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AUSTROADS TECHNICAL SPECIFICATION ATS 5240

Construction of Cast in Place Piles

Austroads

Contents

1. Scope

1.1 Austroads Technical Specification ATS 5240 sets out the requirements for the installation of piles constructed with cast in place reinforced concrete. It covers both unlined piles and piles with a steel lining.

1.2 This Specification does not cover:

a) design of the cast in place concrete piles;

b) concrete filled driven tubular steel piles where the steel tubes are structural components of the piles and the geotechnical strength is primarily determined by the analysis of the driving energy of the steel tube, which are covered by ATS 5230; or

c) continuous flight auger piles, which are covered by ATS 5260.

1.3 Unless specified otherwise in the Contract documents, the piles must be installed and tested in accordance with AS 2159, as amended by this Specification.

2. Referenced Documents

2.1 The following documents are referenced in this Specification:

Australian / New Zealand Standards	
AS 1289.4.3.1	Methods of testing soils for engineering purposes Soil chemical tests - Determination of the pH value of a soil - Electrometric method
AS 1579	Arc-welded steel pipes and fittings for water and wastewater
AS 2159	Piling – Design and Installation
AS 2436	Guide to noise and vibration control on construction, demolition and maintenance sites
AS/NZS 3678	Structural Steel - Hot Rolled Plates, Floorplates and Slabs
NZS 6803	Construction Noise

Austroads	
ATS 2245	Supply of Controlled Low Strength Material
ATS 5230	Driven Piles
ATS 5260	Continuous Flight Auger Piles
ATS 5280	High Strain Dynamic Pile Testing
ATS 5310	Supply and Placement of Reinforcing Steel
ATS 5410	Structural Steelwork – Fabrication and Erection

ATS 5315	Supply of Concrete
ATS 5850	Transportation and Erection of Structural Members

ASTM

ASTM D5882	Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations
ASTM D6760	Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing

International / European Standards

DIN 4150-3	Structural Vibration – Effects of Vibration on Structures

European Federation of Foundation Contractors / Deep Foundations Institute

GSFDP1	Guide to Support Fluids for Deep Foundations

3. Definitions

3.1 In addition to the definitions set out in AS 2159, the following definitions apply to this Specification:

Designer: The Professional Engineer or consultant who is responsible for the design of the piles.

Geotechnical Engineer: A Professional Engineer (or person with other qualifications acceptable to the Principal) with at least 5 years of experience which is relevant to the assessment and verification of pile installation.

Pile Design Documentation: The drawings, procedures, instructions, schedules or similar documentation prepared by the Designer which specify the requirements for installation of the piles.

Piling Supervisor: The Contractor's employee who is responsible for the supervision and control of the piling operations.

Professional Engineer: A person who:

a) has at least 5 years of experience in or structural engineering or geotechnical engineering (as appropriate);

b) is registered on any scheme of registration of engineers prescribed by legislation in the applicable jurisdiction;

c) is appropriately registered or prequalified, if the Principal has implemented an applicable registration or prequalification scheme; and

d) satisfies at least one of the following requirements:

i) is a Chartered Professional Engineer; or

ii) holds a 4-year civil engineering degree from a university that is accredited under the Washington Accord and is registered in a relevant area of practice on the National Engineering Register (in Australia) or the Register of Chartered Professional Engineers (in New Zealand).

3.2 Further to the definition of 'Pile Group" in AS 2159:

a) If the piles are constructed in a secant or soldier pile wall, a Pile Group must not exceed 15 lineal metres of wall alignment.

b) The clear distance between adjacent piles within a Pile Group must not exceed 3 pile diameters.

4. Quality System Requirements

4.1 The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1.

Table 4.1: Quality Plan

Clause	Description of document
5.1	Qualifications and experience of Geotechnical Engineer (unless the Contractor is not required to engage the Geotechnical Engineer).
6.1	Qualifications, minimum training and experience of key personnel piling crew
7.1	Details/procedures for the concrete mix, concrete supply, and where applicable: steel supply, fabrication, handling of the steel piles and/or drilling support fluid.
8.1	Details of the plant and evidence of its capacity to undertake the work.
9.1	If not addressed in the Safety Management Plan, site preparation details and certification from a Professional Engineer.
10.1	Details/procedures for pile construction
10.12	Vibration Mitigation and Monitoring Plan (if applicable)
10.13	Noise Mitigation and Monitoring Plan (if applicable)
11.1	Details/procedures for the use of drilling fluids (if applicable)
17.1	Details/procedures for pile testing

HOLD POINT 1.	
Process Held	Commencement of pile installation.
Submission Details	The Quality Plan must be provided to the Principal at least 10 working days prior to the commencement of pile installation.

5. Geotechnical Engineer

5.1 Unless stated otherwise in the Contract documents, the Contractor must engage a Geotechnical Engineer and ensure that the Geotechnical Engineer complies with this Specification. The Quality Plan must include details of the qualifications and experience of the Geotechnical Engineer.

5.2 The Geotechnical Engineer must:

a) act independently of the Principal, Contractor and any of their sub-contractors, consultants and agents;

b) act with the degree of professional, knowledge, skill, expertise, experience and care which would be reasonably expected of an expert professional providing geotechnical engineering services; and

c) provide copies of all reports and records prepared in connection with this Specification to both the Contractor and Principal.

5.3 The Principal and Contractor must not interfere with or attempt to improperly influence the Geotechnical Engineer in the performance of any of its functions pursuant to this Specification.

6. Contractor's Personnel

6.1 The Quality Plan must include:

a) details of the qualifications and experience of the Piling Supervisor and other key personnel; and

b) the minimum training and experience requirements for the piling crew.

