3. The additional requirements are not fully defined in this Standard. CC4 applies to unusual or special structures for which it is expected that requirements additional to those for CC3 will be defined at a project specific level or by a particular organization, agency or business.

TABLE C4

RISK MATRIX FOR DETERMINATION OF THE CONSTRUCTION CATEGORY (FOR NEW ZEALAND)

Importance level		**1**		**2**		**3 and 4 (see Note 1)**	
Service categories		**SC1**	**SC2**	**SC1**	**SC2**	**SC1**	**SC2**
Fabrication categories	FC1	CC1	CC2	CC2	CC3	CC3	CC3
	FC2	CC2	CC2	CC2	CC3	CC3	CC3

NOTES:

1 Importance Level 5 structures are outside the scope of this determination. Project specific requirements should be determined for such structures.

2 Road and rail bridges with fracture critical components are CC4.

APPENDIX D

GUIDANCE ON ELEMENTS OF A QUALITY MANAGEMENT SYSTEM

(Informative)

D1 INTRODUCTION

AS/NZS ISO 3834 series provides guidance on relevant additional bases for use when AS/NZS ISO 9001 is to be applied to the special process of welding. AS/NZS ISO 3834 series makes it clear that its guidance is not restricted to welding but is applicable to other associated activities (such as post-weld heat treatment) and other hot processes that can affect the metallurgy of the parent materials (such as thermal cutting).

Welding is the core operation in the portfolio of the essential manufacturing/fabrication processes undertaken to produce a finished fabricated assembly or structure. It may be seen that the discipline provided by AS/NZS ISO 3834 series can be readily applied to all the essential processes—whether they be hot processes or otherwise.

This Appendix adapts Annex A of AS/NZS ISO 3834:2008 series to the three essential processes of the following:

(a) Fabrication (see Paragraph D2).

(b) Corrosion protection (see Paragraph D3).

(c) Erection (see Paragraph D4).

Tables D1, D2 and D3 list relevant QMS elements with indications of their applicability to each of the construction categories.

NOTE: Fabrication includes preparation and assembly.

D2 QUALITY SYSTEsM ELEMENTS—FABRICATION

The quality management system elements relevant to fabrication are outlined in Table D1.

TABLE D1

QUALITY SYSTEM ELEMENTS—FABRICATION

Item	Element	Construction category		
		CC3/CC4	CC2	CC1
1	Review of requirements	Review required		
		Record is required	Record may be required	Record is not required
2	Technical review	Review required		
		Record is required	Record may be required	Record is not required
3	Sub-contracting	Treat like a manufacturer for the specific sub-contracted product, services and/or activities. Final responsibility for quality remains with the manufacturer		
4	Operators	Competent personnel are required		
5	Supervisory personnel	Competent personnel are required		No specific requirement
6	Inspection and testing personnel	Competent personnel are required		

(*continued*)

TABLE D1 (*continued*)

Item	Element	Construction category		
		CC3/CC4	CC2	CC1
7	Production and testing equipment	Suitable and available as required for preparation, process execution, testing, transport, lifting in combination with safety equipment and protective clothes		
8	Equipment maintenance	Required to provide, maintain and achieve product conformity		No specific requirement
		Documented plans and records are required	Records are recommended	
9	Description of equipment	List is required		No specific requirement
10	Production planning	Required		No specific requirement
		Documented plans and records are required	Documented plans and records are recommended	No specific requirement
11	Process procedure specifications	Required as work method statements		No specific requirement
12	Qualification of process procedures	If required		No specific requirement
13	Storage of parent material	Protection required from influence by environment, identification shall be maintained through storage		No specific requirement
14	Inspection and testing before, during and after processing	Required utilizing Inspection and Test Plan (ITP)		No specific requirement
15	Non-conformance and corrective actions	Measures of control are implemented, procedures for repair and/or rectification are required		Measures of control are implemented
16	Calibration or validation of measuring, inspection and testing equipment	Required	If required	No specific requirement
17	Identification during process	Required		No specific requirement
18	Traceability	Full (see Clause 4.6)	Partial (see Clause 4.6)	Basic (see Clause 4.6)
19	Quality records	Required		

D3 QUALITY SYSTEM ELEMENTS—CORROSION PROTECTION

The quality system elements relevant to corrosion protection are outlined in Table D2. It lists relevant QMS elements with indications of their applicability to the coating quality level.

TABLE D2
QUALITY SYSTEM ELEMENTS—CORROSION PROTECTION

Item	Element	Coating quality level	
		PC2	PC1
1	Review of requirements	Review required	
		Record is required	Record is not required
3	Sub-contracting	Treat like a manufacturer for the specific sub-contracted product, services and/or activities. Final responsibility for quality remains with the manufacturer	
4	Blasters and applicators	Competent personnel are required	
5	Coordination personnel	Competent personnel are required	
6	Inspection and testing personnel	Competent personnel are required	
7	Production and testing equipment	Suitable and available as required for surface preparation and coating application, testing, and handling in combination with safety equipment and protective clothes	
8	Equipment maintenance	Required to provide, maintain and achieve product conformity	
		Documented plans and records are required	Records are recommended
9	Description of equipment	List is required	No specific requirement
10	Production planning	Required	No specific requirement
		Documented plans and records are required	No specific requirement
11	Product application procedure specifications	Required based on product manufacturer's product data sheet	
12	Health, safety and environmental aspects	Required with observance of product manufacturer's product data sheet, safety data sheet and safety work method statements	
13	Batch testing of products to be applied	If required	
14	Storage and handling of products to be applied	In accordance with product manufacturer's data sheet	
15	Storage and handling of steelwork	Properly stored and handled	
16	Pre-treatment and blast cleaning of surface	Confirmation that the requirements are in accordance with specification.	
17	Inspection and testing before, during and after coating	Confirmation that the requirements are in accordance with specification.	
18	Non-conformance and corrective actions	Measures of control are implemented, procedures for repair and/or rectification are required	
19	Calibration or validation of measuring, inspection and testing equipment	Required	
20	Identification during process	Required	
22	Quality records	Required	

D4 QUALITY SYSTEM ELEMENTS—ERECTION

The quality system elements relevant to erection are outlined in Table D3.

TABLE D3

QUALITY SYSTEM ELEMENTS—ERECTION

Item	Element	Construction category		
		CC3/CC4	CC2	CC1
1	Review of requirements	Review required		
		Record is required	Record may be required	Record is not required
2	Technical review	Review required		
		Record is required	Record may be required	Record is not required
3	Sub-contracting	Treat like a constructor for the specific sub-contracted product, services and/or activities. Final responsibility for quality remains with the constructor		
4	Erectors and erecting	Competent personnel are required		
5	Erection coordination personnel	Competent personnel are required		No specific requirement
6	Survey personnel	Competent personnel are required		
7	Erection equipment	Suitable and available as required for lifting, placing and personnel access in combination with safety equipment and protective clothes.		
8	Equipment maintenance	Required to meet safety regulations, records are required		
9	Description of equipment	List of equipment to be used on each site is required		No specific requirement
10	Erection planning	Documented method statement(s) required		No specific requirement
		Review required	Review if required	No specific requirement
11	Storage and handling of bolts	Protection required from influence by environment, identification shall be maintained through storage		No specific requirement
12	Storage of structural steel components	Identification shall be maintained through storage		No specific requirement
13	Lifting and placing structural steel components	Under responsibility of competent lift coordinator		No specific requirement
14	Lining and levelling steel structure	Under responsibility of competent site engineer		No specific requirement
15	Site bolting	Under responsibility of competent bolting coordinator		No specific requirement
16	Site welding	Under responsibility of competent welding coordinator		No specific requirement
17	Post-erection site painting (e.g. touch up)	Confirmation that the requirements in accordance with product data sheet are fulfilled by visual examination		No specific requirement
18	Inspection and testing before, during and after site painting	Required utilizing Inspection and Test Plan (ITP)		No specific requirement

(*continued*)

TABLE D3 (*continued*)

Item	Element	Construction category		
		CC3/CC4	CC2	CC1
19	Non-conformance and corrective actions	Measures of control are implemented, procedures for repair and/or rectification are required		
20	Calibration or validation of measuring, inspection and testing equipment	Required	If required	No specific requirement
21	Identification during process	If required		No specific requirement
22	Traceability	Full (see Clause 4.6)	Partial (see Clause 4.6)	Basic (see Clause 4.6)
23	As-built records	If required		

APPENDIX E

GUIDANCE ON THE CONTENT OF A QUALITY PLAN

(Informative)

E1 INTRODUCTION

This Appendix provides guidance on matters recommended to be included in a project-specific quality plan for the construction of a steel structure.

E2 CONTENT

E2.1 Management

A project-specific quality plan should address the following matters:

(a) A complete description of the steel structure and its location in relation to the total project.

(b) A project management organization chart containing the names of key personnel, their function and responsibilities during the project, the chain of command that is to apply and the lines of communication that are to be used.

(c) Arrangements for the coordination with other parties throughout the project and for the monitoring of their performance and progress.

(d) The identification of functions to be delegated to subcontractors and any other outside organization.

(e) The identification and proof of competence of qualified personnel to be employed on the project, including welding supervisors, welding inspection personnel, welders and welding operators.

(f) Arrangements for controlling variations, changes and concessions that may be agreed during the project.

E2.2 Specification review

Review of project requirements under the QMS may identify additional or unusual measures beyond those already covered by the company's quality management system. The quality plan may need to be updated to accommodate these measures.

E2.3 Documentation

E2.3.1 *General*

Procedures to manage all incoming documentation issued for construction and documentation issued by the organization for construction should be documented and included in the project-specific quality plan. Such procedures should include a method for the identification of the current revision status and should prevent the use of invalid or obsolete documents by in-house personnel or by subcontractors.

E2.3.2 *Documentation prior to execution*

Procedures should be documented for providing or obtaining (as appropriate) documentation prior to construction, which should include the following:

(a) Certificates for all materials and consumables to be employed on the project.

(b) Weld procedure specifications and qualification records.

(c) Method statements for all activities identified in this Standard.

(d) Design calculations for any temporary works necessitated by the erection method statements.

(e) Arrangements for the scope and the timing of any required second- or third-party approval or acceptance of documentation prior to construction.

(f) Delivery schedules for components delivered to site, together with identification with respect to location within the completed structure.

E2.3.3 *Construction records*

Procedures should be documented for providing documentation of the construction process which should include the following:

(a) All materials and consumables traceable to completed components.

(b) Inspection and test reports and any action taken to deal with nonconformities in relation to the preparation of joint faces prior to welding, welding and completed weldments, geometrical tolerances of manufactured components, surface preparation and corrosion protection, calibration of equipment including those used for the control of tensioning of mechanical fasteners.

(c) Pre-erection survey results leading to acceptance that the site is suitable for erection of steelwork to commence.

(d) Dimensional surveys of the structure and action taken to deal with any nonconformities.

(e) Certificates for completion of erection and handover.

E2.3.4 *Retention of documentary records*

Arrangements should be made for making documentary records available for inspection, and for retaining them for a minimum period of five years, or longer if required by other parties.

E2.4 Inspection and testing procedures

Procedures should be documented which identify a method of identifying all mandatory tests and inspections that are necessary for the project or are required by the construction specification, or by any referenced Standard or by the constructor's quality system.

Such procedures should include the following:

(a) The scope of the tests and inspections required.

(b) Acceptance criteria.

(c) Actions for dealing with nonconformities, corrections and concessions.

Procedures should be documented for project-specific requirements for inspection and testing, including any requirements that particular tests or inspections are to be witnessed and by whom, points where any inspection is to be carried out, identification of hold points associated with witnessing, approval or acceptance of test or inspection results.

APPENDIX F

GEOMETRICAL TOLERANCES

(Normative)

F1 GENERAL

The following Tables of tolerances are contained in this Appendix.

Manufacturing tolerances	
Table F1.1	Structural sections after manufacture
Table F1.2	Flanges of welded profiles
Table F1.3	Structural decking after manufacture
Table F1.4	Press-braked cold-formed profiles

Fabrication tolerances	
Table F2.1	Welded I sections after fabrication and rolled sections after fabrication (hot-rolled or cold-formed)
Table F2.2	Elements of fabrication of components and members
Table F2.3	Components
Table F2.4	Flanges of welded profiles
Table F2.5	Webs of welded profiles or box sections
Table F2.6	Fabricated three plate sections
Table F2.7	Fabricated box sections
Table F2.8	Fabricated trusses and truss elements
Table F2.9	Stiffened plating
Table F2.10	Bridge decks

Erection tolerances	
Table F3.1	Foundations and supports
Table F3.2	Frame setout
Table F3.3	Columns
Table F3.4	Beams
Table F3.5	Crane runway girders
Table F3.6	Bridges
Table F3.7	Bridge decks

The permissible deviations given in the Tables do not include any allowance for elastic deformations induced by the self-weight of the members or components.

Methods of measurement and methods to be used for the measurement of fabricated members and components shall comply with Clause 13.4. Accuracy of measurement shall be assessed in accordance with the requirements of the relevant Part of ISO 17123.

Methods of measurement and methods to be used for the measurement of erected members and components shall comply with Clause 13.11.4. Accuracy of measurement shall be assessed in accordance with the requirements of the relevant Part of ISO 17123 and shall be corrected for temperature using the relevant Part of ISO 17123.

F2 MANUFACTURING TOLERANCES

TABLE F1.1

STRUCTURAL SECTIONS AFTER MANUFACTURE

No.	Criterion	Parameters	Permitted deviations Δ functional tolerances
1	Hot-rolled I, C and L sections conforming to AS/NZS 3679.1	Variation in straightness (both sweep and camber), variation in cross-sectional dimensions	As specified in AS/NZS 3679.1
2	Three plate sections conforming to AS/NZS 3679.2	Variation in straightness (both sweep and camber), variation in cross-sectional dimensions, web tolerance, flange tolerance	As specified in AS/NZS 3679.2
3	Structural hollow sections conforming to AS/NZS 1163	External dimensions, thickness, out-of-roundness, concavity/convexity, straightness	As specified in AS/NZS 1163

TABLE F1.2

FLANGES OF WELDED PROFILES

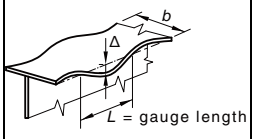
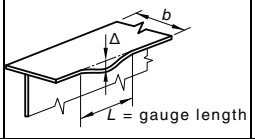
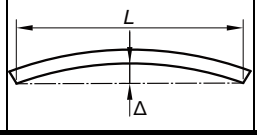
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Flange distortion of I section: 	Deviation (Δ) on gauge length (L) equal to flange width (b)	$\Delta = \pm b/150$ for $b \leq 450$ mm $\Delta = \pm 3$ mm for $b > 450$ mm	$\Delta = \pm b/100$	$\Delta = \pm b/150$
2	Flange undulation of I section: 	Deviation (Δ) on gauge length (L) equal to flange width (b)	$\Delta = \pm b/150$ for $b \leq 450$ mm $\Delta = \pm 3$mm for $b > 450$ mm	$\Delta = \pm b/100$	$\Delta = \pm b/150$
3	Straightness for components to be used unrestrained: 	Deviation (Δ) from straightness	$\Delta = \pm L/750$	$\Delta = \pm L/750$	$\Delta = \pm L/1000$

