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<tr>
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<td>Gary de Leeuw, Matthew Cupitt, Paymon Aria, Dinesh Dineshharan, Robert Loncar, Christie Sebaratnam</td>
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Foreword

This Specification is for the design, supply and construction of civil works for Sydney Water Corporation assets.

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General Terms and Definitions

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<td>Sydney Water</td>
<td>The nominated person or organisation that has written authority to act on Sydney Water’s behalf.</td>
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<td>Supplier</td>
<td>The person or organisation responsible for the fabrication or manufacture and supply of products, materials, equipment and components described herein.</td>
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C1. General

C1.1. Statutory Regulations
All Works shall comply with the requirements of all federal and state laws and regulations in force in New South Wales. Where the Works is subject to the control of statutory or regulatory authorities, the works shall comply with the requirements of the authorities.

Technical requirements specified herein shall not be used to reduce nor remove any obligations the Contractor has for health and safety of all personnel; as required by the appropriate regulations.

C1.2. Standards and Codes
Sydney Water’s Technical Specification: Part 1 - Civil Works is considered the governing (i.e. “over-arching”) standard which specifies the minimum requirements for the materials, design, fabrication, testing, inspection and pre-commissioning of civil works. All Works shall comply with this specification, the WSAA Codes (SW Editions where available) and Australian Standards and Codes as stated in this specification or elsewhere. If no such Standard or Code is nominated, the Works shall comply with the most relevant Australian standards and codes.

If an international or overseas standard or code is proposed in lieu of an Australian Standard, a detailed assessment showing that the proposed standard or code is equivalent, or superior to the relevant Australian standard or code shall be submitted to Sydney Water for acceptance.

If there is no Australian standard or code covering the subject, an international or overseas standard or code, subject to the acceptance by Sydney Water.

C1.3. Proprietary Items
Nomination of a proprietary item by the Sydney Water does not imply preference or exclusivity for the item identified, but only indicates the necessary properties of the item.

Alternatives that are equivalent to the nominated items can be submitted to Sydney Water for acceptance. The submission shall include appropriate technical information, samples, calculations and the reasons for the proposed substitution, as appropriate.

C1.4. Design
General design requirements in relation to design works are included in Section 10. It sets out the minimum standards required by Sydney Water.

C1.5. Recycled and Reused Materials

C1.5.1. Free from Hazardous Substances
All recycled and reused materials used in the Works shall be free from hazardous substances as defined in the Occupational Health and Safety Regulation.

Carcinogenic substances such as asbestos or asbestos containing material in both friable and bonded forms shall not be present in these materials.

C1.5.2. Prior Acceptance
The use of a waste material shall be a bona-fide, fit for purpose, reuse opportunity that causes no harm to the environment or human health. Recycled or reused materials shall only be accepted by the Sydney Water if they meet the requirements of the resource recovery exemptions administered by the relevant government authority.

Prior to its use at any site, a detailed description of the composition and origin of the material shall be submitted for acceptance by the Sydney Water at least 7 days prior to delivery to the site.
C1.5.3. Records
Detailed records shall be kept of the quantity and type of recycled materials used in the Works.

C1.5.4. Certification
Where recycled and reused materials are used in the Works, certification shall be provided from an independent asbestos assessor who is a current member of the Australian Institute of Occupational Hygienists in the ‘asbestos’ category, or from a NATA laboratory accredited for asbestos fibre identification. The certification shall state that the material is free from asbestos or asbestos containing material in both friable and bonded forms.

C1.6. Survey
All necessary survey and setting out shall be to the dimensions and levels shown on the drawings. All site set-out and survey work, where survey work also includes the production of WAC records, shall be conducted in accordance with this specification as well as WSA02, WSA03 and WSA04, or by project specific requirements as nominated by Sydney Water.

All survey work shall be undertaken by a Registered Surveyor.

C1.7. Existing Services
Any details of services provided are not to be taken as indicating all existing services or their exact locations. Irrespective of any information provided, it is required to positively verify the exact location of all services which may be affected by construction activities. If services are located which conflict with information already provided by the Sydney Water, Sydney Water shall be notified at least 20 working days prior to commencement of any construction activity that may affect the service.

The location and depth or dimension of services are not to be determined by scaling from any drawing.

C1.8. Visual Records
The visual record of the work consists of an Initial Record showing the site prior to commencement of the work and a Final Record showing the completed work.

C1.8.1. Initial Record
A detailed photographic record of all areas that will be affected by construction including stockpile areas, storage areas and access tracks shall be provided. Details must include, but not be limited to: structures, roads, pavements, reserves, kerb and gutter, fences, drains and pits. Special attention is to be given to all existing improvements within 5 metres of the proposed works.

A record of notable details and existing damage or faults relating to improvements in the vicinity of the works shall be prepared.

This record will be used in the resolution of disputes between property owners and the Contractor and/or Sydney Water and accordingly should be comprehensive in its coverage of the areas affected by construction activities.

The Initial Record shall be completed and submitted prior to commencing work on the site.

The Initial Record shall be added to as work proceeds if additional areas will be affected by construction activity and the condition has not been previously recorded or if site conditions change.

C1.8.2. Final Record
The photographic record shall be updated to show all of the completed works.

C1.8.3. Format
The photographic records are to be presented in an electronic document which has pages sized at A4.
Each photograph (i.e. digital image) shall be at least 150 x 100 mm when the document is printed at 1:1 scale and each print shall display the date of photography and have a resolution of at least 220 dpi.

The photographs are to be grouped in document chapters or sections which are representative of each section of the work. Each chapter/section is to be referenced/indexed such that particular properties and/or chainages can be examined.

Each chapter/section shall carry notation indicating:

- Chainage at start and finish
- Comments on any existing damage or faults, particularly where they are not obviously visible in the photographs.

C1.9. Hold Points

C1.9.1. Definition of Hold Point

A milestone when acceptance is required from Sydney Water, prior to commencing the subsequent construction activity. Acceptance from Sydney Water shall be sort by providing all necessary documentation as required by this specification and any other relevant specification referred in this specification.

C1.9.2. Release of Hold Points

All necessary testing and records shall be submitted to Sydney Water, for acceptance; at least 20 working days prior to the planned dates of subsequent activities.

All documents related to release of Hold Points shall be submitted together with a Competent Engineer’s check and endorsement.

Any missing or non-complying records may require more than 20 working days for acceptance from Sydney Water.
C2. Earthworks

C2.1. General

C2.1.1. Introduction

The technical specifications described in this section are for earthworks only.

C2.1.2. Setting Out and Construction Tolerance for Earthworks

C2.1.2.1. Setting Out

Unless otherwise specified, the shall do setting out to the dimensions and levels shown in the drawings as specified in C1.6.

In addition to requirements specified in C1, mark on the ground the position and extent of all cuttings and embankments shown on the Drawings, and any cut/fill transitions, using pegs and batter profiles or equivalent, prior to commencement of construction.

C2.1.2.2. Construction Tolerance of Earthworks

Unless noted otherwise, construction tolerances of earthwork shall be as follows,

- Floor of Cutting +0 mm / -50 mm.
- Batters at the toe of batter +0 mm / -150 mm.
- Batter at 2 m above its toe +200 mm / -200 mm.
- Finished Ground Level +25 mm / -25 mm.

C2.1.3. Terms and Definitions

Following are definitions for the terms used within this Earthworks specification section C2.

- **Backfill or Fill**: Earthwork material used as trench fill or backfill or fill; as required by the design, complying the minimum requirements specified within this section of the specification

- **CBR**: 4 days Soaked California Bearing Ratio test results as per AS 1289.6.1.1

- **Compaction**: The process whereby the density of soil is increased by mechanical means. This typically involves, rolling, impact or vibration, or a combination of these processes

- **Contaminated Material**: Material classified as Restricted, Hazardous or Special Waste in accordance with EPA Waste Classification Guidelines

- **Cutting**: An earth or rock excavation within the Site that is made below an existing surface

- **Cohesive Soils**: Those materials which have a well-defined moisture-density relationship when tested in accordance with AS 1289.5.1.1 or AS 1289.5.2.1.

- **Cohesionless Soils**: Poorly graded sand and gravel mixtures, generally with less than 5% fines (ie finer than 75\(\mu\)m), which are non-plastic and which do not exhibit a well-defined moisture-density relationship when tested in accordance with AS 1289.5.1.1 or AS 1289.5.2.1.

- **Competent Geotechnical Engineer**: A third party Geotechnical Engineer who is suitably qualified and experienced to carry out the particular type of work listed in the project specific technical requirements; in compliance with the Sydney Water’s Engineering Competency Standard and accepted by Sydney Water, prior to working on the project.
Technical Specification - Civil

Dewatering Proposal Plan: A Dewatering Plan, including a detailed hydrogeological assessment of all the groundwater induced impacts on all assets owned by Sydney Water and others.

Earthworks: The activities covered by this section C2 of the specification.

Field Density Testing: Field bulk density tested using is the nuclear density gauge (in accordance with AS1289.5.8.1) and moisture content measured in the laboratory.

Fill Embankment: An earth or rock fill structure above an existing and/or excavated surface to create the required works within the site.

Geosynthetics: Prefabricated sheets made of polymeric materials which may be permeable or impermeable. These materials may be used as filter-drainage (if permeable) or foundation reinforcement.

Imported Material: Material obtained from sources other than that generated by excavation in cuttings and other specified excavations within the Site.

NATA: National Association of Testing Authorities.

Paved or Trafficable Areas: Areas where vehicles are able to traffic or parked such as roads, carparks, tracks, driveways, Road easement boundary to boundary.

Pipe Embedment Material: Fill material used to fill around the pipe, including bedding.

Relative Compaction: The field dry density of soil expressed as a percentage of the maximum dry density of the soil determined in the laboratory either by a standard or modified proctor test.

Select Fill: Fill material of specified quality as specified in Clause 2.7.5.

Site won material: Material that is obtained from excavations within the Site.

Standard Dry Density Ratio: Dry density ratio determined using Standard Compaction Testing as per AS1289.5.1.1.

Stripped Surface Level: Level of the surface after stripping of topsoil.

Temporary Erosion and Sediment Control: Control measures which are required in areas currently being worked and are to be provided, as and when required, on a day-to-day basis as the work progresses.

Topsoil: Topsoil is natural surface soil that may contain organic matter.

Trenchfill: Backfill above the pipe embedment fill.

Unpaved or Non-trafficable Areas: Areas where no vehicle access is expected.

Unsuitable Material: Material as defined in Cl 2.7.2.

C2.2. Referenced Documents

Australian Standards

AS 1289 – Methods of Testing Soils for Engineering Purposes

AS 1726 – Geotechnical Site Investigations
WSAA Specifications
Water Services Association of Australia – Product Specifications for Products and Materials

RMS and Maritime Specifications
RMS QA Specification 3051 – Granular Pavement Base and Subbase Materials
RMS QA Specification R67 – High Strength Geosynthetic Reinforcement
RMS QA Specification M208 – Road Openings and Restoration (Low Risk)
RMS QA Specification M209 – Road Openings and Restoration
RMS QA Specification R178 – Vegetation

International Standards
ASTM D4647 – Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test
ASTM D4546-14 – Standard Test Method for One-Dimensional Swell or Collapse of Soils

C2.3. Verification of Ground Conditions
During construction, all necessary geotechnical investigation works as required to verify the geotechnical assumptions applied to the design must be undertaken. The ground conditions shall be verified by a Competent Geotechnical Engineer.

All necessary field testing shall be carried out and recorded in accordance with AS1726. All laboratory testing of soil samples shall be tested in accordance with AS1289, tested at a NATA accredited laboratory.

C2.4. Site Preparation for Earthworks
C2.4.1. Erosion and Sedimentation Control
Before the natural surface is disturbed in an area, an Erosion and Sedimentation Control Plan must be prepared for that area, in accordance with Bluebook guidelines. The Plan shall be superimposed on the appropriate drawings and shall be submitted to Sydney Water at least 20 working days prior to any works, for acceptance.

The Erosion and Sedimentation Control Plan as a minimum shall consist of diagrams and supporting documentation indicating the following:

- The catchment drainage lines and inlets;
- Construction details of all erosion and sedimentation control structures;
- All proposed permanent and temporary erosion sedimentation control measures;
- The proposed location of material stockpiles.

No work is to proceed until this plan has been reviewed and accepted by the Sydney Water.

Temporary erosion and sediment control measures shall remain in place until revegetation is established; including any interim control measures required in disturbed areas that will not be reworked within a period of less than one month.

Temporary erosion and sediment control measures shall be coordinated with the construction of permanent drainage and other permanent control measures. The controls shall be constructed prior
to commencement of the stripping of topsoil, to ensure effective and continuous erosion and sediment control.

All temporary erosion and sediment control works shall be maintained in an operative condition at all times. Silt shall be disposed of in such a manner so as not to cause further erosion and sedimentation of the site.

Unless otherwise directed, temporary control measures are to be removed prior to the end of the all construction activities and all materials used therein removed from the site.

C2.4.2. Clearing

The natural ground surface shall be cleared of all trees, stumps, roots and undergrowth, buildings, fences, poles and debris, such as old foundations, buried pipelines and the like, in the nominated areas within the construction area.

Tree stumps shall be removed for a minimum depth of 300mm below the designed excavation level or finished level. Cavities formed by the removal of stumps and disused services shall be backfilled with the naturally occurring surrounding material or fill material as required by the specific structures or pavements at that location.

Trees outside the area of works to be cleared shall not be removed or lopped without the written consent of Sydney Water.

C2.4.3. Stripping Topsoil

Topsoil removal shall not be commenced until:

- Erosion and sedimentation controls measures have been implemented;
- Clearing, grubbing and removal of cleared materials has been completed.

Before general excavation commences, the ground surface on which fill is to be placed and the area from which cut is to be removed, shall be stripped of any existing topsoil.

The strip depth shall be a minimum of 150mm or deeper if required by Design and/or the Sydney Water. Stripped surfaces shall be inspected by a Competent Geotechnical Engineer to confirm removal of all topsoil.

C2.5. Excavation

All excavation shall be undertaken in accordance with the regulatory and legislative requirements, in addition to the technical requirements set in this specification.

C2.5.1. Utilities, Services and other Hazards

Prior to commencing excavation, a review shall be undertaken to identify the hazards, assess the risks and implement control measures. A work method statement shall be prepared for all excavation works.

No excavation shall occur until;

- up-to-date services searches have been completed,
- all identified services affected by the earthworks have been physically located and
- all necessary precautions to protect, isolate or secure the services have been taken.

No potholing by hand or mechanical means is allowed. All potholing shall be by non-destructive hydro-vacuum excavation techniques to expose or excavate around underground services.

C2.5.2. Excavation Support

All excavation works more than 1.5m deep, shall require an excavation support system.

Details of the excavation support system shall be submitted for acceptance by Sydney Water, at least 20 working days prior to the commencement of installation of excavation support system.
The excavation support shall be designed and installed to provide safety to all persons in and adjacent to the excavation, and to prevent damage to all existing utilities, services, structures, building and roadways in the vicinity. Where required, dilapidation surveys, prior to installation of excavation support, dewatering and excavation works shall be undertaken.

The design of the excavation support system shall be prepared and certified by a Competent Geotechnical Engineer and where applicable, by a Competent Structural Engineer; who meet the requirements of the Sydney Water Engineering Competency Standard.

C2.5.3. Temporary Fencing and Signage around Excavation Works
Suitable temporary fencing, barriers, handrails and signage shall be erected around all excavations.

C2.5.4. Groundwater Control
Drains, sumps, pits, water channels and the like shall be constructed as required, and any pumping plant as may be necessary to prevent water from entering or to remove water from the excavation shall be employed.

If dewatering is proposed, a Dewatering Proposal Plan shall be submitted to the Sydney Water 20 working days prior to any dewatering activity, for acceptance and any such operation shall not commence acceptance has been given.

Appropriate investigations must be undertaken and control measures implemented to avoid any damage to structures, buildings and roadways. A detailed hydrogeological impact assessment shall be carried out; including any control measures implemented, to prevent any damage on all existing assets, due to the dewatering exercise. The assessment shall be included as part of the Dewatering Proposal Plan.

Water from excavations shall be discharged to the nearest suitable discharged point approved by the relevant authorities and accepted by Sydney Water.

C2.5.5. Trenches for Pipe
The line, level and grade of the trenches shall be such as to allow pipelines to be laid as specified herein or as shown in the drawings.

Trenches for pipes shall be excavated to a width and a depth sufficient to enable the pipe, joint, bed, haunch or surround shown in the drawings to be accommodated. Additional excavation shall be provided at the joints to allow for jointing of the pipes.

The width of the trench shall not exceed the limiting width between the faces of the soil that has been used in the structural design of the pipeline. No pipe shall be laid prior to compacting bedding material and compacted fill below the bedding layers.

All efforts shall be made to avoid disturbing the finished trench formation. Any wet or soft materials shall be excavated and made good to the satisfaction to Sydney Water.

C2.5.6. Excavation in Watercourses
Excavations in watercourses are not permitted, unless specifically accepted by Sydney Water.

C2.5.7. Blasting
Explosives or any form of blasting techniques in excavation shall not be used unless specifically accepted by Sydney Water.
C2.6. Stockpiling

C2.6.1. Stockpiling Areas

Stockpiling areas shall be nominated and submitted for acceptance by Sydney Water prior to any stockpiling works. A Stockpiling Plan shall be produced which as a minimum includes the following details of the stockpile:

- location,
- dimensions,
- environmental control measures,
- statutory approvals and consents.

This plan must be submitted for review and acceptance by Sydney Water at least 20 working days before stockpiling.

C2.6.2. Stockpiling of Topsoil

Topsoil material that are stockpiled within Sydney Water sites shall meet the following requirements:

- be free from subsoil, other excavated materials, contaminated materials, refuse, clay lumps and stones, timber or other rubbish;
- be trimmed to a regular shape to facilitate quantity measurement, and with a height not exceeding 2 m and batter slopes not steeper than 2H:1V;
- batters track rolled or stabilised by other means acceptable to the Sydney Water; and
- be seeded with a sterile cover crop in accordance with Specification RMS R178, to encourage vegetation cover. Seeding must be carried out progressively within seven days of completion of each 500 m² of exposed batter face.
- have silt barriers or temporary drainage to prevent the stockpiled topsoil being washed away.
- No traffic shall be allowed on or across stockpiles.

C2.6.3. Stockpiling of Contaminated or Unsuitable Material

Stockpiling of contaminated or unsuitable material is not permitted within the works Site unless otherwise specifically accepted by Sydney Water.

C2.7. Backfill or Fill Material

C2.7.1. General

No material shall be placed or imported to site without the appropriate acceptance being sought from Sydney Water.

Requests submitted to the Sydney Water to place material or import material to site, shall include test results, plans specified herein and as listed in the design drawings.

Should an alternative material be proposed; but is not considered acceptable within requirements noted below, a request to Sydney Water can be made to utilise its preferred material, along with all necessary supporting documentation, including suitable material test reports. This request must be lodged at least 20 working days prior to the intended use of the material on site.

Such material shall only be imported to site, once acceptance is granted by Sydney Water.

C2.7.2. Unsuitable Material

Unsuitable material shall not be used in construction. Unsuitable material includes the following,

- topsoil,
- peat and other highly organic soils, logs, stumps,
- waste,
- material susceptible to spontaneous combustion,
- soluble material such as gypsum and salt rock,
- expansive soils,
- free draining materials susceptible to scouring,
- very fine sand,
- non-cohesive silt,
- Un-compactable material with 4days soaked CBR<3%,
- Material that can be subjected to degradation over time
- organic clay and highly dispersive soils.

Dispersivity potential of soil shall be determined by either using a pinhole test apparatus, according to ASTM D4647 Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test, or crumb test in accordance with AS 1289, Test 3.8.1. In using the pinhole test, any material classified other than ND1 or ND2 (non-dispersive) will be considered as unsuitable. In using crumb test, soils classified as Emerson class number 1, are considered as unsuitable.

Materials with a free swell index higher than 3%, soluble substances more than 3% and organic content more than 5% by weight of dry material are all considered as unsuitable and shall not be used for construction of any earthworks.

Collapsible soils underlying foundations are also considered as unsuitable material and shall be treated before construction of embankments. One dimensional wetting induced swell or collapse strain is determined according to ASTM D4546-14 Standard Test Method for One-Dimensional Swell or Collapse of Soils.

C2.7.3. Imported Material

If the site won material fails to meet the minimum requirements in this section of the specification, imported material may be used. All necessary imported fill and backfill material shall be in accordance with the drawings and the minimum requirements specified herein.

C2.7.4. Pipe Embedment Material

Required pipe embedment material requirements shall be as detailed in the design drawings. Material used for pipe embedment shall meet WSA product specifications as listed below.

WSA-PS-350 - Compaction Sand
WSA-PS-351 - Processed Aggregates
WSA-PS-352 - Controlled Low Strength Materials (CLSM)
WSA-PS-359 - 7mm Processed Aggregate
WSA-PS-360 - Embedment/ Concrete Sand
WSA-PS-361 - Embedment/ 5mm Minus Fine Crushed Rock
WSA-PS-362 - Well Graded Crushed Rock

C2.7.5. Backfill Material Around structures

Backfill materials that are to be placed within H/2 distance from the back of any structure shall be Select Fill, as specified below, where ‘H’ is the height of structure to be backfill against, refer Figure 2.1.
Figure 2.1: Fill Around Structures

The material properties of Select Fill shall be in accordance with Table 2-1. The material shall have the following properties tested in accordance with relevant parts of AS1289.

Table 2-1 Properties of Select Fill Material

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size distribution:</td>
<td></td>
</tr>
<tr>
<td>Percentage passing AS Sieve (by mass)</td>
<td></td>
</tr>
<tr>
<td>53 mm</td>
<td>100%</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>&gt;60%</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>75 µm</td>
<td>&lt;15%</td>
</tr>
<tr>
<td>Coefficient of uniformity ($D_{60}/D_{10}$)</td>
<td>≥5</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>≤15</td>
</tr>
<tr>
<td>CBR</td>
<td>≥8%</td>
</tr>
</tbody>
</table>

Material prone to degradation from oxidation or weathering shall not be used as Select Fill. Material derived from Bringelly Shale shall not be used as Select Fill material.

**C2.7.6. Trenchfill Material for Unpaved Areas**

Trench Backfill shall consist of material that can be compacted to not less than 95% maximum dry density, as determined by AS 1289 Tests 5.1.1 and 5.3.1.

The relative compaction specified for field tests shall be achieved over the full depth of each compaction layer. Each compacted layer shall have a uniform thickness, as recommended in the project specifications. The methods of excavation, transport, depositing and spreading of the fill material shall be selected so as to ensure that the compacted material, in any location, is homogeneous.

The material shall be free of unsuitable materials. Soil materials that have a Plastic Index higher than 30 are also not permitted. All material shall have soaked CBR of at least 3% at 4days.

**C2.7.7. Trenchfill Material for Paved Areas**

Trench backfill material under paved areas shall comply with the relevant road authority requirements.
Where the paved areas are located within Sydney Water owned land and no specific requirements are noted, trench backfill shall be as follows:

- Trench Backfill material, 1m below finished surface levels shall exceed or comply with the requirements specified in C2.7.6
- Trench Backfill material within 1m from finished surface levels and below subbase, shall comply Select Fill material properties, specified in Table 2-1
- Any granular Pavement Base and Subbase material shall comply with RMS QA Specification 3051

C2.7.8. Minimum Frequency of Testing of Source Material

All recommended tests, including Atterberg limits, soaked CBR, dispersivity potential, free swell index and soluble content shall be carried out as minimum one test per 1000 cubic metres of material or part thereof. A minimum of three tests shall be carried out per material type and source.

C2.7.9. Filtration Geotextiles

All filtration geotextiles materials shall comply WSA PS 355.

C2.7.10. High Strength Geosynthetics

High strength Geosynthetics including high strength geotextile and geogrid material shall comply with RMS QA Specification R67.

C2.7.11. Non-Standard Materials

Any non-standard material that are not included in the above specifications (including recycled material) shall be submitted to Sydney Water for review and acceptance with all necessary testing details and suitability certification from a competent geotechnical engineer, a minimum 20 working days prior to being imported to site and/or placed.

C2.8. Compaction

C2.8.1. Compaction Quality Assurance Plan

A Compaction Quality Assurance Plan shall be produced and submitted to Sydney Water for acceptance. It shall include, but not limited to the following:

- The details of the compaction plant to be used on site.
- The locations such plan will be used on site.
- The loose layer thicknesses to be employed where fill is placed.
- The compaction standard to be achieved for each location.
- The systematic pattern of compaction to be employed on site.
- The visual observation requirements used to identify areas of unacceptable and acceptable compaction.
- The rectification methods to be used to rectify area of unacceptable compaction.
- The method to be employed to correlate the locations of placed material against compaction test and material test results.
- The compaction testing requirements for each compaction location to confirm that material has been homogenously compacted; noting any difference in compaction technique used. Such as where hand held compaction equipment are to be used.
- The materials testing requirements needed to achieve a homogenous material, or alternatively, the quality assurance certificates and testing results to be provided where manufactured fill products are brought to site.
- A detailed Inspection Test Plan covering all of the points noted above, as a minimum
Level 1 geotechnical inspection shall be provided in accordance with AS3798 for all earthworks exceeding 3.0m fill or backfill thickness.

C2.8.2. Compaction Near Structures
No compaction shall be carried out with 2m of a reinforced concrete structure until the design 28 days characteristic strength has been achieved.

For each layer, start the compaction at areas immediately adjacent to a structural wall, and then gradually proceed away from the wall. Unless specifically designed for, no vibrating rollers of mass exceeding one tonne, or any other equipment that may potentially cause damage to an earth or liquid retaining structure shall be used to compact fill material located within 2m of the structure.

Where proximity to structures confines or prevents the use of larger compaction equipment, handheld compaction equipment shall be used.

Layer thicknesses shall be reduced achieve design compaction levels using the selected compaction equipment.

C2.8.3. Testing Frequency
Unless otherwise stated in the drawings, field density tests shall be carried out at locations randomly selected by Sydney Water at the following frequency:

(a) one test per 300m² of compacted fill, or part thereof, for each layer of compaction
(b) two tests in each compacted fill layer around access, maintenance and maintenance hole structures.
(c) For pipe trenchfill and embedment material, the frequency of testing shall be one test in each 300 mm layer of fill for every 50 linear metres of pipe laid or part thereof.

All testing shall be carried out by NATA accredited laboratories.

Once fill is placed and compacted in multiple layers for 1.5m of total thickness, the relevant compaction test results shall be submitted and accepted by Sydney Water; prior to proceeding to the next layer of fill layer. The test results shall be checked by a Competent Geotechnical Engineer prior to submission to Sydney Water.

Test results, together with the records of checks completed by a Competent Geotechnical Engineer, shall be submitted to Sydney Water at least 2 workings days prior to the placement of the next layer of fill.

C2.8.4. Test Requirements
Unless otherwise specified, the minimum compaction standard for all filling areas shall be not less than that shown in Table 2-2.

| Table 2-2 Minimum Compaction Standard for Filling Areas |
|---------------------------------------------|-------------|-------------|
| Material Type | Test Method | Relative | Minimum Requirement |
| Cohesionless soils | Standard Compaction AS1289.5.1.1 | Relative compaction stated as Density Index (AS1289.5.6.1) | 70% |
| Cohesive soils | Standard Compaction AS1289.5.1.1 | Standard Dry Density Ratio (AS1289.5.4.1) | 98% |
| | Moisture Content AS1289.5.1.1 | Relative Standard Optimum Moisture Content | 85%-115% |
Where the property owner or road authority or an alternative specification such as the RMS Specification or subdivision earthworks specification requires a higher compaction level, the highest compaction requirement shall be followed.

C2.8.5. Non-Conforming Test Results

When test results are deemed not to comply with the minimum compaction requirements, the entire compaction layer associated with that test result, and any layers above, shall be removed and replaced in accordance with the requirements of the accepted Compaction Quality Assurance Plan.

Compaction testing shall be carried out on the replacement material and provided to Sydney Water for review. No further material shall be placed above the replacement layer until accepted by Sydney Water.

Following identification of a failed compaction test, a quality incident shall be raised with Sydney Water and an investigation shall be undertaken to identify the root cause of the failed test. The quality incident shall then identify what changes need to be made to the Compaction Quality Assurance Plan.

No further compaction work shall take place until Sydney Water has reviewed and accepted the revised Compaction Quality Assurance Plan.

C2.9. Foundation Preparation

C2.9.1. Bearing Capacity and Subgrade Conditions

Bearing capacity for structural foundations and Subgrade ground conditions for pavements, shall be confirmed by a Competent Geotechnical Engineer on site.

The inspection record by the Competent Geotechnical Engineer, together with any relevant compaction test results at the location shall be submitted to Sydney Water for acceptance, prior to commencing any foundation construction works.

C2.9.2. Foundation on Rock

For rock foundation, excavation in rock shall be taken to the depth and profile shown in the drawings. All loose material (including loose rock) shall be removed. Any over-excavation in rock shall be filled with concrete grade N15, as per C3 or better.

Minor fissures shall be thoroughly cleaned out and refilled with concrete, mortar or grout. The rock surface shall be clean and wet at the start of placing concrete.

C2.9.3. Foundation on Soil

Surfaces shall be completely free of depressions, potholes and loose materials in readiness for structure or pavement construction.

Care shall be taken to avoid disturbing materials below foundation level. All loose materials shall be removed before placing the concrete of minimum Grade N15 as per C3 or Select Fill material as per C2.7.5.

C2.10. Surface Restoration

All surfaces disturbed in the course of excavation shall be restored to their original condition.

C2.10.1. Road Openings, Road Plates and Restoration

Excavation, road plates, backfill and pavement restoration for road opening work within all roads, tracks and driveways shall be carried by in accordance with the minimum requirements and technical specifications of RMS QA Specifications M208 and M209; unless otherwise specified by the relevant road asset owner, including Local Councils.
C2.10.2. Restoring other Paved Areas

Unless otherwise specified, bituminous pavements shall be replaced with the same type and thicknesses of surface and base courses as the original pavement.

Unless otherwise specified, concrete pavement shall be replaced with the same type of surfacing and base courses as existing. Reinforcement of 10 mm diameter running in both directions and spaced not more than 300 mm on centres shall be provided whether the original pavement is reinforced or not. Pavement surfaces shall be cut with concrete sawing equipment and cuts shall be at least 150 mm beyond the sides of the trench.

Unless otherwise specified in the drawing, concrete pathways, curbs and gutters, and paving blocks shall be replaced with the same type of surfacing and base courses as the original construction. All concrete cutting shall be carried out using sawing equipment and cuts shall be at least 150 mm beyond the sides of the trench.

C2.10.3. Restoring Landscaped Areas

All landscaped areas shall be restored to original conditions.

C2.11. Records

C2.11.1. Volume of Material

Once excavation works are complete, records of all excavated material; including suitable and unsuitable material shall be recorded and reported to Sydney Water, with all necessary test and inspection results.

C2.11.2. Inspection Reports

All inspections reports and verification testing shall be completed by a Competent Geotechnical Engineer and shall be submitted to Sydney Water, within 20 working days to facilitate necessary acceptance and release of Hold Points when applicable.

C2.12. Hold Points

C2.12.1. Hold Points identified in Earthworks

A summary of hold points identified are listed in Table 2-3 below.

Table 2-3 Summary of Hold Points for Earthworks

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EHP1</td>
<td>Site Clearing</td>
<td>Erosion and Sediment Control Plan</td>
<td>C2.4.1</td>
</tr>
<tr>
<td>EHP2</td>
<td>Excavations more than 1.5m deep</td>
<td>Excavation Support System Design</td>
<td>C2.5.2</td>
</tr>
<tr>
<td>EHP3</td>
<td>Dewatering</td>
<td>Dewatering Proposal Plan</td>
<td>C2.5.4</td>
</tr>
<tr>
<td>EHP4</td>
<td>Excavation in watercourses</td>
<td>Provide all necessary control plans as required and agreed with Sydney Water, based on project specific requirements.</td>
<td>C2.5.6</td>
</tr>
<tr>
<td>EHP5</td>
<td>Blasting</td>
<td>Provide all necessary control plans as required and agreed with Sydney Water based on project specific requirements.</td>
<td>C2.5.7</td>
</tr>
<tr>
<td>EHP6</td>
<td>Stockpiling</td>
<td>Stockpiling Plan</td>
<td>C2.6</td>
</tr>
</tbody>
</table>
## Technical Specification - Civil

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPH7a</td>
<td>Importing any material related to earthworks</td>
<td>Test results of the source material AND Compaction Quality Assurance Plan for the proposed material with the assessment of suitability by Competent Geotechnical Engineer</td>
<td>C2.7 &amp; 2.8</td>
</tr>
<tr>
<td>EPH7b</td>
<td>Commencement of placing fill material sourced within the site</td>
<td>Test results of the source material AND Compaction Quality Assurance Plan for the proposed material with the assessment of suitability by Competent Geotechnical Engineer</td>
<td>C2.7 &amp; 2.8</td>
</tr>
<tr>
<td>EHP8</td>
<td>Placement and compaction of each subsequent layer of fill or backfill</td>
<td>Compaction test results for each layer of compaction from preceding total thickness of 1.5m Fill placed.</td>
<td>C2.8</td>
</tr>
<tr>
<td>EHP9</td>
<td>Construction of Structural Foundation or Pavements</td>
<td>Inspection Report signed by Competent Geotechnical Engineer</td>
<td>C2.9</td>
</tr>
</tbody>
</table>

### C2.12.2. Release of Earthwork Hold Points

All documents related to release of Hold Points in Earthworks shall be submitted to Sydney Water, together with a suitable Competent Geotechnical Engineer’s check and endorsement; to enable acceptance.
C3. Concrete Works

C3.1. General
This specification sets out the requirements for concrete work for:

- The supply and delivery of all concrete, cement mortar and grout for in-situ and precast concrete elements.
- The design, construction, erection and removal of the formwork.
- The supply, fabrication and fixing of the reinforcing steel and other embedded items.
- The placing, compacting, finishing and curing of concrete, cement mortar and grout.
- The repair of faulty concrete work and cracks.

