

Main Roads Technical Standard

MRTS65

Precast Prestressed Concrete Piles

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Precast Prestressed Concrete Piles

1 INTRODUCTION

This Technical Standard applies to the supply and/or installation of precast, prestressed concrete piles.

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

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

2 DEFINITION OF TERMS

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

3 REFERENCED DOCUMENTS

There are no Australian Standards referenced in this document.

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 Standards*.

The Hold Points, Witness Points and Milestones applicable to this Standard are summarised in Table 4.1.

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
5.1	1. Approval of pile casting program		Submission of pile casting program (7 days)
5.2.1	2. Approval of method for handling transport and storage of piles		Submit proposed method of handling, transport and storage, including program and rate of delivery (14 days)
5.2.3.1	3. Approval to transport piles		
6.1	4. Approval of Pile driving procedure		Submit pile driving procedure (21 days)
6.1	5. Driving of piles		
6.1	6. Removal of piling equipment		
10		Stripping of pile heads	

4.2 Construction Procedures

The Contractor shall prepare documented procedures for all construction processes in accordance with the quality system requirements of the Contract. The construction procedure shall include RPEQ certified design of the crane pad, or alternatively a statement confirming no need for a crane pad in specific locations.

Construction procedures for those activities listed in Table 4.2 shall be submitted to the Administrator in accordance with Clause 5 of MRTS50 *Specific Quality System Requirements*.

Where handling and pitching take place, the danger zone must be defined on the basis of the risk assessment taking into account the length of the piles, height of the platform, height of the rig/crane, weather conditions, terrain (slope and roughness), proximity to road, footpath or waterway that may be used by watercraft. The minimum danger zone is defined as the area with a radius equal to the length of the pile, or length of headers, whichever is greater, plus 2m. 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 the road including traffic lane or shoulder, additional traffic control measures must be implemented. Those measures must specify the number and functions of individual traffic controllers deployed for the duration of handling and pitching. . If traffic stops are required, timing, duration and number of stops must be approved by TMR. The road must be closed to traffic for the duration of handling and pitching until the pile is restrained from falling onto the road.

Where pre-boring is permitted the road may be open to traffic immediately following lowering the piles into the hole.

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

The cost of traffic control required for handling and pitching shall be born by the contractor.

Table 4.2 – Construction Procedures

Clause	Procedure
5.2	Handling, transport and storage of piles
6	Pile driving
7	Preboring

4.3 Conformance Requirements

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

Table 4.3 – Conformance Requirements

Clause	Procedure
6	Pile capacity and level for each pile
6.4	Location and tolerances for each pile

5 PRESTRESSED CONCRETE PILES

5.1 Manufacture of Prestressed Concrete Piles

Prestressed concrete piles shall be manufactured in accordance with the requirements of MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Bars*.

The pile casting program shall be submitted to the Administrator at least 7 days before casting commences. **Milestone** Piles shall not be cast until the program is approved by the Administrator. **Hold Point 1** The Administrator may vary the casting length of any un-cast pile, from time to time, basing this determination on the driving history of piles already driven.

Test piles used to determine the depth of penetration shall be cast in the lengths shown on the Drawings. Following driving of the test piles by the Contractor, the Contractor shall submit to the Administrator a proposed amended schedule of casting lengths based on the results of the test piles. The Contractor shall not cast the remaining piles until the amended schedule has been approved by the Administrator [**refer to Hold Point 1**].

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 by impact or by undue bending.

Piles shall not be handled by dragging across the terrain.

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 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.

where f_c is the strength of concrete at time of handling.

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 14 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 designer before being adopted. **Hold Point 2**

For piles up to 21 metres in length, the contractor shall advise the Administrator at least 7 days before taking delivery of the piles, of the anticipated arrival times and the planned date of delivery.

5.2.2 Lifting

Piles shall be handled by lifting with a suitable load sharing mechanism of a type shown in Table 5.2.2, with attachment points located along the pile as shown. Piles shall be protected at all times to prevent spalling of the edges by the handling slings.

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 5.2.2 – Pile Handling Points

Lengths are based on stresses and impact allowances in accordance with Clause 5.2.1	Max Length of Pile When Handled as Shown (mm)		
	450 mm Octagonal	500 mm Octagonal	550 mm Octagonal
	10	11	11
	17	18	19
	25	27	28

5.2.3 Transport

5.2.3.1 General

The Contractor shall assess the route for transport of piles and, in its submission to the Administrator in accordance with Clause 5.2.1, 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**

5.2.3.2 Certification of Equipment

Prime movers shall display a current Certificate of Inspection issued by the Queensland Department of Transport.

Prime movers and trailing equipment shall display a current Licence to Hire issued by the Queensland Department of Transport.