TABLE F1.3
STRUCTURAL DECKING AFTER MANUFACTURE

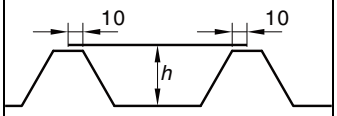
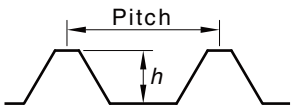
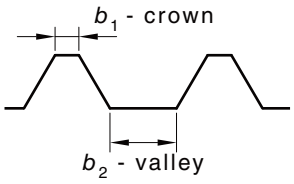
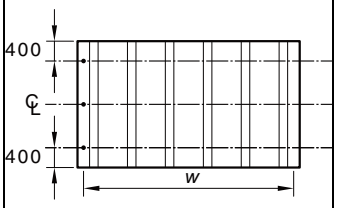
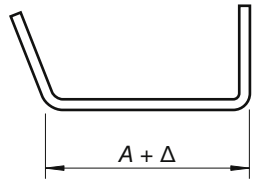
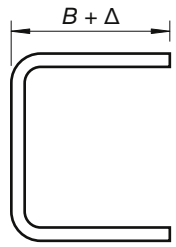
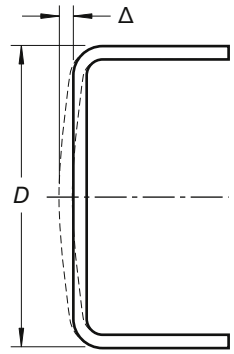
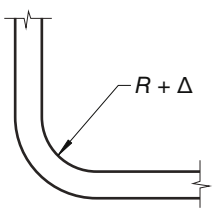
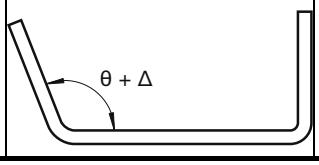
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Depth of profile  h = nominal depth of profile	$h \leq 50$ mm 50 mm < $h \leq 100$ mm $h > 100$ mm Measured on a line across the sheet 400 mm from the end of the sheet	Δ = ±1 mm Δ = ±1.5 mm Δ = ±2 mm where: $\Delta = (h_{measured} - h)$	No requirement	No requirement
2	Depth of stiffeners on crown, valley or web d = nominal depth	Measured in a line across the sheet 400 mm from the end of the sheet	Δ = ±1 mm where: $\Delta = (d_{measured} - d)$	No requirement	No requirement
3	Pitch of profile – distance between centre and adjacent ribs  h = nominal depth of profile	$h \leq 50$ mm 50 mm < $h \leq 100$ mm $h > 100$ mm Measured 400 mm from the end of the sheet	Δ = ±2 mm Δ = ±3 mm Δ = ±4 mm Δ = (measured pitch – nominal pitch)	No requirement	No requirement
4	Widths of crown and valley 	Measured 400 mm from the end of the sheet	Δ = +2 mm −1 mm where: Δ = (measured value – nominal value)	No requirement	No requirement
5	Cover width (w), as stated by the manufacturer  Δ_1, Δ_2 = (measured value – nominal value) $\Delta_3 = w_3 - \left(\frac{w_1 + w_2}{2}\right)$	$h \leq 50$ mm $h > 50$ mm h = nominal profile depth Measured 400 mm from each end of the sheet – w_1, w_2 and at ℄ – w_3	$\Delta_1, \Delta_2, \Delta_3 = \pm 5$ mm $\Delta_1, \Delta_2, \Delta_3 = \pm h/10$ ≤15 mm	No requirement	No requirement
6	Thickness of decking profile as stated by the manufacturer	Deviation from nominal thickness (t)—measured 400 mm from the end of the sheet	$\Delta = \pm t/10$ where Δ = (measured thickness – nominal thickness)	No requirement	No requirement

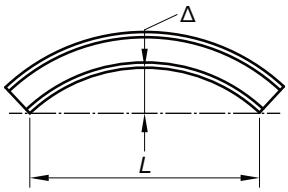
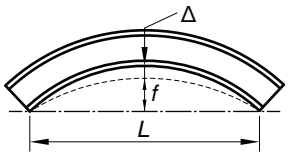
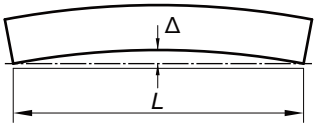
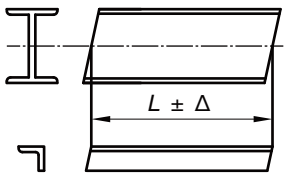
TABLE F1.4
PRESS-BRAKED COLD-FORMED PROFILES

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Internal element width 	Width A between bends: t < 3 mm: Length < 7 m Length ≥ 7 m t ≥ 3 mm: Length < 7 m Length ≥ 7 m	$-\Delta = A/50$	 Δ = ±3 mm Δ = –3 mm / +5 mm Δ = ±5 mm Δ = –5 mm / +9 mm	 Δ = ±2 mm Δ = –2 mm / +4 mm Δ = ±3 mm Δ = –3 mm / +6 mm
2	Outstand element width 	Width B between a bend and a free edge Mill edge: t < 3 mm t ≥ 3 mm Sheared edge: t < 3 mm t ≥ 3 mm	$-\Delta = B/80$	 Δ = –3 mm / +6 mm Δ = –5 mm / +7 mm Δ = –2 mm / +5 mm Δ = –3 mm / +6 mm	 Δ = –2 mm / +4 mm Δ = –3 mm / +5 mm Δ = –1 mm / +3 mm Δ = –2 mm / +4 mm
3	Flatness 	Convexity or concavity	No	Δ = ±D/50	Δ = ±D/100
4	Bend radius 	Internal bend radius R	No requirement	Δ = ±2 mm	Δ = ±1 mm
5	Shape 	Angle θ between adjacent components	No requirement	Δ = ±3°	Δ = ±2°

F3 FABRICATION TOLERANCES

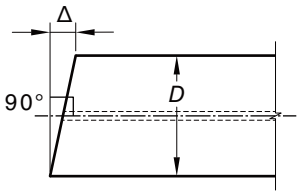
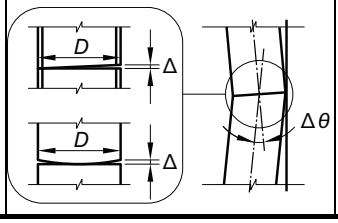
TABLE F2.1

WELDED I SECTIONS AFTER FABRICATION AND ROLLED SECTIONS AFTER FABRICATION (HOT-ROLLED OR COLD-FORMED)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Unintended camber about major axis 	Beam Column where: L = overall length of member Measured with web horizontal, at centre	Δ = lesser of (L/1000; 10 mm) Δ = greater of (L/1000; 3 mm)	Δ = ±L/750 but $\lvert\Delta\rvert \geq 5$ mm Δ = ±L/750 but $\lvert\Delta\rvert \geq 5$ mm	Δ = ±L/750 but $\lvert\Delta\rvert \geq 3$ mm Δ = ±L/750 but $\lvert\Delta\rvert \geq 3$ mm
2	Deviation from intended curve or camber about major axis 	Beam where: f = intended curve or camber at centre, measured with web horizontal, at centre L = overall length of member	Δ = greater of (L/500; 6 mm)	Δ = ±L/500 but $\lvert\Delta\rvert \geq 6$ mm	Δ = ±L/1000 but $\lvert\Delta\rvert \geq 4$ mm
3	Unintended sweep about minor axis 	Beam or column Measured with web vertical, at centre	Δ = greater of (L/1000; 3 mm)	Δ = ±L/750 but $\lvert\Delta\rvert \geq 5$ mm	Δ = ±L/750 but $\lvert\Delta\rvert \geq 3$ mm
4	Deviation from nominal overall length (L) 	Column Beam, tension member: L < 10 m $L \geq 10$ m where: L = nominal overall length of member Measured on the centre line of the section or on the corners for angles	Δ = ±2 mm Δ = ±2 mm = ±4 mm	Δ = ±(L/5000 + 2) mm Δ = ±(L/5000 + 2) mm	Δ = ±(L/10000 + 2) mm Δ = ±(L/10000 + 2) mm

(*continued*)

TABLE F2.1 (*continued*)

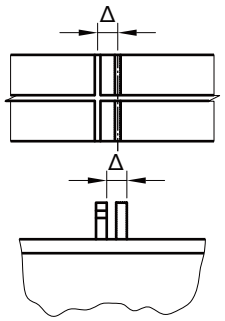
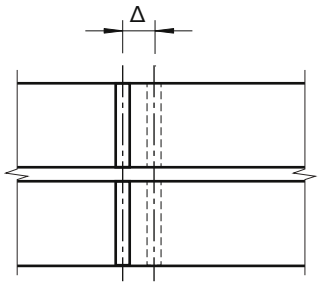
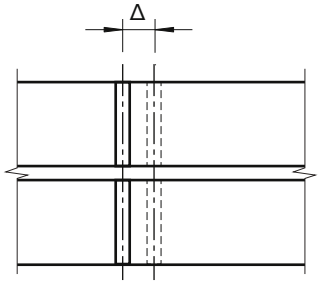
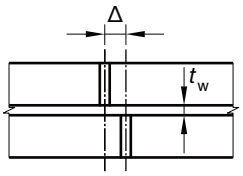
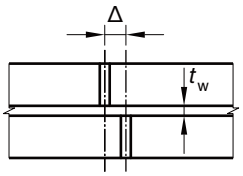
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
5	Squareness of end 	Measured with respect to longitudinal axis of member:			
		Intended for full contact bearing	Δ ≤ 1 mm Δ ≤ 0.5 mm over at least 67% of contact area	Δ = ±*D*/1000	Δ = ±*D*/1000
		Not intended for full contact bearing	No requirement	Δ = ±*D*/100	Δ = ±*D*/300 but |Δ| ≤ 10 mm
6	Full contact splice—gap between bearing surfaces 	Measured when local angular misalignment ΔΘ is occurring at same time as gap Δ	Δ = 0.5 mm over at least 67% of the area with a maximum of 1.0 mm locally ΔΘ = ±1/500 radians	No requirement	No requirement

NOTES:

1 See Table F1.1 for welded sections complying with AS/NZS 3679.2 and rolled sections complying with AS/NZS 3679.1 and AS/NZS 1163.

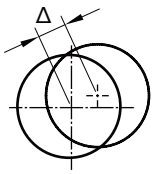
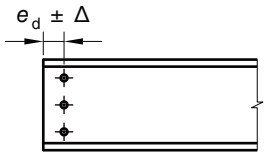
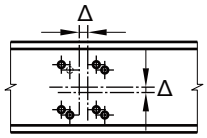
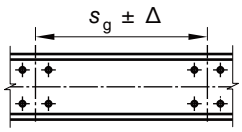
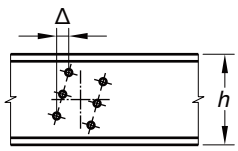
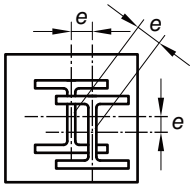
2 Notations such as Δ = ±*L*/750 but |Δ| ≥ 5 mm mean that |Δ| is the larger of *L*/750 and 5 mm.

TABLE F2.2
ELEMENTS OF FABRICATION OF COMPONENTS AND MEMBERS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Position of fitments 	Deviation (Δ) from the intended position, relative to the setting-out position on the primary component/member	Δ = ±3 mm	No requirement	No requirement
2	Position of web stiffeners 	Deviation (Δ) from the intended position, relative to the setting-out position on the primary component/member	Δ = ±5 mm	Δ = ±5 mm	Δ = ±3 mm
3	Position of web stiffeners at support 	Deviation (Δ) from the intended position, relative to the setting-out position on the primary component/member	Δ = ±3 mm	Δ = ±3 mm	Δ = ±2 mm
4	Position of stiffener pairs 	Misalignment (Δ) between a pair of stiffeners welded to a web of thickness (t_w)	Δ = ±t_w/2	Δ = ±t_w/2	Δ = ±t_w/3
5	Position of stiffener pairs at supports 	Misalignment (Δ) between a pair of load-bearing stiffeners welded to a web of thickness (t_w)	Δ = ±t_w/3	Δ = ±t_w/3	Δ = ±t_w/4

(*continued*)

TABLE F2.2 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
6	Position of holes for fasteners 	Deviation (Δ) from the intended position of an individual hole within a group of holes, measured in any direction	Δ = ±2 mm	Δ = ±2 mm	Δ = ±1 mm
7	Position of group of holes from a cut end 	Deviation (Δ) in distance e_d between an individual hole and a cut end where: e_d = nominal distance from centre of hole group to cut end	Δ = –0 mm = + 3 mm	Δ = ±3 mm	Δ = ±2 mm
8	Position of group of holes along member 	Deviation (Δ) of a group of holes from its intended position	Δ = ±2 mm	Δ = ±2 mm	Δ = ±1 mm
9	Spacing of hole groups along a member 	Deviation (Δ) in spacing (s_g) between nominal centres of hole groups General case: Where a single piece is connected by two groups of fasteners	No requirements	Δ = ±5 mm Δ = ±2 mm	Δ = ±2 mm Δ = ±1 mm
10	Twist in a hole group 	Twist (Δ) $h \leq 1000$ mm for $h > 1000$ mm where: h = nominal depth of member	No requirement	Δ = ±2 mm Δ = 4 mm	Δ = ±1 mm Δ = 2 mm
11	Position of column on baseplate 	Unintended eccentricity (e) along either principal axis or in any direction	No requirement	e = 5 mm	e = 3 mm

(*continued*)

TABLE F2.2 (*continued*)

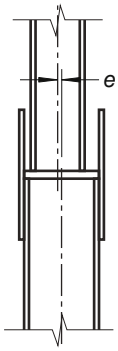
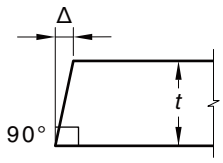
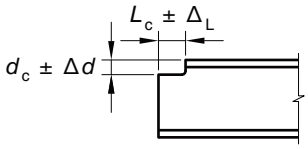
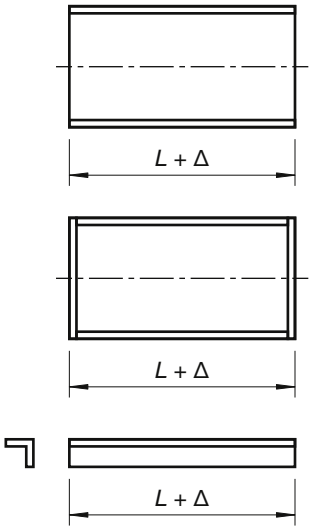
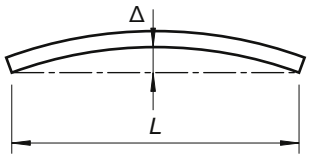
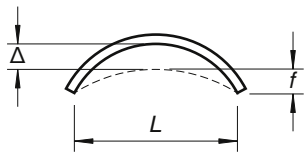
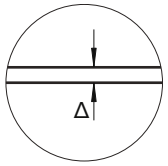
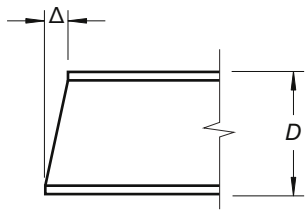
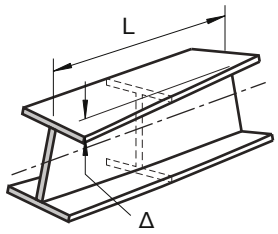
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
12	Column splice 	Non-intended eccentricity e (about either axis)	No requirement	e = 5 mm	e = 3 mm
13	Squareness of cut edges 	Deviation (Δ) from a 90° edge where: t = plate thickness	No requirement	$\Delta = \pm t/10$	$\Delta = \pm t/20$
14	Lengths and depths of copes in members 	Deviation (Δ) from nominated length (L_c) and depth (d_c) of cope Deviation on depth Deviation on length	No requirement	 Δ_d = +0 mm = –3 mm Δ_L = +0 mm = –3 mm	 Δ_d = +0 mm = –2 mm Δ_L = +0 mm = –2 mm

TABLE F2.3
COMPONENTS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Length  	Cut length measured on the centreline (or on the corner for an angle): (a) General case. (b) Ends ready for full contact bearing. Length *L* measured including welded end plates as applicable.	No requirement No requirement	Δ = ±(*L*/5000 + 2) mm Δ = ±1 mm	Δ = ± (*L*/10000 + 2) mm Δ = ±1 mm
2	Length, where sufficient compensation with adjacent component is possible	Cut length measured on centre-line	No requirement	Δ = ±50 mm	Δ = ±50 mm
3	Straightness  	Deviation Δ from rectangular axes of a fabricated or press braked section For rolled or hot finished sections see the relevant product Standard.	No requirement	Δ = ±*L*/750 but |Δ| ≥ 5 mm	Δ = ±*L*/750 but |Δ| ≥ 3 mm
4	Camber or intended curvature on plan  	Offset *f* at mid-length Vertical camber should be measured with the member on its side.	No requirement	Δ = ±*L*/500 but |Δ| ≥ 6 mm	Δ = ±*L*/1000 but |Δ| ≥ 4 mm
5	Surfaces finished for full contact bearing  	Gap Δ between straightedge and surface No surface roughness criterion is specified.		Δ = 0.5 mm High spots to not be proud by more than 0.5 mm	Δ = 0.25 mm High spots to not be proud by more than 0.25 mm

(*continued*)

TABLE F2.3 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
6	Squareness of ends 	Squareness to longitudinal axis:			
		(a) Ends intended for full contact bearing.	No requirement	$\Delta = \pm D/1000$	$\Delta = \pm D/1000$
		(b) Ends not intended for full contact bearing.	No requirement	$\Delta = \pm D/100$	$\Delta = \pm D/300$ but $\lvert\Delta\rvert \le 10$ mm
7	Twist 	Overall deviation Δ in a piece of length L	No requirement		
		For box sections see Table F2.7. For structural hollow sections see the relevant product Standard.		$\Delta = \pm L/700$ but $4 \text{ mm} \le \lvert\Delta\rvert \le 20$ mm	$\Delta = \pm L/1000$ but $3 \text{ mm} \le \lvert\Delta\rvert \le 15$ mm

NOTE: Notations such as $\Delta = \pm d/100$ but $|\Delta| \ge 5$ mm mean that $|\Delta|$ is the larger of $d/100$ and 5 mm.

