Technical Specification

Transport and Main Roads Specifications MRTS65 Precast Prestressed Concrete Piles

November 2020

Queensland Government

Copyright

Licence

CC BY licence summary statement

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Disclaimer

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Contents

1 Introduction

This Technical Specification applies to the installation of precast prestressed concrete piles. Supply of the piles is covered by MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*. A separate Technical Specification, MRTS66 *Driven Steel Piles*, exists for steel piles.

The demarcation between this Technical Specification and MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* is that MRTS73, applies from manufacture to completion of lifting of the piles onto transport in the manufacturer's yard, for delivery either into a job stockpile or directly to the pile driver. This Technical Specification, MRTS65 *Precast Prestressed Concrete Piles*, applies from the time the piles are loaded onto transport in the manufacturer's yard, to driving of the piles in their final position. This includes transport, unloading, storage, lifting / moving at the job or elsewhere, pitching, driving and acceptance or rejection of the completed piles into the project.

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.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definition of terms

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

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

Table 2 – Definition of terms

Term	Definition
alternative hammer	A pile driving hammer, which is lighter than the Conforming hammer, but which must meet or exceed the requirements of Table 7.5.3. The use of such a hammer must be approved by the Administrator prior to use.
conforming hammer	A pile driving hammer of mass and rated energy, which meets or exceeds that defined in Clause 1 of Annexure MRTS65.1 and complies with the requirements of Table 7.5.2. That is, it conforms to (or exceeds) the capability of the Design hammer(s).
CAS	Construction Administration System
design hammer	The pile driving hammer (or hammers) as detailed by the designer in Annexure MRTS65.1 and which conforms to the requirements of Table 7.5.2.
design founding level	The pile toe level shown on the plans (or elsewhere) which represent the designers assumed level to which the piles are to be driven. Since founding level is only an estimate the accuracy of this level may be assumed to be ± 1 m. That is, a pile founding within 1 m of the design founding level may be assumed to be at the founding level for all purposes except payment in which case the actual level is used.
free length	During driving, the unsupported section of a pile above ground level.

Term	Definition
flying leaders	A support structure or frame for the pile hammer which, rather than being attached to both the ground and a crane or similar piece of equipment (ordinary leader) is supported by the pile and/or a system of guy cables or only by a crane.
follower	A rigid section, typically of steel used to temporally extend a pile to facilitate driving to, or below, ground level.
Geotechnical Engineer	A Registered Professional Engineer Queensland (RPEQ) or an experienced engineer working under the direct control of an RPEQ engineer who is registered as a Geotechnical Engineer by the Board of Professional Engineers Queensland (BPEQ). An experienced engineer with extensive geotechnical experience and registered as a Civil Engineer by the BPEQ is deemed to be equivalent.
HSDT	High Strain Dynamic Testing - commonly known by the proprietary term PDA™ testing.
High Strain Dynamic Testing	A device consisting of sensors attached to the pile, associated electronics and software used to monitor and dynamically analyse the pile during most (if not all) of the driving process. See MRTS68 *Dynamic Testing of Piles*.
job hammer	The hammer actually used on the job. It may be either a Conforming hammer or an Alternative hammer. Note the job hammer may change during the project but only with the approval of the Administrator.
minimum penetration	The minimum level to which the pile must be driven to meet the design scour and or fixity requirements. Minimum penetration is listed in Clause 4 of Annexure MRTS65.1 and may also be shown on the relevant drawings. The minimum penetration length is determined from the 'Minimum penetration level' and the level from which pile driving is undertaken.
nominal refusal	A set of typically 2.5 mm per blow typically measured as an average over 10 consecutive blows with the hammer working at the energy nominated in Annexure MRTS65.1. This set is so low that the pile is deemed to have refused.
pad	The temporary surface(s) or embankment(s), usually purpose built, constructed to support the pile driving equipment, cranes and ancillary equipment during pile driving. They may be constructed from fill type materials with or without special panels to further distribute the loads imposed by the equipment. The pad must be certified as being adequate and capable of resisting all the applied loads.
PM	Piling Monitor: a device used to monitor the set, temporary compression, energy input and a range of other parameters during all or part of the driving process.
pile	A prestressed concrete pile or a pile segment (top, middle or bottom) in the case of a spliced pile.
rake	For non-vertical piles, the deviation of the pile from the vertical. Rake may be in the plane of the line of the pier or abutment piles or at some specified orientation from the plane of the pier or abutment line of piles.
set	Permanent displacement of a pile after a full blow of the hammer. Typically measured as the average over 10 consecutive blows.
test pile	Any pile designated as a test pile in the contract documents as a test pile, and the first pile to be driven in any pier or abutment and/or any pile on which a HSDT has been undertaken.

2.1 Notation

The following symbols are used in this specification.

Table 2.1 – Notation

Symbol	Units	Definition
C	mm	Combined temporary compression of the helmet cushion(s), pile and adjacent ground
e	-	Coefficient of restitution
E	tonne.m	Energy input per hammer blow
e_f	-	Efficiency of the hammer blow
E_r	tonne.m	Manufacturers rated energy output of the hammer
f'_c	MPa	Design 28 day characteristic concrete compressive strength of the pile
H	m	Overall height of hammer fall
L	m	Overall length of the pile
M_f	tonnes	Total mass of the fixed part of the hammer and associated gear attached to the top of the pile which is accelerated by the hammer impact. It excludes the mass of the falling part of the hammer. Typically includes the mass of the hammer frame, anvil, helmet and cushioning, but not the falling part of the hammer.
M_m	tonnes	Mass of falling part of the hammer
M_p	tonnes	Mass of pile
N/A	-	Not Applicable
R	kN	Minimum ultimate capacity of the pile
S	mm	Pile set, often reported as the average penetration per blow over 10 blows

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 2159	*Piling – Design and installation*
AS/NZS 1554.3	*Structural steel welding, Part 3: Welding of reinforcing steel*
CAS Manual	*Contract Administration System Manual*
MRTS01	*Introduction to Technical Specifications*
MRTS02	*Provision for Traffic*
MRTS50	*Specific Quality System Requirements*
MRTS56	*Construction Surveying*
MRTS66	*Driven Steel Piles*
MRTS68	*Dynamic Testing of Piles*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS73	*Manufacture of Prestressed Concrete Members and Stressing Units*

Reference	Title
MRTS78	*Fabrication of Structural Steelwork*
NLRG	*National Load Restraint Guide, 2nd Ed., NTC & RTA 2004*
SD2021	*550 Octagonal PSC Piles – Earthquake Classification BEDC-1, Exposure Classification B2*
SD2022	*550 Octagonal PSC Piles – Earthquake Classification BEDC-1, Exposure Classification C1 and C2*
SD2023	*550 Octagonal PSC Piles – Spliced Pile Details*
-	*Transport Operations (Road User Management) Act and Regulations*

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, Witness Points and Milestones applicable to this Technical Specification are summarised in Table 4.1.