C3.2. Referenced Documents
The documents referred to in this specification are:

- AS 1012 Methods of testing concrete
- AS 1141 Methods for sampling and testing aggregates
- AS 1289 Method of testing soils for engineering purposes
- AS 1379 Specification and supply of concrete
- AS 1391 Methods for tensile testing of metals
- AS 1478 Chemical admixtures for concrete, mortar and grout
- AS/NZS 1554 Structural steel welding
- AS 2214 Certification of welding supervisors – Structural steel welding
- AS 2349 Method of sampling Portland and blended cement
- AS 2758 Aggregates and rock for engineering purposes
- AS 2837 Wrought alloy steels – Stainless steel bars and semi-finished products
- AS 3582 Supplementary cementitious materials for use with Portland and blended cement
- AS3735 Concrete structures for retaining liquids
- AS 3600 Concrete structures
- AS 3610 Formwork for concrete
- AS 3799 Liquid membrane-forming curing compounds for concrete
- AS 3972 Portland and blended cements
- AS/NZS 4671 Steel reinforcing materials
C3.3. Definitions

The following definitions apply to this Specification:

Cement: Material conforming to AS 3972. It comprises Portland cement and blended cements.

Concrete: A thoroughly mixed combination of cement, aggregates and water, with or without the addition of chemical admixtures or other materials, all of which separately and when combined conform to the requirements of this specification.

Curing: The control of temperature and moisture in the concrete until the concrete has developed the required properties.

Cover: The distance between the outside of the reinforcement and the nearest permanent surface of the member excluding any surface finishing material or protective coating.

Construction Joint: A joint that is located in a structure for convenience of construction and made so that the load bearing capacity and serviceability of the structure will not be impaired by the inclusion of the joint.

Movement Joint: A joint that is made between parts of a structure for the specific purpose of permitting relative movement between the parts of the structure on either side of the joint.

Nozzle: Attachment at end of delivery hose from which shotcrete is projected

Overspray: Material projected outside the intended receiving surface

Rebound: Shotcrete material that bounces off the receiving surface

Shotcrete: Concrete pneumatically projected onto a surface at high velocity

SCMs: Supplementary cementitious materials (SCMs) are in the form of fly ash, slag or silica fumes that may be blended in the cement or supplied separately to the concrete batching plant

Wet-mix Shotcrete: Shotcrete in which cement, aggregate and water are first mixed together before introduction as concrete into the delivery hose

Water/Cement Ratio: The ratio, by mass, of total free water including water contained in admixture solutions, to total cement including all supplementary cementitious materials, in the concrete mix.

C3.4. Supervision

The concrete supervisor shall be a suitably experienced person accepted by Sydney Water. The supervisor shall supervise the delivery and placing of all concrete works and shall prepare and submit to Sydney Water a daily report on all concrete placed. The report shall contain the serial number of the identification docket for each batch, the classes of concrete, the volume of each batch, the measured slump, the identification test specimen made, the amount of water, if any, added on site, the location and the climatic condition during the pour.

The records of mill certificates of all reinforcement and prestressing tendons delivered shall be retained on site and submitted to Sydney Water when requested.

C3.5. Materials for Concrete

C3.5.1. General

Materials for concrete, cement mortar and grout shall conform to Section 2 of AS 1379 and with the additional requirements of this specification.
C3.5.2. Cement
The cement used shall generally be Type GP – general purpose Portland cement to AS 3972. Where specified, or with the acceptance of Sydney Water, general purpose blended cement (Type GB), sulphate resisting cement (Type SR), shrinkage limited cement (Type SL) or other types of special purpose cement shall be used.

C3.5.3. Fly Ash
Fly ash shall be “fine” grade and shall comply with AS 3582.1. The maximum amount of fly ash shall be 25% by weight of the total cement material.

C3.5.4. Slag
Slag shall be from iron blast furnace and shall comply with AS 3582.2. The maximum amount of slag shall be 50% by weight of the total cement material.

C3.5.5. Silica Fume
Silica fume shall comply with AS 3582.3. The maximum amount of silica fume shall be 10% by weight of the total cement material.

C3.5.6. Supplementary Cementitious Materials
The total amount of supplementary cementitious materials shall not be more than 60% by weight of the total cement material.

C3.5.7. Aggregates
Coarse and fine aggregates for concrete shall comply with the requirements of AS 2758.1. The maximum nominal size of aggregate shall be 20 mm in reinforced concrete and 40 mm in unreinforced concrete. Coarse aggregate shall consist of clean, hard, durable particles substantially retained on a 4.75 mm sieve and shall be obtained from dense, naturally occurring or manufactured gravel or rock. Fine aggregate shall consist of clean, hard tough, durable, uncoated grains, uniform in quality, comprising material of which not less than 90% passes the 4.75 mm sieve. Recycled material or slag products shall not be used as an aggregate unless specified otherwise or accepted by Sydney Water. All materials shall be free from hazardous substances such as asbestos or asbestos containing materials.

For special class concrete, the aggregates shall comply for exposure classification “C” of Table 4 of AS 2758.1.

For normal class concrete, the aggregates shall comply for exposure classification “B1” of Table 4 of AS 2758.1.

The water absorption of aggregate shall be less 3% when tested in accordance with AS 1141.

The alkali reactivity of the aggregate shall be assessed to Clause 10 of AS 2758.1. When aggregates are assessed to have a potential for aggregate alkali reaction, they may be used only in normal class concrete with appropriate safeguards subject to the acceptance by Sydney Water.

Aggregates that are assessed to have a potential for aggregate alkali reaction shall not be used in special class concrete.

C3.5.8. Water
Water used in the manufacture of concrete shall comply with AS 1379.

C3.5.9. Chemical Admixtures
Admixtures that enhance the workability, reduce water/cement ratio, control slump, minimise shrinkage and control the setting time of the concrete may be included in the mix in a control manner, provided they have been proven not to impair the performance concrete.
Where two or more admixtures are proposed for incorporation into a concrete mix, the manufacturers shall certify the compatibility of the admixtures.

Air-entraining admixtures may be used provided that the air content, determined in accordance with AS 1012 does not exceed 4%.

All admixtures shall comply with AS 1478.

C3.6. Design of Concrete Mixes

C3.6.1. Normal Class

Normal classes of concrete are denoted by prefix “N” and the following minimum strength grades shall be used unless otherwise specified in the drawings:

- N15 for all overbreak in excavation and blinding layers.
- N25 for pipeline thrust (anchor) blocks, pipeline encasement, screeding and benching, kerb and guttering and road pavement.
- N32 for reinforced concrete structures not covered above excluding prestressed concrete.
- N40 for prestressed concrete.

C3.6.2. Special Class

Special classes of concrete are denoted by prefix “S”. Special class concrete shall be used for all liquid retaining surfaces including stormwater channels and floors remain damp for considerable periods.

The minimum grade of special class concrete shall be S40.

C3.6.3. Concrete Mix Proportions and Characteristics

Unless otherwise specified in the drawings, the mix proportions and characteristics for all classes of concrete shall comply with Table 3-1.

Table 3-1 Concrete Mix Proportions

<table>
<thead>
<tr>
<th>Concrete Class</th>
<th>Characteristic Strength (f’c) at 28 days (MPa)</th>
<th>Range of Cement Content (kg/m³)</th>
<th>Cement Type</th>
<th>Range of W/C Ratio</th>
<th>Maximum Shrinkage at 56 days</th>
<th>Slump at Point of Delivery (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N15</td>
<td>15</td>
<td>NA</td>
<td>GP/GB</td>
<td>NA</td>
<td>NA</td>
<td>-NA</td>
</tr>
<tr>
<td>N25</td>
<td>25</td>
<td>300-370</td>
<td>GP/GB</td>
<td>0.5 - 0.6</td>
<td>900 x 10⁻⁶</td>
<td>80 - 120 mm (Note 2)</td>
</tr>
<tr>
<td>N32</td>
<td>32</td>
<td>330 - 400</td>
<td>GP/GB</td>
<td>0.5 - 0.55</td>
<td>900 x 10⁻⁶</td>
<td>80 - 120 mm (Note 2)</td>
</tr>
<tr>
<td>N40</td>
<td>40</td>
<td>380 - 450</td>
<td>GP/GB</td>
<td>0.45 - 0.50</td>
<td>900 x 10⁻⁶</td>
<td>80 - 120 mm (Note 2)</td>
</tr>
<tr>
<td>S40</td>
<td>40</td>
<td>430 - 500</td>
<td>SR/SL (Note 1)</td>
<td>0.4 - 0.45</td>
<td>600 x 10⁻⁶</td>
<td>80 - 120 mm (Note 2)</td>
</tr>
<tr>
<td>S50</td>
<td>50</td>
<td>470 - 540</td>
<td>SR/SL (Note 1)</td>
<td>0.35 - 0.40</td>
<td>600 x 10⁻⁶</td>
<td>80 - 120 mm (Note 2)</td>
</tr>
</tbody>
</table>

Notes:

1. Type SR shall be used for sewerage structures including access chambers. Type SL shall be used for other than sewerage structures including stormwater channels.
2. Except for tremie concrete.
C3.6.4. No Fines Concrete

No fines concrete shall be proportioned such that the aggregate/ cement ratio is in the range of 6:1 to 8:1 by mass and water/cement ratio in the range of 0.35 to 0.45 by mass.

The aggregate grading of no fines concrete shall conform to Table 3-2.

**Table 3-2 Aggregate Grading for No Fines Concrete**

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>% Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>100</td>
</tr>
<tr>
<td>19</td>
<td>85 – 100</td>
</tr>
<tr>
<td>9.5</td>
<td>0 – 20</td>
</tr>
<tr>
<td>4.75</td>
<td>0 – 5</td>
</tr>
</tbody>
</table>

C3.6.5. Submission of Mix Design

At least 14 working days prior to commencement of concrete work, the details of each proposed concrete mix shall be submitted to Sydney Water for acceptance, accompanied by test results of each mix proportions and certificates. The certificate shall be from an independent laboratory with appropriate NATA registration stating that the nominated mix and its mix constituents meet the requirements of this specification. The concrete mix details shall include the proportion of slag and fly ash used in the mix design.

The submitted mix details shall include the source of materials to be used, the moisture condition of the aggregates on which the mix is based, the nominated slump, and methods of mixing and transportation.

Submission of mix details and Certificate(s) shall constitute a Hold Point.

C3.6.6. Variation to Mix Design

Unless accepted by Sydney Water, no variation shall be made to the concrete mix in the source of concrete constituents, or in the type, size and grading of the aggregates.

The quantities of the constituents in the mix design may be varied to improve the quality of the concrete. These variations shall not exceed the following:

- Cement: 3% by mass of each constituent
- Aggregates: 5% by mass of each constituent
- Water: 3% by volume or mass
- Admixture: 5% by volume or mass of each admixture and within the manufacturer’s recommendations.

Sydney Water shall be notified in writing details of such variations to the mix design before commencing production.

Notwithstanding the above provisions, the varied concrete mix design shall:

- Not have a water/cement ratio exceeding that nominated for the special class concrete in Table 3-1.
- Conform to the requirements of minimum cement content for the special class concrete in Table 3-1.
- Conform to the requirements of AS 3972.
C3.6.7. Cement Mortar and Grout

A cement mortar is a mixture of cement, water and sand (fine aggregate), with or without chemical admixture with a characteristic strength at 28 days of not less than 32 MPa, unless otherwise stated.

A cement grout is a mixture, similar to cement mortar, but more workable and possibly without any sand or fine aggregates, proportioned to produce a pourable liquid which does not readily segregate into its constituents during pouring or pumping.

C3.7. Supply and Delivery of Concrete

C3.7.1. General

All supplied concrete shall conform to the mix design accepted by the Sydney Water.

C3.7.2. Production

All concrete shall be produced by batch production process. Manual mixing is not allowed.

The concrete supplier shall comply with the requirements of the production assessment outlined in AS 1379 for each class of concrete produced. Records of test results and reports of production assessment for the preceding production interval shall be submitted to Sydney Water for acceptance.

C3.7.3. Ready-Mixed Concrete Delivery

Ready-mixed concrete production method and facilities shall conform to AS 1379. Ready-mixed concrete shall be transported to the point of discharge by truck-mounted drum mixers conforming to the requirements of AS 1379. On completion of batching, the concrete shall be continuously agitated until it is thoroughly mixed. On completion of mixing, the concrete shall be continuously agitated until it is fully discharged.

Each batch of concrete delivered to site shall be accompanied an identification docket that shall be supplied to Sydney Water containing the following information:

- Name of supplier
- Serial Number
- Date of delivery and climatic condition
- Project name and location
- Delivery vehicle identification
- Quantity of concrete
- Class and strength grade
- Designed slump
- Admixtures, if any
- Amount of water added on site.
C3.7.4. Delivery Time
The time that elapses between the wetting of the mix and discharge of the mix at the site shall not exceed the time set out in Table 3-3.

Table 3-3 Elapsed Delivery Time

<table>
<thead>
<tr>
<th>Concrete Temperature at Time of Discharge (ºC)</th>
<th>Maximum Elapsed Time (hrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-23</td>
<td>2.00</td>
</tr>
<tr>
<td>24-26</td>
<td>1.50</td>
</tr>
<tr>
<td>27-29</td>
<td>1.00</td>
</tr>
<tr>
<td>30-32</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Sydney Water may extend these times in special circumstances provided that the concrete complies with the specified performance requirements, including slump.

C3.7.5. Temperature at Point of Delivery
Concrete shall not be delivered if its temperature at the point of discharge from the transport vehicle is less than 10°C or more than 32°C.

C3.8. Placing Concrete
C3.8.1. General
Concrete shall be placed, compacted, finished and cured so as to:

- Prevent segregation or loss of material.
- Prevent premature stiffening.
- Prevent nonconforming displacement of reinforcement, fitments or embedment.
- Produce a dense homogenous product which is monolithic between planned joints and the extremities of members.
- Completely fill the formwork to the intended level, expel entrapped air, and surround all reinforcement, tendons, ducts, anchorages and embedment.
- Provide the specified finishes.
- Control cracking, including that caused by plastic and drying shrinkage, concrete slumping, plastic settlement, crusting and thermal gradients.

Water, contaminants, debris, excess concrete and other materials from concrete placement, compaction, finishing and curing operations shall be disposed of in an environmentally safe manner.

C3.8.2. Placement
Concreting shall be carried out in one continuous operation between ends of member and/or construction joints. Fresh concrete shall not be placed against concrete that has taken its initial set, except at properly formed construction joints.

Concrete shall be supplied at a rate that ensures that all concrete in the form is kept plastic until placed in its final position and compacted and so that no cold joints are formed. Equipment and personnel shall be adequate to maintain the adopted rate of concrete placement.

In vertical forms, the free fall of concrete shall be limited to a maximum of 300 mm using enclosed chutes or access hatches built into the formwork. As far as practicable, chutes or hoses of concrete pumps shall be kept full of concrete during placement with the ends immersed in the placed concrete and withdrawn as the form is filled.
In horizontal forms such as for slabs, concrete shall not be allowed to drop into place from a height exceeding 1.5 m.

Concrete shall not be moved horizontally by the use of vibrators.

If during the progress of the work, if nominated Sydney Water finds that the concrete being placed does not meet the specified requirements, or is in any way unsatisfactory, he may make direction to alter the mix design and/or carry out new trial mixes.

Under conditions of rain, the placing of concrete shall not commence or shall be stopped unless adequate protection is provided to prevent damage to the concrete and the washing of the concrete surface. Concrete exposed to rain before it has set shall be liable to rejection.

C3.8.3. Sequence of Pours

The proposed pour sequence and the location of construction joints shall be submitted to Sydney Water for acceptance.

Shrinkage effects shall be minimised by pouring the concrete sections between construction joints in a sequence such that there will be suitable time delays between adjacent pours.

C3.8.4. Compaction

Concrete shall be compacted immediately after placing by means of internal and/or external vibration. Vibration shall be carried out in a regular and systematic manner to ensure that all concrete is thoroughly compacted. Vibration shall be applied to the full depth of each layer and extended into the top 100 mm of the underlying layer. Concrete shall not be vibrated to the extent where segregation of the ingredients occurs.

Vibrators shall be of the rotary out of balance type and shall be checked prior to use to ensure proper working order.

Internal vibrators shall have a minimum diameter of 50 mm and an operating frequency range between 130 Hz and 200 Hz.

The number of working internal vibrators in use for compacting concrete during a concrete pour shall not be less than one for each 10 cubic metres of concrete placed per hour, with a minimum of two. The number of standby vibrators shall be not less than one quarter of the number of vibrators in use with a minimum of one. Vibrator used for spreading concrete shall not be counted in the number of vibrators used for compaction.

Internal vibrators shall be inserted vertically at spacing not exceeding 350 mm. The vibrator shall be left in place for at least 7 seconds until the air bubbles cease breaking the surface, and then withdrawn slowly. Vibrators shall not be allowed to rest on the reinforcement.

In regions of closely spaced reinforcement, full compaction of concrete directly beneath the closely spaced horizontal reinforcement shall be achieved prior to encasing the reinforcement with concrete.

C3.8.5. Placing in Water

Concrete shall not be placed under water unless accepted by Sydney Water. Details shall be submitted to Sydney Water of the proposed method of placement prepared by a concrete technologist experienced in this type of work.

C3.8.6. Cold Weather Concreting

Concrete shall not be placed if the ambient temperature is below 5°C or expected to fall below 5°C in the 24 hrs after placement.

C3.8.7. Hot Weather Concreting

The placing of concrete in hot weather shall be regulated by approved methods to avoid premature stiffening. Concrete shall not be placed if the ambient temperature is above 35°C.
C3.8.8. Submission of certificate of Conforming of formwork, reinforcement fixing and embedments

At least seven (7) working days prior to the proposed placement of concrete, a Certificate of Conformity in respect of formwork, reinforcement, embedments and other relevant details supported by verification check lists shall be submitted to Sydney Water for acceptance. The Certificate of Conformity shall be prepared a civil/structural engineer who is a chartered member of the Institution of Engineers Australia.

The submission to of certificate of conforming formwork, reinforcement fixing and embedment shall constitute a Hold Point.

C3.9. Finishes to Unformed Surfaces

C3.9.1. Unformed Finishes

Unless specified otherwise, the finishes to unformed concrete surfaces shall be as follows:

- Steel Trowel Finish for process tank floors, top of walls, copings and exposed surfaces.
- Float Finish for building roofs.
- Broom Finish for footpaths.
- Screed Finish for structural members covered by backfill, and all other unformed concrete surface.

C3.9.2. Tolerances

The tolerance for unformed concrete surface, as determined by a straight edge placed on the plane of the concrete surface in any direction, shall be as follows:

- Class A: Maximum deviation from a 3 m straight edge - 3 mm
- Class B: Maximum deviation from a 3 m straight edge - 6 mm
- Class C: Maximum deviation from a 0.6 m straight edge - 3 mm

C3.9.3. Screed Finish

The concrete surface shall be placed, struck off, consolidated and levelled to a Class C tolerance.

C3.9.4. Scratch Finish

After concrete has been placed, struck off, consolidated and levelled to a Class C tolerance, the surface shall be roughened with stiff brushes or raked before the final set.

C3.9.5. Float Finish

After the concrete has been placed, struck off, consolidated and levelled, the concrete shall not be worked on further until ready for floating. Floating shall begin when the water sheen has disappeared and when the mix has stiffened sufficiently to permit the proper operation of a power float. The surface shall then be consolidated with the power float. Hand floating with wood or corked faced floats shall only be used in locations inaccessible to the machine. Trueness of surface shall be rechecked at this stage with a 3 m straight edge at not less than two directions at 90 degrees. All high spots shall be cut down and all low spots shall be filled during this procedure to a Class B tolerance. The slab shall be re-floated immediately to a uniform, smooth, granular texture.

C3.9.6. Steel Trowel Finish

The surface shall be finished first with power floats, as specified above, then with power trowels and finally with hand trowels. The first trowelling after power floating shall be done by a power trowel and shall produce a smooth surface that is relatively free from defects, but which may still contain some trowel marks. Additional trowelling shall be done by hand after the surface has hardened sufficiently. The finished surface shall be free from any trowel marks, uniform in texture and appearance, and shall be planed to a Class A tolerance.
C3.9.7. Broom Finish
Broom finish shall be a coarse transverse scored texture by drawing a broom or hessian belt across
the surface. This operation shall occur immediately after floating.

C3.10. Finishes to Formed Surfaces
All formed surfaces, except where permanently concealed by backfill material, shall have a
minimum of Class 2 surface finish to AS 3610.
All formed finishes that are permanently concealed by backfill material, shall have a minimum of
Class 3 surface finish to AS 3610.
All edges and re-entrant corners shall be provided with 25 mm chamfers or 50x50 fillets.

C3.11. Curing of Concrete
C3.11.1. General
Freshly placed concrete shall be protected from premature drying and excessive hot or cold
temperatures. The concrete shall be maintained at a reasonably constant temperature with
minimum moisture loss for the duration of the curing period.
In windy conditions, windbreaks shall be erected to shield the concrete surfaces during and after
placement.
Freshly placed concrete shall not be subject to external vibration such as pile driving or dynamic
ground compaction.

C3.11.2. Curing Periods
Unless otherwise specified in the drawings, concrete shall be cured continuously for the minimum
curing period shown in Table 3-4, or until the concrete has achieved at least 75% of the
characteristic strength.

Table 3-4 Minimum Curing Time

<table>
<thead>
<tr>
<th>Concrete Class</th>
<th>Wet Curing</th>
<th>Curing Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (GP / GB cement)</td>
<td>4 days or 7 days</td>
<td></td>
</tr>
<tr>
<td>Special (SR / SL cement)</td>
<td>7 days</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

C3.11.3. Curing Methods
Unformed surfaces, and formed surfaces after the formwork is struck off, shall be cured by one of
the following methods:

- Ponding or continuous sprinkling using clean water.
- The use of an absorptive cover kept continuously wet.
- Low pressure steam curing.
- Impermeable membrane fixed and lapped over the moistened concrete surface to exclude air
circulation.
- Membrane curing compound.
C3.11.4. Curing Compounds
Curing compound shall conform to the requirements of AS 3799. The curing compound shall be sprayed to give a uniform cover. The sprayer shall incorporate a device for continuous agitation and mixing of the compound in its container during spraying.

A certificate of conformity from the supplier, supported by test certificates from a NATA approved laboratory certifying that the curing compound conforms to the specification shall be submitted to Sydney Water.

The curing compound shall be applied using a fine spray at the rate stated on the certificate of conformity or at a rate of 0.2 litres/m², whichever is greater. A minimum of two coats shall be applied at the full rate.

The time between the first coat and the second coat shall be in accordance with the manufacturer’s recommendation, or on the basis of trail application.

The curing compound shall be applied to unformed surfaces immediately after completion of all finishing operations, and to formed surfaces within half an hour of the removal of formwork from the section.

The curing membrane shall be maintained intact after its application for the required period. Any damage to the curing membrane shall be made good by respraying of the affected areas.

C3.11.5. Hot Weather Curing
Curing compound shall not be used if the temperature of the surrounding air is higher than 30°C.

C3.11.6. Curing of Wall Concrete in Forms
Consideration shall be given to ensuring the heat of hydration being kept under control to avoid cracks associated with early thermal contraction. This may involve the selection of appropriate material for the form and/or loosening the form slightly at an appropriate time to allow the curing water to reach the concrete surface.

C3.12. Sampling and Testing of Concrete
C3.12.1. Location of Sampling
All concrete samples shall be taken at the point of discharge from the agitator. Where required by Sydney Water, additional sampling shall be carried out at the point of discharge into the forms.

C3.12.2. Method of Sampling
Sampling and identification shall be carried out in accordance with AS 1012.1.

C3.12.3. Frequency of Sampling
For each concrete class supplied to site from a concrete batch, sampling of plastic concrete shall be at least one sample per 25 m³ or part thereof. For each sample, two 100mm diameter 200mm high standard cylinder specimens shall be made and cured in accordance with AS1012.8.

A slump test shall be performed on each sample of fresh concrete in accordance with AS 1012.3.

C3.12.4. Tolerance on Slump
The concrete represented by the sample shall be deemed to be satisfactory if the measure slump is within the limits given in Table 3-5.
Table 3-5  Permissible tolerances on Slump

<table>
<thead>
<tr>
<th>Specified Slump (mm)</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 60</td>
<td>± 10</td>
</tr>
<tr>
<td>60 - 80</td>
<td>± 15</td>
</tr>
<tr>
<td>80 - 110</td>
<td>± 20</td>
</tr>
<tr>
<td>110 - 150</td>
<td>± 30</td>
</tr>
<tr>
<td>&gt; 150</td>
<td>± 40</td>
</tr>
</tbody>
</table>

If the measured slump is not within the specified limits, one repeat test shall be made immediately from another portion of the sample. If the value obtained from the repeat test falls within the specified limits, the concrete represented by the sample is deemed to conform. Otherwise it shall be rejected.

C3.12.5. Compressive Strength of Cylinder Specimens

The compressive strength of each cylinder specimen shall be determined, recorded and reported in accordance with AS 1012.9 by a NATA-approved laboratory.

The compressive strength of a concrete sample shall be the average strength of the two cylinder specimens taken from the sample and tested at the same age. If the two results differ by more than 10% of their average, the cause for such excessive difference shall be investigated. Inclusion or exclusion of the specimen results shall be at the discretion of Sydney Water.

The compressive strength of any concrete sample shall not be less than the characteristic strength of the concrete class.

Where the strength of a sample is less than the characteristic strength, the cause of the non-compliance shall be investigated and an engineering assessment report shall be submitted to Sydney Water for a acceptance. Acceptance of the concrete represented by the sample shall be at the discretion of Sydney Water. Concrete with strength less than 0.85 of the characteristic strength shall be rejected.

C3.13. Joints

C3.13.1. Construction Joints

The locations of construction joints shall be as nominated in the drawings and they shall not be altered without the acceptance of Sydney Water.

All construction joints shall be formed perpendicular to main axes of the member. The deviation of any point on the construction joint from a straight line joining any two points on the joint shall not exceed 1/250 times the distance between the points or 5 mm, whichever is greater.

Vertical construction joints shall not be permitted in the walls of reinforced and prestressed concrete liquid retaining circular tanks.

All construction joints in contact with liquid shall incorporate suitable water stop in the middle of walls and underside of floor slabs and also joint sealants in a preformed groove on the liquid faces.

C3.13.2. Preparation of Surface at Construction Joints

The surfaces of previously placed concrete at construction joints shall be roughened by removing all laitance and sufficient mortar to expose aggregates to a depth of 3mm.

Coarse aggregates which do not remain firmly embedded in the mortar matrix and laitance from projecting reinforcement from previous pour shall be removed.
Immediately prior to the placement of adjoining concrete, the surface of the construction joint and the projecting reinforcement shall be washed clean, and the concrete surface shall be saturated with water, following which all excess water and loose material shall be removed.

At least seven (7) working days prior to proposed placement of concrete, Sydney Water shall be notified for acceptance of completed construction joint preparation.

Notification of the completed construction preparation shall constitute a Hold Point

C3.13.3. Movement Joints

The locations of movement joints shall be as nominated in the drawings and they shall not be altered without the acceptance of Sydney Water.

The movement joints shall have adequate shear strength in the transverse direction to prevent differential movement either by an adequately proportioned concrete shear key or grade 316 stainless steel dowels. Location of the joints shall be such that the stiffness of the adjoining members is compatible.

All dowels shall be accurately positioned at right angles to the mating surfaces and rigidly held in position prior to depositing concrete. A tolerance of no more than 1 in 100 shall be permitted on the alignment of the dowels. The unbonded end of dowels shall be coated in an approved bond breaker such as hot 60 -70 Grade bitumen. At expansion joints, the unbonded end of the dowel shall be sheathed with a dowel cap containing a minimum of 15 mm compressible packer.

All movement joints in contact with liquid shall incorporate suitable water stop in the middle of walls and underside of floor slabs and also joint sealants in a preformed groove on the liquid faces.

All movement joints in stormwater channels and culverts shall be provided with suitable water stops and joint sealants.

C3.13.4. Filler & Sealant in Joints

Fillers and sealants shall be as specified in the drawings and they shall not be altered without the written acceptance of Sydney Water. Where not shown, the minimum depth of sealant in joints shall be 15mm. The applicator installing the fillers and sealants shall be approved by the product manufacturer and accepted by Sydney Water.

Fillers and sealants for the joints shall be applied strictly in accordance with the manufacturer’s written instructions. If these are not adhered to, including directions regarding mixing, pot life, placing temperature, over-heating, etc., any affected material not yet placed shall be discarded and any affected material already placed shall be removed and replaced. Where priming is specified, the primer shall be compatible with the sealant as recommended by the manufacturer.

Prior to the application of primer or sealant, all joint grooves shall be cleaned for the full depth to ensure the groove faces are free of any loose particles or other defects that would impair bond with the sealant. Any excess mortar or concrete shall be removed from the joint and any defects repaired, prior to the application of the sealant.

C3.13.5. Water stops

The installation and jointing of water stops shall be strictly in accordance with manufacturer’s specification. The jointing of PVC water stops and repairs to damaged PVC water stops shall only be carried out by using heat welding.

The PVC water stops shall be of sufficient stiffness and be secured in its place firmly in accordance with manufacturers recommendation so that they remain in the correct position during concreting.

The PVC water stops shall be located in the middle except for the externally placed PVC water stops in floor slabs. Where not shown, a minimum clearance of 50 mm shall be maintained from the nearest face of reinforcement.

Hydrophilic expanding water stops shall be either set in a groove or fixed in its position so that they remain in the correct position during concreting.
C3.14. Cracks in Concrete

At the completion of works, concrete shall not have cracks of width as specified below:

- Special Class Concrete - 0.1 mm
- Normal Class Concrete - 0.2 mm

A scaled elevation of all cracks that exceed the above limits, shall be submitted to Sydney Water at least twenty (20) working days prior to commencing any remediation accepted by Sydney Water. Submission of details of non-compliant cracks and proposed remediation shall constitute a Hold point.

Cracks exceeding the above limits shall be deemed to be non-conforming and shall be repaired in accordance with this specification.

C3.15. Formwork

C3.15.1. General

Formwork, including all supporting members shall conform to the requirements of AS 3610. Formwork shall be designed to account for all load cases in accordance with AS 3610. The design and details shall also account for traffic impact, ground condition, flooding and any other applicable conditions. Where formwork is re-used, the design shall allow for the deterioration of the materials through use and handling.

Formwork shall be so constructed that the concrete can be properly placed and thoroughly compacted and that the hardened concrete shall conform accurately to the required shape, position and level, and to the finishes specified. Care shall be taken in the design of the tightness of the joints during concreting and vibrating operations. All joints in formwork as erected shall be mortar tight.

Formwork shall be fabricated with a "Plasply" surface or equivalent phenolic coating, steel plate or accepted equivalent. Joints shall be minimised on the formwork surface by the use of full size ply sheets or by grinding flush welds or by other accepted method of surface preparation. Formwork openings or removable panels shall be provided in vertical forms where necessary for inspection and cleaning.

Oil used on formwork against surfaces to be exposed shall be of a type that will not stain or discoulour the concrete surface.

Formwork bolts shall be designed so that they may be extracted without damaging the surrounding concrete. The embedded part of all form ties shall be located no closer than 50 mm to the surface of the finished concrete. All holes left by form shall be filled with cement grout to match the concrete.

C3.15.2. Formwork Documentation

All relevant construction requirements listed in the project documentation, including the design assumptions and footing design, shall be noted clearly on the formwork drawings. Pre-camber diagrams where required shall be included in the formwork documentation. The formwork drawings shall be sufficiently comprehensive so that erection and inspection can be carried out without reference to any other documentation.

Documentation, as defined in AS 3610, that describe the formwork assemblies to be erected, together with a certification shall be submitted to Sydney Water.

C3.15.3. Submission of Formwork Documentation and Certification

At least Twenty (20) working days prior to the commencement of erection of formwork, the formwork documentation shall be submitted to Sydney Water for acceptance. The documentation shall be certified by a practising Structural Engineer with the relevant experience in the design of formwork.
and a current chartered member of the Institution of Engineers Australia with the relevant experience in the design of formwork.

Submission of formwork documentation and Certificate shall constitute a Hold Point.

C3.15.4. Test Panels

When test panels are required, they shall be designed and constructed in accordance with AS 3610. The method of constructing the test panels shall simulate concreting operations under conditions which reasonably represent the field conditions.

C3.15.5. Removal of Formwork

Formwork shall be removed in such a way and such a time as to achieve the specified characteristics of concrete, prevent damage to the concrete, and maintain safety at all stages of removal. Unless otherwise accepted by Sydney Water in writing, superimposed loads to any part of the structure shall not be applied until the design concrete strength has been achieved.

C3.15.6. Minimum Time for Stripping of Formwork

Unless accepted by Sydney Water in writing, the minimum time for stripping of formwork shall be as stated in Table 3-6.

Table 3-6 Minimum Time for Stripping of Formwork

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Member</th>
<th>Effective Span, (m)</th>
<th>Form Stripping Time (days) for Average Air Temp, °(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; = 20</td>
</tr>
<tr>
<td>Vertical, Unloaded</td>
<td>Wall, Beam Side</td>
<td>NA</td>
<td>2</td>
</tr>
<tr>
<td>Vertical Load-Bearing</td>
<td>Wall, Column or Load-Bearing Structure</td>
<td>NA</td>
<td>4</td>
</tr>
<tr>
<td>Horizontal Slab</td>
<td>Under 3</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3 to 6</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Over 6</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Horizontal Beam</td>
<td>Under 3</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>3 to 6</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Over 6</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

C3.16. Steel Reinforcement

C3.16.1. General

Unless specified otherwise, steel bars and welded mesh reinforcement for concrete shall be deformed ribbed bars Grade 500N to AS 4671.

Manufacturers and processors of steel reinforcement shall hold a valid certificate of approval issued by the Australian Certification Authority for Reinforcing Steel (ACRS) or by an equivalent certification body accepted by Sydney Water. Sydney Water shall be provided with all the necessary certification documentation prior to the delivery of any reinforcement.

