Technical Specification

Transport and Main Roads Specifications
MRTS63 Cast-In-Place Piles

November 2020

Queensland Government

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1 Introduction

This Technical Specification applies to the construction of cast-in-place, reinforced concrete piles contained in open-ended liners left permanently in place (referred to as lined piles), extending to material of the appropriate competence (generally rock) for bridges and other structures.

The intention of the Technical Specification is that lined piles are cast in dry conditions. Wet holes for placing concrete are only permitted when all reasonable methods to achieve a dry hole have been unsuccessful.

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

The following foundation methods / types are not permitted for use on Transport and Main Roads projects:

a. piles consisting of driven, closed-end tubes that are later filled with concrete except in some specific marine applications

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 Specification does not apply for piles for pad footings, sign gantries and other applications with high moment and low axial loads (refer to MRTS63A *Piles for Ancillary Structures*).

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

The requirements for the manufacture of cast-in-place piles include the use of suppliers and products for the items listed in Table 1 that are registered by Transport and Main Roads.

Table 1 – Items requiring use of registered suppliers and products

Clause	Category of Work
6.1	Reinforcing steel
7	Steelwork fabricator
12	Reinforcing spacers

For information regarding registered suppliers and products for the above items refer to the departmental website, https://www.tmr.qld.gov.au/business-industry/Business-with-us/Approved-products-and-suppliers or email TMRStructuralMaterials@tmr.qld.gov.au.

2 Definition of terms

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

In addition, terms listed in Table 2 are applicable to this Technical Specification.

Table 2 – Definitions of terms

Term	Details
down-the-hole inspection	An inspection involving the lowering down the hole of a person or camera (or similar device) to inspect a socket or part of a socket. Down-the-hole inspections involving people should be considered as a last resort activity and shall only be undertaken in circumstances where it can be safely undertaken.
founding level	The level of the base of the socket at the time of pouring the pile. The design founding level is the design level of the same point.
high workability concrete	Concrete with high workability where consistency is measured as spread rather than slump.
rake	For non-vertical piles, the deviation of the pile from the vertical. Rake may be in the plane of the pier / abutment, or at some specified orientation from the plane of the pier / abutment.
toe of liner	The level of the base of the liner, not to be confused with the 'founding level' which is the base of the socket. The difference between the 'toe of liner' and 'founding level' is the length of the socket.

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 1379	*Specification and supply of concrete*
AS 2159:2009	*Piling – Design and installation*
AS 5100.3	*Bridge design, Part 3: Foundation and soil-supporting structures*
AS/NZS 1554.1	*Structural steel welding, Part 1: Welding of steel structures*
AS/NZS 3678	*Structural steel – Hot-rolled plates, floorplates and slabs*
CAC013M	*Contract Administration System Checklist – Excavation of Liners (MRTS63, 51)*
CAC014M	*Contract Administration System Checklist – Insitu Concrete Piles (MRTS50, 63, 70, 71)*
CAC015M	*Contract Administration System Checklist – Driving Liners (MRTS63)*
CAC021M	*Contract Administration System Checklist – Cast-in-Place Piles (PD03F1, MD02F1, AS 3678, MRTS63, MRTS70)*
CIA Z17	*Recommended Practice: Tremie Concrete for Deep Foundations. Concrete Institute of Australia 2012*
MRTS01	*Introduction to Technical Specifications*
MRTS50	*Specific Quality System Requirements*
MRTS56	*Construction Surveying*

Reference	Title
MRTS63A	*Piles for Ancillary Structures*
MRTS68	*Dynamic Testing of Piles*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS71A	*Stainless Steel Reinforcing*
MRTS78	*Fabrication of Structural Steelwork*
-	*Geotechnical Design Standard – Transport and Main Roads*
-	*Workplace Health and Safety Act,* 2011

4 Quality system requirements

4.1 Hold Points, Witness Points and Milestones

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

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

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness 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)
7	2. Weld Procedures for liner fabrication		
11.1	3. Geotechnical certification of pile capacity. Approval to insert reinforcement cage		
11.9.3			Supply of a suitable camera for inspection
13.1	4. Re-certification of socket / approval to place concrete 5. Approval of the tremie for underwater concreting including continuous supply and placing of concrete		
14	6. Submission and approval of Pile Integrity Test Reports		

4.2 Construction procedures

The Contractor shall prepare documented procedures for all construction processes in accordance with the quality system requirements of the Contract.

