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DRIVEN PRESTRESSED CONCRETE PILES

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IC-DC-B51

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FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification RMS D&C B51 Edition 2 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.
RMS SPECIFICATION D&C B51
DRIVEN PRESTRESSED CONCRETE PILES

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the manufacture and driving of precast prestressed concrete piles.

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 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure B51/C list the HOLD POINTS and WITNESS POINTS that must be observed. Refer to Specification RMS D&C Q6 for the definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure B51/C are Identified Records for the purposes of RMS D&C Q6 Annexure Q/E.

1.2.3 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B51/D and must be implemented.

1.2.4 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 B51/L. Where a minimum frequency is not specified, nominate an appropriate frequency. Frequency of testing must conform to the requirements of RMS D&C Q6.

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

1.2.5 Referenced Documents

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure B51/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 Design Documentation drawings.

**Design Toe Level:** Reduced level (RL) of the pile toe shown on the Design Documentation 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 Design Documentation 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 20 mm from 10 consecutive blows with the Net Driving Energy stated on the Design Documentation 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 Design Documentation drawings for the pile.

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

**Representative Pile:** A pile nominated on the Design Documentation Drawings 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 pile lengths shown on the Design Documentation drawings to be confirmed or altered as necessary. Test Piles which represent piles driven to a resistance are also Representative Piles. Test Piles are nominated on the Design Documentation drawings, and are usually dimensioned 2 (two) metres longer than required by the Design Toe 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 MANUFACTURE OF PILES

2.1 GENERAL

The materials for and manufacture of the piles must be in accordance with the Design Documentation drawings and Specifications RMS D&C B80 and D&C B110.

2.2 (NOT USED)

2.3 CRACKS IN MANUFACTURED PILES

Piles with permanent cracks of width of greater than 0.1 mm are considered to be nonconforming. Measure and map any such cracks and submit the crack maps together with your proposals for repair of the cracks, or other disposition, for the RMS Representative’s acceptance. Piles with such cracks that are repaired to the RMS Representative’s satisfaction may be incorporated in the Works.

2.4 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. All other piles must be identified for traceability.

3 HANDLING AND STACKING OF PILES

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

Determine the Sizes 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 D&C 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 to the pile resistance measured during driving.

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

5 ACCEPTANCE CRITERIA FOR PILE DRIVING

5.1 GENERAL

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

5.2 PILES DRIVEN TO NOMINAL REFUSAL IN ROCK

Apply this Clause where piles are shown on the Design Documentation drawings as being driven to Nominal Refusal in rock.

5.2.1 Pile Resistance

Drive piles to achieve Nominal Refusal in rock, or the required pile resistance as demonstrated by Dynamic Testing in accordance with Clause 5.3.1, at the end of driving.

5.2.2 Dynamic Testing

Carry out Dynamic Testing in accordance with Clause 14 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 Design Documentation drawings.

5.3 PILES DRIVEN TO A RESISTANCE

Apply this Clause where piles are not shown on the Design Documentation drawings as being driven to Nominal Refusal in rock.

Unless specified otherwise, 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.
5.3.1 Pile Resistance

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

(a) For Representative Piles, 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 Design Documentation 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 representative 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 Design Documentation drawings, and demonstrated by Dynamic Testing of that individual pile.

5.4 Minimum Penetration Depth

Apply driving methods that ensure all piles attain the Minimum Penetration Depth shown on the Design Documentation drawings. Where the Minimum Penetration Depth cannot be achieved, obtain the advice of your Designer.

5.5 Positional Tolerances

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

5.6 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 pile 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.
6 TEST PILES

6.1 GENERAL

Where shown on the Design Documentation drawings, drive Test Piles at locations nominated as "Test Piles".

Drive all Test Piles BEFORE manufacture of the remaining piles.

For Test Piles which are also Representative Piles, comply also with the requirements of Clause 7.

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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.

Unless specified otherwise, carry out a restrike test in accordance with Clause 14.3 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, obtain the advice of your Designer.

6.2 CONFIRMATION OR ALTERATION OF PILE LENGTHS

On completion of driving of the Test Piles, consider the driving records and Dynamic Testing reports of the Test Piles to confirm or alter the lengths of piles to be manufactured.

7 REPRESENTATIVE PILES

Drive Representative Piles at locations nominated on the Design Documentation 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 Nominated Authority will attend the site of each Representative Pile and may inspect 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.

Unless specified otherwise, 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 14.3 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, obtain the advice of your Designer.

The driving energy and Set corresponding to the required pile resistance must be the driving parameters for the driving of piles represented by the Representative Pile.

Where Calculated Set and the basis for its calculation are shown on the Design Documentation drawings, these are indicative only and are not to be used as the driving parameters.

The required pile resistance is deemed to be achieved if Nominal Refusal is reached prior to the required resistance being measured by Dynamic Testing, and subsequent Wave Equation Analysis indicates that the required pile resistance has in fact been achieved.

Where more than one Representative Pile is used to represent a pile, the required Set may be obtained by linear interpolation between the resistance versus Set curves.

