Specification

Technical Specification – Civil

Table of Contents

Tables

Figures

Revision details

Version No.	Clause	Description of revision
10.0	All sections	Minor edits and amendments, including revised page numbering. Incorporated Amendment No. 1 to Version 9.0 – 21/01/2020.
	C2.1.3	Clarity in definitions of competent geotechnical engineer, trafficable/paved areas, engineering control for temporary excavations, relative compaction & density index.
	C2.5.2 & C2.12.2	Updated term, excavation support to engineering control. Updated requirements for design of engineering control for temporary excavation and related hold point EPH2 in Table 2-3.
	C2.7.2	Max. allowable free swell index of 3% replaced with CBR swell of max. 2.5%.
	C2.7.6	Compaction requirement for unpaved/non-trafficable areas, referred to Table 2-2 and footnote.
	C2.8.4	Laboratory test requirements clarified with relevant Australian standard reference.
	C3.2	Updated reference documents list.
	C3.3	Included manufactured pozzolan in the definition of supplementary cementitious materials.
	C3.5.3	Updated fly ash grades in accordance with AS 3582.1.
	C3.5.6	Added clause to cover requirements for manufactured pozzolans.
	C3.5.9	Introduced requirements for recycled water.
	C3.6.3	Updated concrete mix design requirements. Introduced sustainability requirement – maximum embodied greenhouse gas footprint – to facilitate implementation of Sydney Water's Nez Zero Carbon Emissions Plan 2030.
	C3.6.5	Revised clause to provide clarity on requirements for a concrete mix submission.
	C3.8.2	Updated maximum drop height for all concrete placements to 1.5 m.
	C3.8.8	Relaxed requirements for a certificate of conformity for slabs on ground and minor structures.
	C3.12.3	Updated requirements for sampling frequency for concrete supplies ≤4 m^3.
	C3.13.1	Updated requirements for waterstops.
	C3.14	Updated limits for a maximum crack width and requirements for crack mapping and remediation methods and procedures submission.
	C3.15.3	Relaxed requirements for a certificate of conformity for slabs on ground and minor structures.
	C3.15.6	Updated requirements for a minimum time for stripping of formwork.
	C3.19.3	Updated requirements for patch repairs.
	C3.22.1	Included the thermal test block results in hold point CHP1.
	C4.2	Updated referenced documents list.
	C4.3.1	Added stainless steel (SS) pipes.
	C4.3.4	Clarified requirements for debeading of PE pipes
	C4.3.10	Added requirements for SS pipes.
	C4.6	Removed pipeline grading requirement from C4.6 and added to C10.14.1.
	C4.8	Removed requirement for inspection by Sydney Water.
	C4.12.1	Removed stabilised material requirements from C4.12.1
	C4.12.3	Added new Clause C4.12.3.
	C4.14.4	Added welding requirements for SS pipes.
	C4.22.2	Removed reference to WPIMS 5027 and added reference to D0001669.
	C4.22.3	Removed reference to WPIMS 5021 and added reference to D0001667.
	C5.2	Updated referenced documents list.
	C5.6.1	Added requirements for fabrication of steelwork.

Version No.	Clause	Description of revision
	C5.7.14	Updated weld inspections and testing requirements. Deleted Table 5-2.
	C5.9.3	Added requirements for connections of new steelwork to existing galvanised steelwork.
	C6.13	Updated requirements for a grout mix submission.
	C7.2	Added Sydney Water reference document.
	C7.4.2	Added requirements regarding management of asbestos and other hazardous building materials.
	C10.1.4.1	Added 'durability design' to the list of required design calculations.
	C10.2	Updated referenced documents list.
	C10.7 and sub clauses	General revision and incorporated requirements from Technical Specification – Mechanical (BMIS0209 Version 11.0)
	C10.9.2	Updated requirements.
	C10.10.4	Removed note 3 in Tables 10-4 and 10-5. Lowering exposure classification is not permitted.
	C10.10.5	Deleted the clause.
	C10.10.7	Updated requirements for butted precast post-tensioned tanks.
	C10.10.8	Deleted the clause.
	C10.11	Deleted sub-clauses and referred to D0001963.
	C10.14.1	Removed pipeline grading requirement from C4.6 and added to C10.14.1. Added requirement for hydraulic design of pressure pipes to AMQ0562 and non-pressure sewer pipes to D0000666.
9.0	All Sections	Minor amendments, including revised page numbering.
	C4.2	Referenced documents updated.
	C4.3	Added requirements for polypropylene pipe. Added new requirements for pipe materials.
	C4.6	Added requirement for basement installations.
	C4.12.1	Revised requirements for cement stabilised sand material.
	C4.14.5	Added new clause for polyethylene pipe joints.
	C4.15	Added new corrosion protection requirements.
	C4.19	Removed tolerance requirement. Added requirement for use of spacers and tracer wire.
	C4.20	Added requirement for use of tracer wire.
	C4.21	Various amendments to align with WSA 02 (Sydney Water Edition).
	C10.14.2	Added requirements for minimum design life.
	C10.14.3.1	Revised requirements for PE design factors.
	C10.14.3.3	Revised dead and live design loads.
	C10.14.5	Added requirements for adjacent parallel pipelines.
8.0	All Sections	Major revisions in all sections. Cross references to all previous versions and clauses must be updated from previous versions.
	C1	Some clause numbers have changed/ deleted and new clauses added.
	C1.2	Hierarchy of documents added.
	C1.6	Survey requirements added.
	C1.7	Requirements on existing services added.
	C1.8	Requirements on visual records added.
	C1.9	Requirements of Hold Points added.
	C2	All clause numbers have changed/ deleted and new clauses added.

Version No.	Clause	Description of revision
		Major revision in Earthworks section includes introduction of compulsory Hold Points throughout construction stages, Revised earthworks material testing requirements and Revised compaction testing requirements.
	C3	Some clause numbers have changed/ deleted and new clauses added.
	C3.5.6	Term “cement” amended to as “cementitious”.
	C3.6.3	Table 3.1 on concrete mix proportions amended.
	C3.6.5	Hold Point for mix design.
	C3.8.8	New certification requirements for formwork & reinforcement fixing and Hold Point.
	C3.13.2	Hold point on preparation of construction joint and readiness for concrete pour.
	C3.14	New requirement for mapping of non-compliant cracks and Hold Point.
	C3.15.3	Hold Point included for formwork design.
	C3.19.1	Hold Point included in concrete repair methodology.
	C3.20	New requirements for reinforced concrete box culverts & open channels.
	C3.21	Clause number amended & Hold Point included for hydrostatic testing.
	C3.22	Hold Point list introduced.
	C4	Some clause numbers have changed/ deleted and new clauses added.
	C4.1	Additional codes and standards specified.
	C4.2	Additional documents referenced.
	C4.5, C4.6	Minor additions.
	C4.6.1	Grading of pipeline to minimise use of air valves added.
	C4.11	Added new clause.
	C4.12	Added requirement for compliance with AS/NZS 2566.2.
	C4.13	Various changes to embedment material and compaction.
	C4.14.2	Trench fill material referenced to Section C2.
	C4.14.3	Added requirement for bending of pipes.
	C4.18.1	Added requirement for concrete encasement of flanged joints.
	C4.19	Amended requirement for bedding of covers.
	C4.20	Major additions and changes to section.
	C5	Some clause numbers have changed/ deleted and new clauses added.
	C5.2	Additional reference ASTM 380M added.
	C5.5.2	Expanded to include materials properties of stainless steel.
	C5.6.1	Expanded to cover off site fabrication.
	C5.6.3	Hold point added on shop drawings.
	C5.6.6	Expanded to limit the method of cutting stainless steel.
	C5.6.8	Hold Point added for splices not identified in design drawings.
	C5.6.9	Expanded to cover enlarging corroded holes.
	C5.7.4	Last sentence on NATA endorsed report not requiring deleted.
	C5.7.6.1	Expanded to include limits on welding of liquid retaining tanks.
	C5.7.15	Hold Point added on weld acceptance.
	5.7.17	Reference standard ASTM 380 included for passivation.
	C5.8.2	Prevention of drilling items that are already galvanised and/or coated added.
	C5.8.6.1	Hold Point added on PCCP certification.
	C5.9.6	Additional details on prevention of stainless nuts seizing and Hold Point installation on HSFG bolts included.
	C5.10.7	Hold Point added on hydrostatic test results.
	C5.11	Hold Point list included.

Version No.	Clause	Description of revision
	C6.13	Reference to cement amended as cementitious. Hold Point included on grout mix design.
	C6.25	Hold Point included for notification of grouting masonry.
	C6.33.2	Hold Point included for crack stitching methodology.
	C6.34	Hold Point list included.
	C7.7	Hold Point included for demolition methodology.
	C7.8	Hold Point list added.
	C9	Major revision in piling section includes introduction of design, construction and testing requirements in reference to RMS specifications. Most clause numbers have changed/ deleted and new clauses added.
	C10	Major changes to design requirements and documentation included. Additional guidance on specific design loading, assessment of the structure Importance Level. Major revision related to reservoirs construction and design requirements. Additional guidance on pipeline design included.
7.0	C2.3	Potholing by hand or mechanical means not allowed.
6.0	C4.2 C4.16	Protective coating requirements references to PCS 100 changed to WSA 201 and Sydney Water's Supplement.
	C5.2 C5.8.2 C5.10.1 C5.11.3	
	C10.1.2 C10.6 C10.8.3 C10.10.4	
	C10.4.3	Wearing course changed to 45 mm AC14.
5.0	C1.5	Recycled and Reuse Material clause amended.
	Table 3-1	Cement type for N class concrete amended.
	C3.11.2 C3.17	Table 3-4 Concrete Curing Time inserted, and clause amended. New clause 'Anchors and Holding Down Bolts' inserted.
	C4.3.6	PVC-O pipes - material class amended.
	C5.7.2	Steel grades changed.
	C10.1.5 Table 10-4 C10.13	New clause on Safety in Design inserted. Note 2 amended. Classes of cover and grates amended.
4.0	C1.5	Clause on recycled materials added.
	C2.15 C2.21	Backfill material not to contain asbestos. Clause on recycled material in landscaping works added.
	C3.5.7	Concrete aggregates not to contain asbestos.
	C8.5	Road base and sub-base materials not to contain asbestos.
3.0	C2.13 C2.15	Design of excavation support by competent engineer. Backfill materials clarified.

Version No.	Clause	Description of revision
	C3.3	Definition of cement mortar, grout, contraction, expansion, isolation joints and sloughing removed. Movement joint added.
	C3.6.7	New clause added.
	C3.13.3	Waterstop & joint sealant requirements for stormwater channel added.
	C3.19	New clause added. Clause heading added.
	C4.2	PCS reference numbers amended. EPS references deleted.
	C4.5	EPS references deleted.
	C4.7	Principal approval required.
	C4.12	Clause heading amended. Concrete encasement added.
	C4.16	PCS references amended.
	C4.18.2	Limitation on precast MH's added.
	C4.18.3	Corrosion protection of MH's amended.
	C5.2	AS/NZS 4020 added. PCS reference amended. AS 4361.1 deleted.
	C5.8.3	Holes for venting & draining added.
	C5.8.5 (old)	Clause on certification of fabrication deleted.
	C5.8.6	Wording changed.
	C5.8.7	Wording changed.
	C5.8.9	AS 1664 added.
	C5.9.2	Wording changed.
	C5.9.14	Weld test requirements amended & Table 5.2 added.
	C5.9.18	Handling of galvanised components added.
	C5.11.6	Preparation of contact faces for HSFG bolts added.
	C5.11.8	Clause deleted.
	C5.12	Clause heading changed.
	C5.12.2	Isolation requirements of galvanised contact faces added.
	C5.12.6	Clause added.
	C8.5	Table 8.1 amended.
	C8.10	Tack coat changed to prime coat.
	C8.12.1	New clause on tack coat.
	C9.7	AS 2159 added.
	C10.1.2	PCS reference added. SS 204 reference added.
	C10.6	PCS reference changed.
	C10.8.3	Roof sheeting & rainwater goods material clarified.
	C10.9.4	Table 10.3 added.
	C10.9.6	K_p value amended.
	C10.9.7	Surcharge load amended.
	C10.10.4	Wet weather storage tank & inlet MH added to the table.
	C10.10.12	Design resistance of soil pressure clarified.

Introduction

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

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

It is the user's sole responsibility to ensure that the copy of the specification is the current version as in use by Sydney Water.

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Acronyms

Acronym	Definition
ABS	Acrylonitrile butadiene styrene
ACRS	Australian Certification Authority for Reinforcing Steel
AINDT	Australian Institute of Non-destructive Testing
APAS	Australian Paint Approval Scheme
ARI	Average recurrence interval
BCA	Building Code of Australia
CAD	Computer aided drafting
CBR	California bearing ratio
CCTV	Closed circuit television
CLSM	Controlled low strength material
CML	Cement mortar lining
DI	Ductile iron
DPC	Damp proof course
DTC	Deemed to comply
EPA	Environment Protection Authority
EPDM	Ethylene propylene diene monomer
FBPE	Fusion bonded polyethylene
FOS	Factor of safety
GRP	Glass reinforced plastic
HGL	Hydraulic grade line

Acronym	Definition
ITR	Inspection and test report
MAOP	Maximum allowable operating pressure
MS	Mild steel
NATA	National Association of Testing Authorities
NDT	Non-destructive testing
NSSCS	National Structural Steelwork Compliance Scheme
PCCP	Painting Contractors Certification Program
PDA	Pile driving analyser
PDM	Pile driving monitor
PE	Polyethylene
PP	Polypropylene
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QA	Quality assurance
RC	Reinforced concrete
SCM	Supplementary cementitious material
SDD	Standard dry density
SDR	Standard dimension ratio
SPS	Sewage pumping station
SS	Stainless steel
STP	Sewage treatment plant
TB	Tension bearing
TF	Tension friction
TfNSW	Transport for New South Wales
UV	Ultraviolet
VC	Vitrified clay
WAC	Work as constructed
WAE	Work as executed
WSAA	Water Services Association of Australia

General terms & definitions

Term	Definition
Competent engineer	A suitably qualified and experienced engineer with the ability to apply knowledge and skills to achieve the intended design, construction, testing or monitoring task. For engineering tasks related to design, engineering personnel who meet requirements of the Sydney Water Engineering Competency Standard.
Design life	The period which the asset or its component is to remain fit for its intended purpose with periodic routine maintenance and without major repairs.
Hold point	As defined in Clause 1.9.1; all construction activity requiring approval from Sydney Water to proceed to the next stage of construction must be recognised as a hold point.
TfNSW specification	Specifications or technical directions issued by Transport for New South Wales (TfNSW).
Sydney Water	A nominated person or organisation that has written authority to act on Sydney Water's behalf.
Supplier	A person or organisation responsible for the fabrication or manufacture and supply of products, materials, equipment and components described herein.
WSAA codes	Code of Practice issued by the Water Services Association of Australia (WSAA).
WSAA code – Sydney Water Edition	WSAA Code with modifications by Sydney Water for use in Sydney Water assets; when available.

C1. General

C1.1 Statutory regulations

All works must comply with the requirements of all federal and state laws and regulations in force in New South Wales (NSW). Where the works are subject to the control of statutory or regulatory authorities, the works must comply with the requirements of the authorities.

Technical requirements specified herein must 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 – Civil is considered the governing (ie "over-arching") standard which specifies the minimum requirements for the materials, design, fabrication, testing, inspection and pre-commissioning of civil works. All works must comply with this specification, the Water Services Association of Australia (WSAA) codes (Sydney Water 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 must 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, must 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 may be used, upon 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.

Alternatives that are equivalent to the nominated items can be submitted to Sydney Water for acceptance. The submission must 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 C10. 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 must 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 must not be present in these materials.

C1.5.2 Prior acceptance

The use of a waste material must be a bona-fide, fit for purpose, reuse opportunity that causes no harm to the environment or human health. Recycled or reused materials must only be accepted by 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 must be submitted for acceptance by the Sydney Water at least seven days prior to delivery to the site.

C1.5.3 Records

Detailed records must 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 must 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 National Association of Testing Authorities (NATA) laboratory accredited for asbestos fibre identification. The certification must 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 must 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 work as constructed (WAC) records, must be conducted in accordance with this specification and WSAA specifications – WSA 02, WSA 03 and WSA 04 – or by project specific requirements as nominated by Sydney Water.

All survey work must 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 actual location of services conflicts with information provided by Sydney Water, the contractor must notify Sydney Water at least 20 working days prior to commencement of any construction activity that may affect the services.

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 must 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 m of the proposed works.

A record of notable details and existing damage or faults relating to improvements in the vicinity of the works must 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 must be completed and submitted prior to commencing work on the site.

The initial record must 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 must be updated to show all 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 (ie digital image) must be at least 150 mm × 100 mm when the document is printed at 1:1 scale and each print must 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 must 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 must be sorted 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 must be submitted to Sydney Water, for acceptance; at least 20 working days prior to the planned dates of subsequent activities, unless specified otherwise for the relevant activity.

All documents related to release of hold points must 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 setting out must be carried out to the dimensions and levels shown in the drawings and as specified in Clause C1.6 of this specification.

In addition to requirements specified in Section 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 must 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 Section C2 of this specification.

Backfill or fill	Earthwork material used as trench fill or backfill or fill; as required by the design, complying the minimum requirements specified within Section C2 of this specification
CBR	4 days soaked California bearing ratio (CBR) 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 µm), 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 or engineering geologist who is suitably qualified and experienced to carry out the particular type of work listed in the project specific technical requirements and accepted by Sydney Water, prior to working on the project. Additional, specific requirements specified in Sydney Water's Engineering Competency Standard must be also met where applicable.
Density Index	The ratio of the difference between the void ratios of a cohesionless soil in its loosest state and existing state to the difference between its void ratio in the loosest and densest states, determined using AS 1289.5.6.1
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 Section C2 of this specification
Engineering Control for temporary excavations	Suitably designed benching or battering or shoring or a combination of different control measures designed by a competent geotechnical engineer and (when required), by a structural engineer.
Field density testing	Field bulk density tested using a nuclear density gauge (in accordance with AS 1289.5.8.1) 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
Paved and/or trafficable areas	Paved areas such as roads, cycleways, footpaths and areas where vehicles are able to traffic, park or are expected to access 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 for cohesive materials or the Density Index of a soil for non-cohesive

	soils expressed as a percentage between the maximum and minimum dry density of the non-cohesive soil.
Road	A surface devoted to travel and movement of goods by vehicles; a road covers the entire width between opposite property boundaries in a road reserve including the road pavement, footways, cycleways and verges.
Road reserve	Land set aside for the road pavement, footway(s) and verge(s).
Select fill	Fill material of specified quality as specified in Clause C2.7.5 of this specification
Site won material	Material that is obtained from excavations within the site
Standard dry density ratio	Dry density ratio of a soil determined using AS 1289.5.4.1 under standard compaction conditions
Stripped surface level	Level of the surface after stripping of topsoil unsuitable materials
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 non-trafficable areas	Areas where no vehicle access is expected eg residential property backyards where no vehicular access is possible
Unsuitable material	Material as defined in Clause C2.7.2 of this specification

C2.2 Referenced documents

Sydney Water documents

D0000833 Engineering Competency Standard

WSAA specifications

Product specifications for products and materials

WSA PS-350 Compaction Sand

WSA PS-351 Processed Aggregates

WSA PS-352 Controlled Low Strength Materials (CLSM)

WSA PS-355 Geotextile Filter Fabric

WSA PS-359 7 mm Processed Aggregate

WSA PS-360 Embedment / Concrete Sand

WSA PS-361 Embedment / 5mm Minus Fine Crushed Rock

WSA PS-362 Well Graded Crushed Rock

Australian standards

AS 1289 Methods of testing soils for engineering purposes (Set)

AS 1289.3.8.1 Methods of testing soils for engineering purposes Method 3.8.1: Soil classification tests – Dispersion – Determination of Emerson class number for a soil

AS 1289.5.4.1	Methods of testing soils for engineering purposes Method 5.4.1: Soil compaction and density tests – Compaction control test – Dry density ratio, moisture variation and moisture ratio
AS 1289.5.6.1	Methods of testing soils for engineering purposes Method 5.6.1: Soil compaction and density tests – Compaction control test – Density index method for a cohesionless material
AS 1726	Geotechnical site investigations
AS 3798	Guidelines on earthworks for commercial and residential developments

TfNSW QA specifications

3051	Granular pavement base and subbase materials
M208	Road openings and restoration (low risk)
M209	Road openings and restoration
R67	High strength geosynthetic reinforcement
R178	Vegetation

International standards

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

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 must be verified by a competent geotechnical engineer.

All necessary field testing must be carried out and recorded in accordance with AS 1726. All laboratory testing of soil samples must be tested in accordance with AS 1289, 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 must be superimposed on the appropriate drawings and must 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, must 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 Sydney Water.

Temporary erosion and sediment control measures must 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 must be coordinated with the construction of permanent drainage and other permanent control measures. The controls must 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 must be maintained in an operative condition at all times. Silt must 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 all construction activities and all materials used therein removed from the site.

C2.4.2 Clearing

The natural ground surface must 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 must be removed. Cavities formed by the removal of stumps and disused services must 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 must not be removed or lopped without the written consent of Sydney Water.

C2.4.3 Stripping topsoil

Topsoil removal must not be commenced until:

- erosion and sedimentation control 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, must be stripped of any existing topsoil.

The strip depth must be as required by design. Stripped surfaces must be inspected by a competent geotechnical engineer to confirm removal of all topsoil.

C2.5 Excavation

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

C2.5.1 Utilities, services and other hazards

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

No excavation must occur until:

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

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

C2.5.2 Engineering control for temporary excavations

Engineering controls are 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.

Unless the excavation is in class III Hawkesbury sandstone or better ground condition; all excavation works more than 1.5 m deep, must require an engineering control. The ground condition must be clearly identified in geotechnical interpretation, as required in Clause C10.3 of this specification.

The design of the engineering control must be prepared and certified by an appropriately competent geotechnical engineer and where applicable, by a competent structural engineer. The competency records of personnel preparing the design of engineering control must be submitted for acceptance by Sydney Water prior to commencement of excavation works.

Where required, dilapidation surveys, prior to installation of excavation support, dewatering and excavation works must be undertaken.

Documentation of engineering control, site verification and as constructed records must be made available to Sydney Water when required.

C2.5.3 Temporary fencing and signage around excavation works

Suitable temporary fencing, barriers, handrails and signage must be erected around all excavations.

C2.5.4 Groundwater control

Drains, sumps, pits, water channels and the like must be constructed as required, along with any pumping plant that may be necessary to prevent water from entering an excavation or to remove water from an excavation must be employed.

If dewatering is proposed, a dewatering proposal plan must be submitted to Sydney Water 20 working days prior to any dewatering activity, for acceptance. Dewatering operations must not commence until acceptance has been given by Sydney Water and other relevant approval authorities.

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

Water from excavations must 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 must be such as to allow pipelines to be laid as specified herein and as shown in the drawings.

Trenches for pipes must 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 must be provided at the joints to allow for jointing of the pipes.

