Technical Specification

Transport and Main Roads Specifications
MRTS66 Driven Steel Piles

October 2016

Queensland Government

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

Contents

1 Introduction

This Technical Specification applies to the supply and/or installation of driven steel piles.

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.

The requirements for supply, fabrication and installation of steel piles shall 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

Clauses	Category of Work
10	Cold Galvanising Paint

For information regarding registered suppliers and products for the above items refer to:

Queensland Department of Transport and Main Roads
Bridge and Marine Engineering
GPO Box 1412
Brisbane Qld 4001

2 Definition of terms

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

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS/NZS 3679.1	Structural steel - Hot-rolled bars and sections
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 1554.1	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

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 and Milestones

Clause	Hold Point	Milestone
6.1	1. Pile driving procedure	Submit pile driving procedure (21 days)
6.1	2. Driving of piles	
6.1	3. Removal of piling equipment	
6.4	4. Remedial measures for out of tolerance piles	
10	5. Driving extended pile	

4.2 Construction procedures

Construction procedures which are required to be submitted by the Contractor to the Administrator in accordance with Clause 5 of MRS50 *Specific Quality System Requirements* are listed in Table 4.2.

Table 4.2 – Construction procedures

Clause	Procedure
6.1	Pile driving

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	Procedure
6.4	Location and tolerances of each pile
6.7	Pile capacity for each pile

5 Steel piles

5.1 Requirements for steel piles

5.1.1 General

Steel used in piles shall comply with the requirements of AS/NZS 3679.1 and to the section sizes and mass per unit length as shown in the Standard Drawings.

5.1.2 Dimensional tolerances

Steel piles shall be supplied within the following tolerances:

a) The length of the pile shall not be less than the gross length as shown in the Standard Drawings.

b) The squareness of the ends of the piles shall be such that the surface at the driving end shall not depart from the true cross-section by more than 2 mm, and

c) The lateral bow shall not exceed 0.0007 of the gross length of the pile.

5.1.3 Supplied lengths

Steel piles shall, where possible, be supplied in single (un-spliced) lengths as shown in the Standard Drawings. Spliced lengths shall be accepted only if the specified gross length exceeds the maximum single length for the section size as supplied by the mill, in which case the splicing shall be in accordance with the requirements of Clause 10.

5.1.4 Hot-dipped galvanising

Piles shall be hot-dipped galvanised in accordance with the requirements of AS/NZS 4680. The average coating mass shall be not less than 600 g/m².

5.2 Transport, handling and storage

5.2.1 General

The method of handling and transport of piles and the location and the method of storage on Site shall be such as to avoid damage to piles or galvanised coatings. Piles shall not be handled by dragging across the terrain. Any damage which occurs to coatings during handling, transport or storage shall be rectified by the Contractor, to the approval of the Administrator. **Nonconformance**

5.2.2 Lifting

Care shall be taken to ensure that galvanised coatings are not damaged during lifting operations.

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.

5.2.3 Transport

5.2.3.1 General

The Contractor shall assess the route from the place of manufacture to the Site to ensure safe transport.

5.2.3.2 Support of units during transport

Steel piles shall be supported on timber packers during transport. Sufficient supports shall be used so that piles are not subject to undue bending or whipping. 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 drop out during transport. Piles shall be kept firmly secured during transport. Piles shall be protected against damage to galvanised coatings caused by securing straps.

5.2.4 Support of piles during storage

Piles shall be supported in such a manner that no damage shall be incurred by the units. Piles shall be stacked on suitable timber bearers in a manner which ensures the piles remain straight, are clear of the ground, and are protected from any damaging influences. Where piles are stacked in more than one layer, the supports for each layer shall be placed directly above the lower supports.

The storage area shall be cleared of rocks, tree stumps etc, 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.

6 Pile driving

6.1 General

Details of the proposed pile driving procedure, including the pile hammer and other equipment to be employed for this operation, shall be included in the Quality Plan and shall be submitted to the Administrator at least 21 days prior to the programmed date for commencement of driving. Milestone Pile driving shall not commence until the procedure is approved by the Administrator. **Hold Point 1**

No pile shall be driven unless it has been inspected and approved by the Administrator. Piles shall be driven only in the presence of the Administrator. **Hold Point 2**

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

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 of its removal to another location. **Hold Point 3**

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

Piles which lift as a result of other pile driving operations nearby shall be re-driven to their correct levels.

6.2 Test pile

Test piles, if specified, shall be driven at locations shown in the Standard Drawings. Such piles, if approved by the Designer, shall form part of the permanent structure.

6.3 Changes in contract level

If, as a result of information gained from the driving of test piles (or any other piles), the Administrator determines that changes to the contract level, as shown in the Standard Drawings, of any of the as yet un-driven piles are necessary, the Contractor shall be notified of such changes, in writing, at the earliest possible time.

