

Technical Specification for Carbon Steel, Stainless Steel & Aluminium Structures

Document Change History

Version History

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# General

## Scope

This Technical Specification applies to the design and construction of steel structures for water and wastewater infrastructure assets by Queensland Urban Utilities.

The purpose of this Technical Specification:

* Is to maintain consistent designs, construction and durability, and appearance requirements for all water and wastewater infrastructure.
* It shall be read in conjunction with all relevant Australian and International standards, and legislative requirements.
* It does not relieve the designers' responsibilities for the design and construction of infrastructure.

The design and construction of steel structures involves design, construction planning, fabrication and erection, construction and maintenance. The work, at each stage, shall be carried out in a manner that all requirements specified in an upstream stage are satisfied. These tasks must be performed consistently.

This Specification provides the standard methods of verification for durability, safety, serviceability and restorability of structures in the design and construction stage of the structure.

## Reference Documents

|  |  |
| --- | --- |
| Reference | Title |
| Carbon Steel |  |
| AS 1101.3 | Part 3: Welding and non-destructive examination |
| AS 1110 | ISO metric hexagon bolts and screws |
| AS 1110.1 | Part 1: Product grades A and B - Bolts |
| AS 1110.2 | Part 2: Product grades A and B - Screws |
| AS 1111 | ISO metric hexagon bolts and screws |
| AS 1111.1 | Part 1: Product grade C - Bolts |
| AS 1111.2 | Part 2: Product grade C - Screws |
| AS 1112 | ISO metric hexagon nuts |
| AS 1112.1 | Part 1: Style 1 - Product grades A and B |
| AS 1112.2 | Part 2: Style 2 - Product grades A and B |
| AS 1112.3 | Part 3: Style 3 - Product grades C |
| AS 1112.4 | Part 4: Chamfered thin nuts - Product grades A and B |
| AS 1170 | Structural design actions |
| AS 1170.0 | Part 0: General principals |
| AS 1170.1 | Part 1: Permanent, imposed and other actions |
| AS 1170.2 | Part 2: Wind actions |
| AS 1170.3 | Part 3: Snow and ice actions |
| AS 1170.4 | Part 4: Earthquake actions in Australia |
| AS 1210 | Pressure vessels |
| AS 1275 | Metric screw threads for fasteners |
| AS 1391 | Metallic materials - Tensile testing at ambient temperature. |
| AS 1657 | Fixed platforms, walkways, stairs and ladders - Design, construction and installation |
| AS 1858 | Electrodes and fluxes for submerged-arc welding |
| AS1858.1 | Part 1: Carbon steels and carbon manganese steels |
| AS 2205 | Methods of destructive testing of welds in metal |
| AS 2205.2.1 | Part 2.1: Transverse butt tensile test |
| AS 2327 | Composite structures |
| AS 2670 | Evaluation of human exposure to whole-body vibration |
| AS 3597 | Structural and pressure vessel steel - Quenched and tempered plate |
| AS 3600 | Concrete structures |
| AS 4000 | Steel structures |
| AS 4291 | Mechanical properties of fasteners made of carbon steel and alloy steel |
| AS 4291.1 | Part 1: Bolts, screws and studs |
| AS 4291.2 | Part 2: Nuts with specific proof load values - Coarse thread |
| AS/NZS 1163 | Cold-formed structural steel hollow sections |
| AS/NSZ 1252 | High strength steel bolts with associated nuts and washers for structural engineering |
| AS/NSZ 1554 | Structural steel welding |
| AS/NSZ 1154.1 | Part 1: Welding of steel structures |
| AS/NSZ 1154.2 | Part 2: Stud welding (steel studs to steel) |
| AS/NSZ 1154.4 | Part 4: Welding of high strength quenched and tempered steels |
| AS/NSZ 1154.5 | Part 5: Welding of steel structures subject to high levels of fatigue loading |
| AS/NSZ 1159 | Hot-dip galvanised steel bolts with associated nuts and washers for tower construction |
| AS/NSZ 1594 | Hot-rolled steel flat products |
| AS/NSZ 1873 | Power-actuated (PA) hand-held fastening tools (series) |
| AS/NSZ 2717 | Welding - Electrodes - Gas metal arc |
| AS/NSZ 2717.1 | Part 1: Ferritic steel electrodes |
| AS/NSZ 3678 | Structural steel - Hot-rolled plates, floorplates and slabs |
| AS/NSZ 3679 | Structural steel |
| AS/NSZ 3679.1 | Part 1: Hot-rolled bars and sections |
| AS/NSZ 3679.2 | Part 2: Welded I sections |
| AS/NSZ 4600 | Cold-formed steel structures |
| AS/NSZ 4855 | Welding consumables - Covered electrodes for manual metal arc welding of non-ally and fine grain steels - Classifications |
| AS/NSZ 4857 | Welding consumables - Covered electrodes for manual metal arc welding of high-strength steels - Classifications |
| ISO 636 | Welding consumables - Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels - Classification |
| ISO 14341 | Welding consumables - Wire electrodes and weld deposits for gas shielded metal arc welding of non-alloy and fine grain steels - Classification |
| ISO 16834 | Welding consumables - Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels - Classification |
| ISO 17632 | Welding consumables - Tubular cored electrodes for gas shielded and non-gas shielded metal arc of non-alloy and fine grain steels - Classification |
| ISO 18276 | Welding consumables - Tubular cored electrodes for gas-shielded and non-gas shielded metal arc welding of high-strength steels - Classification |
| BS 7910 | Guide to methods for assessing the acceptability of flaws in metallic structures |
| AWWA D100 | Standard for Welded Steel Tanks for Water Storage |
| AWWA D103 | Factory-Coated Bolted Steel Tanks For Water Storage |
| Stainless Steel |  |
| AS/NZS 1167.2 | Welding and Brazing – Filler Metals – Filler Metal for Welding |
| AS/NZS 1554.6 | Structural Steel Welding – Welding Stainless Steels for Structural Purposes |
| AS/NZS 4854 | Welding Consumables – Covered Electrodes for Manual Metal Arc Welding of Stainless and Heat-Resisting Steels - Classification |
| ISO 3834 | Quality requirements for fusion welding of metallic materials - Comprehensive quality requirements |
| ISO 3506 | Mechanical Properties of Corrosion-Resistant Stainless Steel Fasteners |
| ASTM A240 | Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications |
| ASTM A276 | Standard Specification for Stainless Steel Bars and Shapes |
| ASTM A312 | Standard Specification for Seamless, Welded and Heavily Cold Worked Austenitic Stainless Steel Pipes |
| ASTM A380 | Standard Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment and Systems |
| ASTM A554 | Standard Specification for Welded Stainless Steel Mechanical Tubing |
| ASTM A789 | Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service |
| Aluminium Alloys |  |
| AS 1231 | Aluminium and aluminium alloys – Anodic oxidation coatings |
| AS 1664 | Aluminium Structures |
| AS/NZS 1665 | Welding of Aluminium Structures |
| AS/NZS 1734 | Aluminium and aluminium alloys – Flat sheet, coiled sheet and plate |
| AS/NZS 1865 | Aluminium and aluminium alloys – Drawn wire, rod, bar and strip |
| AS/NZS 1866 | Aluminium and aluminium alloys – Extruded rod, bar, solid and hollow shapes |
| AS/NZS 1867 | Aluminium and aluminium alloys – Extruded rod, bar, solid and hollow shapes |
| AS 1874 | Aluminium and aluminium alloys – Ingots and castings |
| AS/NZS 18273 | Welding consumables – Wire electrodes, wires and rods for welding of aluminium and aluminium alloys – Classification |
| AS/NZS 3834.2 | Quality requirements for welding – Fusion welding of metallic materials – Comprehensive quality requirements |
| AS/NZS 3834.3 | Quality requirements for welding – Fusion welding of metallic materials – Standards quality requirements |
| ISO 3834 | Quality requirements for fusion welding of metallic materials |