C3.16.2. Protective Coating

Unless otherwise specified, reinforcement with protective coating shall not be used.
C3.16.3. Fabrication and Bending

All reinforcement shall be fabricated to the shape and dimensions shown in the drawings and within the tolerances specified in AS 3600.

Reinforcement shall not be straightened or bent again on site once having been bent, unless specific details have been accepted by Sydney Water in writing in advance, in which case only "cold" bending shall be permitted. Reinforcement already bent and straightened or bent in the reverse direction shall not be bent again within 20 diameters of the previous bend. Reinforcement partially embedded in concrete and bent again, shall be cleaned thoroughly and free of any mortar before depositing concrete against it. Specific details shall be forwarded to Sydney Water for acceptance at least forty eight (48) hrs before commencing any straightening or re-bending location of Splices

Splices in reinforcement shall be made as shown in the drawings. Additional splices or splices at other locations shall require the acceptance of Sydney Water.

Mechanical splices shall be the type specified or accepted by Sydney Water. The installation of splices shall be in accordance with the manufacturers' recommendations. When tested in accordance with AS 1391, mechanical splices shall develop the nominal ultimate tensile or compressive strength of the bar being tested.

C3.16.4. Welding of Reinforcement

Reinforcement in structures shall not be welded unless they are of a weldable grade. Welding procedure shall conform to the manufacturer's recommendations for control of heat input. Where Grade 500 L is welded, it shall be demonstrated or documentary evidence shall be provided to Sydney Water that the welding procedure does not result in the loss of ductility. Grade 500L reinforcement shall not be field welded.

Welding of reinforcement for prestressed members shall not take place after the prestressing tendons have been placed in the reinforcement assemblies or cages being assembled.

C3.16.5. Storage of Reinforcement

Steel reinforcement shall be stored above the ground surface and protected from damage and deterioration due to exposure.

C3.16.6. Surface Condition of Reinforcement

At the time concrete is placed, it shall be clean, free from mortar, rust, mill scale, oil, grease and other non-metallic coating that can impair its bond to concrete or its performance in the member.

C3.16.7. Support of Reinforcement

Reinforcement shall be supported on bar chairs or spacers of adequate strength and of a shape appropriate to the location or concrete bar chairs of the same concrete quality as the concrete element.

Bar chairs and spacers shall be adequate to withstand construction traffic and shall be spaced sufficiently close to maintain the reinforcement in its correct position. Bar chairs shall be placed not more than 800mm apart for bars and 500mm apart for mesh.

C3.16.8. Assembly of Reinforcement

Reinforcement shall be fixed within the tolerances set out in Clause 19.5 of AS 3600.

All intersecting bars shall be tied together with annealed steel wire having a diameter of not less than 1.2 mm, and the ends of the wires shall be turned into the main body of the concrete so as not to project into the concrete cover. All stirrups and ties shall be tied to all main reinforcement at every bar intersection.

Where bundled bars are specified, they shall be tied together at maximum centres of 12 times the diameter of the smallest bar in the bundle so that the bars are in closest possible contact.
Bar chairs on moisture barriers or membranes shall be placed on a metal or plastic plate to prevent damaging the membrane.

**C3.17. Anchors and Holding Down Bolts**

All permanent drill-fixed anchors and holding down bolts in concrete structures shall be of the type shown in the drawings or as nominated in Table 5-1.

Drilled fixed anchors shall be of chemical or non-expansion type. Anchors and holding down bolts shall not be heated or welded after installation.

**C3.18. Shotcreting**

**C3.18.1. General**

Unless accepted by Sydney, shotcrete shall be applied using the wet mix process.

**C3.18.2. Equipment**

The type and capacity of the proposed shotcrete equipment shall have performance records of successful application.

Equipment shall be capable of allowing the shotcrete to leave the nozzle in a continuous uninterrupted stream. Equipment shall be capable of achieving the required level of compaction and quality whilst minimising rebound and overspray.

Delivery hoses shall have an internal diameter of at least 1.33 times the maximum length of fibres to be used or five times the maximum size of the aggregates to be used. Dispensing devices for admixtures added at the nozzle shall be mechanically regulated and have calibrated meters.

**C3.18.3. Applicator**

Application of shotcrete shall only be undertaken by specialist operators experienced in this type of work. A minimum of 14 working days prior to the commencement of shotcreting, full details and relevant experience of the operator shall be submitted to Sydney Water for acceptance. If during the course of the work, Sydney Water determines that the specialist operator is not sufficiently skilled or experienced in the application of shotcrete, acceptance to the use of that operator may be revoked.

Submission of details of the proposed shotcrete applicator shall constitute a Hold Point.

**C3.18.4. Shotcreting**

The procedure, equipment and personnel involved in shotcreting shall produce an end product that is dense, homogenous, without segregation of aggregates or fibres and without sloughing, collapsing, excessive rebound or other visible imperfections. Rebound material shall not be worked into the construction or re-used in the works.

Shotcrete shall be applied in layers not exceeding 150 mm in thickness and with adequate adhesion to the surface or previous layers of shotcrete to prevent sagging or slumping.

The shotcrete shall emerge from the nozzle in a steady, uninterrupted flow. Where the flow becomes intermittent for any reason, it shall be directed away from the works until it becomes constant.

The distance of manually held nozzles from the receiving surface shall be between 0.5 m to 1.0 m. Nozzles shall be held perpendicular to the receiving surface, except where necessary an angle of up to 30° to the vertical may be permitted.

For vertical and near vertical surfaces, application of shotcrete shall commence at the bottom of the surface with full thickness applied before applying any shotcrete overhead.

If shotcreting is terminated for any reason, the hardened concrete surface shall be prepared in accordance with this specification before shotcreting is resumed.
C3.18.5. Placing Around Reinforcement

The nozzle shall be held at a distance and angle that will enable shotcrete to be sprayed behind the mesh before any material is allowed to accumulate on its face.

Shotcrete shall not be sprayed through more than one layer of reinforcement in one application unless preconstruction trials have demonstrated that the reinforcement will be properly encased.

C3.18.6. Trial of Shotcrete Mix

Prior to commencing construction, test panels shall be prepared by the operator on site and test results provided to Sydney Water for acceptance.

The test panels shall be at least 1200 mm x 1200 mm, orientated identical to the works and include reinforcement identical to the actual works.

Four core samples shall be extracted and tested for compressive strength at 7 and 28 days by a NATA approved laboratory.

Where it can be shown that same materials, mix designs, equipment, procedures and personnel have given satisfactory results in other similar works, Sydney Water may at his discretion allow shotcrete being placed in the Works concurrently with the trailing of the test panel.

C3.18.7. Quality Control Tests

Two 25mm diameter full depth cores shall be extracted at right angles to the surface for every 75m² of shotcrete surface at locations nominated by Sydney Water to determine the actual thickness of concrete.

Two 50mm diameter cores of sufficient depth shall be extracted for every 75m² of shotcrete surface approximately 48 hours after the area has been sprayed. One core shall be tested for compressive strength at 7 days and other at 28 days by NATA approved laboratory.

C3.19. Repairs to Concrete

C3.19.1. General

All faulty concrete work and cracks exceeding the limits in this specification shall be rectified. The finish and appearance of the repaired sections shall match the adjacent sound concrete.

At least twenty (20) working days prior to commencing any rectification works, proposal detailing non-conforming areas, extent of areas to be repaired and the proposed methodology for repairs including details of repair materials, data sheets, performance, safety, application and testing procedures shall be submitted to Sydney Water for acceptance. If required by nominated Sydney Water, the proposal shall be certified by a structural engineer with the relevant experience that the repaired structure will meet the designed performance, life and durability requirements.

C3.19.2. Surface Preparation of Faulty Concrete Work

Areas of concrete scheduled for repairs shall be prepared prior to the application of the repair materials.

In areas of spalling or areas which require reforming, surface preparation of concrete shall include removal of all loose, cracked, drummy or softened concrete to ensure the prepared surface is comprised of exposed aggregate and sound concrete. The cleaning shall include the use of portable hand held percussive tools such as "scabblers" and "needle guns".

To avoid feathered edges, the area to be repaired shall be power saw cut around its perimeter to a depth of 10 mm. The saw cutting of the repair area shall be formed by straight lines so that the edges of the repair area are parallel to the general outlines of the structure adjacent to the repair. The width of the saw cut shall be made so that the width of the saw cut is greater at the base of the cutout than at the surface to provide a keying action. Concrete shall be removed so that the repair area is at all points at least 10 mm deep.
C3.19.3. Patch Repairs
Patch repairs shall be carried out to reinstate the areas of defective concrete to the original surface profile.

The patch repair material shall be polymer modified cementitious mortar having a drying shrinkage strain of not more than $400 \times 10^{-6}$ at 56 days.

The repair material shall be compatible with the existing surface in terms of minimum differential shrinkage to prevent cracking.

The prepared concrete surface to be patched shall be soaked with clean fresh water, allowed to dissipate and then primed with a priming agent which will enhance bonding and prevent excessive loss of moisture into the substrate below. While the primer is still tacky the repair material shall be applied without voids and compacted to obtain a uniform consistency. In deeper sections the repair material shall be built up in layers as required to eliminate slumping. The mortar shall be cured by moist curing for a minimum period of four days. All work shall be carried out strictly in accordance with the manufacturer’s instructions.

The colour of the final layer of repair mortar and the texture of the surface finish including board marking shall match the cleaned surfaces adjoining the repair.

C3.19.4. Crack Repairs by Epoxy Injection
All cracks that exceed the limits in this specification shall be repaired by epoxy injection.

The epoxy adhesive used for injection shall consist of a two-component structural epoxy adhesive, processed through continuous positive displacement in-line metering and in-line mixing equipment.

Sufficient epoxy adhesive shall be made available prior to the commencement of each crack injection to ensure that it is completed in a single continuous operation.

The locations of all crack injection points shall be designed and certified by the supplier of the epoxy adhesive system as adequate to completely fill the crack and restore the strength of section.

Epoxy injection shall only be carried out by applicators that are approved by the supplier of the system.

Submission of concrete repair methodology including repair products shall constitute a Hold Point.

C3.20. Reinforced Concrete Box Culverts and Open Channels

C3.20.1. Construction of Reinforced Concrete Box Culverts Using Precast units

Construction of base slabs for the precast concrete box units shall be to the details shown on the drawings. Unless noted otherwise on the drawings, base slabs of box culverts using precast units shall be cast-in place reinforced concrete, cast on a blinding layer of 50mm thick plain concrete.

Precast units crown units shall be installed in accordance with the details shown on the drawings. Where not shown on the drawings, units shall be installed in accordance with AS 1597.

After the installation of the precast crown units, the transverse joint between the adjacent units all around shall be sealed with 250mm wide self adhering membrane of rubberised asphalt integrally bonded to polypropylene mesh (eg Bituthene or accepted equivalent) of minimum thickness of 1.6mm, unless shown otherwise on the drawings.

Lifting holes shall be plugged with cementitious repair mortar to prevent the ingress of materials. Protruding lifting hooks shall be ground back to at least 5 mm below the surface and the recesses shall be filled with epoxy.
C3.20.2. Tolerances

Box culverts and open channels shall be constructed to the tolerances specified Table 3-7

<table>
<thead>
<tr>
<th>Component</th>
<th>Attribute</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box culverts and open channels</td>
<td>Location in Plan</td>
<td>Within 200 mm of the plan position shown on the drawings or specified at any point</td>
</tr>
<tr>
<td>Precast concrete box units</td>
<td>Step between units</td>
<td>On the internal faces of floor of adjacent units 5 mm. On the internal faces of walls and roof 20 mm</td>
</tr>
</tbody>
</table>

C3.20.3. Inspection

On completion of the works, a visual inspection of the box culverts and open channels or arrange for closed circuit television (CCTV) inspections of all box culverts with dimensions that restrict human access, shall be carried out to verify that the works have been constructed within the specified tolerances, free of any waste construction material left inside and to check for visible signs of defect.

A report of these inspections and any nonconformity detected along with the video recording taken during CCTV inspections shall be submitted to Sydney Water.

The inspection and reporting shall be in accordance with WSA 05- Conduit Inspection Reporting Code of Australia.

C3.21. Hydrostatic Testing of Liquid Retaining Structures

All liquid retaining structures other than stormwater channels and culverts shall be hydrostatically tested for leakage.

Testing shall take place prior to placing of backfill around each structure and prior to placing concrete benching, mortar toppings and tiling.

Prior to carrying out the hydrostatic tests, remove all debris from the structures; install temporary blank flanges, plugs or caps on pipework cast through concrete walls; seal with temporary covers any openings in the concrete below top water level and generally ensure that each structure is watertight and ready for testing.

Supplying water for the hydrostatic testing, a supplying and installing pumps and pipes to transfer the water and to empty the structures on completion of the hydrostatic tests shall form part of the contract.

The structure shall be cleaned and initially filled with water at a uniform rate not greater than 2 m in 24 hours. The water level shall be maintained for a stabilizing period of 7 days to allow for absorption and autogenous healing of the concrete. After the stabilizing period, the water level shall be recorded at 24-hour intervals for a test period of 7 days. During this 7-day test period, the total permissible drop in level, after allowing for evaporation and rainfall (if the structure is uncovered) shall not exceed 1/500th of the average water depth of the full tank or 10 mm, whichever is the less.

No repair works shall be carried until the repair methodology and the repair materials have been accepted by Sydney Water. No backfilling around the structure shall take place until these requirements are all met.

Upon completion of the test, the structure shall be emptied and the water disposed of to the satisfaction of Sydney Water. If there is a need to discharge water to the environment, Sydney Water Standard Operating Procedure (SOP) WPIMS 502 shall be followed.

The submission of hydrostatic test results shall constitute a Hold Point for backfilling and commissioning.
Prior to commissioning the tank, the procedures and acceptance criteria detailed in Sydney Water Standard Operating Procedure (SOP) WPIMS5261 shall be followed.

C3.22. Hold Points

A summary of hold points identified for concrete works are listed in Table 3-8 below.

**Table 3-8  Summary of Hold Points for Concrete Works**

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP1</td>
<td>Acceptance of concrete mix design</td>
<td>Concrete mix design &amp; test certificates</td>
<td>C3.6.5</td>
</tr>
<tr>
<td>CHP2</td>
<td>Erection of formwork</td>
<td>Formwork documentation &amp; certification</td>
<td>C3.15.3</td>
</tr>
<tr>
<td>CHP3</td>
<td>Placement of concrete</td>
<td>Submission of conforming formwork, Reinforcement fixing &amp; embedment</td>
<td>C3.8.8</td>
</tr>
<tr>
<td>CHP4</td>
<td>Placement of concrete</td>
<td>Notification of construction joint preparation</td>
<td>C3.13.2</td>
</tr>
<tr>
<td>CHP5</td>
<td>Concrete repair methodology</td>
<td>Non-compliance crack mapping</td>
<td>C3.14</td>
</tr>
<tr>
<td>CHP6</td>
<td>Concrete repairs</td>
<td>Concrete repair products &amp; Repair Methodology</td>
<td>C3.19.1</td>
</tr>
<tr>
<td>CHP7</td>
<td>Shotcreting</td>
<td>Applicator credentials</td>
<td>C3.18.3</td>
</tr>
<tr>
<td>CHP8</td>
<td>Repairs &amp; backfilling</td>
<td>Test results of hydrostatic testing</td>
<td>C3.21</td>
</tr>
</tbody>
</table>
C4. Pipe Laying

C4.1. General

C4.1.1. Introduction

Where applicable, all pipelines and ancillary appurtenances including supports, fittings and valves shall comply with the requirements of the following codes of practice and Australian Standards:

- Water Services Association of Australia – Polyethylene Pipeline Code WSA 01
- Water Services Association of Australia – Vacuum Sewerage Code of Australia WSA 06
- Water Services Association of Australia – Pressure Sewerage Code of Australia WSA 07
- Australian Standard 2566 Buried flexible pipelines Parts 1 and 2

All pipes and materials including joint seals, flange gaskets, O-rings and jointing lubricants for use in contact with drinking water shall comply with the requirements of AS 4020.

C4.1.2. Survey and Setting out for Pipelines

Unless otherwise specified, all necessary setting out to dimensions and levels shown in the drawings as specified in C1.6 shall be done.

C4.2. Referenced Documents

The documents referred to in this specification are:

**Australian Standards:**

- AS 1254 PVC pipes and fittings for storm and surface water applications
- AS 1260 PVC-U pipes and fittings for drain, waste and vent application
- AS 1281 Cement mortar lining of steel pipes and fittings
- AS 1477 PVC pipes and fittings for pressure applications
- AS 1554 Structural steel welding
- AS 1579 Arc-welded steel pipes and fittings for water and wastewater
- AS 1646 Elastomeric seals for waterworks purposes
- AS 1741 Vitrified clay pipes and fittings with flexible joints – Sewer quality
- AS 2032 Installation of PVC pipe systems
- AS 2129 Flanges for pipes, valves and fittings
- AS 2239 Galvanic (sacrificial) anodes for cathodic protection
- AS 2280 Ductile iron pipes and fittings
- AS 2528 Bolts, stud bolts and nuts for flanges and other high and low temperature applications
- AS 2566.1 Buried flexible pipelines Part 1: Structural Design
- AS 2566.2 Buried flexible pipelines Part 2: Installation
- AS 2832.1 Cathodic protection of metals – Pipes and cables
AS 3571.1 Glass filament reinforced thermosetting plastics (GRP) systems based on UP resin. Pressure and non-pressure drainage and sewerage (ISO 10467:2004, MOD)

AS 3571.2 Glass filament reinforced thermosetting plastics (GRP) systems based on UP resin. Pressure and non-pressure water supply (ISO 10639:2004, MOD)

AS 3680 Polyethylene sleeving for ductile iron pipelines

AS 3681 Guidelines for the application of polyethylene sleeving to ductile iron pipelines and fittings

AS 4020 Testing of products for use in contact with drinking water

AS 4058 Precast concrete pipes (pressure and non-pressure)

AS 4087 Metallic flanges for waterworks purposes

AS 4129 Fittings for polyethylene (PE) pipes for pressure applications

AS 4130 Polyethylene (PE) pipes for pressure applications

AS 4131 Polyethylene (PE) compounds for pressure pipes and fittings

AS 4321 Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings

AS 4441 Oriented PVC (PVC-O) pipes for pressure applications

AS 4765 Modified PVC (PVC-M) pipes for pressure applications

AS 4832 Cathodic protection – Installation of galvanic sacrificial anodes in soil

Sydney Water:

WPIMS5027 Sydney Water Standard Operating Procedure (SOP) – Disinfecting New Water Mains

WPIMS5021 Sydney Water Standard Operating Procedure (SOP) – Discharge Protocols

ACP0166 Sydney Water’s Supplement to WSA 201

Water Services Association of Australia:

WSA 01 Polyethylene Pipeline Code

WSA 02 Sewerage Code of Australia, (Sydney Water Edition)

WSA 03 Water Supply Code of Australia, (Sydney Water Edition)

WSA 04 Sewage Pumping Station Code of Australia, (Sydney Water Edition)

WSA 06 Vacuum Sewerage Code of Australia, (Sydney Water Edition)

WSA 07 Pressure Sewerage Code of Australia, (Sydney Water Edition)

WSA109 Flange gaskets and O-rings

WSA113 Reinforced Concrete Pipes with Flexible Thermoplastic Linings

WSA PS-350 Compaction Sand for Pipe Embedment

WSA PS- 351 Processed Aggregates for Pipe Embedment

WSA PS- 352 Controlled Low Strength Materials (CLSM) for Pipe Embedment

WSA 201 Manual for Selection and Application of Protective Coatings

ASTM International:

ASTM F1962 Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
C4.3. Pipe Materials
C4.3.1. General
All water pipelines and sewer systems shall be designed and constructed for a design working life of at least 100 years for which they are used for their intended purpose with normal maintenance but without major repair being necessary.

Pipe materials for pipelines shall generally be as follows, or as stated in the drawings:

<table>
<thead>
<tr>
<th>Category</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water</td>
<td>DI, Steel, PVC, GRP, PE</td>
</tr>
<tr>
<td>Sewer</td>
<td>VC, PVC, GRP, PE, DI, Reinforced Concrete (Plastics-lined)</td>
</tr>
<tr>
<td>Stormwater Drains</td>
<td>Reinforced Concrete, VC, PVC, GRP</td>
</tr>
</tbody>
</table>

The name of the manufacturer, technical details and certificates of compliance including testing reports indicating conformance to the relevant standards, shall be submitted to Sydney Water for acceptance.

C4.3.2. Steel Pipes
Steel pipes and fittings shall comply with the requirements of AS 1579.

Cement mortar lining shall comply with the requirements of AS 1281.

Unless otherwise stated in the drawings, external coating shall be fusion- bonded medium density polyethylene to AS 4321. Steel pipes encased in concrete may be uncoated externally.

C4.3.3. Ductile Iron Pipes
Ductile iron (DI) pressure pipes and fittings shall be Series 2 – Cast Iron Outside Diameter pipes complying with the requirements of AS 2280. Unless otherwise stated in the drawings, pipes shall be externally coated with bituminous or synthetic resin coating and shall be cement mortar lined.

Cement mortar lining shall comply with the requirements of AS 1281.

C4.3.4. Polyethylene Pipes
Polyethylene (PE) pressure pipes shall PE100 Series 1 pipes complying with the requirements of AS 4130 and AS 4131. Unless otherwise specified, the minimum pressure rating to be used shall be PN16.

PE fittings shall be moulded complying with the requirements of AS 4129.

The use of polyethylene pipeline systems shall generally be in accordance with WSAA Code of Practice WSA-01 – Polyethylene Pipeline Code. PE pipes for pressure or gravity sewerage applications shall be internally debeaded.

C4.3.5. GRP Pipes
Glass reinforced plastic (GRP) pipes shall comply with the requirements of AS 3571.1 (ISO10467) for drainage and sewerage use, and AS 3571.2 for water supply use. Unless otherwise specified, the minimum pressure rating to be used shall be PN16.

GRP fittings shall not be used without the acceptance of Sydney Water.

C4.3.6. PVC Pipes
Unless otherwise specified, the minimum pressure rating to be used shall be PN16.

PVC pressure pipes and fittings for pressure applications shall be Series 2 – Cast Iron Outside Diameter (CIOD) series complying with the requirements of AS 1477.

PVC non-pressure pipes and fittings for drainage application shall comply with the requirements of AS 1254.
PVC-U pipes and fittings for drain, waste and vent applications shall comply with the requirements of AS 1260.

PVC-O pipes shall be Series 2 – Cast Iron Outside Diameter (CIOD) series complying with the requirements of AS 4441. Minimum material class shall be Class 450.

PVC-M pipes shall be Series 2 – Cast Iron Outside Diameter (CIOD) series complying with the requirements of AS 4765.

The installation of PVC pipeline systems shall in general be in accordance with AS 2032.

**C4.3.7. Vitrified Clay Pipes**

Vitrified clay (VC) pipes and fittings shall comply with the requirements of AS 1741.

**C4.3.8. Concrete Pipes**

Precast concrete pipes for pressure and non-pressure applications shall generally comply with the requirements of AS 4058.

Reinforced concrete pipes with flexible thermoplastic lining sheet for the purpose of protecting the concrete from corrosion in aggressive sewage environment shall comply with the requirements of WSA 113.

**C4.4. Joints**

Rubber ring and mechanical couplings shall be made using elastomeric gaskets and O-rings to affect the pressure seal.

Flanges shall be manufactured to the requirements of AS 2129, AS 2528, or AS 4087 as is appropriate for the design pressure ratings. Flanges shall be drilled as stated in the drawings. Gaskets shall comply with the requirements of AS 1646 and WSAA specification WSA109.

Drawings of all joints, showing material type, dimensions and tolerances shall be provided to Sydney Water. Details of any necessary testing reports certifying the performance of the proposed jointing system shall also be supplied when applicable.

**C4.5. Ancillary Structures and Appurtenances**

All ancillary structures and appurtenances such as thrust/anchor blocks, bulkheads, trench stops, trench drainage, special pipe support measures, stop valves, hydrants, air valves, chambers, covers and frames, step irons, main taps, service connection valves and fittings shall comply with the material and dimensional requirements as accepted by Sydney Water.

**C4.6. Pipe Laying and Tolerance**

Pipes and fittings shall be laid true to lines, levels and grades shown in the drawings. Pipe laying shall normally be commenced at the downstream end, with the pipes being laid with their sockets upstream.

Pipelines shall be graded to minimise the use of air valves wherever possible. The grading shall be such that no vacuum or syphoning effects result during normal operation and the Hydraulic Grade Line (HGL) is above obvert of the pipeline at all times.

Pipes shall be laid with the barrels firmly and evenly bedded on the bedding material. Socket holes shall be formed in the bedding material and trench bottom to accommodate pipe sockets, if any, to ensure effective bedding and even bearing along the full length of the pipeline.

Tolerances of as-constructed works for pipelines and associated structures are stated in the WSAA codes of practice and shall be applicable unless otherwise specified in the drawings.
C4.6.1. Adjacent Parallel Pipelines

Adjacent parallel pipelines shall comply with requirements of AS2566.2 as a minimum. Suitable vehicular access to each pipeline within easements/access ways shall be provided. Access provisions and requirements for pipelines for each location shall be included in the Safety in Design Report. Where pipes share a common trench, the centre-to-centre spacing between the pipelines is to be given careful consideration. The minimum spacing requirement shall consider, as a minimum, future operation, maintenance and repair, vehicular access, pipe sizes, distances from nearby structures, construction methodology, loadings and pipe depths. A cross section of all proposed adjacent parallel pipes shall be shown in design drawings.

Site specific purpose designed thrust blocks shall be provided to ensure that all thrust is resisted by natural in situ material having adequate bearing capacity.

Thrust forces for parallel pipelines inside at bends shall be transmitted to the outside trench face without allowing transfer of any part of the inner loading to the outer pipeline. Alternatively, where trench material has low bearing capacity, which would result in impractical sizing, these blocks may be keyed to underlying sub grade or both providing adequate structural capacity is achieved.

C4.7. Work Procedure

Prior to the commencement of pipe laying works, the following shall be submitted to Sydney Water for acceptance:

- Method of excavation and management of groundwater, as specified in Section C2.
- Means of transport and storage of pipes and materials.
- Means of storage of excavated materials and disposal of surplus excavated materials off site, as specified in Section C2.

C4.8. Handling and Storage

Pipes and fittings shall be handled, transported and stored in accordance with the manufacturer’s instructions and in a manner not to damage the pipes, joints, internal linings or external coatings.

Where pipes are to be stacked, they shall be arranged so that the sockets and spigots are not loaded and there shall not be excessive load on the lower layer.

Rubber rings for flexible joints shall be stored in an unstressed condition in a cool and dry place not exposed to direct sunlight.

PVC pipes shall be handled carefully and stored away from direct sunlight.

Before a pipe is lowered into the trench, it shall be thoroughly examined to ensure that the internal lining and the outer coating are undamaged. Where necessary, the interiors of pipes and fittings shall be carefully brushed clean. Any damaged parts of the coating or lining shall, before a pipe is used, be made good as directed by Sydney Water.

Pipe laying shall not commence until the bottom of the trench and the pipe bed have been inspected by Sydney Water.

C4.9. Cutting Pipes

Pipes shall be cut by methods recommended by the manufacturer which provide clean and square cuts of the pipe barrels and of the linings, if any, without damage to the pipes or linings. The ends shall be ground or machined to the required chamfer where necessary.

Concrete pipes shall be cut to a square and even finish without splitting or fracturing the wall of the pipe. Reinforcement shall be cut back flush with the concrete and bare metal protected with a protective coating accepted by Sydney Water.
C4.10. Connections to Existing Pipelines

Before commencement of fabrication of any pipework for the connection, the position and level of the existing pipeline at the proposed connection point must be verified by excavating trial pits. Where the location of the existing pipeline is found different from that shown in the drawings, the Sydney Water shall be informed immediately. Sydney Water shall then assess whether any change in design of the connection is required or not prior to works proceeding.

C4.11. Pipes Built Into Structures

Pipes built into structures shall comply with requirements of AS2566.2. The outside surfaces of all pipes and special castings to be built into structures shall be thoroughly cleaned immediately before installation. Pipes passing through water retaining walls and floors shall, unless shown otherwise in the drawings, be built into the structure in-situ. Shuttering shall be formed closely to the pipe and concrete shall be placed and compacted thoroughly around the pipe and puddle flange, if any.

C4.12. Pipe Embedment and Concrete Encasement

C4.12.1. Embedment Material and Compaction

This section specifies additional requirements of compaction for the embedment material for the requirements specified in Section C2.

Pipework shall be provided with the embedment and support of the type shown in the drawings. Unless otherwise specified, cement stabilised embedment sand shall be 10 mm nominal size. The material and mix proportion shall comply with the requirements of WSA PS-352 for controlled low strength materials (CLSM). The 28-day strength shall be not more than 3 MPa.

The material shall be placed in the excavation up to the level of the pipe barrel and shall be tamped and rammed in layers not exceeding 150 mm thick before compaction, to provide a dense well-compacted bed free from soft spots throughout the length of the pipeline.

After the pipes have been properly bedded, the material shall be carefully placed into the space between the pipe and the sides of the trench to the level specified in the drawings. The material shall be carefully deposited in layers not exceeding 150 mm thick before compaction. The placing and the compaction of the material shall proceed equally on both sides of the pipe.

Pipe embedment materials shall be compacted to the standards shown in Table 4-1.

Table 4-1 Minimum Compaction Standard for Pipe Embedment Materials

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Test Method</th>
<th>Relative Compaction (Density Index) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaction sand or processed aggregates</td>
<td>Standard Compaction AS 1289.5.1.1</td>
<td>70</td>
</tr>
</tbody>
</table>

Flooding shall not be used for compaction.

C4.12.2. Concrete Encasement

Where concrete encasement is used, the concrete shall be placed from one side of the pipe and vibrated into place until it comes out from the other side of the pipe in the trench. The placed concrete shall be in full contact with the underside of the barrel of the pipe throughout its length.

A concrete mix with high slump value (180 – 200 mm) shall be used. The concrete shall be placed in one operation and there shall be no horizontal construction joint.

The pipe shall be anchored against flotation.
C4.13. Trench Fill Materials and Compaction

Trench fill materials shall be selected excavated and backfilled in accordance with requirements specified in Section C2.


Joints shall be made strictly in accordance with the manufacturer's instructions. All equipment, machinery and apparatus recommended by the manufacturer shall be utilised in the assembling joints.

Before making any joints, all jointing surfaces shall be thoroughly cleaned and dried, and maintained in such condition until the joints have been completely assembled. Pipes shall be securely fixed in position to prevent movement during and after the making of the joints.

C4.14.2. Rubber Ring Joints

The rubber rings shall be inspected for flaws before making each joint. Jointing fluid shall be applied in accordance with the manufacturer's recommendation.

Gradual change in alignment or grade shall be made by deflecting pipes at the joints. Deflection shall be affected after the joint is made. The maximum deflection at each joint shall not exceed the manufacturer's recommendation. Bending of pipes is not permitted.

For pipelines of diameter that permit man entry, the joint shall be inspected internally immediately after jointing to ensure the correct joint geometry is achieved.

C4.14.3. Flanged Joints

The flanges shall be correctly positioned and the component parts including any insertion ring and gaskets thoroughly cleaned and dried. Insertion rings and gaskets shall be fitted smoothly to the flange without folds and wrinkles. The faces and bolt holes shall be brought fairly together and the joints shall be made by gradually and evenly tightening bolts in diametrically opposed positions. Flanged joints shall not be encased in concrete.

C4.14.4. Welded Joints on Steel Pipes

Welds for steel pipe joints shall be Category SP (structural purpose) of AS 1554.1. All welding shall be carried out to the requirements of AS 1554.1 in respect of material, safety, workmanship and quality.

The proposed welding procedure shall be accordance with Section 4 of AS 1554.1 and must be submitted to Sydney Water prior to works. The welding procedure and consumables shall be qualified using the specified methods. Records of the results of the qualification tests carried out shall be kept and made available for examination.

A welding supervisor (Clause 4.12.1 of AS 1554.1) must be engaged to supervise all welding carried out by welders. Welders shall be suitably qualified to the requirements of Clause 4.12.2 of AS 1554.1.

A suitably qualified inspector must be used to carry out inspection of the welding works. The inspector shall carry out inspection in accordance with Section 7 of AS 1554.1. All welds shall be inspected by visual scanning and examination.

If required in the drawings or other contract documents, non-destructive examination shall be carried out by personnel holding appropriate certification from the Australian Institute of Non-destructiveTesting.

Welding records shall be maintained and submitted to Sydney Water stipulating that all field welds have been carried out and inspected to the requirements of this specification.
All field-welded joints shall also be inspected by Sydney Water before any protective coating or concrete encasement is placed around the outside of the joint.

C4.15. Corrosion Protection of Pipes and Fittings

All buried ductile iron pipes and fittings shall be protected with polyethylene sleeving complying with the requirements of AS 3680. The application of the sleeving to the pipeline shall be carried out in accordance with AS 3681.

For buried ductile iron flanges with galvanised bolts, the bolts heads and nuts shall be covered with plastic cover caps filled with corrosion prevention paste, and then the flange shall be tape wrapped in accordance with WSA 201 and the Sydney Water Supplement.

Buried steel pipes shall be fusion-bonded PE coated to AS4321, or tape wrapped in accordance with WSA 201 and Sydney Water Supplement. The application of the wrapping system shall be carried out strictly in accordance with the manufacturer's instructions in regard to surface preparation and the application of primer, mastic filler and tape.

Tape wrapping or polyethylene sleeving shall overlap a minimum of 300mm into concrete encasement.

Where specified, the steel pipeline shall be protected by a cathodic protection system. The design and construction of the cathodic protection system shall comply with the requirements of AS 2832.1, AS 2239 and AS 4832.

C4.16. Painting of Pipes and Fittings

The paint coatings shall be applied by a pre-qualified painting contractor holding a Class 3 certificate issued by the Painting Contractors Certification Program (PCCP) and all work shall be performed in accordance with the requirements of WSA 201 and the Sydney Water Supplement.

