ROADS AND MARITIME SERVICES (RMS)

QA SPECIFICATION B54

DRIVEN TUBULAR STEEL PILES

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REVISION REGISTER

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<td>Ed 1/Rev 0</td>
<td>First issued.</td>
<td>GM, RNIC</td>
<td>28.09.98</td>
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<td>Ed 1/ Rev 1</td>
<td>Annex B54/1</td>
<td>New schedule listing Identified Records.</td>
<td>GM, RNIC</td>
<td>28.02.00</td>
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<tr>
<td>Ed 1/Rev 2</td>
<td>1.2, Annex B54/2</td>
<td>Minor changes.</td>
<td>GM, RNIC</td>
<td>26.07.00</td>
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<tr>
<td>Ed 1/Rev 3</td>
<td>15 (a)</td>
<td>References to Conditions of Contract changed to suit C1.</td>
<td>GM, RNIC</td>
<td>30.05.01</td>
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<tr>
<td>Ed 1/Rev 4</td>
<td>Annex B54/2</td>
<td>Item 1(a): Testing organisations (vi) and (vii) added. Item 1(b): Testing organisation (iii) added.</td>
<td>GM, RNIC</td>
<td>02.08.01</td>
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<tr>
<td>Ed 2/Rev 0</td>
<td>All</td>
<td>Clauses &amp; annexures rearranged. Text revised to direct imperative style. &quot;Superintendent&quot; replaced by “Principal”. &quot;Contractor&quot; replaced by “you”. “Shall” replaced by “must”. Reformatting and editing including font changes. Revised to align with RTA B50 Ed3/Rev1. New clause after the Table of Contents. Renumbered and revised.</td>
<td>GM, IC</td>
<td>17.11.08</td>
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<tr>
<td>Ed 2/Rev 1</td>
<td>1.3</td>
<td>Definitions of “you” and “your” added. Added: NPER registration as equivalent to CPEngr, Engrs Aust, for certification purposes.</td>
<td>GM, IC</td>
<td>15.01.10</td>
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<td>8.1</td>
<td>Annex M</td>
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<td></td>
<td>8.3</td>
<td>Referenced documents updated.</td>
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<td>Ed 3/Rev 0</td>
<td>Global</td>
<td>Minor editing and rewording to improve clarity.</td>
<td>GM, CPS (Peter Letts)</td>
<td>22.02.14</td>
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<td></td>
<td>1.2.4</td>
<td>Reference to spec Q on frequency of testing added.</td>
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<td></td>
<td>1.3</td>
<td>Clarification added that “Dynamic Testing” is same as “High-Strain Dynamic Testing”.</td>
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<td>2.1</td>
<td>New heading added to form sub-clause 2.1. Subsequent sub-clauses renumbered.</td>
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<td></td>
<td>Clause added to fix driving shoes where shown on the Drawings.</td>
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<td></td>
<td>2.3</td>
<td>Clause reworded to harmonise with corresponding clause in spec B200.</td>
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<td></td>
<td>2.7</td>
<td>Clause on tube fabrication reworded to improve clarity.</td>
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<td></td>
<td>4</td>
<td>Where bottom level of pile cap is more than 2 m below existing surface level,</td>
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<td></td>
<td>requirements for excavation clarified.</td>
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<td></td>
<td>5.3.1</td>
<td>Clause on pile resistance reworded to improve clarity.</td>
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<td></td>
<td>6.1, 7</td>
<td>Minimum period before restrike test increased to 24 hrs to accord with AS 2159.</td>
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<td></td>
<td>6.1</td>
<td>Statement on piling hammer mass and height of drop moved to clause 8.2.</td>
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<td></td>
<td>8.2</td>
<td>Statement on piling hammer mass and height of drop moved here from clause 6.1.</td>
<td></td>
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<td></td>
<td>8.4</td>
<td>Previously clause 8.3.1. Responsibility for cost of preboring under various situations clarified. Details of proposed preboring equipment and methods to be included in PQP. Preboring to nominated depths clarified.</td>
<td></td>
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<td></td>
<td>11.1</td>
<td>Statement added that, for open ended piles, to excavate material inside pile to level shown on Drawings. Hold Point on backfilling and cutting off of a pile moved here from clause 9.3.</td>
<td></td>
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<td></td>
<td>11.3</td>
<td>Requirement for dewatering prior to concreting deleted.</td>
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<tr>
<td>Ed 3/Rev 0 (cont’d)</td>
<td>13.1</td>
<td>Reference to list of approved Dynamic Testing systems in Annex F deleted and replaced by url reference for list of approved bridge components on internet.</td>
<td></td>
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<td></td>
<td>13.2</td>
<td>Previous clause 13.2 on Dynamic Testing equipment deleted. Subsequent clauses renumbered.</td>
<td></td>
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<td></td>
<td>Annex B</td>
<td>Jetting removed from costs of pile driving to be included in Item (c).</td>
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<td></td>
<td>Annex F</td>
<td>Previous lists of approved Dynamic Testing systems in Annex F deleted.</td>
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<td></td>
<td>Annex M</td>
<td>Reference documents updated.</td>
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<tr>
<td>Ed 3/Rev 1</td>
<td>2.6, Annex L</td>
<td>Reference to “B204” replaced by “B201”.</td>
<td>DCS</td>
<td>27.10.17</td>
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<td></td>
<td>Annex M</td>
<td>Referenced documents updated.</td>
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<tr>
<td>Ed 3/Rev 2</td>
<td>5</td>
<td>Previous clause 8 on piling equipment and method moved here to clause 5. Affected clauses renumbered. Previous clause 11.3 and 11.4 combined to form new clause 11.3. Individual clauses rearranged and reworded. Permissible types of concrete specified.</td>
<td>DCS</td>
<td>06.11.18</td>
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DRIVEN TUBULAR STEEL PILES