6.2 The Piling Supervisor must:

a) have at least 5 years of experience in the installation of cast in place piles;

b) be on site at all times when pile installation is in progress; and

c) have the authority to ensure that piling operations are undertaken safely and in accordance with this Specification, including the authority to immediately stop drilling operations if necessary.

7. Materials

General

7.1 The Quality Plan must include:

a) the method of verifying that the reinforcing steel and concrete comply with ATS 5310 and ATS 5315 respectively before being incorporated into the piles;

b) if steel liners are used:

i) details of the steel to be used in the liners and the fabrication process;

ii) full details and procedures required for transportation and lifting of the liner required under ATS 5850 (or a cross reference to these details and procedures); and

c) if drilling support fluid[1] is used:

i) details of its properties,

ii) evidence that it has previously been successfully used in the anticipated soil conditions and with the proposed method of pile hole excavation,

iii) certification from a Professional Engineer (independent of the Contractor) and the Designer (or other evidence acceptable to the Principal) that the use of the drilling support fluid will not compromise the strength and durability assumed in the design of the pile; and

iv) the method of disposal and any environmental approvals necessary.

7.2 Reinforcing steel must comply with ATS 5310.

7.3 Concrete must comply with ATS 5315.

1 Drilling support fluid may only be used if permitted in the Contract documents. Refer Clause 9.12.

7.4 All steel liners must:

a) be sufficiently robust and will not deform under the lateral pressure in the bored hole to enable the pile to be installed in accordance with the requirements of this Specification;

b) have an inside diameter which is not less than the nominal diameter of the pile specified and is sufficient to ensure that the specified concrete cover is maintained at all times;

c) have an out-of-round measurement (i.e. difference in measurements of two diagonals at right angles) of a liner less than 20 mm, provided that the concrete cover specified on the Pile Design Documentation is maintained; and

d) be manufactured so that the centre of any cross-section of the liner along the full length of the liner does not deviate more than 10 mm from the longitudinal axis of the liner and provided that the specified concrete cover is maintained.

7.5 Subject to Clause 7.6, the following applies if permanent steel liners are specified in the Pile Design Documentation:

a) The steel must comply with AS/NZS 3678 and be Grade 250 or higher.

b) The liners must be fabricated from steel plate rolled to a circular cross-sectional shape and welded at the longitudinal joint to form segments which are then shop spliced into suitable lengths.

c) The welds for the longitudinal joints and shop splices must be full penetration butt welds. The longitudinal joints for adjoining segments must be staggered by 90° to each other. The outside of the circumferential welds must be finished flush with surface of the tube.

d) The steel fabrication must comply with ATS 5410, Construction Category CC2.

7.6 If the liner diameter is less than 1.0 m in diameter, spirally welded liners in accordance with AS 1579 may be used in lieu of liners complying with Clause 7.5. Spirally welded liners may be used for piles of any diameter if the pile is rotated, vibrated or pushed into position without driving.

7.7 If temporary steel liners are used, the Contractor is responsible for the design and fabrication of liners which enable the piles to be installed in accordance with the requirements of this Specification.

Drilling Support Fluids (where applicable)

7.8 Any drilling support fluids used must be biodegradable. The type of drilling support fluid must be suitable for the soil conditions in accordance with the recommendations in GSFDP1 (or an alternative publication approved by the Principal).

8. Pile Installation Equipment

8.1 The Quality Plan must include:

a) details of the make, model and relevant details of proposed equipment for pile construction; and

b) evidence of its capacity to carry out the work, including boring, driving/extracting the steel liner (if applicable) and excavating soil and/or rocks from the interior of the pile.

8.2 The pile installation equipment must have:

a) the required capacity to construct the pile in accordance with the requirements of this Specification; and

b) the capability to excavate a minimum of 3 m or 3 pile diameters (whichever is the greater) below the lowest pile toe level shown in the Pile Design Documentation.

9. Site Preparation and Management

General

9.1 The Work Health and Safety Management Plan or Quality Plan must include details, procedures and/or Safe Work Method Statements for:

a) the preparation of the Site (including the working platform) for safe working;

b) control of the site to exclude or restrict access;

c) if applicable, any additional requirements for Site earthworks (refer to Clauses 9.7 and 9.8).

9.2 The Contractor must:

a) ensure that the working area for pile driving is safe and stable for the operation of large machinery and meets the requirements of ATS 5850; and

b) submit certification from a Professional Engineer to the Principal that the site meets the requirements of the applicable Work, Health and Safety Legislation.

9.3 If requested by the Principal, the Contractor must submit supporting calculations, including rollover stability analysis, with the certification.

HOLD POINT 2.	
Process Held	Establishment of the piling rig.
Submission Details	Certification from a Professional Engineer that the site meets the requirements of the applicable Work, Health and Safety Legislation must be submitted to the Principal at least 2 working days prior to the establishment of the piling rig on site.

Site Control Zones

9.4 Further to the Contractor's obligations under the applicable Work Health and Safety legislation, the Contractor must undertake a risk assessment to determine control zones to exclude or restrict access in accordance with Table 9.4.

Table 9.4: Site access restrictions

Site control zone	Description	Restrictions to access
Exclusion Zone (EZ):	The high-risk zone in the immediate vicinity of the piling augur/hammer.	No person can enter the EZ while the piling rig is operating.
Rig Operating Zone (ROZ):	The zone around the foundation rig and ancillary equipment.	Restricted to the foundation operators and workers and other approved workers.
Foundation Work Zone (FWZ):	The complete area required by the foundation contractor.	Restricted to foundation operators and workers and other persons authorised under the Contract.