Where the Works involves the maintenance or removal of paint coatings which contain or may contain lead compounds or other toxic substances, such work shall be undertaken by pre-qualified contractors holding a PCCP Class 5 certificate.

Buried steel pipelines and fittings shall not be painted.

C4.17. Thrust Block Installation

All tees, bends, tapers, valves, end caps and other points in the pipeline where there are unbalanced forces resulting from internal pressure shall be anchored in position by the construction of thrust blocks as shown in the drawings.

Unless otherwise specified in the drawings, Class N25 concrete shall be used for anchor /thrust blocks.

Concrete in anchor and thrust blocks shall be cured for a period of time sufficient to achieve the required strength before being subject to any thrust load.

C4.18. Maintenance holes, Valves Chambers and Ancillary Structures

C4.18.1. General

Pipes shall be built into the walls of the maintenance hole to ensure watertightness. Bases and benching shall be formed as shown in the drawings. Benching shall be rendered and trowelled smooth and shall slope towards the main channel at a slope of 1 in 12, or as shown in the drawings.

Maintenance hole covers and frames shall be fixed in the positions shown in the drawings. The frames shall be solidly bedded in epoxy mortar so that the covers when in position are fair and even with the adjacent surfaces. Frames shall be bedded on the top of cast-in-situ concrete sections or on courses of brickwork, as is shown in the drawings.
C4.18.2. Sewer Maintenance holes
Concrete maintenance holes shall be constructed as shown in the drawings. Concrete maintenance holes shall be suitable for use in aggressive environment and in particular shall resist hydrogen sulphide attack.

Precast concrete maintenance holes, where accepted by Sydney Water, shall be set on cast in-situ concrete base with all the sections stacking together with tongue and groove joints. All joints shall be sealed with an elastomeric ring, epoxy mortar or sealing compound recommended by the precast manufacturer to ensure the watertightness of the maintenance holes. The sealing compound shall be applied in accordance with the manufacturer’s instructions. The top concrete eccentric conical section or precast concrete cover slab shall be bedded on the topmost concrete section and effectively sealed from water entry.

Precast concrete segmental construction shall not be used in water-charged ground, in road reserve with possible vehicular traffic loadings, and shall not be deeper than 6 m to the invert.

C4.18.3. Corrosion Protection of Concrete Maintenance Holes
Internal corrosion protection in the form of approved plastic liners or epoxy coating suitable for use in corrosive sewer environment shall be provided for all maintenance holes on trunk sewers (DN375 and above), all rising main discharge maintenance holes, and the two maintenance holes downstream of the discharge location.

C4.19. Thrust Boring
Bores shall be designed to accommodate the carrier pipe based on the alignment, grade and level as shown in the drawings. Prior to commencement of work, the proposed method statement including design drawings and calculations, machinery and equipment used and working procedure shall be submitted to Sydney Water.

For pressure pipelines, the construction tolerance shall be within ±75mm on the line and grade at any point along the route shown in the drawings.

The boring method shall incorporate a system that will allow tracking of the boring equipment for the entire length of the bore or at any section deemed critical by Sydney Water. The system shall be capable of measuring the elevation, azimuth and gradient of the bore path.

Set-out and alignment survey marks shall be placed and maintained during construction for verification of the alignment of the works at any time. These shall be transferred to the working area as required to ensure correct alignment of the invert of the completed pipeline.

Logs shall be kept containing the dates, times and location, soil conditions, data such as depth, grade and rate of penetration and utility crossings.

Computer data sheets from survey, guidance and control systems shall also be maintained. These boring/drilling logs and data sheets shall be made available to Sydney Water for inspection during the progress of work. On completion of the works, these records shall be submitted to Sydney Water.

All care shall be taken to control, contain and manage the effects of the ingress of any ground water. Remedial treatment of joints, fractures and any other defects in the soil strata shall be undertaken in the event of drilling fluid loss.

Cavities behind casing pipes resulting from over excavation or the removal of boulders shall be filled with grout injected under pressure into the cavities through holes bored in the encasing pipe.

All reasonable precautionary measures shall be taken to avoid damaging the conveying pipe during installation. During installation, the installation force shall be controlled to avoid overstressing the conveying pipe. Once any section of pipe is completed it shall be capped off to prevent entry of personnel or debris, until the adjacent section is ready for connection.
The proposed grouting procedures shall be submitted to Sydney Water. It is required to demonstrate that the proposed grout mixture(s) meet the requirements of this specification and shall include the provision of material data sheets for the proposed grouting materials to be used. The method to achieve the grouting at the specified locations shall ensure complete filling of the annulus and shall be subject to the review and acceptance of Sydney Water. Records shall be maintained of all grouting operations, which shall include but not be limited to the location of all grout lines, volume of grout pumped, grouting pressures, commencement and completion times and grout mixture details. One copy of this record is to be submitted to Sydney Water at the completion of each day that grouting is undertaken.

The grout composition shall ensure that the following properties are attained:

- The grout shall provide an effective stoppage of water ingress and create a permanent seal between the borehole and the conveying pipe.
- The grout shall not undergo any shrinkage.
- The grout shall be of a low-heat characteristic during the curing stage.
- The cured grout shall be impermeable and not develop micro cracks and paths for water flow.
- The adhesive properties of the grout shall ensure no shear movement exists between the borehole and the grout and the conveying pipe and the grout.
- The grout shall remain structurally sound over the long term.
- The grout composition shall allow for ease and confidence of placement at the required location.
- The grout composition shall have no adverse effect on the conveying pipe.
- The grout shall be compatible with the site conditions and be environmentally harmless.

Boring fluids to be used shall be environmentally sound and bio-degradable.

Extreme care shall be taken in minimising the loss of drilling fluids into the ground or the environment. Returned fluids shall be properly contained, reclaimed and recirculated. Precautionary measures shall be undertaken to minimise the impact of any inadvertent spillage of fluids on return or at exit of the drill hole. The mixing, storage, and use of boring fluids shall be managed so as to prevent spillage to the environment. Boring fluid shall be disposed of off-site in a manner acceptable to the authorities.

Any failed bore that cannot be salvaged shall be plugged and cement grouted.

C4.20. Horizontal Directional Drilling

The bore shall be designed and constructed to accommodate the carrier pipe based on the alignment, grade and level as shown in the drawings.

The bore design shall be submitted to Sydney Water for acceptance and shall contain the following:

- The size of the bore.
- The path and location in plan and elevations of the bore.
- The coordinates and reduced levels of the bore at entry and exit.
- Location of underground services.
- Entrance and exit angles, bend radius, setback distances.
- Type and size of drill pipe to be used.
- Details of any temporary or permanent casing pipes that may be required to support the bore.
- Calculations demonstrating carrier and casing pipes are capable of withstanding all temporary loads in accordance with ASTM F1962.
The structural strength of the carrier pipe shall be checked for installation in the proposed bore profile and shall withstand all temporary loads during installation, which shall include but be not limited to the following:

**Pre-installation Loads**
- Hydrostatic test loads.
- Self weight spanning between supporting rollers.

**Installation Loads**
- Bending stresses due to radius of curvature.
- Stresses due to frictional drag within the hole, ground surface and bends.
- Stresses due to frictional drag between pipe and drilling fluid.
- Stresses due to frictional drag between pipe and side of hole.
- Stresses due to torsional force.
- Hydrostatic load due to groundwater, etc.
- Earth overburden loads.
- Loads resulting from drilling fluid and/or grouting, if any.

All precautionary measures must be taken to avoid damaging the conveying pipe during installation. During installation, the installation force shall be controlled to avoid overstressing the conveying pipe. Once any section of pipe is completed it shall be capped off to prevent entry of personnel or debris, until the adjacent section is ready for connection.

Prior to commencement of work on site, a drilling procedure and method statement shall be developed and submitted to Sydney Water.

The drilling method shall incorporate a system that will allow tracking of the drilling equipment for the entire length of the bore or at any section deemed critical by Sydney Water. The system shall be capable of measuring the elevation, azimuth and gradient of the bore path.

Set-out and alignment survey marks shall be placed and maintained during construction for verification of the alignment of the works at any time. These shall be transferred to the working area as required to ensure correct alignment of the invert of the completed pipeline.

Logs shall be containing the dates, times and location, soil conditions, data such as depth, grade and rate of penetration and utility crossings.

Computer data sheets from survey, guidance and control systems shall also be maintained. These boring/drilling logs and data sheets shall be made available to Sydney Water for inspection during the progress of work. On completion of the works, these records shall be submitted to Sydney Water.

The allowable tolerance for the final position of the carrier pipe shall be:
- Tolerance from Target.
  The centre of the finished bore at the exit shall lie within a 1.0 metre diameter circle centred on the designed target.
- Tolerance from Grade
  Reasonable care shall be taken to achieve the design profile of the carrier pipe. The finished pipeline shall be smooth in grade and shall not have any reversed grade to that of the design grade that could result in ponding of flow.
Care shall be taken to control, contain and manage the effects of the ingress of any ground water. Remedial treatment of joints, fractures and any other defects in the soil strata shall be undertaken in the event of drilling fluid loss.

The proposed grouting procedures shall be submitted to Sydney Water. It is required to demonstrate that the proposed grout mixture(s) meet the requirements of this specification and shall include the provision of material data sheets for the proposed grouting materials to be used. The method to achieve the grouting at the specified locations shall ensure complete filling of the annulus and shall be subject to the review and acceptance of Sydney Water. Records shall be maintained of all grouting operations, which shall include but not be limited to the location of all grout lines, volume of grout pumped, grouting pressures, commencement and completion times and grout mixture details. One copy of this record is to be submitted to Sydney Water at the completion of each day that grouting is undertaken.

The grout composition shall ensure that the following properties are attained:

- The grout shall provide an effective stoppage of water ingress and create a permanent seal between the borehole and the conveying pipe.
- The grout shall not undergo any shrinkage.
- The grout shall be of a low-heat characteristic during the curing stage.
- The cured grout shall be impermeable and not develop micro cracks and paths for water flow.
- The adhesive properties of the grout shall ensure no shear movement exists between the borehole and the grout and the conveying pipe and the grout.
- The grout shall remain structurally sound over the long term.
- The grout composition shall allow for ease and confidence of placement at the required location.
- The grout composition shall have no adverse effect on the conveying pipe.
- The grout shall be compatible with the site conditions and be environmentally harmless.

Grouting shall start at the downstream end of the borehole and shall proceed in a continuous manner. Prior to and during the entire grouting operation, the carrier pipe shall be filled full with water.

Drilling fluids to be used shall be environmentally sound and bio-degradable.

Extreme care shall be taken in minimising the loss of drilling fluids into the ground or the environment. Returned fluids shall be properly contained, reclaimed and recirculated. Precautionary measures shall be undertaken to minimise the impact of any inadvertent spillage of fluids on return or at exit of the drill hole. The mixing, storage, and use of drilling fluids shall be managed so as to prevent spillage to the environment. Drilling fluid shall be disposed of off-site in a manner acceptable to the authorities.

Any failed bore that cannot be salvaged shall be plugged and cement grouted.

C4.21. Testing of Sewer and Maintenance Holes

C4.21.1. General

All testing shall be carried out by firms accredited by NATA. All test results shall be documented and submitted to Sydney Water for acceptance.

C4.21.2. CCTV Inspection

On completion of the works, a CCTV inspection of the completed pipeline shall be carried out in accordance with and to the acceptance criteria stipulated in the WSAA Sewerage Code (Sydney Water Edition).
C4.21.3. Air Pressure and Vacuum Test
Either low pressure or vacuum testing shall be undertaken for all completed sewers to detect points of leakage and potential groundwater infiltration. Testing shall be carried out from maintenance hole to maintenance hole generally after backfilling is completed. Short branch drains shall be tested together with the main line. Long branches shall be tested separately.

For sewers of size DN1500 and smaller, either low pressure air testing or vacuum testing shall be undertaken. The methods and acceptance criteria shall be in accordance with that stipulated in the WSAA Sewerage Code (Sydney Water Edition).

For sewers of size greater than DN1500, every joint of the sewer shall be tested. A joint testing apparatus shall be designed and constructed to enable air pressure or vacuum testing the each joint. The acceptance criteria shall be as stipulated in the WSAA Sewerage Code (Sydney Water Edition).

C4.21.4. Infiltration Test
Where a free-standing groundwater table exists at a level of more than 1.5m above the sewer, or where it is specified in the drawings, an infiltration test shall be undertaken as stipulated in the WSAA Sewerage Code (Sydney Water Edition). The measured infiltration over a 24-hour period shall not exceed 5 litres per mm diameter per kilometre of the test length.

C4.21.5. Ovality Test
Ovality testing shall be undertaken of all flexible sewers in accordance with and to the acceptance criteria stipulated in the WSAA Sewerage Code (Sydney Water Edition).

For flexible sewer of size DN300 or less, this test may be waived if single size granular embedment has been used or where an embedment compaction method has been pre-qualified.

C4.21.6. Hydrostatic Test for Sewer Maintenance holes
All precast concrete and at least 50% of cast-in-situ concrete sewer maintenance holes shall be subjected to vacuum testing after completion of backfilling and the fitting of the cover and frame. Vacuum testing shall be undertaken in accordance with and to the acceptance criteria of the WSAA Sewerage Code (Sydney Water Edition).

C4.21.7. Testing of Plastic Lined Concrete Sewers and Maintenance holes
Visual inspection must be carried out of all surfaces of the lining and weld seams for defects.
All field extrusion welds shall be 100% vacuum tested using a suitably designed vacuum box under a partial vacuum of minus 35 kPa. No leakage or drop in vacuum pressure shall be allowed.

C4.21.8. Testing of Inverted Siphons
Pressure tests for all sewer siphons must be undertaken in accordance with and to the acceptance criteria stipulated in the WSAA Sewerage Code (Sydney Water Edition).

C4.22. Testing of Water and Pressure Mains
C4.22.1. Pressure Testing
Pressure tests must be undertaken for all water mains and pressure mains in accordance with and to the acceptance criteria stipulated in the WSAA Water Code (Sydney Water Edition).

The test pressure shall be as stipulated in the Code, unless stated otherwise in the drawings.
Pressure pipelines shall be tested hydrostatically in sections to prove the structural soundness of the various components and appurtenances including pipes, valves and anchorages, and to prove the watertightness of the pipeline. Tests shall be applied to sections of pipeline generally not exceeding 1 km in length, or such other length as may be appropriate. The pipeline shall be backfilled but the pipe joints shall be left uncovered, unless otherwise agreed by Sydney Water.
Temporary anchor or thrust blocks shall be constructed as required at the ends, bends and branch outlets. All concrete anchor blocks shall have achieved the necessary concrete strength before proceeding with the testing.

**C4.22.2. Disinfection of Water Mains**

Unless directed otherwise by Sydney Water, disinfection of all potable water mains shall be carried out before they are placed into service.

Requirements for disinfection are laid down in Sydney Water’s Standard Operating Procedure (SOP) WPIMS 5027 – Disinfecting New Water Mains, and the WSAA Water Code (Sydney Water Edition).

**C4.22.3. Water for Pressure Testing and Disinfection**

Unless directed otherwise, water for pressure testing and disinfection shall be obtained from Sydney Water’s distribution system.

The total volume of water used for testing and disinfection shall be minimised by re-using water from a completed section of the main in other sections.

Following testing or disinfection the water shall be disposed of in the manner acceptable to all statutory authorities including but not limited to local councils and Department of Environment and Climate Change. The requirements of Sydney Water Standard Operating Procedure (SOP) WPIMS 5021- Discharge Protocols, shall be followed.

Prior to carrying out any testing, a management plan showing how water is obtained, used, reused and disposed of at the end of testing works shall be submitted to Sydney Water.

**C4.22.4. Bacteriological Test**

Bacteriological tests shall be carried out on all new disinfected water mains in accordance with the test procedure and the acceptance criteria stipulated in the WSAA Water Code (Sydney Water Edition).
C5. Structural Steel and Aluminium Works

C5.1. General
This Specification sets out the requirements for the materials, fabrication, shop assembly, marking, packing, handling, transport to the site and erection of steel and aluminium members fabricated from plates and/or rolled sections.

C5.2. Referenced Documents
The documents referred to in this specification are:

- AS 1100  Technical drawing
- AS 1101.3  Graphic symbols for general engineering - Welding and non-destructive examination
- AS 1110  ISO metric hexagon bolts and screws - Product grades A and B (all parts)
- AS 1111  ISO metric hexagon bolts and screws - Product grades C (all parts)
- AS 1112  ISO metric hexagon nuts (all parts)
- AS 1163  Cold formed structural steel hollow sections
- AS 1214  Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread series)
- AS 1237  Plain washers for metric bolts, screws and nuts for general purposes (all parts)
- AS/NZS 1252  High strength steel bolts with associated nuts and washers for structural engineering
- AS 1275  Metric screw thread for fasteners
- AS 1397  Steel sheet and str–p - Hot-dipped zinc-coated or aluminium/zinc-coated
- AS 1554  Structural steel welding (all parts)
- AS 1657  Fixed platform, walkways, stairways and ladders - Design, construction and installation
- AS 1664  Aluminium structures (all parts)
- AS 1665  Welding of aluminium structures
- AS 1674  Safety in welding and allied processes (all parts)
- AS 1721  General purpose metric screw threads
- AS/NZS 1734  Aluminium and aluminium alloys - flat sheet, coiled sheet and plate
- AS 1858  Electrodes and fluxes for submerged-arc welding (all parts)
- AS 1866  Aluminium and aluminium alloys - Extruded rod, bar, solid and hollow shapes
- AS/NZS 2465  Unified hexagonal bolts, screws and nuts (UNC & UNF threads)
- AS/NZS 2728  Prefinished/pre-painted sheet metal products for interior/exterior building applications - Performance requirements
- AS 2812  Welding, brazing and cutting of metals - Glossary of terms
- AS 3635  Unified ISO (inch) screw threads, associated gauges and gauging practice
- AS/NZS 3678  Structural steel - Hot-rolled plates, floorplates and slabs
- AS/NZS 3679.1  Structural steel - Hot-rolled bars and sections
C5.3. Acceptance of Subcontractors

All subcontractors engaged to fabricate and erect structural steel and aluminium shall be specialist subcontractors with experience in the type of work to be fabricated and erected and shall be accepted by Sydney Water.

C5.4. Construction Procedure

A construction procedure shall be developed and must ensure that every part of the structure has sufficient design capacity and is stable under construction loads produced by his construction procedure or as a result of construction loads that are applied. Calculations shall be provided for examinations by Sydney Water if required to justify the adequacy of the structure to sustain any loads and/or any fabrication or construction procedures that he may intend to impose. Temporary bracing and/or propping shall be provided as necessary.
C5.5. Materials

C5.5.1. General

All materials supplied shall comply with standards and specifications shown in the drawings unless otherwise specified.

All supplied structural steel and aluminium shall be manufactured by companies using quality management systems certified to AS/NZS ISO 9001 by a third party accredited by the Joint Accreditation System of Australia and New Zealand. All materials shall comply with the relevant Australian Standards and specifications. A mill certificate with appropriate NATA registration from the material supplier shall constitute documentary evidence of compliance.

C5.5.2. Steel

Structural steel shall comply with AS/NZS 3678, AS/NZS 3679 or AS 1163.

Stainless steel shall be Grade 316L to ASTM A240M and A276. Stainless steel shall be chromium nickel austenitic and not hardenable by heat treatment.

Prefinished and pre-painted sheet metal products shall be of the suitable grade, coating class and surface finish to AS 1397 and AS 2728, as specified.

C5.5.3. Aluminium

Aluminium shall be of the alloy suitable in all respects for the purpose being used and in accordance with AS/NZS 1734 and AS 1866.

Unless specified otherwise, the minimum alloy for structural applications shall be 6061 or 6082 for extruded members, 5251, 5454 or 6082 for sheets and plates and 5251 for roof sheeting.

C5.5.4. Bolted Connection

All metric bolts and nuts shall comply with AS 1110, AS 1111, AS 1112 and AS 1252. The threads shall comply with AS 1275 and AS 1721.

All unified bolts and nuts shall comply with AS/NZS 2465. The thread shall comply with AS 3635.

A flat metal washer shall be fitted under each nut. Washers shall comply with AS 1237.

Bolt lengths shall be such that after joints are made up, the bolts shall protrude through the nuts by a minimum of two full bolt threads, but not more than 15 mm.

As a minimum all bolts for structural steelwork and mechanical equipment shall be Grade 8.8 to AS 1252 or Grade 8 to AS 2465. Commercial bolts and nuts to AS 1111 are not permitted in steelwork, except for connections of purlins and girts and in metalwork.

Unless noted otherwise, bolts, nuts and washers shall be galvanised to AS 1214. Where steelwork is painted, bolts, nuts and washers shall also be supplied with adequate surface preparation and painted on erection.

Grade 316 stainless steel bolts, nuts, screws and washers shall be used where:

- In contact with liquid,
- Buried in ground,
- Cast into concrete,
- Subject to corrosive environment including within 1 km from coastline,
- In dismantling joints, gland joints and couplings,
- For all propriety equipment such as valves, pumps etc.

The following measures shall be adopted to prevent galling of stainless steel fasteners:

- Bolts and nut threads shall be rolled or buffed smooth before installation.
• Nuts shall be hand tightened at low speed to reduce heat generated by friction.
• Nuts shall be tightened with a torque wrench to prevent over-tightening.
• Threads shall be thoroughly coated with a non-corrosive anti-seize compound prior to assembly. If in contact with drinking water, the compound shall satisfy the requirements of AS 4020.
• Where possible, significantly different hardness grade for nuts such as grade 431 shall be used.

All bolts in contact with dissimilar material shall incorporate nylon bushes and washers.

Bolts for connections that are subject to vibration shall incorporate a locknut of the same material and proof load.

C5.5.5. Fasteners

Fasteners in structural steelwork and aluminium include screws (including fully threaded bolt without a nut), rivets, nails and proprietary anchors, bolts, clips and clamps.

Screws and nails shall not be used in members and components of thickness 3mm or more. Screws shall be of Grade 316 to AS 2837 in stainless and aluminium work. Self-tapping and self-drilling screws and nails may be supplied in Grade 316 stainless steel to AS 2837, subject to the acceptance by Sydney Water.

Rivets shall not be used in members and components of thickness 3mm or more. Rivets shall not be used to connect dissimilar metals together. Rivets joining metal parts shall be of the same type of metal.

The use of proprietary anchors, bolts, clips and clamps shall be accepted by Sydney water.

C5.5.6. Selection of Material

Unless otherwise specified in the drawings the selection of material shall be as shown in Table 5-1.

All dissimilar metals shall be isolated from one another by an appropriate material as accepted by Sydney Water.

C5.6. Fabrication

C5.6.1. General

Fabrication shall be carried out off-site to suit the assembly on site by means of bolted connections and pins.

Proper allowances shall be made in detailing and fabrication for the correct fit of joints and components, and also for proper access of wrenches, sockets and other tools for erection.

C5.6.2. Workmanship

Finished steelwork and aluminium shall be true and free from twists, kinks, buckles, open joints or other defects. Accuracy shall be observed throughout to ensure all parts fit together properly on erection. Chipping, sheaving and drilling shall be done accurately.

Before being marked off, straightening of any members shall be done by methods that will not injure the material or member, such as by cold rolling or pressing. Straightening by hammering will not be permitted. In addition, the following requirements apply where flame or heating methods are to be used:

• The temperature of the steel shall not exceed 600°C and the temperature reached shall be recorded.
• Steel shall not be artificially cooled until the temperature of the steel has dropped below 300°C.
• Steel shall not be cooled with solid water jets.
- Aluminium shall not be straightened by heating processes, unless carried out as detailed in Section 6.3 of AS/NZS 1664.2.

- All steelwork that will be exposed to view shall have spatter, flux, dags and burrs removed and all weld profile ground smooth prior to surface preparation.

The completed work shall be free from distortions and true to dimensions. Due allowance shall be made for dimensional changes during welding.
## Table 5-1 Selection of Material

<table>
<thead>
<tr>
<th>Location</th>
<th>Framing Members and Plates</th>
<th>Roof and Wall Sheeting</th>
<th>Holding Down Bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accepted Materials*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stainless Steel</td>
<td>Hot rolled Section</td>
<td>Cold formed Section</td>
</tr>
<tr>
<td>More than 1 km from the coastline</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td>(with appropriate protective coating as per WSA 201)</td>
</tr>
<tr>
<td>Within 1 km from the coastline but remain enclosed</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td>(with appropriate protective coating as per WSA 201)</td>
</tr>
<tr>
<td>Buildings and structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 1 km from coastline generally remain opened or not enclosed</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td></td>
</tr>
<tr>
<td>Buildings and structures</td>
<td>All members in clean water tanks</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td></td>
</tr>
<tr>
<td>Members permanently and periodically submerged in liquid other than clean water</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td></td>
</tr>
<tr>
<td>Members not submerged in liquid</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td></td>
</tr>
<tr>
<td>Tanks and Process Compartments</td>
<td>Members in high corrosive environments</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td></td>
<td>Grade 316</td>
<td>(with appropriate protective coating as per WSA 201)*</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- * unless otherwise specified
- + WSA 201 Manual for Selection and Application of Protection Coatings published by Water Services Association of Australia. WSA 201 must be used together with Sydney Water’s Supplement.
- # High corrosive environments include areas within SPS wet wells and inlet structures of STPs or similar where there is a concentration of gases from the sewage environment.
C5.6.3. Shop Drawings

Shop drawings shall be prepared for the fabrication of all members. These drawings to be verified by suitably experienced personnel other than those directly involved in the drafting of the shop drawings.

Four copies of the shop drawings, certified as complying with the requirements listed below, shall be submitted to Sydney Water at least twenty (20) working days before fabrication commences.

The details shown on the shop drawings shall be consistent with the contract drawings and shall comply with the following:

- The marking plan shall show the locations, as appropriate, of any part of the contract drawings.
- Shop drawings shall conform to AS 1100 as appropriate. Drawings showing only the cutting dimensions of webs, flanges and the like shall not be considered as shop drawings.
- Welding and cutting definitions shall conform to AS 2812.
- Welding symbols shall conform to AS 1101.3.
- Complete information regarding the location, type, category, size and extent of all welds shall be clearly shown on the shop drawings. These drawings shall clearly distinguish between shop and field welds.
- Joints or groups of joints in which it is especially important that the welding sequence and technique of welding be carefully controlled to minimise shrinkage stresses and distortion shall be noted in the drawings. Joints where no welding is permitted shall also be clearly indicated. Weld lengths specified in the drawings shall be the required effective lengths.
- Each member shall be clearly identified with the identification marks shown in the drawings. Each type of component shall be further identified to readily distinguish it from other types.
- For assemblies, all associated bolting, accessories and/or joining details shall be shown on the shop drawings.
- Details shall be shown off all holes and attachments required for temporary work such as formwork and lifting lugs. Methods of sealing all such holes shall be shown. Holes shall include for venting and draining during the galvanising process.

The correctness of the shop drawings shall be verified prior to submitting to Sydney Water. Acceptance of the shop drawings by Sydney Water shall not relieve the responsibilities under the Contract.

The submission of shop drawings shall constitute a Hold Point

Two copies of the "Work as Executed" shop drawings shall be submitted to Sydney Water within fourteen (14) working days of the completion of fabrication and erection of the steel members.

C5.6.4. Assembly and Fabrication Procedure

Details of the procedures for assembly and fabrication shall be submitted to Sydney Water for acceptance at least twenty (20) working days prior to commencing fabrication. These procedures shall be comprehensive and shall cover all aspects of the work. The procedures shall include, but are not to be limited to:

- Assembly procedures, including dimensional control and details of manufacturing jigs.
- Welding procedures.
- Qualification of welds, including stud welding.
- Qualification and identification of welders.
- Qualification of welding supervisors.
- System of identification of welders with work.
• Quality control measures.
• Quality control check lists and forms.
• System for identification of components.
• Procedures for trial assembly.
• Procedures for transport, handling and storage, including measures to prevent distortion and damage to the steelwork and its protective coating.

C5.6.5. Fabrication Tolerances

The general tolerance on all dimensions shall be in accordance with Section 14 of AS 4100 for steelwork and any other relevant standard for metalwork. Holes shall be positioned and aligned such that fasteners can be freely inserted through the members perpendicular to the contact face. Bolt holes that cannot be aligned other than by damaging the structure or any component thereof, including corrosion protection, shall be rectified to the satisfaction of Sydney Water. A structural member shall not deviate from straightness or its intended length by more than that recommended in the relevant sections of AS 4100.

Lengths of components shall be such that cumulative variations do not misalign the completed structure. It shall be ensured that all pieces will correctly fit together on assembly. Curving, bending or shaping shall be even and true to the drawings.

Where tolerances are not specified, the absolute tolerance shall be 2mm.

Member dimensions and camber shall be measured for conformance when all fabrication, welding and heating operations are completed and the member has cooled to a uniform temperature.

C5.6.6. Cutting of Steel

Unless otherwise specified, steelwork may be cut by flame cutting, sawing or shearing. Surfaces produced by such cutting shall be representative of good workmanship, finished square (unless a bevelled edge is called for), true to the required dimensions and free from defects that would impair the service performance or compromise the integrity of subsequent fabrication and protective treatment.

Shearing shall not be used for main plates in fabricated girders and all splice plates except in a direction perpendicular to the direction of their main stresses. Shearing of items over 16mm thick shall not be carried out when the item is to be galvanised and subject to tensile stresses unless the item is subsequently stress relieved. Distortions caused by shearing shall be removed.

Re-entrant corners shall be smoothly rounded to a radius of 20mm.

Unless shown otherwise in the drawings, all corners on exposed edges shall be rounded to a radius of approximately 1.5mm, except where such edges are subsequently to be welded. Rolled edges need not be rounded provided the corners have a similar radius.

The cutting methods shall be suitable for the base product.

Gas torches shall not be used to cut stainless steel components. Mechanical cutting may be used.

Flame cutting shall be carried out wherever possible by machines which are mechanically guided and moved at uniform speed. Hand cutting shall only be used for secondary cuts, hole preparation, repairs and other work where machine cutting is not possible.

Any cut surface to be incorporated in a weld shall comply with AS 1554.1 and the depth of isolated gouges shall not be greater than 2mm.

Flame cutting of plates, sections and other components with surfaces which will be used in the "as-cut" condition, shall be carried out with procedures giving minimum reduction in properties at the cut surface and shall satisfy the requirements given below.
Any cut surfaces to be used in the "as cut" condition shall have a surface quality which will not impair subsequent fabrication and protective coating requirements. Flame cut surfaces may require a light surface grind to render them suitable for subsequent protective coating requirements.

C5.6.7. Cutting Of Aluminium Components

Unless otherwise specified, aluminium work may be cut by plasma-arc cutting, sawing, grinding or shearing. Flame cutting shall not be used.

Surfaces produced by such cutting shall be representative of good workmanship, finished square (unless a bevelled edge is called for), true to the required dimensions and free from defects that would impair the service performance or compromise the integrity of subsequent fabrication and protective treatment.

Grinding shall not be used on surfaces prepared for welding.

Re-entrant corners shall be smoothly rounded to a radius of not less than 3mm.

Unless shown otherwise in the drawings, all corners on exposed edges shall be rounded to remove sharp edges, except where such edges are subsequently to be welded. Rolled and extruded edges need not be rounded provided the corners are not sharp.

Plasma-arc cutting shall be carried out wherever possible by machines which are mechanically guided and moved at uniform speed. Hand cutting shall only be used for secondary cuts, hole preparation, repairs and other work where machine cutting is not possible.

Any cut surface to be incorporated in a weld shall comply with AS 1665.

Plasma-arc cutting of plates, sections and other components with surfaces which will be used in the "as-cut" condition, shall be carried out with procedures giving minimum reduction on properties at the cut surface.

C5.6.8. Splices

Shop splices in the component parts of welded members shall be made before the parts are assembled.

Where splice locations are not shown in the drawings or where splices at locations other than those shown in the drawings are proposed details of the design and position of the proposed splices shall be submitted to Sydney Water at least twenty (20) working days for acceptance prior to fabrication.

The submission of proposed splice details shall constitute a Hold Point.

C5.6.9. Holes for Bolting

Unless otherwise specified, the diameter of boltholes shall be in accordance with the requirements of AS 4100 or AS 1664 as appropriate.

Reamed or drilled holes shall be cylindrical and perpendicular to the face of the member unless otherwise shown in the drawings. Reaming and drilling shall be done by mechanical means.

Connecting parts shall be assembled and held securely while being reamed or drilled and shall be match-marked before separating the parts. All burrs shall be removed. Assembled parts shall be taken apart if necessary.

Where existing holes in cleats have been enlarged due to the removal of corroded materials, bolt sizes are to suit new hole diameters and are to be forwarded to Sydney Water for acceptance prior to bolting. All bolts, other than stainless steel, must be galvanised to a minimum of 75 microns to AS 1214.

C5.6.10. Alignment of Holes

All matching holes in any contiguous group shall register with each other so that a gauge or drift 2mm less in diameter than the holes shall pass freely through the assembled contact faces at right angles to them.

All holes shall be placed accurately regardless of variation in dimensions of rolled sections or tolerances allowed in fabrication.
C5.6.11. Holes for Field Connections

Holes for field connections and field splices of main members shall be reamed or drilled with the members assembled in the shop in their correct relative positions.

All adjoining main members in an assembly shall be assembled before reaming or drilling is commenced. All joints and associated splice plates shall be match-marked before the structure is dismantled.

Holes for field connections of minor members may be reamed or drilled with the members assembled.

C5.6.12. Cambering

Camber in a built-up section shall be obtained by cutting webs to the shapes shown in the drawings.

Cambering of rolled sections and adjustment to the camber in built-up sections shall be carried out to the workmanship requirements of this specification.

C5.6.13. Bending

Bending and forming plates or sections during fabrication shall conform to the manufacturer’s recommendations and/or the relevant Australian Standard.

C5.7. Welding

C5.7.1. General

All welding of structural steel shall be category SP in accordance with the appropriate parts in AS 1554 and this specification unless shown otherwise in the drawings.

Welding of aluminium shall comply with the requirements of AS 1665.

All welding shall be continuous and no intermittent welding shall be permitted.

