

Main Roads Technical Standard

MRTS63

Cast-In-Place Piles

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Table of Contents

	Page
1 INTRODUCTION.....	1
2 DEFINITION OF TERMS	1
3 REFERENCED DOCUMENTS	1
4 QUALITY SYSTEM REQUIREMENTS.....	1
4.1 Hold Points, Witness Points and Milestones	1
4.2 Construction Procedures	2
4.3 Lot Size for Testing	2
5 ASSESSMENT OF FOUNDATION INFORMATION	2
6 MATERIALS AND PROCESSES.....	3
6.1 General	3
6.2 Construction Procedures	3
7 FABRICATION OF LINERS	4
7.1 Permanent Steel Liners	4
7.2 Concrete Pipe Liners	4
8 SINKING OF LINERS	4
8.1 General	4
8.2 Liners driven from top	4
8.3 Liners driven by oscillation or vibration	5
8.4 Liners in Pre-Bored Holes.....	5
8.5 Concrete Liners.....	6
8.6 Construction Limitations.....	6
9 TOLERANCES	6
10 EXCAVATION OF CAST-IN-PLACE PILES	6
10.1 General.....	6
10.2 Belling.....	6
10.3 Pile Sockets.....	7
10.4 Certification of Pile Capacity	7
11 GEOTECHNICAL ASSESSMENT	7
11.1 General.....	7
11.2 Geotechnical Assessor.....	7
11.3 Safe Access.....	7
11.4 Dewater and Clean.....	7
11.5 Assessment Methods	7
11.6 Minimum information needed to assess Pile Base Capacity.....	9
11.6.1 General.....	9
11.6.2 Bearing Capacity of Base	9
11.6.3 Ability of Base to sustain Vertical Loads.....	9
11.6.4 Founding Strata has adequate thickness	9
11.6.5 Minimum Bell Area.....	9
11.6.6 Seepage of Water into Pile Excavation	9
11.6.7 Assessment of whether additional information is required	10
11.7 Minimum information to assess Socketed Pile Capacity for dry Piles	10
11.7.1 General	10
11.7.2 Capacity of Base.....	10
11.7.3 Walls of Socket	10
11.7.4 Socket Wall Shear Capacity	10
11.7.5 Presence of Weak Areas in Socket	10
11.8 Stronger Strata than expected in Design	10
11.9 Camera for Dry Pile Inspections.....	11
11.9.1 Features and Capability	11
11.9.2 Non-Conforming Cameras.....	11
11.9.3 Calibration.....	11

11.9.4	Availability on site.....	11
11.10	Certification of Piles that cannot be Dewatered	11
11.10.1	General.....	11
11.10.2	Capacity Reduction Factor for Uniform Socket Material	11
11.10.3	Capacity Reduction Factor for Sockets of Variable Strength Strata	11
11.10.4	Extension of Socket.....	11
11.11	Camera for Underwater Inspection of Pile Base	11
12	STEEL REINFORCING	12
13	CONCRETING	12
13.1	General	12
13.2	Concrete	13
13.3	Slump of Concrete	13
13.4	Placement and Compaction	13
13.4.1	General	13
13.4.2	Concrete Placement in dry conditions	13
13.4.3	Concrete Placement Underwater.....	13
13.4.3.3	Significant delay in concrete placing	14
13.4.3.4	Removal of contaminated concrete at completion of concrete placement.....	14

Cast-In-Place Piles

1 INTRODUCTION

This Technical Standard applies to the construction of cast-in-place, reinforced concrete piles contained in open-ended liners left permanently in place extending to competent rock or hard stratum (referred to as lined piles) for bridges.

The intention of the Technical Standard is that lined piles are cast in dry conditions. Wet holes for placing concrete are only permitted when all methods to have a dry hole have been unsuccessful (for example, extend length of liner and /or grouting).

The base and socket shall be inspected in dry conditions if practical. If the base and socket cannot be inspected dry, then special conditions apply to inspection, capacity, certification and placing of concrete.

The following foundation methods are not permitted for use on Department of Transport and Main Roads' projects –

- a) Piles consisting of driven, closed-end tubes that are later filled with concrete;
- b) Piles using enlarged bases formed by extruding a concrete plug from the base of a liner with an internal drop hammer;
- c) Piles constructed with bentonite or polymer slurry; and
- d) The use of temporary liners that are subsequently removed.

This Technical Standard is not applicable for piles for pad footings, sign gantries and other applications with high moment and low axial loads. (Refer MRTS63A).

This Technical Standard shall be read in conjunction with MRTS01 *Introduction to Technical Standards*, MRTS50 *Specific Quality System Requirements* and other Technical Standards as appropriate (refer Clause 6.1).

This Technical Standard forms part of the Main Roads Specifications and Technical Standards Manual.

2 DEFINITION OF TERMS

The terms used in this Technical Standard shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Standards*.

3 REFERENCED DOCUMENTS

Table 3 lists documents referenced in this Technical Standard.

Table 3 – Referenced Documents

Reference	Title
AS/NZS 3678	Structural steel-Hot-rolled plates, floor plates and slabs
AS/NZS 4058	Precast concrete pipes (pressure and non-pressure)
AS/NZS 1554.1	Structural steel welding – Welding of steel structures
AS 5100.3	Bridge design – Foundations and soil supporting structures
AS 1379	Specification and supply of concrete

4 QUALITY SYSTEM REQUIREMENTS

4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are stated in Clause 5.2 of MRTS01 *Introduction to Technical Standards*.

