

Hong Kong Shooting
Association

**Proposed Shooting
Range at Pillar Point**

Specifications for
Structural Steelwork

ARUP

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1 GENERAL

1.1 Description of the Structural Works

The Architect's Drawings show the layout, principal dimensions and arrangement of the structure, the requirements of which are amplified in the following paragraphs.

1.1.1 Project Information

In addition to the requirements stipulated in this Specification, the Structural Steelwork (Works) shall be carried out in accordance with the requirements stipulated in all other Contract documents and Drawings which contain general information about the project.

1.1.2 Drawings

Tender Drawings, as listed in Bills of Quantities, show the layout, principal dimensions and arrangement of the steelwork. Unless noted otherwise on the Drawings, the Works are designed for the permanent condition only. The Contractor should assess the effects of his/her construction sequence on the design of the structure prior to commencement of the Works.

1.2 Design

1.2.1 Design

The Works shown on the Drawings and described in this Specification has been designed to the Hong Kong Code of Practice for the Structural Use of Steel 2005 and BS 5950.

1.2.2 Slip Factor

Unless noted otherwise, a slip factor of 0.45 has been used in the design of friction grip joints.

1.2.3 Building Regulations and Standards

Unless stated otherwise, all undated references to Building Regulations and various standards cited in this Specification refer to the editions (including any amendments) current at the time of Tender. For dated references, only the edition cited applies. Reference to a Code or Standard shall be deemed to include all other Codes and Standards referred to in the specified Code or Standard.

This Specification shall be deemed to be supplementary to the Hong Kong Building (Construction) Regulations. Wherever differences occur then the more onerous requirement is to prevail.

1.3 Definitions

1.3.1 Shop Drawings

Drawings showing all necessary information to fabricate the Works.

1.3.2 Erection Drawings

Drawings showing the dimension layout of the steel structure from which Shop Drawings are made and which correlate the piece markings with the location in the structure.

1.3.3 Independent Inspection Authority

A competent independent person or a HOKLAS accredited association that verifies compliance with this Specification.

1.3.4 Examiner/Examining Body

An independent person or a HOKLAS accredited association whose competence to verify compliance of welder tests to BS EN 287-1 or welding procedure tests to BS EN ISO 15614-1 has been accepted by the Architect.

1.3.5 Welds

For the purpose of inspection, the weld shall be defined as the weld and the adjacent material.

1.3.5.1 Full Strength Butt Weld (FSBW)

A weld that is not full penetration but is designed to develop full strength of the connection and may have an un-fused land in the centre.

1.3.5.2 Full Penetration Butt Weld (FPBW)

A weld that is fully fused for the full thickness of the material.

1.3.5.3 Partial Penetration Butt Weld (PPBW)

A weld that is similar to a FSBW but is **not** designed to develop the full strength of the connection and will have an un-fused land.

1.3.5.4 Fillet Weld (FW)

A weld that is normally between two plates at right angles. It can also apply to plates lapped (lap weld).

1.4 Abbreviations

ASTM	American Society for Testing and Materials
BA	Building Authority of Hong Kong
BD	Hong Kong Buildings Department
BS	British Standard
BS EN and BS EN ISO	European Standard adopted as British Standard
CSWIP	Certification Scheme for Welding and Inspection Personnel
DAC	Distance-amplitude-curve
ETAG	European Technical Approval Guideline
HKSC	Hong Kong Code of Practice for the Structural Use of Steel 2005
HOKLAS	Hong Kong Laboratory Accreditation Scheme
IRSE	Independent Registered Structural Engineer appointed by the Contractor and approved by the Architect
NDT	Non-destructive testing
PNAP	Practice Notes for Authorized Persons and Registered Structural Engineers
WPAR	Welding Procedure Approval Record
WPQR	Welding Procedure Qualification Record
WPS	Welding Procedure Specification

1.5 Contractor's Drawings and Design Calculations

The Contractor shall produce detailed shop drawings, erection drawings and relevant design calculations. Approval by the Architect of drawings and design calculations prepared by the Contractor does not relieve the Contractor of the responsibility for accuracy of the calculations, detail dimensions on drawings, nor for the general fit-up of parts to be assembled on site.

2 GENERAL REQUIREMENTS

2.1 Hong Kong Building Regulations and Code of Practice

This Specification shall be read in conjunction with the HKSC, PNAPs and Practice Notes for Registered Contractors which cover the implementation of the Hong Kong Building Regulations. In cases of conflict, the more onerous requirement shall prevail.

In this Specification, Hong Kong Building Regulations include the current editions of the Building Ordinance, Building (Administration) Regulations, Building (Planning) Regulations and Building (Construction) Regulations.

2.2 Connection Details

If required by the Architect, the Contractor shall design and detail the connections to satisfy the loads shown on the Drawings. All details are to be substantiated by full calculations unless agreed otherwise by the Architect.

The requirements of BS EN 1011-2 and HKSC in avoiding lamellar tearing when designing connections should be considered.

2.3 Temporary Works

2.3.1 Responsibility

The Contractor shall be responsible for the design, fabrication, erection and removal of all temporary works. The design and details of temporary works shall be checked and endorsed by an approved IRSE before fabrication and erection. Upon completion of erection and prior to operation, the temporary works shall be inspected and certified by the IRSE that they are erected in compliance with the endorsed details.

2.3.2 Stability

The Contractor shall design and provide temporary bracing or restraints to incomplete structure to suit its own sequence and method of working. Alternatively the Contractor shall provide calculations to show that part of the erected structure at its temporary state subjected to relevant loads is still adequate. Any fixing to the permanent structure shall be agreed with the Architect before construction.

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

2.4 Construction Information

2.4.1 Fabrication

The Contractor shall provide the following information to the Architect for review, at least 5 weeks before commencing fabrication (or as otherwise stated in the Contract Documents) and allow another 60 days for submission to BD for approval if necessary:

- (i) Complete and coordinated Shop and Erection Drawings.
- (ii) Calculations and details for connections designed by the Contractor which are required to obtain approval and consent from BD for commencement of the construction works.
- (iii) Detailed method statements for fabrication and corrosion protection application.

- (iv) Details of welding procedures in accordance with BS EN 1011 and approved to BS EN ISO 15614-1 for all welds, including tack and sealing welds.
- (v) Details of proposed shop inspection system, Independent Inspection Authority and Examiner/Examining Body.

The Contractor is entirely at his own risk to commence fabrication works before obtaining approval from the BD.

2.4.2 Erection

The Contractor shall provide the following information to the Architect for review, at least 4 weeks before commencing erection (or as otherwise stated in the Contract Documents) and allow another 60 days for submission to BD for approval if necessary:

- (i) Detailed method statement for erection, taking account of all information provided by the Architect on design, erection and programme.
- (ii) Detailed drawings and calculations for all temporary works, which are to be checked and endorsed by an approved IRSE.
- (iii) Details of proposed site inspection system.

Erection shall not commence until the method statement has been accepted by the Architect. Any such acceptance means that the Architect's design concept for safe erection has not been invalidated.

2.4.3 Holes, Chases, Inserts and Fixings

The Contractor shall obtain Architect's approval for the size and position of any hole, chase, insert or fixing required, including those required by any Sub-contractor, before the related work begins. Unless otherwise specified or approved all holes and chases shall be formed and any inserts or fixings shall be built in at the time of construction. Do not cut or drill any part of the Works without Architect's written approval.

2.4.4 Record Drawings

The Contractor shall provide Record Drawings which show the works as finally fabricated and erected and shall clearly show the location, orientation and level of the erected steel within 4 weeks after completion of each level of the structural steel works or as otherwise stated in the Contract Document.

2.5 Programme

2.5.1 Programme

The Contractor shall provide a detailed programme prior to commencement of any Works to show the planned timing of the various items of work to be done, including:

- (i) Preparation and submission of construction information.
- (ii) Sample testing, order and delivery of materials.
- (iii) Fabrication.
- (iv) Application of protective coatings.
- (v) Transport to site.
- (vi) Erection of temporary works.
- (vii) Erection.

2.5.2 Inspection and Testing

Include in the programme the necessary time for BD's approval and consent as required, all procedural trials, inspection and testing, and trial assemblies.

2.5.3 Progress

Arrange the programme so that actual progress can be monitored against each item.

2.6 Quality Control

2.6.1 Management

The Contractor shall operate an agreed quality management system to BS EN ISO 9001 and BS EN ISO 3834-3 unless otherwise agreed with the Architect, which shall be accessible for audit. All documentation shall be available for inspection during the contract period.

A quality plan shall be prepared by the Contractor which includes his general standards of workmanship. A method statement shall be provided for each stage of the work. The Contractor shall show that he will be able to achieve the specified quality level at each stage and that the procedures for design, detailing, purchasing, fabrication, erection and protective treatment of steel components and structures can provide a completed steelwork that conforms to the requirements of this specification

Unless otherwise agreed, the Contractor shall provide the Architect with extracts of all execution and supervision standards given in his quality manual that are relevant to the Specification.

2.6.2 Inspection System

The Contractor shall operate an inspection system agreed by the Architect to verify that all materials, workmanship and completed Works comply with the specified requirements.

2.6.3 Tests, Procedural Trials, Trial Assemblies

The Contractor shall carry out or arrange to carry out all tests on operatives, procedural trials, tests on materials and workmanship and trial assemblies.

All tests are to be conducted by an approved Inspection Authority.

2.6.4 Personnel

The Contractor shall ensure that all personnel performing inspections and tests have appropriate qualifications, experience or training.

2.6.5 Inspection Status

The Contractor shall operate a system agreed by the Architect for identifying the inspection status at all stages of fabrication and erection.

2.6.6 Records

The Contractor shall keep records on site of all tests on operatives, procedural trials and tests on materials and workmanship. All steelwork delivered to site shall be accompanied by relevant mill certificates and delivery records which are to be cross referenced to the approved fabrication and/or erection drawings. Make records available to the Architect for examination.

2.6.7 Period of Notice

Agree a period of notice with the Architect for all tests and before commencing any trial assembly.

2.6.8 Function of the Independent Inspection Authority

The functions of the Independent Inspection Authority (IIA) shall include, but not limited to the following:

- Review of the Fabricators quality system in relation to the works being carried out.
- Review of the chemical and mechanical properties of materials to be used in the works for conformity.

- Review of all welding procedures proposed (in conjunction with the Architect).
- Checking that personnel have required qualifications and approvals.
- Inspection of fit-up, weld preparations, flame cutting, bending, machining, tack welding, welding pre-heats, completed welding and dimensional conformity as required.
- Witnessing and occasional random verification of NDT carried out by the Fabricator's inspectors.
- Overview of destructive testing programme.
- Witnessing of trial erection.
- Inspection of blast cleaning, application of protective treatments including drying time, overcoating times, stripe coats, minimum coating thickness and quality of surface finish.
- Installation and removal of temporary attachments.
- Any other task that the IIA sees fit to ensure quality at the approval of the Engineer.

3 MATERIALS – SECTIONS, PLATES and BARS

3.1 Hot Rolled Sections, Plates and Bars

Unless otherwise stated all steel material shall conform to BS EN 10025 or BS EN 10210. Quality grades as noted on the Drawings. Steel must be certified to either BS EN 10025 or BS EN 10210.

3.2 Cold Formed Sections

3.2.1 Cold Formed Sections

Steel shall conform to BS 5950-7. Quality grades as noted on the Drawings.

3.2.2 Cold Formed Hollow Sections

Steel shall conform to BS EN 10219-1 and BS EN 10219-2. Quality grades as noted on the Drawings.

3.2.3 Pre-galvanized Steel Sheet

Shall conform to BS EN 10143, BS EN 10326 and BS EN 10327. Quality grades and coating types as noted on the Drawings.