The completed item shall be free from distortions and true to dimensions. All connections shall be welded in a manner such that the finished connections are neat, smooth in appearance, all sharp edges ground and all projections ground smooth suitable for provision of corrosion protection and aesthetic finishes.

Details of welding procedures shall be submitted to Sydney Water prior to fabrication of members utilising the particular procedure.

C5.7.2. Welding Personnel

Welding of steel and aluminium items shall be carried out by skilled welders possessing the required qualifications to AS 1554 and AS 1665 as appropriate, and qualified in the particular welding procedure, welding position, weld type and weld category.

Welding shall be carried out under the supervision of a competent supervisor possessing the qualifications required by AS 1554 and AS 1665 as appropriate.

Details of the qualifications of all welders, together with details of any qualification tests carried out by those welders shall be supplied to Sydney Water prior to the commencement of welding.

All welders shall have an identification number, and that number shall be marked adjacent to weld runs made by the welder. Identification numbers shall not be stamped into metal.

C5.7.3. Welding Inspectors

Welding shall be inspected by a qualified Welding Inspector with suitable training and experience in the fabrication and inspection of welded structures satisfying the requirements of:

- Clause 7.2 of AS/NZS 1554.1 for structural steel
- Clause 7.2 of AS/NZS 1554.6 for stainless steel
- Clause 7.2 of AS 1665 for aluminium
The Welding Inspector is responsible for ensuring that all welding conforms to the requirements of this Specification.

C5.7.4. Non Destructive Testing (NDT) Technician

All various non-destructive tests (NDT e.g. ultrasonic examination, radiography etc.) shall be carried out by technicians suitably qualified and accredited for carrying out the examination method employed satisfying the requirements of:

- Clause 7.4 of AS/NZS 1554.1 for structural steel
- Clause 7.4.2 of AS/NZS 1554.6 for stainless steel
- Clause 7.4.2 of AS/NZS 1665 for aluminium

Such a technician shall be accredited by the Australian Institute of Non-destructive Testing (AINDT).

The currency of the above qualifications and accreditations shall comply with the requirements of the issuing institution. Lapsed qualifications and accreditations will not be acceptable.

All non-destructive test reports shall be prepared by qualified and accredited NDT technicians, and shall contain the NDT technician’s signature and registration number of the NDT technician’s qualification and accreditation.

C5.7.5. Welding Equipment and Safety

All welding machines and equipment shall comply with AS 1674 and the safety requirements of the relevant Statutory Authorities. The machines and equipment shall be designed, installed, operated and maintained to such a standard that welds can readily be made by the machine operators.

C5.7.6. Welding Consumables

A Maker’s Certificate of Compliance shall be supplied for each batch of consumables used.

C5.7.6.1. Steel

Electrodes used in all manual arc welding shall conform to and be selected in accordance with AS/NZS 4854, AS/NZS 4855, AS/NZS 4856 and AS/NZS 4857.

Electrodes and fluxes for submerged arc welding shall confirm to and be selected in accordance with AS 1858.

Welding consumables shall be stored in a manner, which meets the manufacturer’s recommendations. Low hydrogen electrodes drawn for use by a welder shall be kept in a suitable heated container until used. Unused low hydrogen electrodes shall be returned to storage and re-baked before further use.

The minimum nominal tensile strength of weld metal used shall be 480MPa (e.g. E48xx, W50x etc. or stronger) for all structural steel unless indicated otherwise in the drawings or accepted by Sydney Water.

The use of low-hydrogen electrodes is mandatory for manual welding of shell plates, permanent attachments to the shell plates, fittings and for welds joining the shell plate to the bottom plates of liquid retaining tanks.

C5.7.6.2. Aluminium

Welding consumables shall conform to AS/NZS ISO 18273. Welding consumables shall be selected in accordance with Section 2 of AS 1665 and shall only be used in accordance with the manufacture’s recommendations and AS 1665.

Certification shall be obtained, by a recognised authority satisfying the requirements of AS 1665, that the classification and grade of the welding consumables are suitable for welding the aluminium type nominated in the welding procedures.
C5.7.7. **Alignment**

Members to be welded shall be brought into correct alignment and held in position in such a manner to maintain dimensional requirements and uniform gap. Suitable allowances shall be made for warpage and shrinkage.

C5.7.8. **Surfaces to be Welded**

Surfaces to be welded shall be free of loose scale, slag, heavy rust, grease or other material likely to be detrimental to welding or weld properties. The use of weld through primers shall be permitted, provided that the welding procedure is qualified using similarly primed plate. Surfaces to be welded shall be smooth, uniform and free from fins, tears, or other defects, which adversely affect welding.

C5.7.9. **Tack Welds**

Tack welds may be used to hold edges in correct alignment for welding. Tack welds shall be the same size as the root run to be used in the joint and not less than four [4] times the thickness of the thicker part or 100 mm, whichever is the smaller, in length. Tack welds, which are to be incorporated in the final weld or to remain on the completed structure, shall be subject to the same quality and workmanship requirements as the final welds.

C5.7.10. **Weld Quality**

Welds shall show a good even contour, a good penetration and fusion with the parent metal. The surface of the weld along and across the joint shall be reasonably smooth and free from sharp irregularities, grooves and depressions and shall merge smoothly into the plate surface. Unacceptable welds shall be cut out and replaced or otherwise remedied in a manner accepted by Sydney Water.

C5.7.11. **Defective Welds**

Where welds do not meet the surface finish requirements of this specification, they shall be ground to a smooth surface free from sharp crests, sharp troughs and pits. Care shall be taken not to reduce the weld below the design size and not to overheat the joint or introduce grinding cracks. Sharp edges including shear edges, shall be ground to a radius of curvature of not less than 2mm. Weld spatter not capable of ready removal by subsequent cleaning or blasting shall be removed by mechanical means.

C5.7.12. **Weld Procedure Qualification**

Weld procedures shall be developed to meet the requirements of Section 4 of AS 1554.1 for structural steel. Such procedures shall be fully documented on an approved form as indicated in Appendix C of AS 1554.1, and accompanied by NATA endorsed Test Certificates for any tests required.

Welding procedures of stainless steel structures shall meet the requirements of Section 4 of AS 1554.6. Such procedures shall be fully documented on an approved form as indicated in Appendix C of AS 1554.6.

Welding procedures of aluminium structures shall meet the requirements of Section 4 of AS 1665 and documented on an approved form as indicated in Appendix D of AS 1665.

C5.7.13. **Submission of Qualifications for Acceptance**

Weld qualification test records, weld procedure specification and a weld map, indicating the procedures to be adopted on each welded joint shall be submitted to Sydney Water for acceptance at least twenty (20) working days prior to the commencement of welding.

C5.7.14. **Weld Inspections and Testing**

All welds shall be inspected in accordance with AS 1554.1 for structural steel, AS 1554.6 for stainless steel and AS1665 for aluminium. Non-destructive testing (NDT) of welds shall be carried out by a NATA approved independent inspection authority.

Sydney Water shall be provided access to the fabrication workshops to check records and work progress for the purpose of quality surveillance.
All welds shall be 100% visually inspected for defects.

For structures other than liquid retaining tanks, a minimum of 10% of welds shall be subject to radiographic examination. For liquid retaining tanks, the extent of testing of welds shall be in accordance with Table 5.2.

Time of Flight Diffraction (TPOFD) ultrasonic test method in lieu of radiographic test may be permitted by Sydney Water if the technician and the weld inspector can demonstrate suitable training and experience for the proposed tests.

### Table 5-2 Weld testing requirements for liquid retaining tanks

<table>
<thead>
<tr>
<th>Structural Element</th>
<th>Plate Thickness</th>
<th>Type of Weld Testing</th>
<th>Vertical Joints</th>
<th>Horizontal Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bottom Strake</td>
<td>All Other Strakes</td>
</tr>
<tr>
<td>Elevated Tank</td>
<td></td>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Riser</td>
<td>&gt; 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td></td>
<td>up to 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td>Wall</td>
<td>&gt; 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td></td>
<td>up to 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td>Floor</td>
<td>&gt; 25 mm</td>
<td>Radiographic</td>
<td>NA</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>up to 25 mm</td>
<td>Radiographic</td>
<td>NA</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td>On Ground Tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>&gt; 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>up to 25 mm</td>
<td>Radiographic</td>
<td>100%</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td>Wall/Floor Junction</td>
<td>All</td>
<td>Ultrasonic</td>
<td>NA</td>
<td>100%</td>
</tr>
<tr>
<td>Annular Plate (floor)</td>
<td>All</td>
<td>Ultrasonic</td>
<td>NA</td>
<td>100%</td>
</tr>
<tr>
<td>Floor</td>
<td>All</td>
<td>Ultrasonic</td>
<td>NA</td>
<td>1 spot every 3 m of length</td>
</tr>
<tr>
<td></td>
<td>Vacuum Test To API 650</td>
<td>NA</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

### C5.7.15. Weld Acceptance Requirements

Acceptance requirements shall be as detailed in AS 1554 and AS 1665 as appropriate. The weld surface shall be free from excessive weld ripple and smoothly blended with the plate surface. No weld spatter or welding fume shall be permitted on the weld or adjacent plate surface.

At least twenty (20) working days prior to the commencement of welding, a drawing (developed longitudinal section for reservoirs) detailing proposed non-destructive test locations shall be submitted to Sydney Water for acceptance.

The submission of proposed weld testing shall constitute a Hold Point.

The locations and records of NDT shall be submitted to Sydney Water for keeping on completion of the tests.

### C5.7.16. Defective Welds

Defective welds shall be repaired only with the prior acceptance of Sydney Water. Repairs shall be made using qualified procedures and personnel.
All welds failing the testing shall be rectified prior to hydrostatic test.

C5.7.17. **Passivation of Stainless Steel after Fabrication**

All stainless steel fabrications shall be passivated in accordance with ASTM A360 after all welding has been completed to restore corrosion resistance. Passivating of the welded areas shall be carried out in the fabricator's workshop unless accepted by Sydney Water.

Where passivation on site is unavoidable, it shall be carried out in accordance with the Manufacturer’s instructions. No waste shall be flushed down the existing drainage system, unless diluted or neutralised satisfactorily.

Small items such as nuts, bolts, washers, and screws shall be passivated by immersing them overnight in a plastic bucket containing 15%-20% by volume of nitric acid in water. The items shall be thoroughly rinsed in fresh water before use.

Larger items shall be passivated by coating with a proprietary acid paste such as Sandvik pickling paste or suitable equivalent. The articles shall be coated and left overnight then rinsed thoroughly in clean water. As this product is highly corrosive and gives off fumes, it shall be used in a well-ventilated area and personnel shall use rubber gloves. The manufacturer’s safety precautions on the label shall be carefully complied with.

After passivation, fabricated components shall have a clean, matt finish free from scale and discolouration caused by welding or heating.

C5.7.18. **Handling and Storing Structural Steel**

Care shall be taken in the packing and methods of support and lifting during handling of all structural steelwork to prevent distortion or damage to the steelwork and its protective coating.

All open joint ends and projecting parts shall be protected from damage in transit in such a manner as to stiffen the member and prevent distortion.

All components shall be stored at least 200mm above the ground on platforms, slabs or other supports, and in a manner to minimise the risk of contamination or corrosion. Each stack shall be located so that it is kept free from accumulation of dust, mud or moisture.

Galvanised components shall be transported and stored under dry, well-ventilated conditions to prevent the formation of wet staining in accordance with AS/NZS 4680. A passivation treatment after galvanising shall be used to minimise the wet staining which may occur on articles unable to be stored in well ventilated conditions. Prior to erection, all wet staining shall be removed without damaging the galvanised surfaces.

C5.7.19. **Handling and Storing Stainless Steel**

All stainless steel components shall be packed in such a manner that they are protected from damage during transport. They shall be handled and transported such as to prevent distortion or fracture, and if necessary braced to prevent flexing. Self-adhering protective plastic film shall be used for finishes brighter than dull finish.

Bare steel wire rope slings shall not be used in handling the stainless steel components. Any minor scores or gouges in the stainless steel surface shall be carefully filed down with mild abrasives and finished smooth. Where such rectification cannot be satisfactorily carried out, the item shall be treated as nonconforming.

Appropriate care shall be taken when handling stainless steel before, during and after fabrication to prevent contamination with mild steel materials, dust, shavings, weld splatter and the like. Such care is particularly important after passivation and during transport to site, storage and installation as these small particles rust quickly and discolour the surface of the stainless steel. This can destroy the protective oxide film and render it liable to pitting corrosion.

The following practices shall **not** be used:

- Cleaning with steel wool, wire brushes, emery paper
• Cleaning with abrasive compounds containing chlorides
• Blast cleaning
• Using muriatic (i.e. hydrochloric) acid in combination with solder fluxes as it contains iron.

C5.7.20. Handling and Storing Aluminium

All aluminium components shall be packed in such a manner that they are protected from damage during transport. They shall be handled and transported such as to prevent distortion or fracture and, if necessary, braced to prevent flexing.

Bare steel wire rope slings shall not be used in handling the aluminium components. Any scores or gouges in the aluminium extrusions shall be carefully filed down and finished smooth. Where such rectification cannot be satisfactorily carried out, the item shall be treated as nonconforming.

Each load of aluminium components shall be inspected for damage prior to stacking. All components shall be stored at least 200mm above the ground on platforms, slabs or other supports, and in a manner to minimise the risk of contamination or corrosion. Each stack shall be located so that it is kept free from accumulation of dust, mud or moisture.

Contact between surfaces of adjacent units in a bundle or a stack, shall be prevented by separating the adjacent surfaces with suitable packing.

C5.7.21. Report on Completion of Fabrication

Following completion of fabrication, four [4] copies of a report, which shall include the following documentation, together with any other relevant data required by Sydney Water shall be submitted:

- Completed Inspection and Test Report.
- Material Certificates for plate sections and welding consumables used in construction.
- Weld Procedure Specifications, together with Weld Procedure Test Reports and associated Test Certificates.
- Welder Qualification Reports with Test Certificates.
- Copies of all Inspection Certificates, together with a weld map showing the location of all NDT carried out and the location of any repairs carried out.
- Inspection and Test Report and Inspection Certificates for corrosion protection procedures employed.

The above documentation shall be submitted not more than fourteen (14) working days after completion.

C5.8. Protective Coating

C5.8.1. General

Protective coatings shall generally be carried out in accordance with the requirements of WSA 201 and Sydney Water’s Supplement.

C5.8.2. Galvanising

Items to be galvanised shall be pre-treated in accordance with AS/NZS 4680. Sydney Water shall be notified about the intention to proceed with galvanising in sufficient time to enable it to examine the fabricated steelwork prior to galvanising.

The steelwork fabricator shall drill ventilation and drainage holes in all enclosed components of the structure prior to galvanising. These holes shall be sealed with UV stable nylon or acetal plugs after galvanising.

Structural steelwork, which has been galvanised and coated shall not be drilled. Where cables and pipes are to be fixed to structural steelwork, they shall be fixed to the structural steelwork using clamping systems that do not damage the protective coating.
C5.8.3. Shop and Field Treatment
Proposed details of work to be carried out by shop treatment and that to be carried out by field treatment shall be submitted.
The details shall include a program of the work covering the proposed timing for carrying out protective treatment to the surfaces, which are inaccessible in the completed structure and outside of field welds.

C5.8.4. Containment for Removal of Existing Paint in Field
All surface preparation procedures involving the disturbance of hazardous paint shall be carried out in a containment that prevent emissions of dust and debris to the environment and will allow the collection of all wastes and debris generated by the work.
An appropriate containment systems shall be designed and erected to comply with the requirements of AS 4361.

C5.8.5. General Requirement for Coating Material

C5.8.5.1. Australian Paint Approval Scheme (APAS)
All paints shall be supplied by a single manufacturer and be approved under the relevant APAS Specification. A Certificate of Supply or shall be obtained from the manufacturer to certify that the paints supplied conform to the requirements of the specification.

C5.8.5.2. Delivery of Paints
All coating materials shall be brought to the site in their original, unopened containers, bearing the manufacturer's label, batch number, instructions for application and expiry date where applicable.

C5.8.5.3. Packaging of 2-Pack Paints
The amount of each component of 2-pack paint in the containers shall be proportional to the required mix ratio, so that when complete containers are mixed the paint shall contain the correct proportions of each component.

C5.8.5.4. Storage of Paint
All paint containers shall be stored under conditions that do not lead to deterioration of the paint. Stock rotation shall be employed so that all paints are used in the same sequence as they are received.

C5.8.6. General Requirement for Application of Coating

C5.8.6.1. PCCP Certification
The coatings shall be applied by Sydney Water pre-qualified painting contractors who hold a Class 3 Certificate issued by the Painting Contractors Certification Program (PCCP). Where the work involves the maintenance or removal of coatings that contain lead compounds or other toxic substances, such work shall only be undertaken by pre-qualified contractors holding a PCCP Class 5 Certificate.
Painting Contractors certificates shall be submitted to Sydney Water for acceptance at least fourteen (14) working days prior to commencing any painting work.
The submission of proposed painting contractors shall constitute a Hold Point.

C5.8.6.2. Priming of Bare Steel Surfaces
There is no specified minimum time interval for application of primer to the prepared surface, but the prime coat shall be applied to the blast cleaned surfaces before any surface discolouration has occurred. If discolouration has occurred, the surface shall be lightly re-blasted.
Blast cleaned surfaces shall be free of abrasives and surface dust prior to application of primer. Blowing down to remove spent abrasive, removed paint particles and dust from surfaces shall be carried out under full containment conditions with air extraction as specified above. All surfaces to be primed shall be dry and free of any deleterious liquid.

C5.8.6.3. Climatic Conditions and Recoat Intervals

Unless clearly stated in the manufacturer’s printed technical data sheets, documentation prepared by the paint manufacturer shall be submitted, setting out the climatic conditions and recoat intervals recommended by the manufacturer for the application of each paint. The details shall be submitted prior to the commencement of paint application and shall include, but not be limited to, the following:

- The maximum and minimum ambient temperature.
- The maximum and minimum temperature of surfaces to be painted.
- The maximum and minimum dampness of surfaces to be painted.
- The maximum and minimum (if applicable) relative humidity.
- The minimum additional temperature of the surface to be painted above the dew point.
- The minimum and/or maximum time delays between applications of successive coats.

All paint application shall be carried out according to the parameters contained in these recommendations. Should the maximum re-coat interval specified or accepted be exceeded, the surface shall be checked for contamination and cleaned or repaired to the satisfaction of Sydney Water before a subsequent coat is applied.

C5.8.6.4. Brushing In

Paint shall be applied by brush to the following areas prior to the general application of each coat of paint by spray:

- All rivets, bolts, nuts and washers.
- All areas shadowed from paint spray by flanges, rivets, bolt heads and other projections.
- All other area that is difficult to spray.

Wet-on-wet application is permitted.

C5.8.6.5. Stripe Coating

Prior to the application of each coat of paint, a stripe coat of the paint shall be applied to all exposed edges, corners, and welds as well as repaired pitted areas and crevices. Wet-on-wet application is permitted.

C5.8.6.6. Feathering of Edges

Where paint is to be applied to surfaces adjoining a cured coating, the edge of the cured coating shall be feathered by a method approved by the manufacturer.

C5.9. Erection

C5.9.1. Handling, Delivery to Site and Storage

All fabricated items shall be handled in a manner that will not overstress or deform either members or components.

Members yet to be erected shall be stored above ground so as to avoid contamination.
Members bent or buckled from handling or storing shall be liable to rejection. Bolts, nuts and washers shall be supplied and stored in grit free watertight containers.
Burred, damaged or otherwise unserviceable bolts shall not be used.

C5.9.2. General Erection Procedure
All members shall be erected, fixed, adjusted and maintained in their intended vertical lateral alignment and level. Members that do not meet the tolerances specified in Clause 15.3 of AS 4100 shall be liable to rejection.

The safety requirements, erection cranes, equipment, scaffolding and staging shall meet the requirements of the WorkCover Authority of NSW or other controlling Authorities. An erection procedure shall be adopted such that all members can be placed and fixed in position without distortion.

During erection the steelwork shall be made safe against wind and all erection loadings including those due to erection equipment.

Permanent bolting or welding shall not be carried out until correct alignment and any specified pre-set or camber have been obtained in each member of the structure.

Additional members used to facilitate erection shall be affixed in a manner which does not weaken or deface permanent steelwork.

Where steelwork is supported on concrete, masonry or similar material, it shall be set up on packers or wedges of at least 20 mm above the floor level to facilitate alignment and permit subsequent grouting. Such packers, if permanent, shall be of either solid steel or grout of similar strength to the permanent grout. All other packers shall be removed before completion of grouting. All grouts shall be non-shrink grout of a minimum compressive strength of 40 MPa.

At least twenty (20) working days prior to commencing erection, the proposed method of erection shall be submitted to Sydney Water for acceptance. This shall include, but not limited to the following:

- Falsework details including design calculations and certification by a civil/structural engineer who is a Member of the Institution of Engineers, Australia stating that the falsework has been designed in accordance with the relevant Australian Standards.
- Method of stabilising or bracing members during storage, assembly and erection.
- Method of determining and adjusting profile.
- Method of alignment of components.
- Method and order of assembly including temporary fixing.
- Welding proposals including welding procedures, temporary locating devices and order of welding.
- Bolting procedures including method of aligning holes, method of marking bolts, tightening and records.
- Storage of components.

C5.9.3. Site Cutting and Drilling
During erection, components and members shall not be cut, burnt, welded or drilled. Drifting may only be used for bringing parts into position, not to match misaligned holes, or enlarge holes or distort metal. Drilling shall not be used on galvanised items. Any component damaged, including damage to protective coating, shall be repaired as per WSA 201 and Sydney Water’s Supplement.

Galvanised steelwork shall not be cut, drilled, welded or otherwise altered on site. Should alterations to the galvanised steelwork be required after fabrication and galvanising, the steelwork shall be re-galvanised by hot dipping after the final alterations.
C5.9.4. Purlins and Girts

Purlins shall be erected strictly in accordance with the purlin manufacturer’s recommendations and instructions. Purlins shall be fabricated prior to receiving a protective coating. On-site cutting of coated purlins is not permitted.

C5.9.5. Site Welding and Inspection

For site welded joints, the ends of the members and/or segments shall be held in position during welding by suitable temporary devices. On completion of the joints the devices shall be carefully removed and the steel surfaces restored by grinding smooth and flush.

No site welding of structures or any of their components shall be permitted unless the structures/components to be site welded have been nominated in the drawings or accepted by Sydney Water.

It is to be ensured that no stray current from welding will interfere with the Sydney Water’s electrical, earthing and control system.

Site welding and inspection shall be in accordance with this specification.

C5.9.6. Assembly of Bolted Connections

Bolted connections shall be in accordance with the details shown in the drawings.

When assembled, all joint surfaces, including those adjacent to bolt heads, nuts and washers, shall be free from burrs, dirt or other deleterious matter or defects preventing proper seating of the parts.

Where necessary washers shall be tapered or otherwise suitably shaped to give the nuts and heads of bolts a satisfactory bearing. Load indicator washers shall not be used if they could damage the protective coating.

The threaded portion of each bolt shall project through the nut not less than one [1] thread and not more than five [5] threads or 12mm whichever is less when fully tightened. The threaded length of each bolt shall be such that there shall be at least two [2] threads in the bolt holes after tightening the nut.

Where high strength friction grip-type bolts are nominated, the contact surfaces shall be clean as “rolled surfaces or equivalent and in addition shall be free from paint, lacquer, galvanising or other applied finish unless the applied finish has been tested in accordance with Appendix J of AS 4100 to confirm the required friction coefficient of 0.35.

Only stainless steel bolts and nuts to be used for joining stainless steel members. Bolts and nuts and used threads shall be coated with a suitable compound to prevent seizing of bolt to nut occurring. Provision of capping to prevent the loss of this compound is required in aggressive environment.

For joints containing more than eight bolts, the “snug tight” condition shall be checked by a second run over the bolts.

Marking of the bolts prior to final tightening shall allow measurement of the true amount of turn of the nut.

Once fully tightened, bolts shall not be released and re-tightened in either the original position or elsewhere.

The details of proposed tightening method for friction type bolts shall be forwarded to Sydney Water for acceptance at least twenty (20) working days before commencing work.

The submission detailing the method of installing high strength friction grip bolts shall constitute a Hold Point.

C5.9.7. Certificate of Bolting for Tension Bearing (TB) and Tension Friction (TF) Connections

A certificate by a civil/structural engineer who is a Member of the Institution of Engineers, Australia shall be submitted verifying that bolting of tension bearing (TB) and tension friction (TF) has been carried out in accordance with the Specification.
C5.10. Fabrication, Erection and Testing of Circular Liquid Retaining Steel Tanks

C5.10.1. General

All steel plates shall be cold rolled to suit the curvature of the tank and the erection procedure. Any required straightening of material shall be carried out by methods that will not injure the steel, such as by cold rolling or pressing. Straightening by hammering shall not be permitted. Heating may be used only with the prior acceptance of Sydney Water and subject to being certified by a civil/structural engineer who is a Member of the Institute of Engineers, Australia.

Welding sequence shall be devised to minimise deformation of the bottom plates of the floor.

The shell wall shall be erected plumb and circular to the dimensional tolerances specified in API 650. Until the floor and the bottom shell strake have been inspected and accepted by Sydney Water, further erection of the tank shall not proceed.

All exposed sharp edges shall be either rounded to a radius of not less than 5mm or alternatively shall be provided with a chamfer not less than 1mm wide. Rounding off or bevelling of such edges shall be carried out prior to preparation for and application of corrosion protection measures.

C5.10.2. Roof Steelwork

In fixing the roof members to the steel shell brackets, allowance shall be made to accommodate the rounding of the tank shell when the tank is filled.

All roof steelwork except for roof beam support brackets welded to the steel tank shell and the columns welded to the tank floor plate, shall be protective coated as specified.

Roof beam support brackets shall be painted with the same paint system as used for the internal shell as specified.

The tank top stiffening ring shall be painted in the following manner:

- Top horizontal face shall be painted with the same paint system as used for the internal shell as specified.
- Other faces shall be painted with the same paint system as used for the external shell as specified.

All overlapping galvanised surfaces shall be isolated from each other by the application of an inhibitive jointing compound accepted by Sydney Water.

C5.10.3. Purlin System

Purlins shall be aluminium. Cold-formed purlins are not an equivalent substitute.

All angle or channel section trimmers or purlins shall be fixed with the flanges facing down the slope of the roof to prevent moisture being trapped on the flange. Where this configuration cannot be achieved, purlins shall contain drain holes to facilitate the removal of collected moisture. The location and size of such drain holes shall not compromise the structural integrity of the purlin.

All potential contact points between steel and aluminium shall be insulated in the same manner as described herein.

C5.10.4. Roof Cladding - Material

The roof sheeting shall consist of stucco embossed mill finish high strength corrosion resistant aluminium alloy. Typical acceptable alloy grades are 5251. The colour of the roof sheeting shall be as nominated by Sydney Water.

Roof flashing, ridge capping, gutter and moulded closure strips shall be made from the sheeting manufacturer's standard form aluminium roof accessories.
Aluminium hatch frames shall be fabricated from Alloy 6061-T6 or 6082-T6. Flat sheets for hatch and ventilator frames and covers shall be fabricated from Alloy 5251-F or 6082-T6.

Floor plates around access and equipment hatches shall be 6 mm thick aluminium fabricated from Alloy 5251-F.

Aluminium treadplates including perimeter of roof, up to and around ventilation hatches and along one ridge to the central ventilator shall be 3 mm thick Grade 5251 or 6061 with raised angular pattern on the top face. Each piece of tread plate shall be 600mm wide and nominally 1200mm long maximum.

The roof supporting members shall be fabricated from structural steel, Grade 300, to AS 3679, galvanised; or aluminium plates and extruded sections to AS 1734 and AS 1866.

For stitching purposes, only the aluminium M6 tri-fold, positive mandrel retention, "Bulb-Tite" aluminium rivets or accepted equivalent shall be used. Each rivet shall have a neoprene seal.

C5.10.5. Roof Cladding- Installation

Fixing details shall be submitted at least twenty (20) working days prior to installation of the roof cladding.

The laying of the sheeting shall comply with AS 1562 and the following minimum requirements:

- The corrugated roof sheets shall be laid as shown in the drawings such that in each bay the corrugations are laid at right angles to the purlins and parallel to any semi-rafter. The sheets shall span across the purlins and shall be fixed so that there will be no distortion or stressing from thermal movement or other causes.
- No forced fitting or spring fixing of the roof sheeting over the rafters or semi-rafters is permitted.
- Provision shall be made for accommodating expansion / contraction movement where appropriate.
- Side laps shall not be less than one [1] full corrugation, and shall be stitched with aluminium M6 "Bulb-Tite" pop rivets at 450 mm centres through the crest of each rib.
- End laps shall be kept to a minimum, but where necessary, shall not be less than 225 mm. The centre line of end laps shall coincide as nearly as possible with the centre line of the supports and the sheets shall be arranged such that all holes for the main fixing are more than 40 mm from the end of the sheet.
- All sheet laps shall be given two [2] coats of aluminium pigmented bituminous paint or accepted equivalent.
- As a minimum, the sheets shall be fixed to the roof purlins using the 'Capral Positive Fix System' or accepted equivalent. Each fixing shall consist of 6 mm diameter 304/305 stainless steel screws, aluminium formed washers in alloy 5251 and rubber sealing washers through the crest of every second corrugation at intermediate supports and every crest along the ridge lines at the sheet ends. After drilling a pilot hole through the crown and the purlin, the hole in the sheeting shall be opened to 6 mm in diameter, after which the fastener is to be installed.
- To allow for temperature expansion of the sheets, for all fixings further than 6 m from the centre of the tank, the hole in the rib crown shall be slotted after drilling the tapping hole. For these expansion fixings, an EPDM rubber washer with an elongated hole and a PTFE facing on one side shall be used. The washer shall be installed with the PTFE side facing up towards the head of the screw. For these fixings, elongated holes for the main fastenings shall be made in the sheeting in accordance with the 'Capral Positive Fix System'. The elongation of the holes shall be in the radial direction. The washer plate shall protect the PTFE from UV light attack.
- It is important that the roof be completely bird-proof, corrugations shall be completely sealed at all sheet ends with formed aluminium closure strips.
- Any cutting of sheets shall be done in such a manner as to avoid distortion of the profile.
- The termination of the roofing sheet at hips and apex shall have the pan turned up.
• At the outer edge of the roof, the roof sheeting is to be fixed to the stiffener ring through every corrugation. The method of fixing should preferably be by a standard method specified by the sheeting manufacturer.

• Allowance shall be made to accommodate the rounding of the tank shell when the tank is filled, by checking the degree of out-of-roundness of the tank after the top stiffening ring is welded in place.

• Ridge and hip lines which are at every radial beam, shall be covered with the sheeting manufacturer’s standard capping and “tee”-shaped hip support, cut to match the corrugations, lapped a minimum of 225 mm at transverse joints and stitched at 450 mm centres, with aluminium M6 AVDEL tri-fold, positive mandrel retention, Bulb-Tite aluminium rivets or equivalent rivets along longitudinal joints. The capping shall be secured in each wing at centres corresponding to roof fixings. The trough of the sheet ends beneath the ridge and hip capping shall be sealed by filling with a suitable bituminous based filler or another method specified by the sheeting manufacturer that is acceptable to Sydney Water.

• Tread plates for working platform around hatches as indicated in the drawings shall be aluminium, 6mm thick minimum and fixed to supporting framing members with M12 countersunk stainless steel bolts at maximum 500 mm centres. Where the support member is not aluminium, nylon washers and bushes shall also be used to isolate the dissimilar metals.

• Tread plates shall be stitched to the top of the aluminium roof sheeting ribs with M6 tri-fold, positive mandrel retention, “Bulb-Tite” aluminium rivets or equivalent shall be used. Each rivet shall have a neoprene seal.

• All drilling swarf shall be cleared both inside and on the rooftop.

C5.10.6. Connection between Aluminium and Steel Roof Components

All potential points of contact between aluminium and other metallic members shall be insulated with the following:

• For the connection of roof sheets to rafters or purlins, use 0.25mm thick “TESA -51482” PVC tapes or PTFE equivalent.

• For the connection of galvanised tread plates to roof sheets, use 0.8mm thick neoprene strips.

• For connections of all structural members use a minimum 1.5mm thick neoprene sheet.

• The separation tapes or sheets shall be sufficiently wide to provide a minimum overlap of 5 mm on either side of the purlin, beam etc. on which they are stuck.

All fasteners shall be of stainless steel. Nylon bushes and/or nylon washers shall be provided to prevent contact of with steel or aluminium parts.

C5.10.7. Hydrostatic Testing of Steel Tanks

The tanks shall be hydostatically tested, at a time that is accepted by Sydney Water. Determination and application of suitable and appropriate rates for filling and emptying of tanks shall be undertaken.

For the purpose of such testing the tank shall be filled with water to the top water level and shall be kept full for a period of not less than 48 hours. Any leaks including visible wet patches, or defects which may cause leakage, shall be rectified and retested until the tank is completely watertight. If a leak is detected while the tank is being filled with water, the defects responsible for the leak shall be repaired before continuing filling the tank to the top water level.

If there is a need to discharge water to the environment, Sydney Water Standard Operating Procedure (SOP) WPIMS 5021 shall be followed.

In the case of evidence of indication of leakage through a tank’s steel floor where the location of the defects or damages responsible for such leakage cannot be ascertained by means of the conventional hydrostatic
test, vacuum tests on the welded joints in the floor shall be conducted. Vacuum testing shall be carried out generally in accordance with the relevant requirements of AWWA D100. Alternatively, Sydney Water may agree to testing of the floor joints by the magnetic particle method. The tests shall be witnessed by Sydney Water, and the costs of these tests, including the cost of providing the necessary equipment shall form part of the contract.

A copy of the hydrostatic test results shall be submitted to Sydney Water at least twenty (20) working days prior to acceptance of the tank.

The submission of the hydrostatic test results shall constitute a Hold Point for commissioning the tank. The procedures and acceptance criteria detailed in Sydney Water Standard Operating Procedure (SOP) WPIMS5261 shall be followed.