9.5 Each of the site control zones must be defined by temporary fencing or barricading as described in the Safe Work Method Statements. Physical barriers must be in place to prevent accidental entry into any open pile hole.

9.6 Any road within the vicinity of the piling work must be closed to traffic for the period determined to be necessary by the risk assessment. The procedure for closing the road must be included in the Traffic Management Plan.

Site Earthworks

9.7 The Contractor must prepare the Site in accordance with any requirements included in the Pile Design Documentation, such as implementing measures to ameliorate negative skin friction if the piles will penetrate through a newly constructed embankment.

9.8 Where the Site consists of landfill containing refuse, the Contractor must implement any measures necessary to ensure that the piles are accurately installed, without damage, in accordance with the tolerances of this Specification.

10. Pile Construction – General Requirements

Quality Plan

10.1 The Contractor must:

a) install the piles in accordance with the Pile Design Documentation; and

b) ensure that the method of installation does not adversely affect the strength or durability of the piles.

10.2 The Quality Plan must include:

a) documentation showing the sequence of pile installation so as to ensure adequate concrete strength is obtained before commencing installation of adjacent piles;

b) proposed recording forms to be used during installation and testing;

c) details of the installation method, including (where appropriate) procedures, instructions and Inspection and Test Plans for:

i) setting out the piles and monitoring of the piles during construction to ensure that the position of the piles is within the tolerance specified in Clause 18.1;

ii) installation of any steel liners and / or boring of holes;

iii) ensuring that any steel liners remain stable under the actions of lateral loading (such as wind forces, water currents) during and after installation;

iv) construction of the pile hole;

v) monitoring and preventing contamination by ingress of loose material, ground water or mud during pile construction;

vi) cleaning the base / socket of the pile hole and removing dirt and debris;

vii) casting piles underwater, if applicable;

viii) management of hydraulic pressure in “wet” pile holes;

ix) examination of the hole, including details of the equipment to be used and experience of the operator (if required – refer Clause 13.6);

x) the method of placing of the reinforcing cage and the maximum time permitted between the release of Hold Point 3 and the placement of the cage;

xi) the method of ensuring that the specified concrete cover to the pile cage is maintained at all times;

xii) placing concrete – for large piles and in piles passing through gravely soils, this includes the use of a large tremie pipe or multiple tremie pipes equally spaced inside the reinforcing cage perimeter where appropriate;

xiii) the method of withdrawing the tremie pipe;

xiv) how the tremie outlet and concrete levels are monitored;

xv) removal of temporary steel liners without any adverse effects to the pile (where applicable); and

xvi) cutting and breaking back of piles.

d) details of the process to obtain the Geotechnical Engineer's approval of the founding level in accordance with Clause 13;

e) contingency plans for equipment failures during drilling, reinforcement installation or concrete operations, or the interrupted construction process;

f) if required under Clause 10.12, the Vibration Mitigation and Monitoring Plan; and

g) if required under Clause 10.13, the Noise Mitigation and Monitoring Plan.

10.3 If the Contractor proposes to change anything specified in the Pile Design Documentation or the construction methodology in the approved Quality Plan, the Contractor must obtain the endorsement of the Geotechnical Engineer and the Designer before submitting the proposal to the Principal. Any proposal must be accompanied by calculations and / or other evidence validating the proposed change. The Principal is under no obligation to accept any such proposal.

10.4 If the pile diameter is greater than 1.8 m and the piles are to be installed in complex ground conditions (such as where a gravelly layer exists), the Quality Plan must include details of the construction methodology (including concrete technology) to ensure that a conforming pile will be constructed. Adequate evidence showing that the entire pile hole shaft and base will not collapse during execution must be included in the Quality Plan, as well as stability calculations for any unsupported length of the pile.

Pile Installation

10.5 The Contractor must ensure that daily records of all stages of the pile construction process are kept for inclusion in the Pile Installation Records (refer Clause 18.5). The records must be signed by the Piling Supervisor. The operating parameters of the drilling rig (where applicable) must also be recorded when excavating the first pile hole of each Pile Group or if there is change in conditions when excavating a subsequent pile hole.

10.6 The water resulting from the piling operations must be collected, treated and disposed of in accordance with the environmental management requirements specified in the Contract documents.

10.7 Prior to the commencement of the first pile in each pile group, the Contractor must submit certification to the Principal that the pile locations have been set out in accordance with the Pile Design Documentation.

HOLD POINT 3.	
Process Held	Commencement of installation of the first pile in each pile group
Submission Details	Certification of pile locations must be provided to the Principal at least 1 working day (not less than 24 hours) prior to the commencement of installation of the first pile in each pile group.

10.8 At a minimum, the Geotechnical Engineer must be on site during the excavation of each pile hole and for the inspection of each base/socket (where applicable).

WITNESS POINT 1.	
Process	Installation of each pile
Notification Period	At least one working day (not less than 24 hours) prior to the commencement of pile installation.

Noise, Vibration and Property Damage

10.9 The Contractor must ensure that the pile construction process does not result in damage to adjacent newly constructed Works, utility services or existing structures.

10.10 Where newly constructed Works or other property may be damaged by the pile installation process, the Contractor must:

a) comply with any requirement specified by the Designer in regard to the prevention of damage to the Works or other property;

b) provide evidence that a suitably experienced Professional Engineer has assessed the effect of the pile installation on the Works or other property; and

c) comply with any recommendation from the Professional Engineer in regard to the prevention of damage to the Works or other property.

10.11 Unless approved otherwise by a Professional Engineer or Designer, pile installation must not commence until the requirements of Table 10.11 have been satisfied.