## Design Requirements

The steel structures in this Specification shall be designed for ultimate strength and limit states in accordance with the general principles for design specified in the relevant Australian Standards, Codes and is also permissible to carry out design checks for strength and serviceability by testing a structure or component member.

Where the structures are to be used in extreme environments and the design is of a specialist's nature with specialist construction techniques, the Project Brief shall include the particular requirements where appropriate.

### Basic Design Rules

* The design shall include the identification of performance requirements for a structure, structural performance and detailing to meet these performance requirements, and the verification to confirm the performance requirements are met throughout the design service life of the structure.
* All performance requirements that need to be met in order to meet the intended purpose of the structure during construction and during the design service life of the structure shall be determined at the design stage.
* The structural planning stage shall take into consideration factors such as structural characteristics, materials, construction method, maintenance method, and economy so that the performance requirements can be met.
* The structural detailing stage shall take into consideration factors such as shapes, dimensions and connection patterns. These structural details are critical for constructability. It is necessary to take these details into consideration in advance so that the designed structure does not fail to meet the constructability requirements.
* The performance verification requirements for the structure shall be verified in relation to durability, safety, serviceability, restorability, the impact on the environment and landscape throughout the design life. The performance verification refers to tasks of ascertaining, by an appropriate method, that the type of structure, structural cross section, materials to be used, structural specifications, social conditions, constructability and economy meet the specified performance requirements.

## Construction Requirements

The construction requirements in this Specification are for use where structures have been designed to the relevant Australian Standards and Codes, and International Standards.

# Performance Requirements

## General

The design life of the structure shall be determined in consideration of the required service period of the structure, maintenance period, environmental conditions and economy.

All performance requirements of the structure during the construction and design life of the structure shall be specified for every element of the structure. The performance requirements related to durability, safety, serviceability, restorability, environment compatibility, landscape compatibility, etc. shall be specified as appropriate. Detailed requirements related to these performance requirements have to be identified. It is necessary to give careful consideration to the relationship with the performance of each individual element so that the performance required for the entire structure is met.

## Durability

Durability is the resistance of a structure to performance degradation over time resulting from the materials degradation in the structure under expected deterioration actions. The durability of a structure shall be specified for the purpose of maintaining the required performance of safety, serviceability and restorability throughout the design life of the structure. Durability is not independent of performance requirements.

## Safety

Safety shall mean the performance of the structure to prevent risks to users and others in the vicinity under all expected conditions. Safety includes the structural safety and functional safety of the structure. Performance requirements for both, structural safety and functional safety must be specified.

## Serviceability

Serviceability of a structure shall mean the performance that enables users or others in the vicinity to use the structure comfortably and the functional performance required of the structure. Generally, these requirements include:

* Traffic movement.
* Pedestrians' movement.
* Appearance.
* Noise.
* Vibrations.
* Water tightness.
* Water permeability.
* Sound insulation.
* Temperature insulation.
* Variable loads.
* Accidental loads.

The detail design shall address the following serviceability requirements:

* Camber.
* Deflections.
* Drift.
* Vibration.
* Wind induced motion.
* Expansion and contraction.
* Connection slip.

## Maintenance and Repairs

Maintenance and repairs shall mean the performance in restoring the performance of the structure that has degraded due to continued use or accidental loads. It shall be specified as the degree of difficulty in repairing the structure and all factors affected by the performance degradation.

Mechanical performance requirements related to repair ability of steel structures are specified as restorability on condition that non-repairable related factors are separately taken into consideration. When considering the repair ability of steel structures, it is necessary to determine the performance level according to the magnitude of accidental load involved, the state of the structure that can be used without doing repairs and the state of a structure that can be functionally restored in a short period of time.