The Hold Points and Milestones applicable to this Standard are summarised in Table 4.1. There are no Witness Points defined.

Table 4.1 – Hold Points and Milestones

Clause	Hold Point	Milestone
6.2	1. Approval of procedure for construction, excavation, inspection, certification and concreting of piles	Submit procedure for construction of piles (28 days notice period)
10.4	2. Geotechnical certification of pile capacity. Approval to insert reinforcement cage.	
13.1	3. Re-approval of socket / Approval to place concrete.	
13.1	4. Approval of the tremie for underwater concreting including continuous supply and placing of concrete.	

4.2 Construction Procedures

The Contractor shall prepare written procedures for all construction processes as stated in MRTS50 *Specific Quality System Requirements*.

The Contractor shall submit to the Administrator construction procedures in accordance with Clause 5 of MRTS50 *Specific Quality System Requirements* and as listed in Table 4.2.

Table 4.2 – Construction Procedures

Clause	Procedure
6.2	Construction of piles in dry conditions, including sealing and cleaning, inspection and certification. Modified procedure for wet piles, including inspection and certification.
13.4.3	Procedure for placing concrete underwater with a tremie including continuous supply of concrete.

4.3 Lot Size for Testing

The minimum lot size for cast-in-place pile work covered by this Technical Standard is each pile.

5 ASSESSMENT OF FOUNDATION INFORMATION

In assessing the foundation information provided in the tender documents, the Tenderer's attention is drawn to the provisions of the Contract with respect to –

- a) the need for the Contractor to be self-informed of all available information pertaining to the physical conditions upon and below the surface of the Site; and
- b) Latent Conditions.

The borehole drilling logs, cores and the associated reports are available for the Tenderer to make an assessment of the nature of the material when determining the equipment and plant needed. The borehole data represents subsurface information at a specific location only. Information on strata between boreholes is the subject of interpretation and also of the inherent variability of soil and rock strata. Departures from the strata conditions indicated by the borehole information are inevitable.

Subject always to the aforementioned provisions of the Contract, the Contractor shall be deemed to have allowed for such departures as could reasonably be expected.

The Contractor shall make an assessment with regard to the anticipated stability of the socket walls and shall make allowance for any necessary measures required to maintain the stability of the socket during construction.

6 MATERIALS AND PROCESSES

6.1 General

Materials and processes shall conform to the following standards—

- a) Steel for liners As stated on the Drawings but not less than AS/NZS 3678 Grade 250;
- b) Structural steel welding AS 1554.1
- c) Concrete pipe liners AS/NZS 4058 & MRTS25;
- d) Reinforcing steel MRTS71 *Reinforcing Steel*; and
- e) Concrete MRTS70 *Concrete* together with Clause 13 herein.

All reinforcing steel shall be sourced from suppliers certified by ACRS (Australian Certification Authority for Reinforcing Steel).

6.2 Construction Procedures

The Contractor shall submit a procedure for construction, inspection and certification of the piles. The procedure shall give details of the following –

- a) Any preboring proposed shall be detailed and the reasons for such preboring stated. The material is to be stable and safe for preboring. The procedure shall detail the method of grouting the gap between liner and the prebored hole from the base up;
- b) The proposed method of driving or sinking the pile shaft, the equipment to be employed for this operation and the method of sealing the base of the pile against the ingress of water. Such operations shall be safe and practical. For example, pre-drilling all the holes before placing any liners is unsafe and unacceptable. Driving liners to full depth before any excavation within the liner is likely to lead to liner buckling and is therefore unsafe and unacceptable;
- c) The proposed method shall also include an analysis of the maximum hammer input energy of the proposed hammer system to be used to ensure excessive buckling of the liner is avoided. Procedures which could be considered, include limiting the height of drop of the hammer or limiting the mass of the hammer.
- d) The method for excavating the piles, bells and sockets and cleaning the base and socket;
- e) The proposed method of socket construction including details of equipment to be employed, the method of sealing the pile against ingress of water and the method of maintaining stability of the walls. The procedure shall contain specific details on the equipment and methods to ensure the pile base is clean and free of loose material;
- f) A statement of the information required to certify the pile capacity plus any additional geotechnical information to be obtained e.g additional/deeper borelogs, test drilling of the pile base.(Refer to Clause 11);
- g) Procedure for certification of the pile capacity including the methods of inspection to obtain adequate information and the name and qualifications of the Geotechnical Assessor. The procedure shall include the methods of inspection, process of certification to be used, and access arrangements for both dry and wet piles;
- h) The equipment and methods for supplying and placing concrete in dry conditions and underwater if seals cannot be achieved including full details of the tremie and the method of operation; and
- i) The Contractor shall make an assessment with regard to the anticipated stability of the socket walls and shall make allowance for any necessary measures required to maintain the stability of the socket during construction.

The procedure shall minimise the time between any base/socket excavation and certification and placing of concrete.