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
4.2	1. Submission of construction procedures and certified pad designs		
5.1	2. Approval of handling details		Submit transport details for piles over 21 m (if required) (14 days) Submit delivery schedule for piles under 21 m (7 days)
5.3.1	3. Approval to transport		
7.1	4. Approval of Pile driving procedure 5. Piles inspected prior to driving 6. Driving of piles 7. Removal of piling equipment		Submit pile driving procedure (21 days)
7.12.1	8. Refusal above minimum penetration level		
9		1. Stripping of pile heads	
10.1			Submit splicing procedure (21 days)
10.4		2. Splicing of pile elements	
10.5			Submit details of alternative epoxy (21 days, if required)
10.6	9. Testing of Epoxy		

4.2 Construction procedures

The Contractor shall prepare documented procedures for all construction processes in accordance with the quality system requirements of the Contract and submit them to the Administrator in

accordance with Clause 6 of MRTS50 *Specific Quality System Requirements*. The construction procedure shall include, but not be limited to, all lifting procedures (handling, pitching and splicing), and contain an Registered Professional Engineer of Queensland (RPEQ) certified design of both crane pad(s) and piling pad(s), or alternatively a statement confirming no need for a crane or piling pad in specific locations. **Hold Point 1**

Where the construction procedure (or part thereof) has been prepared by a specific piling Contractor, then those procedures shall only apply to work performed by that Contractor. If another Contractor undertakes the described work, then a new work procedure will be required.

Construction procedures for those activities listed in Table 4.2, that is those containing Hold Points, Witness Points or Milestones, shall be submitted to the Administrator in accordance with Clause 6 of MRTS50 *Specific Quality System Requirements*.

During handling, pitching or splicing, the danger zone must be defined on the basis of the risk assessment taking into account the unsupported length of the piles, height of the platform, height of the rig / crane, weather conditions, terrain (slope and roughness), and proximity to road, footpath or waterway that may be used by watercraft. During driving the zone is based on the free length of the pile, the length of the leaders plus hammer. In both cases the minimum danger zone is defined as the area with a radius equal to the free length of the pile, or length of leaders plus hammer, whichever is greater, plus 2 m. The risk assessment must identify other risks that may occur during driving, such as changing the packing and develop appropriate mitigating strategies. Where the danger zone covers a road, including traffic lane or shoulder a traffic management plan conforming to the requirements of MRTS02 *Provision for Traffic* must be developed and approved by the Administrator. Any road within the danger zone must be closed to traffic for the duration of handling pitching and splicing until the pile is restrained from falling.

Where preboring is permitted, the road may be open to traffic immediately following lowering the piles into the hole, provided that the length of prebore and ground conditions make it safe to do so.

> Determination of the safety of the pile to stand in a prebored hole will require the certification of a suitably qualified person, typically a Geotechnical Engineer or an experienced Pile Driving Safety Officer.

The risk assessment must be included in the Pile Driving Procedure and submitted to the Administrator for approval as detailed in Clause 7.1.

The cost of traffic control, where required, during handling and pitching of piles shall be borne by the Contractor.

Table 4.2 – Construction procedures

Clause	Construction Procedure
4.2, 7.1	Pile driving
4.2	RPEQ certified pad designs
4.2, 7.1	Preboring
9.1	Splicing (if required)

4.3 Conformance requirements

The conformance requirements which apply to lots of work covered by this Technical Specification are summarised in Table 4.3.

Table 4.3 – Conformance requirements

Clause	Conformance Procedure
7.1, 7.7	Pile defects
7.1	Compliance to approved piling procedures or damage to piles
7.4	Location and tolerances for each pile
7.10	Pile capacity and founding level for each pile

5 Prestressed concrete piles

5.1 General

Piles shall be manufactured in accordance with MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* and Standard Drawing 2021, 2022 and 2023, unless specifically stated otherwise in the project documents.

Piles shall not be transported, handled or pitched until the concrete has reached f'_c and are at least seven days old (since casting). See also Clause 15.3 of MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

The above requirement means that a pile cannot be transported from the manufacturer's yard until it is at least seven days old and the concrete has attained design strength. It can however be driven immediately after delivery to the job once the above requirements have been achieved.

Handling, transport and storage of piles shall be undertaken with care so as to avoid damage by impact or by undue bending.

Piles shall not be handled by dragging across the terrain at any time including during pitching.

Bending stresses induced in the piles during handling and transport shall be calculated on the basis of 50% increase in the static load to compensate for impact and dynamic effects and these shall be added to the axial stresses due to prestress. The resulting stresses shall not exceed:

a) $0.5f'_c$ in compression, and

b) $0.25\sqrt{f'_c}$ in tension.

Terms are as defined in Table 2.1.

As the Contractor used his procedures to handle the pile, it is the contractor's responsibility to ensure that the above requirements are met.

For piles over 21 metres in length, details of the proposed method of handling, transport and storage shall be provided to the Administrator at least 10 working days before the Contractor proposes to transport and/or take delivery of piles. **Milestone** The Contractor shall also supply details of the anticipated arrival time of the piles on the Site and the planned rate of delivery. Any method proposed by the Contractor shall be approved by the Administrator before being adopted. **Hold Point 2**

For piles up to 21 metres in length, the Contractor shall advise the Administrator at least six working days before taking delivery of the piles, of the anticipated arrival times and the planned date of delivery. **Milestone**

As stated in Clause 1, this Technical Specification is applicable for the movement of piles from the casting yard to pitching of the pile on Site.

5.2 Lifting (not including pitching)

Piles shall be handled by and lifted as shown in Table 5.2, with lifting points located along the pile as shown. Piles shall be in a horizontal position when being lifted, and shall be protected at all times to prevent spalling of the edges by the handling slings. Spliced piles can only be joined once the base section has been driven. The lifting of a completed spliced piles is not permitted. Piles exceeding 28 m in length shall not generally be lifted. If this is required then a special lifting procedure will be required and approved by the Director (Structures Design Review and Standards) and by the Administrator. Such a procedure shall not be used to lift a completed splice pile.

The practice of splicing the two halves of a spliced pile on-site followed by pitching and driving the spliced pile as one unit is explicitly forbidden.