5.2.3.3 Mass of Loads

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


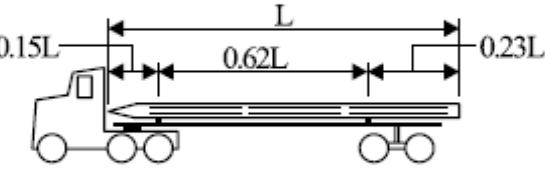
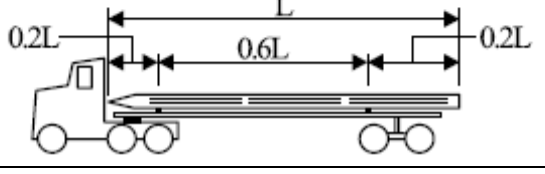
5.2.3.4 Escorts and Pilots

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

5.2.3.5 Support of Units During Transport

Units shall be supported in such a manner that no damage shall be incurred by the units. Piles shall be transported only while supported at the points shown in Table 5.2.3.5. The transport vehicle shall be rigidly connected between the two pile-support points, independently to the pile.

Table 5.2.3.5 – Transport and Storage Points

Support Points	Maximum Length of Pile When Handled as Shown (mm) Note 1		
	450 mm Octagonal	500 mm Octagonal	550 mm Octagonal
	19	20	21
	22	23	24
	25	27	28

Note 1 – Lengths are based on stresses and impact allowances in accordance with Clause 5.2.1

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, the supports for each layer carried on top of another layer shall be placed directly above the previous supports. 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 drop out during transport. Piles shall be kept firmly secured by independent chains at each end of the piles with suitable packing placed between the piles and chains to prevent spalling of the concrete.

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 supported on two level bearers of minimum dimensions 100 mm x 100 mm placed at the points shown in Table 5.2.3.5. Where piles are stacked in more than one layer, the supports for each layer shall be placed directly above the lower supports. Piles shall not be stacked more than three high.

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, 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 handling and pitching, the pile hammer, dynamic testing, the pile cushion material and other equipment to be employed for this operation, shall be included in the Contractor's Quality Plan and shall be submitted to the Administrator at least 21 days prior to the programmed date for commencement of driving. The Contractor's Quality Plan may specify pre-boring if considered necessary for safety reason and not shown on the drawings. The request for pre-boring must be based on contractor's own assessment of the pile design. Pre-boring may be considered and approved by the Administrator following bridge designer's consent. **Milestone** Pile driving shall not commence until the procedure is approved by the Administrator. **Hold Point**

No pile shall be driven unless it has been inspected and approved by the Administrator.

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. **Nonconformance**

Pile driving may proceed at any age after the specified characteristic strength of the concrete has been attained.

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. **Hold Point 5**

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 6**

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

6.2 Test Pile

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

6.3 Changes in Founding Level

If, as a result of information gained from the driving of test piles (or any other piles), the Administrator determines that changes to the founding level as shown on the 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 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** 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.

6.5 Pile Hammer

6.5.1 General

Piles shall be driven by means of –

- a) a drop hammer;
- b) a single acting steam or air hammer; or
- c) a diesel hammer.

Double acting pile hammers shall not be used.

6.5.2 Conforming Hammer

The conforming hammer shall comply with Clauses 6.5.1 and 6.5.2.

The hammer shall be equivalent to the type nominated in Clause 1 of Annexure MRTS65.1 and shall be capable of delivering the minimum energy input per blow stated in Clause 2 of Annexure MRTS65.1.

If piles are driven by means of a drop hammer, the ratio of the mass of the hammer to the mass of the pile shall not be less than that given in Table 6.5.2-A. The drop of the hammer, or of the ram of a steam or air hammer, shall not exceed 2 metres without the approval of the Administrator.

Table 6.5.2-A – Drop Hammer/Pile Mass Ratio

Length of Pile (metres)	$\frac{\text{Mass of Hammer}}{\text{Mass of Pile}}$
< 9	1
9 to 18	$1.33 - \frac{\text{Pile length in metres}}{27}$
> 18	0.67

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 6.5.2-B.

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 6.5.2-B – Value of e_f for Drop, Steam and Air Hammers

Hammer Type	e _f
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_r = the manufacturer's rating of energy output of the hammer in tonne metres;
e_f = efficiency of the blow; and
= 0.7 for a hammer in average working condition unless it can be demonstrated that a greater value is achieved on the Site.

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

6.5.3 Alternative Hammer

Where the Contractor proposes to use an alternative hammer, driving shall comply with Clause 6.5.3.

The absolute minimum ratio of the mass of the alternative hammer to the mass of the pile shall be as given in Table 6.5.3. **(Refer to Hold Point 4)**

Table 6.5.3 –Minimum Hammer Weight

Length of Pile (metres)	Mass of Hammer/Mass of Pile
< 9	0.75
9 to 18	1 - (Pile length in metres) / 36
> 18	0.5

For any hammer lighter than Table 6.5.2(A) but greater than Table 6.5.3, dynamic testing shall be undertaken in accordance with MRTS68. Two test piles shall be driven at the first pier/abutment and 1 test pile at each subsequent abutment or pier. The dynamic analysis is required to demonstrate that –

- a) the pile capacity has been achieved;
- b) the pile has not been cracked; and
- c) the tension wave stresses in the pile are less than 0.6 times the initial prestress in the pile.