Construction procedures for those activities listed in Table 4.2 shall be submitted to the Administrator in accordance with the quality system requirements of the Contract.

Table 4.2 – Construction procedures

Clause	Procedure
6.2	Construction of piles in dry conditions, including sealing and cleaning, inspection and certification and concreting. 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 Specification is each pile.

4.4 Conformance requirements

The conformance requirements which apply to each pile for work covered by this Technical Specification are summarised in Table 4.4.

Table 4.4 – Conformance requirements

Clause	Procedure
7, 8	Damage to steel liners
9	Location and tolerances
10	Size of pile base / socket
11.4	Inability to pump dry the base of the liner
13.4.3.2	Resolution of the issues following the tremie being pulled out
MRTS70	Concrete conformance

5 Assessment of foundation information

In assessing the foundation information provided in the tender documents, the Contractor'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 should be available for the Contractor 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.

In regard to the available foundation information, this will generally include items other than just those included in the contract documents, for example; further reports, test results and samples. It is the responsibility of the Contractor to make the assessment based on all the information not just that which is bound into the contract documents.

In regard to latent conditions the Contractor needs to be aware that these only apply where a material difference exists between what should reasonably have been anticipated by the Contractor and what is found on the Site.

The Contractor shall be deemed to have allowed for the departures as could reasonably be expected.

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/NZS 1554.1.

c) Reinforcing steel - MRTS71 *Reinforcing Steel* or MRTS71A *Stainless Steel Reinforcing*

d) Concrete - MRTS70 *Concrete* together with Clause 13 herein, and

e) Steel – MRTS78 *Fabrication of Structural Steelwork*.

All reinforcing steel shall be sourced from a registered supplier of reinforcing steel (refer to Clause 1).

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 liner, the equipment to be employed for this operation and the method of sealing the base of the pile against the ingress of water. 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.

c) The proposed method for excavating the piles, bells and sockets and cleaning the liner, base and socket.

d) 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.

e) 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.

f) 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 for both dry and wet piles, and

g) 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.

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

Steel liners shall be fabricated in accordance with MRTS78 *Fabrication of Structural Steelwork*, by a registered steel fabricator (refer to Clause 1).

Steel liners shall conform to the dimensions and thicknesses shown on the Drawings. Spirally welded liners are only permitted for piles of less than 1.0 m in diameter.

> Where liners are proposed to be rotated into position rather than driven, it may require the addition of teeth or similar items onto the cutting edge of the liner.

Liners which are to be driven into position shall be fabricated using welded plate segments with all welds either perpendicular to or parallel to the long axis of the liner. The leading edge of the liners shall be reinforced as shown on the Drawings.

Liners which are of a diameter less than 1.0 m may be either spirally welded or fabricated as above. Where spirally welded liners are used, some form of cutting edge should be applied to the leading edge of the liner.

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 the diameter of the 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, buckets or personnel during inspections.

Welding shall be carried out in accordance with the provisions of AS/NZS 1554.1 and MRTS78 *Fabrication of Structural Steelwork*. A Weld Procedure Specification for both shop fabrication of steel liners and any field splice welding shall be submitted to the Administrator for approval prior to welding liners. **Hold Point 2**

All longitudinal and transverse welds, including field splice joints if required, shall be made with full penetration butt welds. Shop fabrication welds shall be made using a submerged arc process. 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.