Table 10.11: Pile installation in the vicinity of a newly concreted pile

Clear distance between the pile under construction and a newly concreted pile	Restriction on construction of new piles
≤ 2.5 m	At least 12 hours has elapsed since the concrete was placed in the pile and it has attained a strength of at least 10 MPa
> 2.5 m and < 9 m	At least 12 hours has elapsed since the concrete was placed in the pile

10.12 If specified in the Contract documents, or if adjacent structures may be damaged by pile construction activities, the Contractor must identify and assess the location of any nearby vibration sensitive structures and develop an appropriate Vibration Mitigation and Monitoring Plan in compliance with AS 2436 or DIN 4150-3.

10.13 If specified in the Contract documents, or if adjacent residents or businesses are likely to be adversely affected by construction noise, the Contractor must identify and assess the location of any nearby noise sensitive structures and/or populations and develop an appropriate Noise Mitigation and Monitoring Plan in compliance with AS 2436 or NZS 6803 (as appropriate).

11. Use of Drilling Support Fluids

11.1 Drilling support fluids may only be used for support of the pile hole if permitted in the Contract documents. If drilling fluids are used, the Quality Plan must include additional details / procedures for:

a) if a polymer-based drilling fluid is used, the applicable test methods, test frequencies and acceptance values for the properties listed in Section 8 of GSFDP1 (or an alternative publication approved by the Principal);

b) managing, cleaning and recirculating the drilling fluid;

c) inspecting the base of the hole to verify that it is clean in accordance with Clause 13.6;

d) cleaning the base of the hole (including removal of material that may dragged in from the sides of the hole during the placement of the reinforcing cage); and

e) during extraction of the auger, ensuring that the hydraulic head in the excavated pile hole will balance the groundwater level (allowing for artesian head if it exists) and suction pressure does not form below the auger.

11.2 Any drilling fluid must:

a) be approved by the Designer and the Principal;

b) not impair the bond between the pile reinforcement and the placed concrete;

c) be easily displaced during pile hole concreting so that the interface layer is carried up to the surface on top of the rising concrete; and

d) be used in accordance with the manufacturer's instructions and the recommended practice described in GSFDP1.

11.3 If bentonite is used, the slurry must be fully hydrated prior to its use and conform to Table 11.3. The slurry must not be left in a completed pile hole for more than 2 hours without agitation.

Table 11.3: Bentonite slurry properties

Property	Test method	Fresh bentonite	Working bentonite (1)	Before concrete placing (2, 3)
Density	ASTM D4380	< 1.10 g/cm3	< 1.25 g/cm3	< 1.15 g/cm3
Marsh Funnel Viscosity	ASTM D6910	32 – 50 seconds	32 – 60 seconds	32 – 50 seconds
Fluid Loss	ASTM D5891	< 30 cm3	< 50 cm3	< 30 cm3
pH	AS 1289.4.3.1	7 – 11	7 – 12	7 – 12
Sand Content by Volume	ASTM D4381	Not applicable	Not applicable	< 4%
Filter Cake	ASTM D5891	< 3 mm	< 6 mm	Not applicable
Test Frequency		Before use, and at least 1 per day	Before use, and at least 1 per pile per day	Before each concrete placing

Notes:

1. *Bentonite slurry that is fully or partially recycled, i.e. other than the first feed from bentonite hydration storage tanks.*
2. *Refers to bentonite slurry inside pile hole just before concrete placing.*
3. *Sample taken from bottom of pile hole.*

11.4 If the use of polymer-based drilling fluid is proposed, a trial pile must be constructed prior to the construction of the first pile in a pile group to verify the suitability of the drilling fluid. If not specified on the Pile Design Documentation, the proposed location of the trail pile must be approved by the Geotechnical Engineer.

12. Installation of Steel Liners

General

12.1 This Clause 11.4 applies to piles where a steel liner is used during the installation of the pile.

12.2 If a permanent steel liner is shown on the Pile Design Documentation, the steel liner must not be removed. Refer to Clause 16 where a temporary steel liner is to be removed.

12.3 Liners must be supplied to the site in the longest lengths possible, commensurate with the overall length of the pile and the transport facilities available.

12.4 The liner must be marked at intervals, not more than 1.0 m apart, which enable the depth of penetration of the liner into the ground to be clearly seen during installation.

Prebored Holes for Steel Liners

12.5 The use of preboring to assist with the installation of steel liners is subject to the following:

a) the Designer has assessed the effect of preboring on the geotechnical strength of the pile and has approved the use of preboring;

b) a copy of that assessment has been provided to the Principal and the Principal has also approved the use of preboring;

c) the material insitu is of a consistency, cohesion and strength such that the hole is be self-supporting until such time as the liner is inserted;

d) the diameter of a prebored hole has been determined by the Designer and is the diameter of a prebored hole is the minimum size to facilitate insertion of the liner; and

e) safe work measures to prevent accidental entry into the pile hole are in place.

Installation of Steel Liners

12.6 The method of installing a steel liner must comply with any requirements specified in the Pile Design Documentation. If nothing is specified, steel liners must be installed by driving or sinking. The liner must be open-ended ended and the excavation of material from inside the steel liner must be such that no significant disturbance is caused to the adjoining ground.

12.7 The toe of the lining must be kept a minimum of 2 pile diameters ahead of the excavation so that the excavation will not cause significant disturbance in the adjoining ground. The alignment of the lining must be controlled with sufficient accuracy to ensure that the drilling head can be inserted and withdrawn without fouling against the liner.

12.8 If splicing of liners is required, the welded connection must be full penetration butt welds over the whole cross-section. Welding must conform to ATS 5410, Construction Category CC2 or better.