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

All efforts must be made to avoid disturbance to the finished trench formation. Any wet or soft materials must be excavated and made good to the satisfaction of 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 for excavation purposes must not be used, unless specifically accepted by Sydney Water.

C2.6 Stockpiling

C2.6.1 Stockpiling areas

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

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

The stockpiling 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 must 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
- stockpiles track rolled during placement to create stable batters or batters stabilised by other means acceptable to Sydney Water

- batters must be seeded with a sterile cover crop in accordance with TfNSW QA Specification R178, to encourage vegetation cover. Seeding must be carried out progressively within seven days of completion of each 500 m^2 of exposed batter face
- have silt barriers or temporary drainage to prevent the stockpiled topsoil being washed away
- traffic must not 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

Material must not be placed or imported to site without the appropriate acceptance being sought from Sydney Water.

Requests submitted to Sydney Water to place material or import material to site, must 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 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.

C2.7.2 Unsuitable material

Unsuitable material must not be used in construction. Unsuitable material includes the following:

- topsoil
- peat or 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 4 days soaked CBR<3%
- material that can be subjected to degradation over time due to factors including, but not limited to; weathering and sustained and repetitive loading in short and long term conditions
- organic clay and highly dispersive soils.

Dispersivity potential of soil must be determined by either using a pinhole test apparatus, according to ASTM D4647, or Emerson crumb test in accordance with AS 1289.3.8.1. 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 CBR swell higher than 2.5%, soluble substances more than 3% and organic content more than 5% by weight of dry material are all considered as unsuitable and must not be used for construction of any earthworks.

Collapsible soils underlying foundations are also considered as unsuitable material and must be treated before construction of embankments. One dimensional wetting induced swell or collapse strain is determined according to ASTM D4546.

C2.7.3 Imported material

If the site won material fails to meet the minimum requirements in Section C2 of this specification, imported material may be used. All necessary imported fill and backfill material must be in accordance with the drawings and the minimum requirements specified herein.

C2.7.4 Pipe embedment material

Required pipe embedment material requirements must be as detailed in the design drawings. Material used for pipe embedment must meet following WSAA product specifications:

- WSA PS-350 Compaction Sand
- WSA PS-351 Processed Aggregates
- WSA PS-352 Controlled Low Strength Materials (CLSM)
- WSA PS-359 7 mm 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 must be select fill, as specified below. 'H' is the height of structure to be backfilled against (Figure 2-1).

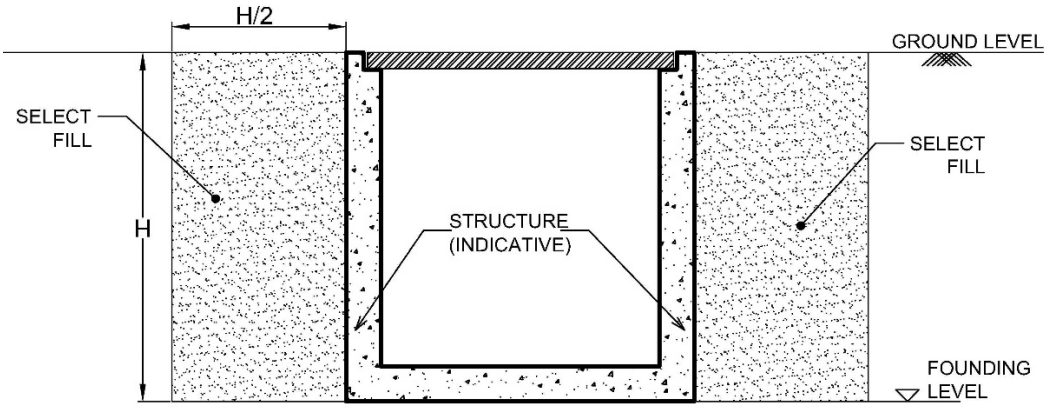

Figure 2-1 Fill around structures

The material properties of select fill must be in accordance with Table 2-1 Properties of select fill material

. The properties must be tested in accordance with relevant parts of AS 1289.

Table 2-1 Properties of select fill material

Property	Requirement
Particle size distribution: Percentage passing AS sieve (by mass)	
53 mm	100%
37.5 mm	>60%
2.36 mm	<50%
75 µm	<15%
Coefficient of uniformity (D_{60}/D_{10})	≥5
Plasticity index	≤15
CBR	≥8%

Material prone to degradation from oxidation or weathering must not be used as select fill. Material derived from Bringelly Shale must not be used as select fill material.

C2.7.6 Fill material for unpaved areas

Fill must consist of material that can be compacted to requirements specified in Table 2-2.

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

The material must be free of unsuitable materials. Soil materials that have a plasticity index higher than 30 are also not permitted. All material must have soaked a 4 day soaked CBR of at least 3%.

C2.7.7 Fill material for paved areas

Fill material under paved areas must 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 must be as follows:

- Fill material, 1 m below finished surface levels must exceed or comply with the requirements specified in Clause C2.7.6.
- Fill material within 1 m from finished surface levels and below subbase, must comply select fill material properties, specified in Table 2-1.Table 2-1 Properties of select fill material
- Any granular pavement base and subbase material must comply with TfNSW 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 must be carried out as minimum one test per 1,000 cubic metres of material or part thereof. A minimum of three tests must be carried out per material type and source.

C2.7.9 Filtration geotextiles

All filtration geotextiles materials must comply WSA PS-355.

C2.7.10 High strength geosynthetics

High strength geosynthetics including high strength geotextile and geogrid material must comply with TfNSW QA Specification R67.

C2.7.11 Non-standard materials

Any non-standard materials that are not included in the above specifications (including recycled material) must 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 must be produced and submitted to Sydney Water for acceptance. It must include, but not limited to the following:

- the details of the compaction plant to be used on site
- the locations such plant 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 areas 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 handheld 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 the points noted above, as a minimum.

  Level 1 geotechnical inspection must be provided in accordance with AS 3798 for all earthworks exceeding 3.0 m fill or backfill thickness.

C2.8.2 Compaction near structures

Compaction must not be carried out within 2 m 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, vibrating rollers of mass exceeding one tonne, or any other equipment that may potentially cause damage to an earth or liquid retaining structure must not be used to compact fill material located within 2 m of the structure.

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

Where design compaction levels cannot be achieved with the selected compaction equipment, layer thicknesses must be reduced until the design compaction levels can be homogeneously achieved through out the full layer.

C2.8.3 Testing frequency

Unless otherwise stated in the drawings, field density tests must be carried out at locations randomly selected by Sydney Water or by a competent geotechnical engineer (as defined in D0000833) or by a level 1 geotechnical supervisor at the following frequency:

- one test per 300 m^2 of compacted fill, or part thereof, for each 300 mm layer of compaction
- two tests in each compacted fill layer around access, maintenance and maintenance hole structures
- for pipe trench fill and embedment material, the frequency of testing must be one test in each 300 mm layer of fill for every 50 linear metres of pipe laid or part thereof.

All testing must be carried out by NATA accredited laboratories.

Once fill is placed and compacted in multiple layers for 1.5 m of total thickness, the relevant compaction test results must be submitted and accepted by Sydney Water; prior to proceeding to the next layer of fill. The test results must 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, must 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 must be not less than that shown in Table 2-2. Where the property owner or road authority or an alternative specification such as a TfNSW specification or subdivision earthworks specification requires a higher compaction level, the highest compaction requirement must be followed.

Table 2-2 Minimum compaction standard for filling areas

Material type	Method	Measure	Minimum requirement
Cohesionless soils	AS 1289.5.6.1	Relative compaction stated as density index	70%
Cohesive soils	AS 1289.5.4.1	Standard dry density (SDD) ratio	98% Note 1
	AS 1289.5.4.1	Relative standard optimum moisture content	85–115%

Note:

1. 95% SDD ratio is permitted where areas are identified to be unpaved and non-trafficable areas and with no structural foundations to be placed on the proposed filled area, subject to the acceptance of the landowner or the relevant regulatory authority. Compaction levels in such areas must be considered based on performance criteria derived from acceptable total and differential settlement allowances.

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, must be removed and replaced in accordance with the requirements of the accepted compaction quality assurance plan.

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

Following identification of a failed compaction test, a quality incident must be raised with Sydney Water and an investigation must be undertaken to identify the root cause of the failed test. The quality incident must then identify what changes need to be made to the compaction quality assurance plan.

No further compaction work must 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, must 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 must be submitted to Sydney Water for acceptance, prior to commencing any foundation construction works.

C2.9.2 Foundation on rock

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

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

C2.9.3 Foundation on soil

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

Care must be taken to avoid disturbing materials below foundation level. All loose materials must be removed before placing the concrete of minimum grade N15 as per Section C3 or select fill material as per Clause C2.7.5 of this specification.

C2.10 Surface restoration

All surfaces disturbed in the course of excavation must 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 must be carried by in accordance with the minimum requirements and technical specifications of TfNSW 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 must be replaced with the same type and thicknesses of surface and base courses as the original pavement.

Unless otherwise specified, concrete pavement must 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 must be provided whether the original pavement is reinforced or not. Pavement surfaces must be cut with concrete sawing equipment and cuts must 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 must be replaced with the same type of surfacing and base courses as the original construction. All concrete cutting must be carried out using sawing equipment and cuts must be at least 150 mm beyond the sides of the trench.

C2.10.3 Restoring landscaped areas

All landscaped areas must 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 must be recorded and reported to Sydney Water, with all necessary test and inspection results.

C2.11.2 Inspection reports

All inspection reports and verification testing must be completed by a competent geotechnical engineer and must 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.

Table 2-3 Summary of hold points for earthworks

Hold point no.	Process held	Required documentation	Relevant clause
EHP1	Site clearing	Erosion and sediment control plan	C2.4.1
EHP2	Excavations more than 1.5 m deep	Engineering competency record for personnel carrying out design of engineering control for temporary excavations	C2.5.2
EHP3	Dewatering	Dewatering proposal plan	C2.5.4
EHP4	Excavation in watercourses	Provide all necessary control plans as required and agreed with Sydney Water, based on project specific requirements.	C2.5.6
EHP5	Blasting	Provide all necessary control plans as required and agreed with Sydney Water based on project specific requirements.	C2.5.7
EHP6	Stockpiling	Stockpiling plan	C2.6

Hold point no.	Process held	Required documentation	Relevant clause
EPH7a	Importing any material related to earthworks	• Test results of the source material confirming the material imported do not have any unsuitable material, suitable for the location proposed in accepted design drawings • Compaction quality assurance plan for the proposed material with the assessment of suitability by a competent geotechnical engineer	C2.7, C2.8
EPH7b	Commencement of placing fill material sourced within the site	• Test results of the source material • Compaction quality assurance plan for the proposed material with the assessment of suitability by a competent geotechnical engineer	C2.7, C2.8
EHP8	Placement and compaction of each subsequent layer of fill or backfill	Compaction test results for each layer of compaction from preceding total thickness of 1.5 m fill placed	C2.8
EHP9	Construction of structural foundation or pavements	Inspection report signed by a competent geotechnical engineer	C2.9

C2.12.2 Release of earthwork hold points

All documents related to release of hold points in earthworks must be submitted to Sydney Water, together with a suitable competent geotechnical engineer's check and endorsement.

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

Sydney Water documents

D0001667	Water Quality Management During Operational Activities
D0001909	Certifying Water Quality when Commissioning/Returning Reservoirs to Service

WSAA specifications

WSA 05	Conduit inspection reporting code of Australia
WSA 201	Manual for selection and application of protective coatings (with integral Sydney Water Supplement)

Australian standards

AS 1012	Methods of testing concrete
AS 1012.1	Methods of testing concrete Method 1: Sampling of concrete
AS 1012.3.1	Methods of testing concrete Method 3.1: Determination of properties related to the consistency of concrete – Slump test
AS 1012.8.1	Methods of testing concrete Method 8.1: Method for making and curing concrete – Compression and indirect tensile test specimens
AS 1012.9	Methods of testing concrete Method 9: Compressive strength tests – Concrete, mortar and grout specimens
AS 1141	Methods for sampling and testing aggregates
AS 1141.35	Methods for sampling and testing aggregates Method 35: Detection of sugar contamination in concrete aggregates
AS 1289	Method of testing soils for engineering purposes
AS 1289.4.2.1	Method of testing soils for engineering purposes Method 4.2.1: Soil chemical tests – Determination of the sulfate content of a natural soil and the sulfate content of the groundwater – Normal method
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/NZS 1580.505.1	Paints and related materials - Methods of test Method 505.1: pH of water-based paints
AS 1597	Precast reinforced concrete box culverts
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 2758.1	Aggregates and rock for engineering purposes Part 1: Concrete aggregates
AS 2837	Wrought alloy steels – Stainless steel bars and semi-finished products
AS 3550.4	Waters Part 4: Determination of solids – Gravimetric method
AS 3582.1	Supplementary cementitious materials Part 1: Fly ash
AS 3582.2	Supplementary cementitious materials Part 2: Slag – Ground granulated blast-furnace
AS 3582.3	Supplementary cementitious materials Part 3: Amorphous silica
AS 3582.4	Supplementary cementitious materials Part 4: Pozzolans – Manufactured
AS 3600	Concrete structures
AS 3610	Formwork for concrete
AS 3735	Concrete structures for retaining liquids
AS 3799	Liquid membrane-forming curing compounds for concrete
AS 3972	Portland and blended cements
AS/NZS 4671	Steel reinforcing materials

TfNSW QA specifications

B80	Concrete work for bridges

International standards

ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement

Other documents

APHA 2540 C	Solids – Total Dissolved Solids Dried at 180 °C
APHA 2540 D	Solids – Total Suspended Solids Dried from 103 to 105 °C
APHA 3120 B	Metals by Plasma Emission Spectroscopy – Inductively Coupled Plasma (ICP) Method
APHA 4110 B	Determination of Anions by Ion Chromatography – Ion Chromatography with Chemical Suppression of Eluent Conductivity
APHA 4500-Cl^-	Chloride
APHA 4500-H^+	pH
APHA 5520	Oil and Grease
CIRIA C766	PB Bamforth, Control of Cracking Caused by Restrained Deformation in Concrete, CIRIA C766, CIRIA, London, UK, 2018, ISBN 978-0-86017-781-4

C3.3 Definitions

The following definitions apply to this specification:

Cement:	Material conforming to AS 3972. It comprises Portland cement and supplementary cementitious materials (SCM).
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.
SCM:	Fly ash, ground granulated blast-furnace slag, silica fume and manufactured pozzolan that comply with AS 3582.1, AS 3582.2, AS 3582.3 and AS 3582.4, respectively.
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 SCMs, in the concrete mix.

C3.4 Supervision

The concrete supervisor must be a suitably experienced person accepted by Sydney Water. The supervisor must supervise the delivery and placing of all concrete works and must prepare and submit to Sydney Water a daily report on all concrete placed. The report must 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 must 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 must conform to section 2 of AS 1379 and with the additional requirements of this specification.

C3.5.2 Cement

The cement used must generally be Type GP – general purpose Portland cement to AS 3972.

Where specified, or with the approval 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 must be used.

C3.5.3 Fly ash

Fly ash must be grade 1 or special grade in accordance with AS 3582.1. The maximum amount of fly ash must be 25% by weight of the total cement material.

C3.5.4 Slag

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

C3.5.5 Silica fume

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

C3.5.6 Manufactured pozzolans

Manufactured pozzolans must comply with AS 3582.4. The maximum amount of manufactured pozzolans must be 25% by weight of the total cement material.

C3.5.7 Supplementary cementitious materials (SCM)

The total amount of SCMs must not exceed 60% by weight of the total cement material.

C3.5.8 Aggregates

Coarse and fine aggregates for concrete must comply with the requirements of AS 2758.1. The maximum nominal size of aggregate must be 20 mm in reinforced concrete and 40 mm in unreinforced concrete. Coarse aggregate must consist of clean, hard, durable particles substantially retained on a 4.75 mm sieve and must be obtained from dense, naturally occurring or manufactured gravel or rock. Fine aggregate must 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 must not be used as an aggregate unless specified otherwise or accepted by Sydney Water. All materials must be free from hazardous substances such as asbestos or asbestos containing materials.

For special class concrete, the aggregates must comply for exposure classification C of table 4 of AS 2758.1.

For normal class concrete, the aggregates must comply for exposure classification B1 of table 4 of AS 2758.1.

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

The alkali reactivity of the aggregate must be assessed to section 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 approval of Sydney Water.

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

C3.5.9 Water

Water used in the manufacture of concrete must comply with AS 1379.

Opportunities for the use of recycled water in concrete mixes must be identified and specified where feasible. Recycled water identified for potential use must undergo rigorous testing to comply with AS 1379 and requirements specified in Table 3-1 before being accepted for use. Ongoing regular quality testing of the recycled water must be adopted.

Table 3-1 Limits for impurities in recycled water

Impurity	Test method	Concentration limit
Sugar	AS 1141.35	≤ 100 ppm
Oil and grease	APHA 5520	≤ 50 ppm
pH	AS/NZS 1580.505.1 or APHA 4500-H^+	> 5.0
Total dissolved solids	AS 3550.4 or APHA 2540 C	≤ 1,700 ppm
Chloride as Cl	APHA 4500-Cl^-	≤ 300 ppm
Sulphate as SO_3	AS 1289.4.2.1 or APHA 4110 B	≤ 350 ppm
Alkali (sodium equivalent)	ASTM C114 or APHA 3120 B	≤ 1,500 ppm
Total suspended solids	AS 3550.4 or APHA 2540 D	≤ 15,000 ppm

C3.5.10 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 controlled 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 must 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 must 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 must 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 must be used for all structures and surfaces designed to AS 3735 (Clause C10.10.1 of this specification).

The minimum grade of special class concrete must 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 cast in-situ and conventional precast concrete must comply with Table 3-2.

Table 3-2 Concrete mix design requirements

Concrete class Note 5	Characteristic strength at 28 days (MPa)	Total cementitious materials content (kg/m^3)		Cement type	Maximum W/C ratio	Maximum drying shrinkage at 56 days (×10^{-6})	Slump at point of delivery (mm) Note 1	Maximum embodied greenhouse gas footprint associated with the cementitious materials (kg CO_{2eqv}) Note 2
		Min	Max					
N15	15	NA	250	GB	NA	NA	80-120	150
N25	25	NA	310	GB	0.65	900	80-120	180
N32	32	NA	360	GB	0.55	900	80-120	210
N40	40	NA	430	GB	0.50	900	80-120	250
S40	40	430	460	SR/SL Note 3	0.45	650 Note 4	80-120	265
S50	50	450	490	SR/SL Note 3	0.40	650 Note 4	80-120	285

Notes:

1. The slump range is specified for conventionally compacted concrete. For high workability concrete (HWC) and self-compacting concrete (SCC) mixes – eg for piling works – refer to TfNSW QA specification B80. Proposed HWC/SCC mixes must be submitted to Sydney Water for acceptance.
2. The embodied greenhouse gas footprint must be calculated based on greenhouse gas intensity factors of 0.01211 kg CO_{2eqv}/kg for fly ash and silica fume, 0.1870 kg CO_{2eqv}/kg for GBFS and 0.9818 kg CO_{2eqv}/kg for Portland cement.

   Across all concrete mixes in the project, at least 40% of fine aggregate must be manufactured sand.

3. Type SR cement must be used for sewerage structures including access chambers. Type SL cement must be used for other than sewerage structures including stormwater channels.
4. Maximum drying shrinkage for S40 and S50 concrete mixes must meet the following additional requirements:
   - 300×10^{-6} at 7 days
   - 400×10^{-6} at 14 days
   - 500×10^{-6} at 28 days.
5. For all concrete members, the peak temperature and maximum temperature differential following concrete placement must not exceed 75 °C and 25 °C respectively. For all concrete mixes proposed for cast in-situ members with the least dimension equal to or greater than 750 mm, thermal test blocks must be cast; and thermal performance information must be submitted to Sydney Water for acceptance at least 14 days prior to commencing concrete works. The thermal performance data of the proposed concrete mixes forms part of the hold point CHP1, Table 3-9 (Clause C3.6.5).

   The thermal test block must comprise 1,000 mm × 1,000 mm × 1,000 mm cube of unreinforced concrete. The block must be cast within 18 mm plywood formwork lined on all surfaces (including the top) with 100 mm thick polystyrene, to allow free expansion and contraction of the concrete and to minimise temperature losses from conduction, convection and` radiation. Placing a polythene sheet 0.2 mm thick on the inside of the polystyrene is required to prevent leakage through joints in the polystyrene and plywood.

   Thermocouples must be placed to record temperature with 2 No. at the geometric centre (T1), 2 No. at the centre of a top face edge (T2), 2 No. at the corner of the same top face edge (T3), 2 No. in the centre of the side face closest to, but not adjacent to the selected corner (T4) (Figure 3-1). Thermocouples along the top and side faces shall be placed with a cover depth of 50 mm. Thermocouples shall be positioned using a wooden dowel or similar. Ambient temperature shall be monitored using a thermocouple positioned on the outside of the thermal block a minimum of 200 mm away, in a shaded area (T5).

   Temperature readings in the concrete and of ambient air temperature at the time of pouring must be recorded and then at intervals of 15 minutes until the peak temperature has been reached and then continued until such time as the temperature has fallen to 40 °C or 12 days after the peak temperature, whichever is longer.

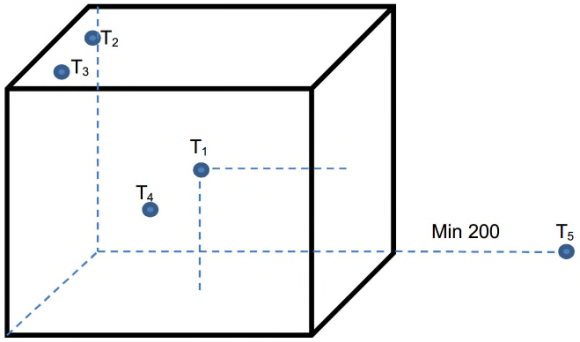

Figure 3-1 Thermal test block layout

The effects of temperature increase from cement hydration in concrete members with the least dimension equal to or greater than 750 mm must be modelled utilising CIRIA C766. Based on the thermal modelling, minimum stripping times must be specified for the concrete members.

C3.6.4 No fines concrete

No fines concrete must 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 must conform to Table 3-3.

Table 3-3 Aggregate grading for no fines concrete

Sieve size (mm)	% Passing by mass
37.5	100
19	85–100
9.5	0–20
4.75	0–5

C3.6.5 Submission of concrete mix design

At least 14 working days prior to commencement of concrete work, the details of each proposed concrete mix must be submitted to Sydney Water for acceptance, accompanied by test certificates. The certificates must be from an independent laboratory with an appropriate NATA registration. Each concrete mix submission must start with a summary showing that the nominated mix and its constituents meet the requirements of this specification.

Submission of concrete mix design, which must include NATA test certificates, constitutes a hold point (CHP1, Table 3-9).