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. **Nonconformance**

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 performed 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.

The liner length shall be marked on the liner at no less than 1 m intervals from the toe of the liner before sinking so that the depth of penetration of the liner into the ground can be clearly seen.

Any liner which is incorrectly located, or damaged, or which shows partial collapse to an extent that it results in a decrease in the load carrying capacity of the pile or reduced durability, may be rejected, removed and replaced, or repaired. **Nonconformance** 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 (hammered, oscillated or rotated), open-ended using a driving rig capable of achieving penetration of the liner to the founding level.

Depending on the nature of the material to be penetrated and the driving energy employed, it is often not possible to drive the liner to level in one continuous operation. In such a case, the liner

should be driven progressively in increments alternating with excavation of material at the toe of the liner. Such a procedure does not entitle the Contractor to extra payment.

Driving of liners is the preferred method to achieving liner penetration. Preboring of liners is only permitted in certain circumstances as stated in Clause 8.4.

Material inside the liner shall be excavated progressively by air lift, grab 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 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. **Nonconformance**

The Contractor may request from the Designer the basis for the design of the liner, including design hammer size or input energy. Should the Contractor wish to use alternative methods, this may necessitate a different liner thickness or design.

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. **Nonconformance**

If it is elected to optimise proposed construction procedure by increasing input energy over and above that necessary, as detailed on the Drawings, to drive liners then a heavier liner is to be used to sustain the application of such increased driving energy. Any change to the nominated liner design is to be approved by the Administrator 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, vibration or rotation

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

The toe of the liner shall be kept far enough ahead of the excavation inside the liner to prevent material entering the partially excavated pile. 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 prebored holes

Liners shall not be placed in prebored holes beyond 3 m in depth without Designer and Administrator approval.

Preboring is only permitted where the material insitu 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.

The diameter of a prebored 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.

Preboring shall be included in the cost of pitching or driving and not paid as a separate item. No additional payment will be made by the Principal for prebored holes.

Any resultant 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 three points equally spaced around the liner circumference.

8.5 Construction limitations

A pile which is located within 2.5 m clear distance from a newly concreted pile shall not be worked on until 18 hours after initial set of the concrete in that adjacent pile.

A pile which is located between 2.5 m and 9 m clear distance from a newly concreted pile shall not be worked on until 12 hours after initial set of concrete in that adjacent pile.

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

9 Tolerances

The completed pile shall be located as shown on the Drawings within the following tolerances:

a)	Top of pile, in plan	75 mm in any direction
b)	Top of pile, vertically	5 mm in height
c)	Variation from vertical or designated rake	20 mm per metre
d)	Bow of pile	1% of length of pile in any direction, and
e)	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. **Nonconformance** Correction may include additional reinforcement or increased dimensions of pile caps or additional piles.

Any design changes consequent to out of tolerance piles will need to be approved (generally undertaken) by the Designer and the Administrator and will be at no cost to the Principal. This includes design costs if applicable.

10 Excavation of cast-in-place piles

10.1 General

All piles shall be excavated to a stratum of adequate capacity to sustain the imposed loadings shown on the Drawings and the socket length shall not be less than that shown on the Drawings without specific approval of the Designer. All excavated material shall be disposed of in accordance with the environmental plan.

When the liner is at its anticipated toe 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, upon attaining this level the liner is not sealed or if during subsequent operation, there is an influx of material into the excavation, the liner shall be re-driven until a new seal or stable sides are achieved. Payment in such circumstances shall be limited to the direct consequence of lengthening the liner / socket. No additional cost shall be ascribed to the Principal in regard to 'setting up to redrive' or similar work items.

Piles may be bored or excavated under water but both inspections and concreting must generally be undertaken in the dry. If wet excavation methods are used, the Contractor must take steps to seal the liner from water ingress prior to inspection and concreting.