3.3 Thin Materials

Steel plate, sheet and strip under 3mm thickness shall conform to BS 1449-1.1, BS EN 10111, BS EN 10209 and BS EN 1993-1-3. Quality grades as noted on the Drawings.

3.4 Through Thickness Properties

Shall conform to Clause 3.1.5 of HKSC. See also Clause 12.2.1 of this Specification for through-thickness tensile tests.

3.5 Dimensions and Tolerances

3.5.1 Plates

Shall conform to BS EN 10029.

3.5.2 Structural Steel I and H Sections

Shall conform to BS 4-1 and BS EN 10034.

3.5.3 Angles

Shall conform to BS EN 10056-1 and BS EN 10056-2.

3.5.4 Hot Finished Hollow Sections

Shall conform to BS EN 10210-2.

3.5.5 Hot Rolled Sections

All other Hot Rolled sections not referred to above shall conform to the relevant BS in Table 1 of BS 5950-2.

3.5.6 Cold Rolled Sections

Shall conform to BS EN 10162.

3.5.7 Cold Formed Hollow Sections

Shall conform to BS EN 10219-2.

3.6 Condition of Steel

Steel for fabrication is not to be more heavily pitted or rusted than Grade C of Swedish Standard SIS 05 59 00.

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

Rectify surface defects in hot finished hollow sections revealed during surface preparation which are not in accordance with the requirements of BS EN 10210-1

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

3.7 Steel Castings and Forgings

Shall conform to Clause 9.5 of HKSC.

3.8 Inspection and Testing

Structural steels shall comply with the requirements of BS 5950-2 and any additional requirements given in Contract documents and on Drawings or as required by BD.

4 MATERIALS – STRUCTURAL FASTENERS**4.1 Ordinary Bolts and Nuts**

Shall conform to BS 3692 or BS 4190 as appropriate.

4.2 Countersunk Bolts

Shall conform to BS 4933.

4.3 High Strength Friction Grip (HSFG) Fasteners

Shall conform to BS 4395: Part 1, General Grade.

4.4 Holding Down Bolts

Shall conform to BS 7419.

4.5 Washers

Plain and tapered steel washers for use with ordinary bolts shall conform to BS 4320. High strength washers for use with HSFG bolts shall conform to BS 4395 Part 1.

4.6 Spring Washers

Shall conform to BS 4464.

4.7 Load Indicating Devices

Where load indicating devices are required, use 'Coronet' load indicating washers manufactured by 'Cooper and Turner' conforming to BS 4395 or Torshear type bolts conforming to JSS II-09 or equivalent subject to the approval of the Architect and BD in friction grip joints.

4.8 Surface Finish

4.8.1 Galvanized

Bolt assemblies are to be galvanized in accordance with BS 7371-6.

4.8.2 Sherardized

Bolt assemblies are to be sherardized in accordance with BS 7371-8 and BS 4921, Class 1.

4.9 Shear Studs

All shear studs to be used in the Works to be proprietary headed studs complying with BS EN ISO 13918 and Clause 10.1.4.1 of HKSC. Diameter and nominal length as noted on the Drawings.

4.10 Stainless Steel Bolts, Nuts and Washers

Bolts and nuts shall conform to BS EN ISO 3506 Parts 1, 2 and 3. Washers should be of stainless steel and should conform to BS EN ISO 7089 or BS EN ISO 7090 as appropriate. The corrosion resistance of the bolts should be equivalent to, or better than, the corrosion resistance of the material to be fastened.

For fasteners with nominal diameters larger than M24 for property classes 70 and 80, the mechanical properties must be agreed between the Contractor and manufacturer and approved by the Architect.

High strength bolts made of stainless steel should not be used as preloaded bolts designed for a specific slip resistance, unless the Contractor can demonstrate, to the satisfaction of the Architect, their acceptability in a particular application from test results.

4.11 Drill-in Anchors

Expansion or chemical anchors shall not be used except otherwise approved by the Architect.

The Contractor shall submit details of all proposed drill-in anchors to be used for the Works to the Architect for approval prior to commencement of the works.

Where approval from the BD is required for the use of such drill-in anchors, the Contractor shall be responsible for the approval to be obtained in a timely manner to facilitate the drill-in work. The cost and delay due to removal of any work without BD approval, or due to any remedial work required as a result of non-approved work shall be borne by the Contractor.

5 MATERIALS – WELDING CONSUMABLES

5.1 Welding Consumables

All welding consumables used for the arc welding of metallic materials are to comply with BS EN ISO 2560, BS EN 440, BS EN 756 or BS EN 758 as appropriate.

5.2 Mechanical Properties

Welding consumables and procedures used in the welding of structural works are to achieve mechanical properties for the deposited weld metal not less than the minima specified for the parent metal.

6 MATERIALS – GROUT

6.1 Grout

Unless otherwise stated on the Drawings, grout around foundation bolts and under column base plates is to be of non-shrink cementitious grout and have a minimum compressive strength at 28 days of 50 N/mm² except otherwise specified on the Drawings and is to be of the following form:-

A fluid Portland cement based grout comprising Portland cement and fine natural aggregate mixed in the ratio 1:1 by volume including the use of approved expanding additives to avoid shrinkage. Sufficient water is to be added to provide a viscosity suitable for the voids to be filled without bleeding or segregation of the fresh grout mix.

Salts and chemical requirements for grouts shall comply with the criteria for concrete as stipulated in the **Standard Specification for Structural Concrete**.

6.2 Trial Mix

For pressure grouting narrow gaps where access is difficult for normal gravity grouting, a trial mix for grout shall be made and tested to demonstrate that the proposed materials, grout mix and method of production will produce grout which complies with the specified requirements on bleeding, free expansion, flow cone efflux time and crushing strength.

If the result of any test does not comply with the specified requirements for the grout, any proposed changes to the materials, grout mix or methods of production shall be submitted to the Architect for review. Further trial mixes shall be made until the result of every test complies with the specified requirements for the grout.

6.3 Sampling and Testing

6.3.1 Bleeding and Free Expansion

For each grout mix, one sample shall be taken from the grout produced in a day. The sample shall be divided into three specimens and each specimen shall be tested within one hour after the grout has been mixed to determine the amount of bleeding and free expansion of the grout. Samples shall be protected from moisture content changes before the tests are carried out.

Bleeding and free expansion of grout shall be tested in accordance with ASTM C940-98a. The bleeding tests shall be completed immediately prior to each application in a day or as directed by the Architect. The amount of bleeding shall not exceed 2% in the first 3 hours and shall not exceed 4% in total. The water shall be reabsorbed by the grout within 24 hours after mixing.

Free expansion of grout shall not exceed 10% at the ambient temperature.

If the result of any test for amount of bleeding or free expansion of grout does not comply with the specified requirements the grout shall be rejected.

6.3.2 Flow Cone Efflux Time

For each grout mix, one sample shall be taken from each batch of grout and tested to determine the flow cone efflux time of the grout. The method of testing shall be in accordance with ASTM C939-02.

Grout having a flow cone efflux time of less than 15 seconds shall be rejected.

6.3.3 Crushing Strength

The sampling, testing and acceptable criteria for the compressive strength for each grout mix, including the trial mix, shall comply with the requirements for designed mix concrete as stipulated in the **Standard Specification for Structural Concrete** except that the size of test cubes shall be 100mm.

6.4 Proprietary Grouts

Use where specified on the Drawings. The proprietary grout shall conform to HKSC. Resin based grout shall only be used where the fire resistance of material is not required.

Provide written confirmation that proprietary grouts used in the Works do not contain high alumina cement.

7 WORKMANSHIP – IDENTIFICATION, STORAGE and HANDLING

7.1 Identification

7.1.1 Marking

The Contractor shall mark and document all materials, components, assemblies and sub assemblies delivered to site, to ensure that they are used as specified, and in the locations as shown in the approved drawings.

7.1.2 Additional Paint Marking

Where appropriate, steel is to have the additional paint marking for identification of steel grade conforming to BS EN 10025-1.

7.1.3 Location of Marks

Piece markings are to be in positions which are not masked by other material after erection.

7.1.4 Hardstamping

No steel is to be hardstamped. Tag-mark steel which is to be blast-cleaned, acid-pickled, metal-sprayed or galvanized.

7.2 Storage

7.2.1 Holding Areas

Lay out steelwork in separate holding areas and keep clean.

7.2.2 Support

Steelwork is to be adequately supported clear of the ground. Individual piece markings are to be visible when members are stacked.

7.2.3 Consumables

Consumables in the Contractor's works and on the Site shall be stored and handled in the manner described in BS EN 1011-1 and in accordance with the relevant standard (See Clause 5.1) and the manufacturer's instructions. Any additional drying or baking of consumables before issue shall be carried out in accordance with the manufacturer's recommendations.

7.3 Handling

Plan and carry out bundling, packing, handling and transport in a manner designed to prevent damage to the steelwork and any protective coating.

Restore any steelwork damaged during off-loading, transportation, storage or erection to conform to the standards of manufacture as given in this specification.

8 WORKMANSHIP – GENERAL**8.1 Cutting**

8.1.1 Process

Cut steel by an automatic or semi-automatic process.

8.1.2 Hand Flame Cutting

Use only where it is impractical to use machine flame cutting and is not to be used without prior approval by the Architect.

8.2 Dressing

8.2.1 Dressing

Dress the edges of all plate cut by flame to remove slag, scale, irregularities and excessive hardening. The hardness value after dressing for flame cut surfaces of all grades of steel is not to exceed 350HV when tested to BS EN ISO 6507-1 with 10kgf.

8.2.2 Grinding

Remove burrs, sharp arrises and ragged edges by grinding.

8.3 Bearing

8.3.1 Compression Joints

Joints that depend on contact bearing are to have the bearing surfaces prepared to a common plane by milling, sawing or other suitable means to the accuracy given in Clause 8.7.6. The bearing surfaces are to be at right angles to the nominal axis of the member or such other angle noted on the drawings.

No work need be carried out on a bearing surface which is to be grouted direct to a foundation.

8.3.2 Stiffeners

Cut and grind bearing stiffeners to ensure a tight bearing along edges in contact with flanges.

8.4 Curving and Straightening

8.4.1 Properties

No curving or straightening is to be carried out which may result in material properties that do not conform to the specified requirements for the as-supplied material.

8.4.2 Methods

Shall conform to Clause 14.2.7 of HKSC.

8.4.3 Procedures

Provide curving or straightening procedures to the Architect for review and approval before commencement of the Works.

8.5 Heating

8.5.1 Properties

No heating is to be carried out to materials that would result in changes of material properties. This applies to normalised steel, controlled rolled steel and quench and tempered steels.

8.5.2 Procedures

Provide heating procedures to the Architect for review and approval before commencement of the Works.

8.6 Temporary Attachments to facilitate Erection

Details of holes and fittings in components necessary for safety or to provide lifting and erection aids shall be included. Unless specified otherwise in the Drawings, such holes and fittings may remain on the permanent structure.

Account shall be taken of Clause 9.5.5 when detailing the welding of temporary attachments.

When removal of attachments is necessary, they shall be flame cut or gouged at a point not closer than 3mm from the surface of the parent material. The residual material may be ground flush and the affected area visually inspected. When the base material thickness exceeds 20mm (or carbon equivalent $> 0.43\%$) it shall also be checked by magnetic particle inspection. Acceptance criteria are as set out in Clause 12.4. Attachments shall not be removed by hammering.

8.7 Accuracy of Fabrication

8.7.1 General

Fabricate steelwork to an accuracy that will enable erection within the specified limits to take place without inducing excessive stresses, deflection or distortion into the structure. The

accuracy of fabrication shall comply with this Specification and Section 15 of HKSC whichever is more stringent. Unless specified otherwise permitted deviations refer to the unstressed condition.