6.4 Location and tolerances

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

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

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

c) the maximum rotation at the pile with respect to position as shown on the Standard Drawings shall be 5 degrees.

The Contractor shall make all effort to drive the piles within the tolerances specified above. If the above tolerances are exceeded **Nonconformance**, the Contractor shall carry out, any remedial measures required to achieve the geometric location of the headstock or pilecap without compromising any other aspect of the structure. 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 adopted until approved by the Administrator. **Hold Point 4**

6.5 Pile hammer

Piles shall be driven by means of:

a) a drop hammer, or

b) a single-acting steam or air hammer, or

c) a diesel hammer.

Double-acting pile hammers shall not be used.

The hammer used for driving shall be equivalent to the type nominated in Clause 1 of Annexure MRTS66.1 and shall be capable of delivering the minimum energy input per blow stated in Clause 2 of Annexure MRTS66.1.

The energy input per blow shall be calculated as follows:

a) For Drop Hammers, Steam or Air Hammers:

$$E = M_m H e_f$$

where:

E = energy input per blow in tonne metres

M_m = mass of the falling part of the hammer in tonnes

H = overall height of fall in metres, and

e_f = efficiency of the blow.

The value of e_f, for vertical operation, for various hammer types is given in Table 6.5.

The effects of raking the leaders and of additional returns of the hoist rope from the hammer to the frame head, shall be taken into consideration in the determination of the value of e_f.

Table 6.5 – Value of ef for drop, steam and air

Hammer Type	ef
Drop hammers having a trigger release.	0.95
Winch-operated drop hammers, single fall and a trailing rope.	0.80
Steam or air hammer which exhausts direct to the atmosphere.	0.90

b) For Diesel Hammers:

$$E = E_r e_f$$

where:

E = energy input per blow in tonne metres

E_r = the manufacturer's rating of energy output of the hammer in tonne metres

e_f = efficiency of the blow

= 0.7 for a hammer in average working condition.

The actual energy delivered shall be calculated from observations on the Site of the height of the drop.

6.6 Pile helmet

Pile helmets shall be of substantial steel construction and be such that the pile is held centrally under the hammer.

The construction of the pile helmet shall allow for uniform bearing across the top of the pile (refer to the squareness-of-ends tolerance in Clause 5.1.2).

6.7 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.

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 not be bent or sprung into position, but shall be effectively guided and held on line 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. The pile shall then be withdrawn, the hole filled, and driving restarted.

Piles shall be driven to the founding level shown in the Standard Drawings, or to such other level accepted by the Administrator in accordance with the following procedures:

a) If, when using the energy input per blow specified in Clause 2 of Annexure MRTS66.1, the minimum acceptable penetration has been achieved, and the final set per blow in Clause 2 of Annexure MRTS66.1 has been obtained and is greater than 5 mm, but the founding level as shown in the Standard Drawings has not been reached, driving shall continue to founding level unless a situation of nominal refusal is reached at a higher level.

b) Nominal refusal shall be deemed to be the situation where 20 mm total penetration is achieved for the final 10 blows using the maximum energy of the hammer. Continued driving where the average penetration is less than for nominal refusal shall not be permitted.

c) If, when using the energy input per blow specified in Clause 2 of Annexure MRTS66.1, the final set per blow, as shown in Clause 2 of Annexure MRTS66.1, is attained before the minimum acceptable penetration has been achieved, driving shall continue with increased energy input from the hammer (up to a maximum of twice the value shown in Clause 2 of Annexure MRTS66.1) until minimum penetration is achieved, unless a condition of nominal refusal is met at a higher level.

d) If the minimum acceptable penetration cannot be obtained under the conditions of driving specified in paragraph (c) above, the Contractor shall, subject to the conditions specified in Clauses 7, 8 and/or 9, overcome the situation by using one or more of the following methods of assistance:

i. pre-boring

ii. drilling and firing, and/or

iii. jetting.

e) The procedure to be followed in regard to driving piles which cannot reach acceptable penetration shall be approved by the Administrator. **Nonconformance**

f) The values of final set per blow necessary to achieve the required minimum ultimate resistance, as given in Clause 2 of Annexure MRTS66.1, have been calculated for the energy input values shown in Clause 2 of Annexure MRTS66.1, and have been based on the use of a minimum amount of cushioning material under the helmet.

g) The values of the final set per blow given in Clause 2 of Annexure MRTS66.1 may be revised, depending on the driving equipment employed in the Works **[Refer to Hold Point 2]**.