C3.6.6 Variation to mix design

The quantities of the constituents in an accepted mix may be varied within the following limits to improve the quality of the concrete:

- cement ±3% by mass of each constituent
- aggregates ±5% by mass of each constituent
- water ±3% by volume or mass
- admixtures ±5% by volume or mass of each admixture and within the manufacturer's recommendations.

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

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

- not have a water/cement ratio exceeding that nominated for the special class concrete in Table 3-2
- conform to the requirements of minimum cement content for the special class concrete in Table 3-2
- 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, like 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 must conform to the mix design accepted by Sydney Water.

C3.7.2 Production

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

The concrete supplier must 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 must be submitted to Sydney Water for approval.

C3.7.3 Ready-mixed concrete delivery

Ready-mixed concrete production method and facilities must conform to AS 1379. Ready-mixed concrete must 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 must be continuously agitated until it is thoroughly mixed. On completion of mixing, the concrete must be continuously agitated until it is fully discharged.

Each batch of concrete delivered to site must be accompanied an identification docket that must 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
- 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 must not exceed the time set out in Table 3-4.

Table 3-4 Elapsed delivery time

Concrete temperature at time of discharge (ºC)	Maximum elapsed time (h)
10–23	2.00
24–26	1.50
27–29	1.00
30–32	0.75

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 must 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 must be placed, compacted, finished and cured so as to:

- prevent segregation or loss of material
- prevent premature stiffening
- prevent non-conforming 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 must be disposed of in an environmentally safe manner.

C3.8.2 Placement

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

Concrete must 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 must be adequate to maintain the adopted rate of concrete placement.

Concrete must not be dropped freely from a height exceeding 1.5 m, nor must be placed in any other manner which results in segregation or loss of mortar or damage to formwork or reinforcement. Where placing concrete would otherwise necessitate a drop exceeding 1.5 m, suitable tremie pipes, chutes or other concreting devices / method approved by Sydney Water must be used to place the concrete to prevent segregation.

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

Under conditions of rain, the placing of concrete must not commence or must be stopped, unless adequate protection is provided to prevent damage to the concrete.

C3.8.3 Sequence of pours

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

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

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

Internal vibrators must 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 must 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 must be not less than one quarter of the number of vibrators in use with a minimum of one. Vibrator used for spreading concrete must not be counted in the number of vibrators used for compaction.

Internal vibrators must be inserted vertically at spacing not exceeding 350 mm. The vibrator must be left in place for at least seven seconds until the air bubbles cease breaking the surface, and then withdrawn slowly. Vibrators must 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 must be achieved prior to encasing the reinforcement with concrete.

C3.8.5 Placing in water

Concrete must not be placed under water unless accepted by Sydney Water. Details must 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 must 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 must be regulated by approved methods to avoid premature stiffening. Concrete must 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 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 must be submitted to Sydney Water for acceptance. The certificate of conformity must be prepared by a competent civil/structural engineer who is a chartered member of the Institution of Engineers Australia.

A competent person may prepare the certificate of conformity in lieu of a chartered civil/structural engineer for the following items:

- formwork and reinforcement for minor structures where footprint is ≤12 m^2 and height ≤2.5 m
- formwork for slab on ground
- reinforcement for footways and roadworks.

The submission of a certificate of conformity in respect to formwork, reinforcement fixing and embedment constitutes a hold point (CHP2, Table 3-9).

C3.9 Finishes to unformed surfaces

C3.9.1 Unformed finishes

Unless specified otherwise, the finishes to unformed concrete surfaces must 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, must 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 must 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 must 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 must not be worked on further until ready for floating. Floating must 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 must then be consolidated with the power float. Hand floating with wood or corked faced floats must only be used in locations inaccessible to the machine. Trueness of surface must be rechecked at this stage with a 3 m straight edge at not less than two directions at 90 degrees. All high spots must be cut down and all low spots must be filled during this procedure to a class B tolerance. The slab must be re-floated immediately to a uniform, smooth, granular texture.

C3.9.6 Steel trowel finish

The surface must be finished first with power floats, as specified above, then with power trowels and finally with hand trowels. The first trowelling after power floating must be done by a power trowel and must produce a smooth surface that is relatively free from defects, but which may still contain some trowel marks. Additional trowelling must be done by hand after the surface has hardened sufficiently. The finished surface must be free from any trowel marks, uniform in texture and appearance, and must be planed to a class A tolerance.

C3.9.7 Broom finish

Broom finish must be a coarse transverse scored texture by drawing a broom or hessian belt across the surface. This operation must occur immediately after floating.

C3.10 Finishes to formed surfaces

All formed surfaces, except where permanently concealed by backfill material, must have a minimum of class 2 surface finish to AS 3610.

All formed finishes that are permanently concealed by backfill material, must have a minimum of class 3 surface finish to AS 3610.

All edges and re-entrant corners must be provided with 25 mm × 25 mm chamfers and 50 mm × 50 mm fillets respectively.

C3.11 Curing of concrete

C3.11.1 General

Freshly placed concrete must be protected from premature drying and excessive hot or cold temperatures. The concrete must be maintained at a reasonably constant temperature with minimum moisture loss for the duration of the curing period.

In windy conditions, windbreaks must be erected to shield the concrete surfaces during and after placement.

Freshly placed concrete must 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 must be cured continuously for the minimum curing period shown in Table 3-5, or until the concrete has achieved at least 75% of the characteristic strength.

Table 3-5 Minimum curing time

Concrete class	Wet curing	Curing compound
Normal (GP/GB cement)	4 days of wet or 7 days of curing compound	
Special (SR/SL cement)	7 days	Not applicable

C3.11.3 Curing methods

Unformed surfaces, and formed surfaces after the formwork is struck off, must 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 must conform to the requirements of AS 3799. The curing compound must be sprayed to give a uniform cover. The sprayer must 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 must be submitted to Sydney Water for acceptance.

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

The time between the first coat and the second coat must be in accordance with the manufacturer's recommendation or based on trial application.

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

C3.11.5 Hot weather curing

Curing compound must 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 must 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 must be taken at the point of discharge from the agitator. Where required by Sydney Water, additional sampling must be carried out at the point of discharge into the forms.

C3.12.2 Method of sampling

Sampling and identification must be carried out in accordance with AS 1012.1.

C3.12.3 Frequency of sampling

For each concrete mix supplied to each site from a concrete batching plant, sampling of fresh concrete must be at least one sample per 25 m^3 or part thereof. For each sample, two 100 mm diameter 200 mm high standard cylinder specimens must be cast and cured in accordance with AS 1012.8.1.

A slump test must be performed on each sample of fresh concrete in accordance with AS 1012.3.1.

Where the volume of concrete supplied for each mix, is ≤4 m^3, sampling frequency may be reduced, provided subsequent supplies of the same concrete mix are within a period of 4 weeks from the same batching plant. In such cases, sampling must be carried out for every cumulative volume of 8 m^3. Records of date, location, and volume of the concrete pours covered by each cumulative volume up to 8 m^3 must be provided to Sydney Water.

C3.12.4 Tolerance on slump

The concrete represented by the sample must be deemed to be satisfactory if the measure slump is within the limits given in Table 3-6.

Table 3-6 Permissible tolerances on slump

Specified slump (mm)	Tolerances (mm)
<60	±10
60–80	±15
80–110	±20
110–150	±30
>150	±40

If the measured slump is not within the specified limits, one repeat test must 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 must be rejected.

C3.12.5 Compressive strength of cylinder specimens

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

The compressive strength of a concrete sample must 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 must be investigated. Inclusion or exclusion of the specimen results must be at the discretion of Sydney Water.

The compressive strength of any concrete sample must 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 must be investigated, and an engineering assessment report must be submitted to Sydney Water for acceptance. Acceptance of the concrete represented by the sample must be at the discretion of Sydney Water. Concrete with strength less than 0.85 of the characteristic strength must be rejected.

C3.13 Joints

C3.13.1 Construction joints

The locations of construction joints must be as nominated in the drawings, and they must not be altered without the approval of Sydney Water.

All construction joints must 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 must not exceed 1/250 times the distance between the points or 5 mm, whichever is greater.

All construction joints in contact with liquid, except for slabs, must incorporate a PVC centre bulb or hydrophilic expanding water stop, located centrally (in the middle) of walls. For slabs on ground, a PVC water stop must be used on the underside of the slab. For suspended slabs, hydrophilic water stop must be incorporated in the middle.

Water stops must be continuous across construction joints at interfacing members in accordance with manufacturers requirements.

C3.13.2 Preparation of surface at construction joints

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

Coarse aggregates which do not remain firmly embedded in the mortar matrix and laitance from projecting reinforcement from previous pour must be removed.

Immediately prior to the placement of adjoining concrete, the surface of the construction joint and the projecting reinforcement must be washed clean, and the concrete surface must be saturated with water, following which all excess water and loose material must be removed.

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

Notification of the completed construction preparation constitutes a hold point (CHP3, Table 3-9).

C3.13.3 Movement joints

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

The movement joints must 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 must be such that the stiffness of the adjoining members is compatible.

All dowels must 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 must be permitted on the alignment of the dowels. The unbonded end of dowels must be coated in an approved bond breaker such as hot 60–70 grade bitumen. At expansion joints, the unbonded end of the dowel must be sheathed with a dowel cap containing a minimum of 15 mm compressible packer.

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

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

C3.13.4 Filler & sealant in joints

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

Fillers and sealants for the joints must 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, any affected material not yet placed must be discarded and any affected material already placed must be removed and replaced. Where priming is specified, the primer must be compatible with the sealant as recommended by the manufacturer.

Prior to the application of primer or sealant, all joint grooves must 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 must 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 must be strictly in accordance with manufacturer's specification. The jointing of PVC water stops and repairs to damaged PVC water stops must only be carried out by using heat welding.

The PVC water stops must 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 must 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 must be maintained from the nearest face of reinforcement.

Hydrophilic expanding water stops must 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

Not earlier than 14 days prior to a reinforced concrete structure being commissioned (for non-liquid retaining structures) or hydrostatically tested (for liquid retaining structures) but not later than 100 days after completing the structure, concrete elements must not have any cracks exceeding the widths specified below:

1. Special class concrete:
   - all exposure classifications to AS 3735 – 0.15 mm
2. Normal class concrete:
   - exposure classification C1, C2 & U to AS 3600 – 0.15 mm
   - exposure classification B1 & B2 to AS 3600 – 0.25 mm
   - exposure classification A1 & A2 to AS 3600 – 0.30 mm.

A plan drawn to scale mapping out all cracks that exceed the above limits, including joint locations and types, adjacent walls and floor elements and any other restraints that may be the cause of the cracking, along with remediation methods and procedures must be submitted to Sydney Water for acceptance at least 7 working days prior to commencing any remediation works.

Submission of details of non-compliant cracks and proposed remediation constitutes a hold point (CHP4, Table 3-9).

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

C3.15 Formwork

C3.15.1 General

Formwork, including all supporting members must conform to the requirements of AS 3610.

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

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

Formwork must be fabricated with a "Plasply" surface or equivalent phenolic coating, steel plate or accepted equivalent. Joints must 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 must be provided in vertical forms where necessary for inspection and cleaning.

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

Formwork bolts must be designed so that they may be extracted without damaging the surrounding concrete. The embedded part of all form ties must be located no closer than 50 mm to the surface of the finished concrete. All holes left by form must 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, must be noted clearly on the formwork drawings. Pre-camber diagrams where required must be included in the formwork documentation.

The formwork drawings must 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 must be submitted to Sydney Water.

C3.15.3 Submission of formwork documentation and certification

The formwork documentation must be submitted to Sydney Water for acceptance at least 14 working days prior to the commencement of erection of formwork. The documentation must be certified by a chartered civil/structural engineer who is a chartered member of the Institution of Engineers Australia with the relevant experience in the design of formwork.

For slabs on ground, and minor structures where the footprint is ≤12 m^2 and the height is ≤2.5 m, a competent person may certify the documentation in lieu of a chartered civil/structural engineer.

Submission of formwork documentation and certification constitutes a hold point (CHP5, Table 3-9).

C3.15.4 Test panels

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

C3.15.5 Removal of formwork

Formwork must 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 must 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 must be as stated in Table 3-7.

Table 3-7 Minimum time for stripping of formwork

Member type [Note 1]	Form stripping time (days) for daily average temperature (T)		
	T > 20 ºC	20 ºC > T > 12 ºC	12 ºC > T > 5 ºC
Walls (No imposed loads until 28 days)	4	6	8
Suspended beams & slabs (No imposed loads until 28 days)	8	10	12
Cast on ground slabs & beams (No imposed loads until 28 days)	2	3	4

Note:

1. The stripping times for walls, suspended beams and suspended slabs cured at temperature below 5 ºC must be increased by half a day for each day on which the daily average temperature was between 2 ºC and 5 ºC or by a whole day for each day on which the daily average temperature was below 2 ºC.

C3.16 Steel reinforcement

C3.16.1 General

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

Manufacturers and processors of steel reinforcement must 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 must 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 must not be used.

C3.16.3 Fabrication and bending

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

Reinforcement must 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 must be permitted. Reinforcement already bent and straightened or bent in the reverse direction must not be bent again within 20 diameters of the previous bend. Reinforcement partially embedded in concrete and bent again, must be cleaned thoroughly and free of any mortar before depositing concrete against it. Specific details must be forwarded to Sydney Water for acceptance at least 48 hrs before commencing any straightening or re-bending location of Splices.

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

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

C3.16.4 Welding of reinforcement

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

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

C3.16.8 Assembly of reinforcement

Reinforcement must be fixed within the tolerances set out in clause 19.5 of AS 3600.

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

Where bundled bars are specified, they must 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 must 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 must be of the type shown in the drawings or as nominated in Table 5-1.

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

C3.18 Shotcreting

C3.18.1 General

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

C3.18.2 Equipment

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

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

Delivery hoses must 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 must be mechanically regulated and have calibrated meters.

C3.18.3 Applicator

Application of shotcrete must 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 must 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, approval to the use of that operator may be revoked.

Submission of details of the proposed shotcrete applicator constitutes a hold point (CHP6, Table 3-9).

C3.18.4 Shotcrete application

The procedure, equipment and personnel involved in shotcreting must 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 must not be worked into the construction or re-used in the works.

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

The distance of manually held nozzles from the receiving surface must be between 0.5 m to 1.0 m. Nozzles must 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 must 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 must be prepared in accordance with this specification before shotcreting is resumed.

C3.18.5 Placing around reinforcement

The nozzle must be held at a distance and angle that will enable shotcrete to be sprayed behind the reinforcement before any material can accumulate on its face.

Shotcrete must 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 must be prepared by the operator on site; and test results must be provided to Sydney Water for acceptance.

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

Four core samples must 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 its discretion allow shotcrete being placed in the Works concurrently with the trailing of the test panel.

C3.18.7 Quality control tests

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

Two 50 mm diameter cores of sufficient depth must be extracted for every 75 m² of shotcrete surface approximately 48 hours after the area has been sprayed. One core must 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 must be rectified. The finish and appearance of the repaired sections must match the adjacent sound concrete.

At least 14 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 must be submitted to Sydney Water for acceptance. If required by Sydney Water, the proposal must be certified by a structural engineer with the relevant experience that the repaired structure will meet the designed performance, life and durability requirements.

Submission of concrete repair methodology including repair products constitutes a hold point (CHP7, Table 3-9).

C3.19.2 Surface preparation of faulty concrete work

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

In areas of spalling or areas which require reforming, surface preparation of concrete must 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 must where necessary include the use of portable handheld percussive tools such as "scabblers" and "needle guns".

To avoid feathered edges, the area to be repaired must be power saw cut around its perimeter to a depth of 10 mm. The saw cutting of the repair area must 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 must be made so that the width of the saw cut is greater at the base of the cut-out than at the surface to provide a keying action. Concrete must be removed so that the repair area is at all points at least 10 mm deep.

C3.19.3 Patch repairs

Patch repairs must be carried out to reinstate the areas of defective concrete to the surface profile specified in the accepted design drawings.

The patch repair material must be a polymer modified cementitious mortar having a drying shrinkage strain of not more than 600 x 10^{-6} at 28 days.

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

All work, including concrete surface preparation, priming, repair mortar application and curing, must be carried out strictly in accordance with the manufacturer's instructions. In deeper sections the repair material must be built up in layers as required to eliminate slumping.

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

C3.19.4 Crack repairs by epoxy injection

All cracks that exceed the limits in this specification must be repaired by epoxy injection.

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

Sufficient epoxy adhesive must 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 must 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 must only be carried out by applicators that are approved by the supplier of the system.

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

Concrete work, including reinforcing steel and other embedded items for base slabs and link slabs must comply with this Technical Specification.

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

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

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

C3.20.2 Construction of cast-in place reinforced concrete box culverts and open channels

Concrete work including reinforcing steel and other embedded items for the cast in place box culverts and channels must be in accordance with this Technical Specification.

C3.20.3 Tolerances

Box culverts and open channels must be constructed to the tolerances specified Table 3-8.

Table 3-8 Maximum construction tolerances

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

C3.20.4 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, must 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 non-conformity detected along with the video recording taken during CCTV inspections shall be submitted to Sydney Water.

The inspection and reporting must be in accordance with WSA 05.

C3.21 Hydrostatic testing of liquid retaining structures

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

Testing must 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 must form part of the contract.

The structure must be cleaned and initially filled with water at a uniform rate not greater than 2 m in 24 hours. The water level must 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 must 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) must not exceed 1/500 of the average water depth of the full tank or 10 mm, whichever is the less.

Evidence of damp patches on the outside surfaces must be investigated and rectified before acceptance.

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

Upon completion of the test, the structure must 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 policy D0001667 must be followed.

The submission of hydrostatic test results constitutes a hold point (CHP8, Table 3-9) for backfilling and commissioning.

Prior to commissioning the tank, the procedures and acceptance criteria detailed in Sydney Water procedure D0001909 must be followed.

C3.22 Hold points

C3.22.1 Hold points identified in concrete works

A summary of hold points identified are listed in Table 3-9.

Table 3-9 Summary of hold points for concrete works

Hold point no.	Process held	Required documentation	Relevant clause
CHP1	Approval of concrete mix design	Concrete mix design & test certificates including the thermal test block results for applicable concrete mixes	C3.6.3, C3.6.5
CHP2	Placement of concrete	Submission of conforming formwork, Reinforcement fixing & embedment	C3.8.8
CHP3	Placement of concrete	Notification of construction joint preparation	C3.13.2
CHP4	Crack repair methodology	Non-compliance crack mapping	C3.14
CHP5	Erection of formwork	Formwork documentation & certification	C3.15.3
CHP6	Shotcreting	Applicator credentials	C3.18.3
CHP7	Concrete repairs	Concrete repair products & Repair Methodology	C3.19.1
CHP8	Repairs & backfilling	Test results of hydrostatic testing	C3.21

C4. Pipe laying

C4.1 General

C4.1.1 Introduction

Where applicable, pipe networks must comply with the requirements of the following WSAA codes of practice:

- Polyethylene Pipeline Code WSA 01
- Sewerage Code of Australia WSA 02, Sydney Water Edition
- Water Supply Code of Australia WSA 03, Sydney Water Edition
- Sewage Pumping Station Code of Australia WSA 04, Sydney Water Edition
- Vacuum Sewerage Code of Australia WSA 06
- Pressure Sewerage Code of Australia WSA 07.

All pipes, fittings and materials including joint seals, flange gaskets, O-rings and jointing lubricants for use in contact with drinking water must 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 Clause 1.6 must be done.

C4.2 Referenced documents

Sydney Water documents

BMIS0209	Technical Specification – Mechanical
CPDMS0018	List of Acceptable Non-Standard Product Specifications
CPDMS0022	Technical Specification – Electrical
CPDMS0026	Reticulation Sewers in Basements
D0000708	Soil Assessment for installation of ductile iron pipes without sleeving
D0001667	Water Quality Management During Operational Activities
D0001669	Work instruction for Disinfection of Water Mains
EPS 210	Engineering Product Specification for Welded Steel Pipes and Fittings
EPS 500	Engineering Product Specification for Network Pipes and Fittings

WSAA specifications

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)
WSA 109	Flange gaskets and O-rings
WSA 113	Reinforced Concrete Pipes with Flexible Thermoplastic Linings
WSA 201	Manual for Selection and Application of Protective Coatings (with integral Sydney Water Supplement)
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

Australian standards

AS 1289.5.6.1	Methods of testing soils for engineering purposes Method 5.6.1: Soil compaction and density tests – Compaction control test – Density index method for a cohesionless material
AS/NZS 1554	Structural steel welding
AS/NZS 1554.1	Structural steel welding Part 1: Welding of steel structures
AS 1646	Elastomeric seals for waterworks purposes
AS 2032	Installation of PVC pipe systems
AS 2033	Installation of polyethylene pipe systems
AS 2239	Galvanic (sacrificial) anodes for cathodic protection
AS 2566.2	Buried flexible pipelines Part 2: Installation
AS 2832.1	Cathodic protection of metals Part 1: Pipes and cables
AS 3680	Polyethylene sleeving for ductile iron pipelines
AS 3681	Guidelines for the application of polyethylene sleeving to ductile iron pipelines and fittings
AS/NZS 3725	Design for Installation of Buried Concrete Pipes
AS 3972	General purpose and blended cements
AS 4020	Testing of products for use in contact with drinking water
AS 4041	Pressure piping
AS 4087	Metallic flanges for waterworks purposes
AS 4321	Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings
AS 4832	Cathodic protection – Installation of galvanic sacrificial anodes in soil

International standards

ASTM A380/A380M	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM F1962	Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings

ISO 13953	Polyethylene (PE) pipes and fittings – Determination of the tensile strength and failure mode of test pieces from a butt-fused joint
ISO 13954	Plastics pipes and fittings – Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm

Plastics Industry Pipe Association of Australia guidelines

POP014	Assessment of Polyethylene Welds

C4.3 Pipe materials

C4.3.1 General

All water pipelines and sewer systems must be designed and constructed for a design life of at least 100 years for which they are used for their intended purpose without major repair being necessary.

Pipe materials for pipelines must be as follows:

- drinking and recycled water: DI, MS, PVC, GRP, PE, SS
- wastewater: VC, PVC, GRP, PE, DI, MS, RC (plastics-lined), PP, SS
- stormwater drains: RC, VC, PVC, GRP, PP.

Installation of buried flexible pipes must comply with the requirements of AS 2566.2.

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

C4.3.2 Mild steel (MS) pipes

Mild steel (MS) pipes and fittings must comply with the requirements of EPS 210. The ratio of external pipe diameter to pipe wall thickness (not including any coatings/linings) must not exceed 120.

C4.3.3 Ductile iron (DI) pipes

Ductile iron (DI) pressure pipes and fittings must comply with the requirements of EPS 500.

C4.3.4 Polyethylene (PE) pipes

Polyethylene (PE) pipes and fittings must comply with the requirements of EPS 500.

Installation of polyethylene pipeline systems must be in accordance with WSA 01 and AS 2033. PE pipes for pressure or gravity wastewater applications must be internally debeaded.

C4.3.5 Glass reinforced thermoplastics (GRP) pipes

Glass reinforced plastic (GRP) pipes and fittings must comply with the requirements of EPS 500. GRP fittings must not be used for pressure applications.