12.9 The inside of the steel liner must be cleaned and be free of any projections (such as weld backing bars) which could be an obstacle to the positioning of the reinforcement cage for the piles or the proper completion of the pile.

12.10 Where the founding layer is on a slope, or in ground that is comprised of variable materials, the Contractor must ensure that the toe of a permanent liner toe is fully embedded in the founding layer.

12.11 Any gap between a permanent steel liner and the ground surrounding the liner must be completely backfilled using flowable fill (i.e., controlled low strength material) in accordance with ATS 2245. The flowable fill must be piped to the base of the prebored hole and the gap filled from the base upwards. Fill must be inserted at a minimum of three points equally spaced around the liner circumference. If the pile is not subject to high lateral loads, the Contractor may submit a proposal to Principal to use sand which is compacted by flooding to fill the gap. The Principal is under no obligation to accept any such proposal.

12.12 The Contractor must record and measure the operating parameters of the drilling rig when installing the liners and submit the records to the Principal in accordance with Clause 18.

13. Pile Founding Level

General

13.1 If during construction of a pile, the founding material is found to be weaker than that assumed in the Pile Design Documentation or shown in a geotechnical investigation, the Geotechnical Engineer

may direct that the design of the pile is changed. Unless the Principal is responsible for the provision of the Pile Design Documentation, the Contractor must submit details of the proposed revised pile design to the Principal. Any such change to the design must be approved by the Geotechnical Engineer and the Designer.

13.2 If during construction of a pile, the material is found to be significantly stronger than that assumed in the Pile Design Documentation or shown in a geotechnical investigation, the Contractor may submit a proposal to the Principal to change the design. Any such proposal must be approved by the Geotechnical Engineer and the Designer. A report of an investigation borehole in the pile hole base to a minimum depth of 5m below the proposed new pile toe level to confirm that the underlying material will meet the design requirements must accompany the proposal. The Principal is under no obligation to accept any such proposal.

13.3 Where specified, after completion of the pile hole, the founding material must be excavated to obtain a rock socket of the depth in the class of rock or founding material specified on the Pile Design Documentation.

13.4 If the pile is designed to be founded, belled and/or socketed into rock, the surfaces must be free of debris and surface smear. If specified in the Pile Design Documentation, the base and side walls of the rock must be roughened to expose intact rock.

13.5 The founding level of each pile must be approved by the Geotechnical Engineer.

Inspection and Condition of the Pile Hole

13.6 A remote downhole inspection of each pile must be carried out, unless specified otherwise in the Pile Design Documentation or the Geotechnical Engineer waives this requirement.

13.7 To the extent practicable, the purpose of the inspection may include all or any of the following:

a) verify the dimensions of the base, socket and/or bell (as applicable);

b) verify that the pile hole has been prepared and cleaned in accordance with this Specification; and

c) record the characteristics of the soil or rock, such as lithology, degree of weathering, and the spacing and orientation of any shear planes or defects within the section of the pile hole without a steel liner.

13.8 A remote downhole inspection must be carried out using a borescope camera or similar device. This device must:

a) be waterproof and capable of recording high-resolution images;

b) be controlled by a display monitor at the surface with the capacity to record data for records such as pile identifier, date, time, operator’s name and pile depth;

c) use a variable-intensity light source which be adjusted to give true colour images and is positioned to enable a perception of depth and surface texture;

d) be equipped with a remote-controlled compressed air nozzle for blowing away any drilling sediments; and

e) be able to be able to be moved to view horizontally (for sockets) and vertically (for the base) by means of a telescopic or articulated pole, push rod or some other controlling device.

13.9 Remote downhole inspections must use a means of calibrating depth and position on circumference, such as a calibrated rod or tape measure lowered to the base and extending the length of the socket.

13.10 If directed by the Geotechnical Engineer, the Contractor must dewater the pile hole and clean it to the extent practicable to enable the inspection to take place. Where a pile cannot be dewatered, cloudy and turbid water may be replaced with clean water to improve visibility for the camera operation underwater.

13.11 In the event that any of the following occur, the Principal may request the Contractor to submit a proposed alternative methodology to assess or reconstruct the pile hole:

a) the pile hole collapses or deforms; or

b) there is ingress of deleterious materials (such as sand, slit, gravel or mud).

13.12 If the Geotechnical Engineer is not satisfied that the pile has reached a level at which the required geotechnical strength has been achieved or the pile hole is not sufficiently clean, the Contractor must extend the pile or take other remedial action.

13.13 The Geotechnical Engineer may direct that test holes are drilled in the pile hole base to verify that the strata underlying the pile hole meets the anticipated strength requirements.

13.14 The following must be submitted to the Principal in accordance with Clause 18:

a) a copy of the Contractor's quality records for construction of the pile hole, including the founding level, signed by the Piling Supervisor;

b) complete records of all inspections; and

c) where practicable, the dimensions of the base, socket and/or bell (as applicable), level of the toe of the permanent steel liner (where applicable) and the characteristics of the founding soil or rock.

Certification

13.15 Once the Geotechnical Engineer is satisfied that the pile hole meets the requirements of this Specification and will achieve the required geotechnical strength, the Geotechnical Engineer must promptly issue an unconditional certificate to the Contractor and to the Principal stating that the pile hole meets the requirements of this Specification.

HOLD POINT 4.	
Process Held	Placement of reinforcing.
Submission Details	Certification from the Geotechnical Engineer that that the pile hole meets the requirements of this Specification must be provided to the Principal prior to the placement of reinforcing and the concrete.