Notwithstanding the permitted deviations given in the following clauses in this section, the steelwork shall be fabricated such that it can be erected within the tolerances given in Clause 11.13 of this Specification.

8.7.2 Built-up Members

Tolerances on built-up members, including castellated beams, are to comply with BS 5950-2:2001.

8.7.3 Length

Members with both ends prepared for contact bearing are not to deviate from the detailed length by more than 1mm.

Members without ends prepared for contact bearing, which are to be framed to other steel parts of the structure, are not to deviate from the detailed length by more than 2mm for members 10m or less in length, and 4mm for members greater than 10m in length.

8.7.4 Straightness

The deviation of a member from a straight line drawn between adjacent points of subsequent effective lateral restraint is not to exceed the greater of 3mm or 0.1% of the distance between restraints unless noted otherwise on the Drawings.

8.7.5 Camber

The deviation from specified or proposed camber is not to exceed the greater of 12mm or 0.1% of the length of the member.

8.7.6 Compression Joints

Gaps in joints that depend on contact bearing when assembled during fabrication are to comply with Clause 15.4.5 of HKSC.

9 WORKMANSHIP – WELDING

9.1 General

9.1.1 Arc Welding

Arc welding of metallic material is to comply with BS EN 1011-1 and BS EN 1011-2 as appropriate, together with clauses contained in this Section.

9.1.2 Welding Technologist

Welding is to be carried out under the direction of a certified International Welding Technologist (IWT) with appropriate qualifications, experience or training as described in BS EN ISO 3834-5. The tasks and responsibilities of such persons shall be clearly defined.

9.1.3 Quality requirements

The Steelwork Contractor's system for the management of welding shall comply with BS EN ISO 3834-3.

All welding documentation (welder qualification certificates, welding-procedure qualification records, welding procedure specifications and associated work instructions) shall be reviewed for applicability by the person responsible for welding coordination (welding coordinator).

The manufacturer and Steelwork Contractor shall have at their disposal sufficient and competent personnel for the planning, performing and supervising of the welding production according to specified requirements.

9.2 Welding Procedures

9.2.1 Approval of Welding Procedures

Welding procedure trials and the qualification records according to BS EN ISO 15614-1 shall be witnessed and endorsed by an Examiner/Examining Body.

Witnessing of procedures shall be undertaken by approved inspectors to BS EN 473 as a minimum and approval by an approved certified IWT as a minimum.

Previous welding procedure approvals to BS EN 288-3:1992 or former national standards may be considered at contract stage and agreed between the contracting parties, providing that the intent of the technical requirements is satisfied and the previous procedure approvals are relevant to the application and production work on which they are to be employed. Where applicable the WPS(s) shall be submitted for review by the Architect at least 2 weeks prior to the start of production.

Documents required to support a WPQR(s) are as follows:

- WPAR(s)
- Complete mechanical test results
- Complete non-destructive test results
- Original material certificates (which should have either a full chemical analysis or the carbon equivalent)
- Consumable certificates (if available)

Summary documents are not acceptable.

Notified fillet welds, partial penetration welds, full strength butt welds and tee butt welds subject to tensile loads $> 0.5 Y_s$, tests shall be completed by additional cruciform test performed in accordance with BS EN ISO 9018.

9.2.2 Preparation of Welding Procedure Specifications

Written welding procedure specifications (WPSs) shall be available in accordance with BS EN ISO 15609-1. They shall comply with the guidance of BS EN 1011-2, Annex C, Method A for the avoidance of hydrogen cracking. Consideration shall be made to the requirements in Annex D of BS EN 1011-2 to ensure that there is adequate toughness in the heat-affected zone (HAZ) of the weld. HAZ toughness shall be as a minimum be equivalent to the parent steel specification.

WPS shall ensure that the range of qualification is within the requirements of Section 8, BS EN ISO 15614-1. In addition to Section 8 of BS EN ISO 15614-1, carbon equivalent is considered an essential variable^(Note). Any change in the carbon equivalent from that given in the WPQR $> + 0.01\%$ and the production material and the procedure will require additional approval. Reduction in the recorded carbon equivalent level for production when compared to the recorded carbon equivalent in the WPQR will not require additional approval.

All WPS shall be reviewed and approved by the IWT before being used in production.

Where WPS(s) are based on previously approved WPQR(s) they shall be submitted to the Examiner/Examining Body for verification of compliance with BS EN ISO 15614-1 and BS EN 1011-2.

(Note: The suitability of WPS for the steel to be welded includes the consideration of the actual Carbon Equivalent (CE) of the steel if this differs from the CE value recorded in the WPQR.)

9.2.3 Charpy V-notch Impact Test

Shall be included, either to BS EN 10045-1 or as instructed by the Architect.

9.2.4 Application of Welding Procedure Specifications

Appropriate work instructions shall be produced from the WPQR(s) under the authority of the welding coordinator. The work instructions shall be either WPS(s) or contain all the relevant information required from the WPS in other formats suitable to the Steelwork Contractor's system. They shall be provided to the welder or welding operator prior to the commencement of welding and shall be made available to the Architect, Employer or Inspection Authority on request and shall include a cross-reference to the WPS upon which they are based. Simple work instructions with minimal information are not acceptable.

9.3 Welder Qualification

9.3.1 Testing

Welders shall be tested to meet the requirements as given in BS EN 287-1.

9.3.2 Certification

Welder testing shall be witnessed and certificates approved/endorsed by an Independent Inspection Authority or Examiner/Examining Body.

9.3.3 Period of Validity

The period of validity of the welder's qualification shall comply with Section 9 of BS EN 287-1.

9.3.4 Limitations

Welders shall work within the stipulated limitations as given in BS EN 287-1 at all times. Welds completed by welders found to be working outside stated limitations may be required to be removed.

9.4 Welding Consumables

Shall be used in accordance with the manufacturer's recommendations.

9.5 Assembly

9.5.1 Fit-up

Joints shall be prepared in accordance with BS EN ISO 9692, Parts 1 and 2 and fitted up to the dimensional accuracy required by the WPS, depending on the process to be used, to ensure that the quality in BS EN ISO 5817, level B is satisfied. Precautions shall be taken to ensure cleanliness of the connection prior to welding.

9.5.2 Jigs

Fabrications assembled in jigs may be completely welded in the jig, or may be removed from the jig after tack welding. It is the responsibility of the Steelwork Contractor to ensure the welds used before removal are adequate.

9.5.3 Tack Welding

Tack welds complying with BS EN 1011-1 and BS EN 1011-2 may be used provided:

- (i) they are laid in an area to be welded and are thoroughly removed by grinding or gouging such that the subsequent welding is unaffected; or
- (ii) they are undertaken by a welder qualified as in Clause 9.3 as short length normal welds of a length at least four times the thickness of the thicker part being joined, or

50mm whichever is the greater. The welding procedure shall comply with Clause 9.2; or

- (iii) they are undertaken by a welder qualified as in Clause 9.3 and the welding procedure complies with Clause 9.2, and the tack is fully re-melted during subsequent welding (this will need to be substantiated by a welding procedure); or
- (iv) they are located away from zones where subsequent welding is to take place and in a zone where only compressive forces are present in service.

9.5.4 Distortion

Welding procedures and sequence of fabrication are to be such that distortion is controlled and reduced to a minimum. But in any case, distortion shall not exceed the tolerances set out in Clause 8.7 of this Specification unless otherwise agreed with the Architect.

9.5.5 Temporary Attachments

Welding of temporary attachments required for fabrication or erection shall comply with BS EN 1011-1 and BS EN 1011-2 and shall be made in accordance with the requirements for a permanent weld and inspected.

9.5.6 Run-on and Run-off Plates

Where possible, use run-on and run-off plates in making butt welds to ensure full throat thickness at the ends. They are to comply with the following requirements:

- (i) The Specification for the plates is to be identical to that for the material being welded.
- (ii) The plates, having a sufficient length to prevent craters due to the stoppage of the weld, are to be prepared in the same profile as the parts being joined.
- (iii) After completion of welding, the plates are to be removed by cutting. The surfaces where they were attached are to be ground smooth and inspected for cracks.

9.5.7 Castellated Beams

Welding is to comply with this Specification.

9.5.8 Production Test Plates

Where production test plates are specified for test purposes they shall be clamped in-line with the joint. The grade and quality of material, carbon equivalent and rolling direction shall match the parent plate, but need not be cut from the same plate or cast.

The production test plates shall meet the requirements of BS EN ISO 15614-1 for tensile, impacts and hardness unless otherwise agreed with the Architect.

9.6 Shear Stud Welding

9.6.1 Method

Fix shear studs in accordance with the manufacturer's recommendations for materials, procedures and equipment. Adequate return earth connections shall be made local to the area being stud welded. The local area around where the stud is to be welded shall be free of standing water before commencement of welding. The welding shall comply with BS EN ISO 14555.

If the studs are to be welded by other than drawn arc and this has not been indicated on the Drawings, the Architect shall be notified. Unless agreed otherwise by the Architect, the size of fillet weld shall be chosen such that the full tension capacity of the stud can be developed.

9.6.2 Trial Welding

Before commencement of the Works, carry out trial welding of studs to demonstrate the suitability of the proposed welding system and equipment. The trials shall be made using the

proposed procedures and on samples of materials representative of those to be used in the work (carbon equivalent, grade and thickness). Test a minimum of ten studs in the trial.

During the work, at the start of each shift, a minimum of two trial welds are to be undertaken by each welder. If either of these trial studs fails a bend test in accordance with Clause 9.10.4, then further trials shall be conducted until satisfactory performance is established.

9.6.3 Visual Inspection

Visually inspect trial welded studs. They are to exhibit full 360 degree 'flash'. See also Clause 12.6.1.

9.6.4 Bend Test

Subject trial welded studs to a 15-degree bend test according to Clause 12.6.2.

9.7 Removal of Slag

Remove slag by light hammering, wire brushing or other methods that do not deform the surface of the weld.

10 WORKMANSHIP – BOLTING

10.1 Holes

10.1.1 Forming and Tolerance

Unless agreed otherwise by the Architect, the forming of holes and the tolerance of hole diameters shall conform to Clause 14.2.5 of HKSC.

Holes for close-tolerance bolts shall be drilled to a diameter equal to the nominal diameter of the shank subject to a tolerance of +0.15 mm and -0 mm.

10.1.2 Size

Holes for ordinary bolts are to be of diameter not more than 2mm greater than the diameter of the bolt for bolts up to 24mm diameter, and not more than 3mm greater than the diameter of the bolt for bolts over 24mm diameter, except in steel base plates and where noted on the Drawings.

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

10.1.3 HSFG Fasteners

Holes to comply with BS 4604.

10.1.4 Drifting

Drifting to align holes shall not enlarge the holes and must not cause damage or distortion to the final assembly.

10.1.5 Reaming

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

Calculations shall be made to demonstrate that the connection remains adequate for the forces in the connection if using pre-loaded bolt assemblies.

10.2 Holes in Hollow Sections

Seal bolt holes and vent holes in hollow sections to prevent the ingress of moisture. If not specified on the Drawings, the Contractor shall show the proposed method on the Shop Drawings.

10.3 Make-up of Bolt Assemblies

For all bolt assemblies the strength grade combination of bolt/nuts/washers is to be as prescribed or recommended in BS 5950-2.

10.4 Condition of Bolts

Bolt assemblies are to be in such condition immediately before installation that the nut turns freely on the bolt. Any bolt assemblies which seize when being tightened shall be replaced.

10.5 Galvanized Nuts

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

10.6 Washers

10.6.1 Washers

Each bolt assembly is to contain at least one washer placed under the part being rotated.