The completed procedure shall be submitted to the Administrator at least 28 days prior to the date for sinking of pile shafts. **Milestone** Work shall not commence until approval from the Administrator has been received in writing. **Hold Point 1**

7 FABRICATION OF LINERS

7.1 Permanent Steel Liners

Steel liners shall be fabricated in accordance with MRTS78 *Fabrication of Structural Steel Work*, by a Transport and Main Roads prequalified steel fabricator.

Steel liners shall conform to the dimensions and thicknesses shown on the Drawings. Spirally welded liners are not permitted. The leading edge of the liners shall be reinforced as shown on the Drawings.

The inside diameter of the liner shall not be less than the nominal diameter shown on the Drawings, nor shall the out-of-round tolerance exceed 5% of diameter of liner. The outside circumference of the steel liner shall not be less than the nominal circumference calculated from the pile diameter and the liner thickness. Steel liners shall not exceed a bow of 1% of the length of the pile in any direction. Liners shall be free of any internal steps or ridges which may interfere with drilling equipment or catch buckets or personnel during inspections.

Welding shall be carried out in accordance with the provisions of AS/NZS 1554.1.

All longitudinal and transverse welds shall be made with full penetration butt welds. Segments shall be rotated 90 degrees to each other so that longitudinal welds along the liner are staggered.

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

Where field joints between lengths are required, they shall employ full penetration butt welds.

Liners shall be stored and transported in such a manner as to prevent damage. Damaged liners shall be repaired or replaced by the Contractor at no additional cost to the Principal. **Non-conformance**

7.2 Concrete Pipe Liners

Concrete pipe liners shall only be flush joined and shall only be used for relatively shallow piles less than 10 m deep.

Concrete pipe liners shall conform to AS/NZS 4058 and be the length, thickness and class shown on the Drawings. Where required, pipe joints shall be made in place to the details shown on the Drawings. Pipes shall be stored and transported in such a manner as to prevent damage. Damaged pipes shall be repaired or replaced by the Contractor at no additional cost to the Principal. **Non-conformance**

8 SINKING OF LINERS

8.1 General

The founding levels shown on the Drawings are provisional levels and have been determined using foundation information available prior to construction. Following excavation of the liner and inspection of the base (and socket if applicable) by the Geotechnical Assessor, the founding level may be varied (subject to minimum requirements shown on the Drawings) to obtain a watertight seal, achieve the design load capacity and obtain the Geotechnical Assessor's certification.

The sinking of pile liners shall be effected from firm ground, temporary supports, a spudded barge or a fixed platform.

Whatever the method used, it shall provide sufficient rigidity to ensure accuracy of sinking under all conditions of tide, stream flow, and/or hammer blow.

Any liner which is incorrectly located, or damaged, or which shows partial collapse to an extent that materially decreases the load carrying capacity of the pile, shall be rejected removed and replaced, or repaired **Non-conformance**. Remedial measures shall be submitted by the Contractor for the approval of the Administrator. Replacement of any rejected pile or other remedial work shall be at no cost to the Principal.

8.2 Liners driven from top

Liners shall be driven open-ended using a pile driving hammer capable of achieving penetration of the liner to the toe of liner level.

Driving of liners is the preferred method to achieve side restraint. Preboring of liners is only permitted in certain circumstances as stated in Clause 8.4.

Depending on the nature of the material to be penetrated and the driving energy employed, it may not always be possible to drive the liner to level in one continuous operation. In such cases the liner shall be driven progressively, in increments which alternate with excavation of material at the toe of the liner.

Material inside the liner shall be excavated progressively by air lift, grab and/or percussion breaking equipment, rotary drilling or other approved means. Unless specifically allowed elsewhere in the Contract, explosives shall not be used.

In soft material and sand, the leading edge of the liner shall be kept far enough below the excavation to prevent material entering the cavity. In hard strata, it may not be possible to advance the liner ahead of the excavation. Then, the excavation may advance below the liner provided the extent of such advance does not undermine the stability of the hole or the operation of the excavation equipment.

At the terminal level, the liner shall penetrate sufficiently deep into firm stratum to form an effective seal against the entry of material and water into the final excavation.

If hard driving or continual driving after refusal results in damage to the liner, the Contractor shall, at no cost to the Principal, repair and, if necessary, reinforce the top of the liner to ensure transfer of the driving forces from the helmet to the liner. **Non-conformance**

If the liner buckles at the base or along the shaft severely enough that the construction of the pile is prevented, the Contractor shall propose remedial action that shall be subject to approval by the Administrator. No additional payment will be made to the Contractor in the event of any remedial action undertaken. **Non-conformance**

If it is elected to optimize proposed construction procedure by increasing input energy over and above that necessary to drive liners as detailed on the drawings, then a heavier liner to be used to sustain the application of such increased driving energy. Any change to the nominated liner design to be approved and no additional cost will be borne by the Principal as a consequence of this change to liner thickness.

8.3 Liners driven by oscillation or vibration

Liners may be driven using an appropriate rig which oscillates the liner in a horizontal plane, or by a rig which vibrates the liner vertically. Either method shall employ a vertical load applied simultaneously with the oscillations or vibrations.

The toe of the liner shall be kept far enough ahead of the excavation inside the liner to prevent material entering the cavity. At the terminal level, the liner shall penetrate sufficiently deep into firm stratum to form an effective seal against the entry of material and water into the final excavation.