## Other Performance Requirements

Environmental compatibility and landscape compatibility performance requirements shall be specified on project specific basis. These performance requirements shall be carefully considered at the structural planning stage and confirmed with verifications.

# Structural Requirements

## General

The type of structure, materials to be used and main dimensions shall be specified so that the performance required of the structure can be met in the most rational way. It shall involve a comprehensive study that takes into consideration factors such as construction methods, maintenance methods, environment and landscape impacts and economy so that the performance required can be met. This shall include the necessary studies and surveys required according to the scope of the project.

## Performance Requirements

The performance requirements shall include the design requirements for durability, safety, serviceability and restorability of the structure are attained and maintained throughout the design life of the structure.

### Durability

The material deterioration and deformation in the structure shall be prevented to attain and maintain the required performance level of durability for the design life of the structure. Alternatively, the structure shall be designed to keep material deterioration at a minimum level. The steel used in the structure shall have the required level of strength, durability and quality.

Every structure, its member and connections shall maintain the required performance throughout the design service life of the structure. Verification is required to confirm that the required performance of the structure will not be lost because of steel corrosion. The durability verification shall include:

* Environmental factors.
* Steel corrosion.
* Protective coating deterioration.

### Safety

The safety of a structure shall be verified by confirming that no structural member reaches the limit of cross-sectional failure and the structure does not reach the limit state of stability under design loads. The structure should be designed so as to prevent the entire structure from collapsing even if some of the structural members reach the limit state of cross-sectional failure.

### Serviceability

The structural members and the structure shall not reach the limit state of serviceability under the design loads. These include cracks, displacement, deformation, stress acceleration and vibration.

### Restorability

It is necessary to select the type of structure that makes repairs and functional restoration as easy as possible in the event of structural damage or wear. The areas that can be damaged or worn should be located in easy to access areas where inspection and repair can easily be performed. Restorability is affected by the degree of difficulty in repairing a damaged structure and the state of implementation of structural measures such as preparation of materials for restoring a damaged structure and developing restoration technologies and establishing an organisational system for restoration.

## Construction Performance

Restraints relating to construction shall be taken into consideration at design stage. Potential complications in fabrication, erection and connection of members can result in lower construction accuracy in situations where structural members are made small for reasons of economy by using high strength materials. Careful design consideration is required in these conditions for members to comply with the structure's performance. This may require, at design stage, consideration of preassembled and prefabricated sections.

## Maintenance Performance

A maintenance strategy and a preliminary maintenance plan for the structure shall be prepared at the design stage to rationalise the maintenance. This information can then be reflected in the maintenance plan. Inspections need to be conducted for every in service structure. These may include:

* Initial inspection at the start of the maintenance period.
* Daily inspections.
* Periodic regular inspections.
* Detailed inspections to evaluate various states in detail.
* Special inspections due to accidental damage.

The type of structure and materials to be used must be determined so that maintenance activities during service can be performed efficiently and cost minimised. E.g. it is desirable to design rigid frame structures in place of structures with movement joints, expansion joints, bearings, etc. where possible. Structures in aggressive environments such as in treatment plants should also consider durability enhancement measures at design stage to reduce the maintenance costs. Some preventative measures may need to be taken during the service life of the structure. These should be considered and allowed for at the design stage.

## Environmental and Landscape Compatibility

The structural design shall consider the influence of steel structures on the natural, social and other environments and landscape.

## Economic Aspects

The design for a structure shall consider its economy from the view point of life cycle costs of the structure. Careful studies are required for the type of structure, structural member dimensions, materials, etc. with regard to economic aspects as the total cost of the project will be determined at the structural planning stage. It is necessary to evaluate economy not only for the initial cost but also for the life cycle, maintenance, repairs and reconstruction costs.

# Verification

## General

The performance verification shall verify that a structure and its members as designed and detailed do not reach the limit state specified during construction and during the design life of the structure. The limit state shall be specified for durability, safety and serviceability. The performance verification for the structure shall be verified by durability and initial load compliance.

The required verification requirements shall be specified at the structural planning stage and included in the Design Basis.

## Verification Requirements

The performance verification prerequisite is that the structural detail requirements for performance verification, other structural detail requirements, construction method requirements and placement requirements in accordance with the Construction Section of this Specification, and the maintenance procedure requirements specified are met.

## Verification Method

The verification of the limit state design shall be confirmed with the compliance requirements to:

* Durability.
* Structural safety.
* Serviceability.
* Seismic design.
* Initial loads.

It is necessary to consider the state of the structure at the end of the design life in view of changes to performance over time.

## Design Calculations

The detail design calculations shall clearly show the required performance and associated limit states of members or structures for verifying durability, safety, serviceability, seismic design etc. compliance.

The calculations shall involve modelling the structure to be constructed according to:

* The shape of the structure.
* Support conditions.
* The state of loads.
* The limit states to be considered.

The structure shall be modelled appropriately according to the analysis method used for verification. Loads shall be modelled appropriately according to the load characteristics and the influence of different types of limit states to be taken into consideration.

Perform a structural analysis by using an analysis model of proven reliability, accuracy and calculating response values such as sectional forces, deflection, stress, strain, crack width, etc. according to verification indices.

The load shall be considered so that response values in the calculations are verified under the least favourable conditions. Sectional forces such as bending moment, shear force, axial force, torsional moment and deflection shall be calculated in accordance with an appropriate analytical theory according to each limit state.

### Connections

The design of connections using bolts, welds, cleats and fittings shall provide an adequate load path between the ends of a member and the component it connects to.