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

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

10.6.2 Taper Washers

Taper washer shall be placed under bolt head and nut bearing on surfaces sloping 3° or more from a plane at right angles to the bolt axis.

10.7 Installation of Spring Washers

Tighten bolt assemblies containing spring washers until the spring washer is completely flattened.

10.8 Locking of Nuts

Secure nuts shall be used in connections subject to vibration or reversal of stresses to prevent loosening. If not specified on the Drawings, the Contractor shall include the proposed method in the erection details.

10.9 Limits to Length

For Grade 8.8 bolts, the bolt length shall be chosen such that at least one complete thread in addition to the thread run-out that shall remain clear between the nut and the unthreaded shank of the bolt after tightening. For higher grades, at least five clear threads shall remain.

For normal grade HSFG bolts, the bolt length shall be chosen such that at least three complete threads in addition to the thread run-out that shall remain clear between the nut and the unthreaded shank of the bolt after tightening. For higher grade, at least five clear threads shall remain.

The length of bolts in all cases is to be such that at least one clear thread shows above the nut after tightening, and at least one thread plus the thread run out is clear between the nut and the unthreaded shank of the bolt.

10.10 Bolt Tightening

Bolt and nut assemblies shall be tightened to BS 5950-2.

10.11 Fitted Bolts

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

10.12 Fit-up

Connected parts shall be firmly drawn together (Connected parts intended to transfer force in friction shall be firmly drawn together with all bolts partially tightened). The joint shall then be examined and if there is any remaining gap which may affect the integrity of the joint, it shall be taken apart and a pack inserted before recommencing the tightening procedure.

10.13 Movement Connections

10.13.1 Slotted Holes

Where slotted holes are provided for movement connections, the joint is to be free to move.

10.13.2 Method

Make bolted movement connections in the following manner:

- (i) The slotted hole is to be wider than the unslotted hole.
- (ii) A shouldered bolt is to be used, with a spring washer under the head and the shoulder bearing on the faying surface of the unslotted member.
- (iii) A flat washer is to be provided under the nut and the nut tightened onto the unslotted member.

10.14 High Strength Friction Grip Fasteners

10.14.1 Tightening

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

10.14.2 Tightening Method

Tightening which complies with BS 4604-1 may be by the torque-control method or load indicating device (see Clause 4.7) used according to the manufacturer's recommendations.

10.14.3 Calibration of Tightening Equipment

The tightening equipment, whatever its type or pattern, shall have a calibration check at least once per shift, and shall be re-calibrated if required by the Architect in accordance with BS 4604.

10.14.4 Discarded Bolt Assemblies

If, after complete tightening, a bolt or nut is slackened off for any reason the whole bolt assembly is to be discarded and not re-used in the Works.

10.15 Faying Surfaces for HSFG Fasteners

10.15.1 Mill-scale

Remove all mill-scale from the faying surfaces of friction grip joints.

10.15.2 Surface Condition

The faying surfaces of friction grip joints are to be free of distortion, deformities or contaminants which may reduce the slip factor below the design value.

10.15.3 Deformed Surfaces

Machine flat. Carry out tests to BS 4604 to determine the slip factor after machining.

11 WORKMANSHIP – ERECTION**11.1 General**

The Contractor shall check before erection of any steelwork that work abutting the steelwork to be erected has been correctly placed in position and level. Any discrepancies shall be reported immediately to the Architect. Checks shall be made in a timely manner which enables connections and modifications to be performed without delay to the erection.

The erection of structural frames shall comply with this Specification, the requirements given in BS 5950-2 and BS 5531. The Contractor shall ensure that appropriate safe systems of work are provided, installed and properly maintained to discharge the duties under current safety legislation.

11.2 Foundation Bolts**11.2.1 Setting-in**

Hold foundation bolts firmly in position during all setting-in operations.

11.2.2 Damage

Protect bolts, threads and nuts against damage, corrosion and contamination at all stages of construction.

11.2.3 Pockets

Keep pockets formed around foundation bolts clean and free from all extraneous matter.

11.3 Drill-in Anchors**11.3.1 General**

All drill-in anchors in the concrete structure shall be demonstrated to have sufficient strength and shall be adequately embedded in such a manner that the load is sufficiently distributed to avoid over stressing of the concrete. The location of fixings shall meet the tolerances required for installation of the fitting-out system. Anchors shall be co-ordinated such that they do not clash with any reinforcing steel bars of the concrete structure. See also Annex B for further requirements of drill-in anchors.

11.3.2 Installation

Installation of anchor bolts must strictly follow the manufacturer's specifications. Any installation procedures or details that deviate from the manufacturer's specifications should be appended by a written statement from the manufacturer to confirm strength of the anchors.

11.3.3 Tolerances on Placement

Any deviation from the correct position of anchor bolt should be reported, appended with justification calculation to prove the capacity of the anchor, to the Architect prior to the installation of the fitting-out items. Minimum edge distance and spacing of anchor bolts should strictly comply with the manufacturer's specification.

11.4 Erection Stresses and Erection Loads

The stress limits given in BS 5950 during handling and erection, shall not be exceeded.

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

11.5 Temporary Works

11.5.1 Loadings

Ensure that the steelwork is adequately braced or restrained to withstand all loadings liable to be encountered during construction without inducing excessive stresses, deflection or distortion in the structure.

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

11.5.2 Removal

Temporary works are to remain in position until such time as construction is sufficiently advanced to allow its safe removal.

11.5.3 Connections

Any connections for temporary works are not to weaken the permanent structure or impair serviceability.

11.5.4 Effect on Permanent Works

The Contractor is responsible for justifying the impact of any temporary works on the permanent structure.

11.6 Alignment

Align each part of the structure as soon as practicable after it has been erected. Do not make permanent connections between members until sufficient of the structure has been aligned, levelled, plumbed and temporarily connected to ensure that members will not be displaced during the subsequent erection or alignment of the remainder of the structure.

11.7 Temperature Adjustments

Take due account of the effects of temperature on the structure and measuring equipment when measurements are made for setting-out and erection, and for dimensional checks carried out subsequently.

11.8 Packings

11.8.1 Packs and Wedges

Plumb and level columns using steel packs and wedges of adequate strength and stiffness and these packs and wedges are not to be larger than necessary for the purpose and of adequate strength and stiffness.

11.8.2 Position

Where packings are to be left in position and subsequently grouted, they are to be placed such that they are totally enclosed by the grout and would not prevent subsequent grouting to completely fill all spaces directly under the base plates.

11.9 Grouting

11.9.1 Grouting

Do not carry out grouting under column base plates until a sufficient portion of the structure has been aligned, levelled, plumbed and adequately braced by other structural components which have been levelled and are securely held by their permanent connections.

As directed by the Architect, the Contractor shall submit detailed method statements for grouting narrow gaps or gaps where the grout materials could not be placed by gravity.

11.9.2 Space Under Base Plate

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

11.9.3 Proprietary Grout

Prepare, mix and place in strict accordance with the manufacturer's instructions and recommendations.

11.10 Sliding Surfaces

Treat the sliding surfaces of uncoated expansion joints with molybdenum disulphide grease before making the connection.

11.11 Thermal Cutting

Do not use thermal cutting equipment on site unless agreed otherwise by the Architect for specific applications.

11.12 Site Welding

Where site welding is required, provide suitable staging, platforms and weather protection for welding operations. Site welding shall comply with all the requirements given in Section 9.0.

11.13 Accuracy of Construction**11.13.1 General**

Except otherwise stated on the Drawings and other Contract documents, the Contractor shall erect steelwork within the limits specified in this Specification and make all necessary allowances and adjustments to achieve this accuracy, taking account of the following:

- (i) All measurements be taken in calm weather, and due note is to be taken of temperature effects on the structure.
- (ii) The deviations shown for I sections apply also to box and tubular sections.
- (iii) Where deviations are shown relative to nominal centrelines of the section, the permitted deviation on cross-section and straightness may be added.
- (iv) Inspect for position and level not less than seven days before the planned start of steelwork erection.
- (v) Notify the Architect of any discrepancies found.
- (vi) Ensure that structures by others, including cast-in components and fixings, to which steelwork attaches, are constructed within the anticipated permitted deviations before commencing steelwork erection.

The permitted deviations specified in this section are **NOT** cumulative. Permitted deviations are of individual components and where it is necessary to combine permitted deviations to establish the acceptability of the position of the steelwork, the deviations shall be combined using the root sum square method as recommended in Clause 9.4 of BS 5606.

The Contractor shall carry out regular checks on the steelworks. If an accumulation of tolerances results in a position which is out of the permissible deviations as specified in this Specification or other Contract documents and Section 15 of HKSC, whichever is more stringent, the Contractor shall propose remedial measures for agreement with the Architect prior to carry out any repair works.

The Contractor shall liaise with all Sub-Contractors and advise the Architect on more stringent requirements in related to the acceptable structural tolerances prior to commencement of Works.

When required by the Architect, the Contractor shall furnish all necessary instruments and labour all at his own cost for the use of the Architect for checking the finished steelworks.

11.13.2 Datum References

At commencement of the Contract, the Contractor shall agree with the Architect the government bench marks as datum levels and for the purpose of setting out the gridlines for the Works.

The Contractor shall obtain the setting out dimensions from the Architect to set out the gridlines, and shall be responsible for the accuracy of his work. Figured dimensions shown on the Drawings shall be taken and the Contractor shall verify all such dimensions and levels before commencement of execution of the Works. The checking of any setting-out or of any line or level by the Architect or his representatives shall not in any way relieve the Contractor of his responsibility for the accuracy.

At every structural level, the Contractor shall establish both a datum level and a horizontal reference grid which shall be related back to the approved base bench mark and base reference grid in the forms agreed by the Architect.

11.13.3 Structural Members

Unless otherwise directed structural members shall be set out from the reference grids and datum levels, and constructed such that the dimension between any two points on different constructed structural members, or between any two points on the same constructed structural member, or between any point on a constructed structural member and any reference grid or datum level, or the formed elements shall agree with the required dimension, whether shown on or calculable from the Drawings, within the degree of accuracy as stipulated in Clause 11.13.1.

The butting surfaces of column sections which are one metre and over in width or depth and are to be in direct bearing shall be specially prepared so that after erection both the permitted deviation in plumb in Clause 15.12.4 of HKSC and the permitted gap in Clause 15.12.7 of HKSC are not exceeded except that the second diagram in Clause 15.12.7 of HKSC shall not apply.

11.13.4 Pre-camber

The Contractor shall determine the exact pre-cambers required according to his proposed construction sequence and method statements for the construction of concrete floor slabs and/or glass/metal features etc., such that the specified level of the slab and/or feature is achieved within the specified tolerances. The Contractor shall allow for carrying out a trial, prior to pre-cambering of the steel, to show that the typical secondary floor beams when supported using the connection details determined by the Contractor, exhibit the predicted deflection characteristics when subjected to loads equivalent to the weight of the concrete slab or glass/metal feature.

The first level of each typical floor being constructed on site will be designated as trial floor to assess the construction tolerances both before and after construction of the floor slabs. The Contractor shall conduct a detailed survey of all the beams on the floor to assess their levels and deflections prior to and after construction of the floor slabs. The findings from this

study will be reviewed against the predicted deflections of beams and the Contractor shall make necessary pre-camber adjustments prior to construction of the next level of floor.

Except otherwise agreed by the Architect, the concrete encasement of the columns will be carried out at the same time as the concreting of the floor slab at the level immediately above and the Contractor should not rely on the composite action of the columns when assessing the pre-camber or propping strategy of the floor beams when casting the floor slab.

12 QUALITY CONTROL

12.1 Materials Test Certificates

12.1.1 Steels

Provide test certificates to demonstrate that steels used in the Works conform to the requirements of this Specification and BS 5950-2.