TABLE F2.4
FLANGES OF WELDED PROFILES

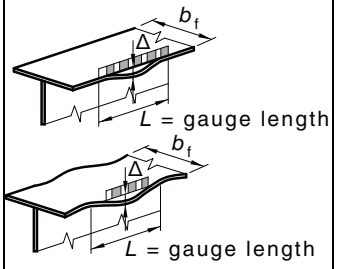
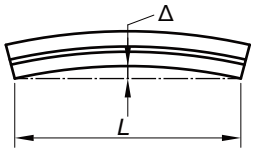
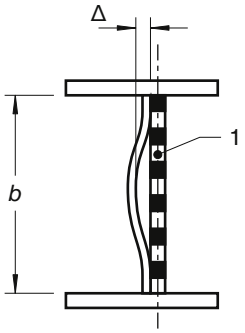
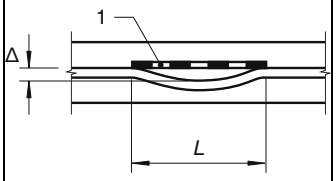
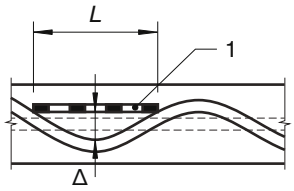
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Undulation of flange 	Deviation (Δ) over gauge length (L) equal to flange width (b_f)			
		$b_f/t_f \le 20$	$\Delta = \pm b_f/150$	$\Delta = b_f/100$	$\Delta = b_f/150$
		$b_f/t_f > 20$	for $b_f \le 450$ mm		
		where:	$\Delta = \pm 3$ mm		
		t_f = flange thickness	for $b_f > 450$ mm		
2	Straightness of each flange 	Deviation (Δ) from line measured between flange ends	$\Delta = L/750$	$\Delta = L/750$	$\Delta = L/1000$
		where:			
		L = total length of flange			

TABLE F2.5
WEBS OF WELDED PROFILES OR BOX SECTIONS

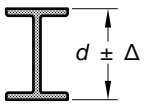
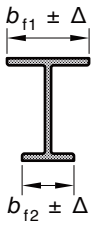
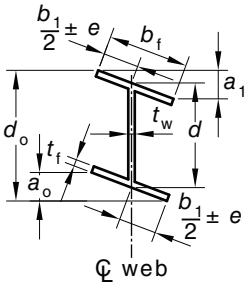
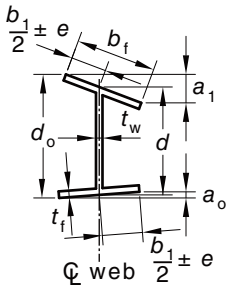
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Web curvature 	Deviation Δ on the web height *b*	Δ = ±*b*/150	Δ = ±*b*/100 but |Δ| ≥ 5 mm	Δ = ±*b*/150 but |Δ| ≥ 3 mm
2	Plate distortion 	Deviation Δ on gauge length *L* = web height *b*	Δ = ±*b*/100 but |Δ| ≥ *t* (*t* = plate thickness)	Δ = ±*b*/100 but |Δ| ≥ 5 mm	Δ = ±*b*/150 but |Δ| ≥ 3 mm
3	Plate undulation 	Deviation Δ on gauge length *L* = web height *b*	Δ = ±*b*/100 but |Δ| ≥ *t* (*t* = plate thickness)	Δ = ±*b*/100 but |Δ| ≥ 5 mm	Δ = ±*b*/150 but |Δ| ≥ 3 mm
4	Castellated beams and cellular beams (fabricated either from plate or from hot-rolled sections) with openings of inscribed nominal diameter *D*	Misalignment of web post: (a) across thickness (b) overlap of opening of nominal radius: *r* *r* = *D*/2 < 200 mm *r* = *D*/2 ≥ 200 mm	No requirement	Δ = ±2 mm Δ = ±2 mm Δ = ±*r*/100 ≤ 5 mm	Δ = ±2 mm Δ = ±2 mm Δ = ±*r*/100 ≤ 5 mm

NOTES:

1 1 = gauge length.

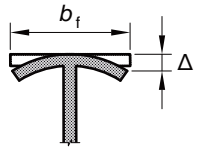
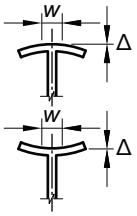
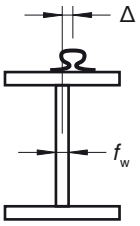
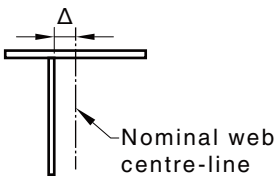
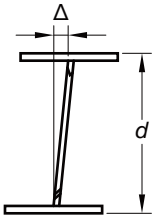
2 Notations such as Δ = ±*d*/100 but |Δ| ≥ 5 mm mean that |Δ| is the larger of *d*/100 and 5 mm.

TABLE F2.6
FABRICATED THREE PLATE SECTIONS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Depth of a section 	Deviation (Δ) from nominal depth (d)			
		$d \leq 900$ mm	Δ = ±3 mm	Δ = ±3 mm	Δ = ±2 mm
		$900 < d \leq 1800$ mm	$\Delta = \pm\left[3 + \frac{(d-900)}{300}\right]$ mm	Δ = ±h/300	Δ = ±h/450
		$d > 1800$ mm	Δ = ±6 mm	Δ = ±6 mm	Δ = ±4 mm
2	Width of a flange 	Deviation (Δ) from nominal width (b_f) of either flange	Δ = ±6 mm	+ Δ = b/100 but |Δ| ≥ 3 mm	+ Δ = b/100 but |Δ| ≥ 2 mm
3	Out-of-square of flanges – individual flange  – total out-of-square of two flanges 	Dimensions Δ_o or Δ_1			
		$b_f \leq 600$ mm	Δ ≤ 3 mm	Δ = b_f /100 but |Δ| ≥ 5 mm	Δ = b_f /100 but |Δ| ≥ 3 mm
		$b_f > 600$ mm	Δ ≤ (b_f /200)	Δ = b_f /100 but |Δ| ≥ 5 mm	Δ = bf /100 but |Δ| ≥ 3 mm
		NOTES: 1 Dimensions d, d_o, Δ_o, Δ_1 are measured parallel to centre-line of web. 2 Dimensions b_f and (0.5 b_f ±e) are measured parallel to the plane of the flange. 3 Dimension (d) is measured at the centre-line of the web.			

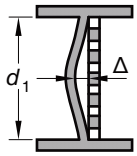
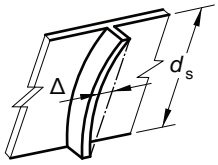
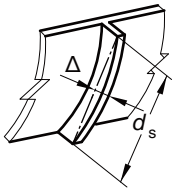
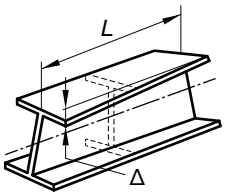
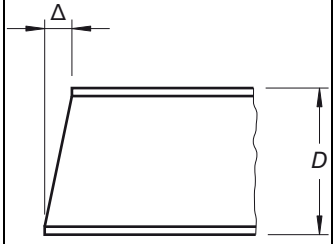
(*continued*)

TABLE F2.6 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
4	Out-of-flatness of flanges 	Deviation (Δ) from nominal flat position: (a) For $b_f \le 450$ mm. (b) For $b_f > 450$ mm. (c) Generally. (d) At bearing location. b_f = width of flange	 Δ = b_f / 150 mm Δ = ±3 mm No requirement No requirement	 Δ = ±b_f /150 but |Δ| ≥ 3 mm Δ = ±b_f /400	 Δ = ±b_f /150 but |Δ| ≥ 2 mm Δ = ±b_f /400
5	Out-of-flatness of top flange of crane runway girder 	Deviation (Δ) in the zone (w) where: w = base width of rail plus 10 mm each side of nominal edge of rail base	No requirement	Δ = ±1 mm	Δ = ±1 mm
6	Eccentricity of rail relative to web 	$t_w \le 10$ mm $t_w > 10$ mm	No requirement No requirement	Δ = 5 mm Δ = t_w /2	Δ = 5 mm Δ = t_w /2
7	Off-centre of a web 	Deviation (Δ) from nominal centre-line of web: (a) Generally. (b) At bearing location.	 Δ = ±6 mm Δ = ±3 mm	 Δ = ±5 mm Δ = ±3 mm	 Δ = ±4 mm Δ = ±2 mm
8	Deviation from verticality of a web at a support 	Deviation (Δ) from correction location $d \le 900$ mm $d > 900$ mm where: d = section depth	 Δ = ±3 mm Δ = ± (d/200) mm	 Δ = ±d/300 but |Δ| ≥ 3 mm	 Δ = ±d/500 but |Δ| ≥ 2 mm

(*continued*)

TABLE F2.6 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
9	Out-of-flatness of a web 	Deviation (Δ) from nominal centre-line of web: (a) Unstiffened web. (b) Stiffened web. (c) Generally.	 $\Delta = \pm d_1/150$ mm $\Delta = d_1/100$ mm	 $\Delta = \pm d_1/100$ but $\lvert\Delta\rvert \geq 5$ mm	 $\Delta = \pm d_1/150$ but $\lvert\Delta\rvert \geq 3$ mm
10	Straightness of a web stiffener—in plane 	Deviation (Δ) from nominal position in the plane of the web where: d_s = length of web stiffener	$\Delta = \pm d_s/250$ mm but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm d_s/250$ but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm d_s/375$ but $\lvert\Delta\rvert \geq 2$ mm
11	Straightness of a web stiffener—out of plane 	Deviation (Δ) from nominal position out of plane of the web where: d_s = length of web stiffener	$\Delta = \pm d_s/500$ mm but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm d_s/500$ but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm d_s/750$ but $\lvert\Delta\rvert \geq 2$ mm
12	Overall twist of member 	Deviation (Δ) from nominal position where: L = member length	No requirement	$\Delta = \pm L/700$ but 4 mm ≤ $\lvert\Delta\rvert$ ≤ 20 mm	$\Delta = \pm L/1000$ but 3 mm ≤ $\lvert\Delta\rvert$ ≤ 15 mm
13	Squareness of ends 	Squareness to longitudinal axis L = member length Ends intended for full contact bearing Ends not intended for full contact bearing	 No requirement No requirement	 $\Delta = \pm D/1000$ $\Delta = \pm D/100$	 $\Delta = \pm D/1000$ $\Delta = \pm D/300$ but $\lvert\Delta\rvert \leq 10$ mm
14	Deviation from intended curve or camber about major axis	Measured with web horizontal, at centre	See Table F2.1, Item 2		
15	Unintended sweep about minor axis	Measured with web vertical, at centre Beam or column	See Table F2.1, Item 3		
16	Deviation from nominal length (L)	Measured on the centre-line of the section	See Table F2.1, Item 4		

(*continued*)

TABLE F2.6 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
17	Unintended camber about major axis	Measured with web horizontal, at centre	See Table F2.1, Item 1		
18	Squareness of ends prepared for bearing at full contact splice	Measured with respect to longitudinal axis of member	See Table F2.1, Item 5		
19	Full contact splice – gap between bearing surfaces	Measured when local angular misalignment is $\Delta\Theta = 1/500$ radians	See Table F2.1, Item 6		

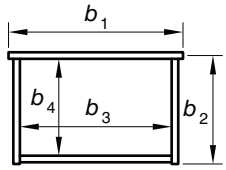
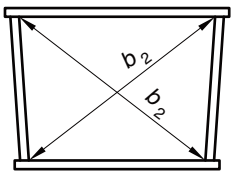
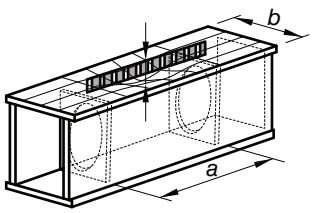
NOTES:

1 See Table F1.1 for welded sections complying with AS/NZS 3679.2.

2 2. Notations such as $\Delta = \pm d/100$ but $|\Delta| \geq 5$ mm mean that $|\Delta|$ is the larger of $d/100$ and 5 mm.