13.16 The reinforcement and concrete must be placed as soon as practicable after the release of Hold Point 3, and in no case more than the time specified in the approved Quality Plan. The pile hole sides and base must be kept in a clean and stable condition, without contamination, softening or collapse until the steel reinforcement and concrete is placed.

13.17 If more than 24 hours elapse after the release of Hold Point 3 without the placement of the reinforcing and concrete, the pile hole must be inspected again, cleaned (if necessary) and Hold Point 3 will reapply.

14. Reinforcement

14.1 The reinforcement must be placed and fixed in accordance with ATS 5310 and this Specification.

14.2 The spacers attached to the cage must be of an approved type and capable of providing the specified concrete cover and maintaining the cage centrally along the longitudinal axis of the pile hole, over the whole length of the pile, after placement and during concreting.

14.3 Where necessary, particularly for raked piles, cages must incorporate provisions for inserting and removing the tremie pipe without the risk of it being snagged.

14.4 The reinforcement cage must be cleaned of all loose material and any material that does not form part of the cage before and after the reinforcement cage is placed.

WITNESS POINT 2.	
Process	Inspection of the reinforcement cage prior to placing into the pile hole and the placement of concrete
Notification Period	The Principal must be notified at least 2 hours prior to the proposed placement of the reinforcement cage into the pile hole.

15. Placing Concrete

General

15.1 Prior to commencement of concreting, the length of the pile from the base must be measured and the socket walls and pile base checked to verify that the condition has not deteriorated since the release of Hold Point 3.

15.2 The concrete must be supplied in accordance with the requirements of ATS 5315.

15.3 The concrete mix must be designed for placement in a cast-in-place pile and address:

a) limiting the excessive bleeding of water;

b) suitability of the combined aggregate grading curves (particularly in the sand component); and

c) the use of appropriate admixtures and the retention of adequate workability during placement.

15.4 The concrete must be of such consistency and be placed in such a manner that:

a) pockets of air, water or ground materials are not entrapped in the concrete;

b) the concrete is homogeneous and achieves its specified strength;

c) supply of concrete is effectively continuous; and

d) the space between the reinforcement and the side wall of the pile hole are completely filled with sound concrete.

15.5 To assist compaction by hydraulic head, the rate of placing the concrete must not be less than 10 m of pile length per hour. Concrete supply must be effectively continuous with delays between concrete delivery trucks of 15 minutes or less, unless an approved specific retarded mix design has been developed to allow for longer delays, as in remote areas.

Method of Placement

15.6 Unless specified otherwise in the Contract documents, a tremie method must be used to place the concrete. If specified in the Pile Design Documentation, a trial pile must be constructed to demonstrate that the concrete can be successfully placed in accordance with this Specification.

15.7 The tremie tube(s) must be capable of discharging the concrete at a rate which is suitable for the pile size and site conditions. A hopper must be attached to the tremie pipe and all joints must be watertight. The hopper and tremie pipe must be clean.

15.8 The Contractor must ensure that the concrete is not contaminated. Taping a steel plate to the tremie outlet is an acceptable method for preventing contamination to the first charge of concrete, but the use of a vermiculite plug for this purpose is not permitted. The tremie pipe must be extended to the base of the pile hole before the tremie is charged with concrete.

15.9 Concreting must not commence until the tremie pipe is fully charged. The outlet of the tremie pipe must not be lifted from the bottom of the hole until the hole has been filled with a minimum of 2 m

depth of concrete. Thereafter, concreting must be kept a minimum of 2 m below the top surface of the concrete and the Contractor must continuously monitor and ensure that the 2 m depth of embedment is to be maintained at all times.

15.10 The rate of withdrawal of the tremie pipe during concreting must be pre-determined by the Contractor based on the actual pile hole diameter and the rate of concrete delivery.

15.11 A tremie pouring record must be kept during the tremie pour and included in the Pile Installation Records (refer Clause18). The tremie pouring record must include:

a) the level or depth (from a point of known height);

b) depth of the base of the pile;

c) time pour started;

d) arrival time of each truck;

e) level or depth to the top surface of the concrete at the start of delivery from each truck;

f) level or depth to the top surface of the concrete and time when the tremie is shortened;

g) the length of tremie kept below the top surface of the concrete during the shortening operation; and

h) the estimated quantity of material allowed to flow to waste at the end of the process.

15.12 If the Contractor considers that the pile hole is dry, it may submit a proposal to the Principal to use a placement method other than a tremie pipe; however, the Principal is under no obligation to accept any such proposal. At a minimum, the proposal must address the methods for:

a) lifting and/or shortening the delivery hose/pipe quickly with delays no longer than 10 minutes;

b) ensuring adequate compaction;

c) preventing the concrete falling onto the reinforcement cage; and

d) minimizing segregation in raked piles.

15.13 Concreting must be continued until sound concrete appears a minimum of 400 mm above the required cut-off level.

15.14 If the placement of concrete underwater ceases at any time before completion of the pile for a period of more than 45 minutes, the Geotechnical Engineer may direct that concrete placement must cease, the concrete allowed to set for at least eight hours and all non-conforming or uncompacted concrete removed before concrete placement recommences.

Tremie Lifted Out of Concrete

15.15 If the tremie base is accidently lifted out of the plastic concrete in the pile at any stage prior to completion of the pile (‘pull out’), concrete placement must stop and remedial action in accordance with Clause 15.16 or 15.17 (as appropriate) immediately implemented.

15.16 If the pull out is within the socket or in the lower 2 m of the pile hole (within the liner), all concrete must be removed as soon as possible, the reinforcement extracted and the socket re-cleaned and certified in accordance with Clause 13.15. The pile must then be re-concreted and finished.