12.1.2 Bolts

Provide test certificates to demonstrate that bolts used in the Works conform to the requirements of this Specification and BS 5950-2.

12.1.3 Welding Consumables

All welding consumables used in the Works need to have certificates to demonstrate that they comply with the requirements of this Specification and BS 5950-2.

12.1.4 Verification

All test certificates are to be verified by an approved Independent Inspection Authority.

12.2 Additional Tests on Steels

12.2.1 Additional Tests

In the areas noted on the Drawings, the material is to be subject to the following additional tests:

- (i) Ultrasonic tests for laminations to the specified acceptance level in accordance with BS EN 10160, Class S2 and E2.
- (ii) Through-thickness tensile tests for through thickness properties to quality class Z25 in accordance with BS EN 10164.

Tests are to be conducted either by the steel manufacturer or by an approved independent HOKLAS accredited laboratory on supplied materials.

12.2.2 Test and Inspection Records

Records of all tests and inspections are to be verified by the approved Independent Inspection Authority.

12.3 Non-Destructive Testing of Welds

12.3.1 Inspection Authority

Examination of welds is to be carried out by an approved Independent Inspection Authority (IIA) or Examiner/Examining Body unless agreed otherwise by the Architect.

12.3.2 Information

The Inspection Authority or Examiner/Examining Body shall be provided with all information to enable inspection to be conducted and reported. This will include access to the contract specification, WPS(s), material certificates (to verify grade), fabrication records (project identification).

Inspection records that fail to be identified to the project or have the correct acceptance criteria stated will be rejected and all work re-inspected. It is the fabricator's responsibility to ensure the inspector has the information required to perform his duties.

12.3.3 Records

Keep records to demonstrate that welds have been inspected as required in Clauses 12.5 and 12.6, have complied with the requirements of Clauses 12.3.4 to 12.3.7 and repairs completed where required.

In these records, fabrications and welds shall be clearly identified to enable traceability of any connections inspected. Identification of connections or welds should conform to the system adopted in the fabrication shop and should not be a separate system devised by the inspection company. All defects shall be recorded in a repair register along with remedial actions and final close out report to verify repair on the same sheet as acceptable work. Separate records for acceptable work and defective work are not acceptable.

The Contractor shall keep records of all weld examinations on site and shall be available for inspection when requested.

12.3.4 Visual Inspection

Visual examination shall be made in accordance with BS EN 970, sections 8, 9 and 10 over the full length of the weld. Such inspections shall be performed before any required non-destructive inspection and results recorded.

A suitably qualified person for visual inspection of welds may be a welding inspector or a welder who can provide evidence of having been trained and assessed for competence in visual inspection of the relevant types of welds during and after welding by a nationally recognised authority (CSWIP to BS EN 473). Internal company training schemes are not acceptable.

12.3.5 Surface Flaw Examination

Magnetic Particle Inspection (MPI) shall be in accordance with Clause 12.5.2 conforming to the recommendations in BS EN 1290.

If MPI is impractical, Dye Penetrant Inspection (DPI) may be used in accordance with the recommendation given in BS EN 571-1, with the permission of the Architect.

Final surface flaw detection of a welded joint shall be carried out after completion of the weld in accordance with the hold times given in Clause 12.3.7.

A suitably qualified person for surface flaw detection of welds should be a welding inspector or a welder who holds a current certificate of competence from a nationally recognised authority (CSWIP to BS EN 473).

12.3.6 Ultrasonic Examination

Where ultrasonic examination is required in accordance with Clause 12.5.2 it shall be made in accordance with the requirements of BS EN 1714 using reference level to Method 1, evaluation reference -14dB (20% DAC) and examination Level B unless otherwise agreed by the Architect, and recorded on the inspection report. Evaluation reference -10dB (33% DAC), as stated in BS EN 1714 will not be accepted. Guidance for the required scans should be taken from BS 3923, or Alternatively BS 3923, Level 2B shall be used.

Ultrasonic inspection to AWS D1.1 is not acceptable to the specification.

Ultrasonic examination of the welded joint shall be carried out after completion of the weld in accordance with the hold times given in Clause 12.3.7.

Inspectors carrying out ultrasonic examination shall hold a current certificate of competence from a nationally recognised authority (CSWIP to BS EN 473).

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

12.3.7 Hold Times before final NDT

If there is a risk of delayed cracking, a period may be needed before the final inspection is made of as-welded fabrications. Recommended minimum hold times are given in Table 12.1.

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

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

Notwithstanding the use of waivers or hold times, whether in accordance with Table 12.1 or otherwise, all identified cracks shall be repaired.

Table 12.1 Recommended Minimum Hold Times

Material Grade	Weld Size (mm)	Heat Input (kJ/mm)	Hold Time (hours)
All grades covered by the Specification unless notified otherwise by the Architect (S275, S355, S420)	$a \text{ or } s \leq 6$	All	Cooling period only
	$6 < a \text{ or } s \leq 12$	≤ 3	8
		> 3	16
	$a \text{ or } s > 12$	≤ 3	16
		> 3	40

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

For individual partial penetration butt welds, the governing criterion is the nominal weld depth (s), but for pairs of partial penetration butt welds welded simultaneously it is the sum of the weld depths (s).

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

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

(iv) The time between weld completion and commencement of NDT shall be stated in the NDT report. In the case of "cooling period only", this will last until the weld has cooled to ambient temperature.

Note: In certain situations, hold times **MAY** need to be greater than shown. This is particularly important when considering weld metal hydrogen cracking of higher strength steels and cases where borderline conditions exist. This remains the responsibility of the Steelwork Contractor to determine.

12.4 Acceptance Criteria for Welds and Corrective Action

The acceptance criteria for welds shall comply with Clause 14.3.6 of the HKSC or Quality Level B specified in Clause 5 of BS EN ISO 5817, whichever is more stringent, except that the scope of weld examination shall comply with Clause 12.5 of this Specification.

If cracking or lamellar tearing is located, inspection should increase to 100% for the weld type using the same WPS. For less serious defects in a joint, examine two additional joints in the group represented by the joint. If the results on these two additional joints are acceptable then the original weld may be repaired and re-examined by similar means.

If the non-destructive examination of the two additional joints reveals unacceptable defects, increase inspection to 100% of weld type using the same WPS.

The Contractor shall inform the Architect and keep record of serious defects (cracks, lamellar tears, incorrect weld type). Consideration should be made as to whether the defect is a procedural problem or welder induced. All defective welds shall be repaired and re-tested to meet the minimum requirements at the Contractor's own cost. The Contractor shall propose remedial measures with a specific repair and re-test procedure for the non-conforming welds for agreement with the Architect prior to carry out any repair works.

12.5 Scope of Weld Examination

12.5.1 Visual Inspection

Visually inspect all welds.

12.5.2 Non-destructive Examination

Frequency of non-destructive examination is to be as follows:

- | | | | |
|-------|---|---|--|
| (i) | Full penetration butt welds and
full strength butt welds |) | 100% ultrasonic and 100% magnetic
particle or penetrant inspection |
| (ii) | Partial penetration butt welds
and fillet welds with a leg length
greater than 12mm |) | 100% first 5 of weld type, then 20% min.
ultrasonic and 20% min. magnetic particle
or penetrant inspection |
| (iii) | Fillet welds with a leg length \leq
12mm |) | 100% first 5 of weld type, then 10% min.
magnetic particle or penetrant inspection |

12.5.3 Selection of Welds to be Examined

Where there is a requirement for less than 100% examination the method of selection of welds to be examined is to be agreed with the Architect before commencement of the Works.

12.6 Shear Stud Welding

12.6.1 Visual Inspection

Visually inspect all stud welds. Subject any stud weld that does not exhibit full 360 degree 'flash' to a 15-degree bend test such that the area of 'no flash' is put in tension. Under this test, the weld is to show no visible signs of cracking.

12.6.2 Bend Test

Subject a minimum of 5%, but not less than two numbers per beam, of the studs that have satisfied the visual inspection to a 15-degree bend test according to American Welding Society standard AWS D1.1 at locations to be agreed with the Architect. Under this test, the weld is to show no visible signs of cracking or lack of fusion.

Where bend testing reveals an unsatisfactory stud weld, test an additional stud on each side of the defective stud. Should either of the two additionally tested studs fail, then all studs shall be considered to be at risk until further testing deems them to be acceptable by the Architect.

Studs subjected to the bend test shall not be straightened.

12.6.3 Defective Studs

Studs with defective welding or that have failed the bend test shall be replaced with a new stud in an adjacent location. The replacement stud shall be inspected according to Clauses 12.6.1 and tested as in 12.6.2 by bending it towards the defective stud. Inspection shall increase to 5 adjacent studs, if further failures are found the cause shall be determined before resuming welding.

If it is necessary to remove the defective stud, it shall be detached and the surface checked in complying with Clause 8.6.

All the costs shall be borne by the Contractor.

12.7 Bolted Connections

Following complete assembly of all bolted connections, check the fit and tightness of the bolts at locations to be agreed with the Architect.

12.7.1 HSFG Bolted Connections

Prior to site painting, check to ascertain that the minimum shank tension has been obtained and that appropriate hardened washers have been fitted in accordance with the requirements of BS 4604.

Records will be required to demonstrate that all HSFG bolts are correctly installed and tensioned.

12.7.2 Non-HSFG Bolted Connections

Place bolts in holes without force, and then tighten to draw connected parts firmly together.

12.7.3 Drill-in Anchors

The Contractor shall carry out loading test of the structural drill-in anchors as required by the Architect and BD at his own cost and time. See Annex B for test of drill-in anchors.

If the loading test fails, the failure mode shall be recorded and the cause shall be determined and reported to the Architect. The Contractor shall propose remedial measures, including justification calculations for any alternate design and method statement, for agreement with the Architect prior to carry out any repair works.

12.8 Fabrication and Erection Tolerances

12.8.1 Survey Records

Records are to be kept of all the required dimensional inspections to demonstrate that the tolerances stipulated in the Specification have been met.

Any deviations from the stated requirements will need a concession from the Architect which will need to be held with the records or steelwork may be rejected. All concessions should clearly identify the member or members affected and should be traceable to individual items.

12.8.2 Verification

The fabrication and erection tolerance records are to be verified as compliant with specified requirements by the Independent Inspection Authority.

12.9 Trial Assembly

Assemble the portions of the steelwork as described on the Drawings.

12.10 Load Testing

The Contractor shall test overhead runway beams to BS 2853.

When it is required and directed by the Architect to establish the capacity of an existing structure or component or to verify design or construction that is not entirely in accordance with the design requirements of the HKSC and BS 5950, the Contractor shall carry out the loading tests for such structure or component in accordance with Section 16 of the HKSC.

13 CORROSION PROTECTION

13.1 Definitions

13.1.1 Dry Film Thickness (DFT)

Minimum dry film thickness of a paint coating. Minimum local thickness of a sprayed metal or galvanized coating.

13.1.2 Hot Dip Galvanized (HDG)

Galvanizing in accordance with BS EN ISO 1461.

13.1.3 Flame-sprayed (FS)

Flame-sprayed in accordance with BS EN ISO 2063.

13.2 General Requirements

13.2.1 Protective Systems

Unless otherwise stated on the Drawings, the reference to the type of protective paint system shall have the requirements specified in Clause 13.8.

13.2.2 Volatile Organic Content (VOC) Limits

All the systems shall comply with local regulations and best practice guidance on VOC emissions from the systems used.

13.2.3 Location

The locations in which each of the systems is to be used are noted on the Drawings.