C4.3.6 Polyvinyl chloride (PVC) pipes

Polyvinyl chloride (PVC) pipes and fittings must comply with requirements of EPS 500. Installation of PVC pipe systems must comply with requirements of AS 2032.

C4.3.7 Vitrified clay (VC) pipes

Vitrified clay (VC) pipes and fittings must comply with the requirements of EPS 500.

C4.3.8 Reinforced concrete pipes (RC)

Precast RC pipes must comply with the requirements of EPS 500. Concrete pipes must not be used for pressure applications. Pipe support type must be minimum type HS under roads, driveways, footpaths/verges/median strips not restricted to vehicles, and parkland with no restriction to vehicular access. Pipe support type must be minimum type H in areas within private properties, and public places, pedestrian malls and footways not subjected to vehicular loading, or have no access for vehicles.

C4.3.9 Polypropylene (PP) pipes

Polypropylene (PP) pipes must comply with the requirements of EPS 500.

C4.3.10 Stainless steel (SS) pipes

Stainless steel pipes and fittings must comply with the requirements of AS 4041. Stainless steel pipes must be grade 316 complying with the requirements of ASTM A312/A312M. Minimum pipe schedule must be 40S.

C4.4 Joints

Pipe joints must comply with the requirements of the relevant product standard nominated in EPS 500.

Flanges must be manufactured to the requirements of AS 4087 as is appropriate for the design pressure. Minimum pressure class must be PN16. Gaskets must comply with the requirements of AS 1646 and WSA 109.

C4.5 Products, fittings, ancillary structures and appurtenances

All pipe products, fittings, ancillary structures and appurtenances including, but not limited to, thrust/anchor blocks, bulkheads, trench stops, trench drainage, special pipe support measures, stop valves, hydrants, air valves, control valves, couplings, clamps, maintenance holes/chambers/shafts, ventshafts, main taps, service connection valves and fittings must comply with the requirements of the relevant WSAA codes of practice, EPS 500, CPDMS0018, BMIS0209, CPDMS0022.

C4.6 Pipe laying and tolerance

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

Pipes must be laid with the barrels firmly and evenly bedded on the bedding material. Socket holes must 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.

Reticulation sewers in basements must be in accordance with the requirements of CPDMS0026.

Tolerances of as-constructed works for pipelines and associated structures are stated in the WSAA codes of practice and must be applicable unless otherwise specified in the drawings.

C4.6.1 Adjacent parallel pipelines

Thrust forces for parallel pipelines at bends must be transmitted to the outside trench face without allowing transfer of any thrust from the inner pipeline to the outer pipeline. Alternatively, anchor blocks may be keyed into native material below the base of the trench.

C4.7 Work procedure

Prior to the commencement of pipe laying works, the following must 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 must 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 must be arranged so that the sockets and spigots are not loaded and there must not be excessive load on the lower layer.

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

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

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

C4.9 Cutting pipes

Pipes must 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 must be ground or machined to the required chamfer where necessary.

Concrete pipes must be cut to a square and even finish without splitting or fracturing the wall of the pipe. Reinforcement must 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, condition 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, or condition is not suitable, Sydney Water must be informed immediately. Sydney Water must 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 must comply with requirements of AS 2566.2. The outside surfaces of all pipes and special castings to be built into structures must be thoroughly cleaned immediately before installation. Pipes passing through water retaining walls and floors must be built into the structure in-situ. Shuttering must be formed closely to the pipe and concrete must 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 must be provided with the embedment and support of the type shown in the drawings.

The material must be placed in the excavation up to the level of the pipe barrel and must 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 must be carefully placed into the space between the pipe and the sides of the trench to the level specified in the drawings. The material must be carefully deposited in layers not exceeding 150 mm thick before compaction. The placing and the compaction of the material must proceed equally on both sides of the pipe.

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

Table 4-1 Minimum compaction standard for pipe embedment materials

Material type	Test method	Relative compaction(density index) (%)
Compaction sand or processed aggregates	AS 1289.5.6.1	70

Flooding must not be used for compaction.

C4.12.2 Concrete encasement

Where concrete encasement is used, the concrete must 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 must be in full contact with the underside of the barrel of the pipe throughout its length.

A concrete mix with medium to high slump value (greater than 120 mm) must be used to facilitate placement and ensure the pipe is encased in a dense homogenous mass of concrete without any voids. The concrete must be placed in one operation and there must be no horizontal construction joint.

All care must be taken to manage flow of concrete down slopes for pipes laid on high grades. The pipe must be anchored against flotation.

C4.12.3 Cement stabilised embedment materials

Cement stabilised sand, where specified, must consist of sand mixed with 5% (20:1) cement by mass. Moisture content must be 8%. Sand must comply with WSA PS-350 (Grade A). Cement must be Type GP or GB complying with requirements of AS 3972. Placement must be in accordance with Clause C4.12.1.

Controlled low strength materials (CLSM) or flowable fill, where specified, must comply with the requirements of WSA PS-352. Embedment material must be 10 mm nominal size. The 28-day strength must not exceed 3 MPa.

C4.13 Trench fill materials and compaction

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

C4.14 Jointing of pipes

C4.14.1 General

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

Before making any joints, all jointing surfaces must be thoroughly cleaned and dried, and maintained in such condition until the joints have been completely assembled. Pipes must 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 must be inspected for flaws before making each joint. Jointing fluid must be applied in accordance with the manufacturer's recommendation.

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

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

Restrained rubber ring joint systems are not permitted, except for ductile iron fittings for PE pipe applications complying with the requirements of EPS 500.

C4.14.3 Flanged joints

Flange jointing must be undertaken in accordance with the requirements of the manufacturer and WSA 109.

The flanges must be correctly positioned and the component parts including any insertion ring and gaskets thoroughly cleaned and dried. Insertion rings and gaskets must be fitted smoothly to the flange without folds and wrinkles. The faces and boltholes must be brought fairly together, and the joints must be made by gradually and evenly tightening bolts in diametrically opposed positions.

Flanged joints must not be encased in concrete.

C4.14.4 Welded joints on mild steel and stainless steel pipes and fittings

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

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

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

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

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

Welding records must 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 must also be inspected by Sydney Water before any protective coating or concrete encasement is placed around the outside of the joint.

Welds for stainless steel pipe and fittings must be in accordance with AS 4041. Partial penetration welds are not permitted. Welds must be chemically cleaned, pickled and fully passivated in accordance with ASTM A380/A380M.

C4.14.5 Polyethylene pipe joints

Jointing of polyethylene pipes must be undertaken in accordance with the requirements of WSA 01.

C4.14.5.1 Butt fusion joints

All butt welds must be visually inspected for uniformity and symmetry around the full circumference and must not contain any sharp notches. The weld must be assessed in accordance with table 1 and table 2 of POP014.

Each external weld bead must be field tested by removal, using a suitable bead removal tool, and assessment in accordance with clause 2.1.1 of POP014. If the bead separates, the parameters and welding process must be investigated and reported to Sydney Water.

Samples for destructive weld testing of butt fusion joints must be provided for each individual pipe size, PE material grade and standard dimension ratio (SDR) as follows:

- 1 pilot weld joint at the start of the project
- 1 joint in the first 100 metres following testing of the pilot weld
- 1 joint in every 20 pipe joints (or part thereof) for the remainder of the pipeline after the testing of the first 100 metres as prescribed above meets the testing requirements.

The pilot weld must be prepared in accordance with ISO 13953. The test sample must be joined with a butt fusion weld using the particular welding machinery, welders and welding process nominated for the particular PE pipeline project. Test samples must be identified by pipe size, SDR, PE material composition grade, date, chainage/location, welder number, machine and welding conditions at the time of welding.

Butt fusion joint weld samples must be submitted for destructive testing to an approved NATA registered testing laboratory. Destructive tensile testing must be performed in accordance with ISO 13953 exhibiting ductile failure, no contamination in the weld plane and minimum tensile strength of 90% parent pipe.

C4.14.5.2 Electrofusion joints

All electrofusion joints must be visually inspected in accordance with the acceptance criteria of table 4 of POP014.

Electrofusion couplings and saddles that indicate error readings, short circuiting, exposed wires, failure of coupling melt indicators and or melt outside the weld zone must be cut out and re-welded. Pipe joints deemed by Sydney Water not to meet these criteria must be re-welded.

Samples for destructive weld testing of electrofusion joints must be provided for each individual pipe size, PE material grade and SDR as follows:

- 1 pilot weld joint at the start of the project
- 1 joint in the first 100 metres following testing of the pilot weld
- 1 joint in every 20 pipe joints (or part thereof) for the remainder of the pipeline after the testing of the first 100 metres as prescribed above meets the testing requirements.

Test samples must be cut such that there is a minimum of 300 mm of pipe protruding either side of the coupling joint. Test samples must be identified by pipe size, SDR, PE material composition grade, date, chainage/location, welder number, machine and welding conditions at the time of welding.

Electrofusion pipe weld samples must be submitted to an approved NATA registered testing laboratory. Welds must be tested for a peel decohesion test in accordance with requirements of ISO 13954.

The acceptance criteria for tested weld samples for electrofusion must not present a brittle failure zone longer than 25% of the fusion zone in the longitudinal axis.

C4.15 Corrosion protection of pipes and fittings

All buried ductile iron pipes and fittings must be protected with polyethylene sleeving complying with the requirements of AS 3680. The application of the sleeving to the pipeline must be carried out in accordance with AS 3681. An assessment in accordance with D0000708 must be undertaken for installation of ductile iron pipe without sleeving.

For buried ductile iron flanges with galvanised bolts, and polyethylene flanges with galvanised bolts and backing rings, the bolts heads and nuts must be covered with plastic cover caps filled with corrosion prevention paste, and then the flange must be tape wrapped in accordance with WSA 201.

Buried steel pipes must be fusion bonded polyethylene (FBPE) coated to AS 4321. Welded joints or local bare sections of shell pipe must be protected with a heat-shrinkable, cross-linked polyolefin sleeve or tape wrapped in accordance with WSA 201. The application of the wrapping system must 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. Concrete encasement, galvanising or liquid applied paint systems are not permitted on buried steel pipes as the primary means of corrosion protection.

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

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

C4.16 Painting of pipes and fittings

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

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

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 must be anchored in position by the construction of thrust blocks as shown in the drawings.

Minimum class of concrete for anchor or thrust blocks must be N25.

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

Maintenance hole covers and frames must be fixed in the positions shown in the drawings. The frames must be solidly bedded in epoxy mortar so that the covers when in position are fair and even with the adjacent surfaces.

C4.18.2 Sewer maintenance holes

Concrete maintenance holes must be constructed as shown in the drawings. Concrete maintenance holes must be suitable for use in aggressive environment and must resist hydrogen sulphide attack.

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

Precast concrete segmental construction must not be used in water-charged ground, in road reserve or areas with possible vehicular traffic loadings and must 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 must be provided for all maintenance holes on sewers (DN375 and above), all pressure main discharge maintenance holes, and the next two maintenance holes downstream of the discharge location.

C4.19 Thrust boring

Bores must 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 must be submitted to Sydney Water.

The boring method must 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 must be capable of measuring the elevation, azimuth and gradient of the bore path.

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

Logs must 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 must also be maintained. These boring/drilling logs and data sheets must be made available to Sydney Water for inspection during the progress of work. On completion of the works, these records must be submitted to Sydney Water.

All care must 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 must be undertaken in the event of drilling fluid loss.

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

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

The proposed grouting procedures must be submitted to Sydney Water. It is required to demonstrate that the proposed grout mixtures meet the requirements of this specification and must 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 must ensure complete filling of the annulus and must be subject to the review and acceptance of Sydney Water. Records must be maintained of all grouting operations, which must 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. Proprietary spacers must be provided to fix position of the carrier pipe within the bore and facilitate grouting.

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

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

- The grout composition must have no adverse effect on the carrier pipe.
- The grout must be compatible with the site conditions and be environmentally harmless.

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

Extreme care must be taken in minimising the loss of drilling fluids into the ground or the environment. Returned fluids must be properly contained, reclaimed and recirculated. Precautionary measures must 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 must be managed to prevent spillage to the environment. Boring fluid must be disposed of off-site in a manner acceptable to the relevant authorities.

Carrier pipes must be installed with tracer wire complying with the requirements of EPS 500 affixed to the pipe and terminated and fixed at an accessible point at each end.

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

C4.20 Horizontal directional drilling

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

The bore design must be submitted to Sydney Water for acceptance and must 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 can withstand all temporary loads in accordance with ASTM F1962.

The structural strength of the carrier pipe must be checked for installation in the proposed bore profile and must withstand all temporary loads during installation, which must 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.

All precautionary measures must be taken to avoid damaging the carrier pipe during installation. During installation, the installation force must be controlled to avoid overstressing the carrier pipe. Once any section of pipe is completed it must 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 must be developed and submitted to Sydney Water.

The drilling method must 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 must be capable of measuring the elevation, azimuth and gradient of the bore path.

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

Logs must be provided 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 must also be maintained. These boring/drilling logs and data sheets must be made available to Sydney Water for inspection during the progress of work. On completion of the works, these records must be submitted to Sydney Water.

The allowable tolerance for the final position of the carrier pipe must be:

- tolerance from target

The centre of the finished bore at the exit must lie within a 1.0 metre diameter circle centred on the designed target.

- tolerance from grade

Reasonable care must be taken to achieve the design profile of the carrier pipe. The finished pipeline must be smooth in grade and must not have any reversed grade to that of the design grade that could result in ponding of flow.

Care must 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 must be undertaken in the event of drilling fluid loss.

The proposed grouting procedures must be submitted to Sydney Water. It is required to demonstrate that the proposed grout mixture meet the requirements of this specification and must 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 must ensure complete filling of the annulus and must be subject to the review and acceptance of Sydney Water. Records must be maintained of all grouting operations, which must 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 must ensure that the following properties are attained:

- The grout must provide an effective stoppage of water ingress and create a permanent seal between the borehole and the carrier pipe.

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

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

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

Extreme care must be taken in minimising the loss of drilling fluids into the ground or the environment. Returned fluids must be properly contained, reclaimed and recirculated. Precautionary measures must 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 must be managed to prevent spillage to the environment. Drilling fluid must be disposed of off-site in a manner acceptable to the authorities.

Carrier pipes must be installed with tracer wire complying with the requirements of EPS 500 affixed to the pipe and terminated and fixed at an accessible point at each end.

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

C4.21 Testing of sewer and maintenance holes

C4.21.1 General

All testing must be carried out by firms accredited by NATA. All test results must 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 must be carried out in accordance with and to the acceptance criteria stipulated in WSA 02 (Sydney Water Edition).

C4.21.3 Air pressure and vacuum test

Either low pressure or vacuum testing must be undertaken for all completed sewers and property connection sewers to detect points of leakage and potential groundwater infiltration.

For sewers of size DN1500 and smaller, either low pressure air testing or vacuum testing must be undertaken. The methods and acceptance criteria must be in accordance with that stipulated in WSA 02 (Sydney Water Edition).

For sewers of size greater than DN1500, every joint of the sewer must be tested. A joint testing apparatus must be designed and constructed to enable air pressure or vacuum testing the each joint. The acceptance criteria must be as stipulated in WSA 02 (Sydney Water Edition).

C4.21.4 Infiltration test

An infiltration test must be undertaken for each catchment or sub-catchment as stipulated in WSA 02 (Sydney Water Edition).

C4.21.5 Ovality test

Ovality testing must be undertaken of all flexible sewers in accordance with and to the acceptance criteria stipulated in WSA 02 (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 Maintenance structures

All sewer maintenance structures must be subjected to vacuum testing. Vacuum testing must be undertaken in accordance with and to the acceptance criteria of WSA 02 (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 must 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 must 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 WSA 02 (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 WSA 03 (Sydney Water Edition).

The test pressure must be as stipulated in WSA 03 (Sydney Water Edition), unless stated otherwise in the drawings.

Pressure pipelines must 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 must be applied to sections of pipeline generally not exceeding 1 km in length, or such other length as may be appropriate. The pipeline must be backfilled, but the pipe joints must be left uncovered, unless otherwise agreed by Sydney Water.

Temporary anchor or thrust blocks must be constructed as required at the ends, bends and branch outlets. All concrete anchor blocks must have achieved the necessary concrete strength before proceeding with the testing.

C4.22.2 Disinfection of water mains

Disinfection of all potable water mains must be carried out before they are placed into service.

Requirements for disinfection are laid down in Sydney Water work instruction D0001669 and WSA 03 (Sydney Water Edition).

C4.22.3 Water for pressure testing and disinfection

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

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

Following testing or disinfection the water must 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 policy D0001667, must 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 must be submitted to Sydney Water.

C4.22.4 Bacteriological test

Bacteriological tests must be carried out on all new disinfected water mains in accordance with the test procedure and the acceptance criteria stipulated in WSA 03 (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

Sydney Water documents

D0001667	Water Quality Management During Operational Activities
D0001909	Certifying Water Quality when Commissioning/Returning Reservoirs to Service
D0001963	Water Reservoir General Technical Specification

WSAA specifications

WSA 201	Manual for Selection and Application of Protective Coatings (with integral Sydney Water Supplement)

Australian standards

AS 1100	Technical drawing
AS 1101.3	Graphic symbols for general engineering Part 3: Welding and non-destructive examination
AS 1110.1	ISO metric hexagon bolts and screws – Product grades A and B Part 1: Bolts
AS 1110.2	ISO metric hexagon bolts and screws – Product grades A and B Part 2: Screws
AS 1111.1	ISO metric hexagon bolts and screws – Product grades C Part 1: Bolts
AS 1111.2	ISO metric hexagon bolts and screws – Product grades C Part 2: Screws
AS 1112.1	ISO metric hexagon nuts Part 1: Style 1 – Product grades A and B
AS 1112.2	ISO metric hexagon nuts Part 2: Style 2 – Product grades A and B
AS 1112.3	ISO metric hexagon nuts Part 3: Product grade C
AS/NZS 1163	Cold formed structural steel hollow sections
AS/NZS 1214	Hot-dip galvanised coatings on threaded fasteners (ISO metric coarse thread series) (ISO 10684:2004, MOD)
AS 1237.1	Plain washers for metric bolts, screws and nuts for general purposes Part 1: General plan
AS 1237.2	Tolerances for fasteners Part 2: Washers for bolts, screws and nuts – Product grades A, C and F
AS/NZS 1252.1	High-strength steel fastener assemblies for structural engineering – Bolts, nuts and washers Part 1: Technical requirements
AS 1275	Metric screw thread for fasteners

AS 1397	Continuous hot-dip metallic coated steel sheet and strip – Coatings of zinc and zinc alloyed with aluminium and magnesium
AS/NZS 1554	Structural steel welding (Set)
AS/NZS 1554.1	Structural steel welding Part 1: Welding of steel structures
AS/NZS 1554.6	Structural steel welding Part 6: Welding stainless steels for structural purposes
AS 1562.1	Design and installation of metal roof and wall cladding Part 1: Metal
AS 1657	Fixed platform, walkways, stairways and ladders – Design, construction and installation
AS 1664.1	Aluminium structures Part 1: Limit state design
AS 1664.1 Supp 1	Aluminium structures Part 1: Limit state design (Supplement 1 to AS/NZS 1664.1:1997)
AS 1664.2	Aluminium structures Part 2: Allowable stress design
AS/NZS 1665	Welding of aluminium structures
AS 1674	Safety in welding and allied processes (Set)
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/NZS 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
AS/NZS 3679.2	Structural steel – Welded I sections
AS 4100	Steel structures
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4361.1	Guide to hazardous paint management Part 1: Lead and other hazardous metallic pigments in industrial applications
AS/NZS 4361.2	Guide to hazardous paint management Part 2: Lead paint in residential, public and commercial buildings
AS/NZS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS/NZS 4854	Welding consumables – Covered electrodes for manual metal arc welding of stainless and heat-resisting steels – Classification
AS/NZS 4855	Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels – Classification

AS/NZS 4856	Welding consumables – Covered electrodes for manual metal arc welding of creep-resisting steels – Classification
AS/NZS 4857	Welding consumables – Covered electrodes for manual metal arc welding of high-strength steels – Classification
AS/NZS 5131	Structural steelwork – Fabrication and erection
AS/NZS ISO 9001	Quality management systems – Requirements
AS/NZS ISO 18273	Welding consumables - Wire electrodes, wires and rods for welding of aluminium and aluminium alloys – Classification
AS/NZS ISO 24598	Welding consumables – Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of creep-resisting steels – Classification
AS/NZS ISO 26304	Welding consumables – Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels – Classification

International standards

ASTM A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A380/A380M	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

Other documents

AWWA D100	American Water Works Association – Welded Carbon Steel Tanks for Water Storage
API Standard 650	American Petroleum Institute – Welded Steel tanks for Oil Storage

C5.3 Acceptance of subcontractors

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

C5.4 Construction procedure

A construction procedure must 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 must 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 must be provided as necessary.

C5.5 Materials

C5.5.1 General

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

All supplied structural steel and aluminium must 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 must comply with the relevant Australian standards and specifications. A mill certificate with appropriate NATA registration from the material supplier must constitute documentary evidence of compliance.

C5.5.2 Steel

Structural steel must comply with AS/NZS 3678, AS/NZS 3679.1, AS/NZS 3679.2 or AS/NZS 1163.

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

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

C5.5.3 Aluminium

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

Unless specified otherwise, the minimum alloy for structural applications must be:

- 6061 or 6082 for extruded members
- 5251, 5454 or 6082 for sheets and plates
- 5251 for roof sheeting.

C5.5.4 Bolted connection

All metric bolts and nuts must comply with AS 1110.1, AS 1110.2, AS 1111.1, AS 1111.2, AS 1112.1, AS 1112.2, AS 1112.3 and AS/NZS 1252.1. The threads must comply with AS 1275 and AS 1721.

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

A flat metal washer must be fitted under each nut. Washers must comply with AS 1237.1 and AS 1237.2.

Bolt lengths must be such that after joints are made up, the bolts must 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 must be grade 8.8 to AS 1252.1 or grade 8 to AS/NZS 2465. Commercial bolts and nuts to AS 1111.1 and AS 1111.2 are not permitted in steelwork, except for connections of purlins and girts and in metalwork.

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

Grade 316 stainless steel bolts, nuts, screws and washers must 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 must be adopted to prevent galling of stainless steel fasteners:

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

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

Bolts for connections that are subject to vibration must 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 must not be used in members and components of thickness 3 mm or more. Screws must be of grade 316 to AS 1110.2 in stainless and aluminium work. Self-tapping and self-drilling screws and nails may be supplied in grade 316 stainless steel to AS 1110.2, subject to the acceptance by Sydney Water.

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

The use of proprietary anchors, bolts, clips and clamps must be accepted by Sydney Water.

C5.5.6 Selection of material

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

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

C5.6 Fabrication

C5.6.1 General

The construction category for fabrication of steelwork must be CC3 to AS/NZS 5131 unless agreed otherwise by Sydney Water.

Steelwork shall be fabricated by fabricators certified under National Structural Steelwork Compliance Scheme (NSSCS).