8.4 Liners in Pre-Bored Holes

Placing a liner in a oversized prebored hole removes lateral stiffness and restraint. Preboring shall only be used under the conditions stated as follows:

The diameter of a pre-bored hole shall be of a minimum size to facilitate insertion of the liner. A concrete liner shall be driven or sunk into firm stratum at its base to prevent the entry of water and other material prior to concreting. A steel liner shall be driven for a minimum of 3 m below the prebore into firm strata to achieve a seal and lateral stability at the base.

When indicated on the drawings, the space between liner and hole shall be backfilled using flowable fill or other approved material, using a method that fills the void around the liner completely. Flowable fill shall be piped to the base of the prebored hole and the gap filled from the base upwards. Fill shall be inserted at a minimum of 3 points equally spaced around the liner circumference.

Pre-bored holes may be used to facilitate installation of reinforced concrete pipe liners or steel liners provided that –

- a) Prior permission of the Administrator and the designer has been obtained in writing [**refer to Hold Point 1**];
- b) The material in situ is of a consistency, cohesion and strength such that the hole shall be self-supporting until such time as the liner is inserted, and it is safe to work around the top of the unlined hole. Preboring is not allowed in strata with sand or gravel layers;
- c) Only one hole in a pile group may be prebored at a time. Preboring of an adjacent pile may begin only after the liner is inserted in the previous hole. If the insitu material is stable, preboring may continue on piles more than 2.5 metres clear distance from the adjacent unlined hole; and

- d) The diameter of a pre-bored hole shall be of a minimum size to facilitate insertion of the liner and the liner is driven or sunk into firm stratum at its base to prevent the entry of water and other material prior to concreting.

No additional payment will be made by the Principal for pre-bored holes.

8.5 Concrete Liners

Where concrete liners are used, they shall be supported vertically at the toe at all times.

At any stage during the excavation, the Administrator may restrict the extent to which the excavation is extended below the toe of the liner.

8.6 Construction Limitations

No pile which is located within 2.5 metres clear distance from a newly concreted pile shall be pre-bored, driven or excavated until 18 hours after initial set of the concrete.

No pile which is located between 2.5 metres and 9 metres clear distance from a newly concreted pile shall be pre-bored, driven or excavated until 12 hours after initial set of concrete.

The top of a newly concreted pile shall not be in contact with the driving platform while another pile is being pre-bored or driven from that platform.

9 TOLERANCES

Prior to concreting, the liner shall be located as shown on the Drawings within the following tolerances –

- | | |
|---|--|
| a) Top of pile, in plan | 75 mm in any direction; |
| b) Variation from vertical or designated batter | 20 mm per metre; |
| c) Bow of pile | 1% of length of pile in any direction; and |
| d) Diameter of liner and socket | 0, + 5% of nominal diameter at any position. |

Any piles which are outside these tolerances shall be corrected by the Contractor to the satisfaction of the Administrator at no additional cost to the Principal. **Non-conformance** Correction may include additional reinforcement or increased dimensions of pile caps or additional piles.

10 EXCAVATION OF CAST-IN-PLACE PILES

10.1 General

All cast-in-place piles shall be founded in rock or hard stratum adequate to sustain the applied loads shown on the Drawings.

When the liner is at its anticipated terminal level and the strata immediately below are considered by the Contractor to be self-supporting and not liable to water inflow, the excavation may proceed to the approved founding level. If, during this operation, there is an influx of water and/or material into the excavation, the liner shall be re-driven until a new seal is formed at no additional cost to the Principal.

The pile shall penetrate the founding strata not less than the distance shown on the Drawings. The pile base shall be clean and free of loose material.

Temporary safety shields shall be used where manual work is carried out in unlined holes and sockets as required by the *Workplace Health and Safety Act*.

After completion of the excavation and prior to any inspection, the pile shall be dewatered, the bearing surface thoroughly cleaned of all foreign and loose material, and the surface dressed to level. Pockets or seams of inferior material shall be removed.

Actual foundation levels and bell and socket dimensions shall be determined by the Contractor subject to the minimum requirements shown on the Drawings and the requirements of this Technical Standard.

10.2 Belling

Excavation of the bell shall not commence until the Geotechnical Assessor has inspected the foundation, and nominated the required bell diameter.

10.3 Pile Sockets

Where pile sockets are detailed, the applied load is to be carried by a combination of socket wall friction and base resistance.

The walls shall be clean and free of smeared material. Smeared walls shall be manually or mechanically cleaned and roughened.

10.4 Certification of Pile Capacity

Foundations are to be logged, inspected and certified by the Geotechnical Assessor as set out in Clause 11 prior to casting concrete. The Geotechnical Assessor shall consider the information available and, when satisfied, certify that the factored geotechnical strength is greater than the design loads shown on the Drawings in accordance with AS 5100.3 and the foundation complies with the minimum requirements shown on the Drawings.

The Contractor shall forward a copy of the geotechnical certification of the foundation to the Administrator prior to concreting. Insertion of reinforcement and concreting of the pile shall not proceed prior to the Administrator releasing the hold point. **Hold Point 2**

'As constructed' records of all excavations, including the rock classification, shall be maintained and forwarded to the Administrator.