13.2.4 Unpainted Elements

The surfaces of the following elements are to be unpainted:

- In composite constructions, the surfaces of steelwork which will subsequently have concrete cast against it.
- All steel elements which will be fully encased in structural concrete.
- Other elements as specified on the Drawings.

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

13.2.5 Compatibility

The Contractor shall provide evidence to demonstrate to the Architect that any further coatings to be applied to the steelwork are fully compatible with the main corrosion protective system.

13.3 Materials

13.3.1 Proprietary Materials

13.3.1.1 Evidence of Compliance

Before commencement of the Works, provide evidence to demonstrate that the proposed materials comply with descriptions in Clause 13.2.1 and on the Drawings.

13.3.1.2 Complying Materials

All proprietary materials deemed to comply with coating descriptions shall be submitted to the Architect for approval.

13.3.2 Manufacturer's Instructions

Obtain from the manufacturer of any proprietary product detailed instructions on the use of the product, specific to the situation found on the Contract.

Comply with the manufacturer's instructions for the use of any product. If these are in conflict with the requirements of the Specification, notify the Architect before commencement of the Works.

13.3.3 Source of Paint Materials

All products in any particular paint scheme are to be obtained from a single manufacturer.

13.3.4 Multiple Coats of a Product

Where two or more coats of a product are to be applied, use a different colour for alternate coats.

13.3.5 Zinc-rich Primers

Zinc-rich primers are to comply with BS 4652 and BS EN ISO12944: Part 5.

13.3.6 Pigments**13.3.6.1 Volume**

Where a paint is defined in the protective system as having a specific pigment, the total pigment is to contain at least 50% by volume of the pigment specified.

13.3.6.2 Primers

Primers are not to be so coloured that early signs of rust breakthrough may be masked. Red iron oxide (red oxide) is not to be used as the principal colouring agent of any primer, including optional prefabrication primers.

13.3.7 Metallic Blast Cleaning Abrasives

Abrasives used for blast cleaning shall be capable of achieving the specified level of cleanliness and surface roughness. Where metal abrasives are used, they shall comply with BS EN ISO 11124.

13.4 Workmanship – Identification, Storage and Handling

13.4.1 Identification

All paints and other products are to be marked or labelled and stored in such a way that identification of product and batch numbers is possible at all times.

13.4.2 Transportation, Storage and Handling**13.4.2.1 Damage**

Establish transportation, storage and handling procedures for coated steelwork to avoid contamination, damage or breakdown of the protective system.

13.4.2.2 Galvanized Materials

Store and transport in such a way as to avoid white rust formation.

13.5 Workmanship – General

13.5.1 Surface Preparation

13.5.1.1 Cleanliness

Before surface preparation in accordance with the protective system requirements, clean the steel surfaces of dirt, grease and other contaminants. They shall at no stage have rusted beyond Rust Grade C of Swedish Standard SIS 05 59 00.

13.5.1.2 Surface Roughness

After surface preparation, the surface roughness is to be compatible with the coating to be applied in accordance with BS EN ISO 8503-2 but nowhere exceeding a peak-to-trough amplitude of 80 micrometres.

13.5.1.3 Rectification of Defects

Rectify all defects in the substrate surface exposed during surface preparation in accordance with Clause 3.5.

Defects which are acceptable to BS EN 10163, BS EN 10210 and BS EN 10219 as appropriate, but which nonetheless will prevent the satisfactory coating of the steelwork, are to be rectified in such a way as to allow coating to be carried out in accordance with the Specification.

13.5.1.4 Rusting

Test steelwork, which has rusted to Rust Grade B of Swedish Standard SIS 05 59 00 at any stage before surface preparation, and steel which has been subject to significant contamination prior to blast-cleaning, in accordance with the method of Appendix G of BS 5493 after surface preparation, to demonstrate that the prepared surface is substantially free of salts. Wash with high-pressure water to remove any excessive salts present.

13.5.2 Surface Condition**13.5.2.1 Contaminants**

Surfaces to which paint is to be applied, whether steel or previous coatings are to be clean and free of any detrimental contaminants.

13.5.2.2 Quality of Surface

The prepared surfaces shall be assessed in regard to visual cleanliness, surface profile and chemical cleanliness, using the methods given in BS EN ISO 12944-4. The requirements for the supervision of these aspects of the work, the frequency of assessment, and the location of the assessment work shall be agreed with the Architect.

The quality of surface preparation specified in the protective system is required to be present at the time of painting. If the surface has degraded beyond this level, re-cleaning is to be carried out.

13.5.3 Application Conditions

During the execution of the corrosion protection work, care shall be taken that the work is not affected by any outside influences that could lead to a reduction in the quality of the coating. In the planning stage before starting the work, the Contractor shall define the measures by which adverse effects on the environment can be avoided or reduced to a minimum.

13.5.3.1 Weather Conditions

In order to ensure the protection required from the coating, the ambient conditions on site shall be checked to ensure that they meet the requirements given in the paint manufacturer's technical data sheet for the particular coating material. This shall also apply to drying and reaction times.

The lowest and highest permissible temperature of the surface to be coated and of the surrounding air plus the permissible relative humidity shall be as stated in the manufacturer's technical data sheet. If adverse weather conditions occur during application, the work shall be stopped and the freshly coated area protected as far as practical.

Coating materials shall not be applied at temperatures below 3°C above the dew point, determined in accordance with BS EN ISO 8502-4. Wet surfaces shall only be painted with those coating materials which are permitted in the technical data sheet or approved by the paint manufacturer.

13.5.3.2 Environment Conditions

Paint work shall take place in an area separated or protected from the work of other trades (blast-cleaning, welding etc.).

13.5.4 Prefabrication Coatings

13.5.4.1 Prefabrication Coating

The Contractor may apply a prefabrication coating at his discretion. This coating, if applied, is to be additional to the main protective system.

13.5.4.2 Evidence of Compatibility

If a prefabrication coating is applied, the Contractor shall provide evidence to the Architect to demonstrate that it is fully compatible with the main protective system.

13.5.4.3 Blast-cleaning

If a prefabrication coating is used, all areas in which this coating is not intact after fabrication are to be locally blast-cleaned to the standard required by the protective system before overcoating.

13.5.5 Method of Application

Where shop applied paint coatings are to be applied by other than airless spray, or site applied paint coatings by other than brush or airless spray, demonstrate that the method of application will result in work in accordance with the Specification.

When painting components are to be welded on site, such components shall be masked in all areas which will be subject to preheating and welding. In the case of multicoated systems, every coat shall be stepped back.

13.5.6 Stripe Coats

All steelwork that will be externally exposed in the finished works is to have an extra stripe coat of primer applied to all edges and corners, and to seal gaps between adjacent components such as bolted connections.

13.5.7 Hot Dip Galvanizing

13.5.7.1 Condition

Supply material to the galvanizer in a suitable condition to be acid-pickled and then galvanized.

High strength steels (in plate, rolled section or bar) of design strength greater than 460 N/mm² should not be galvanized in order to avoid metallurgical change or annealing. Bolts of Grade 10.9 or higher grade or equivalent should not be galvanized.

Hollow sections should be vented if they are to be galvanized. The Contractor shall agree with the Architect the position of vent and drainage holes as laid down in BS EN ISO 14713, and any requirements for subsequent sealing.

13.5.7.2 Uniformity

Carry out galvanizing in such a way as to maximise the smoothness and uniformity of the deposited coating. Only use double-dipping where no alternative exists. Bolts should be spun galvanized.

13.5.7.3 Touch-up

In accordance with Section 6.3 of BS EN ISO 1461:1999. Preparation is to be as required by the manufacturer of the touch-up product being used.

The maximum size of an area of touch-up is to be determined by locating the point on the damaged surface which is furthest from an intact galvanized coating. If the distance from this point to the galvanizing is in excess of 10mm, then the member is to be re-galvanized or rejected.

13.5.8 Sealing of Flame-sprayed Surfaces

Immediately after flame-spraying, seal the surface with a suitable sealer, chosen from Table 4C of BS 5493 and follow general guidelines from Section 6.4 of BS EN ISO 2063. The chosen sealer must be compatible with any further coats to be applied.

13.5.9 Life of Shop Applied Protection

13.5.9.1 Programme

The Contractor shall liaise with the paint manufacturer, to ensure that the expected life of the shop-applied protection is compatible with erection and site painting programmes.

13.5.9.2 Failure

If failure of the shop-applied protection should occur, reinstate the steelwork to an equivalent condition to the unfailed protection. The scheme used is to be compatible with any further coatings.

13.5.10 Making Good

13.5.10.1 Damage

The Contractor shall make good all damage, weld areas and other areas which are not coated in accordance with the Specification.

13.5.10.2 Method

The Contractor shall provide details of the proposed method for making good that will result in protection in accordance with the Specification. Details are to include surface preparation of both exposed steel and other coatings, choice of materials if these differ from those originally specified, means of application and any other relevant considerations.

13.5.11 Reinstatement of Damage Protection in Existing Steel Structures

All reinstatement of damaged coatings in the existing steel structures shall be made good in accordance with Clause 13.5.10.2 to the standard of the original work except otherwise specified on the Drawings.

13.6 Workmanship – Connections

13.6.1 General

13.6.1.1 Equivalent Standard

Prepare and protect all connections, including fasteners, items of bracketry and other small pieces fabricated separately to the main steelwork, to an equivalent standard to the adjacent steel unless noted otherwise on the Drawings.

13.6.1.2 Different System

Where the Contractor proposes to use a different protective system for any part of a connection to that used for the adjacent steel, provide evidence to demonstrate its equivalence and compatibility.

13.6.2 Friction Grip Interfaces

Do not apply paint to friction grip interfaces. If necessary, the faying surfaces are to be masked to prevent rusting beyond Rust Grade C of Swedish Standard SIS 05 59 00. If galvanizing or other metal coatings have been applied, provide evidence to demonstrate that a slip factor not less than the design value will be achieved.

13.6.3 Assembly of Bolted Connections

Assemble bolted connections in externally exposed steelwork, other than friction grip connections, with a coat of primer still wet on the contact faces.

13.6.4 Coated Bolts

Prime galvanized or sherardized bolt assemblies with a compatible etch primer or treat with a mordant solution prior to overcoating.

13.6.5 Sealing of Bolted Connections

Seal all bolted joints against the ingress of water. Before site painting commences, plug gaps at joints with a compatible and suitable filler. Take care that water is not sealed within the joint.

13.6.6 Site Welds**13.6.6.1 Paint**

At the time of welding there is to be no paint, other than suitable prefabrication primer, within 50mm of the weld.

13.6.6.2 Temporary Protection

Apply and remove before welding if this is necessary to ensure that rusting does not occur to a level beyond that allowed by the Specification.

13.6.6.3 Painting of Site Weld Areas

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

13.7 Quality Control**13.7.1 General****13.7.1.1 Inspections and Tests**

Before commencement of the Works, the Contractor shall provide details of the scope and frequency of all inspections and tests to be carried out to assure compliance with the Specification. As a minimum, include all relevant inspections and tests in Table 8 of BS 5493 and follow general guidelines in BS EN ISO 12944: Part 7.

The frequency of inspection and testing is to be sufficient to detect any non-conformances.

13.7.1.2 Notice

The Contractor shall agree with the Architect a period of notice for all tests.

13.7.2 Method Statement

The Contractor shall submit a detailed method statement for the application or reapplication of protective coating(s) explaining how it is intended to carry out the works in accordance with the Specification to the Architect for approval prior to the commencement of works.

At locations where there are significant residual stresses inherent in the steel during fabrication (cold working) and welding, the Contractor shall provide effective measures to improve the corrosion resistance of the material.

The Contractor shall carry out all works in accordance with the method statement.

13.7.3 Test Pieces**13.7.3.1 Test Pieces**

Prepare two sets of test pieces representative in all relevant respects of the Works to be carried out.