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- **B54/B** – Measurement and Payment
- **B54/C** – Schedules of Hold Points, Witness Points and Identified Records
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- **B54/D** – Planning Documents
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FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification RMS B54 Edition 3 Revision 1.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. Additional Text.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. Deleted Text.
RMS QA SPECIFICATION B54
DRIVEN TUBULAR STEEL PILES

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the supply and driving of tubular steel piles, and filling the tubular piles with concrete where applicable.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 (Not Used)

1.2.2 Measurement and Payment

The method of measurement and payment is detailed in Annexure B54/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure B54/C list the HOLD POINTS and WITNESS POINTS that must be observed. Refer to Specification RMS Q for the definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure B54/C are Identified Records for the purposes of RMS Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B54/D and must be implemented.

1.2.5 Frequency of Testing

The Inspection and Test Plan must nominate the proposed frequency of testing to verify conformity of the item, which must not be less than the frequency specified in Annexure B54/L. Where a minimum frequency is not specified, nominate an appropriate frequency. Frequency of testing must conform to the requirements of RMS Q.

You may propose to the Principal a reduced minimum frequency of testing. The proposal must be supported by a statistical analysis verifying consistent process capability and product characteristics. The Principal may vary or restore the specified minimum frequency of testing, either provisionally or permanently, at any time.
1.2.6 Referenced Documents

Unless otherwise specified, the applicable issue of a referenced document, other than an RMS Specification, is the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure B54/M.

1.3 DEFINITIONS

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

**Calculated Set**  The calculated average Set from 10 consecutive blows to achieve the required resistance with the Net Driving Energy stated on the Drawings.

**Contract Level**  Reduced level (RL) of the pile toe shown on the Drawings.

**Dynamic Analysis**  A Wave Equation Analysis of a specific blow using force and velocity measured in Dynamic Testing together with measured pile/soil parameters, to replicate the measured traces of force and velocity and subsequently determine pile resistance, distribution of resistance and pile integrity (e.g. CAPWAP, TNOWAVE).

**Dynamic Data**  The force and velocity near the head of the pile and estimates of pile resistance, Net Driving Energy, pile integrity and stresses in the pile, determined immediately using electronic equipment (e.g. PDA) during pile driving.

**Dynamic Testing**  The measuring and recording of Dynamic Data for each blow of the hammer and subsequent Dynamic Analysis of specific blows. The term is the same as the High-Strain Dynamic Testing of AS 2159.

**Maximum Net Driving Energy**  Net driving energy which must not be exceeded at any time during driving, to prevent damage to the pile.

**Minimum Penetration Depth**  Minimum length of pile below existing surface level or other specified surface level at pile location shown on the Drawings.

**Net Driving Energy**  Driving energy at the top of the pile i.e. after hammer, helmet and cushion losses are accounted for.

**Nominal Driving Energy**  Driving energy nominally imparted by the hammer i.e. before hammer, helmet and cushion losses are accounted for; calculated by multiplying the hammer weight and nominal drop.

**Nominal Refusal**  A penetration of not more than 13 mm from 10 consecutive blows with the Net Driving Energy stated on the Drawings or derived after the driving of Representative Piles.

**Penetration**  Length of pile embedded in the ground.

**Pile Design Load**  The design ultimate axial load shown on the Drawings for the pile.
Driven Tubular Steel Piles

Piling Supervisor
Your employee responsible for supervision and control of the piling operations.

Representative Pile
A pile nominated on the Drawings or by the Principal that represents a number of piles that are driven to a resistance, for the purpose of determining driving parameters using Dynamic Testing. Representative Piles which are driven prior to the manufacture of the piles represented are also Test Piles.

Set
Permanent pile displacement after each drop of the hammer.

Temporary Compression
Elastic deformation of the pile and soil when the hammer strikes the pile.

Test Piles
Piles manufactured and driven to enable the Principal to confirm or alter as necessary the pile lengths shown on the Drawings. Test Piles which represent piles driven to a resistance are also Representative Piles. Test Piles are nominated on the Drawings, and are usually dimensioned 2 (two) metres longer than required by the design Contract Levels.

Wave Equation Analysis
A predictive computer analysis of pile driving, which can use hammer, pile and soil characteristics measured during Dynamic Testing for the determination of resistance versus Set of a pile (bearing graph) or pile driveability (e.g. GRLWEAP)

2 MATERIALS AND SUPPLY OF PILES

2.1 GENERAL
The materials for and supply of the piles must be in accordance with the Drawings and this Specification.

Where shown on the Drawings, supply and fix steel end plates or driving shoes to the pile toes prior to driving.

2.2 FERROUS MATERIALS
The following steels may be used:
- AS 3678 Grades 250 or 350; or
- AS 1548 Any grades; or
- AS 1594 Grade HU 240.

2.3 TESTING OF MATERIALS
All structural steel supplied must be manufactured under quality management systems certified to AS/NZS ISO 9001 by a third party accredited by the Joint Accreditation System of Australia and New Zealand.
Provide evidence that the materials used comply with the relevant Australian Standards and RMS specifications. A mill certificate with appropriate NATA registration from the material supplier will constitute documentary evidence of compliance.

Do not use any material or part in the Works until it has been identified with the tests prior to its use.