**C5.11. Hold Points**

A summary of hold points identified for aluminium works are listed in Table 5-3 below.

**Table 5-3 Summary of Hold Points for structural steel and aluminium works**

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHP1</td>
<td>Fabrication</td>
<td>Shop drawings</td>
<td>C3.6.5</td>
</tr>
<tr>
<td>SHP2</td>
<td>Fabrication</td>
<td>Splices not identified in design drawings</td>
<td>C3.15.3</td>
</tr>
<tr>
<td>SHP3</td>
<td>Weld testing</td>
<td>Location and type of testing</td>
<td>C5.9.15</td>
</tr>
<tr>
<td>SHP4</td>
<td>Painting</td>
<td>PCCP certificates of painting contractors</td>
<td>C5.10.6</td>
</tr>
<tr>
<td>SHP5</td>
<td>Tightening of high strength friction bolts</td>
<td>Tensioning of bolts</td>
<td>C5.11.7</td>
</tr>
<tr>
<td>SHP6</td>
<td>Acceptance of liquid retaining tanks</td>
<td>Hydrostatic test results</td>
<td>C5.12.17</td>
</tr>
</tbody>
</table>
C6. Masonry Work

C6.1. General

This specification sets out the requirements for masonry work for:

- Construction of unreinforced brickwork and blockwork for building and free standing walls.
- Construction of reinforced hollow blockwork for buildings and free-standing walls.

All masonry work shall comply with the drawings, the requirements of the Building Code of Australia and the relevant Australian Standards.

C6.2. Referenced Documents

The documents referred to in this specification are:

AS 1316 Masonry Cement.
AS 1672.1 Limes and Limestone - Limes for building
AS/NZS 2699.1 Built-in components for masonry construction - Wall ties
AS/NZS 2699.2 Built-in components for masonry construction - Connectors and accessories
AS/NZS 2699.3 Built-in components for masonry construction - Lintels and shelf angles (durability requirements)
AS 2758.1 Aggregates and rock for engineering purposes - Concrete aggregates
AS 2870 Residential Slabs and Footing
AS/NZS 2904 Damp-proof courses and flashings
AS 3600 Concrete structures
AS 3700 Masonry structures
AS 3972 Portland and blended cements
AS/NZS 4455 Masonry units and segmental pavers
AS/NZS 4456 Masonry units and segmental pavers - Methods of test
AS/NZS 4680 Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
BCA Building Code of Australia

Cleaning of Masonry Code of Practice - NSW Building & Construction Authority Training Committee Ltd.

C6.3. Masonry

All masonry units shall be fired clay, concrete or calcium silicate to AS/NZS 4455. Unless specified otherwise, properties shall be not less than:

- Masonry units shall comply with Dimensional Category DW1, except that split or irregular faces may be DW0.
- Concrete units shall comply with Dimensional category of DW4
- Masonry units shall meet General Purpose Salt Attack Resistance Grade, except for applications requiring exposure Grade. Applications requiring exposure Grade:
  - Saline wetting or drying.
  - Aggressive soils.
Severe marine environment (within 1 km from coast line).
- Saline or contaminated water including tidal splash zones.
- Within 1 km of an industry producing chemical pollutants.

- Masonry units have characteristic strength as follows:
  - Non load bearing masonry - 10 MPa.
  - Load bearing masonry - 15 MPa.
  - Reinforced Masonry - 15 MPa.

- Masonry unit intended for face application and exposed to the weather shall have:
  - Permeability not more than 2 mm/ minute.
  - Efflorescence potential of Nil or Slight.
  - Colour and texture within the agreed range.

- Concrete masonry units shall have a Mean Coefficient of Residual Drying Contraction not more than 0.6 mm/m.

- Clay masonry units shall have a Mean Coefficient of Expansion not more than 1.0 mm/m.

- Masonry units for reinforced masonry applications shall have the following properties:
  - If units are intended to incorporate both horizontal and vertical reinforcement and are not protected both sides by a waterproof membrane, they shall be "H" or "Double U" configuration.
  - Grout shall flow easily around and encloses the reinforcement in all cases.
  - Cover is consistent with the requirements for durability, strength and fire resistance as appropriate.

**C6.4. Brick Samples for Facework**

Prior to commencing facework, samples consisting of at least 6 bricks of each type shall be submitted to Sydney Water.

Samples of facework shall match the texture and colour of the facework of the existing buildings.

**C6.5. Cement**

Cement shall be Type GP or GB to AS 3972.

**C6.6. Masonry Cement**

Masonry cement shall comply with AS 1316.

**C6.7. Lime**

Lime shall be hydrated building lime complying with AS 1672.

**C6.8. Sand**

Sand shall be well graded and free from salts, vegetable matter and impurities. Sand shall not contain more than 10% of the material passing through the 75 micron sieve. Sand within the limits shown in Table 6-1 is deemed to be suitable.
Table 6-1  Sand Grading Requirements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.76 mm</td>
<td>100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>95-100</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>60-100</td>
</tr>
<tr>
<td>600 µm</td>
<td>30-100</td>
</tr>
<tr>
<td>300 µm</td>
<td>10-50</td>
</tr>
<tr>
<td>150 µm</td>
<td>0-10</td>
</tr>
<tr>
<td>75 µm</td>
<td>0-4</td>
</tr>
</tbody>
</table>

C6.9.  Water Thickener

Water thickener shall be methyl-cellulose based.

C6.10. Mortar

Unless specified otherwise, the durability requirements of mortar shall comply with Table 12.2 of AS 3700.

C6.11. Coloured Mortar

Mortar for facework shall be coloured to match existing buildings. Colouring pigments shall be metallic oxides insoluble in water, mixed with cement and sand compatible with the required colour.

C6.12. Mixing Mortar

Mortar ingredients shall be accurately measured. Shovel measurements shall not be permitted. Mortar shall be thoroughly mixed in a mixer until smooth plastic mass is obtained without lumps of lime or other materials. The materials are to be mixed dry before water is added. Only sufficient water shall be added to provide reasonable trowelling consistency. All mortar shall be used within 30 minutes of mixing and, if not so used, shall be discarded. Excess water shall not be added to improve workability. On no account shall mortar, which has partially set, be revived or reused.

C6.13. Concrete Grout

Unless specified otherwise, the properties of the concrete grout shall be:

- A minimum Portland cement content of 300 kg/m³.
- A maximum aggregate size of 10 mm to Table 1 of AS 2758.1.
- Sufficient slump to completely fill the cores.
- A minimum compressive strength of 20 MPa.

At least twenty (20) working days prior to commencement of grouting work, details of the grout mix, test results and certificates shall be submitted to Sydney Water for acceptance. The certificate shall be from an independent laboratory with appropriate NATA registration stating that the nominated mix and its mix constituents meet the requirements of this specification. The concrete mix details shall include the proportion of slag and fly ash used in the mix design.

Submission of the mix details and Certificate(s) shall constitute a Hold Point.

Unless specified otherwise, joint Material shall:

- Backing rods for control joints, expansion joints and articulation joints shall be expanded polystyrene tube or bead or rigid steel backing profile with closed cell foam adhered to the metal profile face.
- Joint sealant shall be gun grade multi-purpose polyurethane sealant. The colour of the joint sealant shall match the colour of the masonry.
- Control joints and articulation joints shall incorporate de-bonding tape along the bottom of the joint sealant.

C6.15. Damp Proof Courses and Flashing in Buildings

Damp-proof courses and flashings shall be built into the masonry in accordance with drawings, Building Regulations, AS/NZS 2904 and AS 3700.

A course upon which a sheet of damp-proof or flashing material is to be laid shall be flushed upon with mortar over the full width to form an even bed beneath the damp-proof or flashing materials, as necessary to prevent punching.

Where joints in sheets cannot be avoided, the material shall be lapped or sealed against moisture penetration. The length of lapping shall be not less than the thickness of the leaf upon which the sheet is laid. Joints shall not be located at weepholes.

Damp-proofing and flashing materials shall not be breached or punctured during construction, except that they may be pierced where starter bars penetrate the damp-proof course or flashing.

Damp-proof material shall be built in to project from the face of wall. On completion of construction, the projection shall be either cut 25 mm past the face of wall or turned down.

Flashings, including over-flashings, shall be built in with projections that are sufficient size and orientation to direct the moisture from masonry in the required manner.

Flashings intended to hold their shape, shall be manufactured from rigid material (e.g. metal cored material)

Damp-proof courses shall be placed at a maximum of 200 mm above ground floor slab at the internal leaf and let down across the cavity to the joint a minimum of 150 mm above outside ground or paving level.

Where external cavity walls are constructed built up from a rebated raft floor slab, the damp-proof course shall be left down across the cavity to concrete slab level and under outer leaf to project 25 mm past the edge of the concrete slab.

Damp-proof courses and flashings shall be resistant to corrosion and weathering.

Any render finish subsequently applied to the surface shall not be allowed to bridge a damp-proof course or make ineffective any other moisture protection measures.

At least 3 working days prior to the proposed erection of masonry, Sydney Water shall be notified the completed installation of the damp-proof membrane.

C6.16. Slip Joint Material

Slip joint material shall be placed between un-reinforced masonry walls and any supported concrete slab

Unless specified otherwise, slip joint material shall comply with the following requirements.

- Bitumen-coated aluminium.
- Embossed polyethylene.
- Polyethylene-and-bitumen coated aluminium.
Metal slip joint materials shall not be used in locations that are subject to rising salt damp.

C6.17. Wall Ties
Unless otherwise specified, the durability requirements of wall ties shall comply with Table 12.2 of AS 3700 and shall be selected and spaced in accordance with Table 12.5 of AS 3700.

C6.18. Mortar Joints
Mortar joints shall comply with the drawings, Building Regulations and AS 3700. Unless stated otherwise, mortar joints shall comply with the following:

- Mortar joint shall be 10 mm thick.
- Mortar joints in solid or cored face masonry shall be fully bedded. Joints shall be as specified in the drawings.
- Mortar joints in solid or cored backup or non-face masonry shall be fully bedded and flush jointed.
- Mortar joints in hollow blockwork, shall be face shell bedded and shall be ironed, unless a flush joint is specified for aesthetic reasons.

C6.19. Weepholes in Buildings
Unless stated otherwise, weep holes shall be built into the external leaf of cavity walls or veneer walls at centres not exceeding 1.2 metres in the course immediately above a DPC or flashing, except where the head or sill opening is less than 1.0 metre wide.

C6.20. Provision for timber Shrinkage
In masonry veneer construction, a gap in accordance with Table 6-2 below shall be left between the timber frame and the top of the masonry and at window sills, to accommodate timber shrinkage.

Table 6-2 Minimum Clearance Required for Timber Shrinkage

<table>
<thead>
<tr>
<th>Location in Timber Framed Buildings</th>
<th>Minimum Clearances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unseasoned Hardwood Frame</td>
</tr>
<tr>
<td>Sills of lower or single storey windows</td>
<td>10 mm</td>
</tr>
<tr>
<td>Roof overhangs of single storey buildings</td>
<td>16 mm</td>
</tr>
<tr>
<td>Sills of second storey windows</td>
<td>20 mm</td>
</tr>
<tr>
<td>Roof overhangs of two storey buildings</td>
<td>24 mm</td>
</tr>
</tbody>
</table>

C6.21. Control Joints
Vertical control joints including articulation joints, contraction joints and expansion joints shall comply with AS 2870 and AS 3700.

Control joints shall not be placed adjacent to arches. Control joints in concrete masonry arches shall be saw-cut to half the depth of the masonry unit and positioned at the centre of the arch.

Control joints shall be a minimum 10 mm wide and shall consist of polystyrene backing rod and a polyurethane material gunned into the joint to form a minimum of 10 x 10 mm flexible seal. The backing rod
shall be placed into the masonry at a depth, which permits the finish of the control joints to match the mortar joints.

For control joints or articulation joints in cavity walls (i.e. not in veneer walls), extendible masonry ties shall be built into every fourth course.

Where a control joint is located adjacent to a door or window frame, a 10 mm gap shall be provided between the edge of the frame and the masonry to allow for movement.

C6.22. Lintels

Except in the case of arches, masonry over openings shall be supported.

Unless specified otherwise, for openings up to 600 mm width, masonry may bear directly on a timber window head. For openings up to 900 mm width, masonry may be supported by a metal frame. In other cases, masonry shall be supported on lintel of the following types:

- Steel member in accordance with Clause 12.4.2 of AS 3700.
- Reinforced masonry lintels in accordance with Clause 12.4.3 of AS 3700.
- Reinforced concrete in accordance with AS 3600.

Durability requirements of lintels shall be in accordance with Table 12.2 of AS 3700.

At least 3 working days prior to the proposed erection of masonry, Sydney Water shall be notified of the completed installation of lintels.

C6.23. Cavity Wall Construction

Cavity walls shall be constructed with a minimum 50 mm wide cavity, unless specifically detailed otherwise. The wall skins shall be tied together with wall ties in accordance with this specification. All ties shall have a drip crimp and shall be laid with a fall to the outside face and built into each skin not less than 50 mm.

Weepholes shall be provided as detailed in this specification.

Cavities shall be kept of clear mortar droppings by the use of timber cavity slips, laid on, lifted and cleaned every row of ties. Every fourth brick shall be left loose at the bottom of the cavity in the outer leaf so that the cavity can be cleaned.

Where cavity wall extends below ground level, the cavity between the skins shall be filled with cement/sand mortar (1:3), splayed to fall to the base of the weepholes and shall be trowel finish on the top.

C6.24. Reinforced Masonry

All construction of reinforced concrete masonry shall comply with AS 3700. Unless stated otherwise, the following shall apply:

- Vertical steel reinforcement shall be tied using tie wire to steel starter bars through clean-out holes in each reinforced core and fixed in position at the top of the wall by plastic clips or template. Starter bars shall be tied into position to provide the specified lap above the top surface of the footing. The starter bars shall be held in position on the centre line of a reinforced blockwork wall by a timber member or template and controlled within a tolerance of +/- 5 mm through the wall and +/- 50 mm along the wall.
- Horizontal steel may be laid in contact with rebated webs of Double U or H blocks. It shall be held in position by steel ties or plastic clips. Cover to horizontal steel in lintel blocks shall be maintained by the use of wheel type plastic clips.
- The minimum cover (from the edge of the steel reinforcement to the inside face of the block core) shall be 20 mm, except where specified otherwise.
- Where galvanised reinforcement is specified, the galvanising shall be a minimum coating thickness of 85 (mm accordance with AS/NZS 4680.
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- Control joints shall be built into reinforced concrete masonry at all points of potential cracking and at the locations shown in the drawings. The spacing of control joints should not exceed 8.0 metres, except that the spacing of control joints may be increased in reinforced masonry walls meeting the following criteria:
  - Consisting of at least 190 mm hollow concrete units.
  - Built less than 3.0 metres high.
  - Incorporating a top reinforced bond beam.
  - Incorporating N16 horizontal reinforcement at not greater than 400 mm centres.
  - On site classifications A & S to AS 2870.
  - With a reinforced concrete footing of adequate stiffness.
  - Cavities shall be kept clear of mortar droppings and adequate temporary openings shall be provided along the bottom to clean out loose material from the bottoms of hollows before being filled with grout.

C6.25. Grouting

Grouting shall not commence until grout spaces have been cleaned out and the mortar joints have attained sufficient strength to prevent blowouts.

The height of the individual lifts in any pour shall be limited in accordance with the fluidity of grout and shall be certified by a civil/structural engineer who is a member of the Institution of Engineers Australia.

Compaction of the grout shall be by vibration or rodding.

On completion of the last lift, the grout shall be topped up after a waiting period of 15 minutes and the topping vibrated or rodded so as to merge with the previous layer.

Sydney Water shall be given at least seven (7) working days’ notice after cleaning out the bottoms of hollows and ready for grouting.

The submission of proposed grouting shall constitute a Hold Point.

C6.26. Temporary Bracing under Construction

Structures under construction shall be braced, otherwise stabilised as necessary to resist wind and other lateral forces, in such a manner that the structural integrity of the member or structure is not impaired.

C6.27. Premature Loading

Masonry shall not be subjected to any load until it has gained the nominated strength to carry the design load.

C6.28. Temporary Loading

Masonry required to carry temporary load other than specified in the drawings, shall be certified by a civil/structural engineer who is a Member of The Institution of Engineers, Australia.

Details of the certification shall be forwarded to Sydney Water at least twenty (20) working days prior to loading.

C6.29. Rate of Construction

The rate of construction shall be limited as to eliminate any possibility of joint deformation, slumping or instability which may compromise the bond.
C6.30. Tolerances in Masonry Work
All masonry work shall be built to the specified dimensions within the tolerances given in Clause 11.5 of AS 3700.

C6.31. Cleaning Masonry
Cleaning of masonry shall comply with the publication "Cleaning of Masonry Code of Practice-1985". Where the wall is constructed as a freestanding wall, both sides of the wall shall be cleaned of all mortar splashes and stains.
Where acid cleaning is required, the following shall apply:
- The acid mixture shall be 1 part of hydrochloric acid to 15 parts of water.
- Mortar joints shall be a minimum 14 days old before cleaning commences.
- All masonry being cleaned shall be thoroughly wetted by hosing before any acid solution is applied and kept wet ahead of the acid application.
- The acid mixture shall be thoroughly hosed off as the cleaning proceeds.
If high pressure water jet method is used for cleaning, extreme care shall be taken to avoid "blowing out" the joints.

C6.32. Cement Render
Unless specified otherwise, cement render shall comprise a mixture of 2 parts cement, 1 part lime and 4 parts sand. Metal lath shall be galvanised expanded steel mesh.
Each exposed surfaces indicated in the drawings shall be cement rendered minimum 15 mm thick finished off with steel trowel.
Conduits, boxes, services etc. shall be fixed and properly chased before rendering. Any wall chase exceeding 50 mm wide shall be sheathed with well-secured metal lath fixed with galvanised fasteners prior to rendering.

C6.33. Masonry Repairs and Remedial Tying
This section covers remedial ties, pins and straps that may be used to tie cracked masonry together, including securing the external masonry leaf of a cavity wall to the inner leaf in those situations where the ties have been omitted during construction, placed at inappropriate centres or have corroded in service.

C6.33.1. Remedial Pinning and Tying Masonry Walls
Minimum embedment of ties shall be in accordance with the manufacturers’ recommendations.
For cavity walls consisting of two leaves of 110 mm standard brick separated by a 50 mm cavity, the tie shall be 230 mm long and embedded 70 mm.
- A pilot hole (depending on brick hardness) shall be drilled to the required depth (tie length + 10mm) using a long series masonry drill bit fitted to a percussion action power drill.
- Using the Power Driver attachment fitted to a lightweight rotary hammer drill, the tie shall be driven in to the pilot hole approximately 10mm beyond the surface of the near skin.
- After installation of the tie is complete the hole shall be made good either by using a mixture of sand, cement and oxide colouring to match the original surrounding brick surfaces or alternatively with a silicone sealant applied to the hole and coated with brick dust or drillings.
C6.33.2. Crack Stitching

Construction shall be in accordance with the manufacturers' recommendations, and generally as set out below.

- Rake out or cut slots into the horizontal mortar beds, a minimum of 500 mm either side of the crack, to the specified depth.
- Clean out the slots with a blow pump and apply primer.
- Using a pointing gun, inject a bead of grout to the back of the slot.
- Using a finger trowel, or similar, push the stainless steel bars into the grout to obtain good coverage.
- Insert a further bead of grout over the exposed bar, finishing 10 to 15 mm from the face, and iron into the slot using a finger trowel.
- Re-point the mortar and make good.
- Make good the vertical crack with a waterproof filler.

At least twenty(20) working days prior to commencing repair works, full details of proposed repair methodology and product details shall be submitted to Sydney Water for acceptance.

The submission detailing the method of crack stitching shall constitute a Hold Point.

C6.34. Hold Points

A summary of hold points identified for masonry works are listed in Table 6-3 below.

Table 6-3 Summary of Hold Points for Concrete Works

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHP1</td>
<td>Acceptance of concrete grouting mix design</td>
<td>Concrete grout mix design &amp; test certificates</td>
<td>C6.13</td>
</tr>
<tr>
<td>MHP2</td>
<td>Grouting</td>
<td>Notification for grouting</td>
<td>C6.25</td>
</tr>
<tr>
<td>MHP3</td>
<td>Crack Stitching</td>
<td>Materials and methodology</td>
<td>C6.33.2</td>
</tr>
</tbody>
</table>
C7. Demolition

C7.1. General
This specification includes the requirements for the demolition of existing structure and the disposal of resulting materials and components which may or may not be contaminated. It also includes the additional safety and environmental protection requirements to the relevant legislations.

The demolition work includes demolition of any temporary supports and removal of any debris caught in the existing structure.

C7.2. Referenced Documents
The documents referred to in this specification are:

- AS 2187.0 Explosives - Storage, transport and use - Terminology
- AS 2187.1 Explosives - Storage, transport and use - Storage
- AS 2187.2 Explosives - Storage, transport and use - Use of explosives
- AS 2601 Demolition of Structures

C7.3. Definitions
The following definitions shall apply to this Specification

Demolition: The complete or partial dismantling of a structure by pre-planned and controlled methods of procedures

Contaminated Materials: Any material that contains or is made of hazardous substances

Hazardous Substances: A substance that is either listed in NOHSC 10005 or fits the criteria for hazardous set out in NOHSC 1008

Competent: Suitably qualified, adequately trained and appropriately experienced for the particular class or kind of work specified.

C7.4. Method of Demolition

C7.4.1. General
Any available drawings and specifications and carry out testing and inspection of both the structure and site shall be studied in order to produce the proposed methods and procedures for demolition.

In demolishing those parts of the structure containing items to be retained, all reasonable care shall be exercised so as not to damage the items more than necessary for the purpose of the work.

All demolition work shall be carried out in accordance with AS 2601

C7.4.2. Safety Requirements
Irrespective of the class of demolition work, the safety of the public and site personnel is to be ensured.

For work requiring a licence under the OH&S Regulation, the specified class of demolition licence detailed shall be obtained from WorkCover.
Notification to commence the demolition work shall be submitted to WorkCover and obtain written approval before commencement of demolition work.

Where asbestos materials are present, only licensed asbestos removalists shall handle these materials in accordance with the Occupational Health and safety Regulations. Any permits and notifications as required by the relevant parts of the Regulation shall be obtained.

Sydney Water shall be notified immediately if any other hazardous materials are found that require permits by relevant regulatory authorities for handling and disposal.

Records of all licences, notifications, approvals and permits shall be maintained.

C7.4.3. Noise Levels

The noise generated by the demolition activities shall comply with the Noise Abatement Act, the requirements of the EPA, local Council and any other conditions prescribed by Sydney Water.

C7.4.4. Supports and Shielding of Adjoining Structures

Supports and shielding shall be provided to adjoining structures where necessary to prevent damage resulting from the demolition activity. These shall be deemed to be temporary works unless the specified otherwise.

C7.4.5. Use of Explosives

No explosives shall be permitted for demolition work unless demonstrated that there are no other practical alternatives.

Where explosives are proposed, at least twenty (20) working days prior to commencing any demolishing work, details of the types of explosives, type of detonators, method of placing and firing explosives, firing pattern and delay sequence to be used shall be submitted to the Sydney Water. These details shall be verified by a competent person prior to being submitted. For demolition work involving the use of explosives or induced collapsed methods, approval shall be applied for and given by WorkCover.

Where accepted, the transport, storage and use of explosives shall comply with all the relevant parts of AS 2187.

C7.5. Disposal of Demolished Material

The disposal of all demolished material is to be in compliance with the provisions of relevant regulatory authority and the following:

- Materials to be retained by Sydney Water shall be transported and stored in a location nominated in the drawings/specifications. The materials shall be stacked in a neat manner, generally at least 150 mm clear of the ground and supported in such a manner that they are stable and are not subjected to undue stresses.

- Obtaining all necessary approvals, licences and permits required by the NSW EPA to comply with the Protection of the Environment Operations (Waste) Regulations and the Protection of the Environment Operations (Control of burning) Regulations.

C7.6. Clean Up

In addition to the requirements specified in the drawings and specifications, all excavations shall be reinstated to the levels and profiles existing prior to the demolition works.

C7.7. Submission on Methodology

At least twenty (20) working days prior to commencing any demolishing work, all aspects of the demolition and disposal activity shall be submitted to Sydney Water for acceptance. This shall include but not limited to the following:
- Description and classification of demolition work.
- Number and type of mechanical equipment to be used in the demolition activity.
- Program showing the proposed sequence of carrying out the work and highlighting various methods and stages of demolition work.
- Protecting the structural integrity of the adjoining structure.
- Removing without damage the materials or components to be retained.
- Methods of handling and disposing of various demolition waste materials including contaminated materials.
- Proposed waste control facilities in which demolition waste materials will be disposed of or treated.

The submission detailing the method of carrying out demolition works shall constitute a Hold Point.

C7.8. Hold Points

A summary of hold points identified for demolition works are listed in Table 7-1 below.

Table 7-1 Summary of Hold Points for Demolition Works

<table>
<thead>
<tr>
<th>Hold Point No.</th>
<th>Process Held</th>
<th>Required Documentation</th>
<th>Relevant Clause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHP1</td>
<td>Demolition</td>
<td>Method of demolition and safe disposal</td>
<td>C7.7</td>
</tr>
</tbody>
</table>
C8. Roadwork

C8.1. General
Roadwork shall generally be carried out as shown in the drawings. The position and extent of all cuttings and filled areas shall be marked and pegged out on site prior to the commencement of construction.

C8.2. Referenced Documents
The documents referred to in this specification are:
- AS 1012 Methods of testing concrete
- AS 1141 Methods for sampling and testing aggregates
- AS 1160 Bituminous emulsions for the construction and maintenance of pavements
- AS 1214 Hot-dip galvanized coatings on threaded fasteners
- AS 1289 Methods of testing soils for engineering purposes
- AS 1478 Chemical admixtures for concrete, mortar and grout
- AS 1604.1 Specification for preservative treatment – Sawn and round timber
- AS 2150 Hot Mixed Asphalt
- AS 2876 Concrete kerbs and channels (gutters) – Manually or machine placed
- AS 2891 Methods of sampling and testing asphalt
- AS 4671 Steel reinforcing materials
- AS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

C8.3. Removal of Topsoil
The removal of topsoil shall commence only after the proposed erosion and sedimentation controls for the site are as specified in detail, in Section C2.

C8.4. Subgrade Preparation
After stripping the topsoil, all unsuitable materials shall be excavated to the extent directed by Sydney Water. Unsuitable materials shall be removed off site as spoil as specified in Section C2.

The material at the subgrade level, for a thickness of 300 mm, shall have a CBR value not less than 8, and a plasticity index not exceeding 25.

The subgrade surface shall be homogeneous and free from patches containing segregated stone or excess fines.

If fill is required to bring the level to the design formation level, it shall consist of granular material. The fill shall be compacted in maximum 200 mm thick layers to a minimum dry density of not less than 98% standard maximum dry density determined in accordance with AS 1289.5.4.1 and AS 1289.5.5.1.

The formation level of the subgrade shall be finished to the design levels within a tolerance of + 0mm/ -20mm.

C8.5. Road Base and Sub-base Materials
The base and sub-base materials shall be placed and compacted on prepared subgrade formation in accordance with the lines, grades and levels shown in the drawings.
Base and sub-base materials shall be unbound materials consisting of hard, durable particles and fragments of either natural or manufactured material that can be compacted readily to form a firm and stable base or sub-base. All base and sub-base material shall comply RMS QA Specification 3051.

Unbound materials are those that have not been modified or stabilised by any added chemical agent. Unbound material may include recycled crushed concrete building material free from foreign matters like metal, glass, asphalt, ceramics, plaster, clay lumps, rubber, plastic and wood.

Recycled materials where accepted, shall also be free from hazardous substances such as asbestos or asbestos containing materials in both friable and bonded forms.

The formation level of the base and sub-base shall be finished to the design levels within a tolerance of +0 mm / -20 mm.

C8.6. Supply and Transport of Road Base and Sub-base Materials

Details of the supplied materials together with a certificate signed by the supplier verifying that the materials meet with the requirements of this specification shall be supplied to Sydney Water. Testing shall be carried out by a NATA accredited laboratory.

Materials shall be transported to the site in vehicles that are so constructed that loss of material does not occur. Stockpiles, if necessary, shall be formed on clear, even, well-drained, firm ground or constructed floor, and shall be constructed to prevent cross-mixing and segregation.

Non-conforming materials shall be removed from the site and replaced with materials that conform to the specification.

C8.7. Spreading and Compacting Road Base and Sub-base Materials

Each course shall be spread and compacted in uniform thickness which, after trimming, shall provide the layer thickness and lines as shown in the drawings. Each course shall achieve a compacted thickness of not more than 150mm nor less than 100mm unless otherwise agreed by Sydney Water.

The moisture content of the material shall, if necessary, be adjusted prior to compaction by watering or by drying out as required in order to obtain the required compacted density.

Compaction of each layer shall continue until a field dry density of at least 98% of the maximum dry density determined in accordance with AS 1289.5.4.1 and AS 1289.5.5.1 is achieved. Testing shall be carried out at the rate of 2 tests per 500 m2 or part thereof laid and compacted each day.

The allowable deviation from the design level and lines are (10 mm in layer thickness, (10 mm in level at any point, and shall not deviate from the bottom of a 3 m long straight edge by more than 10 mm when placed parallel or transverse to the centreline of the road.

C8.8. Asphaltic Concrete Wearing Surface

Asphaltic concrete used for pavement wearing surface shall be dense, continuously graded asphalt generally in accordance with AS 2150.

Asphaltic concrete is designated as AC10, AC20 and AC40 with the following composition and properties shown in Table 8-1 below.
### Table 8-1  Asphaltic Concrete Surface

<table>
<thead>
<tr>
<th></th>
<th>AC10</th>
<th>AC20</th>
<th>AC40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(A) Aggregate grading</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53.0 mm AS Sieve</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm AS Sieve</td>
<td>-</td>
<td>-</td>
<td>90 – 100</td>
</tr>
<tr>
<td>26.5 mm AS Sieve</td>
<td>-</td>
<td>100</td>
<td>72 – 87</td>
</tr>
<tr>
<td>19.0 mm AS Sieve</td>
<td>-</td>
<td>90 - 100</td>
<td>59 – 76</td>
</tr>
<tr>
<td>13.2 mm AS Sieve</td>
<td>100</td>
<td>71 – 86</td>
<td>-</td>
</tr>
<tr>
<td>9.50 mm AS Sieve</td>
<td>90 - 100</td>
<td>58 – 83</td>
<td>38 – 58</td>
</tr>
<tr>
<td>6.70 mm AS Sieve</td>
<td>68 - 82</td>
<td>46 - 64</td>
<td>-</td>
</tr>
<tr>
<td>4.75 mm AS Sieve</td>
<td>50 - 70</td>
<td>37 - 55</td>
<td>27 – 43</td>
</tr>
<tr>
<td>2.36 mm AS Sieve</td>
<td>32 - 51</td>
<td>24 - 42</td>
<td>16 – 33</td>
</tr>
<tr>
<td>1.18 mm AS Sieve</td>
<td>22 - 40</td>
<td>15 - 32</td>
<td>11 – 26</td>
</tr>
<tr>
<td>0.600 mm AS Sieve</td>
<td>15 - 30</td>
<td>10 - 24</td>
<td>7 – 20</td>
</tr>
<tr>
<td>0.300 mm AS Sieve</td>
<td>10 - 22</td>
<td>7 - 17</td>
<td>5 – 14</td>
</tr>
<tr>
<td>0.150 mm AS Sieve</td>
<td>6 - 14</td>
<td>4 - 12</td>
<td>4 – 10</td>
</tr>
<tr>
<td>0.075 mm AS Sieve</td>
<td>4 - 7</td>
<td>3 - 6</td>
<td>3 – 6</td>
</tr>
<tr>
<td><strong>(B) Binder content</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percentage by mass of total mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.5 - 6.5</td>
<td>3.8 - 5.8</td>
<td>3.0 - 5.0</td>
</tr>
<tr>
<td><strong>(C) Air void</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 - 7</td>
<td>3 - 7</td>
<td>3 – 7</td>
</tr>
<tr>
<td><strong>(D) Minimum voids in mineral aggregate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>

The grading of the combined aggregate shall be determined in accordance with AS 1141.11. The grading of aggregate and the binder content in an asphalt mix shall be determined in accordance with AS 2891.3.1, AS2891.3.2 or AS 2891.3.3.

The air void content and the voids in mineral aggregate shall be determined in accordance with AS2891.8.

### C8.9. Manufacturing and Transport of Asphaltic Concrete

The manufacturing plant shall be of sound design and construction and be capable of consistently producing mixes with the specified properties.

Details of the mix design together with a certificate signed by the supplier verifying that the materials meet the requirements of this specification shall be submitted to Sydney Water. Testing shall be carried out by a NATA accredited laboratory.

Asphaltic concrete shall be transported in vehicles suitably covered and insulated to prevent cooling of the mix during transit.

### C8.10. Prime Coat

A prime coat of bitumen emulsion complying with AS 1160 shall be provided to achieve a bond between the granular surface of the base course and the asphalt.
The prime coat shall be sprayed at a nominal rate between 0.2 and 0.4 litre per m². The application rate shall be doubled for joints and chases.

All contact surfaces of kerbs and other structures and all joints shall have a uniform application of prime coat.

The surface to which the prime coat is applied shall be clean and free from loose stones, dirt, oil or foreign materials.

### C8.11. Spreading and Compaction of Asphaltic Concrete

Asphalt concrete shall arrive on site at a temperature suitable for spreading and compaction for the layer thickness and ambient conditions. Generally, the spreading temperature for dense graded asphalt shall not be less than 145°C and compaction shall be completed before the mix temperature falls below 90°C.

Asphalt paving shall not proceed if the surface temperature of the base material is below 10°C such that spreading and compaction is adversely affected. Asphalt shall not be placed when the surface is wet or while rain is imminent.

The work shall be protected from damage until the required thickness of asphalt has been placed and compacted sufficiently to carry traffic.