Where there is any reason to believe that the geotechnical conditions are not essentially uniform, nominate additional piles to be Representative Piles and determine which piles are represented by those piles.

8 DRIVING EQUIPMENT AND METHOD

8.1 GENERAL

Without limiting the requirements of Specification RMS D&C G22, prior to bringing any piling equipment or 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.

8.2 DRIVING EQUIPMENT

Piles may be driven with diesel, compressed air or drop hammers or a combination of these. Clutch operated drop hammers must not be used.

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.

8.3 DRIVING METHOD

Unless specified otherwise, 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 Project Verifier 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.

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8.4 **USE OF PRE-BORING**

Pre-boring may be used to assist in attaining the Minimum Penetration Depth specified.

Pre-boring may be carried out at your discretion in a manner not detrimental to the pile performance.

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. If you require to change the pre-boring diameter, obtain first the approval of the Designer.

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

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 any pile which requires extending due to excessive pre-boring.

9 **MINIMUM AGE OF PILES BEFORE DRIVING**

Do not drive piles, including piles extended in accordance with Clause 11, until:

(i) at least 7 days after the specified 28 day structural strength of the concrete in the pile has been achieved; or

(ii) the pile concrete maturity exceeds 4,750°C.hrs for normal temperature curing or 350°C.hrs for heat accelerated curing, plus 7 days,

but in either case, no earlier than 14 days after their casting.

10 **DRIVING OPERATION**

10.1 **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.

10.2 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 Design Documentation drawings.

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, ensuring 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.

10.3 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 Design Documentation 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.

Any pile that exhibits permanent cracks greater than 0.1 mm wide or splits during driving or becomes damaged in any way is considered to be nonconforming.
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.

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, carry out additional dynamic tests to re-establish driving criteria.

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.

**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 Nominated Authority will consider the submitted documents and may carry out further surveillance and audit, prior to authorising the release of the Hold Point.

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, carry out a restrike test in accordance with Clause 14.

### 11 EXTENDING PILES PRIOR TO OR DURING DRIVING

#### 11.1 GENERAL

A pile may be extended prior to or during driving by splicing on an additional length of precast prestressed concrete pile of the same structural design.

The connection at the extension must be capable of developing the full structural capacity of the pile, including the bending capacity and durability classification shown on the Design Documentation drawings. For mechanical splices, demonstrate that the connection is capable of developing the required structural capacity of the pile at the connection location.

Provide certification from a Chartered Professional Engineer with membership of Engineers Australia practising in the field of Civil or Structural Engineering (or equivalent) that the extension and connection conform to the requirements of this Clause.

#### 11.2 PRECAST EXTENSIONS

If details of the splice piles are shown on the Design Documentation drawings, splice the piles in accordance with the splice details shown. If no details of the splice are shown on the Design Documentation drawings, splice the piles using pile splices acceptable to the RMS Representative.
RMS approved types of pile splices are listed in the “Lists of RMS Approved Bridge Components and Systems” at:

For piles shorter than 12.0 m, no mechanical splice is permitted.

Unless otherwise noted on the Design Documentation drawings, locate all pile splices at least 5 m below the lowest natural or existing ground surface after the completion of driving.

Mechanical pile splices must not be located where significant corrosion of the splice is likely, unless special corrosion protection measures are taken to ensure the splice design life will be achieved. High corrosive environments include aggressive soils, between high and low ground water levels, and between stream bed and potential scour levels. Include details of these corrosion protection measures in your PROJECT QUALITY PLAN.

For each type of splice, carry out Dynamic Testing in accordance with Clause 14 on the first and second piles which are extended prior to or during driving using that type of splice. Determine the integrity of the spliced piles by testing for the whole of the driving of the section above the last splice, with data recorded for analysis at 1 m intervals. This requirement is in addition to any other requirements for Dynamic Testing.

12 EXTENDING PILES AFTER COMPLETION OF DRIVING

A pile may be extended after completion of driving by casting a cast-in-place reinforced concrete extension to it. This extension must conform to RMS D&C B80.

The connection at the extension must be capable of developing the full structural and bending capacity of the pile.

Any welding of reinforcement carried out as part of the extension must be in accordance with Specification RMS D&C B203 and to the manufacturer's recommendations. Do not weld tendons.

The pile extension must be of the same cross-sectional dimensions as the connecting pile. Concrete used must have the same minimum 28 day compressive strength as that specified for the connecting pile. The concrete durability exposure classification must be as shown on the Design Documentation drawings.

Unless specified otherwise, the following applies:

(a) The number and size of reinforcing bars in the extension must provide at least the same strength as the original pile length. The location of the reinforcing bars in the extension must be similar to the location of the bars in the original pile length.

(b) The lap length of reinforcement, and prestressing strands where required, must conform to AS 5100.5.

Provide a certificate from a Chartered Professional Engineer with membership of Engineers Australia practising in the field of Civil or Structural Engineering or equivalent, verifying that the cast-in-place extension and connection conform to the requirements of this Clause.