## Modelling

Modelling shall involve determining the extent of the region to be analysed and the dimensionality of analysis and modelling structural members according to the response characteristics of the structure under consideration. The extent of the region to be analysed consisting of the structure, ground and boundary elements, etc. shall be defined according to the extent of the region in which the response occurs. If the analysis region includes ground conditions, the model shall be performed so that the influence of such coverage can be evaluated properly.

The structure shall be modelled two or three dimensionally as an assembly of structural members in view of its shape.

## Structural Analysis

A structural analysis method that meets the load and structural modelling need and makes verification indices available shall be used. An analysis of a structural member shall give consideration to the influence of nonlinearity according to response. A structural member may be regarded as a linear member if it is evident that the nonlinearity of the member does not affect verification indices such as sectional forces or that conservative and rational results are obtained.

The structural analysis shall include:

* Safety verification.
* Fatigue failure.
* Structural safety.
* Serviceability verification.
* Seismic verification.

## Structural Details

Each member shall be provided with the necessary requirements, taking into consideration the shape and stiffness of the member, boundary conditions, load characteristics, the state of loadings, unexpected conditions e.g. steel corrosion, cracks, initial defects, construction workability, etc.

## Design Drawings

The design drawings shall include the following basic information on design, construction and maintenance in addition to the structural details.

* Design life.
* Environmental conditions.
* Characteristic values of loads and load combinations.
* Safety factors.
* Characteristic values of materials.
* Information necessary for construction and maintenance.
* Name of structure and place of use.
* Signatures of responsible engineer and design checker with dates.
* Scales and dimensions.
* Type of materials.

### Shop and Erection Drawings

Shop drawings shall be prepared in advance of fabrication and give the complete information necessary for the fabrication of the component parts of the structure, including the location, type and size of welds and bolts.

Erection drawings shall be prepared in advance of erection and give information necessary for erection of the structure.

Shop and erection drawings shall clearly distinguish between shop and field welds and bolts and shall clearly identify pre-tensioned and slip-critical high-strength bolted connections.

Design drawings shall be stored along with the construction record drawings throughout the functional and service life of the structure.

# Design Requirements for Materials

## General

The quality of steel shall consider the following additional material property requirements in addition to comprehensive or tensile stress.

* Strength.
* Modulus of elasticity.
* Deformation characteristics.
* Thermal characteristics.
* Durability.

The effect of loading rate on strength and deformation should also be considered if necessary.

Material properties are classified into mechanical and physical properties. Strength characteristics are expressed by strength under static and fatigue loading. Deformation characteristics are expressed by time independent quantities such as modulus of elasticity and Poisson's ration, and time dependent characteristics such as creep co-efficient and shrink strain.

Durability of steel is time dependent deterioration resulting from various actions e.g. weather, intrusion of chemicals and erosion by chemicals. Quality of steel is influenced by not only by materials used and their composition, but also construction and environmental conditions at the site.

# Loads

## General

Structures shall be designed for appropriate combinations of loads likely to act during the construction stage and design life of the structure with consideration of limit states for performance requirements being considered. Design loads shall be obtained by multiplying characteristic values of load by the appropriate load factor.

Combinations of design loads shall be determined according to the limit states for the required performance of the structure.

Combinations of Design Loads

|  |  |  |
| --- | --- | --- |
| Required Performance | Limit State | Combinations to be Considered |
| Durability | Every Limit State | Permanent Load + Variable Load |
| Safety | Cross-sectional Failure | Permanent Load + Primary Variable Load + Secondary Load |
|  | Fatigue | Permanent Load + Variable Load |
| Serviceability | Every Limit State | Permanent Load + Variable Load |
| Seismic | Every Limit State | Permanent Load + Accidental Load + Secondary Variable Load |

Although a combination of loads may be defined as a design load in some cases, design loads shall be determined for individual type of load in the specific design.

## Load Factors

The characteristic values of load shall be determined respectively for each of limit states for which verification is required.

The characteristic values of permanent loads, primary variable loads and accidental loads used for verification shall be calculated from the maximum values of these loads during construction and the design life of the structure. In cases where the maximum value of the load governs the design, the expected minimum value of the load shall be adopted. The characteristic values of secondary variable loads shall be determined in accordance with the combination of primary variable loads and accidental loads. The characteristic values of loads used for verification of safety against fatigue shall be determined considering varieties in the loads expected to occur during the design life of the structure.

The characteristic values of loads to be used for verification of serviceability shall be calculated using loads that frequently occur during construction and the design life of the structure. The values shall be chosen appropriately depending on the limit state and the combination of loads being considered.

The characteristic values of loads to be used for the verification of seismic resistance shall be determined considering the predetermined level of seismic resistance provided that the value must not be greater than the maximum expected value during the design life of the structure.

The characteristic values of loads to be used for durability shall be calculated using the loads that frequently occur during construction and the design life of the structure.

## Design Loads

The following loads shall be considered for performance verification as appropriate:

* Dead loads.
* Live loads.
* Earth pressure.
* Hydrostatic water pressure.
* Fluid dynamic force.
* Wave action.
* Wind.
* Effect of temperature.
* Seismic loads.
* Loads during construction.
* Other specific load conditions.

## Construction Loads

The following loads shall be considered to act on the structure or part of the structure during construction:

* Dead loads on account of the self-weight of the structure.
* Loads due to construction equipment.
* Wind loads.
* Seismic loads.

The actual values of the loads shall be chosen in consideration of the following:

* The method of construction.
* The structural system during construction.
* The length of the construction period.

## Other Loads

It is necessary to consider other loads than those specified above. The characteristic values shall be determined in accordance with actual situation of the loads.

Impact load is one of the other loads in this clause. Examples of impact loads are vehicle impact, flying objects and ground settlement after completion of the structure.

# Protective Treatment

The coatings and associated surface preparation required for structural steelwork shall be as specified in the design drawings. A single source of coating supply shall be used unless approved otherwise by the design engineer.