Spliced piles must be driven sequentially, that is, the base section driven, splice prepared, the top section spliced into the base section and then driving is completed.

Cranes shall work within their rated capacity. If requested by the Administrator, the Contractor shall make available for inspection the crane manufacturer's load chart for the crane which is proposed for erection with details of counterweight, jib length and rigging.

Table 5.2 – Pile lifting points, for 550 mm octagonal piles

Lifting Diagram (not applicable for pitching)	Pile Length, L (m)
	≤ 28
The distance from the end of the pile to the nearest lifting point shall be 0.21L, where L is the total length of the pile.	

5.3 Transport

5.3.1 General

The Contractor shall assess the route for transport of piles and, in its submission to the Administrator in accordance with Clause 5.1, shall include full details of the transport arrangements, including means of limiting torsional forces on the piles during transport to prevent torsional cracking.

The piles shall be transported only after all inspections required by the Administrator have been satisfactorily completed. **Hold Point 3**

5.3.2 Certification of vehicles

Prime movers shall display a current Certificate of Inspection issued by Transport and Main Roads or be currently registered in the National Heavy Vehicle Accreditation Scheme maintained by the National Heavy Vehicle Regulator.

5.3.3 Mass of loads

All road transport shall comply with the vehicle limits prescribed by the *Transport Operations (Road User Management) Act and Regulations*.

5.3.4 Escorts and pilots

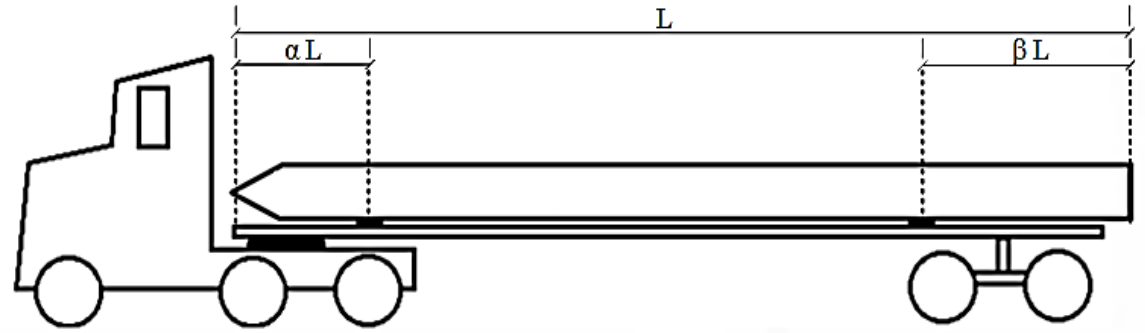
All road transport shall comply with the relevant clauses of the traffic regulations pertaining to provision of pilot vehicles and/or police escorts.

5.3.5 Support of piles during transport

Piles shall be supported in such a manner that no damage shall be incurred by the piles. Piles shall be transported only while supported at the points shown in Table 5.3.5. The transport vehicle shall be rigidly connected between the two pile-support points, independently of the pile.

Table 5.3.5 – Transport and storage points

Pile length (L) m	Support Points		
	Front (αL)	Back (βL)	Middle
≤ 21	0.18L to 0.23L	0.26L to 0.23L	None permitted
21 < L ≤ 24	0.17L to 0.23L	0.21L to 0.23L	None permitted
> 24	0.15L to 0.17L	0.20L to 0.21L	0.12L towards the middle from the back support



Piles shall be protected at all times, to prevent spalling of the edges by supports or by any other cause. Where piles are carried in more than one layer (two layers maximum) the supports for each both layers shall be directly above one another. Piles shall not rest on any support at locations between the approved support points. In addition, timber packing pieces shall be placed between the sides of adjacent piles to prevent contact between the piles during transport. The packing pieces shall be secured in such a manner that they shall not move during transport. Piles restraint shall comply with the NLRG requirements. Packing shall be placed between the piles and lashings to prevent spalling of the concrete.

5.4 Support of piles during storage

During storage, piles shall be supported in such a manner that no damage shall be incurred. Piles shall be supported on adequate stability frames as detailed on Transport and Main Roads Standard Drawing SD2021 with each frame placed at a distance of 0.21L from each end of the pile. Where piles are stacked in more than one layer, the stability frames for each layer shall be placed directly above the lower supports. Piles shall not be stacked more than three units high.

Note the slight difference in the location of the supports. When a pile is transported (Table 5.3.5 applies) and when it is stacked for storage (0.21L from each end). Further information on pile stability frames is available in Section 15.3.2 of MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units.*

Piles shall not rest on any support at locations between the approved support points during storage.

The storage area shall be cleared of rocks, tree stumps, and so on, and brought to an even grade to ensure that piles are supported as described above. The supports shall be of a size to provide sufficient bearing capacity and clearance to the piles for all ground conditions likely to occur during storage. End supports shall be level at all times to ensure that units do not develop a twist during storage.

5.5 Pitching

A procedure for lifting piles during pitching shall be included in the pile driving construction procedure.

During pitching the pile shall be lifted from a point not more than one sixth of the pile length below the top of the pile. Piles shall not be dragged along the ground during pitching.

Lifting of piles during pitching must be undertaken in a safe manner. It is the responsibility of the crane driver to ensure this occurred. A formal lifting procedure should have been provided and approved by the Administrator prior to any lifting.

6 Preboring

A CAS Manual Checklist exists for this Clause.

Preboring of slightly oversize holes (oversize no more than 55 mm of the corner to opposite corner dimension of the pile) through the upper layers to a maximum depth of 3 m shall be permitted to 'pot' the pile or to facilitate pitching unless explicitly banned on the Drawings.

For 550 mm prestressed octagonal piles, the most common pile type currently used, the corner to corner dimension is 595 mm, hance the maximum prebore hole diameter is 650 mm.

Preboring beyond a depth of 3 m shall be permitted if shown on the Project Drawings or as approved by the Administrator. Where such preboring is proposed by the Contractor but not shown on the Drawings, the Designer must re-assess the effect of preboring on the load capacity of the pile. Where moderate or higher strength surface or near surface materials overlies lesser strength material and the design founding material, preboring through the moderate or higher strength material may be considered with the approval of both the Administrator and Designer. If the preboring (beyond 3 m) is not shown on the Drawings the Designer’s agreement is mandatory.

Where preboring below 3 m is used and hole size details are not given on the Drawings, the diameter of the drill bit used shall not exceed the side-to-side dimension of the pile less 55 mm. Driving through the length of the undersize hole shall be carried out with caution and with minimal energy input.