11 GEOTECHNICAL ASSESSMENT

11.1 General

The purpose of the geotechnical assessment is to confirm that the design requirements have been achieved, and the foundation is safe, adequate and durable.

The Geotechnical Assessor shall select sufficient processes from Table 11.5 to obtain the information needed to certify the foundations using the original geotechnical investigation and reports, any additional investigation and reports undertaken during the Contract and inspection and investigation of the foundation material. Where there is not sufficient information, the Contractor shall undertake additional investigations. [Refer to Clause 6.2 Construction Procedure]

11.2 Geotechnical Assessor

Unless stated otherwise in Clause 1 of Annexure MRTS63.1, the Geotechnical Assessor shall be a geotechnical engineer and shall be an RPEQ. Where stated in Clause 1 of Annexure MRTS63.1, the Geotechnical Assessor may be an engineering geologist with at least 10 years experience in heavy civil engineering foundation design and assessment procedures and shall be an RPEQ..

The name and qualifications of the Geotechnical Assessor shall be submitted to the Administrator at least 28 days prior to commencing pile construction [Refer to Hold Point 1].

11.3 Safe Access

As part of the construction procedures, the Contractor shall undertake a safety and hazard assessment to ensure all procedures are in accordance with the *Workplace Health and Safety Act*.

If the pile capacity assessment and certification requires down the pile access, the Contractor shall provide sufficient equipment and safe transport within the pile for personnel, the Administrator and the Geotechnical Assessor who will certify the pile capacity.

The Contractor shall install an approved safety shield in all unlined sockets greater than 1.2 m long during periods of work or inspection.

11.4 Dewater and Clean

Prior to any assessment requiring the pile to be dewatered, the Contractor shall pump the hole dry using an appropriate sump arrangement and clean the pile base to allow full assessment.

11.5 Assessment Methods

The foundation assessment shall be based on a combination of methods of obtaining data on foundation capacity, as set out in Table 11.5 which gives the different types of information gathered in a geotechnical investigation and the limits to which each piece of information is to be used in the geotechnical certification

process. The drill cores and a copy of the borelogs and geotechnical report shall be kept on site until foundations are completed.

Table 11.5 – Methods of obtaining data for foundation assessment

Process & Information Obtained		Use
1.	Borelogs (Provided a minimum of 3 boreholes or 50% of all boreholes at the bridge site are a minimum of 2 x pile diameters deeper than the pile base and no weak layers are identified).	
	1.1 Borelog > 10 m from pile	Assessing bearing capacity, pile ult.load ≤ 2000 kN.
	1.2 Borelog < 10 m from pile	Assessing bearing capacity, pile ult load ≤ 10,000 kN
	1.3 Borelog at each pile	Assessing bearing capacity, pile ult load > 10,000 kN.
2.	Inspection of material removed while excavating pile	
	2.1 Drill cuttings	Assessing levels of strata of distinctly different types. Not adequate for socket assessment.
	2.2 Rock pieces from drill bucket	Assessing approximate levels of strata, material types, and confirming borehole data. Not adequate for socket assessment.
3.	Visual Inspection – Remote	
	3.1 From surface using mirrors etc. Non-conforming camera in a dry pile (refer Clause 11.9.2)	<ul style="list-style-type: none"> • Is base clean? • Has socket collapsed or deteriorated? • Hole wet or dry.
	3.2 Camera conforming to Clause 11.9.1 used in dry pile.	As for 3.1, plus identification of strata, condition / weathering and roughness of socket walls. Detection of weak bands, faults, intrusions.
	3.3 Camera conforming to Clause 11.11 used in a wet pile	Is the base Clean? Detection of weak bands, faults and intrusions
4.	Visual Inspection – down pile	
	Full inspection of base and socket with torch, tools, sampling, and clear, detailed photos.	<ul style="list-style-type: none"> • Approval of foundation strata for bearing capacity – all loads. • Required bell diameter achieved. • Classification of rock, lithology and weathering. • Defect spacing and orientation. • Bands of weak rock, intrusions, shear zones and fault lines assessed. • Macro weathering profile in three dimensions assessed. • Water seepage assessed (increase in depth with time)

Process & Information Obtained		Use
5.	Test holes in pile base.	
	Drill to 2 x pile diameter deep. Record times / 250 mm penetration.	<ul style="list-style-type: none"> • Confirms strength of base strata, and absence of serious defects in critical stress zone. • Alternate data to Borelogs above. • Required for piles over 5000 kN ultimate if no borelog data.
6.	Pile socket capacity load tests	
	Confirms base and socket capacities to loads of twice the ultimate design load of pile.	<ul style="list-style-type: none"> • Confirms service loads and movements. • Elastic and inelastic settlements. • Confirms ultimate load capacities and movements.

11.6 Minimum information needed to assess Pile Base Capacity

11.6.1 General

For end bearing piles, the following factors shall be assessed using information gathered from the methods listed in Table 11.5, prior to certification of pile capacity.

11.6.2 Bearing Capacity of Base

The bearing capacity of the pile shall be determined by:

- The founding level stratum has been reached and the pile base is embedded into the founding strata by the minimum dimensions shown on the drawings.
- The founding stratum has been identified from the borelogs as having sufficient capacity and samples taken during excavation confirm the base stratum is adequate.