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

The procedure for the transportation, handling and storage of the coated steelwork shall be arranged to minimise the risk of damage to the coatings.

## Surface Preparation

The surface cleanliness and preparation grade of the steelwork to be coated shall be in accordance with the coating supplier requirements. Surface defects revealed during surface preparation shall be repaired.

## Surface Profile

The surface profile of the steelwork to be coated shall be compatible with the coating to be applied and the coating supplier requirements.

## Hot Dip Galvanising

Steelwork to be hot dip galvanised to AS 4680 system designation HDG600 and threaded fasteners to AS 1214. Repair damaged galvanised coating as follows:

* Power clean to AS 1627.2.
* If inaccessible clean by hand to AS 1627.7.
* Solvent clean/degrease to AS 1627.1.
* Apply tin/zinc to pre-heated steel overlapping the galvanising coating.

All galvanised components shall be inspected after galvanising. The results of post galvanising shall be recorded.

If evidence of cracking is identified after galvanising, the component and similar shaped components fabricated and welded shall be identified and quarantined as non-conforming. A photographic record shall be made. Quarantined components may only be repaired for use with the written approval of the design engineer.

## Paint System

The paint system shall be as follows unless designated otherwise on the design drawings.

* Surface preparation to Sa 2.5.
* First coat zinc rich primer to a dry film thickness of 75 microns.
* Second coat epoxy micacecous iron oxide paint to a dry film thickness of 125 microns.
* Third coat epoxy micacecous iron oxide paint to a dry film thickness of 125 microns.
* Colour grey.

### Painting of Site Welding Areas and Fasteners

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

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

### Inspection of Site Applied Coatings

Site applied coatings shall be monitored for the quality of the materials used, the thickness of the applied coatings and that the application process is in accordance with the coating manufacturer's requirements.

### Coating Surfaces Encased in Concrete

Structural steel surfaces to be enclosed in concrete may be left unpainted and need not be blast cleaned unless specified otherwise in the design drawings.

### Contact Surfaces

Surfaces inaccessible after shop assembly shall be cleaned and painted prior to assembly, except for contact surfaces, if required by the design documents.

Paint is permitted in bearing-type connections. Slip-critical connections shall be prepared as detailed in the design documents

Machine-finished surfaces shall be protected against corrosion by a rust inhibitive coating that can be removed prior to erection, or which has characteristics that make removal prior to erection unnecessary.

# Welded Steel Tanks and Reservoirs for Water Storage

The materials, design, fabrication, erection, and testing of the welded steel tank shall be in accordance with AWWA D100 - Standard for Welded Steel Tanks for Water Storage. The design for all sections of the steel tank shall be as per the unit tension/compression stresses allowed for material classes listed in AWWA D100. Designing as per Section 14 of AWWA D100 will not be permitted. The minimum plate thickness of all tank parts shall be in accordance with AWWA D100. A corrosion allowance shall be included based on the water analysis. All materials furnished by the tank manufacturer, which are in contact with the stored water shall be certified and comply with AS 4020.

The tank shall have a domed steel roof to minimise water ponding on the roof plates. The roof radius shall be between 0.8 and 1.2 times the tank diameter. The roof plates and rafter to roof plates shall be seal welded. The minimum thickness for seal welded roof plates shall be 6 mm.

The concrete tank floor shall be covered with a welded steel liner to provide a water tight boundary. The minimum thickness of the liner plate shall be 6 mm. Liner plates may be placed directly on the concrete when the liner plates are formed to match the shape of the tank floor. Liner plates that are not formed to match the shape of the tank floor shall have the space between the liner plates and the tank floor completely filled with flow able grout. All liner plates shall be tested using the vacuum box testing method before the tank is painted.

All welds on the tank exterior and interior shall be ground smooth and blended to a NACE-D profile to maintain the maximum life of the protective coating system.

Concrete to Tank Interface

The concrete to tank interface region includes those portions of the concrete support structure and welded tank that are affected by the transfer of forces between the concrete tank floor, ring beam, tank bottom and support structure. The design of the interface region shall be based on an analysis using finite element or similar analysis which can accurately model the interaction of the intersecting elements. The analysis shall provide results including the shear, moment and compression or tension caused by the intersecting elements in the interface region.

The analysis shall consider the transfer of forces from the intersecting elements under all anticipated load conditions. These load conditions shall include the eccentricity of loads, restraint effects caused by shrinkage and thermal loads, long term effects caused by concrete creep and the effect of anchorage of the welded steel tank to the concrete.

The geometry of the interface region shall provide positive drainage at the top of the wall and ring beam. Condensation, precipitation or debris shall not be allowed to accumulate in this area.

Inspection Rails

Inspection rails shall be provided to inspect the interior of the tank. The tails shall be attached to the underside of the roof. One rail shall be near the centre of the tank and the second approximately 450 mm from the tank shell. A third rail shall be provided for tanks larger than 20 m diameter. The rails shall be accessible from the roof personnel and maintenance hatch.

Exterior Coating System

* Shop Primer - Apply one coat of inorganic zinc silicate or similar approved to a dry film thickness of 15 to 30 microns. Immediately after abrasive blast cleaning to Sa 2.5 and before any rusting occurs.
* Field Surface Preparation - All rusted, abraded, welded and unpainted areas to be prepared and blast cleaned to surface preparation to Sa 2.5.
* First coat - zinc rich primer or similar approved to a dry film thickness of 75 microns.
* Second coat - High build epoxy or similar approved to a dry film thickness of 200 microns.
* Third coat - Acrylic 2 pack or similar approved to a dry film thickness of 50 microns.
* Total dry film thickness 325 microns.
* Finish colour selected by owner.