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

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

Before being marked off, straightening of any members must 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 must not exceed 600 °C and the temperature reached must be recorded.
- Steel must not be artificially cooled until the temperature of the steel has dropped below 300 °C.
- Steel must not be cooled with solid water jets.
- Aluminium must not be straightened by heating processes, unless carried out as detailed in clause 6.3 of AS/NZS 1664.2.
- All steelwork that will be exposed to view must have spatter, flux, dags and burrs removed and all weld profile ground smooth prior to surface preparation.

The completed work must be free from distortions and true to dimensions. Due allowance must be made for dimensional changes during welding.

Table 5-1 Selection of material

Location		Accepted materials Note 1							
		Framing members and plates				Roof and wall sheeting		Holding down bolts	
		Stainless steel grade 316	Hot rolled section Note 3	Cold formed section Note 3	Aluminium	Aluminium	Prefinished/pre-painted sheet metal	Stainless steelgrade 316L	Galvanised steel
Buildings and structures	More than 1 km from the coastline	✓	✓	✓	✓	✓	✓	✓	✓
	Within 1 km from the coastline but remain enclosed	✓	✓	✓	✓	✓	✓	✓	✓
	Within 1 km from coastline generally remain opened or not enclosed	✓	✓	×	✓	✓	×	✓	×
Tanks and process compartments	All members in clean water tanks	✓	✓	×	✓	✓	×	✓	×
	Members permanently and periodically submerged in liquid other than clean water	✓	✓	×	×	✓	×		×
	Members not submerged in liquid	✓	✓	×	✓	✓	×	✓	×
	Members in high corrosive environments Note 2	✓	×	×	×	×	×	✓	×

Notes:

1. Unless otherwise specified.

2. High corrosive environments include areas within sewage pumping station (SPS) wet wells and inlet structures of sewage treatment plants (STP) or similar where there is a concentration of gases from the sewage environment.

3. An appropriate protective coating must be applied in accordance with WSA 201.

C5.6.3 Shop drawings

Shop drawings must 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, must be submitted to Sydney Water at least 20 working days before fabrication commences.

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

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

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

The submission of shop drawings constitutes a hold point (SHP1, Table 5-2).

Two copies of the work as executed (WAE) shop drawings must be submitted to Sydney Water within 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 must be submitted to Sydney Water for acceptance at least 14 working days prior to commencing fabrication. These procedures must be comprehensive and must cover all aspects of the work. The procedures must 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 must be in accordance with section 14 of AS 4100 for steelwork and any other relevant standard for metalwork. Holes must 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, must be rectified to the satisfaction of Sydney Water. A structural member must not deviate from straightness or its intended length by more than that recommended in the relevant sections of AS 4100.

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

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

Member dimensions and camber must 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 must 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 must 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 16 mm thick must 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 must be removed.

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

Unless shown otherwise in the drawings, all corners on exposed edges must be rounded to a radius of approximately 1.5 mm, 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 must be suitable for the base product.

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

Flame cutting must be carried out wherever possible by machines which are mechanically guided and moved at uniform speed. Hand cutting must 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 must comply with AS/NZS 1554.1 and the depth of isolated gouges must not be greater than 2 mm.

Flame cutting of plates, sections and other components with surfaces which will be used in the "as-cut" condition, must be carried out with procedures giving minimum reduction in properties at the cut surface and must satisfy the requirements given below.

Any cut surfaces to be used in the "as cut" condition must 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 must not be used.

Surfaces produced by such cutting must 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 must not be used on surfaces prepared for welding.

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

Unless shown otherwise in the drawings, all corners on exposed edges must 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 must be carried out wherever possible by machines which are mechanically guided and moved at uniform speed. Hand cutting must 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 must comply with AS/NZS 1665.

Plasma-arc cutting of plates, sections and other components with surfaces which will be used in the "as-cut" condition, must 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 must 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 must be submitted to Sydney Water at least 14 working days for acceptance prior to fabrication.

The submission of proposed splice details constitutes a hold point (SHP2, Table 5-2).

C5.6.9 Holes for bolting

Unless otherwise specified, the diameter of boltholes must be in accordance with the requirements of AS 4100, AS 1664.1 or AS 1664.2 as appropriate.

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

Connecting parts must be assembled and held securely while being reamed or drilled and must be match-marked before separating the parts. All burrs must be removed. Assembled parts must 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 µm to AS/NZS 1214.

C5.6.10 Alignment of holes

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

All holes must 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 must be reamed or drilled with the members assembled in the shop in their correct relative positions.

All adjoining main members in an assembly must be assembled before reaming or drilling is commenced. All joints and associated splice plates must 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 must 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 must be carried out to the workmanship requirements of this specification.

C5.6.13 Bending

Bending and forming plates or sections during fabrication must conform to the manufacturer's recommendations and/or the relevant Australian standard.

C5.7 Welding

C5.7.1 General

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

Welding of aluminium must comply with the requirements of AS/NZS 1665.

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

The completed item must be free from distortions and true to dimensions. All connections must 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 must be submitted to Sydney Water at least 14 days prior to fabrication of members utilising the particular procedure.

C5.7.2 Welding personnel

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

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

Details of the qualifications of all welders, together with details of any qualification tests carried out by those welders must be supplied to Sydney Water at least 14 days prior to the commencement of welding.

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

C5.7.3 Welding inspectors

Welding must 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/NZS 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 NDT eg ultrasonic examination, radiography etc must 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 must be accredited by the AINDT.

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

All NDT reports must be prepared by qualified and accredited NDT technicians and must 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 must comply with AS 1674 and the safety requirements of the relevant statutory authorities. The machines and equipment must 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 must be supplied for each batch of consumables used.

C5.7.6.1 Steel

Electrodes used in all manual arc welding must 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 must confirm to and be selected in accordance with AS/NZS ISO 24598 and AS/NZS ISO 26304.

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

The minimum nominal tensile strength of weld metal used must be 480 MPa (eg 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 must conform to AS/NZS ISO 18273. Welding consumables must be selected in accordance with section 2 of AS/NZS 1665 and must only be used in accordance with the manufacture's recommendations and AS/NZS 1665.

Certification must be obtained, by a recognised authority satisfying the requirements of AS/NZS 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 must be brought into correct alignment and held in position in such a manner to maintain dimensional requirements and uniform gap. Suitable allowances must be made for warpage and shrinkage.

C5.7.8 Surfaces to be welded

Surfaces to be welded must 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 must be permitted, provided that the welding procedure is qualified using similarly primed plate. Surfaces to be welded must 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 must be the same size as the root run to be used in the joint and not less than four 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, must be subject to the same quality and workmanship requirements as the final welds.

C5.7.10 Weld quality

Welds must show a good even contour, a good penetration and fusion with the parent metal.

The surface of the weld along and across the joint must be reasonably smooth and free from sharp irregularities, grooves and depressions and must merge smoothly into the plate surface. Unacceptable welds must 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 must be ground to a smooth surface free from sharp crests, sharp troughs and pits. Care must 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, must be ground to a radius of curvature of not less than 2 mm. Weld spatter not capable of ready removal by subsequent cleaning or blasting must be removed by mechanical means.

C5.7.12 Weld procedure qualification

Weld procedures must be developed to meet the requirements of section 4 of AS 1554.1 for structural steel. Such procedures must be fully documented on an approved form as indicated in appendix C of AS/NZS 1554.1 and accompanied by NATA endorsed test certificates for any tests required.

Welding procedures of stainless steel structures must meet the requirements of section 4 of AS/NZS 1554.6. Such procedures must be fully documented on an approved form as indicated in appendix C of AS/NZS 1554.6.

Welding procedures of aluminium structures must meet the requirements of section 4 of AS/NZS 1665 and documented on an approved form as indicated in appendix D of AS/NZS 1665.

C5.7.13 Submission of qualifications for approval

Weld qualification test records, weld procedure specification and a weld map, indicating the procedures to be adopted on each welded joint must be submitted to Sydney Water for acceptance at least 14 working days prior to the commencement of welding.

C5.7.14 Weld inspections and testing

All welds must be inspected in accordance with AS/NZS 1554.1 for structural steel, AS/NZS 1554.6 for stainless steel and AS/NZS 1665 for aluminium. NDT of welds must be carried out by a NATA approved independent inspection authority.

Sydney Water must be provided access to the fabrication workshops to check records and work progress for the purpose of quality surveillance.

All welds must be 100% visually scanned. Structural steel welds must be 50% visually examined. Stainless steel welds must be 100% visually examined.

For structures other than liquid retaining tanks, a minimum of 10% of welds must be subject to radiographic examination.

For liquid retaining tanks, the extent weld testing must comply with D0001963.

C5.7.15 Weld acceptance requirements

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

At least 14 working days prior to the commencement of welding, a drawing (developed long section for reservoirs) detailing proposed non-destructive test locations must be submitted to Sydney Water for acceptance.

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

The submission of proposed weld testing constitutes a hold point (SHP3, Table 5-2).

C5.7.16 Defective welds

Defective welds must be repaired only with the prior acceptance of Sydney Water. Repairs must be made using qualified procedures and personnel.

All welds failing the testing must be rectified prior to hydrostatic test.

C5.7.17 Passivation of stainless steel after fabrication

All stainless steel fabrications must be passivated in accordance with ASTM A380/A380M after all welding has been completed to restore corrosion resistance. Passivating of the welded areas must be carried out in the fabricator's workshop unless accepted by Sydney Water.

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

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

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

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

C5.7.18 Handling and storing structural steel

Care must 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 must be protected from damage in transit in such a manner as to stiffen the member and prevent distortion.

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

Galvanised components must 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 must 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 must be removed without damaging the galvanised surfaces.

C5.7.19 Handling and storing stainless steel

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

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

Appropriate care must 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 must **not** be used:

- cleaning with steel wool, wire brushes, emery paper
- cleaning with abrasive compounds containing chlorides
- blast cleaning
- using muriatic (ie hydrochloric) acid in combination with solder fluxes as it contains iron.

C5.7.20 Handling and storing aluminium

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

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

Each load of aluminium components must be inspected for damage prior to stacking. All components must be stored at least 200 mm above the ground on platforms, slabs or other supports and in a manner to minimise the risk of contamination or corrosion. Each stack must 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, must be prevented by separating the adjacent surfaces with suitable packing.

C5.7.21 Report on completion of fabrication

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

- completed inspection and test report (ITR)
- 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
- ITR and inspection certificates for corrosion protection procedures employed.

The above documentation must be submitted not more than 14 working days after completion.

C5.8 Protective coating

C5.8.1 General

Protective coatings must generally be carried out in accordance with the requirements of WSA 201.

C5.8.2 Galvanising

Items to be galvanised must be pre-treated in accordance with AS/NZS 4680. Sydney Water must 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 must drill ventilation and drainage holes in all enclosed components of the structure prior to galvanising. These holes must be sealed with UV stable nylon or acetal plugs after galvanising.

Structural steelwork, which has been galvanised and coated must not be drilled. Where cables and pipes are to be fixed to structural steelwork, they must 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 must be submitted.

The details must 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 must 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.

Appropriate containment systems must be designed and erected to comply with the requirements of AS/NZS 4361.1 and AS/NZS 4361.2.

C5.8.5 General requirement for coating material

C5.8.5.1 Australian paint approval scheme (APAS)

All paints must be supplied by a single manufacturer and be approved under the relevant APAS specification. A certificate of supply or must 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 must 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 must be proportional to the required mix ratio, so that when complete containers are mixed the paint must contain the correct proportions of each component.

C5.8.5.4 Storage of paint

All paint containers must be stored under conditions that do not lead to deterioration of the paint. Stock rotation must 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 must be applied by Sydney Water pre-qualified painting contractors who hold a class 3 certificate issued by PCCP. Where the work involves the maintenance or removal of coatings that contain lead compounds or other toxic substances, such work must only be undertaken by pre-qualified contractors holding a PCCP class 5 certificate.

Painting contractor certificates must be submitted to Sydney Water for acceptance at least 14 working days prior to commencing any painting work.

The submission of proposed painting contractors constitutes a hold point (SHP4, Table 5-2).

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 must be applied to the blast cleaned surfaces before any surface discolouration has occurred. If discolouration has occurred, the surface must be lightly re-blasted.

Blast cleaned surfaces must 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 must be carried out under full containment conditions with air extraction as specified above. All surfaces to be primed must 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 must be submitted, setting out the climatic conditions and recoat intervals recommended by the manufacturer for the application of each paint.

The details must be submitted prior to the commencement of paint application and must 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 must be carried out according to the parameters contained in these recommendations.

Should the maximum re-coat interval specified or accepted be exceeded, the surface must 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 must 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 must 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 must be feathered by a method approved by the manufacturer.

C5.9 Erection

C5.9.1 Handling, delivery to site and storage

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

Members yet to be erected must be stored above ground to avoid contamination.

Members bent or buckled from handling or storing must be liable to rejection.

Bolts, nuts and washers must be supplied and stored in grit free watertight containers.

Burred, damaged or otherwise unserviceable bolts must not be used.

C5.9.2 General erection procedure

All members must 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 must be liable to rejection.

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

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

Permanent bolting or welding must 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 must be affixed in a manner which does not weaken or deface permanent steelwork.

Where steelwork is supported on concrete, masonry or similar material, it must 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, must be of either solid steel or grout of similar strength to the permanent grout. All other packers must be removed before completion of grouting. All grouts must be non-shrink high strength such as Epirez Supaflow HF grout or accepted equivalent.

At least 14 working days prior to commencing erection, the proposed method of erection must be submitted to Sydney Water for acceptance. This must 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 must 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 must not be used on galvanised items. Any component damaged, including damage to protective coating, must be repaired as per WSA 201.

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

Connections of new steelwork to existing galvanised steelwork, is only permitted under the following conditions:

- The proposed location of attachment to existing structure is not in a member that connects directly to any columns, or in a member which has less than 15% reserve capacity, inclusive of the additional load.
- The maximum affected area of each affected member must be less than 0.5% of overall member area or 250 cm^2 whichever is less.
- Any individual size of repair must not exceed 40 cm^2 per face.
- A minimum dimension for removal of existing coating and surface preparation around all welds must be within the range of 25 to 100 mm on weld faces and the far faces.
- A minimum dimension for removal of existing coating and surface preparation around all drilled holes and cut faces must be within the range of 15 to 25 mm.

- Prior to application of coating reinstatement to members deeper (or wider) than 200 mm, the surface preparation must be inspected and approved by Sydney Water nominated authorised personnel (eg coating inspector).
- The coating reinstatement around drilled holes, cut faces and welds must comply with WSA 201.
- The submission of design of new steelwork connecting to an existing galvanised steelwork constitutes a hold point (SHP5, Table 5-2).

C5.9.4 Purlins and girts

Purlins must be erected strictly in accordance with the purlin manufacturer's recommendations and instructions. Purlins must 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 must be held in position during welding by suitable temporary devices. On completion of the joints the devices must be carefully removed, and the steel surfaces restored by grinding smooth and flush.

No site welding of structures or any of their components must 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 Sydney Water's electrical, earthing and control system.

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

C5.9.6 Assembly of bolted connections

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

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

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

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

Where high strength friction grip-type bolts are nominated, the contact surfaces must be clean as "rolled surfaces or equivalent and in addition must 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 must 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 must be checked by a second run over the bolts.

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

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

The details of proposed tightening method for friction type bolts must be forwarded to Sydney Water for acceptance at least 14 working days before commencing work.

The submission detailing the method of installing high strength friction grip bolts constitutes a hold point (SHP6, Table 5-2).

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 must be submitted verifying that bolting of TB and TF has been carried out in accordance with this specification.

C5.10 Fabrication, erection and testing of circular liquid retaining steel tanks

C5.10.1 General

All steel plates must be cold rolled to suit the curvature of the tank and the erection procedure.

Any required straightening of material must be carried out by methods that will not injure the steel, such as by cold rolling or pressing. Straightening by hammering must not be permitted. Heating may be used only with the prior approval 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 must be devised to minimise deformation of the bottom plates of the floor.

The shell wall must 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 must not proceed.

All exposed sharp edges must be either rounded to a radius of not less than 5 mm or alternatively must be provided with a chamfer not less than 1 mm wide. Rounding off or bevelling of such edges must 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 must 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, must be protective coated as specified.

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

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

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

All overlapping galvanised surfaces must be isolated from each other by the application of an inhibitive jointing compound such as Dulux Foster C1 Mastic or accepted equivalent.

C5.10.3 Purlin system

Purlins must be aluminium. Cold-formed "Zincalume" purlins are not an equivalent substitute.

All angle or channel section trimmers or purlins must 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 must contain drain holes to facilitate the removal of collected moisture. The location and size of such drain holes must not compromise the structural integrity of the purlin. All potential contact points between steel and aluminium must be insulated in the same manner as described herein.

C5.10.4 Roof cladding - material

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

Roof flashing, ridge capping, gutter and moulded closure strips must be made from the sheeting manufacturer's standard form aluminium roof accessories.

Aluminium hatch frames must be fabricated from alloy 6061-T6 or 6082-T6. Flat sheets for hatch and ventilator frames and covers must be fabricated from alloy 5251-F or 6082-T6.

Floor plates around access and equipment hatches must 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 must be 3 mm thick grade 5251or 6061 with raised angular pattern on the top face. Each piece of tread plate must be 600 mm wide and nominally 1200 mm long maximum.

The roof supporting members must be fabricated from structural steel, grade 300, to AS 3679.1 and AS 3679.2, galvanised; or aluminium plates and extruded sections to AS/NZS 1734 and AS/NZS 1866.

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

C5.10.5 Roof cladding - installation

Fixing details must be submitted at least 20 working days prior to installation of the roof cladding. The laying of the sheeting must comply with AS 1562.1 and the following minimum requirements:

- The corrugated roof sheets must 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 must span across the purlins and must 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 must be made for accommodating expansion / contraction movement where appropriate.
- Side laps must not be less than one full corrugation and must be stitched with aluminium M6 "Bulb-Tite" pop rivets at 450 mm centres through the crest of each rib.

- End laps must be kept to a minimum, but where necessary, must not be less than 225 mm. The centre line of end laps must coincide as nearly as possible with the centre line of the supports and the sheets must be arranged such that all holes for the main fixing are more than 40 mm from the end of the sheet.
- All sheet laps must be given two coats of aluminium pigmented bituminous paint or accepted equivalent.
- As a minimum, the sheets must be fixed to the roof purlins using the 'Capral Positive Fix System' or accepted equivalent. Each fixing must 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 must 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 must be slotted after drilling the tapping hole. For these expansion fixings, an EPDM rubber washer with an elongated hole and a polytetrafluoroethylene (PTFE) (or Teflon) facing on one side must be used. The washer must be installed with the PTFE side facing up towards the head of the screw. For these fixings, elongated holes for the main fastenings must be made in the sheeting in accordance with the 'Capral Positive Fix System'. The elongation of the holes must be in the radial direction. The washer plate must protect the PTFE from UV light attack.
- It is important that the roof be completely bird-proof, corrugations must be completely sealed at all sheet ends with formed aluminium closure strips.
- Any cutting of sheets must be done in such a manner as to avoid distortion of the profile.
- The termination of the roofing sheet at hips and apex must 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 must 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, must 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 must be secured in each wing at centres corresponding to roof fixings. The trough of the sheet ends beneath the ridge and hip capping must 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 must be aluminium, 6 mm 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 must also be used to isolate the dissimilar metals.
- Tread plates must be stitched to the top of the aluminium roof sheeting ribs with M6 tri-fold, positive mandrel retention, "Bulb-Tite" aluminium rivets or equivalent must be used. Each rivet must have a neoprene seal.
- All drilling swarf must 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 must be insulated with the following:

- For the connection of roof sheets to rafters or purlins, use 0.25 mm thick "TESA -51482" PVC tapes or PTFE equivalent.
- For the connection of galvanised tread plates to roof sheets, use 0.8 mm thick neoprene strips.
- For connections of all structural members, use a minimum 1.5 mm thick neoprene sheet.
- The separation tapes or sheets must 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 must be of stainless steel. Nylon bushes and/or nylon washers must be provided to prevent contact of with steel or aluminium parts.

C5.10.7 Hydrostatic testing of steel tanks

The tanks must be hydrostatically tested, at a time that is accepted by Sydney Water.

Determination and application of suitable and appropriate rates for filling and emptying of tanks must be undertaken.

For the purpose of such testing the tank must be filled with water to the top water level and must be kept full for a period of not less than 48 hours. Any leaks including visible wet patches, or defects which may cause leakage, must 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 must 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 policy D0001667 must 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 must be conducted. Vacuum testing must 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 must be witnessed by Sydney Water, and the costs of these tests, including the cost of providing the necessary equipment must form part of the contract.

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

The submission of the hydrostatic test results constitutes a hold point (SHP7, Table 5-2) for commissioning the tank. The procedures and acceptance criteria detailed in Sydney Water procedure D0001909 must be followed.

C5.11 Hold points

C5.11.1 Hold points identified in structural steel and aluminium works

A summary of hold points identified are listed in Table 5-2.

Table 5-2 Summary of hold points for structural steel and aluminium works

Hold point no.	Process held	Required documentation	Relevant clause
SHP1	Fabrication	Shop drawings	C5.6.3
SHP2	Fabrication	Splices not identified in design drawings	C5.6.8
SHP3	Weld testing	Location and type of testing	C5.7.15
SHP4	Painting	PCCP certificates of painting contractors	C5.8.6.1
SHP5	Connection of new steelwork to an existing galvanised steelwork	Evidence of compliance with requirements of Clause 5.9.3.	C5.9.3
SHP6	Installation of high strength friction bolts	Tensioning of bolts	C5.9.6
SHP7	Acceptance of liquid retaining tanks	Hydrostatic test results	C5.10.7

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 must comply with the drawings, the requirements of the Building Code of Australia (BCA) and the relevant Australian standards.

C6.2 Referenced documents

Australian standards

AS 1316	Masonry cement
AS 1672.1	Limes and limestones Part 1: Limes for building
AS/NZS 2699.1	Built-in components for masonry construction Part 1: Wall ties
AS/NZS 2699.2	Built-in components for masonry construction Part 2: Connectors and accessories
AS/NZS 2699.3	Built-in components for masonry construction Part 3: Lintels and shelf angles (durability requirements)
AS 2758.1	Aggregates and rock for engineering purposes Part 1: 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 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles

Other documents

BCA	Building Code of Australia

Cleaning of Masonry Code of Practice - NSW Building & Construction Authority Training Committee Ltd.

C6.3 Masonry

All masonry units must be fired clay, concrete or calcium silicate to AS/NZS 4455. Unless specified otherwise, properties must be not less than:

- Masonry units must comply with dimensional category DW1, except that split or irregular faces may be DW0.
- Concrete units must comply with dimensional category of DW4.
- Masonry units must 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 coastline)
  - 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 must have:
  - permeability not more than 2 mm/minute
  - efflorescence potential of nil or slight
  - colour and texture within the agreed range.
- Concrete masonry units must have a mean coefficient of residual drying contraction not more than 0.6 mm/m.
- Clay masonry units must have a mean coefficient of expansion not more than 1.0 mm/m.
- Masonry units for reinforced masonry applications must 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 must be "H" or "Double U" configuration.
  - Grout must 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 must be submitted to Sydney Water.