For safety reasons, holes shall be sealed with rigidly fixed covers immediately after drilling.

Preboring through harder material to facilitate access to softer layers is a high-risk activity, likely to result in breaking (in tension) of the piles. Approval for this type of activity should not be given without consideration of all the risks.

Provided the maximum prebore hole diameters are not exceeded no requirement exists to back fill the annulus between the pile and the natural material. If these dimensions are exceeded however then the annulus must be properly backfilled with either a granular material or grout.

7 Pile driving

7.1 General

A CAS Manual Checklist exists for this Clause.

Details of the proposed pile driving procedure, including handling, pitching, splicing (if required), pile hammer, HSDT procedures and sub-contractor (at least for the required piles as applicable), PM procedures for the last 10 blows, pile cushion material, helmet and other equipment to be employed for this operation, and the risk assessment as required in Clause 4.2 shall be included in the Contractor's Quality Plan and shall be submitted to the Administrator at least 18 working days prior to the programmed date for commencement of driving. **Milestone**

All these various items are defined in this specification as follows: pile driving procedure – Clause 7, Pile handling – Clause 5, Pitching – Clause 5.5, Splicing – Clause 9, Hammer – Clause 7.5 and Annexure, HSDT – Clause 7.10 and Annexure, PM – Clause 7.9, Cushion and helmet and other equipment – Clause 7.6, Risk assessment – Clause 4.2.

The Contractor's Quality Plan may request preboring if considered necessary for the Contractor's mode of operation, or for safety reasons but not shown on the Drawings. Any request for preboring must be based on the Contractor's own assessment of the pile design and the Site's geotechnical conditions. Preboring may be considered and may be approved by the Administrator following the Designer's consent. Pile driving shall not commence until the procedure is approved by the Administrator. **Hold Point 4**

No pile shall be driven unless it has been inspected and approved by the Administrator (or their delegate). **Hold Point 5**

Any pile exhibiting a defect which may affect its behaviour during driving and/or serviceability or durability in service, shall be rejected and shall not be used in the Works. **Nonconformance**

Pile driving may proceed provided that both the specified characteristic 28 day strength of the concrete has been attained and the pile is at least seven days old.

If at any stage during driving operations the approved procedures are not followed or any damage to the pile occurs, pile driving shall cease until the problem is corrected. **Nonconformance**

Piles shall be driven only in the presence of the Administrator (or his delegate). **Hold Point 6**

During driving a log of penetration shall be kept for each pile as detailed in Clause 7.8.

All piles (including piles tested with a High Strain Dynamic Tester) shall be monitored for at least the last 10 blows using a PM device as detailed in Clause 7.9.

At least 15% of all piles, including at least two piles at the first pier or abutment and at least one pile per pier or abutment after that, and all test piles shall be tested using a High Strain Dynamic Tester as detailed in Clause 7.10.

All raked piles shall be tested with a High Strain Dynamic Tester, checked against vertical piles in the same group or structure.

Local excavation (if any) shall be completed before driving of piles is commenced. The driving equipment, once set up, shall remain in position until the Administrator approves its removal to another location. **Hold Point 7**

Ground material forced up between the piles during the driving operation shall be removed by the Contractor.

Pile driving procedures shall be planned to avoid heave of already driven piles in the same abutment or pier. Piles that have already been driven in the same abutment or pier shall be monitored before and after driving of piles in that abutment or pier to check for heave of piles that have already been driven. If the heave of any piles that have already been driven exceeds 5 mm, then the piles shall be subject to a minimum 15 blow restrike with PM to confirm set and capacity has still been achieved.

Measurement of heave shall be undertaken by a Surveyor using procedures and equipment capable of measuring the height of the pile to an accuracy of plus or minus 1 mm, or by a person deemed competent by a Surveyor using procedures developed by a Surveyor and appropriate equipment capable of the same accuracy. The final results / report shall be certified either by the Surveyor, or RPEQ Engineer and submitted to the Administrator before any stripping of the pile head occurs.

For further technical surveying advice, email TMR_Spatial_Enquiry@tmr.qld.gov.au.

7.2 Test pile

A test pile is any pile designated as a test pile in the Contract documents as well as the first pile driven in each pier or abutment and any pile on which a high strain dynamic test is conducted.

Test piles shall be driven at locations shown on the Drawings. Such piles, if approved by the Administrator, shall form part of the permanent structure.

All test piles shall be tested using both a HSDT for the majority of the drive and a PM for the last 10 blows of the drive.

Majority of the drive – HSDT on the test pile(s) shall be performed over the full length of the drive to determine driving stresses, impact energy, and geotechnical capacity in addition to establishing pile driving parameters for installation of the remaining piles in the pier of abutment.

7.3 Changes in founding level

If as a result of information gained from the driving of test piles (or any other piles), the Administrator determines with the agreement of the Designer and Geotechnical and Structures Sections of Transport and Main Roads that changes to the founding level shown on the Drawings are necessary, the Contractor shall be notified of such changes. Notification shall be in writing at the earliest possible time.

When consulting with Transport and Main Roads Geotechnical and Structures Sections, a detailed written assessment shall be submitted either by the Contractor and/or the Designer through the Administrator demonstrating that the changes in founding level are acceptable.

7.4 Location and tolerances

Piles shall be located in the positions shown on the Drawings within the following tolerances:

a) the maximum lateral displacement of the pile head from its correct position shall be 75 mm, and

b) the maximum deviation from the specified rake shall be 20 mm per metre.

The Contractor shall make all efforts to drive the piles within the tolerances specified above. If the above tolerances are exceeded, the Contractor shall carry out any remedial measures required so that the geometric location of the headstock can be achieved without compromising any other design aspect of the bridge. **Nonconformance** Piles shall not be forcibly realigned or sprung into tolerance. Prior to the commencement of the remedial measures, the Contractor shall submit a certified design for the remedial measures. The remedial measures shall not be used until approved by the Administrator.

7.5 Pile hammer

7.5.1 General

Piles shall be driven using either a conforming hammer equivalent to the design hammer as nominated in Clause 1 of Annexure MRTS65.1 or an Alternative hammer in accordance with Clause 7.5.2 or 7.5.3 (an Alternative hammer). The actual hammer used is termed the 'job hammer'.

7.5.2 Conforming and design hammer

The Design hammer is the hammer the designer has nominated for use during the contract having cognisance of the geotechnical conditions existing of the Site, the mass of the piles to be driven, the design depths of installation, and the required capacity of the piles. The details of the Design hammer are shown in Clause 1 of Annexure MRTS65.1. A Conforming hammer is one which meets or exceeds the capability of the Design hammer in terms of falling mass, drop height and rated energy and its input energy can be adjusted to consistently achieve a similar energy input as the Design hammer after all relevant losses have been accounted for. It also conforms to the requirements of Table 7.5.2.