11.6.3 Ability of Base to sustain Vertical Loads

The base shall be free of all loose material/debris immediately before placing concrete.

11.6.4 Founding Strata has adequate thickness

Where borelogs in close proximity to the pile location (at least 50% of abutment and pier locations with a minimum of 3 per bridge site) have not reached a minimum 3 m or two pile diameters below the pile base level, at least one pile base at each abutment and pier location shall be test drilled

The test hole shall be 24 mm minimum diameter drilled to a depth of at least 2.4 metres or two pile diameters, whichever is longer, below the bottom of the excavation to ensure that suitable material persists to that level [refer to Hold Point 2]. The driller shall record the time taken to drill each 250 mm increment of depth, and any “soft spots” of lesser strength required for end bearing pressure. Test Drilling shall be supervised by the Geotechnical Assessor. A written record, clearly identifying the pile number and location, signed and dated shall be supplied to the Administrator.

11.6.5 Minimum Bell Area

If pile belling is required, the pile base has at least the nominal area of the bell determined in accordance with Clause 10.2.

11.6.6 Seepage of Water into Pile Excavation

Where any visual inspection indicates water is leaking into the pile, the rate of leakage shall be assessed. A suitably marked stick or tape measure shall be placed on the base and the depth of water increase per minute shall be recorded for at least 15 minutes.

11.6.7 Assessment of whether additional information is required

For the following situations, the Geotechnical Assessor shall assess whether the information is adequate or whether further information is required prior to certification –

- a) Piles with ultimate design vertical loads on the base exceeding 7000 kN;
- b) Piles with uplift load (ultimate) exceeding 500 kN;
- c) Where the pile group consists of a single pile in a foundation, with no redundancy; and
- d) Where the assessed design ultimate bearing capacity of the founding strata is less than twice the design ultimate bearing stress in the base of the pile.

Where inspection of the pile base indicates material that is weaker than the material assessed in the borelogs and this would alter the design significantly, the changes shall be referred to the designer and shall have approval of the designer and the Administrator prior to finalising the new foundation design.

11.7 *Minimum information to assess Socketed Pile Capacity for dry Piles*

11.7.1 General

For piles that are designed to transfer a proportion of the vertical load into the foundation through shear in the socket wall, the following factors shall be assessed using information gathered from the methods listed in Table 11.5, prior to certification of pile capacity. If the socket cannot be dewatered the provisions of Clause 11.10 also apply.

11.7.2 Capacity of Base

The base capacity shall be assessed as set out in Clause 11.6.

11.7.3 Walls of Socket

After excavation, a visual inspection of the socket walls shall be undertaken to ensure the socket walls are self supporting, and no portion of the wall has collapsed or is likely to collapse. The walls are to be clean and free of smeared material.

11.7.4 Socket Wall Shear Capacity

If socket walls are relatively uniform in strength, assessment may be made with a conforming video camera inspection. If the socket consists of several variable strength strata layers, and more than 50% of socket capacity relies on strata occurring over less than one-third of the socket wall, a down-the-hole visual inspection shall be undertaken.

11.7.5 Presence of Weak Areas in Socket

Where visual inspection with a conforming video camera indicates any of the following defects that may significantly reduce the design socket capacity, a down-the-hole inspection shall be made to assess the effect on socket capacity –

- a) Material substantially differs from that shown on borelogs;
- b) Defect spacings and orientation are worse than that assessed from borelogs;
- c) Bands of weak rock, intrusions, shear zones or fault lines are evident, but not assessed in socket design; or
- d) Macro weathering appears worse than that recorded in the borelogs.

If the Geotechnical Assessor finds that the socket material has less capacity than that assumed in design, the changes shall be referred to the designer and shall have approval of the designer and the Administrator prior to finalising the new foundation design.

11.8 *Stronger Strata than expected in Design*

If during excavation of a pile base or socket, the founding material is found to be significantly stronger than that assumed in the design, such that it is proposed to change the foundation design, a down-the-hole inspection shall be undertaken to assess and confirm the founding strata properties. The changes shall be referred to the designer and shall have approval of the designer and the Administrator prior to finalising the new foundation design.

11.9 Camera for Dry Pile Inspections

11.9.1 Features and Capability

To obtain adequate information, the camera used for pile inspections shall have at least the following features –

- a) Robust, high resolution and water resistant colour video camera controlled by a display monitor at the surface with the capacity to record data for QA records (Pile identifier, date, time, operator's name, pile depth and so on);
- b) Equipped with variable-intensity light source that can be adjusted to give true colour images of the foundation material; and
- c) Able to be moved to view horizontally (sockets) and vertically (base) by means of a telescopic or articulated pole, push rod or some other controlling device.

In addition to the above requirements, the camera should preferably incorporate an off-set light source so that shadows can give a perception of depth and surface texture can be determined.

The camera shall be operated by an experienced person who can obtain a clear stable image with high definition.

The camera shall be available on site at least two (2) weeks before the first pile inspection and the Contractor shall demonstrate its compliance to the Administrator before it is used in pile assessment.

11.9.2 Non-Conforming Cameras

Cameras that do not conform to the above requirements are non-conforming, and can only be used to determine certain information as set out in Table 11.5.