2.4 DEFECTS IN FERROUS MATERIALS

Defects in the steel tubes and other components arising from their manufacturing which become evident at any stage are considered to be nonconformities.

Submit your proposal for repair or replacement of the defective materials in your PROJECT QUALITY PLAN.

2.5 CUTTING OF STEEL

You may cut steelwork using flame cutting, sawing or shearing unless specified otherwise. Finish surfaces produced by such cutting square (unless a bevelled edge is called for), true and smooth, to the required dimensions.

2.6 WELDING

All welding procedures, welder qualifications and welding must conform to Specification RMS B201 for Weld Category SP.

2.7 FABRICATION

Fabricated tubular steel piles must be one of the following types:

(a) Tubes fabricated from steel plate rolled to a circular cross-sectional shape and welded at the longitudinal joint to form segments which are then shop spliced into suitable lengths. The welds for the longitudinal joints and shop splices must be full penetration butt welds. The longitudinal joints for adjoining segments must be staggered by 90° to each other.

(b) Spirally welded tubes complying with AS 1579. The welds must be full penetration butt welds carried out using the submerged arc process from both sides of the plate.

2.8 PROTECTIVE TREATMENT AND CLEANING OF STEEL PILES

Where protective treatment of the steel piles is required, submit details of the proposed method of applying the treatment.

Thoroughly clean off all mud, grease, loose rust, loose mill scale, weld spatter, etc from the portions of the piles which are to be embedded or encased in concrete, prior to the embedment or encasement.

2.9 MARKING OF PILES

Clearly and indelibly mark all Test Piles at one metre intervals commencing from the toe to show penetration depths attained during driving.

Mark all other piles for traceability purposes.
3 **HANDLING AND STACKING OF PILES**

Verify, by engineering calculations, that your method of lifting and stacking of piles will not cause any damage to the piles.

Determine the size of bearers placed on foundation material, accounting for the site conditions, to keep piles clear of each other and the ground.

Bearers must support the piles over their full width and, where the piles are stacked in more than one layer, be in line vertically to avoid additional bending in any pile in the stack.

Damaged piles are considered to be nonconforming.

4 **SITE PREPARATION**

Carry out any excavation or backfilling in the vicinity of the piles in accordance with Specification RMS B30.

Where the ground level is to be permanently lowered, such as for an excavated channel, do not drive piles located in the area to be excavated until such excavation is complete.

Where the level of the bottom of the pile cap is more than two metres below the existing natural surface level, prior to the driving of the piles, carry out excavation for the pile cap to a level which is not more than two metres higher than the level of the bottom of the pile cap, to reduce any temporary contribution of the ground above the bottom level to the pile resistance measured during driving.

Where piles are shown on the Drawings as penetrating through a new embankment, place and compact the new embankment prior to driving the piles, unless otherwise specified.

5 **PILING PLANT AND PILING METHOD**

5.1 **GENERAL**

Without limiting the requirements of Specification RMS G22, prior to bringing any piling plant to the Site, provide drawings and calculations certified by a Chartered Professional Engineer with membership of Engineers Australia practising in the field of geotechnical engineering (or equivalent) of any working platforms or supports required to keep the piling rig stable and safe during piling operations at the Site.

An equivalent to membership of Engineers Australia would be an Engineer registered on the National Engineering Register (NER) in the general area of practice of Civil Engineering and experienced in the geotechnical assessment of the stability and safety of working platforms or supports for piling rig during piling operations.

5.2 **DRIVING EQUIPMENT**

You may drive piles using diesel, compressed air, drop or vibration hammers or a combination of these. Do not use clutch operated drop hammers.
The piling hammer must be capable of achieving the specified Net Driving Energy. Drop hammers must be of sufficient mass to achieve the Net Driving Energy with a drop of not more than two metres.

The driving equipment must be capable of producing a consistent driving energy with a variation of less than 10% between piles at equivalent stages of driving.

Maintain the equipment including packing so that whenever measurements are made to determine the driving resistance including restriking, the Net Driving Energy will not differ by more than 10% from that used to establish the driving parameters.

Replace the packing regularly to maintain efficient cushioning of the driving force.

### 5.3 DRIVING METHOD

Unless specified otherwise or approved otherwise by the Principal, the method of driving must be in accordance with AS 2159 and the requirements of this Specification.

Prior to commencing piling operations on site, submit to the Principal certification, including calculations, by a Chartered Professional Engineer with membership of Engineers Australia practising in the field of Civil or Structural Engineering (or equivalent), verifying that under the proposed setting-up and site conditions, the equipment nominated will be used within its safe working capacities.

An equivalent to membership of Engineers Australia would be an Engineer registered on the National Engineering Register (NER) in the general area of practice of Civil or Structural Engineering.

### HOLD POINT

<table>
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<th>Process Held:</th>
<th>Setting up of piling frame and driving of all piles, including Test Piles and Representative Piles.</th>
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<td>Submission Details:</td>
<td>Details of the proposed driving equipment and method together with certification, including calculations, by a Chartered Professional Engineer with membership of Engineers Australia practising in the field of Civil or Structural Engineering (or equivalent), verifying that under the proposed setting-up and site conditions, the equipment nominated will be used within its safe working capacities.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Principal will consider the details and certification submitted, prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>

### 5.4 USE OF PRE-BORING

You may use pre-boring to assist in attaining the Minimum Penetration Depth specified.

Where pre-boring to nominated depths is shown on the Drawings, the cost of pre-boring must be included in the rate for Item (c) in Annexure B54/B. Where pre-boring is not shown on the Drawings but is directed by the Principal, the cost of the pre-boring will be borne by the Principal.