6.6 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 material **[refer Hold Point 4]**. 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 4]**. The timber block (if used) shall have the grain parallel to the axis of the pile.

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.

Should a pile split or crack during driving or become damaged in any way such that the split, crack or other damage is detrimental to the strength or durability of the pile, such pile shall be rejected. **Nonconformance**
 The Administrator's decision as to whether a split or crack or other damage is detrimental to the strength or durability of the pile shall be final.

In order to avoid damage to the piles by tension stress waves caused by the impact of a drop hammer, driving shall commence with an initial energy input of the order of 1.0 tonne metre. The energy input shall be gradually increased as the pile tightens until a set per blow of approximately 25 mm is obtained at approximately one half of the maximum anticipated energy input.

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 during this stage.

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

6.8 Pile Capacity and Pile Set

The minimum ultimate capacity for the various piles is given in Clause 2 of Annexure MRTS65.1.

The values of final set per blow given in Clause 2 of Annexure MRTS65.1 have been calculated using the energy stated in Clause 2 of Annexure MRTS65.1 and the use of a minimum amount of cushion material sufficient only to prevent damage to the pile during driving.

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

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

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,
 - = 0.25 for 300 mm hardwood packing (acting alone); or
 - = 0.40 for 100 mm of Novasteen (acting alone);
- R = minimum ultimate capacity of pile in kiloNewtons given in Clause 2 of Annexure MRTS65.1; and
- C = combined temporary compression of the helmet cushion(s), pile and adjacent ground in millimetres.

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*.

6.9 Pile Penetration

Piles shall be driven using the specified hammer until both the calculated set and the minimum penetration (if this is shown on the Drawings) have been attained. If, at that stage, the pile is not yet at the specified founding level, driving shall continue until either the specified founding level or nominal refusal is attained, whichever is attained first. 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.

In all cases, a pile shall not be terminated at a higher level than the founding level shown on the Drawings (or higher than the minimum penetration level where this is shown on the Drawings) without the written approval of the Administrator.

Piles which contain additional bonding bars cast into the head end shall be driven until a minimum length equal to the bond length of these bars remains in the pile below the cutoff level. Pile heads shall not be cut to level without this bond length remaining, without the Administrator's approval. **Nonconformance**

If the specified founding level is not reached under the above conditions of driving, additional measures may be adopted, such as an increase in the driving energy, pre-boring, jetting, drilling and firing, or a combination of these, to obtain an acceptable penetration. Drilling and firing with the partially driven pile in place shall not be permitted.

If a pile, on driving the whole of the cast length, fails to meet the minimum capacity requirements of Clause 2 of Annexure MRTS65.1, the Contractor may extend the leaders, if necessary, and continue driving (using a follower) until the required pile capacity is achieved. The pile shall then be extended in reinforced concrete as specified in Clause 11.

6.10 Follower

A follower shall only be used in the circumstances outlined in Clause 6.9. It shall not be used merely to suit the Contractor's mode of operation.

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 shall 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.

7 PRE-BORING

Pre-bored holes for piles shall be used only if shown on the Drawings or approved by the Administrator.

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

Where pre-boring to facilitate penetration of the pile is used pursuant to Clause 6.9 and details are not given on the Drawings, the diameter shall not exceed the side-to-side dimension of the pile less 50 mm, except in exceptional circumstances. Driving through the length of undersize hole shall be carried out with caution with reduced energy input.

Pre-boring of oversize holes through the upper layers of the foundation material, to facilitate pitching or driving of a pile shall not occur unless shown on the Drawings or approved by the Administrator. Where pre-boring is proposed by the contractor but not shown on the drawings the designer must re-assess the effect of pre-boring on the load capacity of the pile. Where the weak alluvium type of materials overlay the hard load bearing material, pre-boring through the alluvium may be considered as its contribution to the skin friction could be small. Where well consolidated granular material or XW rock is found near the surface, pre-boring is likely to have a significant impact on the skin friction capacity of the pile. If the pre-boring is not shown on the drawings the designer's assessment is mandatory.

8 JETTING

Jetting of piles shall be carried out only if shown on the Drawings.

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 on the Drawings.

Details of the drilling operation, the type of explosive used, and the method of charging and firing shall be submitted to the Administrator with the proposed pile driving procedure [refer Hold Point 4].

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 STRIPPING OF THE PILE HEAD

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

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. Percussion 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, 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.

11 PILE EXTENSION

Piles shall be extended as required, consequent to authorised driving below the founding level shown on the Drawings. **Nonconformance**

The pile shall be stripped as described in Clause 10 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.

The extended bars shall be secured in position and held by circumferential ties (or spirals) consisting of 6.3 mm wire at 150 mm pitch (or equivalent).

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 5 bar diameters with the main bars in the pile head. The bars shall be welded each side over the full lap length using a weld of 6 mm minimum throat thickness.

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 the 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 SUPPLEMENTARY REQUIREMENTS

The requirements of MRTS65 *Precast Prestressed Concrete Piles* are varied by the Supplementary requirements given in Clause 3 of Annexure MRTS65.1.