For heavy hammers, of mass over 125% of the Design hammer, it is critical that the input energy can be accurately controlled to give an equivalent energy input as the Design hammer. When using a heavy hammer, the input energy should be adjusted to give a typical driving set of 5 mm to 10 mm per blow (measured as an average over ten blows). Provided this can be achieved there is no upper limit on the mass of a heavy hammer.

The drop of the hammer or of the ram shall not exceed 2 m.

Table 7.5.2 – Hammer / pile mass ratio

Length of Pile[1]	Minimum mass ratio (M_m/M_p)
< 9 m	1
9 m to 18 m	$1.33 - \left(\frac{L}{27}\right)$
> 18 m	0.67

Note:

[1] For spliced piles the pile length shall be taken as the length of the base section during driving of that section, and the total spliced pile length after completion of the splice for driving thereafter.

The energy input per blow shall be calculated as follows:

a) For drop hammers $E = M_m.H.e_f$

b) For diesel hammers $E = E_r.e_f$

Where the terms are as defined in Table 2.1.

The inputs for the calculations may be determined using the data obtained from the high strain dynamic tester and PM monitoring of the driving.

The pile driving process shall also be controlled such that for a Conforming or Design hammer, the stresses in the pile during driving shall not exceed 0.8 times f'_c in compression and 0.75 times the initial prestress in tension if the stresses in the pile are not monitored during driving, or 0.82 times the initial prestress in tension if the stresses in the pile are monitored (HSDT) during driving.

The following are the typical values for e_f:

For Drop hammers with trigger release	0.95
Winch Operated Drop hammers, single fall and a trailing rope	0.80
Steam or Air hammers which exhaust directly into the atmosphere	0.90
Any other hammer type in average working condition	0.70

When driving raked piles the hammer efficiency will be reduced due to friction in the ram guides and it may be necessary to use a more powerful hammer than is required to drive vertical piles.

Note: The minimum hammer mass determined using the data in Table 7.5.2 may differ from the conforming hammer shown in Clause 1 of Annexure MRTS65.1. Table 7.5.2 gives the general minimum requirements based solely on the mass of the pile, while the Annexure gives the specific requirements for the contract taking into account the geotechnical conditions of the Site.

7.5.3 Alternative hammer

Where the Contractor proposes to use a hammer, for some or all of the pile driving, which is of smaller size (mass or rated energy) than the Design hammer detailed in Annexure MRTS65.1, it shall comply with or exceed the requirements shown in Table 7.5.3. Requests to use an Alternative hammer shall be referred to the Administrator for his consideration, and potentially his approval. Such requests shall include revised Minimum Energy Inputs per blow and final set to be achieved when using the proposed hammer. Note that this final set shall not be less than 2.5 mm/blow, measured as an average over ten blows, and the drop height shall not exceed 2 m.

Essentially a revised Annexure MRTS65.1 should be provided for the new hammer, however the following data must not be revised to suit the alternative hammer details; Clause 3 – Required Minimum Ultimate Capacity, Clause 4 – all. Clause 5 should generally not be changed but in some circumstances, depending on the content of Clause 5 it may require amendment.

Since the 2.5 mm/blow measured as an average over ten blows is defined as nominal refusal, irrespective of hammer size, a set less than this is unacceptable. Approval should not be given to use a hammer which would require a final set of less than 2.5 mm/blow.

Approval should not be given to a hammer not conforming to Table 7.5.3 or one requiring a drop height of 2 m or more.

Table 7.5.3 – Hammer / pile mass ratio

Length of Pile[1]	Minimum mass ratio (M_m/M_p)
< 9 m	0.75
9 m to 18 m	$1 - \left(\frac{L}{36}\right)$
> 18 m	0.5

Note:

[1] For spliced piles the pile length shall be taken as the length of the base section during driving of that section, and the total spliced pile length after completion of the splice for driving thereafter.

The pile driving process shall also be controlled such that for the Alternative hammer, the stresses in the pile during driving shall not exceed 0.8 times f'_c in compression and 0.55 times the initial prestress in tension if the stresses in the pile are not monitored during driving, or 0.60 times the initial prestress in tension if the stresses in the pile are monitored (HSDT) during driving.

At least two test piles shall be driven at the first pier / abutment piled and at least one test pile at each subsequent abutment or pier. The dynamic analysis, which shall comply with the requirements of MRTS68 *Dynamic Testing of Piles* is required to demonstrate that:

a) the pile capacity has been achieved

b) the pile has not been damaged

c) the specified tension and compression wave stresses in the pile are not exceeded in the pile, and

d) the pile monitoring results and the dynamic analysis results correlate.

Generally, the same hammer as used for a test pile shall be used for normal production piles. Where a hammer change is required a further test pile shall be driven for each change in hammer. Prior to approval of an alternative hammer (or any hammer other than a Conforming hammer), the Administrator shall obtain from the Contractor a table of revised sets for the pile driving using the Alternative hammer (Clause 3 of Annexure MRTS65.1).

Due to the uncertainty in calculating the effective energy of hammers which impart extra energy, it is imperative that the final set of all the piles driven using such hammers are monitored using a PM. They may also require a higher frequency of dynamic testing (high strain) particularly initially.

7.6 Pile helmet

The pile helmet shall be of substantial steel construction and cylindrical in shape where it overlaps the side of the pile so as to permit the pile to rotate freely about its vertical axis. The helmet shall be loose fitting on the pile head, with no more than 15 mm uniform clearance to the outermost points around the periphery of the pile.

The helmet shall slide in and be guided by the leaders of the pile frame and shall remain in contact over the whole area of the top of the pile under its own weight.

The helmet shall have a steel diaphragm fitted at approximately mid height.

Between the steel diaphragm and the pile head there shall be placed an approved cushion of pine, natural-fibre rope, rubber, plywood or other approved packing / cushioning material **[Refer Hold Point 1]**. On top of the diaphragm, and fitting tightly into the helmet, there shall be placed a hardwood block approximately 300 mm long, or an approved packing of equivalent stiffness **[Refer Hold Point 1]**. The timber block (if used) shall have the grain parallel to the axis of the pile.