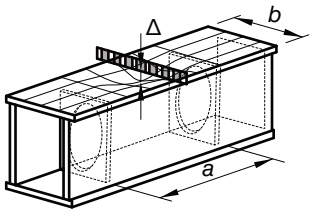
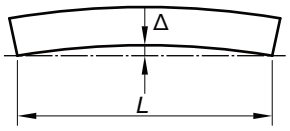
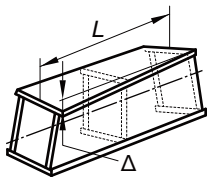
TABLE F2.7

FABRICATED BOX SECTIONS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Widths of component plates 	Deviation (Δ) in internal dimensions (b_3, b_4) and in external dimensions (b_1, b_2)			
		$b_i \leq 300$ mm	$\Delta = -(b_i/100)+3$ mm		
		$300 < b_i \leq 900$ mm	$\Delta = \pm 3$ mm	$\Delta = \pm 3$ mm	$\Delta = \pm 2$ mm
		$900 < b_i \leq 1800$ mm	$\Delta = \pm(b_i/300)$ mm	$\Delta = \pm(b_i/300)$	$\Delta = \pm(b_i/450)$
		$b_i > 1800$ mm	$\Delta = \pm 6$ mm	$\Delta = \pm 6$ mm	$\Delta = \pm 4$ mm
2	Squareness at locations of diaphragms and supports 	Deviation (Δ) between actual and intended value where: $\Delta=\lvert(b_1\text{-}b_2)_{act}\text{-}(b_1\text{-}b_2)_{nom}\rvert$ 'act' = actual 'nom' = nominal	$\Delta = (b_1 + b_2)/400$ mm but $\lvert\Delta\rvert \geq 5$ mm	$\Delta = (b_1 + b_2)_{nom}/400$ but $\lvert\Delta\rvert \geq 6$ mm	$\Delta = (b_1 + b_2)_{nom}/600$ but $\lvert\Delta\rvert \geq 4$ mm
3	Out of plane imperfections of plate panels between webs or stiffeners, general case 	Deviation (Δ) perpendicular to the plane of the plate			
		$a > 2b$	$\Delta = \pm b/125$	$\Delta = \pm b/125$	$\Delta = \pm b/125$
		$a \leq 2b$	$\Delta = \pm a/250$	$\Delta = \pm a/250$	$\Delta = \pm a/250$
		where: a = distance c/c of diaphragms b = plate width			

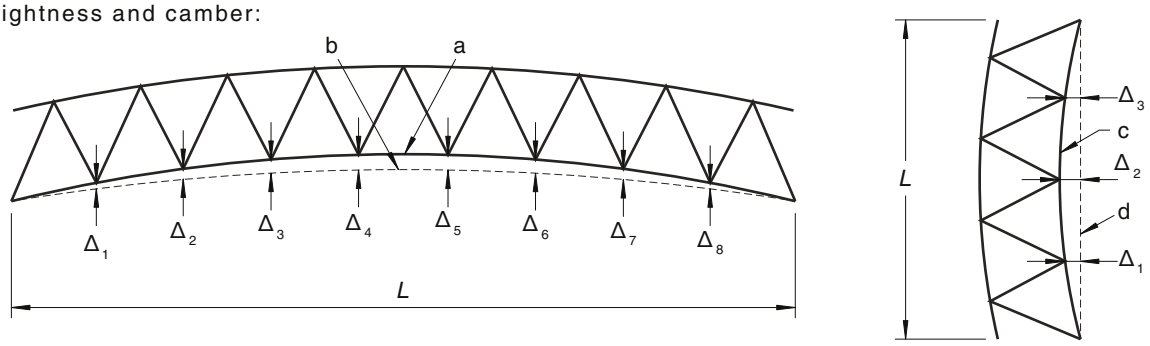
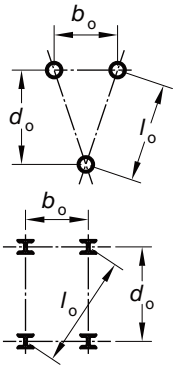
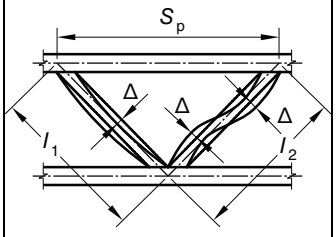
(*continued*)

TABLE F2.7 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
4	Out of plane imperfections of plate panels between webs or stiffeners (special case with compression in the transverse direction – the general case applies unless this special case is specified) 	Deviation (Δ) perpendicular to the plane of the plate $b > 2a$ $b \leq 2a$	 $\Delta = \pm a/125$ mm $\Delta = \pm b/250$ mm	 $\Delta = \pm a/125$ $\Delta = \pm b/250$	 $\Delta = \pm a/125$ $\Delta = \pm b/250$
5	Web and flange plate straightness 	Deviation (Δ) from nominal straight line between ends of plates, measured over total length (L) Beams/girders Columns/struts	 $\Delta = \pm L/500$ but $\lvert\Delta\rvert \leq 3$ mm $\Delta = \pm L/750$ but $\lvert\Delta\rvert \leq 3$ mm	$\Delta = \pm L/750$	$\Delta = \pm L/1000$
6	Overall twist of a member 	Deviation (Δ) over piece of length (L)	No requirement	$\Delta = \pm L/700$ but 4 mm ≤ $\lvert\Delta\rvert$ ≤10 mm	$\Delta = \pm L/1000$ but 3 mm ≤ $\lvert\Delta\rvert$ ≤8 mm
7	Deviation from intended curve or camber about major axis	Measured with web horizontal, at centre	See Table F2.1, Item 2		
8	Unintended sweep about minor axis	Measured with web vertical, at centre Beam or column	See Table F2.1, Item 3		
9	Deviation from nominal length (L)	Measured on the centre line of the section	See Table F2.1, Item 4		
10	Unintended camber about major axis	Measured with web horizontal, at centre	See Table F2.1, Item 1		
11	Squareness of ends prepared for bearing at full contact splice	Measured with respect to longitudinal axis of member	See Table F2.1, Item 5		
12	Full contact splice – gap between bearing surfaces	Measured when local angular misalignment is $\Delta\Theta = 1/500$ radians	See Table F2.1, Item 6		

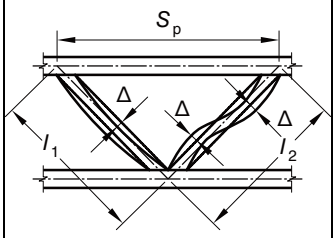
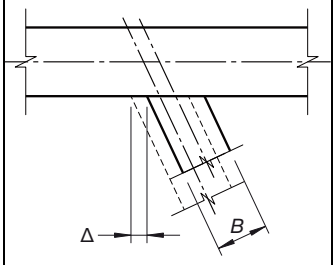
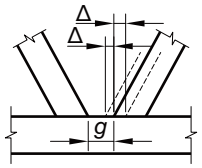
NOTE: Notations such as $\Delta = \pm d/100$ but $\lvert\Delta\rvert \geq 5$ mm mean that $\lvert\Delta\rvert$ is the larger of $d/100$ and 5 mm.

TABLE F2.8
FABRICATED TRUSSES AND TRUSS ELEMENTS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Straightness and camber of truss of overall length (L) Straightness and camber:  Note: Deviations measured after welding, with the component lying flat on its side.				
	LEGEND: a = actual camber b = intended camber c = actual line d = intended line	Deviation (Δ_i) of the actual positions (a) or (c) at each panel point relative to a straight line (d) or to the intended camber (b), when measured after completion of welding with the truss lying flat in its side	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 12$ mm	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 12$ mm	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 6$ mm
2	Cross-sectional dimensions  	Deviation (Δ) of dimensions d_o , b_o and l_o as appropriate $c_o \leq 300$ mm $300 < c_o < 1000$ mm $c_o \geq 1000$ mm where $c_o = d_o$, b_o or l_o as appropriate	No requirement	$\Delta = \pm 3$ mm $\Delta = \pm 5$ mm $\Delta = \pm 10$ mm	$\Delta = \pm 2$ mm $\Delta = \pm 4$ mm $\Delta = \pm 6$ mm
3	Dimensions of a truss panel  	Deviation (Δ) of individual panel dimensions (s_p, l_1, l_2) between intersections of centre-lines of members at panel points Individual dimension Cumulative longitudinal dimensions $\Sigma(\Delta s_p)$	No requirement	$\Delta = \pm 5$ mm $\Delta = \pm 10$ mm	$\Delta = \pm 3$ mm $\Delta = \pm 6$ mm

(*continued*)

TABLE F2.8 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
4	Straightness of truss diagonals 	Deviation (Δ) from nominal straight line between panel points at intersection of member centre-lines where: l = relevant diagonal length l_1 or l_2	Δ = l/750 mm but |Δ| >4 mm	Δ = ±L/500 but |Δ| ≥ 6 mm	Δ = ±L/1000 but |Δ| ≥ 3 mm
5	Eccentricity at diagonal to chord joint 	Deviation (Δ) of diagonal member from nominal position where: B = depth of diagonal	No requirement	Δ = ±(B/20 + 5) mm	Δ = ±(B/40 + 3) mm
6	Gap joints 	Deviation (Δ) in gap in gap joint between diagonals of nominal thicknesses t_1 and t_2 $g \geq (t_1+t_2)$ where: g = gap	No requirement	Δ = ±5 mm	Δ = ±3 mm

NOTE: Notations such as Δ = ±d/100 but |Δ| ≥ 5 mm mean that |Δ| is the larger of d/100 and 5 mm.

TABLE F2.9
STIFFENED PLATING

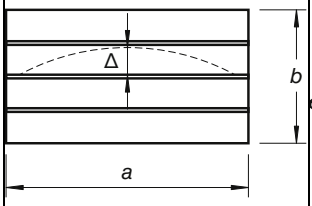
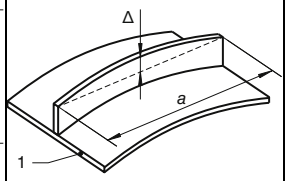
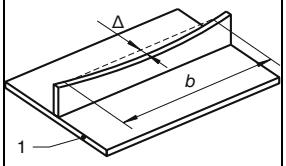
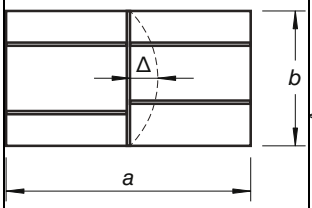
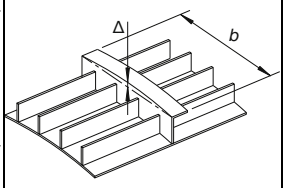
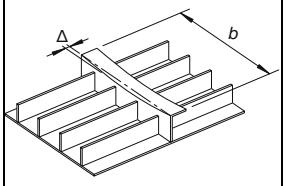
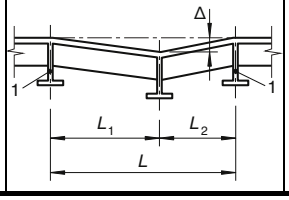
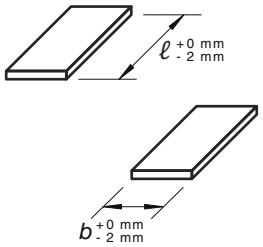
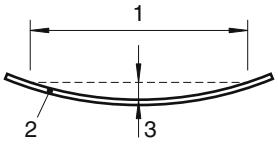
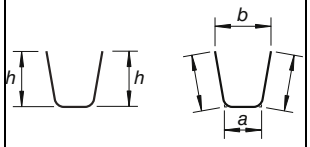
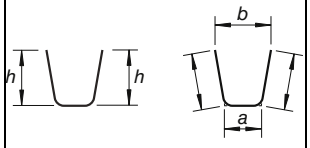
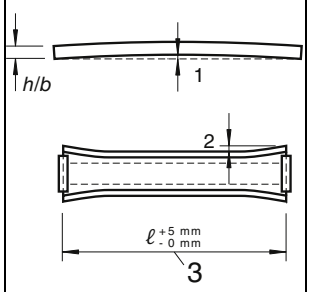
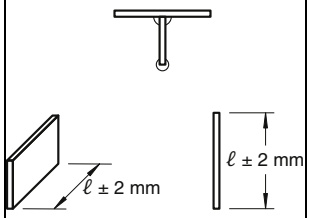
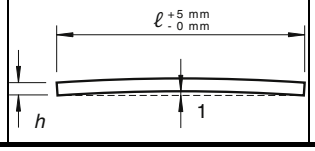
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Straightness of stiffeners Longitudinal stiffeners in longitudinally stiffened plating  	Deviation Δ perpendicular to the plate  	Δ = ±*a*/400	Δ = ±*a*/400	Δ = ±*a*/750 but |Δ| ≥ 2 mm
2	LEGEND: 1 = plate	Deviation Δ parallel to the plate measured relative to a gauge length equal to the width b of the plating  	Δ = ±*b*/400	Δ = ±*b*/400	Δ = ±*b*/500
3	Straightness of stiffeners Transverse stiffeners in transversely and longitudinally stiffened plating  	Deviation Δ perpendicular to the plate  	Smaller of: Δ = ±*a*/400 or Δ = ±*b*/400	Smaller of: Δ = ±*a*/400 or Δ = ±*b*/400	Smaller of: Δ = ±*a*/500 or Δ = ±*b*/750 but |Δ| ≥ 2 mm
4		Deviation Δ parallel to the plate  	Δ = ±*b*/400	Δ = ±*b*/400	Δ = ±*b*/500
5	Levels of cross-frames in stiffened plating LEGEND: 1 = cross-frame	Level relative to adjacent cross-frames  	Δ = ±*L*/400	Δ = ±*L*/400	Δ = ±*L*/500 but |Δ| ≥ 3 mm

TABLE F2.10
BRIDGE DECKS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Length/depth/width of plate for deck 	Overall dimensions *l*, *b* after cutting and straightening by rolling inclusive of provisions for shrinkage and after application of the final weld preparation	No requirement	No requirement	0 ≥ Δ ≥ −2 mm (no positive value given)
2	Flatness of plate for deck 	After application of the final weld preparation LEGEND: 1 = gauge length 2000 mm 2 = plate 3 = fit up gap Δ	No requirement	According to AS 1365	Δ = ±2 mm
3	Formed profile for passing through crossbeams: (a) With cope holes 	Height *h*, width *a* and *b* Note for *a* or *b*: If the tolerances are exceeded, the cut-outs in the crossbeams are to be adapted to meet maximum gap width measured at a distance of at least 500 mm from the end	No requirement	Δ*h* = ±3 mm Δ*a* = ±2 mm Δ*b* = ±3 mm	+2 mm ≥ Δ(*h* or *a* or *b*) ≥ −1 mm
	(b) Without cope holes 	Note for *b*: If the tolerances are exceeded, the cut-outs in the crossbeams are to be adapted to meet maximum gap width measured at a distance of at least 500 mm from the end	No requirement	Δ*h* = ±2 mm Δ*a* = ±1 mm Δ*b* = ±2.5 mm	Δ = ±0.5 mm
4	Straightness of formed profile 	LEGEND: 1 max. gap Δ_1 2 max. widening Δ_2 3 for stiffener splices with splice plates Δ_3 radius $r = r \pm \Delta_r$ rotation Δ_φ measured on a plane surface over 4 m length parallelism Δ_p	No requirement	$\Delta_1 = \pm L/500$ $\Delta_2 = 5$ mm 5 mm ≥ Δ_3 ≥ 0 $\Delta_r = \pm 0.20$ r $\Delta_\varphi = \pm 1°$ $\Delta_p = \pm 2$ mm	$\Delta_1 = \pm L/1000$ $\Delta_2 = 1$ mm 5 mm ≥ Δ_3 ≥ 0 $\Delta_r = \pm 2$ mm $\Delta_\varphi = \pm 1°$ $\Delta p = \pm 2$ mm

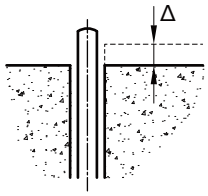
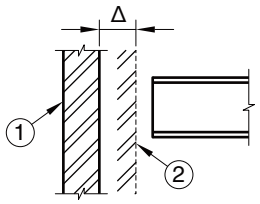
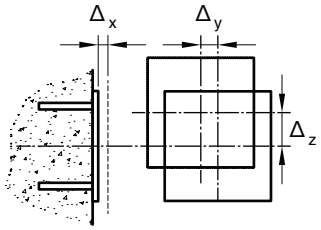
(*continued*)

TABLE F2.10 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
5	Length/width of flat profile for welding on both sides 	Overall dimensions *l*, *h*	No requirement	Δ = ±2 mm	Δ = ±2 mm
6	Straightness of flat profile for welding on both sides 	LEGEND: max. gap Δ_1 length Δ_l	No requirement	$\Delta_1 = \pm L/1000$ 5 mm ≥ Δ_l ≥ 0	$\Delta_1 = \pm L/1000$ 5 mm ≥ Δ_l ≥ 0