You may also carry out pre-boring at your discretion even where not specified or directed, in a manner which is not detrimental to the pile performance, in which case the costs of the pre-boring will be borne by you.
In all cases where pre-boring is used, submit details of your proposed pre-boring equipment and methods including pre-boring diameter in the PROJECT QUALITY PLAN. Notify the Principal if you require to change the pre-boring diameter, unless previously approved by the Principal.

The depth of pre-boring must not exceed the Minimum Penetration Depth specified.

Where pre-boring is required, determine the depth of pre-boring by trial and error during the pre-boring of Test Piles/Representative Piles where such piles are specified. Otherwise, determine the depth of pre-boring by trial and error during the actual driving of piles.

Carry out pre-boring of the second and third Test Piles/Representative Piles using information derived from the driving and Dynamic Testing of the first and second Test Piles/Representative Piles respectively.

If the sides of the pre-bored hole are not self-supporting, provide temporary support for the hole.

To ensure that the pile is properly supported laterally and will develop skin resistance in the pre-bored hole, before driving, backfill any space remaining between the pile and the sides of the pre-bored hole with a suitable granular material, and compact by flooding the granular material. Remove any temporary support after the pre-bored hole has been backfilled.

Record the diameter, use of any temporary support and reduced level (RL) of the bottom of all pre-bored holes as part of the pile driving record.

Extend as necessary, at your cost, any pile which, in the Principal's opinion, requires extending due to excessive pre-boring.

6 ACCEPTANCE CRITERIA FOR PILE DRIVING

6.1 GENERAL

Drawings prepared to AS 5100 show ultimate loads. Ultimate loads are used as the basis for this Specification.

6.2 PILES DRIVEN TO NOMINAL REFUSAL IN ROCK

This clause applies where piles are shown on the Drawings to be driven to Nominal Refusal in rock.

6.2.1 Pile Resistance

Drive piles to achieve Nominal Refusal in rock, or to the required pile resistance as demonstrated by Dynamic Testing in accordance with Clause 6.3.1, at the end of driving.

6.2.2 Dynamic Testing

Carry out Dynamic Testing in accordance with Clause 13 to verify the Net Driving Energy delivered by the driving equipment and the distribution of resistance along the pile to confirm that the pile is founded in rock, on at least one pile for each different pile rake and each different piling equipment set-up. This must include the first Test Pile driven, if Test Piles are nominated on the Drawings.
6.3 **Piles Driven to a Resistance**

This clause applies where piles are NOT shown on the Drawings to be driven to Nominal Refusal in rock.

Unless specified otherwise or instructed by the Principal, if the driving record indicates that some piles of a footing have founded in rock or in another hard layer, then drive all piles of the footing to found in that same layer.

6.3.1 **Pile Resistance**

After achieving the Minimum Penetration Depth shown on the Drawings, drive the piles further to achieve the required pile resistance, given as follows:

(a) For Representative Piles (refer Clause 8), the required pile resistance is at least the Pile Design Load divided by the applicable geotechnical strength reduction factor, both of which are shown on the Drawings, and demonstrated by Dynamic Testing.

(b) For piles represented by a Representative Pile, the required pile resistance is the same as in item (a) above but demonstrated by the driving parameters established during the driving of that Representative Pile to achieve the same pile resistance.

(c) For an individual pile not represented by a Representative Pile, the required pile resistance is at least the Pile Design Load divided by the applicable geotechnical strength reduction factor for individual pile testing, both of which are shown on the Drawings, and demonstrated by Dynamic Testing of that individual pile.

You may propose to carry out Dynamic Testing of an individual pile, but any acceptance of such proposal will be at the absolute discretion of the Principal. Payment for such testing when accepted by the Principal must be in accordance with Item (l) in Annexure B54/B.

6.4 **Minimum Penetration Depth**

Apply driving methods that will ensure that all piles attain the Minimum Penetration Depth shown on the Drawings. Where the Minimum Penetration Depth cannot be achieved, notify the Principal. The Principal will determine whether a pile that does not reach Minimum Penetration Depth is acceptable.

6.5 **Positional Tolerances**

Drive piles with tolerances not exceeding the positional tolerance requirements specified in AS 2159.

6.6 **Driving Records**

Prepare a driving record for each pile. The driving record must contain at least the following information:

(a) Date of driving pile.

(b) Design location, inclination and dimensions of pile.

(c) Ground surface level at the time of driving, and toe level at end of driving.

(d) Reports of Dynamic Testing, including restrike tests, when carried out.

(e) Record of Sets and Temporary Compressions for Test Piles and Representative Piles including restrike test results and, for other piles, at the end of driving.
(f) Type and size of hammer and its stroke, or for double acting hammers the number of blows per minute.

(g) Type and condition of packing on the pile head, and of the dolly or follower.

(h) Sequence of driving in pile groups.

(i) Actual location and any apparent deviation from design location and inclination.

(j) Any other relevant information.

Make suitable provision in the records for the names and signatures of your personnel responsible for driving and testing the piles and for verifying its conformity with the specification requirements.

7 TEST PILES

7.1 GENERAL

Drive Test Piles at locations nominated on the Drawings as “Test Piles”.

Drive all Test Piles first BEFORE driving the remaining piles.

For Test Piles which are also Representative Piles, comply also with the requirements of Clause 8.