7.7 Driving procedure

To avoid damage by bending, the piles shall be driven from a fixed frame having sufficient rigidity to ensure accuracy of driving and freedom from bending of the pile under all conditions of tides, stream flow, hammer action or other disturbance which may occur during the driving. Flying leaders shall not be used unless the Contractor can demonstrate to the satisfaction of both the Administrator and the Director (Structures Design, Review and Standards) that the system used for such leaders will only transmit axial loads to the pile. Use of flying leaders shall not continue if piles deviate from vertical or if piles start to show damage during driving.

> Extensive spalling of the head of the pile is evidence that the hammer is not sitting correctly on the pile.

The force of the hammer blow shall be directed along the longitudinal axis of the pile. Care shall be taken to avoid inducing torsional stresses into the pile by ensuring that the pile is not restrained against rotation about its longitudinal axis.

Piles shall be guided and held on line particularly during the initial stages of driving. Shortly after commencement of driving and at regular intervals throughout the driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile. Attempts to correct any tendency for the pile to run off line by the application of significant horizontal restraint shall not be permitted. If the indications are that a driven pile shall terminate outside the specified tolerances, driving operations on that pile shall cease (see also Clause 7.4).

Particular care shall be exercised when driving into prebored holes as detailed in Clause 6.

A pile shall be rejected when:

1. In the opinion of the Administrator, a pile splits or cracks during driving and is damaged in any way such that the split, crack or other damage is materially detrimental to the strength or durability of the pile. **Nonconformance**
2. The pile is positioned out of tolerance. **Nonconformance**
3. When either PM or HSDT monitoring indicates that the pile is damaged.

The Administrator's decision to reject a pile shall be final.

In order to avoid damage to the piles by tension stress waves caused by the impact of the hammer, driving shall commence with an initial energy input limited to the minimum energy which can be achieved for the Conforming hammer. The energy input shall be gradually increased incrementally as the pile resistance increases. Driving shall then continue to final set with increasing energy input and decreasing penetration per blow, with the provision that the maximum penetration of 25 mm per blow shall not be exceeded. If penetration exceeds 25 mm per blow, the driving energy shall be reduced to such an extent that 25 mm set is again attained.

Damage to piles is not generally caused by using even a grossly oversize hammer. Likely causes of pile damage are, in order of likelihood:

1. hammer and pile not properly aligned
2. worn or damaged packing / cushioning material
3. excessive drop height, and
4. driving into a prebored hole using excessive energy.

Driving with a diesel hammer shall commence with the fuel throttled to the minimum required for the hammer to fire.

7.8 Pile driving log

During driving, the Contractor shall keep a log of progress of the drive showing the number of blows (including hammer input energy or drop height) per 0.25 m of penetration, as detailed in Clause 12, Item 2. Where the piling Contractor uses an automatic system (generally hard wired into the piling rig) this will suffice provided it gives at least the same information, Where a pile is tested by a HSDT then this will also suffice provided specifically the depth of penetration (at not greater than 0.25 m intervals) is recorded by the system.

7.9 Monitoring of pile driving (PM)

PM testing shall be undertaken on all piles for at least the last 10 blows of the drive.

Where a pile has been tested using HSDT the standard PM testing for the last 10 blows shall also be undertaken and these results correlated with the HSDT data. The results of the PM information shall be correlated with HSDT to determine the input parameters for calculation of capacity using the Hiley Formula as shown in Clause 7.11.

The Contractor shall supply complete digital and paper records of pile driving (including all HSDT and PM records) and pile hammer details to the Administrator in accordance with MRTS50 *Specific Quality System Requirements*.

Where the PM monitoring indicates that the pile is damaged this information shall be immediately reported to the Administrator. See also Clause 7.7.

A number of proprietary PM systems exist. Some are offset from the pile some are hard wired into the pile frame. Provided the system records all the required parameters, the specific system is the Contractor's decision.

7.10 High Strain Dynamic Testing (HSDT)

HSDT of piles using wave equation analysis shall be used to confirm the ultimate pile capacity at the positions nominated in MRTS68 *Dynamic Testing of Piles* and Annexure MRTS68.1. The procedure for HSDT testing shall be in accordance with the requirements of MRTS68 *Dynamic Testing of Piles*.

Where the HSDT testing indicates that the pile is damaged this information shall be immediately reported to the Administrator. See also Clause 7.7.

7.11 Pile capacity and pile set

The minimum ultimate capacity for the various piles is given in Clause 3 of Annexure MRTS65.1.

The values of final set per blow given in Clause 3 of Annexure MRTS65.1 should be calculated using the job hammer energy stated in Clause 3 of Annexure MRTS65.1 and the use of a minimum amount of cushion material sufficient only to prevent damage to the pile during driving. If the Annexure uses a hammer other than the job hammer it shall be recalculated to conform to the job hammer requirements. See also Clause 7.5.

Required values of final set shall be calculated using the following version of the Hiley Formula, using the actual equipment details, coefficients for temporary compressions and efficiency of each blow as measured on the Site.

$$S = 9800 \times \frac{[M_m + e^2(M_f + M_p)]}{M_m + M_f + M_p} \times \frac{E}{R} - 0.5C$$

Terms are as defined in Table 2.1.

The following are the expected typical values for 'e' in the Hiley equation.

e = 0.25 for 300 mm hardwood packing (acting alone), or

e = 0.40 for 100 mm of Novasteen (acting alone).

If the monitoring device used determines the value of 'e' then this value may be used rather than the assumed values as above.

7.12 Pile penetration

Piles shall be driven until both the calculated set and the minimum penetration (this should be shown on the Drawings or in Annexure MRTS65.1, Clauses 3 and 4) have been attained. If, the calculated set has been achieved but, the pile is not yet at the specified founding level, driving shall continue until either the specified founding level or nominal refusal has been achieved, whichever is attained first. Nominal refusal shall be deemed to be the situation where 25 mm total penetration is achieved for 10 blows using the specified energy of the Conforming hammer. Where the job hammer is an Alternative hammer, set and nominal refusal values shall be recalculated to suite the parameters of the job hammer. Where set or design founding level are not achieved then one or more of Clauses 7.12.1 to 7.12.3 become operative.

Driving shall not continue when the average penetration over a 250 mm interval is less than that of nominal refusal, which is 2.5 mm per blow.

The intent of the 250 mm limit is to avoid a situation where a very thin hard band exists which could be piled through. The 250 mm limit should not be enforced as the minimum over which refusal shall be determined. That is, only 10 blows may be adequate to define nominal refusal in a situation where a pile is refusing on hard rock. Engineering judgement needs to be used.

In all cases, a pile shall not be terminated at a level more than 1 m above the founding level shown on the Drawings, or above the minimum penetration level as shown on the Drawings or Annexure MRTS65.1, without the written approval of the Designer and Administrator.