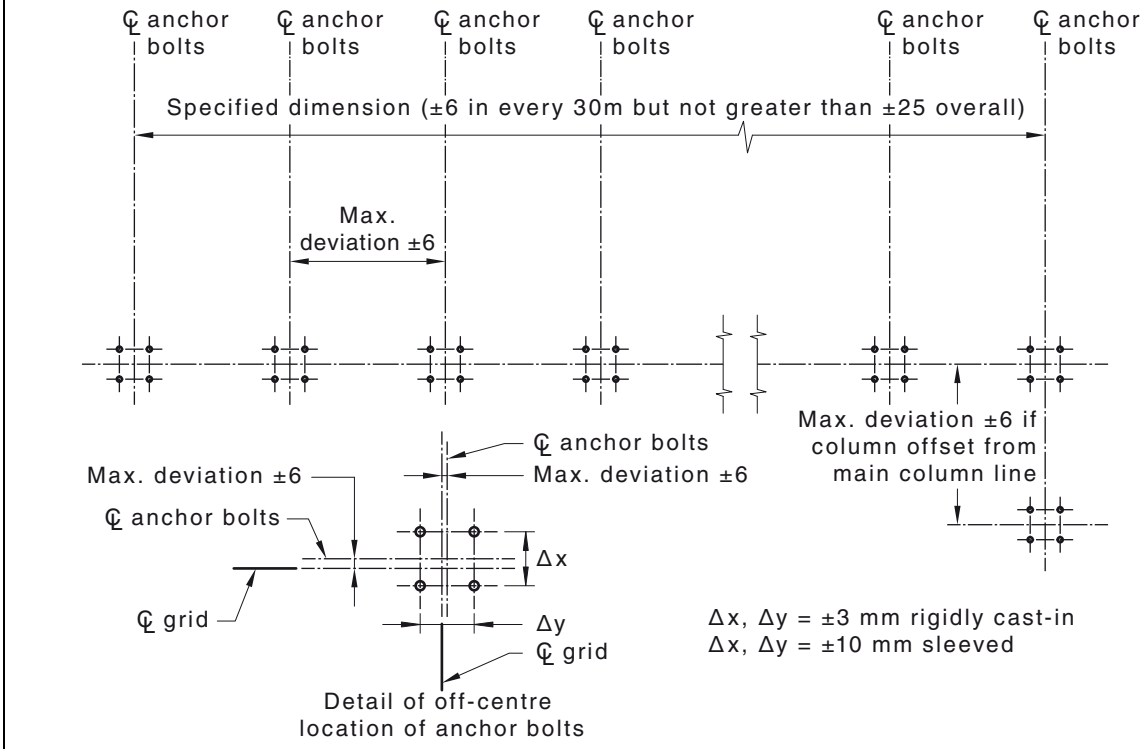
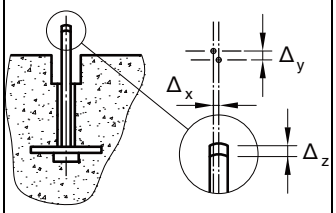
F4 ERECTION TOLERANCES

TABLE F3.1
FOUNDATIONS AND SUPPORTS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Level of foundation 	Deviation (Δ) from specified level Below Above	No requirement	 Δ = –15 mm Δ = +5 mm	 Δ = –15 mm Δ = +5 mm
2	Position of vertical wall – concrete or masonry 	Deviation (Δ) of 1 actual position from specified position 2 at steelwork support point wall < 4 m high 4 m < wall < 8 m wall > 8 m high where: *h* = wall height in metres	 Δ = ±15 mm Δ = ±20 mm Δ = ±20 + (h-8) ≤ 50 mm	Δ = ±25 mm	Δ = ±25 mm
3	Embedded cast-in fixing plates to walls – concrete or masonry 	Deviation (Δ_x, Δ_y, Δ_z) of centre-lines of the plate relative to the specified positions of the centre-lines NOTE: Deviations are measured locally at the actual wall position.	No requirement	Δ_x, Δ_y, Δ_z = ± 10 mm	Δ_x, Δ_y, Δ_z = ±10 mm
4	Distances between anchor bolt groups NOTE: Established column line is the actual field line most representative of the centres of the as-built anchor bolt groups along a line of columns.	Deviation (Δ) from specified dimensions: (a) Centre-to-centre of adjacent bolt groups (b) Centre of any bolt group to established column line through that group (c) Accumulation along an established column line of multiple anchor bolt groups	 No requirement No requirement No requirement	 Δ = ± 6 mm Δ = ± 6 mm Δ = 6 mm per 30 m ≤ 25 mm	 Δ = ±6 mm Δ = ±6 mm Δ = 6 mm per 30 m ≤ 25 mm

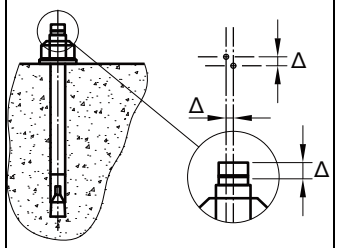
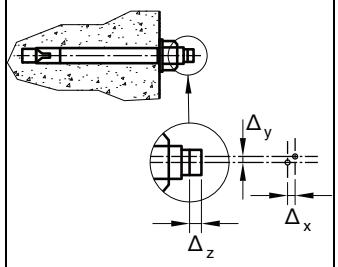
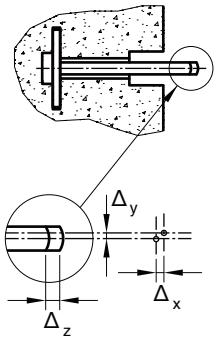
(*continued*)

TABLE F3.1 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
					
5	Cast-in foundation bolt in concrete – prepared for adjustment  NOTE: A minimum clearance of 25 mm around the bolt should be provided for adjustment.	Vertical deviation (Δ_z) of bolt protrusion relative to intended position			
		Low	No requirement	$\Delta_z = -5$ mm	$\Delta_z = -5$ mm
		High		$\Delta_z = +25$ mm	$\Delta_z = +25$ mm
		Horizontal deviation (Δ_x, Δ_y) of bolt centre from specified position at top of concrete in bolt group	No requirement	Δ_x, $\Delta_y = \pm 10$ mm	Δ_x, $\Delta_y = \pm 10$ mm
		NOTE: The permitted deviation for location of the centre of a bolt group is 6 mm.			

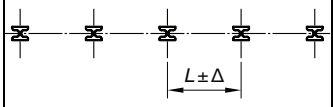
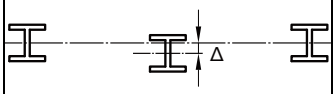
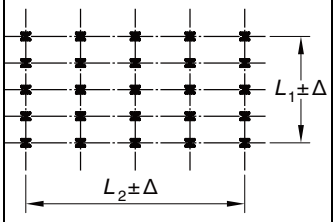
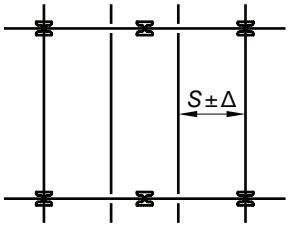
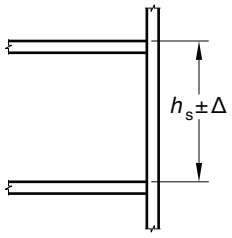
(*continued*)

TABLE F3.1 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
6	Cast-in foundation bolt in concrete – not prepared for adjustment 	Vertical deviation (Δ_z) of bolt protrusion relative to intended position			
		Low	No requirement	Δ_z = –5 mm	Δ_z = –5 mm
		High		Δ_z = +45 mm	Δ_z = +45 mm
		Horizontal deviation (Δ_x, Δ_y) of bolt centre from specified position at top of concrete in bolt group	No requirement	Δ_x, Δ_y = ±3 mm	Δ_x, Δ_y = ±3 mm
		NOTE: The permitted deviation for location also applies to the centre of a bolt group.			
7	Cast-in wall bolt in concrete – not prepared for adjustment 	Horizontal deviation (Δ_z) of bolt protrusion relative to intended position			
		Inwards	No requirement	Δ_z = –5 mm	Δ_z = –5 mm
		Outwards		Δ_z = +45 mm	Δ_z = +45 mm
		Horizontal and vertical deviations (Δ_x, Δ_y) of bolt centre from specified position at face of wall in bolt group	No requirement	Δ_x, Δ_y = ±3 mm	Δ_x, Δ_y = ±3 mm
		NOTE: The permitted deviation for location also applies to the centre of a bolt group.			
8	Cast-in wall bolt in concrete – prepared for adjustment 	Horizontal deviation (Δ_z) of bolt protrusion relative to intended position			
		Inwards	No requirement	Δ_z = –5 mm	Δ_z = –5 mm
		Outwards		Δ_z = +25 mm	Δ_z = +25 mm
		Horizontal and vertical deviations (Δ_x, Δ_y) of bolt centre from specified position at face of wall in bolt group	No requirement	Δ_x, Δ_y = ±10 mm	Δ_x, Δ_y = ±10 mm
		NOTE: The permitted deviation for location also applies to the centre of a bolt group.			

NOTE: The tolerances in this Table are provided for reference only and would not normally be considered within the scope of application of the Standard.

TABLE F3.2
FRAME SETOUT

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Column spacing along grid 	Deviation (Δ) from specified distance (L) between column centres at base plate level	Δ = ±15 mm		
		$L \leq 5$ m		Δ = ±10 mm	Δ = ±7 mm
		$L > 5$ m		Δ = ±0.2(L+45) mm (L in metres)	Δ = ±0.2(L+30) mm (L in metres)
2	Column alignment off grid 	Deviation (Δ) of the centre of the column off correct grid at base plate level	Δ = ±15 mm	Δ = ±10 mm	Δ = ±7 mm
3	Overall length of building 	Deviation ($\Sigma\Delta l_c$) from correct value			
		$L \leq 30$ m	$\Sigma\Delta l_c \leq \pm 20$ mm	Δ = ±20 mm	Δ = ±16 mm
		30 m < L < 250 m	$\Sigma\Delta l_c \leq \pm$ (20 + 0.25(Σl_c − 30)) mm	Δ = ±0.25(L+50) mm	Δ = ±0.2(L+50) mm
		$L \geq 250$ m	$\Sigma\Delta l_c \leq \pm$ (20 + 0.25(Σl_c − 30)) mm	Δ = ±0.1(L+500) mm (L in metres)	Δ = ±0.1(L+350) mm (L in metres)
4	Beam spacing 	Deviation (Δ) from specified spacing(s) between adjacent erected beams measured at corresponding ends	No requirement	Δ = ±10 mm	Δ = ±5 mm
5	Storey height 	Deviation (Δ) of storey height (h_s) measured at beam ends relative to levels of beams	Δ = ±20 mm	Δ = ±10 mm	Δ = ±5 mm

(*continued*)

TABLE F3.2 (*continued*)

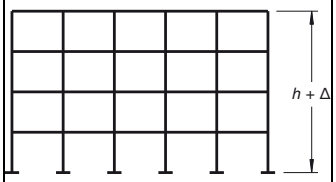
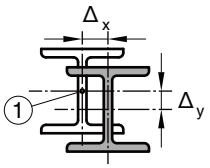
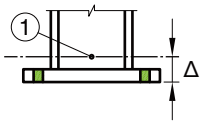
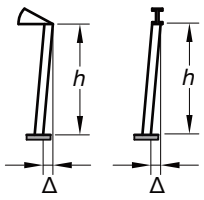
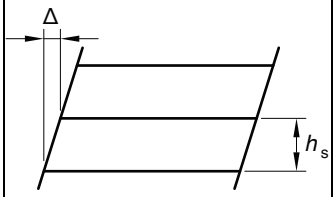
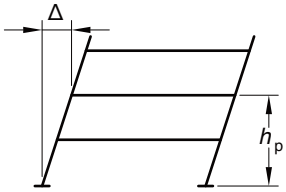
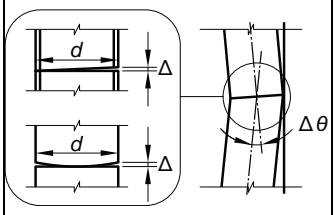
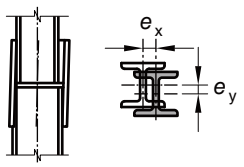
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
6	Overall height  NOTE: This requirement applies along both sides of the building. h = the correct overall height of steelwork, being the vertical distance from underside of column baseplate to the top of the finished floor level shown at any location along the building (metres)	Deviation ($\Sigma\Delta h_b$) from correct value $h \leq 30$ m $h > 30$ m $h \leq 20$ m 20 m < h < 100 m $h \geq 100$ m	 $\Delta = \pm 20$ mm $\Delta = \pm(20 + 0.25(h - 30))$ mm	 $\Delta = \pm 20$ mm $\Delta = \pm 0.5(h + 20)$ mm $\Delta = \pm 0.2(h + 200)$ mm (h in metres)	 $\Delta = \pm 10$ mm $\Delta = \pm 0.25(h + 20)$ mm $\Delta = \pm 0.1(h + 200)$ mm (h in metres)

TABLE F3.3
COLUMNS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Position of column at base  	Deviation (Δ_x, Δ_y) of column section centre-line from specified position 1	Δ_x, $\Delta_y = \pm 6$ mm	Δ_x, $\Delta_y = \pm 10$ mm	Δ_x, $\Delta_y = \pm 5$ mm
2	Level of column at base  	Deviation (Δ) of the underside of the base plate from the specified level 1	$\Delta = \pm 10$ mm	$\Delta = \pm 5$ mm	$\Delta = \pm 5$ mm
3	Inclination of single storey column  	Deviation (Δ) of top of column relative to base column about both principal axes where: h = height of column	$\Delta = \pm h/500$ mm	$\Delta = \pm h/300$ mm	$\Delta = \pm h/500$ mm

(*continued*)

TABLE F3.3 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
4	Plumbing of multi-storey column over single storey of height h_s 	Deviation (Δ) of column centre-line in plan relative to a vertical line through its centre at the next lowest level, about both principal axes where: h_s = storey height	Δ = ±h_s/500 mm	Δ = ±h_s/500 mm	Δ = ±h_s/1000 mm
5	Plumbing of multi-storey column over its total height  where: n = number of storeys over height h_p	Deviation (Δ) at any point of column height (h_p)of its centre-line relative to its correct position: Point < 60 m above base Point > 60 m above base Point at any height above base	Δ = ±h_p/500 mm ≤ 25 mm Δ = ±h_p/500 mm ≤ 25 + (h_p – 60)/3 mm ≤ 50 mm	Δ = ±h_p/(300√n) mm	Δ = ±h_p/(500√n) mm
6	Full contact splice – alignment and gap between bearing surfaces 	Local angular misalignment (Δθ) occurring at same time as gap (Δ) is measured	Δθ = 1/500 radians Δ = 0.5 mm over at least 67% of the area with a maximum of 1.0 mm locally	No requirement	No requirement
7	Eccentricity at column splice 	Unintended eccentricity about either principal axis (e_x or e_y)	e_x, e_y = ±2 mm	e_x, e_y = ±5 mm	e_x, e_y = ±3 mm

(*continued*)

TABLE F3.3 (*continued*)

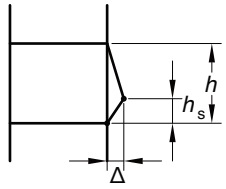
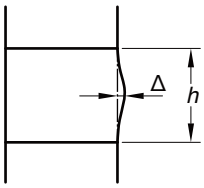
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
8	Straightness of a spliced column between adjacent storey levels 	Deviation (Δ) in location of the column in plan relative to a straight line between correct position points at adjacent storey levels where: $h_s \le h/2$ h = storey height	Consistent with plumbing requirements in Item 5	$\Delta = \pm h_s/750$ mm	$\Delta = \pm h_s/1000$ mm
9	Straightness of an unspliced continuous column between adjacent storey levels 	Deviation (Δ_x, Δ_y) about either principal axis of the location in plan relative to a straight line between correct position points at adjacent storey levels where: h = storey height	$\Delta = \pm h/500$ mm	$\Delta = \pm h/750$ mm	$\Delta = \pm h/1000$ mm

TABLE F3.4
BEAMS

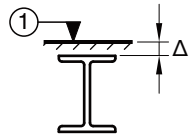
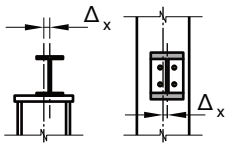
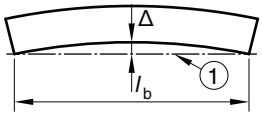
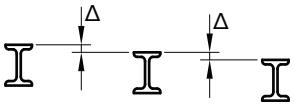
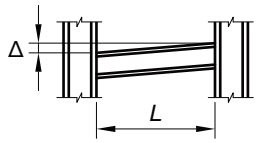
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Level of a beam 	Deviation (Δ) at a beam end connection measured relative to the specified floor level 1	Δ = ±10 mm	Δ = ±10 mm	Δ = ±5 mm
2	Location of a beam 	Deviation (Δ_x) of web of beam horizontally from its correct position at connections to other members	Δ_x = ±3 mm	Δ_x = ±5 mm	Δ_x = ±3 mm
3	Sweep of erected beam 	Deviation (Δ) of beam flange from intended position 1 where: l_b = length between points of effective bracing or restraint	Δ = ±l_b/500 mm	Δ = ±l_b/500 mm	Δ = ±l_b/1000 mm
4	Relative beam level  NOTE: Actual camber of any primary beam to which the beam being assessed is connected needs to be taken into account in making the assessment.	Deviation (Δ) of adjacent beams at corresponding end connections	Δ = ±10 mm	Δ = ±10 mm	Δ = ±5 mm
5	Slope of beam 	Deviation (Δ) in level of one end of beam relative to other end, where: L = beam length	Δ = ±L/500 mm ≤ 10 mm	Δ = ±L/500 mm ≤ 10 mm	Δ = ±L/1000 mm ≤ 5 mm