<table>
<thead>
<tr>
<th>HOLD POINT</th>
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</thead>
<tbody>
<tr>
<td>Process Held:</td>
</tr>
<tr>
<td>Submission Details:</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
</tr>
</tbody>
</table>

Record the number of blows per metre for Test Piles over the whole driven length. For the last ten blows, record the final Set in mm and the average Temporary Compression per blow.

Perform Dynamic Testing over the whole driven length and record data for analysis from the start to the end of driving on the steel tube alone.

Verify the resistance of the Test Pile before or after filling the tube with concrete, as specified on the Drawings.

Unless specified otherwise, carry out a restrike test in accordance with Clause 13.3 after a minimum period of 24 hours. Where restriking a pile is carried out, the driving parameters achieved must be equal to or better than those measured at the end of driving and the distribution of resistance along the pile must be effectively unchanged. Where these criteria are not met, submit the driving records to the Principal and take such action as directed by the Principal.

Notwithstanding that a Test Pile may have achieved the required pile resistance and the required Minimum Penetration Depth, the Principal may require further driving of the Test Pile.
7.2 CONFIRMATION OR ALTERATION OF PILE LENGTHS

On completion of driving of the Test Piles, submit to the Principal the driving records and Dynamic Testing reports of the Test Piles.

Allow three working days for the Principal to consider your submission and instruct the lengths of the remaining piles.

HOLD POINT

Process Held: Making up the pile lengths, and driving of piles represented by the Test Piles. Driving of all piles, other than Test Piles.

Submission Details: Driving records and Dynamic Testing reports of all Test Piles including restrike test results.

Release of Hold Point: The Principal will consider the driving records of the Test Piles and will confirm or alter the pile lengths shown on the Drawings, prior to authorising the release of the Hold Point.

8 REPRESENTATIVE PILES

Drive Representative Piles at locations nominated on the Drawings as “Representative Piles”.

HOLD POINT

Process Held: Driving of each Representative Pile.

Submission Details: Notification of the time and location of the driving of each Representative Pile at least one working day prior to commencing.

Release of Hold Point: The Principal will inspect the location of each Representative Pile, and may review the arrangements for monitoring, prior to authorising the release of the Hold Point.

Record the number of blows per metre for Representative Piles over the whole driven length. For the last ten blows, record the final Set in mm and the average Temporary Compression per blow.

Perform Dynamic Testing over the whole driven length and record data for analysis from the start to the end of driving on the steel tube alone.

Verify the resistance of the Representative Pile before or after filling the tube with concrete, as specified on the Drawings.

Unless specified otherwise or accepted by the Principal, the Set must be in the range of 3 mm to 10 mm per blow at the end of the driving so that the full pile resistance is mobilised and can be measured using Dynamic Testing equipment.

Unless specified otherwise, carry out a restrike test in accordance with Clause 13.3 after a minimum period of 24 hours. Where restriking a pile is carried out, the driving parameters achieved must be equal to or better than those measured at the end of driving and the distribution of resistance along the
9 DRIVING OPERATION

9.1 GENERAL

Your Piling Supervisor must supervise and control the driving at all times.

During all driving operations, the driving equipment, procedures and parameters must be in accordance with the procedures established during driving of the Test Pile/Representative Pile. At the end of driving and during restriking, the Net Driving Energy delivered to the pile must be within 10% of that used at the end of driving and restriking of the appropriate Test Pile/Representative Pile.

Confirm during driving using the records of the driving of the Test Pile/Representative Pile that the pile is being driven in the same manner, using the records of number of blows per metre, Penetration and Temporary Compressions.

If driving operations cease for any reason other than to perform a restrike test, then upon recommencement of driving, allow the striking of a minimum of 30 blows at the required Net Driving Energy before assessing whether the pile has met the required driving criteria.

At all times during the driving operation, adjust the driving equipment such that the blow of the hammer is directed centrally and axially on the pile head.

9.2 RESTRICTION ON STRESSES AND NET DRIVING ENERGY DURING DRIVING

During driving, including testing and restriking of piles, ensure at all times that the driving stresses do not exceed those for installation specified in AS 2159, and that the Net Driving Energy does not exceed the Maximum Net Driving Energy shown on the Drawings, unless approved otherwise by the Principal.
Avoid damage to the pile caused by excessive stresses during driving. Initially limit the Net Driving Energy to no more than half of the required Net Driving Energy and the pile Set to no greater than 10 mm per blow. Then gradually increase the energy, ensure at all times that the Set of the pile does not exceed 25 mm per blow when the driving is between one half and the full required Net Driving Energy.

Should damage to the pile be likely during driving, modify the driving procedure further so as to prevent damage from occurring.

In the case of a diesel hammer, the initial Net Driving Energy may need to be limited to the free fall of the hammer.

9.3 DRIVING OF PILES

**WITNESS POINT**

Process to be Witnessed: Driving of each pile.

Submission Details: Notification of the time and location of the driving of each pile at least one working day prior to commencing.

During pitching, lift and support piles at the positions on the pile shown on the Drawings.

During the initial stages of driving, do not bend or spring piles into position but effectively hold and guide the pile.

At all stages of driving, the pile frame must not exert any undue lateral force on the pile using frequent checks. Do not use significant horizontal force to correct any tendency for the pile to run off line.

At all times, do not restrain the pile against rotation about its longitudinal axis.

If, during driving, the head of a pile is damaged to the extent that further driving is not possible, investigate the causes of the damage and prove that damage has not occurred elsewhere in the pile. Otherwise, extract the pile immediately and replace it with a sound pile. This work will be at your expense unless the cause of the damage was outside your control.

