SA Water

SOUTH AUSTRALIAN WATER CORPORATION

TG 106

TECHNICAL GUIDELINE

DESIGN & DOCUMENTATION REQUIREMENTS FOR REINFORCED CONCRETE CIRCULAR SURFACE WATER STORAGE TANKS & ASSOCIATED WORKS

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Major Changes Incorporated In This Edition

This is the first edition of TG106.

Contents

Section 1: Scope

This Technical Guideline has been prepared to set out and give guidance on the following:

- The design and documentation of above ground circular concrete water storage tanks
- The functional requirements of above ground water storage tanks,
- The design of associated works.

This scope does not cover the installation of any required electrical equipment such as float switches and level transducer.

Section 2: Referenced Documents

Unless specified otherwise, any Standard referred to in this Guideline, including SA Water Standard Specifications, shall be the latest edition (including amendments) of that Standard.

References including the following may be relevant in undertaking tank design and construction for SA Water projects.

2.1 SA WATER TECHNICAL STANDARDS

TS1(a)	Supply and Delivery of Lean Mix, No Fines, Grade 20 or 25 Concrete
TS1(b)	Supply and Delivery of Grade 32, 40 or 50 Concrete
TS2	PVC Waterstop
TS3(a)	Fine and Coarse Aggregates for Concrete in Mild Exposure Conditions (excluding lightweight aggregates)
TS3(a)	Fine and Coarse Aggregates for Concrete for Water Retaining Structures and in Aggressive Environments (excluding lightweight aggregates)
TS4	Packing Sand (Pipe embedment and trench fill sand)
TS29	The Protection of Ductile Iron and Cast Iron Pipework Fittings in Below Ground Pipelines using Denso Petrolatum tape Wrapping System.
TS30	The Welding of Joints and Specials for Steel Concrete Lined Pipes.
TS30a	Welding Specification – Welding and Welding Procedure Qualification
TS68	Reinforced Concrete Construction for Liquid Retaining Structures and / or Aggressive Environments
TS95	Requirements for Technical Drawings

2.2 SA WATER TECHNICAL GUIDELINES

TG10	General Technical Information for Geotechnical Design
TG30	Tank Pipework and Valves
TG61	Practical Understanding and Interpretation of Technical Standard TS30a, Welding Specification, Welding & Welding Procedure Qualification
TG96	Guidelines for the Design of Anchors and Thrust Blocks on Buried Pipelines with Unrestrained Flexible Joints and for the Anchorage of Pipe on Steep Grades
TG104	Guidelines for the Design of Pipe End Dissipators
TG 105	Allowable Pipe Size, Class and Materials for Water Mains

SA Water "Water Quality Monitoring Handbook

2.3 DTEI STANDARD SPECIFICATION FOR SUPPLY OF PAVEMENT MATERIAL

PM3/40 QG Quarry Waste (Quarried Material Grading Based) 40 mm
PM2/20 QG Quarry Rubble (Quarried Material Grading Based) 20 mm
SPM20C3 20mm 3% Cement Stabilised Class 1 Pavement Material (Mix Design)

2.4 STANDARDS ASSOCIATION OF AUSTRALIA

AS 1100	Technical Drawing (all parts)
AS 1101	Graphic Symbols for General Engineering
AS 1111	ISO metric hexagon bolts and screws
AS 1112	ISO metric hexagon nuts
AS 1214	Hot dip galvanised coatings on threaded fasteners
AS 1237	Plain washers for metric bolts, screws and nuts for general purposes
AS 1289.5.1.1	Methods of testing soils for engineering purposes – Soil compaction and density tests – Determination of the dry density/moisture content relation of a soil using standard compactive effort

AS 1289.5.2.1	Methods of testing soils for engineering purposes – Soil compaction and density tests – Determination of the dry density or moisture content relation of a soil using modified compactive effort
AS 1289.5.4.1	Methods of testing soils for engineering purposes – Soil compaction and density tests – Compaction control test – Dry density ratio, moisture variation and moisture ratio
AS 1289.5.6.1	Compaction control test -Density Index method for a cohesionless material
AS 1289	Methods of testing soils for engineering purposes
AS 1379	Specification and Supply of Concrete
AS 1432	Copper tubes for plumbing, gasfitting and drainage applications
AS 1553	Structural steel welding (all parts)
AS 1657	Fixed platform, walkways, stairways and ladders
AS 1769	Welded stainless steel tubes for plumbing applications
AS 1796	Certification of welders and welding supervision
AS 1891.4	Industrial fall-arrest systems and devices
AS 2062	Methods for non-destructive penetrant testing of products and components
AS 2129	Flanges for pipes, valves and fittings
AS 2207	Methods for the ultrasonic testing of fusion welded joints in steels
AS 2528	Bolts, studbolts and nuts for flanges and other high and low temperature applications
AS 2758.1	Aggregates and rock for engineering purposes – Concrete aggregates
AS 2832	Cathodic Protection of Metals (all parts)
AS 2870	Residential Slabs and Footings
AS 2890.2	Off-street commercial vehicle facilities
AS 3500.1	Plumbing and drainage – Water services
AS 3566.2	Self-drilling screws for the building and construction industries – Corrosion resistance requirements
AS 3600	The use of reinforced concrete in structures
AS 3610	Formwork for concrete
AS 3678	Hot-rolled structural steel plates, floorplates and slabs
AS 3700	Masonry Structures
AS 3735	Concrete structures for retaining liquids
AS 3735	Concrete structures for retaining liquids - Commentary
AS 3972	Portland and blended cements
AS 4041	Pressure piping
AS 4087	Metallic Flanges for Waterworks Purposes
AS 4020	Testing of products for use in contract with drinking water
AS 4100	Steel Structures
AS 4331	Metallic Flanges (all parts)
AS 4671	Steel reinforcing materials
AS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS 4801	Occupational health and safety management systems – Specification with guidance for use
AS5100.4	Bridge Design – Bearings and Deck Joints
AS 9000	Quality systems - Guidelines for selection and use
AS 9001	Quality systems - Model for quality assurance in design, development, production, installation and servicing
AS 9002	Quality systems - Model for quality assurance in production, installation and servicing
AS 9003	Quality systems - Model for quality assurance in final inspection and test
AS 9004	Quality management and quality system elements

Section 3: Definitions

Anchor Block	A reinforced concrete block which is cast around a straight piece of pipe (fitted with thrust collar or puddle flange) and which is designed to restrain the pipe against longitudinal movement
Autogenous healing	Self-generated healing of cracks in the concrete tank structure by the reaction of tank stored water and the concrete paste
Convective Load	The load of water sloshing inside the tank during an earthquake
Ladder Guard	Cover plate and frame approximately two metres high by ladder width wide fixed with hinges to the ladder stile at the base of the access ladder with padlock security to prevent the climbing of the ladder by unauthorised persons
Mudring	Conically shaped ring, 150mm high, fitted around the outlet pipes on the tank floor to prevent sediment on the floor of the tank entering the outlet pipe
Non-trafficable roof	Roof not used for floor type activities, apply loadings in accordance with AS1170.1, Table 3.2, R2 (i) Structural elements
Overflow Dissipator	Vertical concrete chamber with inflow pipe at its base designed to reduce flow velocities of water entering it by discharging it vertically such that the water flows out over the chamber rim at shallow depth
Impulsive Load	The load of water inside the tank moving in unison with the structure during an earthquake
Inspection hatch	500mm by 500mm approx covered opening in the tank roof, with cross bars, through which inspection is undertaken but no access gained
Shall	Direction with which the contractor or designer must comply
Steelwork Shop Drawings	Comprehensive steelwork fabrication and construction drawings showing all relevant details including each assembly, component and connection together with information relative to cutting, welding, bolting, surface treatment and erection
Precast Shop drawings	Comprehensive precast manufacture drawings showing all relevant details including the panel dimensions, setout of cast in elements and pockets, reinforcement size and layout including cog lengths, laps, cover and surface finishes
Scour	Waste pipe provided to allow emptying and cleaning out of the tank

Sloshing	Splashing of water inside tank due to horizontal tank movement
Thrust Block	An un-reinforced block of concrete cast against the ground to resist thrust from a pipe. (Can be horizontal, vertical upwards or vertical downwards, refer TG 96)
Thrust collar	Steel ring plates welded to the perimeter of the pipe to engage an anchor block
Underdrains	Slotted PVC pipe drains, usually 80mm diameter, surrounded in gravel, wrapped in geotextile and placed under the floor of the tank prior to pouring
Waterstop	Preformed strips that are wholly or partially embedded in the concrete during construction at joint locations throughout the tank to provide a permanent water tight seal during the full range of joint movements
Water tight	A tank is considered watertight when it passes the testing requirements of AS3735 and this guideline.

Section 4: Design

4.1 TANK DESIGN

General

As essential parts of the water supply system it is important that SA Water tanks have a long watertight and maintenance free life. Tanks shall be designed to have a serviceable life of 100 years. All aspects including the structural design, material selection, joint design and construction techniques are required to be to a high standard. All the components inside the tank shall be suitable for use with potable water in accordance with AS/NZS 4020. All design work shall be in accordance with the relevant Australian Standards, AS3735 in particular, SA Water Technical Standards and SA Water Technical Guidelines.

All concrete used in the construction of the tank shall be 'special class' S40 complying with all the requirements of TS 68, specifically, batching, mixing, delivery, testing, placing, curing and stripping.

The volume of the tank required will typically be provided by SA Water. The volume specified shall be the volume the tank contains to overflow level.

The design shall also take account of the following general requirements;

- Simple robust detailing has been found to be most effective
- A freeboard of 300mm shall be provided between the top of the overflow bellmouth and the top of the tank walls
- In designing the tank allow for it to be full of water to the top of the wall.
- The tank shall be roofed with multiple access hatches
- An access platform shall be provided on top of the roof adjacent the access hatches.
- A sampling point accessible from ground level is to be integrated into the design in accordance with drawing 04-1605-01 from the SA Water “Water Quality Monitoring Handbook”
- The tank design shall be co-ordinated with the mechanical, hydraulic and electrical engineering design to ensure all necessary embedments and penetrations are properly designed and detailed.
- The excavation for the tank foundation shall be taken down to a minimum level of 150mm below the underside of the floor/footing or additionally until “rock” is encountered.
- Consideration shall be given by the designer to the effects of tank leakage upon the tank foundation material, base, footing and floor slab, particularly on sites with clay or collapsing soils.

Site Survey

A site survey will typically be provided by SA Water showing the following;

- Site contours
- Site features
- Boundaries

The survey will be made available in electronic format. The designer shall compare the site survey with their observations during a site inspection and report any discrepancies to SA Water.

Geotechnical Investigation

Tanks can vary greatly in size and the geotechnical investigation needs to be appropriate for the size under consideration. As a minimum sufficient trail pits and boreholes shall be excavated to establish a good working knowledge of the sub-surface conditions beneath the

tank walls and tank floor slabs. The geotechnical investigation and report should address the following issues;

- Effect of water exposure on the founding soils
- Variability in bearing capacity
- Possible differential settlement performance
- Possible total settlement performance
- Water table location and potential maximum and minimum levels.
- Subgrade preparation
- Base type and compaction
- Horizontal bearing capacity for thrust block design
- Suitable batter slopes for the long term stability of new cut embankments
- Construction issues

SA Water will typically provide preliminary geotechnical information for the purposes of tendering only. This does not relieve the designer of the responsibility for obtaining all the above mentioned information in the design phase. Fees for additional Geotechnical Investigations or professional advice required by the Design Engineer are the responsibility of the design and construct contractor and shall be included in the tender.

Underdrains

Provide underdrains where soils on site could be affected by water leakage. Place drains directly under floor joints and direct discharge to the low side of the site. The drain layout shall be partitioned to enable the location of the tank leakage to be identified.

Alternatively or in addition where underdrains are adopted consider the use of a 75mm minimum layer of no fines concrete (with conventional concrete placed beneath column and wall footings.) Divide the no fines concrete into zones to enable the location of the tank leakage to be identified.

At least one layer of 0.2 mm thick polyethylene membrane shall be provided over the no fines concrete layer in accordance with AS 2870 with joints lapped a minimum of 200 mm and sealed with an approved 75 mm wide pressure sensitive tape.

Structural Computations

Tanks shall be designed to take account of the following loads and actions;

- Liquid load
- Wind load
- Flotation
- Differential temperature gradients through walls
- Moisture variation in the tank material
- Earthquake
- Ground movements
- Construction loads

Loads shall be combined for stability and serviceability in accordance with the requirements of AS3735.

General computations shall be undertaken in accordance with;

- ***Portland Cement Association*** Circular Concrete Tanks Without Prestressing 1992
- AS 3735 Concrete Structures for retaining liquids.
- AS 3735 Supp 1 Concrete Structures for retaining liquids – Commentary.

Using these references the Engineer shall determine the tank wall thicknesses, type and spacing of vertical and hoop reinforcement, footing size and footing reinforcement. Alternative recognised design methods may be used subject to SA Water approval which must be sought before proceeding with the computations.

The PCA design involves the use of factors derived from various tables to determine the distribution of hoop stresses and vertical bending moment in the tank walls and thereby tank wall vertical and horizontal reinforcement. The design uses an approximation between a fully fixed and a pinned base connection of the wall to the footing.

In addition to the PCA design method temperature gradients through the tank walls shall be taken into account. A temperature gradient exists when the temperature on the exterior of the tank wall differs from that of the interior of the wall. Since the tank wall cannot expand or contract freely stresses are induced which produce additional hoop forces and a circumferential moment. The temperature induced hoop forces and moment can require the addition of 10 to 20% additional hoop reinforcement over that needed for water retaining forces alone. The Commentary to AS3735 provides a method for calculating the temperature induced hoop tension and moment which shall be added to the effects of liquid and other loads.

Tanks shall also be designed for earthquake forces in accordance with;

- Standards Association of New Zealand, NZS 3106, Code of Practice for Concrete Structures for the storage of liquids.
- Portland Cement Association, Design of Liquid-Containing Concrete Structures for Earthquake Forces
- AS1170.4 Minimum design loads on structures, Part 4: Earthquake loads.

Earthquake design shall take account of the following

- The weight of the storage tank shall include the weight of the tank structure, attachments including platforms and piping as well as the water stored to its maximum capacity.
- Check global overturning and sliding allowing for water sloshing loads.
- Attachments to the tank including platforms, piping, mechanical and electrical components shall be fixed so as to resist horizontal earthquake forces in accordance with AS1170.4, Section 5.
- Check the effect of sloshing of water within the tank and its load on the tank structure walls and roof (where sloshing exceeds tank freeboard water will impart an upward force on the roof)

The size of reinforcing should be chosen recognising that cracking can be better controlled by using a large number of smaller diameter bars rather than fewer large diameter bars.

Lapped splices are acceptable in tension ring reinforcement of circular tanks provided that

- Splices are staggered horizontally around the perimeter of the tank by not less than 1000mm,
- Splices should not coincide in vertical arrays more frequently than every third bar,
- Lap lengths extend 50% further than the minimum requirements of AS3600.

Given SA Water's preference for reducing the number of joints in tanks and the high temperature differentials in South Australia, the 25% reduction in minimum reinforcement ratio allowed under section 3.2.2 of AS3735 is <u>not</u> permitted to be used in design of SA Water tanks.

Tank Floor Slab

Concrete tank floor slab design shall comply with the following;

- A floor thickness not less than 150mm
- The tank floor shall have a 1 in 200 fall from the centre of the tank towards the perimeter of the tank. (allows for easier cleanout of the tank)
- There shall be no abrupt changes of level in the tank floor, including at columns and perimeter beams.
- The number of construction joints shall be kept to a minimum.
- The number of columns supporting the roof shall be kept to a minimum
- There are no movement joints in the floor slab
- Joints around inlets and outlets must contain waterstops
- A 0.2 mm thick polyethylene membrane shall be provided on all ground surfaces in contact with new concrete in accordance with AS 2870 with joints lapped a minimum of 200 mm and sealed with an approved 75 mm wide pressure sensitive tape.
- Where on rock provide a lean mix concrete base below the tank floor slab. Align any construction joints in the lean mix concrete base with construction joints in the floor slab. Install a 0.2 mm thick polyethylene membrane between the lean mix concrete and the floor slab.
- Consider using cement treated quarry rubble as filling beneath tanks on non-rock sites.
- Inlet, outlet and overflow pipes under the tank floor shall be encased in reinforced concrete.

Post tensioned floor slabs are acceptable provided careful consideration is given to;

- The treatment of underfloor pipe penetrations
- The treatment of floor thickenings
- Provision of slip layers beneath the slab
- Effective corrosion protection of the tendons.

Tank Walls

Concrete tank walls design shall comply with the following;

- A minimum wall thickness of 180mm for tanks walls less than 3m high
- A minimum wall thickness of 300mm for tank walls greater than 3m high
- A 65mm cover to reinforcement from the water retaining face
- A 50m cover to reinforcement from the external face
- The tank walls shall be vertical internally with no corbel at the top
- Eliminate penetrations through the walls of the tank whenever possible
- The liquid retaining face of the walls shall have a class 2 finish as a minimum in accordance with AS 3610.
- Tank walls shall not be buried or backfilled against unless specified otherwise by SA Water.

Concrete tank walls may be precast. It has however been the experience of SA Water that the detailing and construction of joints at the wall to wall and wall to floor junctions has not been adequate in the past and required significant rework on site and input from SA Water to resolve watertightness issues. Joint details shall ensure that adequate space is provided at in-situ stitching sections for reinforcement, waterstops and the concrete without the concrete becoming honeycombed or boney. Refer also to the comments on joints and waterstops below. Unbonded tendons are not permitted except in special post-tensioned systems where the tendons are protected by a non-corrodible duct packed with insoluble, non-corrosive grease.

Joints, Waterstops and Sealants.

Joints in tanks are critical to the performance of the structure. Problems with joints are the main cause of tank leakage. SA Water recommends the adoption of simple robust detailing at tank joints. The following is required;

- Only PVC waterstops of the type outlined in TS2 shall be specified,
- Placement of concrete around waterstops shall be in accordance with TS2,
- Hydrophilic waterstops are not permitted,
- Flexible bearings under tank walls are not permitted,
- Sealants shall not be relied upon as primary seals,
- Vertical joints are not permitted in tank walls,
- Construction joints shall be detailed in accordance with AS3735 and TS68.

Tank Pipework

Consideration shall be given to ensuring water circulation in the tank and the regular turnover of stored water in the tank by the elimination of dead storage pockets. Where possible space the inlet and outlet pipes on opposite sides of the tank or consider the addition of flow deflectors to the pipe inlet. The designer shall advise and discuss water quality issues with the SA Water *"Water Quality Improvement Group."*

The inlet, outlet and overflow pipes below the tank floor shall be MSCL encased in reinforced lean mix concrete with a minimum cover of 230 mm around the pipe.

Stainless steel gratings shall be fitted over the inlet and outlet to the tank. The gratings shall be trafficable and removeable and not dislodge under normal operation.

The inlet pipe shall be flush with the tank floor. The designer/contractor shall consult with SA Water regarding the requirement for a mud ring on the tank outlet. If required, a fibreglass or stainless steel mud ring rising 150 mm above the tank floor level shall be fitted to the tank outlet.

A scour shall be provided off the main inlet pipe. The scour shall be connected to the tank overflow main.

A tank overflow system comprising a vertical overflow pipe with bellmouth, overflow main and outlet with dissipater shall be provided. The overflow pipe and bell mouth inlet inside the tank may be GRP. The manufacturer and/or design engineer shall determine the wall thickness and details of the GRP construction allowing for the possible external only or external and internal water pressures on the overflow pipe.

Pipework Materials

All pipework below tanks shall be mild steel concrete lined pipe (MSCL). Specials shall be fabricated from Grade 250 mild steel in accordance with AS 1579 and lined internally with cement mortar in accordance with AS 1281. Inlet, outlet and overflow pipes under the tank floor shall be encased in reinforced concrete.

Valve Chambers, Thrust & Anchor Block Design

Buried pipework shall be restrained as necessary by valve chambers, anchors or thrust blocks designed and detailed in accordance with TG96. Restrained joint pipe systems will generally not be approved.

The designer shall take account of the following in the design;

- The use of unrestrained or restrained pipeline jointing
- Unrestrained or restrained fixing of the pipeline at valve chamber walls
- Hydraulic forces
- Temperature forces
- Vertical as well as horizontal changes in pipe direction
- Restraint of pipes laid on steep grades
- Flotation effects of high water tables/leaking tanks
- Differential settlement between pipes and valve chambers
- Surge and water hammer effects
- The worst combination of closed and open valves
- Reversal of forces on anchors and chambers

For pipelines up to 300mm diameter valve chambers shall be constructed in accordance with the SA Water "Water Supply Manual".

All valves and pipework shall be installed below the level of the tank base. Reflux valves shall be installed in valve chambers. Valve chambers shall be designed to provide safe and easy entry/exit as well as sufficient working room around the reflux valve for safe and easy maintenance of the valve. As a guide, clearance of approx 1000mm shall be provided between the reflux valve and the chamber walls and the valve shall be installed approx 850mm above the chamber floor.

Where possible, the valve chambers shall be located in areas not subject to vehicle loading. If this is not possible and the valve chamber must be trafficable, the valve chamber design must take account of this.

For pipelines 300mm and greater valve chambers shall be of reinforced concrete construction with a minimum reinforcement cover of 75mm. Non-trafficable valve chamber covers shall have hot dip galvanized covers fitted with hinges and a lifting handle and be capable of supporting a 2.5 kPa live load. Trafficable covers shall be heavy duty, Class "D" to AS3996. Covers shall be fully removable to allow for the entire chamber to be accessed from above. Divide the cover into manageable sections in accordance with OH&S guidelines. Wherever possible valve chamber pits shall be drained to ensure they cannot fill with water.

Pipe End Dissipator Design

Design of the pipe end dissipator at the end of the overflow pipe shall take account of the recommendations of TG104 and provide for safe discharge of tank overflows.

4.2 TANK ROOF DESIGN

A roof shall be provided to completely cover the tank. The tank roof design shall be in accordance with the following;

- The roof shall be designed to have a serviceable life of 50 years
- The tank roof shall be designed as "non-trafficable"
- The roof and roof to tank joint shall not allow dust or vermin to enter the tank
- Water shall not pond on the tank roof
- The tank roof framing shall support the access hatches and service platform requirements outlined in the "Tank Access" part of this specification. All necessary additional trimming and structural framing shall be designed and provided.
- The roof design includes design and detailing of the hatches and service platforms.
- Fixing of the roof shall allow for contraction and expansion thermal movements relative to its supporting members.

- Service platforms shall be designed to support a 2.5kPa uniformly distributed load or a 3.5kN concentrated load.
- The roof framing shall support a central safety harness anchor point and the load it may impart in accordance with AS 1891.4 Industrial fall-arrest systems and devices, Section 3.0.
- The number of columns supporting the roof shall be kept to a minimum
- The columns shall tiedown the roof against uplift under the tank empty condition.
- Rainwater gutters and downpipes (if required by SA Water).
- Roof sheeting shall be installed in single lengths with a spring curved ridge or spring-arched roof profile.
- Concealed fix roof sheeting systems are not permitted.
- Site welding is not permitted.

The designer must properly assess wind speed to AS1170.3 including a topographic factor as tanks are often located atop hills. The roof is to be designed as having a class 4 level of importance in accordance with the Building Code of Australia.

The tank roof shall be constructed from either of the following systems;

Colorbond Aluminium Sheeting and Aluminium Framing

The roof covering shall be colorbond aluminium with a minimum thickness of 0.8 mm. Rafters and purlins shall be aluminium and shall be insulated from the concrete with PVC sheet or other approved insulating material with a minimum thickness of 1.0 mm. The roof shall be fixed with a suitable screw system that makes allowance for thermal movements which are considerably higher than steel. A screw system having oversize washers with slotted holes could be adopted. The designer shall take into consideration that the amount of movement in the roof is likely to increase towards its perimeter and adopt suitably long slotted hole. The screw system shall also meet the requirements of Corrosivity Category C4 to AS 3566.2. Alternatively aluminium hook bolts can be used to fix the roof sheeting. Assembly bolts shall be grade 316 stainless steel. Dissimilar metals shall be isolated.

Colorbond Steel Sheeting and Hot Dip Galvanised Framing

The roof covering shall be BHP steel sheet grade G550 with a base metal thickness of not less than 0.6mm with a Colorbond XRW coating in accordance with AS 1397. The roof shall be separated from the purlins with a PVC capping such as supplied by Australian Plastic Profiles Pty Ltd. The roof shall be fixed to the purlins with 10 mm hot dip galvanised hook bolts or 6 mm 316S/S hook bolts. At side laps and similar situations self tapping screws may be used that meet the requirements of Corrosivity Category C4 to AS 3566.2. Beams and purlins for the roof structure shall be hot rolled. All I beams and channels shall be hot dip galvanised to AS/NZS 4680, minimum coating 750g/m^3. Assembly bolts shall be grade 316 stainless steel.

4.3 TANK ACCESS DESIGN

The requirements for tank access will vary depending upon the tank's size and shall be confirmed with SA Water prior to undertaking the design. Following are the typical requirements for access to tanks of 0.5ML and greater.

- 2.5m x 2.5m sliding through roof access hatch with a fall arrest net and padlock. The sliding hatch shall also be designed such that there is no danger of the person opening the hatch falling through the hatch opening.
- 0.5m x 0.5m hinged inspection hatch with crossbar fall protection and padlock.
- A staircase with landings and balustrade following the curve of the outside of the tank and meeting the requirements of AS 1657 (Fixed platform, walkways, stairways and ladders) and with appropriate security fencing at the base OR an external rung type

access ladder with a lockable guard and toe shield. Where the tank ladder provides access to an intermediate platform, the supports and safety rails of the platform shall be enclosed in anti-climb weld mesh.
- A service platform with guardrails and gates atop the tank.
- A central hitching post meeting the requirements of AS 1891.4 “Industrial fall-arrest systems and devices” for attachment of a lanyard to enable safe inspection of the entire tank roof.
- Safe access from the service platform to the central hitching post.

An internal tank ladder is not required.

A fall arrest net (such as that supplied and installed by Nationwide Netmakers, contact 02-4928-1188) shall be installed beneath the 2.5m x 2.5m sliding hatch opening. The net shall include 2m of trailing rope of each rope size used in the net. The net shall be fixed using 10mm G316 SS eye bolts and spring hooks around the perimeter of the sliding hatch. The safety net system shall meet the British/European Standard BS EN 1263.1:2002, Safety Nets – Safety Requirements, test method.

All handrails shall be designed in accordance with AS 1657. Handrails shall be constructed of the same material as the tank roof structure in order to achieve a similar life span. Steel handrails shall be type ‘Monowills’ or approved equivalent and be hot dipped galvanized in accordance with AS 1650. Site welding is not permitted.

4.4 DESIGN OF SITEWORKS ASSOCIATED WITH TANKS

When undertaking siteworks design site specific considerations shall be taken into account such as;
- Clearances to overhead and underground services
- Effect of cut/fill on adjacent structures or trees
- Existing overland stormwater flows
- Access

Siteworks shall also be designed to ensure the following is provided as a minimum;
- A level platform at the nominated height suitable to support the tank foundations and base slab taking into account the tank design requirements and geotechnical conditions.
- A minimum 1m wide concrete walkway immediately around the tank perimeter with appropriate cross fall, jointing and sealing.
- A minimum 4m wide all weather access track from the adjacent roadway that allows a 12.5m heavy rigid vehicle in accordance with AS2890.2 to access the tank.
- An all weather hardstand area extending a minimum 3m all around the tank that connects to the all weather access track.
- Grading of the site to ensure roof and site water drains away from the tank foundations so as not to adversely affect the tank base or subgrade.
- Safe discharge of stormwater that does not affect adjacent properties
- Safe discharge of tank overflows
- Stable embankment slopes at grades to suit the material type.

Cut off drains shall be provided at the base of slopes above tank formation level. The cut off drains shall grade to ensure ponding of water does not occur between the tank and the embankment. Good drainage of the site is especially critical where tanks are not founded on rock.

Tanks shall be founded uniformly. A bench beneath a tank made by cut and fill of the site is not acceptable. Any soft areas shall be excavated and replaced with low strength concrete, particularly over rock of varying depth or quality.

Section 5: Documentation

5.1 DESIGN COMPUTATIONS

A set of completed computations shall be provided to SA Water by the tank designers to show that the requirements of this technical guideline and the material referenced within it have been adhered to. The computations shall be clear and legible. The computations shall include a design philosophy and contents page. The computation pages shall be numbered and clearly define each element being designed, the design outcome and code references.

5.2 DESIGN DRAWINGS

Documentation for the construction of the tank and its associated works shall be produced by the tank designers to convey to the construction contractor all the necessary information to enable the works to be constructed in accordance with this technical guideline and the material referenced within it. All drawings shall be produced in accordance with TS 95, the SA Water Technical Standard "Requirements for Technical Drawings"

The following elements shall be shown on the drawings (unless elements are not required by SA Water);

- Tank Floor and Column Layout Plan with floor penetrations
- Wall and Footing Section
- Wall, Footing, Floor Joint & Floor Penetration Details
- Floor & Column Section & Detail
- Roof Beam and Purlin Layout Plan
- Roof Beam Details, Connections and Connection Schedule
- Access Ladder General Arrangement
- Access Ladder Details and Connections to Tank
- Intermediate Access Ladder Landing Platforms and Details(where required)
- Access Ladder Cage Elevation and Plan Details
- Access Ladder Guard Front and Side Elevation & Plan Detail
- Sliding Trapdoor and Service Platform Plan
- Sliding Trapdoor Details
- Service Platform and Handrail Details
- Sampling Hatch Detail
- Sampling Pipework Details (if required by SA Water)
- Chlorination System Details(if required by SA Water)
- Inlet and Outlet Pipe Details
- Internal Overflow Pipe Details, fixings, bellmouth and pipe restraint
- Outlet Pipe Grating and Mud Ring Details
- Details of all pipework (above and below ground) associated with the tank
- Valve Chamber and Anchor Blocks Plan and Details
- Site Layout Plan
- Site Grading, Drainage and Pavement Plan
- Pipe End Dissipator, Cover & Scour Protection Plan, Sections and Details

The following information shall be shown on the drawings as a minimum;

- Live loads used in design
- Wind loads used in design
- Earthquake loads used in design

- Class of concrete
- Grade and type of reinforcement or tendons
- Shape and size of each member
- Finish on unformed surfaces
- Class of formwork to AS3610 to formed surfaces
- The size, quantity and location of all reinforcement, tendons and structural fixings and the minimum cover to each
- The curing procedure and duration
- The force required in each tendon, the maximum jacking force to be applied, calculated tendon extension and the order in which tendons are to be stressed.
- The location and details of planned construction joints
- The minimum time before stripping forms
- Any constraint on construction assumed in the design
- Any special protective coatings

Design drawings shall be submitted for review by SA Water for all of the above design elements at the following stages unless noted otherwise;

- 50% complete
- 90% complete
- Construction Issue

Where precast wall panels are proposed to be used the joint details shall be submitted to SA Water for review prior to the 50% completion issue.

5.3 COPYRIGHT AND INTELLECTUAL PROPERTY

In many instances, the drawings will be produced for SA Water and the copyright and intellectual property rights will remain with SA Water. In other cases, drawings will be produced (eg. pumps, valves) where the intellectual property remains with the designer/manufacturer. Unless clearly indicated to the contrary on the drawing(s), SA Water will assume the right to copy any drawing for internal use.

5.4 DESIGN APPROVAL

Acceptance of the design (and any other relevant details) whether expressed or implied, shall not relieve the Design Consultant, Design Engineer, Certifier, Contractor or Sub-Contractor of any of their obligations under the contract, nor of the responsibility for the correctness of the details submitted.

Section 6: Specification

6.1 GENERAL

A specification for the construction of the tank and its associated works shall be produced by the tank designers to convey to the construction contractor all the necessary information to enable the works to be constructed in accordance with the designer's requirements, this technical guideline and the material referenced within it. The specification shall as a minimum incorporate the requirements as set out below.

6.2 GEOTECHNICAL

It is the responsibility of the contractor to verify the geotechnical report on site and advise the Design Engineer of any variations in the ground conditions to those identified in the report supplied or subsequent commissioned reports. The Design Engineer shall recommend any modifications to the design or construction procedures to ensure the foundations for any and all parts of the work are acceptable. Should any unforeseen geotechnical conditions be revealed during the construction that will affect the tendered price or the design in any way, the Contractor shall immediately advise the Superintendent's Representative.

6.3 CONTRACTOR'S SUBMISSIONS

The contractor shall submit the following information, and where material and services are to be procured, samples and information on service providers shall be submitted two weeks ***prior to order*** of the relevant product or service;

- Supply the name of the proposed ready mixed concrete supplier and proof that they have a certified quality assurance system meeting the requirements of AS/NZS ISO 9001.
- Supply the name of the proposed NATA registered laboratory undertaking compaction testing.
- Submit plans showing the proposed topsoil stockpiling area.
- Submit details of proposed protection of significant trees.
- Submit a sample of the waterstop to be used in the works.
- Submit a sample of the form tie to be used in the wall formwork construction.
- Submit a sample of all types of bar spacers to be used on the project and identify where they are to be used.
- Supply a valid certificate of approval issued by the Australian Certification Authority for Reinforcing Steel (ACRS) showing compliance of the reinforcement to be used on the project with AS4671.
- Supply a Manufacturer's Test Certificate and a Compliance Certificate for high strength structural steel bolts used on the project to AS/ 1252 – 1996
- Submit a sample of the proposed roof sheeting, full width by 150mm long. Supply a test certificate in accordance with Clause A4 of AS1397 for each batch of roofing material delivered to site.
- Submit evidence that the safety net system complies with the British/European Standard BS EN 1263.1:2002, Safety Nets – Safety Requirements, test method.

6.4 SHOP DRAWINGS - REVIEW

All shop drawings shall be reviewed by the Contractor and Design Engineer. A copy of the reviewed drawings with the Contractor and Design Engineer's signatures' and comments shall be sent to SA Water for information.

6.5 SURVEYING

Tank Set-Out

The contractor is responsible for all survey and set-out work. The contractor shall engage a licensed surveyor to personally carry out duties including the following;

1) Prior to construction commencing, establish site boundaries and easement boundaries and the location of the tank in accordance with the drawings and benchmarks.

2) During construction activities to check on;

- the levels of inlet and outlet pipes
- levels of overflow pipe
- grading of the tank floor slab
- verticality of the tank walls
- height and consistency in the level of the rim of the tank
- diameter of the tank and roundness of the tank (if circular)
- straightness of walls and internal angles of tank (if not circular).

3) During construction activities where existing survey marks are in danger of being lost or damaged by construction activities, a new survey mark must be established and coordinated.

Certification of Set Out

The Contractor shall supply SA Water written statements from the surveyor that the required works have been constructed in accordance with the “For Construction” design documents.

6.6 INSPECTIONS

Inspections shall be undertaken by the Design Engineer at the following stages of construction;

- Base or subgrade prior to covering
- Elements to be concealed in the final work prior to covering (eg; inlet, outlet and overflow pipework)
- Reinforcement fixed in place (including on or off-site precast panel construction)
- Completed formwork prior to placing concrete

Inspection reports shall include;

- Date and time of inspection
- Person undertaking the inspection
- Identification of the inspected work or portion of the work
- Requirements for additional work or changes to the inspected work in order for the construction to comply with the requirements of the drawings and specification or the Engineer’s endorsement that the inspected work complies with the intent of the documentation and that construction may proceed.

Copies of all inspection reports shall be supplied to SA Water.

Not withstanding the Design Engineers inspections concrete shall only be placed in the presence of the Superintendent's Representative and the Contractor shall give not less than 48 hours (not including weekends or public holidays) notice of their intention to commence placing. The sequence and procedure of placing and the method of compaction shall be approved by the Superintendent's Representative before placing commences.

6.7 QUALITY CONTROL

Tank Concrete Testing

All testing shall be undertaken in accordance with TS68, "Reinforced Concrete Construction for Liquid Retaining Structures and/or Aggressive Environments".
Testing includes but is not limited to the following:

- Laboratory trial mixing and testing (prior to concrete production)
- Site Trial Mixing (1.0m^3 of approved laboratory mix {per trial} batched at the concretor's production facility and delivered to site)
- Slump Testing on site of every batch
- Wet density test at start of contract and then at every 500m^3
- Dry density on each cylinder taken for compressive testing
- Compressive tests on the trial mix and at the rate of one sample per 25 m^3 and one sample per day if the daily pour is less than 25m^3.
- Production and project assessment in accordance with AS1379
- Drying shrinkage tests at one sample per 100m^3 (or part thereof)
- Chloride testing on the trial mix and then at every 500m^3 of concrete batched

PVC Waterstop Weld Testing

If satisfactory documented evidence of successful welding of PVC waterstop by the nominated operator in the prior twelve months cannot be provided to the satisfaction of the Superintendent's Representative the test requirements of TS2 shall apply.

Roof Testing

The Superintendent's Representative may test the roof and flashings with water. Any leaks shall be made good immediately by the Contractor to the satisfaction of the Superintendent's Representative.

Water Testing of the Tank on Completion

Testing of the tank shall be undertaken in accordance with AS 3735 with the following additional requirements;

- Testing shall not be carried out until 14 days after the final wall pour has been placed or until 28 days after the first wall pour has been placed, whichever is later. Before testing commences the Contractor shall ensure the inside of the tank and tank pipework are thoroughly cleaned to remove all loose and foreign material. The tank must also be sterilised by SA Water following cleaning but prior to testing.

- The tank shall be tested by filling it with water at a rate of 500 mm per day maximum provided that no defects are disclosed during that time.

- Any defects in the tank shall be remedied by the Contractor, as soon as they are disclosed. Leak repairs if required shall be undertaken in accordance with TS 68 from the water retaining surface of the tank.

- Any cost incurred for discharging water from the tank, to enable repairs to be made, and for refilling the tank shall be borne by the Contractor. Test water shall not be discharged to the overflow pipe.

- The Date of Practical Completion of the tank will be taken as the date on which the tank is accepted by the Superintendent's Representative as having satisfactorily passed the water test

6.8 CONCRETE & REINFORCEMENT

The manufacture, supply, testing and placement of concrete shall be in accordance with TS68, “Reinforced Concrete Construction for Liquid Retaining Structures and/or Aggressive Environments”.

The placing and fixing of reinforcement shall be in accordance with TS68, “Reinforced Concrete Construction for Liquid Retaining Structures and/or Aggressive Environments”.

Concrete members shall be cured such that all concrete surfaces remain moist at all times for at least 7 days or until concrete has attained 75% of the specified strength.

No items including tie wire that could be corroded by the environment shall be embedded in the cover zone. Where hot dip- galvanised reinforcement is used it is subject to the requirements of AS3735 Section C5.3.1.2.

6.9 WATER STOPS

Waterstops shall be installed in accordance with TS2, PVC Waterstop. In particular take care to ensure that PVC waterstops are accurately held in position during concreting and the air is no trapped between the concrete and waterstop.

6.10 ROOFING

All roof sheets shall be laid in single lengths. Sheets which are cut or trimmed to shape shall be left with a clean cut edge with no distortion of the profile or cross section. Cut edges shall be recoated immediately after cutting in accordance with Appendix G of AS 1650. Side laps on the sheets shall be self-locking along the entire length of the sheets. The ingress of dust into the tank shall be prevented by sealing the flutes.

6.11 COMPLETION

All earthworks cut faces and disturbed areas shall be reinstated with a layer of topsoil not less than 150 mm thick to the satisfaction of the Superintendent’s Representative. Remove all temporary works and cleanup the site.