In calculating revised values of final set, the following version of the Hiley Formula shall be used, using the actual equipment, coefficients for temporary compressions, efficiency of blow, etc, as measured on the driving equipment used by the Contractor:

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

where:

s = pile set in millimetres

M_m = mass of the falling part of the hammer in tonnes

M_f = mass of pile helmet for drop hammers or combined mass of pile helmet plus anvil for steam, air or diesel hammers in tonnes

M_p = mass of pile in tonnes

E = energy input per blow in tonne metres as calculated in accordance with Clause 6.5

e = Coefficient of Restitution

= 0.55 for steel hammer on steel pile without packing, or

= 0.40 for 100 mm of Novasteen

R = minimum ultimate capacity of pile in kiloNewtons given in Clause 2 of Annexure MRTS66.1, and

C = combined temporary compression of the helmet cushion(s), pile and adjacent ground in millimetres

h) Where provided for in the Contract, dynamic testing of piles using wave equation analysis shall be used to confirm the ultimate pile capacity. The procedure for dynamic testing and the number and location of piles to be tested shall be in accordance with the requirements of MRTS68 *Dynamic Testing of Piles*.

i) Any pile which fails to attain the specified set at founding level shall be extended in accordance with the provisions of Clause 10. **Nonconformance** Driving shall then continue as required

Where possible, driving of the first section of the pile shall be completed before the next section is spliced on, and

j) If at any time during the driving operation, the use of a follower becomes necessary, the follower shall be placed in position and driving recommenced within one hour of the cessation of driving.

The additional penetration obtained from the last eight blows prior to placing the follower in position and the additional penetration obtained from the first eight blows after the follower is in position (using the same driving energy per blow) shall be recorded.

The above records of penetration shall be used to calculate the energy loss which results from use of the follower. The energy input shall then be adjusted upwards to provide for such a loss, or alternatively the final set per blow of the hammer shall be revised to allow for the reduced energy input.

7 Pre-boring

Pre-bored holes for piles shall be used only if shown in the Standard Drawings or if otherwise authorised in writing by the Administrator **[Refer to Hold Point 1]**.

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

Pre-boring of oversize holes through the upper layers of the foundation material, to facilitate pitching or driving of a pile, shall not occur without approval from the Administrator, who will determine the diameter of such holes and the back-filling requirements.

8 Jetting

Jetting of piles shall be carried out only if shown in the Standard Drawings or if authorised by the Administrator **[Refer to Hold Point 1]**.

A minimum of two jets, with a minimum diameter of 20 mm, shall be employed in the operation. Jet nozzles shall be uniformly disposed about the periphery of the pile and shall be located as close to the toe as is practicable.

The pumping plant shall have the capacity to deliver water continuously with sufficient volume and at sufficient pressure (at least 700 kPa) to freely erode the material adjacent to the toe of the pile. Valves shall be fitted to each delivery line to enable the amount of water delivered to each jet to be controlled independently.

Jetting shall cease one metre before the required penetration is reached. The jets shall then be withdrawn and the driving operation continued unassisted for the remaining depth.

9 Drilling and firing

Drilling and firing for piles shall be used only if shown in the Standard Drawings or if otherwise authorised by the Administrator **[Refer to Hold Point 1]**.

The drilling operation, the type of explosive used, and the method of charging and firing shall all require approval of the Administrator.

Unless otherwise approved by the Administrator **[Refer to Hold Point 1]**, the amount of explosive charge per hole shall not exceed the following:

$$W = 8D^2$$

where:

W = the mass of explosive charge fired in any one delay period in grams, and

D = the distance from the hole to the nearest structure or pile in metres.

provided that at all times the peak particle velocity of the shock wave, measured at nearest pile already in place, shall not exceed 50 mm/second.

10 Extension to piles

Extensions to piles shall be made as follows:

a) The extension section shall have a section size and mass per unit length equal to that of the previously driven section.

b) The extension section shall be aligned accurately with the previously driven section of the pile.

c) The joint edges shall be prepared and the sections welded together using full penetration double vee butt welds, all in accordance with AS/NZS 1554.1, and

d) The welded joint shall be protected with a cold galvanising paint which is compatible with the original coating and registered by the department (refer Clause 1). The paint shall be applied in accordance with the manufacturer's recommendations.

Driving shall not recommence until the welded splice, including the protection coating, has been inspected and approved by the Administrator. **Hold Point 5**

11 Trimming of pile head

Following completion of driving, the pile head shall be trimmed by cutting off the top of the pile to the correct level as shown in the Standard Drawings.

12 Bond bars

After the trimming of the pile head is complete, grade 400Y bond bars shall be welded to the pile head.

The size of the bond bars and the size of the welds shall be as shown in the Standard Drawings.

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

13 Supplementary requirements

The requirements of MRTS66 *Driven Steel Piles* are varied by the Supplementary requirements given in Clause 3 of Annexure MRTS66.1