13.7.3.2 Coating

Coat test pieces in accordance with the method statement.

13.7.3.3 Tests

Confirm, by means of tests on one set of test pieces, that the proposed method will result in work which complies with the Specification.

13.7.3.4 Retention of Test Pieces

Protect and retain the second set of test pieces for the duration of the Contract.

13.7.3.5 Results of Tests

No work is to be carried out until the Contractor has confirmed in writing that the results of the tests comply with the Specification. Provide the Architect with a copy of the test results.

13.7.3.6 Quality Standards

The quality standards established by the test pieces are to become the minimum standard for the Works.

13.7.4 Modification to Method Statement**13.7.4.1 Test Pieces**

If it is proposed to modify the method statement, produce two sets of test pieces, identical with the initial test pieces, using the proposed modified method.

13.7.4.2 Tests

Confirm, by means of tests on one set of test pieces, that the proposed modification will not result in a reduction in the quality of work produced below that being produced by the current method.

13.7.4.3 Retention of Test Pieces

Protect and retain the second set of test pieces for the duration of the Contract.

13.7.4.4 Results of Tests

No work is to be carried out using the modified method until the Contractor has confirmed in writing that the results of the tests comply with the Specification. Provide the Architect with a copy of the test results.

13.7.4.5 Quality Standards

The quality standards established by the test results are to become the minimum standard for the Works.

13.7.5 Testing**13.7.5.1 Coating Thickness**

After the application of each coat of paint, and before the application of following coats, ensure that the coat has been applied to the required dry film thickness by the use of any of the methods in BS 3900: Part C5 and BS EN ISO 2808 for measuring dry film thickness. Wet film thickness measurements are not to be used for this purpose.

13.7.5.2 Adhesion

Ensure, by means of adhesion tests to BS 3900: Part E6 and BS EN ISO 2409, carried out on representative areas chosen to be non-obtrusive in the final condition, that the adhesion of any completed paint scheme is not worse than classification 2 of that standard.

The test area is to be touched-up in accordance with the Specification.

13.7.5.3 Flame-sprayed Zinc

Test in accordance with Section 8 of BS EN ISO 2063.

13.7.5.4 Hot Dip Galvanized Steel Elements

Test in accordance with Section 6.2 of BS EN ISO 1461:1999 for coating thickness, using coupons of the same material as the element, and galvanized with the element.

All galvanized components shall be subjected to post-galvanizing inspection as specified on the Drawings for Liquid Metal Assisted Cracking (LMAC) in accordance with the procedures in Table 13.1. Any linear or crack-like indications shall be recorded and reported to the Architect as soon as possible. Additional NDT by MPI is required when there is evidence of a susceptibility to cracking. The operator shall be trained to recognise the diffused indicators due to the presence of the coating.

Table 13.1 Post-Galvanizing Inspection Procedures

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

If evidence of cracking is identified, then the component and all similarly shaped components fabricated with similar materials and weld details shall be identified and quarantined as non-conforming products. A photographic record of the cracking shall be made and procedure PGI-3 shall then be used to establish the scope and origin of the problem.

Quarantined components may only be repaired for use in the Works with the agreement of the Architect and the components shall be repaired using an appropriate welding repair procedure in compliance with the guidance on the BCSA and GA Publication No. 40/05 – *Galvanizing Structural Steelwork – An Approach to the Management of Liquid Metal Assisted Cracking*. The Steelwork Contractor shall prepare the welding procedure and submit to the Architect for approval prior to carrying out the repair works.

The results of post-galvanising inspection and any repair works shall be recorded. These records shall be made available to the Architect on request.

13.7.6 Inspection of Site Applied Coatings

If coatings are required, other than those covered by Clause 13.6.6, to be applied on site, then an inspection plan for the site application work shall be included in the project quality plan.

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

13.8 Protective Paint Systems

Externally exposed steelwork:

Type E-1

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Zinc Rich Epoxy ^{note (3)}	75	Shop
Barrier	Epoxy MIO ^{note (4)}	100	Shop
Finish	Acrylic / Urethane	50	Site

Type E-2

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Epoxy Zinc Phosphate	75	Shop
Barrier	Epoxy MIO ^{note (4)}	100	Shop
Finish	Acrylic / Urethane	50	Site

Internal steelwork:

Type I-1

Surface Preparation:	None Required		
Coat	Material	Thickness	Application
Primer	No corrosion protective paint required		
Finish			

Type I-2

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Epoxy Zinc Phosphate	75	Shop
Finish	As specified by the Architect		Site

Type I-3

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Epoxy Zinc Rich ^{note (3)}	75	Shop

Type I-4

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Epoxy primer / finish	125	Shop

Type I-5

Surface Preparation:	Blast clean to Sa2½ of Swedish Standard SIS 05 59 00		
Coat	Material ^{note (1)}	Thickness ^{note (2)}	Application
Primer	Epoxy Zinc Phosphate	50	Shop
Barrier	Epoxy MIO ^{note (4)}	125	Shop
Finish	Acrylic/Urethane	50	Site

- Notes: (1) See Clause 13.3.3.
 (2) The thickness as quoted is **Minimum** DFT in microns.
 (3) See Clause 13.3.5.
 (4) MIO: Micaceous iron oxide

14 Fire Protection

14.1 General

14.1.1 General Requirements

Unless otherwise specified on the Drawings or encased in solid structural concrete, all steelworks shall be protected against fire by applying insulating materials to ensure that the steel section does not exceed the limiting temperature within the fire resistance period as specified by the Architect or according to the Code of Practice for Fire Resisting Construction 1996 whichever is more stringent.

Clause 13.2.2 regarding the VOC emission limits shall apply.

14.1.2 Compatibility

The Contractor shall provide evidence to demonstrate to the Architect that the fire protection coating to be used for the steelwork is fully compatible with a) the material to which it is applied; b) the decorative or protective surface finishes where required, and its fire protection performance or stickability would not be impaired. The use of alternative primers should be in accordance with the manufacturer's recommendations. (See also Clause 13.2.5)

In all applications the properties of the surfacing finish have to accommodate any dimensional movement of the spray.

14.1.3 Section Factor (H_p/A)

The 'Section Factor' is the ratio of the surface perimeter exposed to radiation and convection, H_p , to the cross-sectional area, A , and has units of m^{-1} .

The section factor for different types of protection methods on different shapes/forms of the structural steelwork shall be assessed by the Contractor in accordance with the manufacturer's specifications and agreed with the Architect.

The thickness of protection to be applied to a section having a calculated H_p/A less than the minimum H_p/A given in the manufacturer's data sheets shall be the thickness required at that minimum value. If the calculated H_p/A of a section exceeds the maximum figure in the data sheets reference should be made to the manufacturer for an individual assessment by an appropriate authority as defined in Clause 14.2.1. The thickness should not exceed the maximum coating range for which the product has been validated.

14.2 Materials

The fire protection materials and proprietary products shall comply with BS 8202 or ETAG 018 - *Fire Protective Products* and shall be approved by the Architect. Interior or exterior application, impact and abrasion resistance factors shall also be considered in the selection of materials.

14.2.1 Fire Testing and Performance Assessment Reports

All fire protection materials should have been subjected to an appropriate fire test in accordance with BS 476-20, BS 476-21 and Clause 12.2.1 of the HKSC. The test report indicating that the construction elements and the structural members are capable of resisting the action of fire for the specified criteria shall include the information as stated in Clause 12 of BS 476-20.

The performance and thicknesses of the fire protection materials should be assessed from standard fire tests at accredited laboratories. The assessment report shall include, but not limited to the following details:

- Fire protection material / product / system - Brief description of generic types.
- Test specimens - Number of specimens and sizes used in the analyses.
- Surface preparation and primer details.
- Details of method of analysis adopted.
- Compliance with criteria of acceptability, details of any constraints and permitted extensions.
- Predictive analyses at each critical temperature with summary of test results and summary of analysis data.
- Predicted thicknesses for various Section Factors and critical temperatures - Data sheets.
- Physical performance and retention of material/product/system.
- Method of application (validity of assessment for the application method).
- The test reports used for the assessment should be appended to the Assessment Report.
- Reasons for the omission of any test data, if any.

The test and assessment reports shall be prepared and endorsed by a HOKLAS accredited laboratory or other accredited laboratory which has mutual recognition agreements / arrangements with the HOKLAS or the BA. Or alternatively, the assessment report may be prepared and endorse by an independent authority having the appropriate qualifications and experience in fire resisting construction recognized by the BA. Both the reports shall be submitted to the Architect for record.

14.2.2 Mechanical Retention

For the sprayed application of coatings, mechanical retention should be provided for elements without a re-entrant profile, or when the structural members are not encapsulated unless test evidence is available to demonstrate that there is adequate bond between the spray and the substrate (including primers or other coatings); or the spray is locked into position by virtue of the shape of the element.

Reinforcement in the form of a corrosion protected wire mesh, 25, 38 or 50mm x 0.9mm, is also required on a) 'I' or 'H' steel sections with dimensions of web exceeding 650mm and flange exceeding 325mm; and b) circular sections with diameter exceeding 325mm or on hollow sections with a single face exceeding 325mm except where applicable test data is available to show such reinforcement is unnecessary. The mesh should be in the middle third of the thickness and be retained by welded pins and non-return washers at nominal 500mm centres.

However, if any mesh reinforcement has been used with the coating system during the fire tests, then the same system must be adopted when used in the Works.

Plastic pins, self-adhesive pins or adhesive fixed pins must not be used for mechanical retention fixings.

Where expanded steel lathing is used to form a hollow encasement, it should be spaced from any steel surface to allow penetration of the lath by the fire protection material to form a mechanical key.

14.3 Workmanship

14.3.1 General

The supplier/manufacturer's specification for transport, storage and handling of the materials/products should be strictly followed.

To ensure that the stickability of the coating system is not impaired, the application techniques of the products, including the number of coats applied as instructed by the manufacturer must be strictly followed.

For the surface preparation of the steel, reference should be made to the individual requirements specified by the fire protection product manufacturer.

14.3.2 Passive Fire Protection System

Shall comply with Clauses 10.1 to 10.8 of BS 8202-1:1995.

14.3.3 Reactive Fire Protection System

Shall comply with Clauses 6.2, 6.3.2 and 6.3.3 of BS 8202-2:1992.

14.3.4 Defects and Damage

The Contractor shall rectify all the defects and damage to the standard of this Specification.

14.4 Quality Control

14.4.1 Method Statement

The Contractor shall prepare and submit the method statement including spacing of fixings for the mechanical retention to the Architect for approval prior to the commencement of works.

For materials undergo dimensional changes after application, the Contractor should take special care to recognize this factor for site control purposes.

14.4.2 Passive Fire Protection System

Shall comply with Clause 10.9 of BS 8202-1:1995.

14.4.3 Reactive Fire Protection System

Shall comply with Clause 9 of BS 8202-2:1992.

The dry film thickness shall be measured using an instrument employing either the electromagnetic induction or eddy current principle, with a probe contact diameter of minimally 2.5mm according to BS EN ISO 2808. The instrument shall satisfy the following criteria:

- a) Possess a total range greater than the highest thickness to be measured.
- b) Provide a digital display of coating thicknesses and be capable of storing measured values.
- c) Capability to calculate statistical parameters – max/min values, mean and standard deviation.
- d) Capability to provide hard copy print out of data.

The instrument shall be operated in accordance with the manufacturer's instruction for use. Calibration shall be carried out immediately prior to any series of measurements being taken.

In the case of a primer being employed, primer thickness shall be determined prior to application of the intumescent coating and subsequently subtracted from the measured total thickness of primer and intumescent coating.