Interior Coating System

* Shop Primer - Apply one coat of inorganic zinc silicate or similar approved to a dry film thickness of 15 to 30 microns. Immediately after abrasive blast cleaning to Sa 2.5 and before any rusting occurs.
* Field Surface Preparation - All rusted, abraded, welded and unpainted areas to be prepared and blast cleaned to surface preparation to Sa 3.
* First coat - Very high build epoxy to a dry film thickness of 250 microns.
* Second coat - Very high build epoxy to a dry film thickness of 250 microns.
* Total dry film thickness 500 microns.
* Paint to comply with AS 4020.

# Pre-fabricated Steel Panel Tanks and Reservoirs

The materials, design, fabrication, erection, and testing of the pre-fabricated steel tanks and reservoirs shall be in accordance with AWWA D103 - Factory Coated Bolted Steel Tanks for Water Storage. All materials furnished by the tank manufacturer, which are in contact with the stored water shall be certified and comply with AS 4020.

Design requirements for intermediate horizontal wind stiffeners shall be of the "web truss" type with an extended tail creating multiple layers of stiffener, permitting wind loads to be distributed around the tank. Rolled steel angle stiffeners are not permitted for use as intermediate horizontal wind stiffeners.

Bolts

The threaded portion of the bolts shall not be exposed to the shear plane between tank sheets at the lap joints. All bolts for the tank shell and roof shall be installed with the head portion inside the tank, and the nut and washer on the outside. Lap joint bolts shall be designed to prevent rotation during tightening. Bolt lengths shall achieve a neat and uniform appearance. Excessive thread length beyond the nut after tightening will not be permitted. Bolts to be hot dip galvanised as a minimum.

Sealant

The sealant shall be a one component, moisture cure polyurethane compound. The sealant shall cure to a rubber like consistency and have excellent adhesion to the coating, have low shrinkage, be suitable for internal and external exposure and comply with AS 4020. EPDM or neoprene gaskets and tape type seals shall not be used other than for pipe fittings and access door.

Erection

Field erection of the bolted‐steel tanks and components shall be in strict accordance with the procedures established by manufacturer and performed by the manufacturer or an authorized dealer of the tank manufacturer regularly engaged in erection of these tanks.

An electrical leak detection test shall be performed on the inside surface of each panel after erection for the glass fused steel bolted tanks. Every sheet shall be 100% tested for holidays and any sheet with unacceptable discontinuity shall be rejected.

## Coating Systems

### Pre-fabricated Steel Bolted Panel Tanks

Wall structure - Zincalume steel, Colorbond steel or Colorbond Ultra steel panels complying with AS 1397.

Protective coating - Zincalume steel (zinc/aluminium/magnesium alloy) AM125 heavy duty coating and Colorbond steel.

Bolting specification - Galvanised, flanged head, high tensile bolts.

Dome roof - Zincalume steel, Colorbond steel or Colorbond Ultra steel. Heavy duty, G600, hot dipped fully self-supporting galvanised roof trusses.

### Glass Fused to Steel Bolted Tanks

The glass fused plate coating shall have a thin glass layer that is fused to the steel uniformly with no pin holes and fish scale defects. A thick glass layer is not permitted as it results in fish scale defects due to differences in the co-efficient in thermal expansion between the glass and mild steel. The design and performance of the coating shall allow for the movement of the tank including the performance of the coating at the bolt hole connections. The performance of the coating shall allow for damage during site assembly, routine maintenance and impact of rocks, stones or other hard materials impact when mowing around the tank.

The coating thickness on the edges of the panels and the bolt holes shall be the same as the sides of the panels. The edges of the steel plates shall be bevelled to achieve the minimum coating thickness. Field repairs to the coating are not permitted. Coating thickness and discontinuity (holidays) shall be verified in the field after erection of the tank. The use of joint sealant over the panel joints and bolts, to increase the coating durability, will not be accepted.

# Structural Stainless Steelwork

## General

This section applies to the additional requirements for design, fabrication and erection of structural stainless steel structures.

Component design, detailing and specification are fundamental to the success of the project. It is essential for the designer not only to consider the required properties such as corrosion resistance, but it is also important to consider the secondary qualities such as physical and mechanical properties and fabricability of any component grade. The appropriate choice must ultimately provide both short term and long term benefits i.e. cost effective fabrication and installation, and a long trouble free life.

Galvanic reaction may be created where stainless steel is used in conjunction with metals. The designer must recognise the impatible metal pair and environment combination and, if they are unavoidable, detail the insulation or exclusion of the electrolyte. The most common occurrence of galvanic pairs is with fasteners.

Fabrication of stainless steelwork to be performed by component organisations accredited by Australian Stainless Steel Development Association or equivalent. Evidence of equivalent supporting knowledge and competence must be supplied by non-accredited fabricators.

The Hold Points and Witness Points applicable to the specification shall be prepared by the designer.

The contractor shall submit the construction procedures to the designer for approval.

The contractor shall supply to the designer the welding procedure specification for the welding to be undertaken in accordance with AS/NZS 1554.6. Welding shall not be carried out until the welding procedure specification has been approved.

## Materials

### Plate and sections

Steel shall comply with the requirements of the following standards:

* Flat Bar ASTM A276.
* Round Bar ASTM A276.
* Round Tube ASTM A312.
* Square Tube ASTM A554.
* Plate, Sheet & Coil ASTM A240.
* Duplex Tube ASTM A789.

All stainless steel shall be Grade 316 (UNS S31600) or Grade 316L (UNS S31603). When specified on the engineering drawings, duplex stainless steel shall be Grade 2205. Material manufactured to other standards will be accepted provided the material comply with the appropriate ASTM standards.

### Welding consumables

Welding consumables shall be compatible with the parent materials, shall be classified and identified in accordance with the provisions of AS/NZS 1167.2 and/or AS/NZS 4854.