Effectively, only three limitations are placed on the method of excavation. Firstly, the method used must be safe and compliant with Workplace Health and Safety (WH&S) requirements. Secondly, explosives shall not be used without specific approval. Thirdly, the time limitations detailed in Clause 8.5 must be followed.

In regard to the use of choppers, some operators have stated that this procedure is not permissible under the WH&S Act and Regulations. This statement is not correct, choppers may be used provided they are used safely and with the relevant approvals.

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.

When a pile is to terminate above the design level, then the concurrence of the Designer to this change must be obtained, this is not just a geotechnical decision.

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, the Contractor shall take all reasonable steps to dewater the pile to facilitate inspection. Prior to inspection, the bearing surface shall be 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 recorded by the Contractor. In all cases, these shall equal or exceed the dimension shown on the Drawings and the requirements of this Technical Specification. Any variation from the Drawings must be approved by the Designer.

10.2 Belling

Excavation of the bell shall not commence until the Geotechnical Assessor has inspected the foundation and nominated the required bell diameter. The nominated bell diameter shall not be less than the minimum nominal diameter specified in the Drawings.

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 as per the *Geotechnical Design Standard*.

The walls shall be clean and free of smeared material. Smeared walls shall be cleaned and roughened prior to certification and subsequent concreting.

11 Geotechnical certification

11.1 General

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

Prior to geotechnical certification, the Contractor shall certify that the foundations are at the required level and the base is clean and free of all loose material and ready for geotechnical certification.

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 ground conditions are in accordance with the design assumptions, the factored geotechnical strength pertaining to the pile axial capacity is greater than the design loads shown on the Drawings in accordance with AS 5100.3 and the foundation complies with the requirements shown on the Drawings. The Height of the toe of the liner and the founding level of the pile, and the magnitude and direction of any rake, will also be recorded in the geotechnical certification in accordance with the requirements of MRTS56 *Construction Surveying*.

Where the Geotechnical Assessor issues a conditional certificate, for example, the base or walls need to be further cleaned, then the certifier shall release the condition prior to moving to the next stage of the construction process. The Geotechnical Assessor shall ensure all issues are resolved prior to the next stage of construction.

The Contractor shall forward a copy of the geotechnical certification of the foundation to the Administrator for their approval. Insertion of reinforcement and concreting of the pile shall not proceed prior to the Administrator's approval of the certification. **Hold Point 3**

As-constructed records of all excavations, including the rock classification, and the basis upon which the certifier issued the certificate, shall be maintained and forwarded to the Administrator.

11.2 Geotechnical Assessor

Unless stated otherwise in Clause 1 or Annexure MRTS63.1, the Geotechnical Assessor shall be either a Geotechnical Engineer who is also a Registered Professional Engineer Queensland (RPEQ) with at least five years' experience in the design and assessment of bored pile foundations. 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.

Unless approved otherwise by the Administrator, the Geotechnical Assessor shall be independent from the pile design, pile driving and installation, and pile testing organisations or companies.

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

The role of the Geotechnical Assessor is critical to the process of constructing the pile. The assessor certification cannot be over ridden by the Contractor. Should an issue arise between the Assessor and the Contractor then this should be referred to the Administrator who may need to obtain independent expert advice regarding the issues.

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

11.4 Dewater and clean

The Contractor shall attempt to pump the hole dry using an appropriate sump arrangement and clean the pile base to allow full assessment. If the pile cannot be pumped dry this shall constitute a Nonconformance. **Nonconformance**

While the criterion for concreting a pile is an inflow rate which causes a rise in water level of less than 12 mm / minute to facilitate inspections, much greater rates of inflow can be tolerated. It would be expected that the Contractor would have adequate pumping equipment to remove water at these higher flow rates.