14.4.4 Deviations

In respect of fire resistance, section factor (H_p/A) and thickness, together with protection details, no deviation can be made except for specific situations where some variation may be necessary. Such variations must be validated by an independent authority as defined in Clause 14.2.1, or an appropriate HOKLAS accredited testing laboratory and subject to the approval by the Architect.

Annex A: List of International Standards

A1 British Standards

BS 4-1	Structural steel sections - Part 1: Specification for hot rolled sections
BS 476-20	Fire tests on building materials and structures Part 20: Method for determination of the fire resistance of elements of construction (general principles)
BS 476-21	Fire tests on building materials and structures Part 21: Methods for determination of the fire resistance of loadbearing elements of construction
BS 1449-1.1	Steel plate, sheet and strip Part 1: Specification for carbon and carbon manganese plate, sheet and strip - Section 1.1 General specification
BS 2853	The design and testing of steel overhead runway beams
BS 3692	ISO metric precision hexagon bolts, screws and nuts
BS 3900	Methods of test for paints Part C5: Determination of film thickness Part E6: Cross-cut test
BS 3923	Methods for ultrasonic examination of welds. Part 1: Methods for manual examination of fusion welds in ferritic steels Part 2: Automatic examination of fusion welded butt joints in ferritic steels
BS 4190	ISO metric black hexagon bolts, screws and nuts
BS 4320	Metal washers for general engineering purposes
BS 4395	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering Part 1: General grade Part 2: Higher grade bolts and nuts and general grade washers
BS 4464	Spring washers for general engineering and automobile purposes (metric series)
BS 4604	Specification for the use of high strength friction grip bolts in structural steelwork. Metric series Part 1: General grade Part 2: Higher grade (parallel shank)
BS 4652	Metallic zinc-rich priming paint (organic media)
BS 4800	Schedule of paint colours for building purposes
BS 4921	Sherardized coatings on iron and steel articles
BS 4933	ISO metric black cup and countersunk head bolts and screws with hexagon nuts
BS 5493	Code of practice for protective coating of iron and steel structures against corrosion
BS 5531	Code of Practice for Safety in erecting structural frames
BS 5950	Structural use of steelwork in building Part 1: Code of practice for design - rolled and welded sections Part 2: Specification for materials, fabrication and erection - Rolled and welded sections Part 7: Specification for materials and workmanship: cold formed sections

BS 7371-6	Coatings on metal fasteners. Specification for hot dipped galvanized coatings
BS 7371-8	Coatings on metal fasteners. Specification for sherardized coatings
BS 7419	Specification for holding down bolts
BS 8202-1	Coatings for fire protection of building elements Part 1: Code of practice for the selection and installation of sprayed mineral coatings
BS 8202-2	Coatings for fire protection of building elements Part 2: Code of practice for the use of intumescent coating systems to metallic substrates for providing fire resistance
BS EN 287-1	Qualification test of welders - Fusion welding – Part 1: Steels
BS EN 288-3 (Replaced by BS EN ISO 15614-1)	Specification and approval of welding procedures for metallic materials Part 3: Welding procedure tests for arc welding of steels
BS EN 440	Welding consumables. Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels. Classification
BS EN 473	Non-destructive testing. Qualification and certification of NDT personnel. General principles
BS EN 571-1	Non-destructive testing - Penetrant testing - Part 1: General principles
BS EN 756	Welding consumables. Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels. Classification
BS EN 758	Welding consumables. Tubular cored electrodes for metal arc welding with and without a gas shield of non-alloy and fine grain steels. Classification
BS EN 970	Non-destructive examination of fusion welds. Visual Examination
BS EN 1011-1	Welding - Recommendations for welding of metallic materials Part 1: General guidance for arc welding
BS EN 1011-2	Welding - Recommendations for welding of metallic materials Part 2: Arc welding of ferritic steels
BS EN 1290	Non-destructive examination of welds. Magnetic particle examination of welds
BS EN 1714	Non-destructive testing of welded joints. Ultrasonic testing of welded joint
BS EN 1993-1-3	Eurocode 3: Design of steel structures. Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
BS EN 10024	Hot rolled taper flange I sections. Tolerances on shape and dimensions
BS EN 10025-1	Hot rolled products of structural steels Part 1: General technical delivery conditions
BS EN 10025-2	Hot rolled products of structural steels Part 2: Technical delivery conditions for non-alloy structural steels
BS EN 10025-3	Hot rolled products of structural steels Part 3: Technical delivery conditions for normalized / normalized rolled weldable fine grain structural steels
BS EN 10025-4	Hot rolled products of structural steels Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

BS EN 10025-5	Hot rolled products of structural steels Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
BS EN 10025-6	Hot rolled products of structural steels Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
BS EN 10029	Specification for tolerances on dimensions, shape and mass for hot-rolled steel plates 3mm thick or above
BS EN 10034	Structural steel I and H sections. Tolerances on shape and dimensions
BS EN 10045-1	Charpy impact test on metallic materials test method (V- and U- notches)
BS EN 10055	Hot rolled steel equal flange tees with radiused root and toes. Dimensions and tolerances on shape and dimensions
BS EN 10056-1	Specification for structural steel equal and unequal leg angles Part 1: Dimensions
BS EN 10056-2	Specification for structural steel equal and unequal leg angles Part 2: Tolerances on shape and dimensions
BS EN 10111	Continuously hot-rolled low carbon steel sheet and strip for cold forming Technical delivery conditions
BS EN 10143	Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape
BS EN 10160	Ultrasonic testing of steel flat product of thickness equal or greater than 6mm (Reflection Method)
BS EN 10162	Cold rolled steel sections – Technical delivery conditions – Dimensions and cross-sectional tolerances
BS EN 10163	Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections. Part 1: General requirements Part 2: Plate and wide flats Part 3: Sections
BS EN 10164	Steel products with improved deformation properties perpendicular to the surface of the product – Technical delivery conditions
BS EN 10209	Cold rolled low carbon steel flat products for vitreous enamelling. Technical delivery conditions
BS EN 10210-1	Hot finished structural hollow sections of non-alloy and fine grain steels Part 1: Technical delivery conditions
BS EN 10210-2	Hot finished structural hollow sections of non-alloy and fine grain steels Part 2: Tolerances, dimensions and sectional properties
BS EN 10219-1	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery condition
BS EN 10219-2	Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties
BS EN 10279	Hot rolled steel channels. Tolerances on shape, dimension and mass
BS EN 10326	Continuously hot-dip coated strip and sheet of structural steels-Technical delivery conditions
BS EN 10327	Continuously hot-dip coated strip and sheet of low carbon steels for cold forming. Technical delivery conditions

BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles – Specification and test methods
BS EN ISO 2063 (Replace BS EN 22063)	Thermal Spraying – Metallic and other inorganic coatings – Zinc, aluminium and their alloys
BS EN ISO 2409	Paint and varnishes – Cross-cut-test
BS EN ISO 2560	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification
BS EN ISO 2808	Paint and varnishes – Determination of film thickness
BS EN ISO 3506	Mechanical properties of corrosion-resistant stainless-steel fasteners. Part 1: Bolts, screws and studs Part 2: Nuts Part 3: Set screws and similar fasteners not under tensile stress
BS EN ISO 3834-3	Quality requirements for fusion welding of metallic materials. Standard quality requirements
BS EN ISO 3834-5	Quality requirements for fusion welding of metallic materials. Documents with which it is necessary to conform to claim conformity to the quality requirements of ISO 3834-2, ISO 3834-3 or ISO 3834-4
BS EN ISO 5817	Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections
BS EN ISO 6507-1	Metallic materials. Vickers hardness test. Part 1: Test method
BS EN ISO 7089	Plain washers. Normal series. Product grade A
BS EN ISO 7090	Plain washers, chamfered. Normal series. Product grade A
BS EN ISO 8501-1	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
BS EN ISO 8502-4	Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness. Guidance on the estimation of the probability of condensation prior to paint application
BS EN ISO 8503-2	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the grading of surface profile of abrasive blast-cleaned steel. Comparator procedure
BS EN ISO 9001	Quality management systems. Requirements
BS EN ISO 9018	Destructive tests on welds in metallic materials. Tensile test on cruciform and lapped joints
BS EN ISO 9692-1	Welding and allied processes. Recommendations for joint preparation. Manual metal-arc welding, gas-shielded metal-arc welding, gas welding, TIG welding and beam welding of steels
BS EN ISO 9692-2	Welding and allied processes. Joint preparation. Submerged arc welding of steels
BS EN ISO 11124-2	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Chilled-iron grit
BS EN ISO 11124-3	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. High-carbon cast-steel shot and grit

BS EN ISO 12944	Paint and varnishes – Corrosion protection of steel structures by protective paint systems – Part 4: Types of surface and surface preparation Part 5: Protective paint systems Part 7: Execution and supervision of paint work
BS EN ISO 13918	Welding. Studs and ceramic ferrules for arc stud welding
BS EN ISO 14555	Welding. Arc stud welding of metallic materials
BS EN ISO 14713	Protection against corrosion of iron and steel in structures - Zinc and aluminium coatings - Guidelines
BS EN ISO 15609-1	Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding
BS EN ISO 15614-1	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys

A2 Swedish Standards

SIS 05 59 00	Pictorial surface preparation standards for painting steel surfaces.
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A3 American Standards

ANSI/AWS D1.1	Structural Welding Code – Steel
ASTM C939-02	Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C940-98a	Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory

A4 Japanese Standards

JSS II-09	Sets of torshear type high strength bolt, hexagon nut and plain washers for structural joints (by Society of Steel Construction of Japan)
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Annex B: Construction, Performance and Test of Drill-in Anchors

B1 Construction and Performance

The drill-in anchors shall comply with Clauses 11.3 and 12.7.3 of this Specification and the following requirements:

- (a) Qualified site supervision of the drilled-in anchor works by an experienced and competent person should be provided to ensure that the works are carried out in accordance with the plans approved by BD and that the required standards are complied with.
- (b) Strength tests on a representative number of the drilled-in anchors, as directed by the Architect, are required to be carried out in accordance with the test criteria specified in paragraph B2 below and should be carried out by a recognized laboratory independent of the Contractor.
- (c) A method statement on the anchor tests mentioned under item (b) above is required to be submitted to the Architect for BD submission prior to the application for consent to the commencement of the drill-in works.
- (d) Upon completion of the works, a report is required to be submitted to the Architect, which should include:
 - (i) All results of the strength tests of the drilled-in anchors.
 - (ii) A discussion on any problems encountered during the installation of the anchor bolts and how they were overcome.
 - (iii) A statement signed by the Contractor's structural engineer to confirm that all drilled-in anchors have been installed in accordance with the anchor manufacturer's recommendations.

B2 Testing

Strength tests of the drilled-in anchors should satisfy the following criteria:

- (a) Sampling rate should be i) at least 5% of anchors acting in shear and 10% of anchors acting in tension or 5 numbers each, whichever is more, of each type and size of the anchors installed; or ii) as required by BD whichever is more stringent.
- (b) Each representative anchor should be tested for tensile load by pullout test or shear load by shear load test as appropriate.
- (c) Test load should not be less than 1.5 times the recommended working load of the anchor as specified by the anchor manufacturer.
- (d) Upon the maximum test load is reached, the load should be maintained for at least one hour, and the readings of load and deformation should be taken at the beginning and end of this period to establish whether the tested anchor is subject to creep and relaxation of load under this maximum test load.
- (e) Recovery of the deformation after removal of all loads should be at least 80% of the total deformation at the maximum test load, and the tested anchor should not show any signs of separation, plastic deformation or deleterious effect.

Reference may be made to BS 5080 Parts 1 & 2 for the testing procedures for drilled-in anchors including apparatus set-up, load application and results presentation.