If damage in the pile has not occurred elsewhere, cut off the damaged pile head and continue driving. Where, as a result of the cutting off, the pile requires a splice, restore the pile to its correct length. This work will be at your expense unless the need for the splice was outside your control. A suitable off-cut length of pile may be used for this purpose.

Where the pile driving equipment is altered, test the driving equipment to determine the relationship between the operation of the equipment and the Net Driving Energy at the head of the pile. Such a test will be at your own expense.

Where there is reason to believe that the Net Driving Energy differs by more than 10% from the Net Driving Energy measured during driving at equivalent stages of the Test Pile/Representative Pile, the Principal may direct that additional dynamic tests be carried out to re-establish driving criteria.

In this instance, if the test shows that the Net Driving Energy at the head of the pile differs by more than 10% from the Net Driving Energy measured during driving at equivalent stages of the Test Pile/Representative Pile, then you must bear the full cost of the test and of any retest, after modification of the driving equipment or system, and of any other costs. Otherwise, payment will be made in accordance with Item (k) in Annexure B54/B.
If the required pile resistance or Nominal Refusal is obtained before the Minimum Penetration Depth is reached and rock is not encountered, prior to driving any other piles, amend the driving method as necessary to reach the Minimum Penetration Depth without damaging the piles.

Where it is uncertain that the piles have been driven in the same manner as the Test Piles/Representative Piles, where driving has been interrupted prematurely, or a check on pile resistance needs to be made, or for any other reason, the Principal may require a restrike test to be made in accordance with Clause 13, with payment in accordance with Item (k) in Annexure B54/B.

### HOLD POINT
(For piles not founded in rock and if the Minimum Penetration Depth is not achieved)

**Process Held:** Driving of any further piles.

**Submission Details:** Details of the amended driving method, together with certification that the amended driving method is likely to result in achieving the Minimum Penetration Depth before the required pile resistance is obtained.

**Release of Hold Point:** The Principal will consider the submitted documents and may carry out further surveillance and audit, prior to authorising the release of the Hold Point.

### 10 SPlicing OF PILES

If a pile needs to be lengthened, splice on an additional length of identical tubular steel pile.

Unless specified otherwise, the welded connection for pile splices must be full penetration butt welds over the whole cross section. Welding must be in accordance with Clause 2.6.

### 11 BACKFILLING AND CONCRETING OF PILES

#### 11.1 GENERAL

For piles driven open ended, if upon completion of driving, the level of material inside the tube is higher than the level shown on the Drawings, excavate the pile to the level shown on the Drawings without disturbing the soil plug at the bottom of the hole.

If the level of material inside the tube is below the bottom level of the reinforced concrete section shown on the Drawings, backfill the pile shaft to this level with sand or other approved granular material. Compact the granular material by flooding with it with water.
Prior to concreting a pile, bring the bottom of the hole to a clean and stable condition and maintain in that condition without contamination or softening until concrete is placed.

If the bottom of the pile cannot be kept clean and stable to prevent contamination of the concrete when it is placed, place a concrete plug and allow the concrete to set before the reinforcement is placed in position. The top of the plug must be approximately level, and be not higher than the specified bottom level of the reinforced concrete.

### 11.2 Reinforcement

Supply and place reinforcement in accordance with Specification RMS B80.

Thoroughly clean the pile shaft of all loose material, including any material adhering to the inside of the tube, before the reinforcement is placed.

Fabricate and place the reinforcement cage so that the projecting bars from the pile will pass through the pile-cap bars. Use spacers attached to the cage to maintain the cage in position after placement.

### 11.3 Concreting

Supply and place concrete in accordance with RMS B80.

Use only high workability concrete or self-compacting concrete conforming to Annexure B80/G of RMS B80.

Use a rigid tremie pipe and a hopper to place concrete in piles. Where a concrete pump is used, a flexible rubber hose may be used to transport the concrete between the discharge hopper of the pump and the hopper of the tremie. Ensure that the hose is still capable of doing this when the bottom end of the tremie is raised to the top of the pile at the end of concreting.

The tremie pipe must be watertight throughout. Tape a steel plate to the bottom end of the tremie pipe or alternatively use a vermiculite, foam or styrene plug or greased rubber or sponge ball, or similar, prior to concreting.

Insert the tremie pipe inside the pile hole until the bottom end of the tremie is at the base of pile hole before the tremie is charged with concrete.

In wet pile holes, do not commence concreting until the pile hole is filled with such head of water as to equalise the external water pressure from the surrounding ground.
Place the concrete in such a manner and with such consistency that pockets of air or water or ground materials are not entrapped in the concrete, and the space between the reinforcement and the side walls of the hole are completely filled with compacted concrete.

Provide a continuous supply of concrete so that each pile hole is concreted in one uninterrupted operation.

During concreting, lift the tremie pipe progressively as the concrete level rises, but at all times keeping the bottom end of the tremie pipe a minimum of two metres below the top surface of the concrete until sound concrete appears at a minimum of 400 mm above the pile cut-off level, to avoid defective concrete at or below cut-off level.

The Principal may approve concreting to a lower height above the cut-off level in dry piles, if adequate measures are taken to avoid defective concrete at or below the pile cut-off level.

12 CUT-OFF AND CLEAN-UP OF PILE TOP

After the completion of backfilling and concreting, if applicable, carefully remove any concrete and/or tube above the cut-off level shown on the Drawings without damaging the permanent work, not earlier than 24 hours after completion of placement of concrete.

Clean the top of the pile to be later embedded in concrete of laitance and any loose material. Keep the reinforcement protruding from the pile clean and protect it from rusting and damage.