11.5 Assessment methods

The Geotechnical Assessor shall select sufficient processes to obtain the information needed to certify the foundations using the original geotechnical investigation cores and reports, any additional investigation cores, samples obtained during the Contract and inspection or investigation of the foundation material. Where there is not sufficient information, the Contractor may undertake additional investigations (refer to Clause 6.2 (f)). Dewatering and cleaning of piles is the fundamental process which must occur prior to the Assessor attempting to certify the pile. If an excavation cannot be dewatered, then the Assessor must determine how the required information can be obtained to permit the excavation to be certified.

The foundation assessment shall be based on a combination of methods for obtaining data on foundation capacity. As a review of the geotechnical investigation data is fundamental to any assessment, the drill cores and a copy of the borelogs and geotechnical report shall be kept on the Site until foundations are completed.

The Geotechnical Assessor is expected to use their professional judgment in determining the acceptability of the foundation. A range of tools may be used by the Assessor. These include a review of the Geotechnical Report and cores and samples obtained during that investigation. The collection and analysis of samples obtained during the excavation of the socket, taking into account not only the properties of the material but also analysing the likely location within the socket such samples may be derived. Inspections of the socket must be undertaken. This can be undertaken either directly (inspection from the surface or down-the-hole inspection) or indirectly using a camera or similar device. Soundings to determine the depth of the socket should be considered an integral part of the process.

Table 11.5 – Procedures to verify geotechnical capacity

	Process and 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).	• 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.
	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.	• 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 and information obtained		Use
5	Test holes in pile base	
	Drill to 2 x pile diameter deep. Record times / 250 mm penetration.	• 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.	• Confirms service loads and movements. • Elastic and inelastic settlements. • Confirms ultimate load capacities and movements.

The tools / procedures used must be adequate to enable the Geotechnical Assessor to come to a conclusion regarding the adequacy of the foundation.

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 on the Site prior to certification of pile capacity.

11.6.2 Bearing capacity of base

The bearing capacity of the pile shall be deemed adequate if:

a) the founding level stratum has been reached and the pile base is embedded into the founding strata by the minimum dimensions shown on the drawing

b) the founding stratum has been identified from both the borelogs and samples taken during excavation as having sufficient capacity to confirm the base stratum is adequate, and

c) the strata has been certified by the Geotechnical Assessor as being 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 three 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 m 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 3]**. The driller shall record the time taken to drill each 250 mm increment of depth, and any regions of lesser strength than the required 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.

In some circumstances it may be impractical to drill through the liner to conduct test drilling. Drilling adjacent to the pile may be acceptable.

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 an inspection indicates water is leaking into the pile excavation, the rate of leakage shall be measured. The rate of water ingress per minute shall be recorded over at least 15 minutes.

Where the rate of water ingress exceeds 12 mm per minute, rise in water level the pile shall be regarded as a 'wet' pile.

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 further information is required prior to certification:

a) piles with design vertical loads on the base exceeding 7000 kN

b) piles with design uplift load exceeding 500 kN

c) where the pile group consists of a single pile in a foundation, with no redundancy

d) where the assessed ultimate bearing capacity of the founding strata is less than twice the design bearing stress in the base of the pile, and

e) piles with high levels of water inflow.

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 pile capacity

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, prior to certification of pile capacity.

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 clean, free from smear, appear self-supporting, and no portion of the wall has collapsed or appears likely to collapse.

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 more detailed inspection shall be undertaken.

11.7.5 Presence of weak areas in socket

Where the inspection / certification indicates any of the following defects occur that may significantly reduce the design socket capacity, a down-the-hole inspection shall be made to assess the effect on socket capacity when:

a) material substantially differs from that shown on borelogs

b) defect spacing 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 or subsequent certification, the material is found to be significantly stronger than that assumed in the design, a change in design may be proposed. All such 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 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/waterproof (as appropriate) 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 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.

11.9.2 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.

11.9.3 Availability on the Site

The camera to be used for inspection shall be available on the 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. **Milestone**

11.10 Underwater inspection

Where a pile cannot be dewatered, inspection of the base shall be carried out using a waterproof camera. Cloudy and turbid water shall be replaced with clean water to improve visibility for the camera operation under water.