TABLE F3.5
CRANE RUNWAY GIRDERS

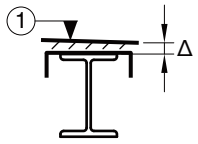
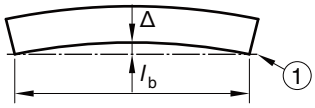
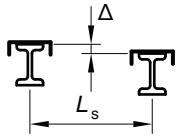
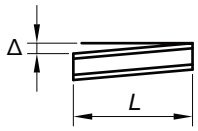
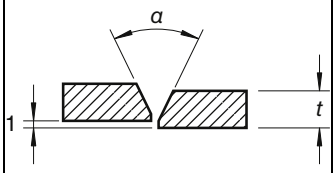
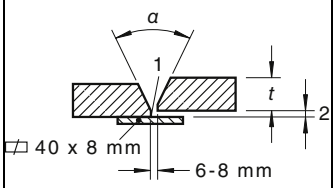
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Level of a beam 	Deviation (Δ) at a beam end connection measured relative to the specified level 1	Δ = ±10 mm	Δ = ±15 mm	Δ = ±10 mm
2	Sweep of erected beam 	Deviation (Δ) of beam flange from intended position 1 where: l_b = length between points of effective bracing or restraint	Δ = ±l_b /500 mm	No requirement	No requirement
3	Level difference across the crane bay 	Deviation (Δ) between levels of top flanges of crane girders supporting same crane where: L_s = span of bay For L_s ≤ 10 m For L_s > 10 m	Δ = ±L_s /1000 ≤ 10 mm NOTE: Deviation is as per AS 1418.18	 Δ = ±20 mm Δ = ±L_s/500	 Δ = ±10 mm Δ = ±L_s/1000
4	Level difference between opposite ends of a crane girder 	Deviation (Δ) in level of one end of beam relative to other end where: L = girder span	Δ = ±L/1000 ≤ 10 mm NOTE: Deviation is as per AS 1418.18	Δ = ±L/500	Δ = ±L/1000
5	Rail alignment	Responsibility to be defined in construction specification. Fixings shall allow sufficient adjustment to permit deviations to be within limit specified	As per AS 1418.1	No requirement	No requirement

TABLE F3.6
BRIDGES

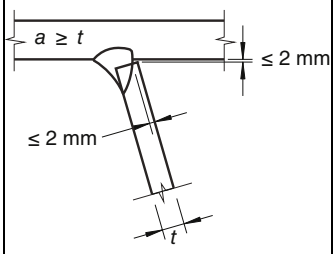
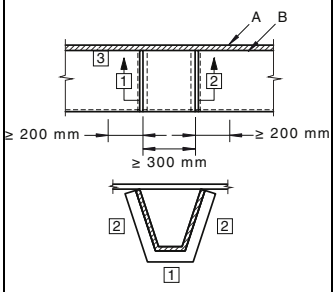
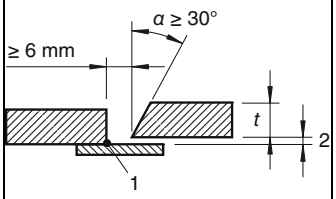
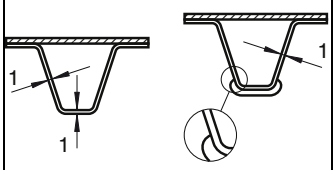
No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Span length	Deviation Δ of distance L between two consecutive supports measured on top of upper flange	No requirement	$\Delta = \pm(30 + L/10000)$	$\Delta = \pm(30 + L/10000)$
2	Bridge elevation or plan profile	Deviation Δ from nominal profile taking into account as-built levels of supports: $L \leq 20$ m $L > 20$ m Where: L = distance between two consecutive supports	No requirement	$\Delta = \pm (L/1000)$ $\lvert\Delta\rvert = (L/2000 + 10\text{ mm}) \leq 35$ mm	$\Delta = \pm (L/1000)$ $\lvert\Delta\rvert = (L/2000 + 10\text{ mm}) \leq 35$ mm

TABLE F3.7
BRIDGE DECKS

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
1	Splices of deck plate without backing strip or splice of lower flange or web of crossbeam 	LEGEND: 1 = misalignment Δ before welding	No requirement	Δ = ±2 mm	Δ = ±2 mm
2	Splices of deck plate with backing strip 	LEGEND: 1 = root run 2 = misalignment Δ before welding Fit-up gaps Δ_g between plate and backing strip after welding	No requirement	Δ = 2 mm $\lvert\Delta_g\rvert$ = 1 mm	Δ = 2 mm $\lvert\Delta_g\rvert$ = 1 mm

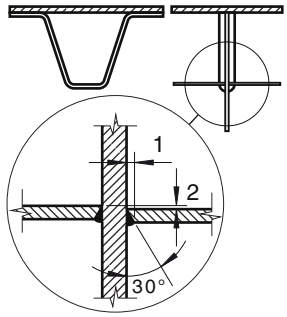
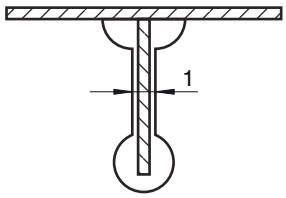
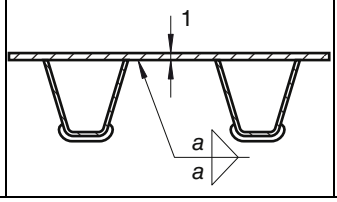
(*continued*)

TABLE F3.7 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
3	Stiffener-deck plate connection 	Root penetration Fit up gap	No requirement	Δ = 2 mm	Δ = 2 mm
4	Stiffener-stiffener connection with splice plates 	Misalignment Δ between stiffener and splice plate before welding	No requirement	Δ = ±2 mm	Δ = ±2 mm
5	Stiffener to stiffener connection with splice plates 	LEGEND: 1 = continuous root run 2 = misalignment Δ before welding	No requirement	Δ = 2 mm	Δ = 2 mm
6	Stiffener-crossbeam connection with key stiffeners passing through the crossbeam with or without cope holes 	LEGEND 1 max. gap Δ_1 minimum throat thickness a: for gap width $s \le 2$ mm: $a = a_{nom}$ according to analysis for gap widths $s > 2$ mm: $a = a_{nom} + (s - 2)$ But $a \ge 4$ mm	No requirement	$\Delta_1 = 3$ mm	$\Delta_1 = 3$ mm

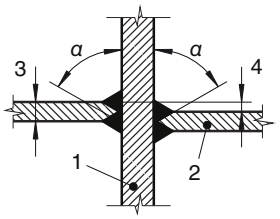
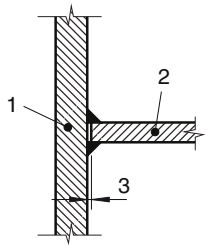
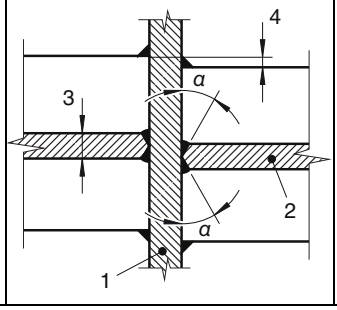
(*continued*)

TABLE F3.7 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
7	Stiffener-crossbeam connection with stiffeners fitted between crossbeams (not passing through) 	LEGEND: 1 = max. gap Δ_1 2 = misalignment Δ_2 before welding	No requirement	Δ_1 = 2 mm Δ_2 = ±2 mm	Δ_1 = 2 mm Δ_2 = ±2 mm
8	Stiffener-crossbeam connection with flats passing through 	LEGEND: 1 = max. gap Δ_1	No requirement	Δ = 1 mm	Δ = 1 mm
9	Connection of web of crossbeam to deck plate (with or without cope holes) 	LEGEND: 1 = max. gap Δ between deck plate and web of crossbeam before welding	No requirement	Δ = 1 mm	Δ = 1 mm

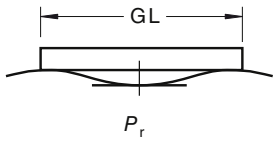
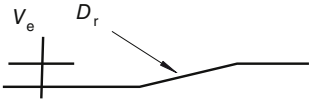
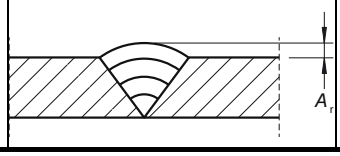
(*continued*)

TABLE 3.7 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
10	Connection of webs of crossbeams to web of main girder a) for continous crossbeams  b) for non-continous crossbeams  	LEGEND: 1 = web of main girder 2 = web of crossbeam 3 = in fig. a) $t_{w,crossb}$ in fig. b) gap Δ_b 4 = misalignment Δ_a before welding	No requirement	$\Delta_a = \pm 0.5\ t_{w,crossb}$ Δ_b = 2 mm	$\Delta_a = \pm 0.5\ t_{w,crossb}$ Δ_b = 2 mm
11	Connection of crossbeam flanges to web of main girder  	LEGEND: 1 = web of main girder 2 = web of crossbeam 3 = $t_{w,crossb}$ 4 = misalignment Δ before welding	No requirement	$\Delta = \pm 0.5\ t_{w,crossb}$	$\Delta = \pm 0.5\ t_{w,crossb}$

(*continued*)

TABLE F3.7 (*continued*)

No.	Criterion	Parameters	Permitted deviation Δ		
			Essential tolerances	Functional tolerances	
			Class 1 and 2	Class 1	Class 2
12	Fit-up of orthotropic decks of plate thickness t after erection  	Difference in level at junction: $t \leq 10$ mm 10 mm < $t \leq 70$ mm $t > 70$ mm	No requirement	$V_e = 2$ mm $V_e = 5$ mm $V_e = 8$ mm	
		Slope at junction: $t \leq 10$ mm 10 mm < $t \leq 70$ mm $t > 70$ mm	No requirement	$D_r = 8\%$ $D_r = 9\%$ $D_r = 10\%$	
	LEGEND: GL gauge length P_r deviation V_e step D_r slope	Flatness in all directions: $t \leq 10$ mm	No requirement	$P_r = 3$ mm over gauge length 1 m $P_r = 4$ mm over gauge length 3 m $P_r = 5$ mm over gauge length 5 m	
		$t > 70$ mm General case Longitudinally NOTE: Values for P_r may be interpolated for 10 mm < $t \leq 70$ mm.		$P_r = 5$ mm over gauge length 3 m $P_r = 18$ mm over gauge length 3 m	
13	Orthotropic deck welding 	Protusion A_r of weld above the surrounding surface	No requirement	$A_r = -0$ mm/+1 mm	

APPENDIX G

STANDARD TEST FOR EVALUATION OF SLIP FACTOR

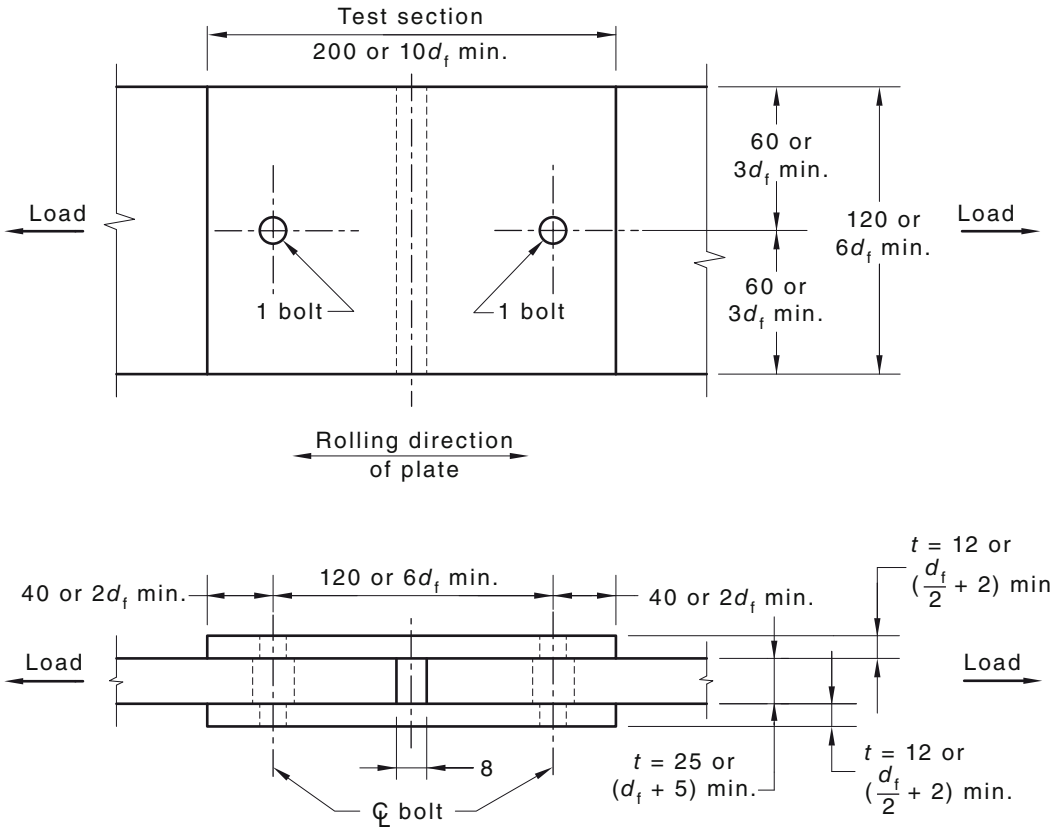
(Normative)

G1 TEST SPECIMENS

G1.1 Form

The standard test specimen shall be a symmetrical double coverplated butt connection as shown in Figure G1. The inner plates shall be equal in thickness.

NOTE: It is suggested that the use of M20 bolts will prove to be most convenient, with 25 mm inner plates and 12 mm outer plates.



NOTES:

1 d_f is the diameter of the bolt.

2 t is the thickness of the plate.

3 Holes in plates:

Cover plates	22 mm or d_f + 2 mm
Inner plates	23 mm or d_f + 3 mm

4 Length and width of inner plates outside of test section may be increased to suit the laboratory's testing facilities.

5 Dimensions are shown for the use of M20 bolts. Dimensions in parentheses are for use of bolts with nominal diameter d_f mm, which should not be less than 16 mm.

DIMENSIONS IN MILLIMETRES

FIGURE G1 STANDARD TEST SPECIMEN

G1.2 Assembly and measurement

Care shall be taken in assembling the specimen to ensure that neither bolt is in bearing in the direction of loading, and that the surface condition of the friction faces is maintained in the same condition to be achieved in the field. If it is necessary to machine the ends of the inner plates to fit into the loading machine grip, machining oil shall not be allowed to contaminate the surfaces. Bolts shall be tensioned in the same manner as that to be used in the field and shall develop at least the minimum bolt tension given in Table G1 below.

TABLE G1

MINIMUM BOLT TENSION

Nominal diameter of bolt	Minimum bolt tension kN
M16	95
M20	145
M24	210
M30	335
M36	490

NOTE: The minimum bolt tensions given in this Table are approximately equivalent to the minimum proof loads derived from a proof load stress of 600 MPa, as specified in AS 4291.1.