The following options need to be considered when contemplating changing the founding level of piles.

If set is achieved above design founding level, do you stop at that level or continue driving to the design founding level or to nominal refusal whichever occurred first? Note that there may be contractual implications of the decisions as well as geotechnical issues, for example; disposal of unused length of pile, the quantum of pile driving will be reduced, are the head bars long enough or will new head bars be required, is the proposed founding strata adequate, is it underlain by lesser strength material? As a general rule it may be better contractually to drive to nominal refusal or design level, but never at a set of less than nominal refusal of 2.5 mm per blow measured as an average over 10 blows.

When a pile is driven to design level, and set is achieved, stop driving at the design level.

If the pile reaches design level and set has not been achieved, then if possible, continue driving until set has been reached and then stop. If the pile is driven as far as it can be without the need to extend the pile (for driving), then it may be reasonable to do a restrike. If on restrike set is obtained, then stop. If on restrike set is not achieved, a review of the pile design may need to be undertaken.

In regard to extending the pile, if the pile must be extended and then driven this is the worst possible situation in terms of delay to the project. Where a pile only needs to be extended for structural purposes (that is, will not be driven further) this is a relatively quick and simple operation.

7.12.1 Piles refuse above minimum penetration level

Where the pile cannot be driven to the minimum penetration level, then driving shall cease and the Designer contacted to determine the issue and for advice. **Hold Point 8**

When piles are consistently hanging up, it may be prudent to determine the capacity of the pile in the 'high' founding level and then reassess the design rather than take extraordinary efforts to achieve penetration. It would be prudent to undertake HSDT or PM such a pile to ensure damage is not occurring to the pile. When piles hang up the Designer and Transport and Main Roads Structures should be contacted to determine what the issues are at the Site.

7.12.2 Piles do not achieve capacity below founding level

If the full length of the pile has been driven and the pile fails to meet the minimum capacity requirements of Clause 3 of Annexure MRTS65.1, the Contractor shall continue driving using a follower until the required pile capacity is achieved. The pile shall then be extended using reinforced concrete as specified in Clause 10.

The Contractor may request a restrike (Clause 7.12.3), as detailed below, at any stage when driving below founding level. If the restrike is successful (set has been achieved) then the pile shall be accepted, otherwise further driving as detailed above shall be undertaken.

If the pile has been driven using a follower and cannot be practically driven further and still has not reached the required capacity, then piling shall cease, and the Designer contacted to determine the issue and for advice.

7.12.3 Restrike

If the design pile penetration has been reached or exceeded, but set not yet attained, the Contractor may request a restrike of the pile. In this case piling shall cease for at least 12 hours, and the pile restruck using the nominated driving energy as detailed in Clause 3 of Annexure MRTS65.1 for a minimum of a total of 15 blows. The set shall then be determined over the last 10 blows. If the required set is achieved the pile shall be accepted.

7.13 Follower

A follower shall only be used in the circumstances outlined in Clause 7.12.2, it shall not be used simply for the convenience of the Contractor.

Interface packing shall be used between the pile and the follower so as to ensure a uniform transfer of driving stresses across the interface.

A sleeve or other device shall be used to ensure alignment of the follower with the pile during driving.

The required set shall be recalculated to include the effects of the follower and the interface packing.

Where circumstances warrant the use of a follower, it shall be employed with the minimum of interruption to the driving sequence. Nevertheless, some tightening of the previously driven portion of the pile may occur as a result of the delay and it may be necessary to continue driving for some time with full energy input and minimal set until the pile again loosens sufficiently to continue penetrating at the same rate as before the interruption.

8 Survey

As Constructed survey of piles shall be completed in accordance with MRTS56 *Construction Surveying.*

9 Stripping of the pile head

Stripping of pile heads shall be a Witness Point. **Witness Point 1**

In order to prevent spalling below the concrete cut-off level, stripping of a pile shall be preceded by cutting a circumferential notch, approximately 30 mm deep, at the level above which the concrete is to be removed. Tools used to remove the concrete immediately above and adjacent to the notch shall be directed inwards, towards the centre of the pile so as to avoid spalling of the concrete below the cut-off level.

If additional measures are necessary to prevent spalling, the concrete immediately below the notch shall be firmly clamped around the periphery by a shaped steel band, and tightened against the concrete on all faces.

Care shall be exercised during the stripping operation to ensure that the longitudinal reinforcement and/or prestressing strands are not damaged in any way. Explosives shall not be used for the stripping operation. When stripping prestressed concrete piles, shock release of the stressing force shall be avoided.

The upper end of the pile shall be stripped to expose the longitudinal reinforcement (and/or strands) for the bond lengths shown on the Drawings.

If these are not shown, the bond lengths shall not be less than:

a) 30 bar diameters for Grade 500N deformed bars, or

b) 50 diameters for prestressing strand.

Where bars (or strands) of different diameters are used, the stripped length shall be equal to the longest of the individual requirements.

10 Pile splicing

10.1 General

This clause applies to splices between prestressed pile segments. All splices shall be full moment capacity splices. Where the pile design requires splices between prestressed concrete sections and other types, for example steel sections, job specific requirements shall be developed. The Contractor shall supply pile splicing procedures to the Administrator at least 18 working days prior to any splicing. **Milestone**

> Pile splicing relates to the situation where the design calls for the joining of piles during the driving process. Pile extensions (Clause 10), relates to the situation where a pile is over driven and as a result the pile must be extended, generally without further driving, to enable the pile's incorporation into the headstock, pile cap or other element.

10.2 Tolerances on position of dowel bars

Splice dowel bars and formed holes shall both be parallel to the centreline of the pile element. The tolerance on position of the dowels shall be ± 2 mm.

The orientations of the set of dowel bars in an upper element and the formed holes in a lower element shall be such that the dowel bars of any top element can be inserted into the formed holes of any bottom element and the octagonal shape of both elements is contained within the same steel splice sleeve.

10.3 Manufacture of steel pile sleeves

Steel splice sleeves shall be manufactured and hot-dip galvanised to the details shown on the Drawings and in accordance with the requirements of MRTS78 *Fabrication of Structural Steelwork*.

Corrosion protection shall be applied as shown on the Drawings and in accordance with the manufacturer's specifications.

10.4 Splicing of pile elements

Splicing of pile elements shall be in accordance with the details shown on the Drawings. The splicing elements, including the sleeve, dowels and holes shall be cleaned and free of dust and moisture prior to commencing the splice.

The gaps between the pile elements and the steel sleeve, between the ends of the pile elements, and around the dowel bars in the formed holes shall be filled with epoxy.