Samples of facework must match the texture and colour of the facework of the existing buildings.

C6.5 Cement

Cement must be Type GP or GB to AS 3972.

C6.6 Masonry cement

Masonry cement must comply with AS 1316.

C6.7 Lime

Lime must be hydrated building lime complying with AS 1672.1.

C6.8 Sand

Sand must be well graded and free from salts, vegetable matter and impurities. Sand must not contain more than 10% of the material passing through the 75 µm sieve. Sand within the limits shown in Table 6-1 is deemed to be suitable.

Table 6-1 Sand grading requirements

Sieve size	% Passing by mass
4.76 mm	100
2.36 mm	95–100
1.18 mm	60–100
600 µm	30–100
300 µm	10–50
150 µm	0–10
75 µm	0–4

C6.9 Water thickener

Water thickener must be methyl-cellulose based.

C6.10 Mortar

Unless specified otherwise, the durability requirements of mortar must comply with table 12.2 of AS 3700.

C6.11 Coloured mortar

Mortar for facework must be coloured to match existing buildings. Colouring pigments must be metallic oxides insoluble in water, mixed with cement and sand compatible with the required colour.

C6.12 Mixing mortar

Mortar ingredients must be accurately measured. Shovel measurements must not be permitted. Mortar must 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 must be added to provide reasonable trowelling consistency. All mortar must be used within 30 minutes of mixing and, if not so used, must be discarded. Excess water must not be added to improve workability. On no account must mortar, which has partially set, be revived or reused.

C6.13 Concrete grout

Unless specified otherwise, the properties of the concrete grout must be:

- a minimum cementitious content of 300 kg/ m^3
- 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 14 working days prior to commencement of grouting work, details of the grout mix, test results and test certificates must be submitted to Sydney Water for acceptance.

The certificates must be from an independent laboratory with an appropriate NATA. Each grout mix submission must start with a summary showing that the nominated mix and its mix constituents meet the requirements of this specification. Submission of the mix details and certificates constitutes a hold point (MHP1, Table 6-3).

C6.14 Joint material

Unless specified otherwise, joint material must:

- Backing rods for control joints, expansion joints and articulation joints must be expanded polystyrene tube or bead or rigid steel backing profile with closed cell foam adhered to the metal profile face.
- Joint sealant must be gun grade multi-purpose polyurethane sealant. The colour of the joint sealant must match the colour of the masonry.
- Control joints and articulation joints must 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 must 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 must 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 must be lapped or sealed against moisture penetration. The length of lapping must be not less than the thickness of the leaf upon which the sheet is laid. Joints must not be located at weepholes.

Damp-proofing and flashing materials must 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 must be built into project from the face of wall. On completion of construction, the projection must be either cut 25 mm past the face of wall or turned down.

Flashings, including over-flashings, must 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, must be manufactured from rigid material (eg metal cored material).

Damp proof courses must 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 must 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 must be resistant to corrosion and weathering.

Any render finish subsequently applied to the surface must not be allowed to bridge a damp-proof course or make ineffective any other moisture protection measures.

At least three working days prior to the proposed erection of masonry, Sydney Water must be notified the completed installation of the damp-proof membrane.

C6.16 Slip joint material

Slip joint material must be placed between un-reinforced masonry walls and any supported concrete slab.

Unless specified otherwise, slip joint material must comply with the following requirements:

- bitumen-coated aluminium
- embossed polyethylene
- polyethylene-and-bitumen coated aluminium.

Metal slip joint materials must 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 must comply with table 12.2 of AS 3700 and must be selected and spaced in accordance with table 12.5 of AS 3700.

C6.18 Mortar joints

Mortar joints must comply with the drawings, building regulations and AS 3700. Unless stated otherwise, mortar joints must comply with the following:

- Mortar joint must be 10 mm thick.
- Mortar joints in solid or cored face masonry must be fully bedded. Joints must be as specified in the drawings.
- Mortar joints in solid or cored backup or non-face masonry must be fully bedded and flush jointed.
- Mortar joints in hollow blockwork, must be face shell bedded and must be ironed, unless a flush joint is specified for aesthetic reasons.

C6.19 Weepholes in buildings

Unless stated otherwise, weep holes must 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 damp proof course (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 must be left between the timber frame and the top of the masonry and at windowsills, to accommodate timber shrinkage.

Table 6-2 Minimum clearance required for timer shrinkage

Location in timber framed buildings	Minimum clearances (mm)	
	Unseasoned hardwood frame	Other timber frame
Sills of lower or single storey windows	10	5
Roof overhangs of single storey buildings	16	8
Sills of second storey windows	20	10
Roof overhangs of two storey buildings	24	12

C6.21 Control joints

Vertical control joints including articulation joints, contraction joints and expansion joints must comply with AS 2870 and AS 3700.

Control joints must not be placed adjacent to arches. Control joints in concrete masonry arches must be saw-cut to half the depth of the masonry unit and positioned at the centre of the arch.

Control joints must be a minimum 10 mm wide and must consist of polystyrene backing rod and a polyurethane material gunned into the joint to form a minimum of 10 mm × 10 mm flexible seal. The backing rod must 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 (ie not in veneer walls), extendible masonry ties must be built into every fourth course.

Where a control joint is located adjacent to a door or window frame, a 10 mm gap must 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 must 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 must 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 must be in accordance with table 12.2 of AS 3700.

At least 3 working days prior to the proposed erection of masonry, Sydney Water must be notified of the completed installation of lintels.

C6.23 Cavity wall construction

Cavity walls must be constructed with a minimum 50 mm wide cavity, unless specifically detailed otherwise. The wall skins must be tied together with wall ties in accordance with this specification. All ties must have a drip crimp and must be laid with a fall to the outside face and built into each skin not less than 50 mm.

Weepholes must be provided as detailed in this specification.

Cavities must 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 must 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 must be filled with cement/sand mortar (1:3), splayed to fall to the base of the weepholes and must be trowel finish on the top.

C6.24 Reinforced masonry

All construction of reinforced concrete masonry must comply with AS 3700. Unless stated otherwise, the following must apply:

- Vertical steel reinforcement must 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 must be tied into position to provide the specified lap above the top surface of the footing. The starter bars must 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 must be held in position by steel ties or plastic clips. Cover to horizontal steel in lintel blocks must 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) must be 20 mm, except where specified otherwise.
- Where galvanised reinforcement is specified, the galvanising must be a minimum coating thickness of 85 µm in accordance with AS/NZS 4680.
- Control joints must 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 must be kept clear of mortar droppings and adequate temporary openings must be provided along the bottom to clean out loose material from the bottoms of hollows before being filled with grout.

C6.25 Grouting

Grouting must 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 must be limited in accordance with the fluidity of grout and must be certified by a civil/structural engineer who is a member of the Institution of Engineers Australia.

Compaction of the grout must be by vibration or rodding.

On completion of the last lift, the grout must 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 must be given at least seven working days' notice after cleaning out the bottoms of hollows and ready for grouting.

The submission of proposed grouting constitutes a hold point (MHP2, Table 6-3).

C6.26 Temporary bracing under construction

Structures under construction must 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 must 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, must be certified by a civil/structural engineer who is a member of the Institution of Engineers Australia.

Details of the certification must be forwarded to Sydney Water at least 20 working days prior to loading.

C6.29 Rate of construction

The rate of construction must 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 must be built to the specified dimensions within the tolerances given in clause 11.5 of AS 3700.

C6.31 Cleaning masonry

Cleaning of masonry must 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 must be cleaned of all mortar splashes and stains.

Where acid cleaning is required, the following must apply:

- The acid mixture must be 1 part of hydrochloric acid to 15 parts of water.
- Mortar joints must be a minimum 14 days old before cleaning commences.
- All masonry being cleaned must be thoroughly wetted by hosing before any acid solution is applied and kept wet ahead of the acid application.
- The acid mixture must be thoroughly hosed off as the cleaning proceeds.

If high pressure water jet method is used for cleaning, extreme care must be taken to avoid "blowing out" the joints.

C6.32 Cement render

Unless specified otherwise, cement render must comprise a mixture of 2 parts cement, 1 part lime and 4 parts sand. Metal lath must be galvanised expanded steel mesh.

Each exposed surface indicated in the drawings must be cement rendered minimum 15 mm thick finished off with steel trowel.

Conduits, boxes, services etc. must be fixed and properly chased before rendering. Any wall chase exceeding 50 mm wide must 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 must 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 must be 230 mm long and embedded 70 mm.

- A pilot hole (depending on brick hardness) must be drilled to the required depth (tie length + 10 mm) 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 must be driven into the pilot hole approximately 10 mm beyond the surface of the near skin.
- After installation of the tie is complete the hole must 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 must 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.
- Inject a bead of grout to the back of the slot using a pointing gun.
- Push the stainless steel bars into the grout to obtain good coverage using a finger trowel, or similar.
- 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 14 working days prior to commencing repair works, full details of proposed repair methodology and product details must be submitted to Sydney Water for acceptance.

The submission detailing the method of crack stitching constitutes a hold point (MHP3, Table 6-3).

C6.34 Hold points

C6.34.1 Hold points identified in masonry works

A summary of hold points identified are listed in Table 6-3.

Table 6-3 Summary of hold points for concrete works

Hold point no.	Process held	Required documentation	Relevant clause
MHP1	Approval of concrete grouting mix design	Concrete grout mix design & test certificates	C6.13
MHP2	Grouting	Notification for grouting	C6.25
MHP3	Crack Stitching	Materials and methodology	C6.33.2

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

Sydney Water documents

746607	Procedure – Asbestos Management – Minor works

Australian standards

AS 2187.0	Explosives – Storage, transport and use Part 0: Terminology
AS 2187.1	Explosives – Storage, transport and use Part 1: Storage
AS 2187.2	Explosives – Storage and use Part 3: Use of explosives
AS 2601	The demolition of structures

Other documents

Occupational Health and Safety Act 2000

Occupational Health and Safety Regulations 2001

Protection of the Environment Operations 1997

Protection of the Environment Operations (Waste) Regulations 1996

Protection of the Environment Operations (Control of Burnings) Regulations 2000

NOHSC:1008	Approved Criteria for Classifying Hazardous Substances- National Occupational Health & Safety Commission
NOHSC:10005	List of Designated Hazardous Substances- National Occupational Health & Safety Commission.

C7.3 Definitions

The following definitions must 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 must 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 must be exercised so as not to damage the items more than necessary for the purpose of the work.

All demolition work must 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 must be obtained from WorkCover.

Notification to commence the demolition work must be submitted to WorkCover and obtain written approval before commencement of demolition work.

Where asbestos materials are present, only licensed asbestos removalists must handle these materials in accordance with the Occupational Health and Safety Regulations. The absence of asbestos or other Hazardous Building Materials (HBMs) should be assessed by consulting the HBM Register available from Sydney Water's HazCentral application. Where a building or area to be disturbed has not been assessed, contact Property Environmental Services for advice (refer to Asbestos Management - Minor Works procedure for further information). Any permits and notifications as required by the relevant parts of the regulation must be obtained.

Sydney Water must 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 must be maintained. Details of asbestos or other Hazardous Building Materials and associated Clearance Certificates must be provided to PropertyEnvironmental@sydneywater.com.au so that HBM Registers can be updated.

C7.4.3 Noise levels

The noise generated by the demolition activities must comply with the Noise Abatement Act, the requirements of the Environment Protection Authority (EPA), local council and any other conditions prescribed by Sydney Water.

C7.4.4 Supports and shielding of adjoining structures

Supports and shielding must be provided to adjoining structures where necessary to prevent damage resulting from the demolition activity. These must be deemed to be temporary works unless the specified otherwise.

C7.4.5 Use of explosives

No explosives must be permitted for demolition work unless demonstrated that there are no other practical alternatives.

Where explosives are proposed, at least 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 must be submitted to Sydney Water. These details must be verified by a competent person prior to being submitted. For demolition work involving the use of explosives or induced collapsed methods, approval must be applied for and given by WorkCover.

Where accepted, the transport, storage and use of explosives must comply with AS 2187.0, AS 2187.1 and AS 2187.2.

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 must be transported and stored in a location nominated in the drawings/specifications. The materials must 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 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 must be reinstated to the levels and profiles existing prior to the demolition works.

C7.7 Submission on methodology

At least 14 working days prior to commencing any demolishing work, all aspects of the demolition and disposal activity must be submitted to Sydney Water for acceptance. This must 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 constitutes a hold point (DHP1, Table 7-1).

C7.8 Hold points

C7.8.1 Hold points identified in demolition works

A summary of hold points identified are listed in Table 7-1.

Table 7-1 Summary of hold points for demolition works

Hold point No.	Process held	Required documentation	Relevant clause
DHP1	Demolition	Method of demolition and safe disposal	C7.7

C8. Roadwork

C8.1 General

Roadwork must generally be carried out as shown in the drawings. The position and extent of all cuttings and filled areas must be marked and pegged out on site prior to the commencement of construction.

C8.2 Referenced documents

Australian standards

AS 1012.3.1	Methods of testing concrete Method 3.1: Determination of properties related to the consistency of concrete – Slump test
AS 1012.9	Methods of testing concrete Method 9: Compressive strength tests – Concrete, mortar and grout specimens
AS 1141.11.1	Methods for sampling and testing aggregates Method 11.1: article size distribution – Sieving method
AS 1160	Bituminous emulsions for the construction and maintenance of pavements
AS/NZS 1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series) (ISO 10684:2004, MOD)
AS 1289.5.4.1	Methods of testing soils for engineering purposes Method 5.4.1: Soil compaction and density tests – Compaction control test – Dry density ratio, moisture variation and moisture ratio
AS 1289.5.5.1	Methods of testing soils for engineering purposes Method 5.5.1: Soil compaction and density tests – Determination of the minimum and maximum dry density of a cohesionless material – Standard method
AS 1478.1	Chemical admixtures for concrete, mortar and grout Part 1: Admixtures for concrete
AS/NZS 1604.1	Preservative-treated wood-based products Part 1: Products and treatment
AS 2150	Asphalt – A guide to good practice
AS 2876	Concrete kerbs and channels (gutters) – Manually or machine placed
AS/NZS 2891.3.1	Methods of sampling and testing asphalt Method 3.1: Binder content and aggregate grading – Reflux method
AS/NZS 2891.3.2	Methods of sampling and testing asphalt Method 3.2: Binder content and aggregate grading – Centrifugal extraction method
AS/NZS 2891.3.3	Methods of sampling and testing asphalt Method 3.3: Binder content and aggregate grading – Pressure filter method
AS/NZS 2891.8	Methods of sampling and testing asphalt Method 8: Voids and volumetric properties of compacted asphalt mixes
AS/NZS 4671	Steel for the reinforcement of concrete
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

TfNSW QA specifications

3051 Granular pavement base and subbase materials

C8.3 Removal of topsoil

The removal of topsoil must 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 must be excavated to the extent directed by Sydney Water. Unsuitable materials must be removed off site as spoil as specified in Section C2.

The material at the subgrade level, for a thickness of 300 mm, must have a CBR value not less than 8, and a plasticity index not exceeding 25.

The subgrade surface must 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 must consist of granular material. The fill must 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 must be finished to the design levels within a tolerance of +0 mm / -20 mm.

C8.5 Road base and sub-base materials

The base and sub-base materials must 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 must 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 must comply TfNSW 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, must 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 must 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 must be supplied to Sydney Water. Testing must be carried out by a NATA accredited laboratory.

Materials must be transported to the site in vehicles that are so constructed that loss of material does not occur. Stockpiles, if necessary, must be formed on clear, even, well-drained, firm ground or constructed floor, and must be constructed to prevent cross-mixing and segregation.

Non-conforming materials must 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 must be spread and compacted in uniform thickness which, after trimming, must provide the layer thickness and lines as shown in the drawings. Each course must achieve a compacted thickness of not more than 150 mm nor less than 100 mm unless otherwise agreed by Sydney Water.

The moisture content of the material must, 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 must continue until a field dry density of at least 98% of the maximum dry density determined in accordance with AS 1289.5.4.1 is achieved. Testing must be carried out at the rate of 2 tests per 500 m^2 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 must 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 must 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.

Table 8-1 Asphaltic concrete surface

(A) Aggregate grading	**AC10**	**AC20**	**AC40**
	Mass percentage passing		
53.0 mm AS Sieve	-	-	100
37.5 mm AS Sieve	-	-	90–100
26.5 mm AS Sieve	-	100	72–87
19.0 mm AS Sieve	-	90–100	59–76
13.2 mm AS Sieve	100	71–86	-
9.50 mm AS Sieve	90–100	58–83	38–58
6.70 mm AS Sieve	68–82	46–64	-
4.75 mm AS Sieve	50–70	37–55	27–43
2.36 mm AS Sieve	32–51	24–42	16–33
1.18 mm AS Sieve	22–40	15–32	11–26
0.600 mm AS Sieve	15–30	10–24	7–20
0.300 mm AS Sieve	10–22	7–17	5–14
0.150 mm AS Sieve	6–14	4–12	4–10
0.075 mm AS Sieve	4–7	3–6	3–6
(B) Binder content	Percentage by mass of total mix		
	4.5–6.5	3.8–5.8	3.0–5.0
(C) Air void	Percentage		
	3–7	3–7	3–7

(D) Minimum voids in mineral aggregate	Percentage		
	16	14	12

The grading of the combined aggregate must be determined in accordance with AS 1141.11.1. The grading of aggregate and the binder content in an asphalt mix must be determined in accordance with AS/NZS 2891.3.1, AS/NZS 2891.3.2 or AS/NZS 2891.3.3.

The air void content and the voids in mineral aggregate must be determined in accordance with AS/NZS 2891.8.

C8.9 Manufacturing and transport of asphaltic concrete

The manufacturing plant must 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 must be submitted to Sydney Water. Testing must be carried out by a NATA accredited laboratory.

Asphaltic concrete must 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 must be provided to achieve a bond between the granular surface of the base course and the asphalt.

The prime coat must be sprayed at a nominal rate between 0.2 and 0.4 L/m^2. The application rate must be doubled for joints and chases.

All contact surfaces of kerbs and other structures and all joints must have a uniform application of prime coat.

The surface to which the prime coat is applied must be clean and free from loose stones, dirt, oil or foreign materials.

C8.11 Spreading and compaction of asphaltic concrete

Asphalt concrete must 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 must not be less than 145 °C and compaction must be complete before the mix temperature falls below 90 °C.

Asphalt paving must not proceed if the surface temperature of the base material is below 10 °C such that spreading and compaction are adversely affected. Asphalt must not be placed when the surface is wet or while rain is imminent.

The work must be protected from damage until the required thickness of asphalt has been placed and compacted sufficiently to carry traffic.

Asphalt must preferably be spread by self-propelled paving machine. The spread material must be examined constantly for faults in texture and surface shape. Any segregated, torn or deficient areas must be corrected while the asphalt is hot.

If hand placing is used, the asphalt must be deposited in position and spread using rakes. To avoid segregation of particles, the asphalt must not be thrown or scattered.

The thickness of any compacted layer must generally be within the limits of 2.5 to 4.0 times the nominal mix size.

The number and extent of joints in layers must be kept to a minimum. The density and surface finish at joints must be the same as in other areas of the layer.

Compaction must 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 must be within the range of percentage values nominated in this specification. Tests must be carried out at a rate of 2 tests per 500 m² or part thereof laid and compacted each day.

Each layer of asphalt must be finished to a plane surface, parallel to the plane of the finished surface of the wearing course. The finished asphalt pavement must 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 must 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 must 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 must 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 must comply with AS 1478.1. Steel reinforcement must comply with AS/NZS 4671 and must be supplied together with a NATA endorsed test certificate.

Consistence of the concrete determined by measuring the slump in accordance with AS 1012.3.1 must be 55 to 65 mm.

Forms must be designed and constructed so that they can be removed without damaging the concrete and must be braced in a substantial and unyielding manner. Forms must be mortar tight and de-bonded to ensure non-adhesion of concrete to the surface of the forms.

Concrete must be deposited continuously between the specified joints and spread uniformly in the forms without segregation. The concrete must then be compacted to the full thickness of the slab in one operation.

The surface texture of the finished concrete surface must be uniform and must be affected by brushing evenly across the slab in one direction at right angles to the longitudinal axis of the carriageway. Brushing must 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 must be 0.5 mm nominally.

Curing compound must be applied to the concrete surface immediately after the surface has been textured.

Traffic must not be allowed on the concrete surface until an in-situ compressive strength of 30 MPa is reached.

Materials for joints must be used in accordance with manufacturers' recommendations or as otherwise shown in the drawings. Dowel bars, tie bars and sleeves must be securely fixed in position through holes in the formwork. Joints must be formed perpendicular to the top surface of the slab.

Transverse joints must be straight and perpendicular to the longitudinal axis of the carriageway and must be formed only at the specified positions. The joints must be continued through kerbs, edges and gutters and their foundation and backing.

Longitudinal joints must be formed only at the specified positions.

Grooves in concrete carriageway slabs must 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 must be removed from the groove. Caulking material if required must be firmly packed in the bottom of the groove. Bond breaker tape must 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 must be applied to the sides of the groove. The joint sealant must 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 must 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 must not exceed 3 mm.

Two pairs of 100 mm diameter cylindrical test specimens must be moulded for compressive strength testing in accordance with AS 1012.9, one at 7 days and the other at 28 days. The frequency of sampling must be one sample per 25 m^3 or part thereof the concrete delivered to site on the day of concreting.

The compressive strength must not be less than 32 MPa at 28 days.

C8.13 Kerb and gutter

Kerb and gutter must be constructed in fixed forms, extrusion or slip forming in conformity with the lines and grades shown in the drawings and must generally be in accordance with AS 2876.

Concrete edge strips must 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 must not deviate from the bottom of a 3 m log straight edge by more than 10 mm.

C8.14 Proprietary safety barrier systems

Safety barrier systems must be supplied and constructed as shown in the drawings. Proprietary safety barrier systems and devices must 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 must be submitted to Sydney Water.

All steel or ferrous metal components must generally be hot dip galvanized in accordance with AS/NZS 4680. All ferrous bolts, nuts and washers must be galvanised in accordance with AS/NZS 1214.

Timber posts and block out pieces must be strength grade F8 Australian slash pine preservative treated to hazard level 4 in accordance with AS/NZS 1604.1.