Between snug-tightening and final tensioning, the bolt extension shall be measured using a dial gauge micrometer or a displacement transducer with a resolution of 0.003 mm or finer. The final measurement shall be made immediately prior to testing. The cone-sphere anvil measuring technique described in AS/NZS 1252 for proof load measurements or other equivalent technique is suitable.

Bolt tension shall be ascertained from a calibration curve determined from load cell tests of at least three bolts of the test batch. In establishing the calibration curve, the bolt grip through the load cell shall be as close as practicable to that used in the specimens, the same method of extension measurement and tensioning shall be employed, and the calibration shall be based on the mean result. For the purposes of this test only, the initial snug-tight condition shall be finger tight.

Alternatively, when a bolt tension load cell is not available, the bolts shall be tensioned to at least 80% and not more than 100% of their specified proof loads, and the tension induced in the bolts calculated from the following equation:

$$N_{ti} = \frac{E\Delta \times 10^{-3}}{\frac{a_o}{A_o} + \left[\frac{a_t + \frac{t_n}{2}}{A_s}\right]} \quad \ldots \text{G1}$$

where

N_{ti} = tension induced in the bolt, in kilonewtons (kN)

E = Young's modulus of elasticity, 200 000 MPa

Δ = measured total extension of the bolt when tightened from a finger-tight condition to final tensioned condition, in millimetres

a_o = length of the unthreaded portion of the bolt shank contained within the grip before tensioning, in millimetres. In this context, the grip includes the washer thickness

A_o = plain shank area of the unthreaded portion of the bolt, in square millimetres

a_t = length of the threaded portion of the bolt contained within the grip before tensioning, in millimetres. In this context, the grip includes the washer thickness

t_n = thickness of the nut, in millimetres

A_s = tensile stress area of the bolt as defined in AS 1275, in square millimetres

It is not necessary for both bolts in the one specimen to have identical tension induced in them.

G1.3 Number of specimens

Tests on at least three specimens shall be undertaken, but five is preferred as a practical minimum number.

G2 INSTRUMENTATION

Two pairs of dial gauge micrometers or displacement transducers having an effective resolution achieving 0.003 mm or finer shall be symmetrically disposed over gauge lengths of 3 df on each edge of the specimen so as to measure the deformation between the inner plates from the bolt positions to the centre of the cover plates. The deformation of each half of the joint shall be taken as the mean of the deformation at each edge. The deformation so measured is therefore the sum of the elastic extension of the cover plates and any slip at the bolt positions.

Figure G2 shows a typically instrumented test specimen. It is essential that the micrometers or transducers be securely mounted since they may be shock loaded as slip occurs.

G3 METHOD OF TESTING

The method of testing shall satisfy the following requirements:

(a) *Type of loading* Specimens shall be tested only by tensile loading.

(b) *Loading rate* Up to the slip load, force shall be applied in increments exceeding neither 25 kN nor 0.25 times of the slip load of the connection assuming a slip factor of 0.35 and the calculated bolt tension. The loading rate shall be approximately uniform at not more than 50 kN/min within each load increment. Slower loading rates are preferred. Each load increment shall be applied after creep at constant load due to the preceding load increment has effectively ceased.

NOTES:

1 Since slip will in all probability occur at one bolt position before the other, it is clear that the first bolt may slip into bearing before the slip load at the other bolt position is attained.

2 After attainment of the slip load at one bolt position, the loading rate and increment size may be adjusted at the discretion of the operator.

G4 SLIP LOAD

Slip is usually well defined and easily detected when a sudden increase in deformation occurs. One or more sharp clearly audible reports may also be heard. However, with some types of surface, and occasionally with normal surfaces, the incidence of slip is not so well defined. In these cases, the load corresponding to a slip of 0.13 mm shall be used to define the slip load.

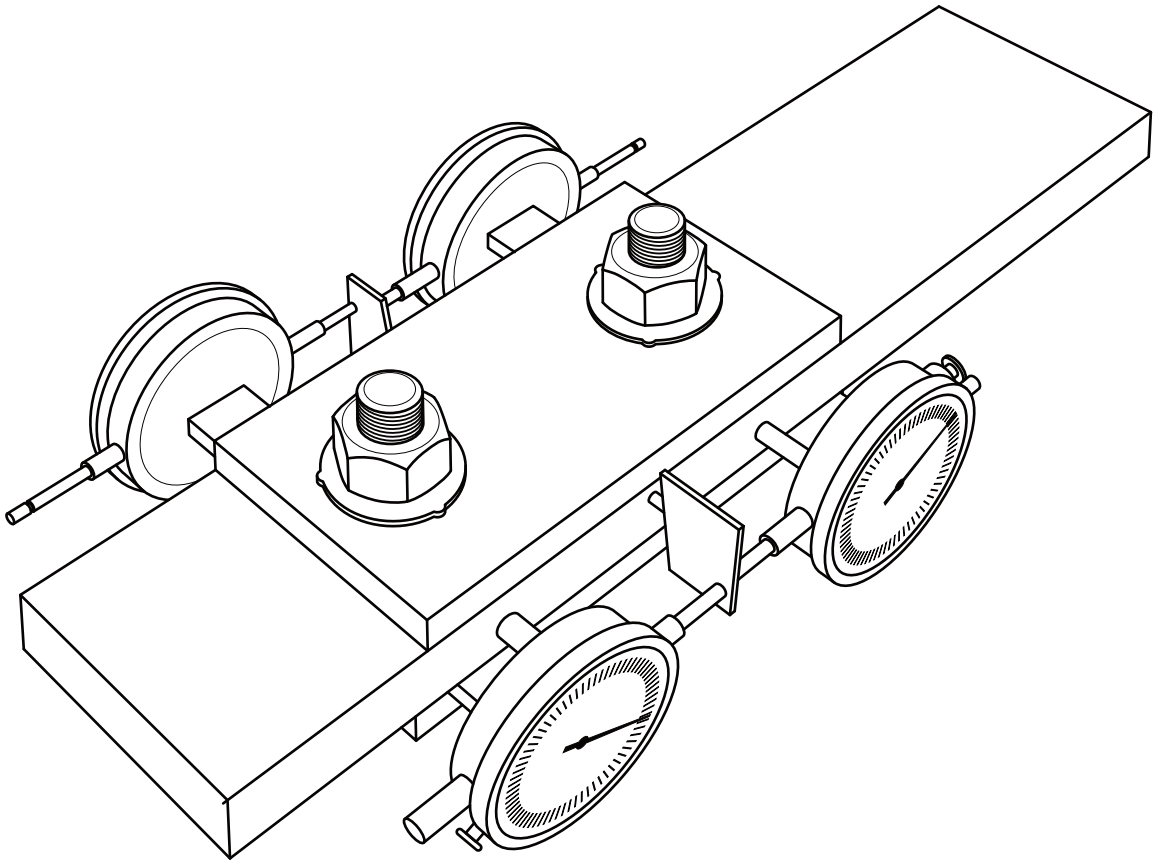


FIGURE G2 TYPICALLY INSTRUMENTED TEST ASSEMBLY

G5 SLIP FACTOR

The slip factor (μ) to be used in design shall be calculated from—

$$\mu = k(\mu_m - 164\delta) \quad \text{. . . G2}$$

where

k = 0.85 when 3 specimens are tested

= 0.90 when 5 or more specimens are tested

μ_m = mean value of slip factor for all tests

$$= \frac{1}{2n}\left(\sum_{i=1}^{2n}\mu_i\right)$$

δ = standard deviation of slip factor for all tests

$$= \sqrt{\left[\frac{1}{2n-1}\sum_{i=1}^{2n}(\mu_i - \mu_m)^2\right]}$$

n = the number of specimens tested, each providing two estimates of μ

V_{si} = the measured slip load at the position of the ith bolt

N_{ti} = the tension induced in the ith bolt by the tensioning as calculated from Equation G1

$$\mu_i = \frac{1}{2}\left(\frac{V_{si}}{N_{ti}}\right)$$

However, if the calculated value of μ is less than the lowest of all values of μ_i, then μ may be taken as equal to the lowest value of μ_i.

APPENDIX H

INSPECTION OF BOLT TENSION USING A TORQUE WRENCH

(Informative)

H1 GENERAL

The correlation between the torque required to fully tension a calibration specimen and that which will be required on a bolt-nut assembly installed in a structural connection, will be materially affected by such factors as—

(a) the actual condition of the thread and the bearing face surface and their lubrication;

(b) the occurrence of galling during tensioning; and

(c) the time lapse between tensioning and inspection.

With due regard for these limitations, the procedure given in this Appendix is considered the most practical method for an independent assessment of whether gross undertensioning exists.

H2 CALIBRATION

The inspection wrench may be either a hand-operated or an adjustable-torque power-operated wrench. It should be calibrated at least once per shift, or more frequently if the need to closely simulate the condition of the bolts in the structure so demands.

The torque value determined during calibration may not be transferred to another wrench.

At least three bolts, desirably of the same size (the minimum length may have to be selected to suit the calibrating device) and condition as those under inspection, should be placed individually in a calibrating device capable of indicating bolt tension. A hardened washer should be placed under the part turned.

Each calibration specimen should be tensioned in the calibrating device by any convenient means to 1.05 times the minimum bolt tension specified for that diameter in Table G1. The inspection wrench then should be applied to the tensioned bolt, and the torque necessary to turn the nut or bolt head 5° (approximately 25 mm at 300 mm radius) in the tensioning direction should be determined. The average torque measured in the tests of at least three bolts should be taken as the job inspection torque.

H3 INSPECTION

Bolts represented by the sample which have been tensioned in the structure should be inspected by applying, in the tensioning direction, the inspection wrench with its job inspection torque to such proportion of the bolts in the structure as prescribed.

NOTE: For guidance, it is suggested that a suitable sample size would be 10% of the bolts, but not less than two bolts in each connection.

H4 ACTION

Where no further rotation occurs under the torque applied by the inspection wrench, the connection should be accepted as properly tensioned.

Where any nut or bolt head is turned by the application of the job-inspection torque, this torque should then be applied to all other bolts in the connection and all bolts whose nut or head is turned by the job inspection torque should be tensioned and re-inspected. Alternatively, the fabricator or erector may retension all of the bolts in the connection and then resubmit the connection for inspection.

APPENDIX I

INSPECTION OF WELDING AND BOLTING (NEW ZEALAND ONLY)

(Informative)

I1 APPLICATION

Appendix I provides guidance for specifying the extent of inspection for steel connections subject to seismic and fatigue loads. This Appendix is classified as 'informative' as its use in New Zealand is optional. Where the Appendix is applied, conformance with the requirements herein is mandatory.

I2 INSPECTION OF WELDING TO AS/NZS 1554.1 AND AS/NZS 1554.5

I2.1 General

The minimum extent of inspection of welding shall be in accordance with the provisions of this Appendix otherwise all inspections shall conform with the requirements of Section 7 of AS/NZS 1554.1 and AS/NZS 1554.5.

If a welded structure or component is to be heat treated the final inspection shall be carried out after the heat treatment.

I2.2 Extent of non-destructive examination

I2.2.1 *General*

The minimum extent of non-destructive examination (NDE) is a function of weld failure consequence category and weld demand level.

I2.2.2 *Weld failure consequence category*

The selection of weld failure consequence category A, B or C shall be determined by the competent person in accordance with Table I1, where:

(a) *A – Major* Failure of weld would result in collapse of the structure.

(b) *B – Moderate* Failure of weld would result in loss of service but not collapse.

(c) *C – Minor* Failure may not cause immediate loss of service but would require remedial work.

TABLE I1
WELD AND TENSIONED BOLT FAILURE CONSEQUENCE CATEGORY

Category	Description
A Major	Steel moment frames with low redundancy (four or fewer beams per floor resisting lateral forces in each principal direction). Steel EBF and CBF frames with low redundancy (two frames in each principal direction). Any shear joint supporting gravity loads from two or more floors. Splices resisting applied tension or bending. Fracture critical members of bridges. Crane girders S4 and above classification in accordance with AS 1418.1.
B Moderate	Joints in steel moment frames with redundancy. Joints in EBF and CBF frames with redundancy. Joints in steel moment frames with a designed secondary system for lateral loading. Any shear joint supporting gravity loads from more than one member at a given floor level. Splices resisting only shear or compression or both. Non-FCM portions of bridge girders. Joints in bracing frames of residential houses less than three storeys.
C Minor	Shear, compression and tension joints supporting single members only, and not part of the lateral force-resisting system. Joints not required to carry gravity loads.

I2.2.3 *Seismic weld demand levels*

Seismic weld demand levels shall comply with Table I2.

TABLE I2
SEISMIC WELD DEMAND CATEGORY

Category	Description
H High	Welds in which connected member element stresses are expected to be above the yield level, with significant strain hardening development. (Member Categories 1 and 2).
M Medium	Welds in which connected member element stresses are anticipated to be at or slightly exceed yield level. (Member Category 3).
L Low	Welds in which stresses are anticipated to remain below yield stresses or will remain in compression. (Member Category 4).

NOTE: For application of these weld demand categories to various types of seismic resisting systems see Tables I3 and I4.

I2.2.4 *Seismic weld demand categories for MRF, EBF and CBF*

Weld demand categories are preselected in accordance with the principles of Table I2 for MRF, EBF and CBF as tabulated in Table I3 and Table I4.

For New Zealand, inspection of fatigue welds shall also comply with the specific requirements of the relevant fatigue detail classification in NZS 3404.1.

NOTE: The use of UT may be reduced on the basis of the plate thickness limits in Table I5.

TABLE I3

MOMENT RESISTING FRAME WELD DEMAND DESIGNATION

Frame structural ductility category	Weld location (refer to Figure I1)								
	1	2	3	4	5	6	7	8	9
1, 2	M (H) (see Notes)	M	M	H (M) (see Notes)	M	H	M	H	M
3	M	L	M	M	L	M	L	M	L
4	L	L	L	L	L	L	L	L	L

NOTES:

1 The figure in the bracket applies if the principal yielding region is located in the beam adjacent to the column.

2 Table I2 describes H, M and L.

TABLE I4

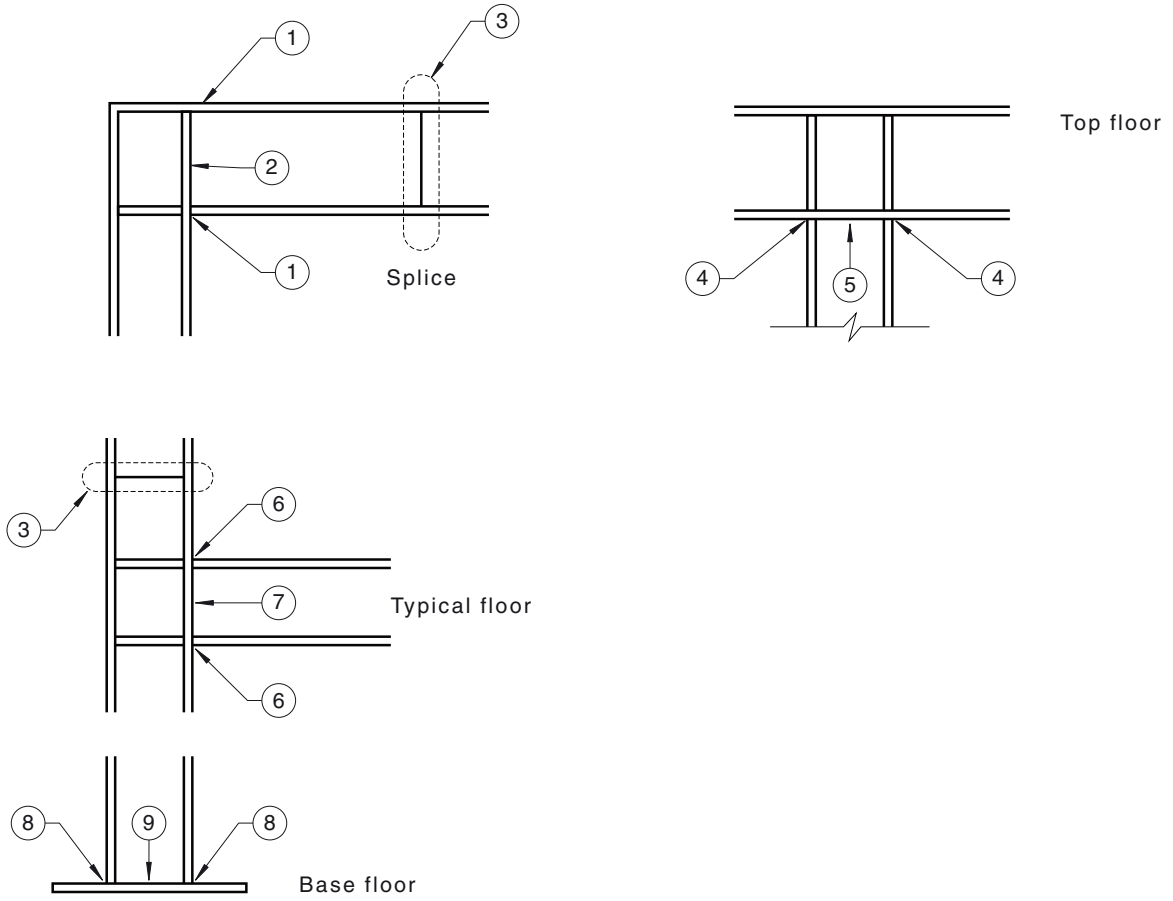
EBF WELD DEMAND DESIGNATION

Frame structural ductility category	Weld location (refer to Figure I2)					
	1	2	3	4	5	6
1, 2	M	M (H) (see Notes)	M	H	H	M
3	M	M	M	M	M	M
4	L	L	L	L	L	L