While for concreting purposes a pile is classified as 'wet' when the rate of inflow is 12 mm per minute, for assessment / certification purposes, inflow rates well in excess of this figure can be handled and the pile still certified using the same procedure as a 'dry' pile. It would be expected that the Contractor would have adequate pumps to permit pumping out of piles to permit certification of piles at high flow rates.

11.10.1 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.

11.10.2 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.

11.10.3 Extension of socket

Any socket extensions necessitated by Clauses 11.10.1 and 11.10.2, including all consequential costs and delays, shall be at no additional cost to the Principal other than for the excavation and concreting items.

12 Steel reinforcing

Steel reinforcing shall be supplied and placed in accordance with the requirements of MRTS71 *Reinforcing Steel* and MRTS71A *Stainless Steel Reinforcing*. Steel reinforcing shall be assembled as detailed on the Drawings to form a rigid cage capable of being lowered into the excavation without disintegration.

MRTS71 *Reinforcing Steel* and MRTS71A *Stainless Steel Reinforcing* require the use of registered suppliers of reinforcement.

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, or 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 two 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.

Note: Care must be exercised during the placement of the reinforcement to avoid conflicts with other reinforcement such as that required for the pile caps or headstocks or anchors.

13 Concreting

13.1 General

After excavation has been completed and the pile foundation certified by the Geotechnical Assessor and the certificate accepted by the Administrator, **[refer to Hold Point 3]** the reinforcement shall be inserted and concreting operations shall commence without delay.

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 re-cleaned (if required) and re-certified. **Hold Point 4**

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. 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 5**

13.2 Concrete

Concrete shall comply with the requirements of MRTS70 *Concrete* except where specifically stated in this clause and Clause 13.3.

The concrete mix shall be designed to limit excessive bleeding of water, which is likely to occur in deep concrete pours and to be tested for water retention in accordance with MRTS70 *Concrete*.

The mix design shall include the selection of suitable combined aggregate grading curves (particularly in the sand component), the use of appropriate admixtures and the need to retain adequate workability during placement particularly for piles cast in wet conditions.

13.3 Slump or spread of concrete

The target slump or spread of concrete shall be selected from the range given in MRTS70 *Concrete* for either dry or wet conditions. A mix specified by spread is recommended for wet pile conditions.

With the approval of the Administrator a wet pile concrete mix may be used in a dry pile.

Slump or spread tests on delivery shall conform to the target slump or spread and the tolerances given in MRTS70 *Concrete*.

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 per minute, measured over 15 minutes or more, concrete shall be placed using underwater techniques after the water level has stabilised (refer to Clause 13.4.3).

Prior to commencement of concreting, the length of the pile from the base to the top of the liner shall be measured and the socket walls and pile base checked for cleanliness.

To assist compaction by hydraulic head, the rate of placing the concrete shall not be less than 10 m 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 or shall be compacted using vibration.

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. In a salt water environment, the pile shall be pumped as dry as possible and then filled using fresh water to minimise the salt content of the pile water during concreting.

The placement of concrete underwater shall be effected by means of a watertight tremie 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.

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 m of pile length per hour.

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

A tremie pouring record shall be kept during the tremie pour, in which is recorded the following:

- the level or depth (from a point of known Height)
- depth of the base of the pile
- time pour started
- arrival time of each truck
- depth at the start of delivery from each truck
- depth and time when the tremie is shortened
- the length of tremie kept within the concrete column during the shortening operation, and
- the estimated quantity of material allowed to flow to waste at the end of the process.

Tremie placement of concrete is a high-risk procedure unless all staff are fully aware of the procedures to be followed. A concrete pump does not constitute a tremie and shall not be used as a substitute to a tremie.

An example of a suitable tremie pouring record can be found in Appendix D3 of CIA Z17.