Alternatively, you may propose to extend a pile after the completion of driving, by splicing an additional length of precast prestressed concrete pile in accordance with Clause 11.
13 **CUTTING OFF AND STRIPPING OF PILES**

<table>
<thead>
<tr>
<th>HOLD POINT</th>
<th>(On the completion of the driving of each pile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Held:</td>
<td>Cutting off and stripping or extending a pile after completion of driving.</td>
</tr>
<tr>
<td>Submission Details:</td>
<td>Driving records and survey report showing the alignment and plan position of the pile. Certification by the Piling Supervisor that the pile has been driven in accordance with this Specification</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Nominated Authority will consider the details submitted, prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>

Do NOT use explosives for the cutting off and stripping operations. Use only hand held equipment.

The methods used to cut off and strip the pile must not result in spalling, cracking and/or scoring of the face of the pile below the cut-off level and damage to the reinforcement and stressing tendons along their full final length. The top of the pile after cutting must be undamaged, sound, free of laitance and any loose material and must have a profile with surface roughness not less than 3 mm.

The stripping must expose the longitudinal reinforcement (and/or strands) for the stress development lengths shown on the Design Documentation drawings. If they are not shown on the Design Documentation drawings, the stress development lengths must conform to AS 5100.5 for the development of the yield strength of bars in tension.

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

14 **DYNAMIC TESTING**

14.1 **GENERAL**


14.2 **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.

14.3 **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, obtain the advice of your Designer.

14.4 **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), showing a minimum of six (6) different resistances and the corresponding blowcounts.

14.5 **Report**

Provide to the RMS Representative and Project Verifier 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) 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.
ANNEXURES B51/A TO B51/B – (NOT USED)

ANNEXURE B51/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.2.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Hold</td>
<td>Driving of each Test Pile</td>
</tr>
<tr>
<td>7</td>
<td>Hold</td>
<td>Driving of each Representative Pile</td>
</tr>
<tr>
<td>8.3</td>
<td>Hold</td>
<td>Setting up of driving frame and driving of all piles, including Test Piles and Representative Piles</td>
</tr>
<tr>
<td>10.3</td>
<td>Witness</td>
<td>Driving of each Pile</td>
</tr>
<tr>
<td>10.3</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>13</td>
<td>Hold</td>
<td>Cutting off and stripping or extending a pile after completion of driving</td>
</tr>
</tbody>
</table>

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of RMS D&C Q6 Annexure Q/E.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description of Identified Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6</td>
<td>Driving Records and survey report for each pile</td>
</tr>
<tr>
<td>6.2</td>
<td>Driving Records of each Test Pile</td>
</tr>
<tr>
<td>7</td>
<td>Driving Records for each Representative Pile</td>
</tr>
<tr>
<td>11, 12</td>
<td>Engineer's certification of conformity of pile extension and connection</td>
</tr>
<tr>
<td>14.5</td>
<td>Dynamic Test report for each tested pile</td>
</tr>
</tbody>
</table>
ANNEXURE B51/D – PLANNING DOCUMENTS

Refer to Clause 1.2.3.

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.

(a) pile driving record sheets (refer to Clause 5.6);
(b) 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 (refer to Clause 8.2);
(c) pile driving method (refer to Clauses 8.3 and 10);
(d) proposed preboring diameter, and equipment and methods to be used for pre-boring (refer to Clause 8.4);
(e) pile lifting method (refer to Clause 10.3);
(f) method and materials for splicing and/or extending piles (refer to Clauses 11 and 12);
(g) details of additional corrosion protection measures adopted for mechanical pile splices in aggressive environment, where applicable (refer to Clause 11.2.1); and
(h) Dynamic Testing organisation and system, and field testing personnel (refer to Clause 14);

ANNEXURES B51/E TO B51/K – (NOT USED)

ANNEXURE B51/L – FREQUENCY OF TESTING

Refer to Clause 1.2.4.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Characteristic Analysed</th>
<th>Test Method</th>
<th>Minimum Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Concrete for piles</td>
<td>RMS D&amp;C B80</td>
<td>RMS D&amp;C B80</td>
</tr>
<tr>
<td>5.5</td>
<td>Pile position</td>
<td>RMS D&amp;C Q6 Annexure Q/K</td>
<td>Each pile</td>
</tr>
<tr>
<td>6, 7</td>
<td>Pile resistance by Dynamic Testing</td>
<td>Clause 14</td>
<td>Each Test Pile or Representative Pile</td>
</tr>
</tbody>
</table>
ANNEXURE B51/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.5.

RMS Specifications

RMS D&C G22    Work Health and Safety (Construction Works)
RMS D&C Q6     Quality Management System (Type 6)
RMS D&C B30    Excavation and Backfill for Bridgeworks
RMS D&C B80    Concrete Work for Bridges
RMS D&C B110   Supply of Pretensioned Precast Concrete Members
RMS D&C B203   Welding of Steel Reinforcement

Australian Standards

AS 2159        Piling - Design and Installation
AS 5100 (Set)  Bridge design
AS 5100.5      Part 5: Concrete