Remove any unused off-cuts remaining at the end of the Contract from the Site.

13 DYNAMIC TESTING

13.1 GENERAL

Carry out Dynamic Testing in accordance with this Clause and AS 2159 using an approved organisation with approved equipment using an approved dynamic testing system, with subsequent wave equation analysis or signal matching carried out using an approved computer program, all as listed in the “Lists of RMS Approved Bridge Components and Systems” at:

13.2 PROCEDURE

Use the following testing procedure:

(a) Attach four bolt-on transducers to the pile at a minimum of 1.5 times the maximum pile width below the head of the pile in accordance with the requirements of the system supplier.

(b) Following the connection of the transducers to the analyzer, strike the pile with sufficient energy to verify the required pile resistance.

To avoid pile damage, immediately report to the Piling Supervisor if the allowable driving stresses could be exceeded at any time during the driving.

Record the driving stresses, measured pile resistance, Nominal Driving Energy, measured Net Driving Energy and Set.
The relationship between Net Driving Energy and Set determined from a dynamic test is valid only for the specific combination of hammer, helmet, cushion, pile rake, pile size, pile material and founding material.

13.3 **RESTRIKE TEST**

When a restrike test is required, consider only the first 20 blows at the beginning of the driving to be part of the restrike test. Measure the driving parameters at the required Net Driving Energy on blow numbers 6 to 15 inclusive.

The acceptance criteria for a restrike test on a pile are that the driving parameters achieved must be equal to or better than those measured at the end of driving and the distribution of resistance along the pile must be effectively unchanged. Where these criteria are not met, submit the driving records to the Principal and take such action as directed by the Principal at the Principal’s cost.

13.4 **DYNAMIC ANALYSIS**

Analyse the dynamic test results for each pile tested. Analyses must include full Dynamic Analysis using measured field parameters of the test data (e.g. CAPWAP) and resistance versus Set curves (e.g. GRLWEAP analysis), when requested by the Principal, showing a minimum of six (6) different resistances and the corresponding blowcounts.

13.5 **REPORT**

Provide to the Principal two copies of a report for each pile tested including:

(a) Complete PDA (or approved equivalent) output for all blows, including driving stresses and Net Driving Energy.

(b) CAPWAP (or approved equivalent) analyses for selected blows.

(c) When requested by the Principal, GRLWEAP (or approved equivalent) output in the form of resistance versus Set curves giving the true pile resistance for specific driving energies, using data measured during driving.

(d) Certification that the tested pile has been driven in accordance with this Specification. If it is not possible for this certification to be provided due to nonconformities in the driving or the driven pile, provide instead an itemised nonconformity report together with the proposed disposition.
ANNEXURE B54/A – (NOT USED)

ANNEXURE B54/B – MEASUREMENT AND PAYMENT

Refer to Clause 1.2.2.

The Lump Sum covers all activities required to construct piling to the resistance shown on the Drawings plus the value of work under the Provisional Quantity work included in the Schedule of Prices.

In the Schedule of Prices accompanying the Lump Sum Tender, the cost of piling, including Test Piles and Representative Piles, is divided into the following items (similar items must be separately provided for each size of pile):

(a) Supply of Piles

This item includes the cost of supply, manufacture and delivery of tubular steel piles of the number and lengths shown on the Drawings. The units are per pile and per metre of pile length (Provisional Quantity). The quantities are the total number and total length of piles shown on the Drawings.

The rates include the cost of any splices required to make up each full length of pile to suit the Contract Levels from shorter lengths of pile stock, but do not include the cost of the supply and fitting of toe end plates or driving shoes.

The per metre of pile length (Provisional Quantity) rate included in the Schedule of Prices may be used by the Principal in accordance with the Conditions of Contract for the purpose of valuing variations due to changes of the pile lengths instructed under Clause 7.2.

(b) Supply and Fitting of Toe End Plates or Driving Shoes

This item applies only when toe end plates or driving shoes are shown on the Drawings. The unit is per pile.

(c) Driving of Piles

This item includes all costs associated with driving tubular steel piles of the number and lengths shown on the Drawings. The units are per pile and per metre of pile length (Provisional Quantity). The quantities are the total number and total length of piles shown on the Drawings.

Payment for pre-boring will be in accordance with Clause 5.4.

The per metre of pile length (Provisional Quantity) rate included in the Schedule of Prices may be used by the Principal in accordance with the Conditions of Contract for the purpose of valuing adjustments to the Contract Price due to changes of the pile lengths instructed under Clause 7.2.

(d) Splicing of Piles - Provisional Quantity

Where this item is included in the Schedule of Estimated Quantities, payment for splices, in accordance with Clause 10, between tubular steel pile lengths (including the supply of all materials but not including the tubular steel pile lengths) will be made at the tendered rate for this item. The unit of measurement is per splice.
This item is only applicable where the pile is lengthened when instructed by the Principal under Clause 7.2, and such lengthening necessarily requires an additional splice.

No payment will be made for splices used by you to make up piles from shorter lengths than the lengths shown on the Drawings, nor for any splices that are made by you for your own convenience, e.g. to suit your pile driving equipment, nor where the pile is extended as a result of excessive pre-boring.

(e) Backfilling
This item includes all costs associated with backfilling of piles with sand or other approved granular material, in accordance with Clause 11. The unit is per pile.

(f) Reinforcement
This item includes all costs associated with the supply and fixing of reinforcement in accordance with Clause 11. The unit is per tonne.

(g) Concreting
This item includes all costs associated with the concreting of piles in accordance with Clause 11. The unit is per metre of concreted pile length.