NOTES:

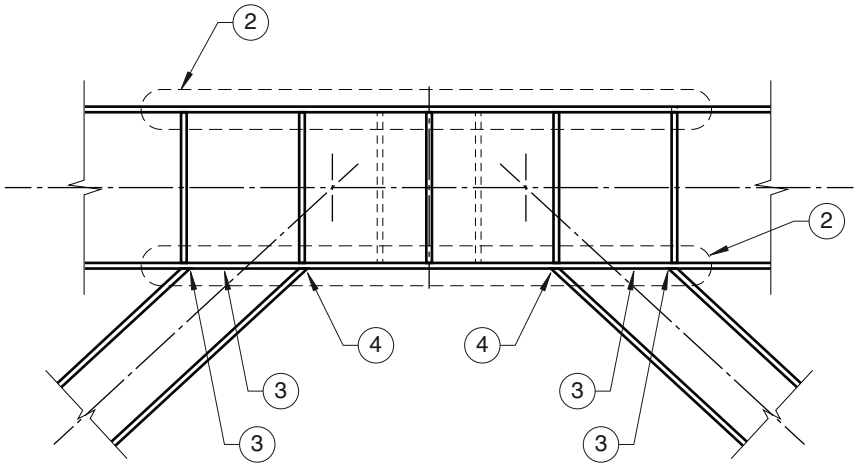
1 The requirement to test web to flange CP welds applies only to welded beams used as active links.

2 Table I2 describes H, M and L.

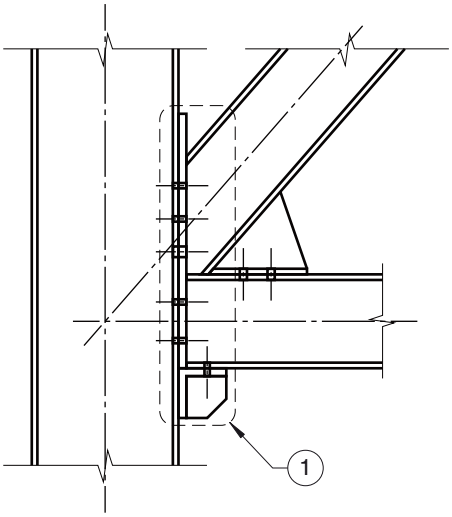


NOTE: See Table I3 for information relating to the weld locations indicated.

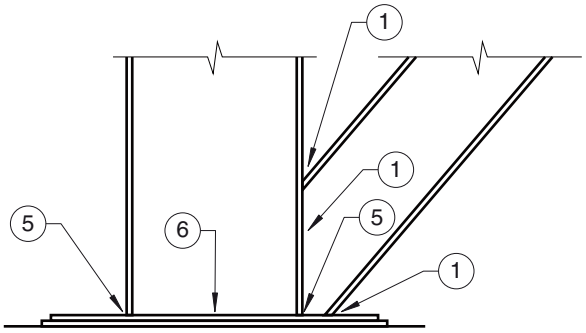
FIGURE I1 MOMENT RESISTING FRAME WELD LOCATION DIAGRAM



Link zone



Collector beam/brace connection



Baseplate detail

NOTE: See Table I4 for information relating to the weld locations indicated.

FIGURE I2 EBF WELD LOCATION DIAGRAM

I2.2.5 *Extent of non-destructive examination after non-compliance*

Where a proportion of NDE less than 100% is required and non-compliance results from a test, retesting shall be carried out. Where testing has been done at regular intervals and welder traceability is documented then three consecutive joints shall be inspected. If conformity is achieved then frequency of testing shall reduce back to the inspection levels required in Table I7.

I2.2.6 *Inspection of k-areas in members of seismic resisting frames*

When thermal cutting, or welding of doubler plates, continuity plates, or welding of stiffeners has been performed in the k-area, the web shall be tested for cracks using MT. The MT examination area shall include the k-area base metal within 75 mm of the weld or cut (see Figure I3).

k-area requirements are applicable to hot-rolled sections with elements greater than 32 mm thick.

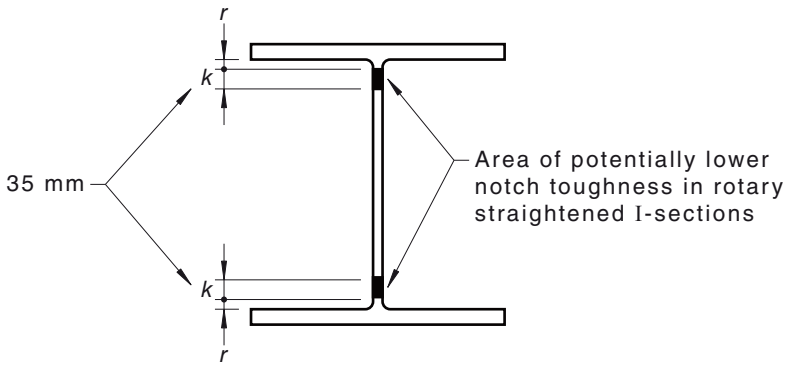


FIGURE I3 LOCATION OF k-AREA ZONE

I2.2.7 *Ultrasonic examination of welds*

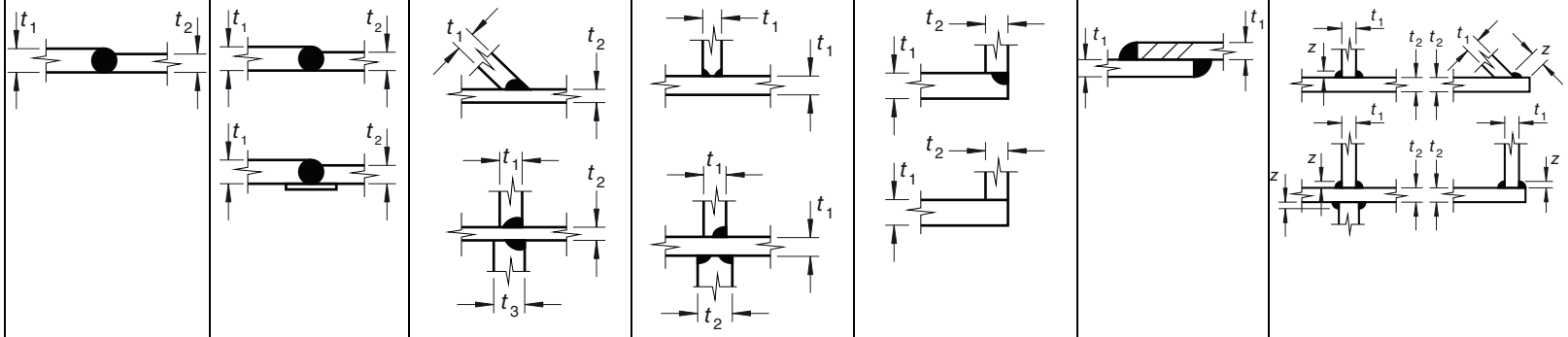
For the minimum plate thickness requiring ultrasonic or radiographic examination (UT) at welds, see Table I5.

I2.2.8 *Visual examination*

Visual examination shall meet the requirements of AS/NZS 1554.1 or AS/NZS 1554.5, as appropriate.

TABLE I5

THICKNESS OF PLATE REQUIRING ULTRASONIC EXAMINATION

Weld type	Butts full and partial penetration (including butts with reinforcing fillets)					Fillet		
Joint type	In-line butt		Tee and cruciform		Corner	Lap	Tee, cruciform and corner	
Procedures	S/S	D/S and S/S+B	S/S	D/S and S/S+B	All	All	All	
Key *t* greatest *t* at a joint *z* greatest *z* at a joint S/S single sided D/S double sided +B backing NM not mandatory	**Examples** 							
NDE method	*t* (mm)	*t* (mm)	*t* (mm)	*t* (mm)	*t* (mm)	*t* (mm)	*z* (mm)	
Ultrasonic examination (UT)	≥ 10	≥ 12	≥ 12	≥ 20	≥ 30	NM	NM	≥ 20

NOTE: The requirements of this Table shall not preclude the use of non-destructive examination (NDE) outside the limits shown where the results of visual examination of NDE show that a lapse in quality may have occurred in specific joints.

I2.2.9 *Visual means*

The extent of NDE by visual means shall be in accordance with Tables I6 and I7.

TABLE I6

EXTENT OF NON-DESTRUCTIVE EXAMINATION FOR WELDS TO AS/NZS 1554, PARTS 1 AND 5

Weld category	Weld failure consequence	Visual scanning %	Visual examination %
GP	C	100	25
SP	B or C	100	25
	A	100	100
Fatigue	A or B	100	100

NOTE: Visual means of NDE implies two levels of examination:

(a) *Visual scanning*—to determine that no welds called for in the drawings are omitted and to detect gross defects.

(b) *Visual examination*—to examine a percentage of the welds to determine whether the required weld quality (see Table 6.2 of AS/NZS 1554.1:2015) has been achieved.

I2.2.10 *Other NDE (ultrasonic, magnetic particle, liquid penetrant)*

The extent of NDE other than visual means shall be in accordance with Table I7.

TABLE I7

EXTENT OF NON-DESTRUCTIVE EXAMINATION FOR WELDS TO AS/NZS 1554.1 (ULTRASONIC OR RADIOGRAPHIC (UT), MAGNETIC PARTICLE (MT), LIQUID PENETRANT (LP) (see Note 1)

Weld failure consequence	Non-seismic	Seismic demand			Fatigue (see Notes 2 and 3)
		H High	M Medium	L Low	
A Major	CPW UT 10% of joints	CPW UT 100% *k*-area MT 100% Fillet weld MT 25%	CPW UT 25% including 10 of the first 10 joints *k*-area MT 100%	CPW UT 10% including 2 of the first 10 joints *k*-area MT 10%	CPW UT 100% *k*-area MT 100% Fillet weld MT 25%
B Moderate	Nil	CPW UT 25% including 10 of the first 10 joints. *k*-area MT 100%	CPW UT 25% including 10 of the first 10 joints *k*-area MT 100%	Nil	CPW UT 25% including 10 of the first 10 joints. *k*-area MT 100% Fillet weld MT 10%
C Minor	Nil	CPW UT 25% including 10 of the first 10 joints. *k*-area MT 10%	CPW UT 10% including 2 of the first 10 joints	Nil	

NOTES:

1 The use of MT or LP is used for supplementary inspection in conjunction with visual examination.

2 Inspection of fatigue welds shall also comply with the specific requirements of the relevant fatigue detail classification in Tables 7 and 8 of NZS 3404.1:2009.

3 The use of UT may be reduced on the basis of the plate thickness limits in Table I5.

I2.3 Removal of temporary attachments

For the removal of temporary attachments refer to the relevant provisions of AS/NZS 1554.1 or AS/NZS 1554.5 as applicable.

I3 INSPECTION OF BOLTED CONNECTIONS

I3.1 Traceability of bolts

Mill certificates shall be available for tensioned bolts in the connections with moderate or high consequences of failure as detailed in Table I1.

I3.2 Tensioned bolts

The methods of tensioning specified in Clause 8.5 shall comply with the following requirements:

(a) Part-turn tensioning—the correct part-turn from the snug-tight position shall be measured or observed.

(b) Direct-tension indicator device—the minimum tension developed in the bolt shall be shown directly by the device.

(c) Where the part-turn method has been used and the nut and bolt threads have been match-marked after snug-tightening, then visual scanning of each bolted connection is sufficient. Visual scanning shall also be sufficient if direct-tension indicating washers have been used. However, if there is no visual evidence of tensioning then verification of bolt tensioning in accordance with Paragraph J2.3 may be required.

To ensure that all bolts are fully tensioned, the bolts that were tensioned first should be checked, as subsequent tensioning of other bolts may loosen the bolts initially tensioned in a connection.

I3.3 Verification of bolt tension

Bolt tensioning may be verified by removal of a sample of bolts and measurement of the thread spacing within the installed grip zone beneath the base of the nut and the unthreaded portion of the bolt shank. If permanent stretch in the spacing of those threads is detected, compared to the spacing of the other threads in the bolt, then the bolt may be considered to have been adequately tensioned.

Alternatively, suitably calibrated ultrasonic bolt extension testing equipment may be used.

Bolts that have been loosened off for verification of tensioning and have been found to have been permanently stretched shall be replaced with new bolts. Bolts shall only be removed for verification from locations approved by a competent person.

I3.4 Damaged items

Bolts, nuts and washers that, on visual examination, show any evidence of physical defects shall be removed and replaced by new items.

NOTES

Standards Australia

Standards Australia is an independent company, limited by guarantee, which prepares and publishes most of the voluntary technical and commercial standards used in Australia. These standards are developed through an open process of consultation and consensus, in which all interested parties are invited to participate. Through a Memorandum of Understanding with the Commonwealth government, Standards Australia is recognized as Australia's peak national standards body.

Standards New Zealand

The first national Standards organization was created in New Zealand in 1932. The New Zealand Standards Executive is established under the Standards and Accreditation Act 2015 and is the national body responsible for the production of Standards.

Australian/New Zealand Standards

Under a Memorandum of Understanding between Standards Australia and Standards New Zealand, Australian/New Zealand Standards are prepared by committees of experts from industry, governments, consumers and other sectors. The requirements or recommendations contained in published Standards are a consensus of the views of representative interests and also take account of comments received from other sources. They reflect the latest scientific and industry experience. Australian/New Zealand Standards are kept under continuous review after publication and are updated regularly to take account of changing technology.

International Involvement

Standards Australia and Standards New Zealand are responsible for ensuring that the Australian and New Zealand viewpoints are considered in the formulation of international Standards and that the latest international experience is incorporated in national and Joint Standards. This role is vital in assisting local industry to compete in international markets. Both organizations are the national members of ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission).

Visit our web sites

www.standards.org.au www.standards.govt.nz

GPO Box 476 Sydney NSW 2001
Phone (02) 9237 6000
Fax (02) 9237 6010
Email mail@standards.org.au
Internet www.standards.org.au

15 Stout Street Wellington 6011
(PO Box 1473 Wellington 6011)
Freephone 0800 782 632
Phone (04) 498 5990
Fax (04) 498 5994
Email enquiries@standards.govt.nz
Website www.standards.govt.nz

ISBN 978 1 76035 629 3

Printed in Australia