Asphalt shall preferably be spread by self-propelled paving machine. The spread material shall be examined constantly for faults in texture and surface shape. Any segregated, torn or deficient areas shall be corrected while the asphalt is hot.

If hand placing is used, the asphalt shall be deposited in position and spread using rakes. To avoid segregation of particles, the asphalt shall not be thrown or scattered.

The thickness of any compacted layer shall generally be within the limits of 2.5 to 4.0 times the nominal mix size.

The number and extent of joints in layers shall be kept to a minimum. The density and surface finish at joints shall be the same as in other areas of the layer.

Compaction shall be carried out using static or vibratory steel wheel rollers, and/or pneumatic tyre rollers. Impact compactors such as vibratory plates, hand tampers and similar equipment may be used in small inaccessible areas.

The density of the compacted asphalt determined by the calculation of air void content in accordance with AS 2891.8 shall be within the range of percentage values nominated in this specification. Tests shall be carried out at a rate of 2 tests per 500 m² or part thereof laid and compacted each day.

Each layer of asphalt shall be finished to a plane surface, parallel to the plane of the finished surface of the wearing course. The finished asphalt pavement shall be to the lines and levels shown in the drawings.

The allowable deviation from the design level and lines are ±10 mm in layer thickness, ±5 mm in level at any point, and shall not deviate from the bottom of a 3 m log straight edge by more than 10 mm when placed parallel or transverse to the centreline of the road.

### C8.12. Concrete Carriageway

The compressive strength and flexural strength of concrete at 28 days shall not be less than 32.0 MPa and 4.7 MPa respectively.

Details of the concrete mix design together with results of trial mixes to demonstrate that the proposed mix design complies with the specification shall be supplied to Sydney Water. Certificates and test results by NATA accredited laboratories certifying the compliance of the mix constituents are also required.

Chemical admixtures and their use shall comply with AS 1478. Steel reinforcement shall comply with AS 4671 and shall be supplied together with a NATA endorsed test certificate.
Consistence of the concrete determined by measuring the slump in accordance with AS 1012.3 shall be 55 to 65 mm.

Forms shall be designed and constructed so that they can be removed without damaging the concrete and shall be braced in a substantial and unyielding manner. Forms shall be mortar tight and de-bonded to ensure non-adhesion of concrete to the surface of the forms.

Concrete shall be deposited continuously between the specified joints and spread uniformly in the forms without segregation. The concrete shall then be compacted to the full thickness of the slab in one operation.

The surface texture of the finished concrete surface shall be uniform and shall be effected by brushing evenly across the slab in one direction at right angles to the longitudinal axis of the carriageway. Brushing shall be carried out using a texturing comb after the moisture film has disappeared from the concrete surface and before the initial set is complete. Texture depth shall be 0.5mm nominally.

Curing compound shall be applied to the concrete surface immediately after the surface has been textured. Traffic shall not be allowed on the concrete surface until an in-situ compressive strength of 30 MPa is reached.

Materials for joints shall be used in accordance with manufacturers' recommendations or as otherwise shown in the drawings. Dowel bars, tie bars and sleeves shall be securely fixed in position through holes in the formwork. Joints shall be formed perpendicular to the top surface of the slab.

Transverse joints shall be straight and perpendicular to the longitudinal axis of the carriageway and shall be formed only at the specified positions. The joints shall be continued through kerbs, edges and gutters and their foundation and backing.

Longitudinal joints shall be formed only at the specified positions.

Grooves in concrete carriageway slabs shall be straight and formed either by sawing to the specified width and depth, or by fixing forming strip to the surface of the adjacent hardened concrete slab.

Immediately before sealing of the groove, dirt and loose material shall be removed from the groove. Caulking material if required shall be firmly packed in the bottom of the groove. Bond breaker tape shall be fixed continuously and evenly along the bottom of the groove for the full width and length of the groove. Primer for the joint sealant shall be applied to the sides of the groove. The joint sealant shall be mixed and applied strictly to the manufacturer's recommendation.

The allowable deviation of the finished carriageway from the design level and lines are ±10 mm in layer thickness, ±5 mm in level at any point, and shall not deviate from the bottom of a 3 m log straight edge by more than 10 mm when placed parallel or transverse to the centreline of the road.

The difference in level of the concrete surfaces across joints shall not exceed 3 mm.

Two pairs of 100 mm diameter cylindrical test specimens shall be moulded for compressive strength testing in accordance with AS 1012, one at 7 days and the other at 28 days. The frequency of sampling shall be one sample per 25 m³ or part thereof the concrete delivered to site on the day of concreting.

The compressive strength shall not be less than 32 MPa at 28 days.

C8.13. Kerb and Gutter

Kerb and gutter shall be constructed in fixed forms, extrusion or slip forming in conformity with the lines and grades shown in the drawings, and shall generally be in accordance with AS 2876.

Concrete edge strips shall be provided as specified in drawings, to the edges of all permanent pavements, including vehicle and other parking areas. Edge strips are to be constructed of concrete of grade 25 MPa as a minimum.

The allowable deviation of kerbs and concrete edge strips from the design level and lines are ±5 mm in level at any point, and shall not deviate from the bottom of a 3 m log straight edge by more than 10 mm.

Safety barrier systems shall be supplied and constructed as shown in the drawings. Proprietary safety barrier systems and devices shall be installed strictly in accordance with the manufacturer’s recommendations.

Details of type, manufacturer, strength grade, component materials and the method of installation of the proposed safety barrier system shall be submitted to Sydney Water.

All steel or ferrous metal components shall generally be hot dip galvanized in accordance with AS 4680. All ferrous bolts, nuts and washers shall be galvanized in accordance with AS 1214.

Timber posts and blockout pieces shall be strength grade F8 Australian Slash Pine preservative treated to hazard level 4 in accordance with AS 1604.

On completion of construction, the tolerance on the height of the barrier shall be ±20 mm. The tolerance for the line of the safety barrier shall be ±20 mm on plan view, and ±15 mm from the upright axis at the top of the barrier.
C9. Piling

C9.1. General
This specification sets out the minimum requirements for the design, construction and testing of pile foundation systems to support permanent structures.

C9.2. Referenced Documents
The documents referred to in this specification are:

- AS 1163 Structural steel hollow sections
- AS 1379 Specification and supply of concrete
- AS 1450 Steel tubes for mechanical purposes
- AS 1604 Specification for preservative treatment – Sawn and round timber
- AS 2159 Piling – Design and installation
- AS 2832 Cathodic protection of metals – Pipes and cables
- AS 3600 Concrete Structures
- AS 3818.3 Timber- Heavy Structural Products- Visually Graded, Part 3- Piles
- AS/NZS 3678 Structural steel – Hot-rolled plates, floorplates and slabs
- AS/NZS 3679.1 Structural Steel – Hot rolled bars and sections
- AS/NZS 3679.2 Structural steel – Welded I sections
- RMS BTD 2007/13 Durability of Steel Piles in Contact with Acid Sulfate Soils
- RMS BTD 2011/08 Testing of Cast In-Place Concrete Piles
- RMS BTD 2011/02 Use of CFA Piles on Bridges
- RMS B50 QA Specification Driven Reinforced Concrete piles
- RMS B51 QA Specification Driven Prestressed Concrete Piles
- RMS B53 QA Specification Driven H-Section Steel Piles
- RMS B54 QA Specification Driven Steel Tube piles
- RMS B58 QA Specification for Permanently Cased Cast-In-Place Reinforced Concrete Piles
- RMS B59 QA Specification Bored Cast-In-Place Reinforced Concrete Piles (Without permanent Casing)
- RMS B61 QA Specification Driven Composite Piles
- RMS B63 QA Specification Concrete Injected (CFA) Piling

C9.3. Geotechnical Verification During Construction
For any piling system, all necessary geotechnical investigations shall be carried out to inform design, in accordance to requirements specified in C10.

C9.4. Durability of Pile Foundations
The design life of piling systems shall be minimum 100 years, unless specified otherwise.
Unless otherwise specified, exposure classification for all piles as per AS 2159 shall apply for the range of conditions in the soil and groundwater surrounding the piles. Minimum cover for concrete piles shall be in accordance with AS 2159.

Minimum corrosion allowance of 2mm per face shall be allowed for all steel piles. Where Acid Sulfate soils are present, durability of steel piles shall comply RMS BTD 2007/13.

Where cathodic protection is applied to steel piles, it shall conform to AS 2832.

C9.5. Materials

Unless otherwise specified, all materials used in pile construction shall comply with the appropriate Australian Standard. Concrete for plain, reinforced and prestressed concrete piles shall comply with the requirement of AS 3600, AS 2159 and AS 1379.

Steel for piles and pile fitments shall comply with the requirements of AS 1163, AS 1450, AS 3678, AS 3679.1 and AS3679.2.

Timber pile material, where permitted shall be hardwood in accordance with AS 3818.3 and treated for H6 as per AS1604.1.

C9.6. Driven Piles

C9.6.1. Construction

All driven piles listed below shall be installed and tested in accordance with the RMS Specifications listed below; unless specifically specified otherwise within this specification.

- Driven Reinforced Concrete piles: RMS QA Specification B50
- Driven Prestressed Concrete Piles: RMS QA Specification B51
- Driven H-Section Steel Piles: RMS QA Specification B53
- Driven Steel Tube piles: RMS QA Specification B54
- Driven Composite Piles: RMS QA Specification B61

All hold points and witness points listed in the RMS QA specifications shall also apply and shall be released by Sydney Water.

C9.6.2. Pile Driving, Testing and Monitoring

All piles shall be driven to resistance and achieve the pile minimum Penetration length (the length of the pile below ground level) indicated in design drawings.

Piles shall be driven to resistance with driving energy and set determined by the applicable representative pile, nominated in design drawings.

The calculated set and energy shown on design drawings shall be used as indicative only and are not to be used as driving parameters.

Pile driving analyser (PDA or similar) and pile driving monitor (PDM) shall be conducted concurrently to establish correlation for driving impact energy and pile capacity for all representative piles. PDM shall be undertaken during the installation of all piles with sufficient sensors to monitor the performance of the hammer, calculate the net transferred energy and stresses in the pile, estimate the mobilised capacity of the pile and determine the pile set.

For steel driven piles, driving stresses shall not exceed 0.9 x fsy (or 0.8 x fsy during sustained hard driving).

For concrete driven piles, driving stresses shall be checked in accordance with AS 2159. Maximum driving energy to limit driving stresses shall be adjusted as required based on monitoring and testing of representative piles.
The specialist pile driving contractor shall assess the driving conditions and may increase the pile section properties and adjust the driving shoe detail to suit their assessment. Any proposed change to the pile properties shall be submitted to Sydney Water for acceptance.

Where a pile achieves the required driving resistance based on the parameters set by the representative pile(s) at a depth greater than 1.0m higher than the contract level, the piling contractor shall conduct PDA load testing of the pile to prove sufficient capacity has been achieved.

Piles shall be constructed within ±60mm in plan from the design position. Pilot holes shall only be drilled (to facilitate driveability) with the acceptance of Sydney Water.

Min. 1 PDA test shall be carried out on a pile constructed with pilot holes; in addition to the PDA tests originally required by design drawings.

C9.7. Bored Cast in-situ Concrete Piles

C9.7.1. Construction

All bored piles shall be constructed in accordance with RMS QA Specifications B58 or B59; as applicable when installed with and without a permanent casing.

C9.7.2. Pile Embedment Material

Pile embedment and socket material for each pile shall be verified at each Bored Pile, by a suitably experienced and Competent Geotechnical Engineer, in accordance with Sydney Water Competency Standard.

C9.7.3. Testing

Pile integrity testing and load testing shall be carried out as required by the RMS BTD Specification BTD 2011/08.

C9.8. CFA Piles

C9.8.1. Selection and Suitability of CFA Piles

CFA pile shall be checked for suitability and designed as outlined in RMS BTD 2011/02.

C9.8.2. Construction

All CFA piles shall be constructed in accordance with RMS QA Specifications B63.

C9.9. Screw Piles

C9.9.1. Installation

All screw piles shall be designed and installed in accordance to AS2159. Detailed design of the pile shall be submitted to Sydney Water, minimum 10 working days prior to importing screw piles to site.

C9.9.2. Testing

Each screw pile type shall have minimum one Ultimate Load Test carried in similar ground condition, in accordance with AS2159. Test results from other sites, with similar ground and loading conditions may be used.

The load test shall be verified and certified for site specific ground condition by a suitably qualified Competent Geotechnical Engineer.

Where sufficient load test results in similar ground conditions from another site are not available; minimum one sacrificial ultimate load test on a single pile within the site shall be carried out.
Unless accepted prior by Sydney Water, each pile tested shall represent each type of pile used in construction and ground conditions encountered on site. Each test shall represent and verify the geotechnical capacities adopted for the permanent pile.

Number of test piles and location shall be agreed with Sydney Water, 20 working days prior to the testing.

C9.10. Timber Piles
Treated timber piles may be used to support DN300 or smaller pipes. All treated piles shall be labelled in accordance with AS1604.1 and made available for Sydney Water, prior to installation.

Use of timber piles are not allowed to support other permanent structures and pipework; with design life greater than 50 years.

C9.11. Other Pile Types
Other pile types shall only be used with prior acceptance from the Sydney Water. All required specifications and design details shall be submitted to Sydney Water, minimum 20 working days prior to mobilisation of piling material and equipment to work site.
C10. Design Requirements

C10.1. General

C10.1.1. Scope

The design specification clauses herein outline minimum requirements in relation to design works; in addition to technical requirements specified in other parts of this specification and any other relevant standards and specifications.

All preliminary works and site investigations required to complete the design of the project must be undertaken.

These specification clauses provide only the minimum requirements for the design and detailing of works. All design work shall be carried out with the highest standard of care and due diligence. All design work shall be fit for the purpose with due consideration of technical, economic and safety risks.

C10.1.2. Standards and Codes

All design work shall comply with Australian Standards and codes as stated in this specification and any other codes as specified by Sydney Water.

Where appropriate, the design shall also comply with the following standards and codes, in addition to requirements specified in this technical specification:

- D0000653 Sydney Water- Safety in Design Procedure
- D0000833 Sydney Water- Engineering Competency Standard
- WSA 01 Polyethylene Pipeline Code
- WSA 02 Sewerage Code of Australia (Sydney Water Edition)
- WSA 03 Water Supply Code of Australia (Sydney Water Edition)
- WSA 04 Sewage Pumping Station Code of Australia (Sydney Water Edition)
- WSA 06 Vacuum Sewerage Code
- WSA 07 Pressure Sewerage Code of Australia
- WSA 201 Manual for Selection and Application of Protective Coatings
- ACP0166 Sydney Water’s Supplement to WSA 201
- Sydney Water Hydraulic System Services IICATS Standards.

C10.1.3. Design Personnel

The design shall be prepared by personnel who meet the qualification and experience requirements detailed in the Sydney Water’s Engineering Competency Standard.

C10.1.4. Extent of Design Documentation

C10.1.4.1. Design Calculations

Design calculations shall be documented, checked and verified by competent design personnel in accordance with the Sydney Water Engineering Competency Standard.

Design calculations shall clearly show the following:

- Applicability of codes and standards.
- Aim of design.
• Basis of design including strength and serviceability performance, design assumptions, economic, physical, aesthetic and other constraints.
• Design life.
• Design actions or loads.
• Design resistance or strength.
• Analytical methods and software used.
• Safety considerations.
• Environmental considerations.

C10.1.4.2. Design Verifications
Where required by the Engineering Competency Standard or as per the Contract, all necessary verification records from all verifiers and independent verifiers as defined in the Engineering Competency Standard shall be provided.

C10.1.4.3. Design Drawings
Design drawings shall be prepared and submitted in discrete and complete packages for elements or components of the Works.

Each drawing shall be complete and shall have been checked for accuracy and verified fit for purpose prior to submission.


If appropriate, design drawings for water and sewage pipelines shall comply with the requirements set out in Appendix SW3 – Drafting Requirements of the WSAA Water and Sewerage Codes (Sydney Water Edition). To facilitate drafting, a software package (AutoCAD utility) and Drafting Software User Guide are available for use.

C10.1.4.4. Design Report
A design report shall be prepared and submitted which meets industry accepted norms as well as meeting the requirements for Safety in Design. The design report shall inform the reader of all atypical hazards associated with the fabrication, construction, installation, commissioning, testing, operation, maintenance and demolition of the works so designed. Mitigation measures to reduce the level of risk to as low as reasonably practicable shall also be provided.

C10.1.4.5. Project Specification
When requested as part of the scope of work, a specification customised for the project shall be prepared based on this specification, Sydney Water’s DTC drawings and any other relevant Sydney Water specifications.

The inclusions of such a specification will be determined on a project-by-project basis but shall include:
• Reference to this specification and other relevant Sydney Water specifications
• Reference to specific Sydney Water DTC drawings
• Project specific civil and structural requirements
• Existing Sydney Water WAE drawings (if applicable)
- **Scope of Works**
- **Work by others and works excluded from the Scope of Works**

**C10.1.5. Safety in Design**

The requirements of the Safety in Design procedure specified in Sydney Water’s D0000653: Safety in Design Procedure shall be complied with. All necessary documentation related to Safety in Design shall be produced.

**C10.1.6. Design life of assets**

Apart from office buildings and buildings that house instruments only, the default design life of all other assets shall be 100 years.

The design life of buildings and buildings that house instruments only, shall be 50 years.

**C10.2. Referenced Documents**

The documents referred to in this specification are:

- **AS/NZS 1170.0** Structural Design Actions – General Principles
- **AS 1170.4** Structural Design Actions – Earthquake Actions in Australia
- **AS 1418.1** Cranes, Hoists and Winches- Crane Runways and Monorails
- **AS 1657** Fixed Platforms, Walkways, Stairways and Ladders – Design, Construction and Installation
- **AS 1604.1** Specification for Preservative Treatment- Part 1: Sawn and Round Timber
- **AS 1726** Geotechnical Site Investigation
- **AS 2082** Timber – Hardwood for Structural Purposes
- **AS 2159** Piling- Design and Installation
- **AS 2179** Specifications for Rainwater Goods, Accessories and Fasteners
- **AS 2272** Plywood – Marine
- **AS 2876** Concrete Kerbs and Channels (Gutters)
- **AS 2890.1** Off-street Car Parking
- **AS 2890.2** Off-street Commercial Vehicle Facilities
- **NZS 3106** Concrete Structures for the Storage of Liquids
- **AS 3500** Plumbing and Drainage Set
- **AS 3600** Concrete Structures
- **AS 3735** Concrete Structures retaining Liquid
- **AS 3996** Metal Access Covers, Road Grates and Frames
- **AS 5100** Bridge Design, Parts 1 to 7
- **AUSTROADS** AP-G34/06 – Australian Design Vehicles and Turning Path Templates
- **AUSTROADS** AGPT 02/08 – Guide to Pavement Technology – Part 2: Pavement Structural Design
- **WSAA WSA PS-315** Fixed Ladders in Water Supply and Sewerage Applications
- **ANSI/AWWA D100** Welded Carbon Steel Tanks for Water Storage
C10.3. Geotechnical Investigations

C10.3.1. General

Geotechnical investigations shall be scoped and carried out for each site and logged in accordance with AS 1726; by a suitably qualified, Competent Geotechnical Engineer, in accordance with Sydney Water Engineering Competency Standard.

The Competent Geotechnical Engineer shall review all existing geotechnical investigation information provided by Sydney Water; where available.

Where inadequate information is identified, additional geotechnical investigations shall be proposed and carried out.

The purpose of the investigation shall provide sufficient information on site conditions to allow design and construction details to be finalised.

All field and laboratory geotechnical investigation test results shall be submitted to Sydney Water in a report as electronic files in "*.pdf" format and as an AGS 4.0 file format.

C10.3.2. Scope of Geotechnical Investigations

The adequacy of all existing, available geotechnical investigation data shall be investigated and all necessary additional field and laboratory geotechnical investigations required for the design and construction of the proposed works shall be undertaken.

The scope of geotechnical investigations shall be prepared and submitted to Sydney Water for acceptance, including the following details as necessary:

- Desktop study of the available geotechnical data, identifying gaps and required additional geotechnical investigations for each design element,
- Layout Plan of existing and proposed Geotechnical Investigation locations with reference to each proposed design element, existing services and other details as necessary,
- Proposed minimum and maximum depth of investigations,
- Proposed method of drilling/ excavation for investigation,
- Proposed groundwater monitoring,
- Proposed schedule of laboratory testing,
- Proposed method and accuracy of survey of geotechnical investigation locations,
- Table of summary of all proposed geotechnical investigations and suitability of expected investigation results to inform design elements.
• The document shall also include all necessary safe work, health and safety documentation related to
the proposed works.

The geotechnical investigation proposal shall be submitted to Sydney Water, minimum 10 working days
prior to mobilisation to site.

C10.3.3. Geotechnical Investigation Factual Report

Where geotechnical investigations are carried out, a Geotechnical Factual Report shall be produced to
document all field investigations results, geotechnical logs and laboratory test results.

The Factual Report shall consist the following as a minimum:
• Purpose of the geotechnical investigations,
• Fieldwork methodology,
• Summary table of location of investigation and levels, the accuracy of investigation locations shall have:
  – Horizontal location accuracy = ±1.0m MGA
  – Vertical levels accuracy = ±0.1mAHD
• Piezometer or Water standpipe installation details (where applicable),
• Groundwater monitoring records,
• Laboratory test results,
• Plan of geotechnical investigations carried out in relevance to the proposed design elements overlaid on
  latest aerial photograph and utilities and services,
• Detailed Geotechnical borehole logs and where applicable, coloured photographs of rock cores,
• Laboratory test results from NATA accredited test laboratory

C10.3.4. Geotechnical Interpretation and Design

C10.3.4.1. Geotechnical Interpretive Report

The designer shall carry out geotechnical interpretation of all the available geotechnical factual information
from historical and newly carried out investigations; to provide geotechnical inputs to the design and
construction of all proposed elements.

The details of advice shall be up to date and appropriate to each design element. The Geotechnical
Interpretive Report shall include, but not limited to the following details:
• Topography of the area and report on any site conditions which may affect the design or construction of
  the proposed structure,
• Geology of the site,
• Soil landscape of the site,
• The subsurface soil profile drawn as geological sections across the site; using all available boreholes,
  cone penetration test and test pits as necessary,
• List all collected samples, test results and classify the soil strata,
• Groundwater levels and impact to the design,
• Engineering properties of the soil and groundwater,
• Chemical characteristics of the soil and groundwater such as soil salinity, aggressivity and Acid Sulfate
  potential,
- Specific characteristics of groundwater, expansive soil, ground heave, negative skin friction effects and slope stability,
- Provide recommendations on the type(s) of foundations, temporary and permanent earth retention,
- Bearing capacity values of the soils and rock at each proposed founding levels of structures, together with the recommended strength reduction factor;
- Estimate of the anticipated total and differential settlements for the proposed structure due to imposed dead and live loads at each structural foundation and pipes,
- Provide advice on excavability of the material present on site,
- Provide advice on material re-useability as earthworks material to satisfy technical requirements specified in this specification,
- Provide recommendations on construction procedures and construability considerations,
- Provide recommendations on earth pressure coefficients for design actions and design resistance,
- Provide recommendations on geotechnical, groundwater related impact on existing assets in vicinity,
- The potential effect of site conditions on pile durability, such as soil and ground water aggressivity,
- Provide advice on geotechnical risks, limitations, gaps in available geotechnical data and where applicable, provide recommendations for further geotechnical investigations,
- Provide recommendations for geotechnical ground verifications required on site, during construction.

The Geotechnical Interpretive Report shall be updated at the end of each design stage of the project to suit any design change in the design elements and shall be consistent with the overall design.

C10.3.5. Geotechnical Stability Checks

C10.3.5.1. Shallow Footings
Geotechnical stability of shallow footings shall be checked in accordance with AS5100.3.

C10.3.5.2. Slope Stability
All cut slopes and fill embankments shall be designed with a minimum long-term Factor of Safety (FOS) of 1.5 and a minimum short term FOS of 1.25. Short term loading conditions shall include (but not limited),
- seismic load,
- flooding,
- rapid drawdown,
- scour,
- impact loads transferred to the slope

Where an existing slope is proposed to be modified or support new structures; the existing slope shall be treated as a new structure and shall meet the above factor of safety requirements.

C10.4. Roadworks

C10.4.1. General
Roads shall be provided to service all buildings, facilities and structures where vehicular access is required. Roads shall extend to locations where installation and removal of heavy equipment requires mobile cranes and truck transportation.

Roads are required to carry traffic for the operation and maintenance of assets including mobile cranes, tankers, articulated vehicles, transportation trucks carrying sludge and chemicals, coaches, vans and passenger cars.
Roads shall be provided with turning areas, passing bays, kerbs and gutters, stormwater surface drainage, sub-surface drainage, trench drains and edge drains.

Hardstand areas shall be provided for the standing of heavy vehicles, mobile lifting equipment such as cranes, and for areas where regular cleaning and washing of the ground surface is required.

Parking areas shall be provided for parking of cars, vans and service vehicles.

Appurtenances such as fencing, railing and vehicular barriers shall be provided to protect facilities and structures from damage and people from injury by vehicles using the road.

Road lighting, road marking and traffic signage shall be provided where appropriate.

### C10.4.2. Width of Roads

The widths of roads shall provide passageway and passing clearances for the appropriate vehicle class using the road.

The minimum width for two-way roads shall be 6.2m. The minimum width for one-way roads shall be 4.0m.

Unless otherwise specified, the following AUSTROADS Design Vehicles shall be used in the design:

- Roads for use by heavy transportation vehicles – Single Articulated (19.0m long, 2.5m wide).
- Roads for use by normal service vehicles – Service Vehicle Class (8.8m long, 2.5m wide).
- Roads for use by cars and vans – Car/Van Vehicle Class (5.2m long, 1.94m wide).

The geometry and turning radii of roads shall comply with the requirements of AUSTROADS AP-G34/06 for the appropriate Design Vehicle classes.

For the design of parking areas, the requirements of Australian Standard AS 2890.1 or AS 2890.2 shall be met.

### C10.4.3. Pavement Design

The assessment of design input parameters and design methods for both flexible and rigid pavements shall be in accordance with AUSTROADS AGPT 02/08 – Part 2.

The minimum pavement design shall be as follows for a subgrade of minimum CBR=5% for minimum 1m depth below subbase level:

- Rigid pavement – 150mm thick reinforced concrete slab over a minimum of 100mm thick DGB20 base course.
- Flexible pavement – 45mm thick wearing course of AC14 asphaltic concrete, 150mm thick DGB20 base course, and 200mm thick DGS40 sub-base course.

Site specific pavement design shall be produced for ground conditions with CBR<5% for minimum 1m depth below subbase level.

### C10.4.4. Rigid Pavement

Rigid pavements of reinforced concrete shall be provided for:

- Vehicle washing bays.
- Hardstand area, parking area, loading bay, boom gate approach slabs, etc. for vehicles transporting chemicals, sludge and corrosive materials.

### C10.4.5. Kerb and Gutters

Kerbs shall be of the semi-mountable type integral with formed gutters or trays as shown in AS 2876.
C10.4.6. Flooding
Roads shall be designed at levels free from flooding during storm events having an ARI of not less than 100 years, or other higher ARI events specified by Local Government Councils or other appropriate authorities.

C10.5. Stormwater Drainage Design
C10.5.1. Background
While Sydney Water manages major stormwater drainage assets in the Sydney region, it recognises the role of local government as the principal flood management authority. Sydney Water supports the NSW government Flood Policy and the efforts of Councils to implement the Floodplain Development Manual merit-based assessment process.

C10.5.2. Drainage Amplifications
Within the Floodplain Development Manual process, Sydney Water may undertake flood mitigation and drainage amplifications related to existing Sydney Water stormwater assets. The appropriate level of service shall be established jointly between Council and Sydney Water within a Council adopted Floodplain Risk Management Plan.

C10.6. Protective Coating Systems
Protective coating systems used in all Sydney Water assets shall comply with WSA 201 and Sydney Water’s Supplement.

C10.7. Platforms, Walkways, Open Flooring, Stairways and Handrails
C10.7.1. General
Access platforms, walkways and stairs shall be provided to give safe access to all areas of structures and equipment that requires operation and maintenance. These may include observation, inspection, control, adjustment/lubrication of equipment and machinery, replacement of flange gaskets and gland packings, valves, cranes, temperature, pressure and flow sensors, tapping points and other instruments.

Platforms, walkways, step irons, stairs and handrails shall comply with the requirements of AS 1657, WSAA Product Specification WSA PS-315 and all relevant WorkCover NSW requirements.

All walkways and stairways shall have a minimum width of 1,000 mm. Wider walkways and platforms shall be provided as required to accommodate handling of equipment and passage of personnel.

Platforms may be of the demountable type as required.

Access stairway treads shall have a surface pattern that will provide a non-slip grip even when immersed in liquid.

C10.7.2. Floor Plates and Gratings
Floor plates and gratings shall be of sufficient thickness to carry the design loads. The deflection (excluding support structure) under the design loads shall not exceed 1/250 of the span with a maximum value of 5 mm.

Floor gratings shall be either hot-dipped galvanised mild steel or aluminium. Gratings shall have serrated edge load carrying bars at appropriate spacing. Each grating panel shall have edge bars welded across the end of the load bars, notches or penetrations. The edge bar shall be the same section as the load bars.

Every panel shall be fastened to the supporting structure using the proprietary screws and clamps of the floor plate supplier, except for the step grates. Load carrying bars shall travel in the direction between the supporting structural members. There shall be no raised projections above the floor levels of the platforms or walkways.
Mild steel floor plates shall have a thickness not less than 6mm. Plating shall have a surface pattern which shall be of a no-slip type.

Both the load bearing and transverse bars in rectangular panels shall be positioned symmetrically around the centre-line of the panel in both directions so that when the panels are fixed together the bars are in line with each other.

Removable plating and grating panels shall be in sizes suitable for removal by hand and be provided with cut-outs or devices for lifting. The maximum weight of each removable panel shall be not more than 16 kg for manual handling by one person, or not more than 32 kg for two persons. Otherwise, the maximum weight of each panel shall be not more than 45 kg.

If there is a risk of objects falling through gratings or open flooring causing injury to persons, a protective mesh or net shall be provided.

In cases where security is required, the plates or grating hatches shall be lockable using a key- alike system.

**C10.7.3. Cut-outs**

Cut-outs in floor plates and gratings shall be provided in positions required for operation of valve spindles, etc. Cut-outs shall be approximately 150 x 150 mm and the exposed edges shall be fitted with welded trim bars across the longitudinal runners. Band bars shall be provided around all cut-outs and butt joints between panels.

**C10.7.4. Deflection Limits for Beams Supporting Platforms and Walkways**

Deflection limits for support beams of platforms and walkways shall be as shown in Table 10-1.

<table>
<thead>
<tr>
<th>Type of Beam</th>
<th>Deflection Limit for Span</th>
<th>Deflection Limit for Cantilever</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting Platforms and Walkways for Accessing Valves, Penstocks and similar operational items</td>
<td>≤ Span / 350</td>
<td>≤ Span / 175</td>
</tr>
<tr>
<td>Supporting Platforms and Walkways only</td>
<td>≤ Span / 250</td>
<td>≤ Span / 125</td>
</tr>
</tbody>
</table>

**C10.7.5. Handrails and Kickplates**

All stairways, platforms and walkways shall be enclosed by hand railing unless there is less than 100 mm between the walkways and an adjacent structure. In such a case, kickplates shall still be required.

Hand railing shall be of uniform appearance and manufacture. Mono-Wills tubular handrail system or any equivalent proprietary system is acceptable.

Stanchions shall be set at not more than 2 m centres. Joints in the rails shall be inside stanchion knuckles or connection receptacles. Mono-Wills tubular stanchion system or any equivalent proprietary system is acceptable.

Installation of stanchions and handrails shall be strictly in accordance with the manufacturers printed instructions and no deviations shall be permitted unless accepted in advance by Sydney Water.

A 6 mm thick kickplate shall be provided unless exempted in advance by Sydney Water and shall project 100 mm above the floor level of the platforms and walkways.

Stairway openings on platforms and walkways shall be protected with self-closing safety gates or booms. Chains shall not be used.
C10.8. Buildings

C10.8.1. General

Unless otherwise specified, all buildings shall be designed to satisfy the requirements of the Building Code of Australia 2008, the NSW State Government building regulations, the requirements of the local Council and any other legislative technical requirements applicable to the site in which the buildings are located.

The style, appearance and colour scheme of new buildings shall be similar to existing similar buildings in the compound as far as practical.

If existing buildings are altered, the alterations shall ensure that the new works are in keeping with the style, appearance and colour of the existing building.

C10.8.2. Performance Requirements

All buildings shall be designed to prevent progressive collapse and minimise local damage and loss of amenity through excessive deformation, vibration and degradation. It must be designed to withstand the combination of loads and other actions to which it may reasonably subjected.

All buildings and rooms shall be functional and sized to facilitate easy access to equipment. All doors and passageways shall be designed so that equipment and machinery can be moved in and out of the building.

Natural ventilation shall be provided as far as possible except where odour control is required. Forced air ventilation or air-conditioning shall be provided to underground spaces, galleries and in controlled environment where comfort of people and protection of equipment are required.

Building systems and materials shall be selected to suit the environment.

C10.8.3. Construction Materials

Unless otherwise specified, all buildings shall have reinforced concrete floors.

Protective coating to steelwork shall comply with WSA 201 and Sydney Water’s Supplements.

All buildings shall be fit for purpose, secure from weather, vermin and resistant to attack from vandals. All external doors shall be solid core doors with deadlocks. All locks shall be master-keyed, or keyed alike to the system already in use.

The interior shall be finished neatly using lined ceilings (except in plant rooms) and face brick or rendered walls with slip resistant floors. Translucent roof sheeting or skylights may be used to maximise natural lighting.

Unless otherwise specified, metal roof and wall sheets shall be marine grade aluminium, Colorbond, Ultra Steel sheetings, or accepted equivalent.

Adequate tread plates or cat-walk shall be provided on metal roof where access is required for operational needs. Where access is required on metal roof, the deflection of the roof sheeting under design load shall not exceed 1/250 of the span, with a maximum value of 5 mm.