11.9.3 Calibration

Remote camera inspections shall 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.

11.9.4 Availability on site

The camera to be used for inspection shall be available on site at least two weeks before completion of the first pile excavation and the Contractor shall demonstrate its compliance to the Administrator before it is used in pile assessment.

11.10 Certification of Piles that cannot be Dewatered

11.10.1 General

Where a pile cannot be dewatered, inspection of the base shall be carried out using a waterproof camera complying with Clause 11.11.

11.10.2 Capacity Reduction Factor for Uniform Socket Material

When the socket wall is of uniform strength, the design socket friction capacity shall be reduced by an additional capacity reduction factor of 0.7 because the design assumptions cannot be fully confirmed by inspection.

11.10.3 Capacity Reduction Factor for Sockets of Variable Strength Strata

When the socket wall capacity is non-uniform and more than 50% of the socket capacity relies on strata occurring over less than one third of the socket wall, the design socket shear capacity shall be reduced by an additional capacity reduction factor of 0.5.

11.10.4 Extension of Socket

Any socket extensions necessitated by Clauses 11.10.2 and 11.10.3, including all consequential costs and delays, shall be at no cost to the Principal.

11.11 Camera for Underwater Inspection of Pile Base

An attempt should be made to dewater the pile hole and conduct video inspections in dry conditions. Alternatively, cloudy and turbid water should be replaced with clean water to improve visibility for the camera operation under water.

The camera used for underwater pile hole inspections shall have at least the following features –

- a) Robust high-resolution colour video camera in a waterproof casing controlled by a display monitor at the surface with the capacity to record data for QA records (Pile identifier, date, time, operator's name, pile depth and so on);
- b) Equipped with variable intensity light source that enables true-colour representation of the rock can be adjusted to give true colour images of the foundation material;
- c) An air void between camera lens and rock face so that clear video can be taken; and
- d) Able to be moved to cover the entire surface of the pile base and wall by means of a telescopic or articulated pole, push rod or some other controlling device in vertical piles. Control of camera movements in raked piles may require specialist accessories

In addition to the above requirements, the camera should preferably incorporate water jets of clean water that can rinse the camera lens or waterproof glass plate enclosure clean in turbid water, flush any mud off the base or wall surfaces and estimate the depth of any fine or loose material on the base or wall.

The camera shall be operated by an experienced person who can obtain clear, stable, true-colour, high-definition images.

The camera shall be available on site at least two weeks before the first pile inspection and the Contractor shall demonstrate its compliance to the Administrator before it is used in pile assessment.

12 STEEL REINFORCING

Steel reinforcing shall be supplied and placed in accordance with the requirements of MRTS71 *Reinforcing Steel*. Steel reinforcing shall be assembled as detailed on the Drawings to form a rigid cage capable of being lowered into the excavation without any disintegration occurring.

Cover to steel reinforcing shall be maintained using approved spacers or stainless steel nibs welded to the longitudinal reinforcement. The spacers shall be located on the periphery of the pile cage 90 degrees apart at a maximum of 2.5 m centres axially, as shown on the Drawings.

Where welded cages with a continuous spirally wound helix are used, the distance between spacers may be increased to 4 m provided that there are always at least 2 sets of spacers on each cage.

Prior to lowering the reinforcing cage, the pile excavation shall be cleaned of all loose material. If there is any evidence of spacers crushing or being displaced after lowering the reinforcement cage into the liner, the cage shall be withdrawn and alternative stronger spacers fitted.

13 CONCRETING

13.1 General

After excavation has been completed and the pile foundation certified by the Geotechnical Assessor and accepted by the Administrator, [refer to Hold Point 2] the reinforcement shall be inserted and concreting operations shall commence without delay. The foundation shall be rechecked immediately prior to placement of concrete to ensure that no deterioration has occurred in the intervening period.

Where there has been a delay of more than 24 hours between certification and when the Contractor is ready to start concreting or when the foundation has been observed to deteriorate significantly, the foundation shall be cleaned if required and re-inspected. **Hold Point 3**

If water flow into the pile exceeds 12 mm per minute, concrete shall be placed underwater as stated in Clause 13.4.3. It shall not be placed until the inflow has ceased, and the water level inside the liner has stabilised. This can be achieved more quickly by pumping fresh water into the liner until internal and external water levels are equal.

All concrete shall be placed in accordance with MRTS70 *Concrete* except as otherwise specified in Clauses 13.2 to 13.4. The Contractor shall observe all relevant milestones and hold points in MRTS70 *Concrete*. Placement of concrete underwater shall only commence after the tremie and the placing procedure have been accepted for use by the Administrator. **Hold Point 4**

The placing of concrete shall effectively be a continuous operation from the toe level to the top of pile unless the Administrator approves otherwise. The Contractor shall arrange a regular supply of concrete deliveries with no delays in delivery exceeding 15 minutes.

13.2 Concrete

Concrete shall comply with the requirements of MRTS70, except where specifically stated in this Clause.

The concrete mix shall be designed to limit excessive bleeding of water, which is likely to occur in deep concrete pours.

The mix design shall include the selection of suitable combined aggregate grading curves, the use of appropriate admixtures and the need to retain adequate workability during placement.