### Stainless steel bolts, nuts and washers

Stainless steel bolts shall be Grade 316 (UNS S31600) nuts shall be grade 304 (UNS S 30400) A2-70 and washers shall be Grade 316 (UNS S31600) unless noted otherwise on the engineering drawings. All stainless steel bolts and nuts shall conform to the requirements of ISO 3506. Materials manufactured to other standards will be accepted provided the material comply with the appropriate ISO standard.

## Fabrication

All stainless steel structural components shall be fabricated in accordance with AS/NZS 1554.6.

# Structural Aluminium

## General

This section applies to the additional requirements for design, fabrication and erection of structural aluminium structures.

Component design, detailing and specification are fundamental to the success of the project. It is essential for the designer not only to consider the required properties such as corrosion resistance, but it is also important to consider the secondary qualities such as physical and mechanical properties and fabricability of any component grade. The appropriate choice must ultimately provide both short term and long term benefits i.e. cost effective fabrication and installation, and a long trouble free life.

Galvanic reaction may be created where aluminium members are used in conjunction with other metals. The designer must recognise the impatible metal pair and environment combination and, if they are unavoidable, detail the insulation or exclusion of the electrolyte. The most common occurrence of galvanic pairs is with fasteners.

Fabrication of aluminium structures to be performed by component organisations. Evidence of supporting knowledge and competence must be supplied by fabricators.

The Hold Points and Witness Points applicable to the specification shall be prepared by the designer.

The contractor shall submit the construction procedures to the designer for approval.

The contractor shall supply to the designer the welding procedure specification for the welding to be undertaken in accordance with AS/NZS 1665. Welding shall not be carried out until the welding procedure specification has been approved.

## Materials

### Plates and Sections

Aluminium shall comply with the following standards, as relevant:

* Plate AS/NZS 1734.
* Drawn bar and rod AS/NZS 1865.
* Extruded bar and rod AS/NZS 1866.
* Tube AS/NZS 1867.
* Castings AS 1874.

The grade of aluminium and/or the manufacturer’s part number for fittings shall be as shown in the Drawings.

The contractor shall supply to the designer prior to the commencement of fabrication, copies of the aluminium manufacturer’s test certificates, showing the chemical properties and results of tensile and elongation tests.

Aluminium fabrication shall not commence until the designer has reviewed and approved the material test certificates.

If test certificates are not available, then the contactor shall submit to the designer for approval a proposal for selecting samples for testing of tensile strength and elongation, chemical analysis and in accordance with the appropriate Australian Standard at no expense to the Principal. Minimum testing requirements are 2 percent of each size and grade of product with a minimum sample size of one for each size and grade of the aluminium.

### Welding Consumables

Welding electrodes shall be compatible with the parent metal and shall be classified and identified in accordance with the provisions of AS/NZS 18273.

### Bolts, Nuts and Washers

Bolts, nuts and washers shall be stainless steel Grade 316 unless noted otherwise in the engineering drawings. Stainless steel bolts and nuts shall have an ISO coarse pitch metric thread.

Stainless steel bolts shall be Grade 316 (UNS S31600) nuts shall be grade 304 (UNS S 30400) A2-70 and washers shall be Grade 316 (UNS S31600) unless noted otherwise on the engineering drawings. All stainless steel bolts and nuts shall conform to the requirements of ISO 3506. Materials manufactured to other standards will be accepted provided the material comply with the appropriate ISO standard

## Fabrication

All aluminium components shall be fabricated in accordance with AS 1664 and AS/NZS 1665.

Bending of aluminium plate or sheet shall be carried out in a press to produce clean straight bends with no distortion in the adjacent flat surfaces.

Prior to bending, any rags present on sheared edges shall be removed by grinding or filing to prevent the possibility of plate splitting on the outside corner.

Welding shall be carried out in accordance with the provisions of AS/NZS 1665.

# Check Lists

## Proposed Works

Information required by the steelwork contractor.

* Brief description of the structure.
* The intended purpose of the structure.
* Details of the site where the works will be constructed.

## Design

Detailing of steelwork based on the engineer's design and drawings.

* Statement describing the design concept.
* Design drawings showing all the relevant details and dimensions for the structure.
* Design standards to be used.
* Particulars of any aesthetic, structural or clearance limits or environmental conditions which may affect detailing or protective coating.
* Parts of the steelwork where the manufacturing process must be restricted including locations where holes cannot be punched.
* Details of any dynamic or vibrating forces if fatigue is a design criteria.
* Property classes of bolt assemblies with coatings.
* Details of fixings and bolts to foundations or walls.
* Details of bedding material under base plates.
* Camber and pre-sets required in fabrication.

## Workmanship

* Special welding procedures which have to be approved before work commences.
* Project specific non-destructive testing.

## Erection

* An outline of the method of erection with the sequence of erecting the structure including positions of temporary bracing and other restraints as required providing stability to individual members or the whole structure.
* Site plan showing position of datum level and setting out lines.
* Limitations of dimensions or weights of components to be delivered to site or ground capacity limits for heavy loads.
* Design factors which would affect construction sequence or which may create an unusual hazard during construction.
* Responsibility for touch-up or damaged areas and cleaning of surfaces treated on site and specification for repairs.

Inspection and/or tests to be carried out or witnessed by the engineer.

## Protective Treatment

* The requirements for surface preparation and the grade of preparation.
* Thickness and composition of sprayed coatings.
* Requirements for galvanising including post galvanising inspection.
* Requirements for paint treatment.
* Responsibility for touch-up or damaged areas and cleaning of surfaces treated on site and specification for repairs.

# Products

All materials used in the structure shall comply with the Project Brief and the current Australian Standards. Specific samples may require testing. The constructor shall arrange for the samples to be supplied, identified, stored and tested, and the results issued.

Propriety products and materials shall be used in accordance with the manufacturer's written requirements and instructions.