Flashings, eave gutters, outlets, downpipes and the like shall be provided. Rainwater goods, accessories and fasteners shall be powdered coated aluminium, or zinc/aluminium alloy-coated steel to AS 2179 and shall be designed in accordance with AS 3500.

C10.9. Design Loads

C10.9.1. Design Ground Water Level

The design ground water level shall be the value assuming the water level is at ground level or, where information is available, the ground water level with an annual probability of exceedance of 1 in 100.
C10.9.2. Flotation of Structures Founded Below Ground Level

For structures founded below ground level, buoyancy checks shall be carried out when the structure is empty with the external groundwater situated at the design ground water level. The design shall account for the local rise in ground water level caused by the damming effect of the structure on the natural ground water flow regime.

Buoyancy forces shall be resisted by the provision of either sufficient dead load to resist the flotation forces in accordance AS 1170.0, or the provision of an adequately designed pumped subsoil drainage system.

Under suitable conditions, the provision of pop-up valves may be permitted in conjunction with adequate underfloor drainage system for clear water tank operations. Pop-up valves shall not be used for tanks holding sewage, sludge or liquid with solid contents.

The diameter of the pop-up valves shall be not less than 150 mm. The number and spacing shall be determined by the discharge characteristics of the valve, and shall be located on a grid not more than 6 m x 6 m. The system shall include the facility and access to inspect and clean out the subsoil drains.

C10.9.3. Minimum Design Imposed Load

Unless specified otherwise, the minimum design live loads shall comply with Table 10-2.

Table 10-2 Minimum Design Imposed Loads

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Imposed Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal roof, not accessible except for maintenance *</td>
<td>To AS 1170.1, but not less than 0.5 kPa</td>
</tr>
<tr>
<td>Metal roof, designated areas for walkways and platform *</td>
<td>2.5 kPa</td>
</tr>
<tr>
<td>Ceiling Space</td>
<td>0.5 kPa</td>
</tr>
<tr>
<td>Concrete roof, accessible but no vehicular traffic and not for public assembly *</td>
<td>2.5 kPa</td>
</tr>
<tr>
<td>Areas subjected to vehicular traffic</td>
<td>SM1600 to AS S100.2</td>
</tr>
<tr>
<td>Platforms and walkways</td>
<td>To AS 1657 but not less than 2.5 kPa</td>
</tr>
<tr>
<td>Office floors</td>
<td>3 kPa</td>
</tr>
<tr>
<td>Storage Rooms</td>
<td>4 kPa</td>
</tr>
<tr>
<td>Control Rooms</td>
<td>5 kPa</td>
</tr>
<tr>
<td>Equipment Rooms</td>
<td>8 kPa</td>
</tr>
</tbody>
</table>

Note: * Roof surface must be at least 300mm above the adjacent ground level, or protected with adequately designed barriers/bollards to exclude vehicular traffic.

C10.9.4. Importance Levels for Earthquake and Wind Loads

For the assessment of wind and earthquake loads for new structures, the “Importance Level” shall be in accordance with the guidelines in Table F1 of AS 1170.0 and the Building Code of Australia. Unless accepted in advance by Sydney Water, the values for importance levels shall be as in Table 10.3.

The internal wind coefficient for the reservoir shell shall be more severe than -0.5 (suction).
### Table 10-3 Importance levels for structures

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Importance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Dams &amp; water containment assets assessed as ‘declared dams’</td>
<td>5</td>
</tr>
<tr>
<td>Water storage reservoirs required for disaster recovery (such as supplying</td>
<td>4</td>
</tr>
<tr>
<td>water for firefighting and to hospitals), drinking water pump stations &amp;</td>
<td></td>
</tr>
<tr>
<td>drinking water aqueducts</td>
<td></td>
</tr>
<tr>
<td>Water storage reservoirs not required for disaster recovery</td>
<td>3</td>
</tr>
<tr>
<td>Bridges and stormwater aqueducts within Sydney Water property</td>
<td>3</td>
</tr>
<tr>
<td>Wastewater facilities</td>
<td>3</td>
</tr>
<tr>
<td>Stormwater assets</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note (1): Refer Clause 10.17*

**C10.9.5. Hydrostatic pressure Loading**

All structures shall be designed for imposed hydrostatic forces for all operating conditions and external ground water table.

**C10.9.6. Seismic Loads on Liquid Retaining Structures**

Seismic loads shall be based on the entire weight of liquid retaining structures and their contents or shall take account of the separate effects of the liquid content, using internationally recognised methods. A recommended code for the above is the New Zealand Standards NZS 3106 : Concrete Structures for the Storage of Liquids.

The horizontal earthquake force on the structure shall be calculated using the following formulae.

\[ F = \sqrt{F_I^2 + F_C^2} \]

where:
- \( F_I \) = Inertia component
- \( F_C \) = Convective (oscillating or sloshing) component

and, where determination of \( F_I \) and \( F_C \) shall be as follows:

**Inertia Component**

The inertia component of the earthquake shall be calculated according to the following formulae:

\[ F_I = C_I \cdot (W_S + W_I) \]

where:
- \( W_S \) = Effective weight of the structure if it were empty (This would include the weight of the walls and roof. It would also include the weight of the floor if the structure was elevated)
- \( W_I \) = Weight of the impulsive liquid contents of the structure (For calculation of \( W_I \) and its effective height above the floor of the liquid retaining structure, refer to NZS 3106)
- \( C_I \) = Inertia coefficient
  = \( A_0 \cdot C_H \cdot T_I \)

and where:
- \( A_0 \) = Base acceleration coefficient
  = \( k_p \cdot Z \cdot S_p / \mu \)
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\[ C_h(T_I) = \text{Spectral Shape Factor as a function of } T_I \text{ (Values are given in AS 1170.4)} \]

\[ k_p = \text{Probability factor from Table 3.1 of AS1170.4 for the annual probability of exceedance}\]

\[ Z = \text{Hazard factor from AS 1170.4} \]

\[ S_p = \text{Structural performance factor equal to 1.0} \]

\[ \mu = \text{Structural ductility factor equal to:} \]

\[ = 2.0 \text{ for ductile structures capable of absorbing considerable energy after experience first yielding. Joints would need to be able to develop high values of plastic hinge rotation without exhibiting brittle behaviour and without experiencing local or overall buckling. Brittle behaviour shall be avoided by good detailing including satisfactory overlapping between reinforcement in columns, beams, walls and slabs.} \]

\[ = 1.0 \text{ for other structures} \]

\[ T_I = \text{Fundamental natural period of the structure in the dimension being considered} \]

Convective (Oscillating or Sloshing) Component

The convective component of the earthquake force shall be calculated according to the following formulae:

\[ F_C = C_C \times W_C \]

Where:

\[ W_C = \text{Weight of the convective contents of the structure (For calculation of } W_C \text{ and effective height above the floor level of the liquid retaining structure, refer to NZS 3106)} \]

\[ C_C = \text{Convective coefficient} \]

\[ = 2.7 A_0 / T_C^{1.4} \]

and where:

\[ A_0 = \text{Base acceleration coefficient as defined in this in section before} \]

\[ T_C = \text{Fundamental natural period of the structure in the sloshing (For calculation of } T_C \text{, refer to NZS3106)} \]

Hydrostatic Pressure Distribution due to Seismic Loads

Hydrostatic pressure distribution due to earthquake induced loads may be calculated in accordance with NZS 3106.

The surface reservoirs shall be designed to meet Wind loadings and Earthquake loadings, including when each reservoir is empty, partially full or full and the hatches are open or closed.

C10.9.7. Lateral Soil Loads

For design actions, all structures or parts of structures located below ground level shall be designed for the following soil pressures:

- “Active” soil pressure for walls with adequate wall movement (e.g. cantilever walls). In such cases for design action, a minimum lateral earth pressure coefficient of \((K_a)\) adopted shall be 0.35.

- "At Rest" soil pressure for relatively stiff walls (e.g. propped cantilevers, cantilever walls of tanks near corners etc.). In such cases for design action, a minimum lateral earth pressure coefficient \((K_0)\) adopted shall be 0.5.

- A minimum surcharge load of 10 kPa where vehicular traffic is restricted by bollards.
- A minimum surcharge loading of 20 kPa where unrestricted vehicular access is required for maintenance purposes.
- Earthquake induced additional soil pressure.
- Compaction induced additional soil pressure.

All design checks shall be carried out using load combinations presented in AS 5100.3.

**C10.9.8. Spacing for Bollards & Design Loads for Restricting Vehicular Access**

The bollards shall be spaced at no more than 2.0 m centres and shall be designed for an ultimate load of 45 kN applied at 1 m above the pavement level.

**C10.9.9. Vibration Loads**

The effect of vibration and torque of the equipment on footings shall be considered. If data for the design of the footings is not available from the manufacturer or investigation is not carried by an industry recognised specialist, the weight of the footing $W_1$ shall not be less than 3 times of the weight of the equipment $W_2$.

For vertical vibration, $W_1$ shall be confined to the area $(a+2t) \times (b+2t)$, where:

- $a$ & $b$ refer to the plan dimensions of the equipment.
- $t$ refers to the thickness of the supporting slab.

For horizontal vibrations, $W_1$ may be taken as the weight of the horizontal bracing structure.

**C10.9.10. Dynamic Loads**

Dynamic loads related to Crane Runways and Monorails shall be calculated to AS 1418.1 shall not be less than the following:

- Vertical - 25 % of the total load including trolley.
- Horizontal transverse - 20 % of the total load including trolley.
- Horizontal longitudinal – 10 % of the total load including trolley.

**C10.9.11. Thrust Loads**

Thrust loads from all anchored components of hydraulic conveyances shall be considered on the structure.

**C10.10. Concrete Structures**

**C10.10.1. Liquid Retaining Concrete Structures**

Concrete structures for the storage and conveyance of liquids such as water, sewage, sludge and stormwater shall be designed to the requirements of AS 3735.

For the purpose of design for serviceability, strength and durability, the structure or member shall be regarded as in contact with the liquid if:

- Surfaces are predominantly submerged (quiescent, agitated or flowing), or subject to alternate wet and dry cycles due to condensation, splashing or washing.
- Buried surfaces that are below the design ground water table.
- Surfaces are used for hardstand area subjected to washing and hosing down at least once a week.
- Surfaces are on the inside of bunds including the floor and walls that are constructed to contain spillage of storage tanks.
C10.10.2. Durability Requirements (concrete grade & cover to reinforcement) for Concrete Structures

The durability requirements for non-liquid retaining structures designed for 50 year design life shall be in accordance with AS 3600 and 100 year design life shall be in accordance with AS5100.

For liquid retaining structures, Table 10-4 lists the minimum durability requirements for typical exposure categories for 50 year design life and Table 10-5 lists the minimum durability requirements for typical exposure categories for 100 year design life

For structural members formed by spinning or rolling concrete with water/cement ratio of less than 0.35, the minimum cover to liquid retaining surfaces shall be

- Exposure classifications B1 & B2 - 20 mm & 30 mm for design lives 50 years & 100 years respectively
- Exposure classifications C & D - 30 mm & 40 mm for design lives 50 years & 100 years respectively

C10.10.3. Reduction in Cover Requirements for Galvanised and Austenitic Stainless steel Reinforcement

The normal cover requirements may be reduced by up to 10 mm for galvanised reinforcement and 20 mm for austenitic stainless steel reinforcement. The minimum cover provided shall not be less than 25 mm or 50 % more than the largest aggregates used in the concrete.

C10.10.4. Areas to be Designed as Alternate Wet and Dry to AS 3735

All surfaces above the minimum operating level shall be designed as being subjected to alternate wetting and drying (Table 3.5 of AS 3735).

### Table 10-4 Minimum Durability Requirements for Typical Exposure Classifications in Liquid Retaining Structures For 50 Year Design Life

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Liquid Retaining Surfaces / Exposure Classification</th>
<th>Concrete Grade S40</th>
<th>Concrete Grade S50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standard Formwork</td>
<td>Rigid Formwork &amp; Intense Compaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard Formwork</td>
<td>Rigid Formwork &amp; Intense Compaction</td>
</tr>
<tr>
<td>Sewerage Structures</td>
<td>Walls &amp; Roof / D</td>
<td>75 mm¹</td>
<td>60 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>75 mm</td>
<td>60 mm</td>
</tr>
<tr>
<td>Sewage Pumping Stations - Wet Wells, inlet access chambers</td>
<td>Walls &amp; Roof / D</td>
<td>75 mm¹</td>
<td>60 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>75 mm</td>
<td>60 mm</td>
</tr>
<tr>
<td>Sewage Wet Weather Overflow Storage Tanks – Sharing the same air space as the dry weather wet wells</td>
<td>Walls &amp; Roof / D</td>
<td>75 mm¹</td>
<td>60 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>75 mm</td>
<td>60 mm</td>
</tr>
<tr>
<td>Sewage Wet Weather Overflow Storage Tanks – Not sharing the same air space as wet wells</td>
<td>Walls, Roof &amp; Floor / C</td>
<td>75 mm</td>
<td>60 mm</td>
</tr>
<tr>
<td>Sewage Treatment Plants– Inlet Structures</td>
<td>Walls &amp; Roof / D</td>
<td>75 mm¹</td>
<td>60 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>75 mm</td>
<td>60 mm</td>
</tr>
</tbody>
</table>
### Table 10-5 Minimum Durability Requirements for Typical Exposure Classifications in Liquid Retaining Structures For 100 Year Design Life

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Liquid Retaining Surfaces / Exposure Classification</th>
<th>Concrete Grade S40</th>
<th>Concrete Grade S50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standard Formwork</td>
<td>Rigid Formwork &amp; Intense Compaction</td>
</tr>
<tr>
<td>Sewerage Structures</td>
<td>Walls &amp; Roof / D</td>
<td>NA</td>
<td>70 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>NA</td>
<td>70 mm</td>
</tr>
<tr>
<td>Sewage Pumping Stations - Wet Wells, inlet access chambers</td>
<td>Walls &amp; Roof / D</td>
<td>NA</td>
<td>70 mm¹</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>NA</td>
<td>70 mm</td>
</tr>
<tr>
<td>Structure Type</td>
<td>Liquid Retaining Surfaces / Exposure Classification</td>
<td>Concrete Grade S40</td>
<td>Concrete Grade S50</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Sewage Wet Weather Overflow Storage Tanks – Sharing the same air space as the dry weather wet wells</td>
<td>Walls &amp; Roof / D</td>
<td>70 mm</td>
<td>700 mm</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>70 mm</td>
<td>55 mm</td>
</tr>
<tr>
<td>Sewage Wet Weather Overflow Storage Tanks – Not sharing the same air space as wet wells</td>
<td>Walls, Roof &amp; Floor / C</td>
<td>70 mm</td>
<td>70 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 mm</td>
<td></td>
</tr>
<tr>
<td>Sewage Treatment Plants– Inlet Structures</td>
<td>Walls &amp; Roof / D</td>
<td>70 mm</td>
<td>70 mm</td>
</tr>
<tr>
<td></td>
<td>Floor / C</td>
<td>70 mm</td>
<td>55 mm</td>
</tr>
<tr>
<td>Sewage Treatment Plants- Digesters and Anaerobic Sludge Holding Tanks with roof</td>
<td>Walls, &amp; Roof / C</td>
<td>70 mm</td>
<td>70 mm</td>
</tr>
<tr>
<td></td>
<td>Floor / B2</td>
<td>60 mm</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 mm</td>
<td></td>
</tr>
<tr>
<td>Sewage Treatment Plants- Sed Tanks, Aeration Tanks, Filters and other Effluent Holding Tanks without roof</td>
<td>Floor &amp; Walls / B2</td>
<td>60 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>Sewage Treatment Plants–Recycle Water Storage Tanks &amp; Chlorination Tanks</td>
<td>Floor, Walls &amp; Roof / B2</td>
<td>60 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 mm</td>
<td></td>
</tr>
<tr>
<td>Hard Stand Areas Hosed Down Periodically</td>
<td>Floor / B1</td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 mm</td>
<td>35 mm</td>
</tr>
<tr>
<td>Chemical Storage Tanks- Emergency Spillage &amp; Containment Surfaces</td>
<td>Floor &amp; Bund Walls / B2</td>
<td>B 60 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>Stormwater Channels in non Tidal Zones</td>
<td>Floor Walls &amp; Roof / B1</td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 mm</td>
<td>35 mm</td>
</tr>
<tr>
<td>Stormwater Channels in Tidal Zones</td>
<td>Floor Walls &amp; Roof / C</td>
<td>(NA)</td>
<td>70 mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 mm²</td>
<td>45 mm²</td>
</tr>
<tr>
<td>Water Treatment Plants</td>
<td>Floor, Walls &amp; Roof / B2</td>
<td>60 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>Potable Water Reservoirs</td>
<td>Floor, Walls &amp; Roof / B1</td>
<td>50 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 mm</td>
<td>35 mm</td>
</tr>
<tr>
<td>Structures in Sea Water</td>
<td>All Exterior Surfaces / C</td>
<td>70 mm²</td>
<td>65 mm²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 mm²</td>
<td></td>
</tr>
</tbody>
</table>

Notes for Table 10-4 and 10-5:
1. In addition to the required cover, the concrete surfaces shall be as per WSA 201 and Sydney Water’s Supplement,
2. In addition to the required cover, the reinforcement shall be stainless steel or galvanised carbon steel
3. Normal odour extraction shall not be permitted for the lowering the exposure classification unless the system is specifically designed to eliminate all dead zones and certified by ventilation specialist.
**C10.10.5. Vertical Construction Joints**

Vertical construction joints shall not be permitted in circular liquid retaining structures.

**C10.10.6. Minimum Thickness of Reinforced Concrete Members**

Minimum thickness for singly reinforced member shall be 150 mm. The thickness of doubly reinforced member shall be adequate to maintain a minimum clear distance of 75 mm between parallel reinforcement.

**C10.10.7. Prestressed Concrete Tanks**

Prestressing shall be achieved by post-tensioning tendons that are placed within the structural member. On completion of post-tensioning, the ducts shall be completely filled with grout as soon as practicable.

Unbonded tendons, i.e. post-tensioned tendons that are protected by sheathing, grease and prestressing achieved by wire winding method and subsequently protected by shotcrete shall not be permitted.

**C10.10.8. Crack Control Requirements for Serviceability**

For concrete liquid retaining structures, the maximum crack width that shall be permitted prior to being in service is 0.1 mm. When in service, the crack control requirements shall be in accordance with AS 3735.

For concrete structures other than for liquid retaining, the maximum crack width that shall be permitted prior to being in service is as follows:

- Exposure classification A2 – 0.4 mm
- Exposure classification B1 – 0.3 mm
- Exposure classifications B2 & C – 0.2 mm

All cracks that do not meet the above requirements shall be investigated by an independent structural engineer as accepted by Sydney Water. The investigation report shall detail the reasons for these cracks and measures to be implemented to repair these cracks to meet the specified performance, design life and durability requirements.

The same procedures shall apply to other defects such as cold joints, honeycombing etc.

**C10.10.9. Minimum Reinforcement in Reinforced Concrete Liquid Retaining Structures**

Minimum reinforcement in reinforced concrete liquid retaining structures shall be in accordance with Table 3.1 of AS 3735.

The minimum reinforcement shall be proportioned for the full thickness of the member irrespective of whether one or both surfaces are designated as liquid retaining structures.

No reduction in the minimum reinforcement shall be permitted irrespective of joint spacing or length.

**C10.10.10. Minimum Conventional Reinforcement in Post-Tensioned Concrete Liquid retaining Structures**

Minimum conventional reinforcement in post-tensioned concrete liquid retaining structures shall be 50 % of the reinforcement required in accordance with Table 3.1 of AS 3735.

The minimum reinforcement shall be proportioned for the full thickness of the member irrespective of whether one or both faces are designated as liquid retaining structures.

**C10.10.11. Minimum Reinforcement for Members of Non Liquid Retaining Structures**

Minimum reinforcement for non-liquid retaining structures shall be as follows:

- Exposure classification A2 - 0.25 %
- Exposure classification B1 - 0.35 %
- Exposure classifications B2 & C - 0.45 %.
C10.10.12. Load Combinations for Serviceability to AS 3735 for Liquid Retaining Concrete Structures

In addition to the requirements of serviceability to AS 3735, the following additional load combinations shall be considered typically for walls and floors of structures founded below ground level:

- Normal operating conditions – external soil pressure and ground water table shall not be taken into account in Group A serviceability calculations. However, the desirable effect of external soil pressure may be used when the earth pressure coefficient, subject to a maximum value of 0.20, is substantiated by adequate soil testing corresponding to a characteristic value for design resistance.

- Maximum overload conditions - external soil pressure and ground water table shall not be taken into account in Group B serviceability calculations. However, the desirable effect of external soil pressure may be used when the earth pressure coefficient, subject to a maximum value of 0.20, is substantiated by adequate soil testing.

- As (1) above with earthquake load for Group B serviceability.

- Structure empty with design earth pressure (excluding surcharge loads) and design ground water table for Group B serviceability.

- Structure empty with design earth pressure including surcharge loads for Group B serviceability.

- Individual compartments with adjacent compartment empty for normal operating condition for Group A serviceability.

- Individual compartments with adjacent compartment empty for maximum overload condition for Group B serviceability.

- Individual compartments with adjacent compartment empty for normal operating condition with earthquake for Group B serviceability.

- Baffle walls for normal operating condition with a minimum of 1 m hydrostatic pressure differential for Group A serviceability.

- Baffle walls for normal operating condition with earthquake for Group B serviceability.

- Baffle walls without adequate openings for flow balancing shall be designed as 6, 7 & 8 above.

The effects of shrinkage and swelling effects and, temperature variations and temperature gradients shall be combined with the above load combinations as appropriate in accordance with Clause 2.4 of AS 3735.

C10.10.13. Reinforcement Details at Opening “L” and “T” joints

The reinforcement details in all opening joints (e.g. wall to floor and wall to wall) shall conform to recommended practices to avoid premature diagonal cracking of concrete inside the joint.

For details not conforming to published recommended practices, appropriate reduction in the actual moment capacity of the joint (not member capacity adjacent to the joint) shall be taken into consideration.

Details complying to published recommended practices, as a minimum shall include the following:

- At “L” joints, the reinforcement from the joining members shall overlap within the joint as “U” bars with transverse reinforcement located inside each corner of the overlap. The extension of the “U” bar past the inside face of corner shall be at least equal to the anchorage length.

- At “T” joints, the cogs of the starter bars shall be turned towards the opposite face reinforcement. The extension of the cog past the opposite face reinforcement shall be at least equal to the anchorage length.
C10.10.14. Reinforcement Details at Penetrations

As a minimum, the reinforcement truncated by penetrations shall be compensated as follows:

- Additional reinforcement adjacent to the penetration in each direction shall be provided within half the size of the penetration on all four sides. The amount of reinforcement provided on each side shall be at least equal to one bar more than the half the number of bars truncated by the penetration. The compensating bars shall extend past the other compensating bars in the orthogonal direction by amount at least equal to the anchorage length.

- Circular penetrations of 600 mm dia or more, shall incorporate 2 additional diagonal trimmers at each corner. The trimmer bars at each corner shall be spaced no more than 100 mm centres and extend past the other trimmer bars in the orthogonal direction by an amount at least equal to the anchorage length.

C10.11. Circular Liquid Retaining Steel Tanks

C10.11.1. Welded Tanks

All tanks shall be continuously welded unless accepted by Sydney Water at concept design stage.

C10.11.1.1. Applicable Codes and Standards

Circular tanks shall be designed in accordance with relevant Australian Standards and codes of practice. Where not covered by the relevant Australian Standards and codes of practice, the elements of the tank shall be designed and detailed to ANSI/AWWA D100-05 and API 650.

C10.11.1.2. Design of Wall Plates

The design of wall plates shall be based on elastic allowable stress appropriate for the grade of steel and welded joint efficiency of 100%.

The allowable stress for normal operating condition for Grade 250 steel shall be 137 MPa.

C10.11.1.3. Minimum Corrosion Allowance on Interior Surfaces

Design shall cater for the following corrosion allowances on the interior surfaces of reservoir:

- Plates and cleats – 2 mm per exposed face
- Roof framing members and support such as columns, rafters and purlins - 1 mm per exposed face.

C10.11.1.4. Minimum Thickness of Wall Plates

The minimum wall plate thickness shall be 8 mm.

C10.11.1.5. Minimum Thickness of Floor Plates

The tank floor shall consist of either a reinforced concrete floor or a welded steel floor meeting the following minimum requirements:

- Annular / sketch plate – 12 mm
- Floor plate – 10 mm

C10.11.1.6. Minimum Thickness of Cleats, Connections & Structural Members on Inside the Reservoir

- Cleats, Connections and Protuberances from the tank – 12 mm
- Flange thickness on channels, I sections and T sections – 10 mm
- Web thickness on channels, I sections and T sections – 6 mm
- Leg thickness on angles – 10 mm
- Wall thickness on tubes and hollow sections – 6 mm
- Thickness on plates (excluding wall and floor) – 6 mm

C10.11.1.7. Fillet Welds
- The size of fillet welds shall make allowance for long term corrosion.
- Minimum 6 mm continuous fillet welding shall be used for all connections, including seal welds. Intermittent welding shall not be permitted.

C10.11.1.8. Welding
Weld details shall comply with the following:
- Full penetration butt welds shall be adopted for wall and sketch plates with backing run for wall plates.
- Continuous fillet welds shall be adopted for floor plates.
- Minimum size of fillet weld shall be 6 mm.
- Joint efficiency of the weld shall be 100%.
- No seal weld or intermittent weld shall be permitted.

C10.11.1.9. Creep Control brackets for on ground tanks
Adequately designed creep control brackets shall be employed to prevent tanks from gradually creeping sideways due to uneven thermal effects when tank is empty and also before pipework is connected.

C10.11.1.10. Tanks Located Below Finished Ground Level
Tanks located below finished ground level shall be separated by a retaining wall with a minimum clearance of 2 m from the tank wall. No part of the tank shall be covered with back fill.

C10.11.2. Bolted Tank
C10.11.2.1. General
Bolted tanks shall not be used unless the following is demonstrated and accepted by Sydney Water:
- Minimum design life shall be fifty (50) years
- Maintenance free ten (10) year performance records of at least three tanks of identical construction in Australia shall be provided
- All material components shall a minimum warranty period of 15 years
- The requirements of AWWA D103 shall be complied to factory-coated bolted carbon steel tanks for water storage. Bolted steel tanks for other cargo e.g. wastewater sludge and chemicals, the requirements of ISO 28765 shall apply.
- Interior and exterior coatings shall be glass fused-to-steel (vitreous enamel) coating. Prior to fabrication of the steel panels, an Inspection and Testing Plan for the coating shall be submitted to Sydney Water for acceptance. The inspection and testing shall be undertaken by a certified 3rd party coating Inspector. Sydney Water (and its representative) reserves the right to carry out quality audits on the work from time-to-time.
- Sealants and gaskets shall have adequate chemical resistant to the intended cargo. For drinking water purpose, they shall be demonstrated to have long-term chemical resistant to a minimum of 2 ppm of free chlorine solution.
- 25 mm x 50 mm joint sealant shall be provided in a preformed recess on both faces of the embedded section of the wall stakes.
- Neoprene strip of appropriate harness shall be inserted in every lap joints
• Assembly shall use high strength friction grip bolts
• No more than 3 three rows bolts shall be provided at any location
• Floor shall be made of structural concrete slab
• Bottom wall strakes shall be embedded to a minimum depth of 200 mm into floor slab
• Roof shall be designed to the required of conventional welded tanks
• Panels shall be hot-rolled, high-strength low alloy carbon steels.
• Minimum material thickness and corrosion allowance shall be as per welded reservoir
• A minimum of one spare panel shall be supplied for every 20 panels.

C10.11.2.2  Design of Bolted Tanks
Where bolted tank is accepted by Sydney Water, the design shall be in accordance with ANSI/AWWA D103 and BS EN ISO 28765, as appropriate and the additional requirements of clause C10.11.1 except for welding components of tank shell and floor.

C10.12.  Timber Stop Boards and Logs
The properties of timber species in the manufacturer of stop logs and stop boards shall be as follows:
• Tallowwood with a minimum stress grade of F22, to AS 2082.
• Marine grade plywood with a minimum stress grade of F14, to AS 2272.

C10.13.  Covers and Grates
The classes for covers and grates to AS 3996 shall be as follows:
• Class D – for public and private road carriageways, footpaths/verges/median strips not restricted to vehicles, driveways in areas zoned ‘residential, industrial or commercial’, and parkland with no restriction to vehicular access.
• Class B – for areas within private properties, and public places, pedestrian malls and footways not subjected to vehicular loading or have no access for vehicles.

All covers and grates designed for manual handling shall be provided with handles and shall generally be sized for maximum 16 kg single-person or 32 kg two-person lift. However, the necessary risk assessment shall be undertaken to ascertain that these manual tasks will not pose a risk of injury to the operator; otherwise other appropriate designs shall be used.

C10.14.  Pipeline Design

The hydraulic design of pressure pipes shall be in accordance with WSA 03 Water Supply Code of Australia (Sydney Water Edition) or WSA 04 Sewage Pumping Station Code of Australia (Sydney Water Edition), WSA 06 Vacuum Sewerage Code of Australia and WSA 07 Pressure Sewerage Code of Australia (Sydney Water Edition) as appropriate.

The hydraulic design of non-pressure sewer pipes shall be in accordance with WSA 02 Sewerage Code of Australia (Sydney Water Edition).

C10.14.2.  Pipe Structural Design
Pipelines shall be designed to resist all imposed loads and actions (temporary and permanent) without failure over its intended life. Combined longitudinal and transverse effects shall be considered. In poor or unsuitable ground, special foundation provisions shall be specified to ensure it can support imposed loads.
C10.14.3. Buried flexible pipelines

Structural design of buried flexible pipelines shall be in accordance with AS/NZS 2566.1, typically for the following material types:

- Mild Steel (MS)
- Ductile Iron (DI)
- Un-Plasticised Polyvinyl Chloride (uPVC)
- Orientated PVC (oPVC)
- Modified PVC (mPVC)
- Polyethylene (PE)
- Polypropylene (PP)
- Glass Reinforced Plastic (GRP)
- Acrylonitrile Butadiene Styrene (ABS)

Pipes with high ring bending stiffness may be classified as rigid for design purposes. A check shall be undertaken to determine whether the pipe is acting in flexible or rigid mode.

C10.14.3.1. Pipe Material Characteristics

The typical pipe material characteristic values specified in Table 2.1 of AS2566.1 are a guide only and should be verified with the manufacturer of the pipe product.

Design factors shall be applied to PE pipe as nominated in Appendix C of AS/NZS 4130 to determine the overall service (design) co-efficient (C) and Maximum Allowable Operating Pressure (MAOP). A design factor \((f_d)\) of 1.4 shall be applied to PE pipes where depth of cover exceeds 2.5m. The MAOP shall be the allowable long term internal pressure \((P_{all})\) for structural design of flexible pipes in accordance with AS/NZS 2566.1.

C10.14.3.2. Ring Bending Stiffness

The ring bending stiffness for homogeneous plain or solid wall liners may be determined using the method described in AS2566.1. For structured wall, profiled wall or composite pipes, stiffness shall be determined through testing.

Flexible pipes shall have an initial ring bending stiffness of \(\geq 10000 \text{ N/m/m}\).

To determine the minimum wall thickness in DI pipe for use in the ring bending stiffness calculation, the following must be used:

\[
 t_{pipe\ stiffness} = \frac{(specified\ minimum\ t + specified\ nominal\ t)}{2}
\]

For materials where the nominal wall thickness of the pipe is close to the specified minimum wall thickness, the minimum wall thickness shall be used for calculating ring bending stiffness.

Typically, DI pipe and Steel pipe are supplied with cement mortar lining (CML). The CML shall not be included in the calculation of the overall pipe stiffness.

C10.14.3.3. Design Loads

Vertical earth pressures shall comprise the full height of soil above the pipe without reductions for trench effects (e.g. load reduction due to friction against the trench wall). Bulk unit weight of fill shall be 20 kN/m³.
Road vehicle loads shall be taken as SM1600 as given in AS5100.2 for the following loading types listed in Table 10-6.

**Table 10-6 Road Vehicle Load**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Main Road</td>
<td>Maximum load case for SM1600 single or dual lane</td>
</tr>
<tr>
<td>B - Light Road</td>
<td>Maximum load case for SM1600 single lane</td>
</tr>
<tr>
<td>C - Field load</td>
<td>60% of light road loading</td>
</tr>
</tbody>
</table>

The pipe shall be designed to resist hydrostatic pressures from a water table located at the surface, or where suitable information is available, the ground water level with an annual probability of exceedance of 1 in 100. External hydrostatic load due to grouting shall be considered where applicable.

**C10.14.4. Rigid pipe structural design (non pressure)**

Structural design of Reinforced Concrete (RC) pipes shall be in accordance with AS/NZS 3725. Structural design of Vitrified Clay (VC) pipes shall be in accordance with AS 4060 or BS EN 1295-1 National annex A.

**C10.15. Earth Retaining Wall Design**

**C10.15.1. Loads, Load Factors and Strength Reduction Factors**

All retaining walls shall be designed using load factors and strength reduction factors listed in AS5100.3; accommodating loading listed in this Section 10, as appropriate.

**C10.15.2. Embedded Piled Retaining Walls**

All temporary and permanent embedded retaining walls shall be designed using the CIRIA guideline C760.

**C10.16. Ground Anchorages**

**C10.16.1. General**

All ground anchorages shall be designed in accordance with AS5100.3.

**C10.16.2. Soil Nails**

All soil nails shall be designed to satisfy RMS QA Specification R64.

**C10.16.3. Ground Anchors or Rock Bolts**

All ground anchors shall be designed to satisfy RMS QA Specification B114.

**C10.16.4. Reinforced Soil Walls**

All reinforcers soil walls shall be designed in accordance with RMS QA Specification R57.

**C10.17. Declaration of Dams**

Where a new water containment asset is proposed, the asset shall be checked against requirement for Declared Dams, under Dam Safety Act and any associated regulations.