Splicing shall be a Witness Point. **Witness Point 2**

10.5 Epoxy for splice

Epoxy used for pile splice shall be a rapid set liquid epoxy binder for use in civil engineering applications where fast development of high compressive and impact strength is essential. The cured epoxy shall have the following minimum strength:

a) ultimate compressive strength (cured) 120 MPa, and

b) ultimate flexural strength (cured) shall be 55 MPa.

Details of alternative epoxy products and their properties shall be submitted to the Administrator for approval of use not less than 18 working days prior to splicing of pile elements. **Milestone**

10.6 Application and curing of epoxy

Epoxy shall be applied to the details shown on the Drawings and to the Manufacturer's specifications.

Epoxy must be fully cured. Pile driving may be resumed when tests on the samples show that the epoxy has reached at least 60 MPa compressive strength. Application of uniform heat may be applied to the splice to accelerate strength gain.

The epoxy used in each pile splice shall be tested and conform to Clause 9.5 prior to commencing driving. **Hold Point 9**

10.7 Testing of epoxy

10.7.1 Equipment

The equipment required for epoxy testing on the Site is as follows and is to be provided by the Contractor:

i. test frame
ii. 25 tonne hydraulic jack
iii. pump, gauge, hose
iv. base piece of epoxy test piece
v. circular ring with dial gauge
vi. top swivel section (two plates separated by roller bearing to ensure axial load), and
vii. load cell and readout unit.

If heat has been used for accelerating epoxy strength gain, the specimen shall be cooled prior to undertaking testing. The test specimen shall be at constant temperature for testing.

10.7.2 Test procedure

1. Make epoxy test sample 200 mm long, 50 mm diameter.
2. When cured, cut 25 mm off each end, then cut to create three 50 mm long test specimens.
3. The specimen shall be placed on the test base. The top swivel section shall be supported on the ball bearing which is placed on top of the test specimen.
4. Place test ring at mid-height of specimen.
5. Apply 120 kN to specimen, i.e. approximately 60 MPa pressure.
6. Acceptance criteria:
   a) diameter of test specimen does not increase by more than 1.0%, and
   b) two tests to pass. In the event of one pass and one fail, a third test shall be undertaken.

11 Pile extension

Pile extensions generally (but not exclusively) relate to circumstances where piles are to be extended without further driving. Pile splicing (Clause 9) is a totally different situation requiring the use of special pile segments which incorporate a splicing element.

Piles shall be extended as required, consequent to authorised driving below the founding level shown on Drawings. The design of the extension shall be forwarded by the Contractor through the Administrator to the Designer for approval. Design approval shall be from the Designer to the Administrator to the Contractor.

The pile shall be stripped as described in Clause 8 and the reinforcement extended using lapped bars. The number and size of bars shall be such that the total cross-sectional area of reinforcement in the extension shall equal the total cross-sectional area of bars plus strands existing at the base of the extension. The number of bars shall be subject to confirmation by the Designer at the time of construction of the extension.

If re-driving is to take place, spiral reinforcement shall be installed to the same detail as for the existing pile head.

As an alternative to full length laps, the structural grade reinforcement may be extended by fillet welding bars of shorter laps. Welded bars shall be located on the same pitch-circle diameter as the main bars and shall be lapped with the main bars in the pile head. Welded splice joints between bars shall be double lap splice joints complying with AS 1554.3.

All welding to reinforcement shall be carried out in accordance with the requirements of MRTS71 *Reinforcing Steel*. Before commencing any such welding, details of the proposed splice shall be submitted to the Administrator for approval.

Welding shall be performed only by qualified welders. The Administrator may require sample specimens to be submitted by the intended welder for testing purposes.

No welding of, or to, prestressing strands shall be permitted. Prestressing strands shall be adequately protected during any welding operations adjacent to them.

The pile extension shall be formed to the same cross-sectional profile and filled with concrete of the same strength as that specified for the original pile.

Concreting operations shall be carried out in accordance with the requirements of MRTS70 *Concrete*.

12 Approvals of changes

Since formal approval is required for a number of changes from the As Designed requirements, the process to be followed is as described below.

The Contractor shall request from the Administrator approval of a change to the specification or design. The Administrator may consult widely (including but not limited to the Designer or Transport and Main Roads Structures, or the department generally) to help in resolving any issue. Potential areas of change include (but not limited to) changes in hammer details, founding levels, prebore details which may relate to all piles or specific piles. The Administrator may request information or a recommendation from others, for example the Designer, to aid in his acceptance or rejection process.

The Designer may recommend or reject all or some of the requested changes or accept some or all. If any change is accepted. Where as a result of a Contractors request a change is required, (for example to Annexure MRTS65.1 as a result of a change to hammer details), the Contractor shall submit a draft revised completed (and certified by an RPEQ) Annexure with the request. This revised Annexure will then become 'the' Annexure for purposes of part or all of the Specification once the request has been approved by the Administrator. Multiple changes may require multiple cycles of this procedure.

A Contractor may request that a different hammer is to be used for all driving (a global request applying for all piles), or that a different hammer is used for a specified number of piles, for example; all abutment piles or piles on say Pier 3. Similarly, with founding levels, they may relate to one or more piles or positions.

Where a request involves a change in founding level of less than 1 m, then this should be treated as a variation, to be approved by the Administrator, rather than a change to the Specification. See also the comments regarding the accuracy of the design founding level in Table 2.1.

13 As Constructed records

The Contractor shall provide the following As Constructed records in relation to pile driving for each pile, no later than 24 working days after completion of piling:

1. The base RL and diameter of prebore.
2. Pile driving log at maximum interval of 0.25 m, showing the number of blows required for the interval, job hammer type / model, hammer input energy or drop height, cushioning material type and thickness and when it was changed, date and time of start and end of pile driving.
3. In relation to the last 10 blows for each pile, for each blow the penetration, temporary compression, job hammer type and hammer input energy or drop height.
4. PM record for the entire section of pile driving where a PM was used, both in graphical and tabular (digital) format.
5. Where a High Strain Dynamic Test has been undertaken, the test record shall include at least all the above data for example; job hammer details, energy input, set (to an accuracy of at least 1 mm) as well as the full pile driving record for each blow from start to finish. This record must also include a depth or RL record accurate to 1 mm.
6. All As Constructed survey information in accordance with this specification and MRTS56 *Construction Surveying.*

14 Supplementary requirements

The requirements of MRTS65 *Precast Prestressed Concrete Piles* are varied by the supplementary requirements given in Clause 5 of Annexure MRTS65.1.