When placed in dry conditions, concrete shall be compacted by mechanical vibration or by dropping the concrete 2 to 3 m from the end of the delivery pipe.

13.3 Slump of Concrete

The target slump of concrete shall be selected from the range below –

- a) For concrete placed in dry conditions 120 mm to 160 mm; and
- b) For concrete placed by tremie underwater 160 mm to 200 mm.

Slump tests on delivery shall conform to the target slump and the tolerances given below (conforming to AS 1379).

Tolerances on slump –

- a) 120 to 150 mm slump tolerance \pm 30 mm.
- b) 160 to 200 mm slump tolerance \pm 40 mm.

13.4 Placement and Compaction

13.4.1 General

Concrete shall be placed in dry conditions except where ingress of water into the hole is too great to ensure a homogeneous mass of concrete of the specified strength. Where the rise of water in the bottom of the pile exceeds 12 mm/minute, measured over 15 minutes or more, concrete shall be placed using underwater techniques after the water level has stabilised.

To assist compaction by hydraulic head, the rate of placing the concrete shall not be less than 10 metres of pile length per hour.

Concrete supply shall 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.

13.4.2 Concrete Placement in dry conditions

The base of the pile shall be clean and all water removed immediately prior to placing concrete. This shall be confirmed by direct observation or by using a camera.

The method of placement shall allow the following –

- a) Delivery hose or pipe to 2 m above the pile base; and
- b) Ability to lift and/or shorten the delivery hose/pipe quickly with delays no longer than 10 minutes.

Concrete shall be dropped 2 to 3 m from the end of the delivery hose/pipe onto the concrete surface to provide compaction.

The delivery hose/pipe shall be positioned so that the concrete does not fall onto the reinforcement cage. For raked piles, the Contractor shall detail in the procedure for construction of piles the method of delivering concrete down the piles that minimises the risk of segregation. [Refer to Hold Point 1]

The top 3 m of concrete shall be well compacted with a concrete vibrator with a minimum diameter of 50 mm.

13.4.3 Concrete Placement Underwater

13.4.3.1 General

Before placing any concrete underwater, the liner shall be full of water to a level at least equal to the external water level or to a stable level with no further inflow or out flow.

The placement of concrete underwater shall be effected by means of a watertight tremie pipe which complies with the following requirements –

- a) A tremie long enough to rest on the pile base with watertight seals at all joints and a base that can be sealed. The seal shall be designed to break and allow discharge of concrete when the pipe and hopper are filled, and the tremie is lifted no more than 300 mm off the pile base. Suitable types of seals include balls, bags of vermiculite or similar materials or a plate attached to the base of the tremie which will break away when the tremie is full of concrete and lifted off the base; or
A concrete pump with hydraulic boom with a hose reaching to the pile base and a means of separating the water and concrete with a compressible “ball”;
- b) A controlled means of carefully raising the discharge end so that it always remains embedded 2 m in the concrete;
- c) Adjustable pipe length or removable segments; and
- d) A supply of concrete that is effectively continuous and a rate of placing not less than 10 metres of pile length per hour.

Procedures shall comply with MRTS70 for underwater placement. The tremie shall remain in the concrete at all times.

13.4.3.2 Tremie lifted out of concrete

If the tremie base is lifted out of the concrete in the pile at any stage prior to completion, a non-conformance has occurred. **Non-conformance**

Concrete placement shall stop and the concrete shall be allowed to set for a minimum of 8 hours. All water and contaminated concrete (typically 2 metres) shall be removed and the concrete surface levelled, cleaned and inspected. When approved by the Administrator, the rest of the concrete shall be placed using dry placement methods.

13.4.3.3 Significant delay in concrete placing

If the placement of concrete underwater ceases at any time before completion of the pile for a period of more than 45 minutes, concrete placement shall cease and the concrete allowed to set for at least 8 hours. All water and contaminated concrete (typically 2 m or 2 pile diameters deep, which ever is the greater) shall be removed and the pile finished as stated above.

13.4.3.4 Removal of contaminated concrete at completion of concrete placement

The top section of concrete (typically 2 metres or 2 pile diameters deep, which ever is the greater) placed underwater may be contaminated, have excessive water content or be mainly a mortar-water mixture. This shall all be removed and not be allowed to form part of the final structure.

Hence, when placing underwater, the pile liner shall be extended by at least 2 m and subsequently cut back or the liner shall be finished to level and the contaminated material allowed to overflow. This overflow shall be captured on site and not allowed to run off Site or into the stream.

If the latter method is used, concrete placement shall continue until the pile surface is all sound concrete with the same slump and consistency as the concrete out of the truck and then the top 3 metres of pile concrete shall be compacted with internal vibrators of 50 mm minimum diameter.

Careful operation of the tremie will limit the volume of contaminated material.

After concrete has hardened, the pile shall be cut back to the specified level or to the level of sound concrete, whichever is the lower. If any concrete below the specified cut off level is contaminated or lacks the normal proportion of coarse aggregate, it shall be removed. When cutting off, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile. Cracked or defective concrete shall be cut away. The pile shall be repaired in an approved manner to provide a full and sound section at the cut off level.

All such repair and replacement shall be at no cost to the Principal.