13.4.3.2 Tremie lifted out of concrete

If the tremie base is lifted out of the concrete (a pull out) in the pile at any stage prior to completion, concrete placement shall stop and pull out resolved. **Nonconformance**

If the pull out is within the socket or in the lower 2 m of the shaft (within the liner), all concrete shall be removed, the reinforcement extracted and the socket re-cleaned and certified. The pile shall then be re-concreted and finished.

This can only be achieved while the concrete is still wet. If this process is delayed, then removal of even partially set concrete from within the pile becomes problematic, resulting in additional delay and cost.

If the pull out is within the liner and beyond the bottom 2 m of the liner, then all contaminated concrete or at least the top 2 m of the concrete shall be removed using a grab or similar device. This work may either done either immediately following the pull out, when the concrete is still wet, or following partial set of the concrete not less than eight hours after the event. A construction joint shall be prepared at

the revised top of the concrete surface, the surface levelled, cleaned and inspected. When approved by the Administrator, the rest of the concrete shall be placed using dry placement methods after removal of all water from the pile (refer Clause 13.4.2).

Coring the pile is a last resort suitable method for confirming the quality of the concrete in the affected zone. The excavation of wet or partially set concrete will require equipment small enough to fit within the reinforcement cage.

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 eight hours. All water and contaminated concrete (typically the top 2 m or 2 pile diameters, whichever is the greater) shall be removed and the pile finished as stated in Clause 13.4.3.2.

13.4.3.4 Removal of contaminated concrete at completion of concrete placement (wet pours)

On completion of a wet pour, the top section of concrete, the greater of 2 m or 2 pile diameters, shall all be removed and not be allowed to form part of the final structure.

When placing underwater, the pile liner shall be extended by at least 2 m above the design cut off level 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 the Site and not allowed to run off Site.

If the overflow 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 m 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 broken 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.

14 Pile Integrity Testing

Pile Integrity Testing shall be undertaken on a minimum of one pile, but not less than 25% of the piles, in each abutment and pier whichever is greater. The method of testing unless otherwise specified shall be low strain pulse echo method in accordance with Clause 8.8 and Appendix D of AS 2159. Acceptance of testing results shall be in accordance with Clause 8.8.3 of AS 2159. The selection of piles for testing shall be at the sole discretion of the Administrator and may be based on pile construction records.

Pile Integrity Testing shall not be a substitute for coring or load testing of the pile if there is a nonconformance associated with the concrete or concreting process in the pile, or as a substitute for Geotechnical Certification of the pile or foundation.

Unless approved otherwise by the Administrator, the Pile Integrity Testing shall be conducted by a company or organisation independent of the pile designer, and piledriving / installation companies or organisations.

No further construction above the pile cut off level shall commence until the Pile Integrity Test reports have been submitted and approved by the Administrator. **Hold Point 6**

15 Survey

After completion of pile construction and cutback to the specified level, an As Constructed survey of the pile shall be completed in accordance with MRTS56 *Construction Surveying.*

16 As Constructed records

The Contractor shall provide the following As Constructed records in relation to each pile, no later than 28 days after completion of piling:

1. The base Height of both liner and pile extracted from the Geotechnical Assessors Report.
2. Assessment of the pile socket and base certified by the Geotechnical Assessor. The pile certification shall contain all the Site records obtained during the inspection, such as excavation machinery used, pile excavation logs including photos of excavated materials, liner installation records including final toe Height, pile socket inspection records including photographs, and any insitu / Site testing procedures and associated results.
3. Tremie Pouring Record for each pile.
4. All concrete testing results, and
5. All As Constructed survey information in accordance with this Technical Specification and MRTS56 *Construction Surveying.*

17 Supplementary requirements

The requirements of MRTS63 *Cast-In-Place Piles* may be varied by the Supplementary requirements given in Clause 1 of Annexure MRTS63.1.