(h) Cutting Off of Piles
This item includes all costs associated with the cutting off of all piles in accordance with Clause 12.

(i) Flame Cut Holes in Piles for Reinforcement - Provisional Quantity
Where this item is included in the Schedule of Estimated Quantities, payment for all costs associated with the cutting of holes in a steel pile to allow for the placing of reinforcement will be made at the tendered rate for this item.

The unit is per pile.

(j) Dynamic Testing of Test Piles/Representative Piles for Resistance
This item includes mobilisation and Dynamic Testing in accordance with Clause 13 for each Test Pile/Representative Pile to determine the Net Driving Energy and Set at the required resistance. The unit of measurement is per pile tested.

(k) Dynamic Testing of Piles to Verify Dynamic Data - Provisional Quantity
This item includes Dynamic Testing or restrike testing in accordance with Clause 13 when testing is instructed by the Principal to verify the Net Driving Energy delivered by the driving equipment or other Dynamic Data in accordance with Clauses 6.2, 8 or 9.3. The unit of measurement is per pile tested.

Payment is subject to the provisions of Clause 9.3.

(l) Dynamic Testing of Individual Piles for Resistance - Provisional Quantity
This item includes the cost of Dynamic Testing in accordance with Clause 13 of individual piles in accordance with Clause 6.3.1 (c), the cost of which will be borne by you if pile lengths supplied differ
from those instructed under Clause 7.2, but otherwise this testing will be paid for at the tendered rate for this item.
ANNEXURE B54/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Type</th>
<th>Description</th>
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<tbody>
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<td>Hold</td>
<td>Setting up of driving frame and driving of all piles, including Test Piles and Representative Piles</td>
</tr>
<tr>
<td>7.1</td>
<td>Hold</td>
<td>Driving of each Test Pile</td>
</tr>
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<td>7.2</td>
<td>Hold</td>
<td>Making up the pile lengths and driving of all piles represented by the Test Piles. Driving of all piles, other than Test Piles</td>
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<td>8</td>
<td>Hold</td>
<td>Driving of each Representative Pile</td>
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<td>9.3</td>
<td>Witness</td>
<td>Driving of each Pile</td>
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<tr>
<td>9.3</td>
<td>Hold</td>
<td>Driving of any further piles (for piles not founded in rock and Minimum Penetration Depth is not achieved)</td>
</tr>
<tr>
<td>11.1</td>
<td>Hold</td>
<td>Backfilling (if applicable) and cutting off of a pile after completion of driving</td>
</tr>
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</table>

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of RMS Q Annexure Q/E.

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<tr>
<th>Clause</th>
<th>Description of Identified Record</th>
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<td>13.5</td>
<td>Dynamic Testing report for each tested pile</td>
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ANNEXURE B54/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. Review the requirements of this Specification and other contract documents to determine any additional documentation requirements.

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<tr>
<th>Clause</th>
<th>Description of Document</th>
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<tr>
<td>2.8</td>
<td>Application of protective treatment, if required</td>
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<tr>
<td>5.2</td>
<td>Driving equipment including pile hammer, pile helmet, cushion assembly, pile driving rig, crane, leaders and/or other equipment proposed for lifting and driving piles and for positioning and supporting piles during driving</td>
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<td>5.3 &amp; 9</td>
<td>Pile driving method</td>
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<td>Pile driving record sheets</td>
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<td>Pile lifting method</td>
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<td>13</td>
<td>Dynamic Testing organisation and system, and field testing personnel</td>
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ANNEXURES B54/E TO B54/K – (NOT USED)

ANNEXURE B54/L – FREQUENCY OF TESTING

Refer to Clause 1.2.4.

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<th>Test Method</th>
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<td>RMS B201</td>
<td>RMS B201</td>
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<td>6.5</td>
<td>Pile position</td>
<td>RMS Q Annexure Q/K</td>
<td>Each pile</td>
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<td>7, 8</td>
<td>Pile resistance by Dynamic Testing</td>
<td>Clause 13</td>
<td>Each Test Pile or Representative Pile</td>
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<tr>
<td>11.3</td>
<td>Concrete quality</td>
<td>RMS B80</td>
<td>RMS B80</td>
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ANNEXURE B54/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.5.

**RMS Specifications**

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<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>RMS G22</td>
<td>Work Health and Safety (Construction and Maintenance Works)</td>
</tr>
<tr>
<td>RMS Q</td>
<td>Quality Management System</td>
</tr>
<tr>
<td>RMS B30</td>
<td>Excavation and Backfill for Bridgeworks</td>
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<tr>
<td>RMS B80</td>
<td>Concrete Work for Bridges</td>
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<tr>
<td>RMS B201</td>
<td>Steelwork for Bridges</td>
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**Australian Standards**

<table>
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<tr>
<td>AS 1548</td>
<td>Fine grained, weldable steel plates for pressure equipment</td>
</tr>
<tr>
<td>AS 1579</td>
<td>Arc-welded steel pipes and fittings for water and waste-water</td>
</tr>
<tr>
<td>AS/NZS 1594</td>
<td>Hot-rolled steel flat products</td>
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<tr>
<td>AS 2159</td>
<td>Piling - Design and Installation</td>
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<tr>
<td>AS/NZS 3678</td>
<td>Structural steel - Hot-rolled plates, floorplates and slabs</td>
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<tr>
<td>AS 5100</td>
<td>Bridge design</td>
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<tr>
<td>AS/NZS ISO 9001</td>
<td>Quality management systems - Requirements</td>
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