On completion of construction, the tolerance on the height of the barrier must be ±20 mm. The tolerance for the line of the safety barrier must 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

Sydney Water documents

D0000833	Engineering Competency Standard

Australian standards

AS/NZS 1163	Cold-formed structural steel hollow sections
AS 1379	Specification and supply of concrete
AS 1450	Steel tubes for mechanical purposes
AS/NZS 1604.1	Preservative-treated wood-based products Part 1: Products and treatment
AS 2159	Piling – Design and installation
AS 2832.1	Cathodic protection of metals Part 1: Pipes and cables
AS 3600	Concrete Structures
AS/NZS 3678	Structural steel – Hot-rolled plates, floorplates and slabs
AS/NZS 3679.1	Structural Steel Part 1: Hot rolled bars and sections
AS/NZS 3679.2	Structural steel Part 2: Welded I sections
AS 3818.3	Timber – Heavy Structural Products – Visually Graded Part 3: Piles

TfNSW documents

BTD 2007/13	Durability of Steel Piles in Contact with Acid Sulfate Soils
BTD 2011/08	Testing of Cast-In-Place Concrete Piles
BTD 2011/02	Use of CFA Piles on Bridges
B50	QA Specification Driven Reinforced Concrete Piles
B51	QA Specification Driven Prestressed Concrete Piles
B53	QA Specification Driven H-Section Steel Piles
B54	QA Specification Driven Tubular Steel Piles
B58	QA Specification Bored Cast-In-Place Reinforced Concrete Piles (with permanent casing)
B59	QA Specification Bored Cast-In-Place Reinforced Concrete Piles (without permanent casing)
B61	QA Specification Driven Composite Piles
B63	QA Specification Continuous Flight Auger (CFA) Piles

C9.3 Geotechnical verification during construction

For any piling system, all necessary geotechnical investigations must be carried out to inform design, in accordance with requirements specified in Section C10.

C9.4 Durability of pile foundations

The design life of piling systems must be minimum 100 years, unless specified otherwise.

Unless otherwise specified, exposure classification for all piles as per AS 2159 must apply for the range of conditions in the soil and groundwater surrounding the piles. Minimum cover for concrete piles must be in accordance with AS 2159.

Minimum corrosion allowance of 2 mm per face must be allowed for all steel piles. Where acid sulphate soils are present, durability of steel piles must comply with TfNSW BTD 2007/13.

Where cathodic protection is applied to steel piles, it must conform to AS 2832.1.

C9.5 Materials

Unless otherwise specified, all materials used in pile construction must comply with the appropriate Australian standard. Concrete for plain, reinforced and prestressed concrete piles must comply with the requirement of AS 3600, AS 2159 and AS 1379.

Steel for piles and pile fitments must comply with the requirements of AS/NZS 1163, AS 1450, AS/NZS 3678, AS/NZS 3679.1 and AS/NZS 3679.2.

Timber pile material, where permitted must be hardwood in accordance with AS 3818.3 and treated for H6 as per AS/NZS 1604.1.

C9.6 Driven piles

C9.6.1 Construction

All driven piles listed below must be installed and tested in accordance with the TfNSW specifications listed below, unless specifically specified otherwise within this specification:

- driven reinforced concrete piles: TfNSW QA Specification B50
- driven prestressed concrete piles: TfNSW QA Specification B51
- driven H-section steel piles: TfNSW QA Specification B53
- driven steel tube piles: TfNSW QA Specification B54
- driven composite piles: TfNSW QA Specification B61.

All hold points and witness points listed in the TfNSW QA specifications must also apply and must be released by Sydney Water.

C9.6.2 Pile driving, testing and monitoring

All piles must be driven to resistance and achieve the pile minimum penetration length (the length of the pile below ground level) indicated in design drawings.

Piles must 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 must 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) must be conducted concurrently to establish correlation for driving impact energy and pile capacity for all representative piles.

PDM must 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 must not exceed 0.9 × f_{sy} (or 0.8 × f_{sy} during sustained hard driving). For concrete driven piles, driving stresses must be checked in accordance with AS 2159. Maximum driving energy to limit driving stresses must be adjusted as required based on monitoring and testing of representative piles.

The specialist pile driving contractor must 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 must 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 1.0 m higher than the contract level, the piling contractor must conduct PDA load testing of the pile to prove sufficient capacity has been achieved.

Piles must be constructed within ±60mm in plan from the design position. Pilot holes must only be drilled (to facilitate driveability) with the acceptance of Sydney Water.

Minimum 1 PDA test must 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 must be constructed in accordance with TfNSW QA Specification B58 or B59 when installed with or without a permanent casing respectively.

C9.7.2 Pile embedment material

Pile embedment and socket material for each pile must be verified at each bored pile, by a suitably experienced and competent geotechnical engineer/engineering geologist, in accordance with D0000833.

C9.7.3 Testing

Pile integrity testing and load testing must be carried out as required by TfNSW BTD 2011/08.

C9.8 CFA piles

C9.8.1 Selection and suitability of CFA piles

CFA pile must be checked for suitability and designed as outlined in TfNSW BTD 2011/02.

C9.8.2 Construction

All CFA piles must be constructed in accordance with TfNSW QA Specification B63.

C9.9 Screw piles

C9.9.1 Installation

All screw piles must be designed and installed in accordance with AS 2159. Detailed design of the pile must be submitted to Sydney Water, minimum 10 working days prior to importing screw piles to site.

C9.9.2 Testing

Each screw pile type must have minimum one ultimate load test carried in similar ground condition, in accordance with AS 2159. Test results from other sites, with similar ground and loading conditions may be used.

The load test must be verified and certified for site specific ground condition by a suitably qualified competent geotechnical engineer/engineering geologist.

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 must be carried out.

Unless accepted prior by Sydney Water, each pile tested must represent each type of pile used in construction and ground conditions encountered on site. Each test must represent and verify the geotechnical capacities adopted for the permanent pile.

Number of test piles and location must 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 must be labelled in accordance with AS/NZS 1604.1 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 must only be used with prior acceptance from Sydney Water. All required specifications and design details must 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 must be carried out with the highest standard of care and due diligence. All design work must be fit for the purpose with due consideration of technical, economic and safety risks.

C10.1.2 Standards and codes

All design work must comply with Australian standards and codes as stated in this specification and any other codes as specified by Sydney Water.

Where appropriate, the design must 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

Sydney Water Hydraulic System Services IICATS Standards

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 (with integral Sydney Water Supplement).

C10.1.3 Design personnel

The design must be prepared by personnel who meet the qualification and experience requirements detailed in Sydney Water Engineering Competency Standard.

C10.1.4 Extent of design documentation

C10.1.4.1 Design calculations

Design calculations must be documented, checked and verified by competent design personnel in accordance with Sydney Water Engineering Competency Standard.

Design calculations must 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 (including durability design)
- 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 must be provided.

C10.1.4.3 Design drawings

Design drawings must be prepared and submitted in discrete and complete packages for elements or components of the works.

Each drawing must be complete and must have been checked for accuracy and verified fit for purpose prior to submission.

All drawings must be prepared in accordance with Sydney Water Computer Aided Drafting (CAD) Standard for civil, structural, mechanical and electrical engineering drawings.

If appropriate, design drawings for water and sewage pipelines must 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 must be prepared and submitted which meets industry accepted norms as well as meeting the requirements for safety in design. The design report must 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 must also be provided.

C10.1.4.5 Project specification

When requested as part of the scope of work, a specification customised for the project must be prepared based on this specification, Sydney Water's deemed to comply (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 must 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 D0000653 must be complied with. All necessary documentation related to safety in design must 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 must be 100 years.

The design life of buildings and buildings that house instruments only, must be 50 years.

C10.2 Referenced documents

Sydney Water documents

AMQ0562	Water System Planning Guideline
CPDMS0021	Computer Aided Drafting (CAD) Standard
D0000653	Safety in Design Procedure
D0000666	Wastewater Network Planning Guideline
D0000833	Engineering Competency Standard
D0001963	Water Reservoir General Technical Specification

Hydraulic System Services IICATS Standards

WSAA specifications

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 (Sydney Water Edition)
WSA 201	Manual for Selection and Application of Protective Coatings (with integral Sydney Water Supplement)
WSA PS-314	Steps for Underground Man Entry Chambers – Water Supply and Sewerage
WSA PS-315	Fixed Ladders in Water Supply and Sewerage Applications

Australian standards

AS/NZS 1170.0	Structural design actions Part 0: General principles

AS/NZS 1170.1	Structural design actions Part 1: Permanent, imposed and other actions
AS 1170.4	Structural design actions Part 4: Earthquake actions in Australia
AS 1418.1	Cranes, hoists and winches Part 1: General requirements
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS/NZS 1604.1	Preservative-treated wood-based products Part 1: Products and treatment
AS 1726	Geotechnical site investigations
AS 2082	Timber – Hardwood – Visually stress-graded for structural purposes
AS 2159	Piling – Design and installation
AS/NZS 2179.1	Specifications for rainwater goods, accessories and fasteners Part 1: Metal shape or sheet rainwater goods, and metal accessories and fasteners
AS/NZS 2272	Plywood – Marine
AS/NZS 2566.1	Buried flexible pipelines Part 1: Structural design
AS/NZS 2566.2	Buried flexible pipelines Part 2: Installation
AS 2876	Concrete kerbs and channels (gutters) – Manually or machine placed
AS/NZS 2890.1	Parking facilities Part 1: Off-street car parking
AS 2890.2	Parking facilities Part 2: Off-street commercial vehicle facilities
AS/NZS 3500	Plumbing and drainage (Set)
AS 3600	Concrete structures
AS/NZS 3725	Design for installation of buried concrete pipes
AS 3735	Concrete structures for retaining liquids
AS 3996	Access covers and grates
AS 4060	Loads on buried vitrified clay pipes
AS/NZS 4130	Polyethylene (PE) pipes for pressure applications
AS 5100	Bridge Design (Set)
AS 5100.2	Bridge Design Part 2: Design loads
AS 5100.3	Bridge Design Part 3: Foundation and soil-supporting structures

TfNSW documents

B114	QA Specification for Ground Anchors
BTD 2007/13	Technical Direction for Durability of Steel Piles in Contact with Acid Sulfate Soils
R64	QA Specification for Soil Nails
R57	QA Specification for Reinforced Soil Walls

Austroads documents

AP-G34	Austroads Design Vehicles and Turning Path Templates

AGPT02/08	Guide to Pavement Technology Part 2: Pavement Structural Design

International standards

BS EN 1295-1	Structural design of buried pipelines under various conditions of loading. General requirements
BS EN ISO 28765	Vitreous and porcelain enamels. Design of bolted steel tanks for the storage or treatment of water or municipal or industrial effluents and sludges
NZS 3106	Design of concrete structures for the storage of liquids

Other documents

ANSI/AWWA D103	Standard for Factory-Coated Bolted Carbon Steel Tanks for Water Storage
BCA	Building Code of Australia
CIRIA C760	Gaba, A., Hardy, S., Doughty, L., Powrie, W. and Selematas D. Guidance on Embedded Retaining Wall Design. CIRIA C760, London, UK, 2017; ISBN: 978-0-86017-764-7

C10.3 Geotechnical investigations

C10.3.1 General

Geotechnical investigations must be scoped and carried out for each site and logged in accordance with AS 1726; by a suitably qualified, competent engineering geologist or geotechnical engineer, in accordance with D0000833.

The competent engineering geologist/geotechnical engineer must review all existing geotechnical investigation information provided by Sydney Water; when available.

Where inadequate information is identified, additional geotechnical investigations must be proposed and carried out.

The purpose of the investigation must provide sufficient information on site conditions to allow design and construction details to be finalised.

All field and laboratory geotechnical investigation test results must 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 must be investigated, and all necessary additional field and laboratory geotechnical investigations required for the design and construction of the proposed works must be undertaken.

The scope of geotechnical investigations must be prepared and submitted to Sydney Water for acceptance, including the following details as necessary:

- project understanding
- 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 must also include all necessary safe work, health and safety documentation related to the proposed works.

The geotechnical investigation proposal must 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 must be produced to document all field investigations results, geotechnical logs and laboratory test results.

The factual report must consist of 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 must have:
  - horizontal location accuracy = ±1.0 m MGA
  - vertical levels accuracy = ±0.1 m AHD
- 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.

The laboratory test results must be from a NATA accredited test laboratory.

C10.3.4 Geotechnical interpretation and design

C10.3.4.1 Geotechnical interpretive report

The designer must 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 must be up to date and appropriate to each design element. The geotechnical interpretive report must include, but not limited to the following details:

- project understanding
- 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 sulphate 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
- advice on excavability of the material present on site
- advice on material re-useability as earthworks material to satisfy technical requirements specified in this specification
- recommendations on construction procedures and construability considerations
- recommendations on earth pressure coefficients for design actions and design resistance
- 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
- advice on geotechnical risks, limitations, gaps in available geotechnical data and where applicable, provide recommendations for further geotechnical investigations
- recommendations for geotechnical ground verifications required on site, during construction.

The geotechnical interpretive report must be updated at the end of each design stage of the project to suit any design change in the design elements and must be consistent with the overall design.

C10.3.5 Geotechnical stability checks

C10.3.5.1 Shallow footings

Geotechnical stability of shallow footings must be checked in accordance with AS 5100.3.

C10.3.5.2 Slope stability

All cut slopes and fill embankments must 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 must include (but not limited to):

- seismic load
- flooding
- rapid drawdown
- scour

- impact loads transferred to the slope
- groundwater level/pressure variations.

Where an existing slope is proposed to be modified or support new structures; the existing slope must be treated as a new structure and must meet the above factor of safety requirements.

C10.4 Roadworks

C10.4.1 General

Roads must be provided to service all buildings, facilities and structures where vehicular access is required. Roads must 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 must be provided with turning areas, passing bays, kerbs and gutters, stormwater surface drainage, sub-surface drainage, trench drains and edge drains.

Hardstand areas must 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 must be provided for parking of cars, vans and service vehicles.

Appurtenances such as fencing, railing and vehicular barriers must 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 must be provided where appropriate.

C10.4.2 Width of roads

The widths of roads must provide passageway and passing clearances for the appropriate vehicle class using the road.

The minimum width for two-way roads must be 6.2 m. The minimum width for one-way roads must be 4.0 m.

Unless otherwise specified, the following Austroads design vehicles must be used in the design:

- roads for use by heavy transportation vehicles - single articulated (19.0 m long, 2.5 m wide)
- roads for use by normal service vehicles - service vehicle class (8.8 m long, 2.5 m wide)
- roads for use by cars and vans - car/van vehicle class (5.2 m long, 1.94 m wide).

The geometry and turning radii of roads must comply with the requirements of AP-G34 for the appropriate design vehicle classes.

For the design of parking areas, the requirements of AS/NZS 2890.1 or AS 2890.2 must be met.

C10.4.3 Pavement design

The assessment of design input parameters and design methods for both flexible and rigid pavements must be in accordance with AGPT02/08.

The minimum pavement design must be as follows for a subgrade of minimum CBR = 5% for minimum 1 m depth below subbase level:

- rigid pavement – 150 mm thick reinforced concrete slab over a minimum of 100 mm thick DGB20 base course
- flexible pavement – 45 mm thick wearing course of AC14 asphaltic concrete, 150 mm thick DGB20 base course, and 200 mm thick DGS40 sub-base course.

Site specific pavement design must be produced for ground conditions with CBR < 5% for minimum 1 m depth below subbase level.

C10.4.4 Rigid pavement

Rigid pavements of reinforced concrete must 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 must be of the semi-mountable type integral with formed gutters or trays as shown in AS 2876.

C10.4.6 Flooding

Roads must be designed at levels free from flooding during storm events having an average recurrence interval (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 must 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 must comply with WSA 201.

C10.7 Platforms, walkways, open flooring, stairways and handrails

C10.7.1 General

Access platforms, walkways, ladders, stairs and step irons must 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.

Stairways, inclined tread ladders or inclined rung ladders with slopes within the preferred ranges specified in AS 1657, in this order of preference, must be used. Vertical ladders and step irons must not be used except in maintenance holes.

Platforms, walkways, ladders, stairs, step irons, and handrails must comply with the requirements of AS 1657, WSA PS-315 and all relevant WorkCover NSW requirements.

All walkways and stairways must have a minimum width of 1,000 mm. Wider walkways and platforms must 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 must have a surface pattern that will provide a non-slip grip even when immersed in liquid.

Rungs for rung ladders and steps must be made from twisted, deformed or other slip resistant bars.

Where portable ladders are to be used (eg access into sewage pumping station wet wells), adequate stainless-steel ladder tie points must be provided.

Steps for maintenance holes and person entry chambers must be in accordance with WSA PS-314.

Step irons (individual rung ladder) installed in chambers and maintenance holes within sewage pumping station sites must be made from deformed 316 grade stainless steel and must be minimum 400 mm wide. Plastic encapsulated step irons or rungs must not be used.

C10.7.2 Floor plates and gratings

Floor plates and gratings must be of sufficient thickness to carry the design loads. The deflection (excluding support structure) under the design loads must not exceed 1/250 of the span with a maximum value of 5 mm.

Floor gratings must be either hot-dipped galvanised mild steel or aluminium.

Gratings must have serrated edge load carrying bars at appropriate spacing. Each grating panel must have edge bars welded across the end of the load bars, notches or penetrations. The edge bar must be the same section as the load bars.

Every panel must be installed in accordance with the manufacturer's instruction and fastened to the supporting structure using the proprietary screws and clamps recommended by the supplier, except for the step grates, and must not rely on adjacent sections to prevent lateral movement. They must be fixed such that the removal of any element or panel will not affect the integrity of the remaining sections. Where panels are not required to be removable, they must be permanently fixed down via welding, screws or similar.

All plate and grating fixings must meet the following requirements:

- Match the design life of the grate or cover.
- Secured to supporting structure.
- Prevent lateral movement of the panel even if adjacent panels are removed.
- Be durable to wheel loads and foot traffic as required.
- Must not create a trip hazard (be of a low profile).

- Resistant to vibration as required.

Load carrying bars must travel in the direction between the supporting structural members. There must be no raised projections above the floor levels of the platforms or walkways.

Mild steel floor plates must have a thickness not less than 6 mm. Plating must have a surface pattern which must be of a non-slip type. Where fully supported by grating, mild steel floor plates must have a thickness not less than 3 mm.

Both the load bearing and transverse bars in rectangular panels must 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 must 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 must be not more than 16 kg for manual handling by one person, or not more than 32 kg for two persons, or not more than 32 kg for one person if hinged.

If there is a risk of objects falling through gratings or open flooring causing injury to persons, a protective mesh or net must be provided.

In cases where security is required, the plates or grating hatches must be lockable using a key.

C10.7.3 Cut-outs

Cut-outs or penetrations in floor plates and gratings must be provided at positions required for operation of valve spindles or other purpose as necessary. Cut-outs for operation of valve spindles must be circular with a clear opening diameter of 80 mm. Cut-out size for other purposes must not exceed 125 mm × 125 mm. Clearance between protrusions and grating cut-out must not exceed the load bar spacing.

The exposed edges of the load bars must be fitted with welded trim bars. Band bars must be provided around all cut-outs and butt joints between panels. Cut-outs must be adequately compensated to reinstate the loss in structural performance.

C10.7.4 Deflection limits for beams supporting platforms and walkways

Deflection limits for support beams of platforms and walkways must be as shown in Table 10-1.

Table 10-1 Deflection limits of beams supporting platforms and walkways

Type of beam	Deflection limit for span	Deflection limit for cantilever
Supporting platforms and walkways for accessing valves, penstocks and similar operational items	≤ Span/350	≤ Span/175
Supporting platforms and walkways only	≤ Span/250	≤ Span/125

C10.7.5 Handrails and kickplates

All stairways, platforms and walkways must be enclosed by hand railing unless there is less than 100 mm between the walkways and an adjacent structure. In such a case, kickplates must still be required.

Hand railing must be of uniform appearance and manufacture. Monowills tubular handrail system or any equivalent proprietary system is acceptable.

Stanchions must be set at not more than 2 m centres. Joints in the rails must be inside stanchion knuckles or connection receptacles. Monowills tubular stanchion system or any equivalent proprietary system is acceptable.

Installation of stanchions and handrails must be strictly in accordance with the manufacturers printed instructions and no deviations must be permitted unless accepted in advance by Sydney Water.

A 6 mm thick kickplate must be provided unless exempted in advance by Sydney Water and must project 100 mm above the floor level of the platforms and walkways.

Stairway openings on platforms and walkways must be protected with self-closing safety gates or booms. Chains must not be used.

C10.8 Buildings

C10.8.1 General

Unless otherwise specified, all buildings must be designed to satisfy the requirements of the BCA 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 must be similar to existing similar buildings in the compound as far as practical.

If existing buildings are altered, the alterations must 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 must 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 must be functional and sized to facilitate easy access to equipment. All doors and passageways must be designed so that equipment and machinery can be moved in and out of the building.

Natural ventilation must be provided as far as possible except where odour control is required. Forced air ventilation or air-conditioning must be provided to underground spaces, galleries and in controlled environment where comfort of people and protection of equipment are required.

Building systems and materials must be selected to suit the environment.

C10.8.3 Construction materials

Unless otherwise specified, all buildings must have reinforced concrete floors.

Protective coating to steelwork must comply with WSA 201.

All buildings must be fit for purpose, secure from weather, vermin and resistant to attack from vandals. All external doors must be solid core doors with deadlocks. All locks must be master-keyed, or keyed alike to the system already in use.

The interior must 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 must be marine grade aluminium, Colorbond Ultra Steel sheeting, or accepted equivalent.

Adequate tread plates or catwalk must 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 must not exceed 1/250 of the span, with a maximum value of 5 mm.

Flashings, eave gutters, outlets, downpipes and the like must be provided. Rainwater goods, accessories and fasteners must be powdered coated aluminium, or zinc/aluminium alloy-coated steel to AS/NZS 2179.1 and must be designed in accordance with AS/NZS 3500.

C10.9 Design loads

C10.9.1 Design ground water level

The design ground water level must 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 must be carried out for the scenario when the structure is empty with groundwater situated at the design ground water level. The design must 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 must be resisted by the provision of either sufficient dead load to resist the flotation forces in accordance AS/NZS 1170.0, or the provision of an adequately designed pumped subsoil drainage system with redundancy demonstrated in design allowing for blockage of minimum 25% of the subsoil drain system.

Pop-up valves on the floor are only allowed in clear water tanks with adequately designed drainage system with redundancy demonstrated in design allowing for blockage of minimum of 25 % of the subsoil drainage system.

The diameter of the pop-up valves must be not less than 150 mm. The number and spacing must be determined by the discharge characteristics of the valve, and must be located on a grid with spacing of not more than 6 m × 6 m.

Where subsoil drainage system is used to address buoyancy effects, the system must include the facility and access to inspect and clean out any potential blockages.

C10.9.3 Minimum design imposed loads

Unless specified otherwise, the minimum design live loads must comply with Table 10-2.

Table 10-2 Minimum design imposed loads

Location	Minimum imposed loads
Metal roof, not accessible except for maintenance Note 1	To AS/NZS 1170.1, but not less than 0.5 kPa
Metal roof, designated areas for walkways and platform Note 1	2.5 kPa
Ceiling Space	0.5 kPa

Location	Minimum imposed loads
Concrete roof, accessible but no vehicular traffic and not for public assembly Note 1	2.5 kPa
Areas subjected to vehicular traffic	SM1600 to AS 5100.2
Platforms and walkways	To AS 1657, but not less than 2.5 kPa
Office floors	3 kPa
Storage rooms	4 kPa
Control rooms	5 kPa
Equipment rooms	8 kPa

Notes:

1. Roof surface must be at least 300 mm 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 must be in accordance with the guidelines in table F1 of AS/NZS 1170.0 and the BCA. Unless accepted in advance by Sydney Water, the values for importance levels must be as in Table 10.3.