## Steel Products

Materials shall be steel in rolled sections, structural hollow sections, plates or bars and shall comply with the appropriate Australian Standard. The full steel designation shall be given including standard number and strength grade so the correct property for fracture toughness and weld ability are confirmed.

### Testing

Steel products for use in the works shall have been specifically tested and the steel product manufacturer shall supply the Compliance Certificate. The steelwork contractor shall have access to the manufacturer's Compliance Certificate. A copy shall be provided to the client.

### Dimensions and Tolerances

Dimensions and tolerances shall comply with the appropriate Australian standard.

### Surface Condition

Surface defects in hot rolled sections, plates and wide flats revealed during surface preparation which are not in accordance with the appropriate Australian Standard shall be rectified accordingly.

Surface defects in structural hollow sections revealed during surface preparation which are not in accordance with the appropriate Australian Standard shall be rectified accordingly.

Surface defects in cold rolled sections revealed during surface preparation which are not in accordance with the appropriate Australian Standard shall be rectified accordingly.

## Welding Consumables

Welding consumables manufactured to Australian Standards shall be supplied with the approved markings for compliance. Consumables for use in metal arc welding shall comply with the appropriate Australian Standard. Consumables used for completing welding of steels shall have a weather resistance at least equivalent to the parent metal.

### Storage

Consumables in the steelwork contractors works and on the site shall be stored and handled in the manner described in the manufacturers written instructions and the appropriate Australian Standard. Any drying or baking of consumables before use shall be carried out in accordance with the manufacturer's instructions.

## Structural Fasteners

Fastener assemblies manufactured to Australian Standards shall be supplied complete with the compliance markings. The steelwork contractor shall make certificates of conformity, provided by the manufacturer of structural fasteners, available to the engineer if requested. Hold down bolt assemblies shall be as detailed in the design drawings.

Specific coating requirements, if required, shall be provided by the fastener manufacturer and shall comply with the appropriate part of the relevant Australian Standard e.g. electroplating or hot dip galvanising.

## Protective Treatment Materials

Paint materials and other coatings supplied shall be in accordance with the relevant Australian Standard for the materials specified in the Project Brief. The composition of zinc in galvanising baths shall be in accordance with the appropriate Australian Standard unless agreed otherwise.

## Propriety Items

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

## Substitution of Materials and Form

Material quality or form of components may be substituted with the written approval of the design engineer if it can be demonstrated that the structural properties are not less suitable then the design component and that compatibility with the intent of the design is maintained.

## Water Stops

Water stops in all construction joints and movement joints to be supplied and installed with the manufacturer's written instructions.

# Construction

## Erection

The steelwork contractor shall prepare a written method statement for the erection procedure. It shall include the information and requirements provided by the design engineer.

## Handling and Storage

Components shall be handled and safely stored in such a manner as to minimise the risk of surface abrasion and damage. Fasteners and small fittings shall be stored under cover in dry conditions.

## Damaged Steelwork

Steel work damaged during off-loading, transportation, storage or erection shall be restored to the standards specified in the Project Brief.

## Column Base Plates

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

The base plate packs shall be placed so they do not prevent subsequent grouting to completely fill all spaces directly under the base plate. The base plate packs may be left permanently in place provided there are no corrosion issues in the future and do not compromise the capacity of the grout.

## Grouting

Grouting shall not be carried out under the column base plates until the structure has been lined, levelled, plumbed, braced and all load members erected. The area under the base plates shall be prepared to the requirements of the grout manufacturer specification before placing the grout.

## Stability

The steelwork contractor shall design and provide temporary bracing and/or restraints based on the design requirements and the erection procedure. The temporary bracing and restraints used during erection, which do not form part of the permanent structure, shall be removed after the structure has been lined, levelled and plumbed provided that sufficient permanent steelwork and/or permanent bracing has been erected to confirm the stability of the structure under the worst expected loading conditions.

## Erection Loads

The steelwork contractor shall confirm that no part of the structure is permanently distorted by stacking of materials or temporary erection loads during the erection process. The principal contractor shall confirm that no other contractor shall place loads on the partly erected structure.

## Lining and Levelling

Each part of the structure shall be aligned as soon as practicable after it has been erected. Permanent connections shall not be made between components until sufficient of the structure has been aligned, levelled and plumbed and temporarily connected to confirm the components will not be displaced during subsequent erection or alignment of the remainder of the structure. Alignment of the structure and the lack of fit in connections may be adjusted by the use of shims. Shims shall be secured if they are in danger of coming loose.

Tolerances for shop fabricated steel and field erected steel shall comply with the relevant requirements of AS 4100, unless specified otherwise on the design drawings.

## Temperature Effect

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

## Site Welding

Site welding shall be carried out in accordance with the relevant Australian Standard and the design specification. Precautions shall be taken so the welding current does not damage components it passes through and adequate return earth connections are made locally to the area being welded. Welding shall not be permitted during inclement weather.

Site welding of attachments to installed embedment in contact with concrete shall be done in such a manner as to avoid excessive thermal expansion of the embedment which could result in spalling or cracking of the concrete or excessive stress in the embedment anchors.

## Site Bolting

All bolted connections shall be visibly checked after they are bolted up with the structure aligned. Connections identified during snagging that do not have the full complement of bolts shall be checked for fit up after the missing bolts have been installed.

## Site Modification of Structural Steelwork

Modifications that are liable to affect the strength of a structural member, the efficiency of a joint, or the integrity of a structure shall not be made without the prior written approval of the design engineer. Procedures and method shall be submitted to and approved by the design engineer.

## Water Stops

The method to maintain the water stops in the correct position and prevent movement or damage during construction is to be agreed with the engineer.

## Joint Sealants

All expansion and contraction joints and internal and external wall joints shall receive a joint sealant application.