15.17 The following applies if the pull out occurs at a level which is more than 2 m above the toe of the liner:

a) All contaminated concrete and all concrete within 2 m of the level that the pull out occurred must be removed using a grab or similar device.

b) The concrete removal must be done either immediately following the pull out, when the concrete is still wet, or at least 8 hours after the pull-out when the concrete has partially set.

c) A construction joint must be prepared at the interface between the clean surface of the concrete and the lower face of the subsequent concrete casting.

HOLD POINT 5.	
Process Held	Recommencement of pile concreting after a pull out.
Submission Details	Notification that the construction joint meets the requirements of this Specification must be submitted to the Principal prior to the recommencement of concreting.

16. Extraction of Temporary Liners

16.1 This Clause 16 applies where a temporary liner is used for the construction of an unlined pile.

16.2 The concrete must not become contaminated or the reinforcement cover compromised by soil or rock dislodging from the side of the pile hole during the extraction of the liners. The pile hole must be completely filled up with concrete to the exclusion of any voids.

16.3 The Contractor must ensure that the:

a) concrete is still fluid at close to the original slump during extraction;

b) liner is withdrawn slowly during concreting and the concrete has been poured to a level sufficient to withstand the pressure from the earth and groundwater so that water or soil does not enter from outside the liner;

c) soil pressure at the toe of the liner is balanced by the mass of the concrete within the liner;

d) free surface of the concrete is at least 1.5 m above the bottom of the liner; and

e) direction of pull on the temporary liner aligns with the longitudinal axis of the pile.

16.4 The last section of liner must not be withdrawn until the concreting operation is completed.

16.5 Vibrating liner extractors may be used subject to compliance with statutory regulations (e.g. noise and vibration control) and the Conditions of Contract regarding protection of persons and property.

16.6 A temporary steel liner may be left in place for a notionally unlined pile, subject to:

a) the prior approval of the Designer and the Principal;

b) the liner does not encroach on the minimum socket length and/or the length of the pile required for developing skin friction specified on the Pile Design Documentation (if applicable); and

c) the minimum cover to reinforcement specified on the Pile Design Documentation is maintained.

17. Pile Testing

General

17.1 If the following information has not been previously provided in accordance with ATS 5280, the Quality Plan must include:

a) details of the testing organization, including names, qualifications and experience of the personnel underrating the testing;

b) details of the impact device (including hammer weight and drop height), transducers and any other apparatus used for pile testing;

c) details of equipment used for pile integrity testing;

d) details of how the transducers will be attached to the pile and their location on the pile;

e) details of equipment and software for recording, processing, displaying, analysing and reporting data;

f) where applicable, a procedure for ensuring that equipment is calibrated and evidence that only calibration equipment will be used for the testing;

g) reference to applicable standards for undertaking the testing (for example, ASTM D5882);

h) test methods and/or procedures for preparation and undertaking the testing;

i) details of the record sheets proposed for monitoring results; and

j) if cross-hole sonic logging is used, the following information:

i) number, diameter, location and length of the logging tubes;

ii) procedure for securing the tubes in location during concreting;

iii) grout material details and procedure for filling the tubes after the completion of cross-hole sonic testing.

17.2 The Contractor must ensure that testing to verify that the piles comply with this Specification is carried out in accordance with AS 2159 and this Clause 17.

17.3 A Test Pile must be installed using the same equipment and methodology as the remaining piles.

17.4 Static load testing is not required unless specified in the Pile Design Documentation.

17.5 Where the Principal has in place a scheme of registered or approved of suppliers/systems for undertaking pile testing, the testing must be carried out by a registered or approved supplier/system.

17.6 For piling carried out in New South Wales, the pile testing must be carried out by an approved organisation with approved equipment using an approved dynamic testing system, with subsequent wave equation analysis or signal matching carried out using an approved computer program. Refer to TfNSW TS 01621, available from the TfNSW Standards Portal standards.transport.nsw.gov.au.

17.7 For piling carried out in Victoria, all testing must be undertaken by a pre-qualified consultant in accordance with the Department of Transport Victoria scheme for pre-qualification. Refer: https://www.vicroads.vic.gov.au/business-and-industry/tenders-and-suppliers/contractors-and-consultants/prequalification-scheme.

High Strain Dynamic Pile Testing

17.8 Unless specified otherwise in the Contract documents, at a minimum, high strain dynamic pile testing (HSDPT) must be performed on:

a) any pile designated as a Test Pile in the Pile Design Documentation;

b) the first pile installed in each Pile Group;

c) an additional pile in the first Pile Group to be installed (ie, a total of 2 for that Pile Group);

d) any pile of which the founding level varies by more than 2 metres from the Test Pile for that Pile Group; and

e) immediately following any change in the pile installation equipment or method of installation.

17.9 At least 15% of the total number of piles must be tested by high-strain dynamic pile testing.

17.10 HSDPT must be carried out in accordance with ATS 5280.

17.11 The HSDPT must:

a) be used to establish the installation parameters and acceptance criteria for the other untested piles in the Pile Group; and

b) demonstrate that the pile meets the acceptance criteria specified in Section 8 of AS 2159 and any other criteria specified in the Pile Design Documentation.

Pile Integrity Testing

17.12 Pile integrity testing must be carried out in accordance with AS 2159 using the test method specified in the Pile Design Documentation.

17.13 If the frequency of integrity testing is not specified, the testing must be carried out on the first 6 piles constructed and subject to acceptable integrity test results being obtained, not less than 1 in 3 of the remaining piles thereafter. If any pile fails to meet the acceptance criteria, all piles in the Pile Group must be tested.