The internal wind coefficient for the reservoir shell must be more severe than -0.5 (suction).

Table 10-3 Importance levels for structures

Structure type	Importance level
Dams & water containment assets assessed as ‘declared dams’ Note 1	5
• Water storage tanks and reservoirs associated with drinking water, supply to hospitals and firefighting • Pump stations associated with drinking water, supply to hospitals and firefighting • Pipelines and aqueducts associated with drinking water, supply to hospitals and firefighting	4
Other water storage tanks and reservoirs not included under Importance Level 4	3
Bridges and stormwater aqueducts	3
Wastewater facilities	3
In ground stormwater assets	2

Notes:

1. Refer to Clause C10.17.

C10.9.5 Hydrostatic pressure loading

All structures must 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 must be based on the entire weight of liquid retaining structures and their contents or must take account of the separate effects of the liquid content, using internationally recognised methods. A recommended code for the above is NZS 3106.

The horizontal earthquake force on the structure must be calculated using Equation 10-1.

$$F = \sqrt{(F_I^2 + F_C^2)} \quad (10\text{-}1)$$

where:

F_I = Inertia component (Equation 10-2)

F_C = Convective (oscillating or sloshing) component (Equation 10-5).

The inertia component of the earthquake must be calculated according to Equation (10-2):

$$F_I = C_I (W_S + W_I) \quad (10\text{-}2)$$

where:

C_I = Inertia coefficient (Equation 10-3)

W_S = Weight of the structure excluding water

W_I = Weight of the inertia liquid content of the structure (For calculation of W_I and its effective height above the floor of the liquid retaining structure, refer to NZS 3106).

$$C_I = A_0 C_h(T_I) \quad (10\text{-}3)$$

where:

A_0 = Base acceleration coefficient (Equation 10-4)

$C_h(T_I)$ = Spectral shape factor as a function of T_I (Values are given in AS 1170.4)

T_I = Fundamental natural period of the structure in the dimension being considered.

$$A_0 = k_p Z S_p / \mu \quad (10\text{-}4)$$

where:

k_p = Probability factor from table 3.1 of AS 1170.4 for the annual probability of exceedance corresponding to the importance level

Z = Hazard factor from AS 1170.4

S_p = Structural performance factor equal to 1.0

μ = Structural ductility factor which equals to:

= 2.0 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 must be avoided by good detailing including satisfactory overlapping between reinforcement in columns, beams, walls and slabs

= 1.0 for other structures.

The convective component of the earthquake force must be calculated according to Equation 10-5:

$$F_C = C_C W_C \quad (10\text{-}5)$$

where:

C_C = Convective coefficient (Equation 10-6)

W_C = Weight of the convective liquid contentof the structure (For calculation of W_C and effective height above the floor level of the liquid retaining structure, refer to NZS 3106).

$$C_C = 2.7\ A_0 / T_C^{1.4} \quad (10\text{-}6)$$

where:

A_0 = Base acceleration coefficient (Equation 10-4)

T_C = Fundamental natural period of the structure in the sloshing (For calculation of T_C, refer to NZS 3106).

Hydrostatic pressure distribution due to earthquake induced loads (F_I and F_c) must be calculated in accordance with NZS 3106.

C10.9.7 Lateral soil loads

For design actions, all structures or parts of structures located below ground level must be designed for the following soil pressures:

- "Active" soil pressure for walls with adequate wall movement (eg cantilever walls). In such cases for design action, a minimum lateral earth pressure coefficient of (K_a) adopted must be 0.35.
- "At rest" soil pressure for relatively stiff walls (eg propped cantilevers, cantilever walls of tanks near corners etc). In such cases for design action, a minimum lateral earth pressure coefficient (K_0) adopted must 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 must 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 must be spaced at no more than 2.0 m centres and must 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 must be considered. If data for the design of the footings is not available from the manufacturer or investigation is not carried out by an industry recognised specialist, the weight of the footing W_1 must not be less than 3 times of the weight of the equipment W_2.

For vertical vibration, W_1 must be confined to the area (a + 2t) × (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 braced structure.

C10.9.10 Dynamic loads

Dynamic loads related to crane runways and monorails must be calculated to AS 1418.1 and must 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 must be considered on the structure.

C10.10 Concrete structures

C10.10.1 Liquid retaining concrete structures

The following must be designed to the requirements of AS 3735:

- structures and pipes for the storage and conveyance of liquids such as water, wastewater and stormwater
- surfaces subject to alternate wet and dry cycles due to condensation, buried surfaces below the 1 in 10 year ground water table
- surfaces of hardstand areas subject to washing and hosing down at least once a week
- surfaces on inside of bunds including floor meant to contain spillage of chemicals.

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 must be in accordance with AS 3600 and 100 year design life must be in accordance with AS 5100.

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 must be:

- for exposure classifications B1 and B2, 20 mm and 30 mm for design lives 50 years and 100 years respectively
- for exposure classifications C and D, 30 mm and 40 mm for design lives 50 years and 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 must 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 must 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 to AS 3735 for 50 year design life

Structure type	Liquid retaining surfaces / Exposure classification	Concrete grade S40		Concrete grade S50	
		Standard formwork	Rigid formwork & intense compaction	Standard formwork	Rigid formwork & intense compaction
Sewerage structures	Walls & roof / D	75 mm Note 1	60 mm Note 1	55 mm Note 1	45 mm Note 1
	Floor / C	75 mm	60 mm	55 mm	45 mm
Sewage pumping stations – wet wells, inlet access chambers	Walls & roof / D	75 mm Note 1	60 mm Note 1	55 mm Note 1	45 mm Note 1
	Floor / C	75 mm	60 mm	55 mm	45 mm
Sewage wet weather overflow storage tanks – sharing the same air space as the dry weather wet wells	Walls & roof / D	75 mm Note 1	60 mm Note 1	55 mm Note 1	45 mm Note 1
	Floor / C	75 mm	60 mm	55 mm	45 mm
Sewage wet weather overflow storage tanks – not sharing the same air space as wet wells	Walls, roof & floor / C	75 mm	60 mm	55 mm	45 mm
Sewage treatment plants – inlet structures	Walls & roof / D	75 mm Note 1	60 mm Note 1	55 mm Note 1	45 mm Note 1
	Floor / C	75 mm	60 mm	55 mm	45 mm
Sewage treatment plants – digesters and anaerobic sludge holding tanks with roof	Walls, & roof / C	75 mm	60 mm	55 mm	45 mm
	Floor / B2	50 mm	40 mm	40 mm	30 mm
Sewage treatment plants – sed tanks, aeration tanks, filters and other effluent holding tanks without roof	Floor & walls / B2	50 mm	40 mm	40 mm	30 mm
Sewage treatment plants – recycle water storage tanks & chlorination tanks	Floor, walls & roof / B2	50 mm	40 mm	40 mm	30 mm
Hard stand areas hosed down periodically	Floor / B1	40 mm	30 mm	40 mm	30 mm
Chemical storage tanks – emergency spillage & containment surfaces	Floor & bund walls / B2	50 mm Note 1	40 mm	40 mm	30 mm
Stormwater channels in non-tidal zones	Floor walls & roof / B1	40 mm	30 mm	40 mm	30 mm
Stormwater channels in tidal zones	Floor walls & roof / C	75 mm Note 2	60 mm Note 2	55 mm Note 2	45 mm Note 2
Water treatment plants	Floor, walls & roof / B2	50 mm	40 mm	40 mm	30 mm
Potable water reservoirs	Floor, walls & roof / B1	40 mm	40 mm	40 mm	25 mm
Structures in sea water	All exterior surfaces / C	75 mm Note 2	55 mm Note 2	55 mm Note 2	45 mm Note 2

Notes:
1. In addition to the required cover, the concrete surfaces must be protected as per WSA 201.
2. In addition to the required cover, the reinforcement must be stainless steel or galvanised carbon steel.

Table 10-5 Minimum durability requirements for typical exposure classifications to AS 3735 for 100 year design life

Structure type	Liquid retaining surfaces / Exposure classification	Concrete grade S40		Concrete grade S50	
		Standard formwork	Rigid formwork & intense compaction	Standard Formwork	Rigid Formwork & Intense Compaction
Sewerage structures	Walls & roof / D	NA	70 mm Note 1	70 mm Note 1	55 mm Note 1
	Floor / C	NA	70 mm	70 mm	55 mm
Sewage pumping stations – wet wells, inlet access chambers	Walls & roof / D	NA	70 mm Note 1	70 mm Note 1	55 mm Note 1
	Floor / C	NA	70 mm	70 mm	55 mm
Sewage wet weather overflow storage tanks – sharing the same air space as the dry weather wet wells	Walls & roof / D	NA	70 mm Note 1	70 mm Note 1	55 mm Note 1
	Floor / C	NA	70 mm	70 mm	55 mm
Sewage wet weather overflow storage tanks – not sharing the same air space as wet wells	Walls, roof & floor / C	NA	70 mm	70 mm	55 mm
Sewage treatment plants – inlet structures	Walls & roof / D	NA	70 mm Note 1	70 mm Note 1	55 mm Note 1
	Floor / C	NA	70 mm	70 mm	55 mm
Sewage treatment plants – digesters and anaerobic sludge holding tanks with roof	Walls, & roof / C	NA	70 mm	70 mm	55 mm
	Floor / B2	60 mm	50 mm	50 mm	40 mm
Sewage treatment plants – sed tanks, aeration tanks, filters and other effluent holding tanks without roof	Floor & walls / B2	60 mm	50 mm	50 mm	40 mm
Sewage treatment plants – recycle water storage tanks & chlorination tanks	Floor, walls & roof / B2	60 mm	50 mm	50 mm	40 mm
Hard stand areas hosed down periodically	Floor / B1	50 mm	40 mm	45 mm	35 mm
Chemical storage tanks – emergency spillage & containment surfaces	Floor & bund walls / B2	60 mm Note 1	50 mm	50 mm	40 mm
Stormwater channels in non-tidal zones	Floor walls & roof / B1	50 mm	40 mm	45 mm	35 mm
Stormwater channels in tidal zones	Floor walls & roof / C	NA	70 mm Note 2	65 mm Note 2	55 mm Note 2
Water treatment plants	Floor, walls & roof / B2	60 mm	50 mm	50 mm	40 mm
Potable water reservoirs	Floor, walls & roof / B1	50 mm	40 mm	45 mm	35 mm
Structures in sea water	All exterior surfaces / C	NA	70mm Note 2	65 mm Note 2	55 mm Note 2

Notes:
1. In addition to the required cover, the concrete surfaces must be as per WSA 201.
2. In addition to the required cover, the reinforcement must be stainless steel or galvanised carbon steel.

C10.10.5 Deleted

C10.10.6 Minimum thickness of reinforced concrete members

Minimum thickness for singly reinforced member must be 150 mm. The thickness of doubly reinforced member must be adequate to maintain a minimum clear distance of 75 mm between parallel reinforcement.

C10.10.7 Prestressed concrete tanks

Prestressing must be achieved by post-tensioning tendons that are placed within the structural member. On completion of post-tensioning, the ducts must be completely filled with grout as soon as practicable.

Unbonded tendons, ie post-tensioned tendons that are protected by sheathing, grease and prestressing achieved by wire winding method and subsequently protected by shotcrete must not be permitted.

Butted precast post-tensioned tanks must not be permitted unless the joints are stitched with cast in-situ concrete with a minimum width of 750 mm and with fully lapped conventional reinforcement.

C10.10.8 Deleted

C10.10.9 Minimum reinforcement in reinforced concrete liquid retaining structures

Minimum reinforcement in reinforced concrete liquid retaining structures must be in accordance with table 3.1 of AS 3735.

The minimum reinforcement must 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 must 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 must be 50% of the reinforcement required in accordance with table 3.1 of AS 3735.

The minimum reinforcement must 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 must be:

- 0.25% for exposure classification A2
- 0.35% for exposure classification B1
- 0.45% for exposure classifications B2 and C.

C10.10.12 Load combinations for serviceability to AS 3735 for liquid retaining concrete structures

The following load combinations must be considered as a minimum for walls and floors of structures founded below ground level:

1. Normal operating conditions – external soil pressure and ground water table must 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.

2. Maximum overload conditions – external soil pressure and ground water table must 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.
3. As item 1 in this list but with earthquake load for group B serviceability.
4. Structure empty with design earth pressure excluding surcharge loads and design ground water table for group B serviceability.
5. Structure empty with design earth pressure including surcharge loads for group B serviceability.
6. Individual compartments with adjacent compartment empty for normal operating condition for group A serviceability.
7. Individual compartments with adjacent compartment empty for maximum overload condition for group B serviceability.
8. Individual compartments with adjacent compartment empty for normal operating condition with earthquake for group B serviceability.
9. Baffle walls for normal operating condition with a minimum of 1 m hydrostatic pressure differential for group A serviceability.
10. Baffle walls for normal operating condition with earthquake for group B serviceability.
11. Baffle walls without adequate openings for flow balancing must be designed as items 6, 7 & 8 in this list.

The effects of shrinkage and swelling effects and, temperature variations and temperature gradients must 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 (eg wall to floor and wall to wall) must 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) must be taken into consideration.

Details complying to published recommended practices, as a minimum must include the following:

- At “L” joints, the reinforcement from the joining members must 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 must be at least equal to the anchorage length.
- At “T” joints, the cogs of the starter bars must be turned towards the opposite face reinforcement. The extension of the cog past the opposite face reinforcement must be at least equal to the anchorage length.

C10.10.14 Reinforcement details at penetrations

As a minimum, the reinforcement truncated by penetrations must be compensated as follows:

- Additional reinforcement adjacent to the penetration in each direction must be provided within half the size of the penetration on all four sides. The amount of reinforcement provided on each side must be at least equal to one bar more than the half the number of bars truncated by the penetration.

  The compensating bars must extend past the other compensating bars in the orthogonal direction by amount at least equal to the anchorage length.
- Circular penetrations of 600 mm diameter or more, must incorporate 2 additional diagonal trimmers at each corner. The trimmer bars at each corner must 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 must be continuously welded unless accepted by Sydney Water at concept design stage.

Circular tanks must be designed in accordance with D0001963.

C10.11.1.1 Tanks located below finished ground level

Tanks located below finished ground level must be separated by a retaining wall with a minimum clearance of 2 m from the tank wall. No part of the tank must be covered with back fill.

C10.11.2 Bolted tank

C10.11.2.1 General

Bolted tanks must not be used unless the following is demonstrated and accepted by Sydney Water:

- Minimum design life must be 50 years.
- Maintenance free 10 year performance records of at least three tanks of identical construction in Australia must be provided.
- All material components must have a minimum warranty period of 15 years.
- The requirements of AWWA D103 must be complied to factory-coated bolted carbon steel tanks for water storage. Bolted steel tanks for other cargo eg wastewater sludge and chemicals, the requirements of BS EN ISO 28765 must apply.
- Proprietary bolted tank designs also must be verified to the requirements of this specification by a structural engineer meeting Sydney Water Engineering Competency Standard (D0000833).
- Interior and exterior coatings must be glass fused-to-steel (vitreous enamel) coating. Prior to fabrication of the steel panels, an ITP for the coating must be submitted to Sydney Water for approval. The inspection and testing must be undertaken by a certified third party coating inspector. Sydney Water reserves the right to carry out quality audits on the work from time to time.
- Sealants and gaskets must have adequate chemical resistant to the intended cargo. For drinking water purpose, they must be demonstrated to have long-term chemical resistant to a minimum of 2 ppm of free chlorine solution.
- 25 mm × 50 mm joint sealant must be provided in a preformed recess on both faces of the embedded section of the wall stakes.
- Neoprene strip of appropriate harness must be inserted in every lap joints.

- Assembly must use high strength friction grip bolts.
- No more than 3 rows of bolts must be provided at any location.
- Floor must be made of structural concrete slab.
- Bottom wall strakes must be embedded to a minimum depth of 200 mm into floor slab.
- Roof must be designed to the requirement of conventional welded tanks.
- Panels must be hot-rolled, high-strength low alloy carbon steels.
- Minimum material thickness and corrosion allowance must be as per welded reservoir.
- A minimum of one spare panel must be supplied for every 20 panels.

C10.11.2.2 Design of bolted tanks

Where bolted tank is accepted by Sydney Water, the design must be in accordance with ANSI/AWWA D103 and BS EN ISO 28765, as appropriate and the additional requirements of Clause C10.11.1 of this specification 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 must 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/NZS 2272.

C10.13 Covers and grates

The classes for covers and grates to AS 3996 must 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 must be provided with handles and must generally be sized for maximum 16 kg single-person or 32 kg two-person lift. However, the necessary risk assessment must be undertaken to ascertain that these manual tasks will not pose a risk of injury to the operator; otherwise, other appropriate designs must be used.

C10.14 Pipeline design

C10.14.1 Hydraulic design

The hydraulic design of pressure pipes must be in accordance with AMQ0562, WSA 03, WSA 04, WSA 06 and WSA 07 as appropriate.

Pressure pipelines must be graded to minimise the use of air valves and scours wherever possible. The grading must be such that no vacuum or syphoning effects result during normal operation and the hydraulic grade line (HGL) is always at least 5 m above obvert of the pipeline and air valves.

The hydraulic design of non-pressure sewer pipes must be in accordance with D0000666 and WSA 02 as appropriate.

C10.14.2 Pipe structural design

Pipelines must be designed to resist all imposed loads and actions (temporary and permanent) without failure over its design life. The minimum design life for buried pipes must be 100 years.
Combined longitudinal and transverse effects must be considered. In poor or unsuitable ground, special foundation provisions must be specified to ensure pipework can support imposed loads.

C10.14.3 Buried flexible pipelines

Structural design of buried flexible pipelines must be in accordance with AS/NZS 2566.1, typically for the following material types:

- MS
- DI
- un-plasticised PVC (uPVC)
- orientated PVC (oPVC)
- modified PVC (mPVC)
- PE
- PP
- GRP
- acrylonitrile butadiene styrene (ABS)
- stainless steel.

Pipes with high ring bending stiffness may be classified as rigid for design purposes. A check must 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 AS/NZS 2566.1 are a guide only and should be verified with the manufacturer of the pipe product.

Design factors must 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 minimum design factor (f_2) of 1.2 must be applied where depth of cover exceeds 2.5 m, and 1.4 where depth of cover exceeds 5 m. The MAOP must 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 must be determined using the method described in AS/NZS 2566.1. For structured wall, profiled wall or composite pipes, stiffness must be determined through testing.

Flexible pipes must have an initial ring bending stiffness of ≥10,000 N/m/m.

To determine the minimum wall thickness in DI pipe for use in the ring bending stiffness calculation, Equation 10-7 must be used.

$$t_{\text{pipe stiffness}} = \frac{(\text{specified minimum t} + \text{specified nominal t})}{2} \quad (10\text{-}7)$$

For materials where the nominal wall thickness of the pipe is close to the specified minimum wall thickness, the minimum wall thickness must be used for calculating ring bending stiffness. Typically, DI and MS pipes

are supplied with cement mortar lining (CML). The CML must not be included in the calculation of the overall pipe stiffness.

C10.14.3.3 Design loads

Vertical dead load due to trench or embankment fill must comprise the full height of soil above the pipe without reductions for upward shearing or frictional forces between the soil prism load and adjacent soil, or cohesion of undisturbed soil for trenchless applications. Bulk unit weight of fill must be 20 kN/m^3.

Road vehicle live loads must be taken as SM1600 as given in AS 5100.2 for the following loading types listed in Table 10-6.

Table 10-6 Road vehicle load

Type	Description	Load
A – major road	Major public and private road carriageways, driveways in industrial and commercial areas	Maximum load case for SM1600 single or dual lane
B – minor road	Minor public and private road carriageways, driveways in residential areas, footpaths/verges/median strips not restricted to vehicles, parkland with no restriction to vehicular access	Maximum load case for SM1600 single lane
C – field load	Areas within private properties, and public places, pedestrian malls and footways not subjected to vehicular loading or have no access for vehicles	60% of minor road loading

The pipe must 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 must be considered where applicable.

C10.14.4 Rigid pipe structural design (non-pressure)

Structural design of RC pipes must be in accordance with AS/NZS 3725. Structural design of VC pipes must be in accordance with AS 4060 or BS EN 1295-1 National annex A.

C10.14.5 Adjacent parallel pipelines

Adjacent parallel pipelines must comply with requirements of AS/NZS 2566.2. Suitable vehicular access to each pipeline within easements or access ways must be provided. Access provisions and requirements for pipelines for each location must be included in the safety in design report. Where pipes share a common trench, the centre-to-centre spacing between the pipelines must be given careful consideration, but must not be less than 1 m. The minimum spacing requirement must consider, as a minimum, future operation, excavation, maintenance and repair, vehicular access, pipe sizes, distances from nearby structures, construction methodology, loadings and relative pipe depths. A cross section of all proposed adjacent parallel pipes must be shown in design drawings.

Site specific purpose designed thrust blocks must be provided to ensure that all thrust is resisted by native material having adequate bearing capacity.

C10.15 Earth retaining wall design

C10.15.1 Loads, load factors and strength reduction factors

All retaining walls must be designed using load factors and strength reduction factors listed in AS 5100.3, accommodating loading listed in Section C10 of this specification, as appropriate.

C10.15.2 Embedded retaining walls

All temporary and permanent embedded retaining walls must be designed using CIRIA C760.

C10.16 Ground anchorages

C10.16.1 General

All ground anchorages must be designed in accordance with AS 5100.3.

C10.16.2 Soil nails

All soil nails must be designed to satisfy TfNSW QA Specification R64.

C10.16.3 Ground anchors or rock bolts

All ground anchors must be designed to satisfy TfNSW QA Specification B114.

C10.16.4 Reinforced soil walls

All reinforced soil walls must be designed in accordance with TfNSW QA Specification R57.

C10.17 Declaration of dams

Where a new water containment asset is proposed, the asset must be checked against requirement for declared dams, under Dam Safety Act and any associated regulations.

Ownership

Ownership

Role	Title
Group	Engineering & Technical Support
Owner	Norbert Schaeper, Engineering Manager, Urban Design and Engineering
Author	Robert Loncar, Technical Director – Civil Engineering
BMIS Number	CPDMS0023

Change history

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1.0	David Trinh, Tony Petrevski, Christie Sebaratnam, Sum Tong	11/8/2008	Peter Gillman	11/8/2008
2.0	Sum Tong, Christie Sebaratnam	31/5/2010	Peter Gillman	31/5/2010
3.0	Sum Tong, Christie Sebaratnam	21/9/2011	Peter Gillman	21/9/2011
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8.0	Dinesh Dineshharan, Gary de Leeuw, Paymon Aria, Robert Loncar, Christie Sebaratnam	14/8/2019	Norbert Schaeper	15/8/2019
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10.0	Dinesh Dineshharan, Christie Sebaratnam, Robert Loncar, Maxim Kovtun	26/07/2022	Norbert Schaeper	08/2022