17.14 Where applicable to the method of pile integrity testing, the testing must be carried out in accordance with ASTM D 5882. If thermal integrity testing is used, it must be carried out in accordance with ASTM D7949.

17.15 Integrity testing equipment must be capable of checking cross-sectional irregularities in piles and identifying the location of discontinuity and characteristics of any significant anomalies such as voids or contaminants over the full length of the pile.

17.16 Integrity testing must not be carried out until the concrete has achieved a compressive strength of at least 25 MPa and not before 7 days after casting of the pile.

Cross-Hole Sonic Logging

17.17 If cross-hole sonic logging is specified for integrity testing, the testing must be carried out in accordance with ASTM D6760.

17.18 Logging tubes for cross-hole sonic logging must be installed in accordance with the following:

a) The logging tubes must be spaced equally around the perimeter at an equal distance from the pile axis.

b) Sufficient number of logging tubes must be provided such that the testing will be able to cover the entire cross-section of the pile.

c) The tube centre-to-centre spacing must be 0.25 to 0.3 m, unless approved otherwise by the Designer.

d) The logging tubes must be extended to the bottom of the pile hole to enable testing the whole length of the pile.

e) Round steel logging tubes that are watertight and free from contamination (e.g. oil, dirt, loose rust, mill scale, etc.) must be used to ensure adequate bond between the tube and the surrounding concrete. Plastic or PVC tubes must not be used.

f) The diameter of the logging tubes must be appropriate for the sonic logging probes used.

17.19 The logging tubes must be secured to the inside of the main bars of the reinforcement cage. The tubes must be protected against contamination and blockages by sealing the bottom and top ends of the tubes with watertight threaded caps before inserting the cage into the pile hole.

17.20 The logging tubes must be filled with water prior to concrete placement to avoid debonding between the tube and the surrounding concrete.

17.21 Should any of the logging tubes become blocked, the Principal may require drilling new holes or further integrity testing by other means.

17.22 After completion of the cross-hole sonic testing, the logging tubes must be dewatered and filled with pourable shrinkage-compensated grout with concrete strength not less than that of the pile concrete. Filling of the tubes with grout must commence from the bottom of the tube gradually filling up to the top to prevent air entrapment.

Reporting

17.23 Raw data and an initial field estimate of capacity from HSDPT and pile integrity testing must be submitted to the Principal within 24 hours of each test. The final estimate of capacity by Wave Matching must be submitted to the Principal within 3 working days of each HSDPT.

17.24 A full detailed test report must be provided to the Principal within 5 working days of each test. The report must include the pile installation records (refer to Clause 18.6) and the additional information included in Section 7 of ASTM D5882 (where applicable).

17.25 Concrete strength test results (or any other records required by ATS 5315) must be submitted to the Principal within 3 working days of the completion of the test.

18. Pile Completion

General

18.1 The Contractor must verify that the piles have been constructed in accordance with the tolerances in AS 2159, except that the inclination tolerance for vertical piles is 1%.

18.2 At least 24 hours after completion of the concrete pour, the concrete above the level specified on the Pile Design Documentation must be removed as follows:

a) concrete removal is preceded by cutting a circumferential notch, approximately 30 mm deep;

b) explosives must not be used under any circumstances;

c) the top of the pile after concrete removal must be free of laitance and any loose material and have a profile with surface roughness not less than 3 mm;

d) exposed reinforcement is kept clean and is free of damage along the full final length; and

e) where reinforced bars of different diameters are used, the stripped length of the reinforcing bars must be based on the longest of the individual requirements.

18.3 Below the cut-off level, the pile must not be spalled, cracked or damaged.

18.4 Unless specified otherwise in the Contract documents, all excavated material, excess concrete and waste must be removed from the Site.

Installation Records

18.5 All test results, records and reports must be provided in an electronic format which is acceptable to the Principal.

18.6 Pile installation records must be kept in accordance with AS 2159. In addition, the following must be recorded for each pile installed:

a) location in pile group;

b) concrete volume;

c) the reduced level of the pile base;

d) any approval from the Geotechnical Engineer to change the Pile Design Documentation; and

e) traceability for each concrete batch used in the piles.

18.7 The pile installation records must be signed by the Piling Supervisor and provided to the Principal within 12 hours of the completion of the pile.

Certification of Conformance

18.8 Within 15 working days of the completion of a pile or group of piles, the Contractor must submit to the Principal a certificate from the Geotechnical Engineer (or, if the Contractor is not required to engage the Geotechnical Engineer, a Professional Engineer with at least 5 years of relevant experience) certifying that the piling has been constructed and tested in accordance with this Specification.

Annexure A: Hold Points, Witness Points and Records

The following is a summary of the Witness Points / Hold Points that apply to this Specification and the Records that the Contractor must submit to the Principal to demonstrate compliance with this Specification.

CLAUSE	HOLD POINT	WITNESS POINT	RECORD
4.1	1. Commencement of pile installation		Quality Plan
9.2	2. Establishment of the piling rig		Certification from the Professional Engineer
10.7	3. Installation of first pile in each group		Certification of pile set-out
10.8		1. Installation of each pile	
13.15	4. Insertion of reinforcing and concreting of each pile		Inspection Reports and Certificate from the Geotechnical Engineer
14.4		2. Inspection of the reinforcement cage prior to placing into the pile hole and the placement of concrete	
15.17	5. Recommencement of pile concreting after a pull out		Evidence of compliant construction joint
17.23			Test data
17.23			Test report
17.25			Concrete test results
18.7			Installation Records
18.8			Geotechnical Engineer's Certification

Amendment Record

Amendment no.	Clauses amended	Action	Date
-	New specification	New	February 2025

Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed