

# TRANSPORT FOR NSW (TfNSW)

## QA SPECIFICATION B50

### DRIVEN REINFORCED CONCRETE PILES

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#### REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 2/Rev 0		First issued. Based on B51 Ed 2/Rev 0. Supersedes commonly used TB50.	GM, PSP (W Ho)	05/06/96
Ed 2/Rev 1	9.1, 10.3 Annex 1 2, 3 Annex 2 Annex 2 8.4 10.3	Converted to MS Word 6.0c. References to RTA Specifications changed. Witness Points defined. Acceptable subcontractors, processes and equipment lists moved from Clauses 8.2 and 11.1. Clause 3 - Addition of Frankijoint to the list of approved pile splices. Restrike test criteria specified. Note regarding failed restrike test.	GM, RNIC (W Ho)	04.07.97
Ed 2/Rev 2	9.1 11	Witness Point changed to a Hold Point. Engineer's certificate required.	GM, RNIC (W Ho)	18.07.97
Ed 2/Rev 3	1.2, 6.3 1.4 9.4, 10.5(d) 15(a)	Editorial changes to document. Title of Design Code changed. Clause deleted, referred to RTA Q. Hold Point submission details and driving records include restrike test result. Changes to valuation of splice.	GM, RNIC (W Ho)	03.09.97
Ed 2/Rev 4	1.2, 11.2	For welding, AS 1554.3 is replaced by RTA B204.	GM, RNIC J Woodward	23.09.98
Ed 2/Rev 5	Annex 1 Annex 2	New schedule listing Identified Records. Golder Associates & Ground Engineering added to 1(a).	GM, RNIC	28.02.00
Ed 2/Rev 6	1.2, Annex 2	Minor changes.	GM, RNIC	27.07.00

<b>Ed/Rev Number</b>	<b>Clause Number</b>	<b>Description of Revision</b>	<b>Authorised By</b>	<b>Date</b>
Ed 2/Rev 7	15 (a) & (b)	References to Conditions of Contract changed to suit C1.	GM, RNIC	30.05.01
Ed 2/Rev 8	Annex 2	Item 1(a): Testing organisations (vi) and (vii) added. Item 1(b): Testing organisation (iii) added. Item 3: Mechanical pile splices item (e) added.	GM, RNIC	02.08.01
Ed 3/Rev 0	Various  Foreword 1.3 5, 7, 8.2.1, 10 5.1 5.4 6 6.1, 7 7 10.1 10.2 14 14.3 14.4 14.6 Annexures	Clauses & annexures rearranged Text revised to direct imperative style. "Superintendent" replaced by "Principal". Reformatting and minor editing "Shall" replaced by "must". Minor editorial and font changes.  New clause after the Table of Contents  New definitions added  Location of paragraphs changed  New clause HB77 replaced by AS 5100  Notify if depth not achieved  Requirements transferred from Clause 7  Dynamic Testing extended  Requirements transferred from Clause 8.1  Limit on stresses  Restrike test may be ordered Submit certification  Apply to restrike tests  Process if stresses could be exceeded  Process if resistance changes  Reporting requirements changed  Renumbered and revised.	GM, RNIC	23.12.04
Ed 3/Rev 1	2  3 5.2.1 5.3.1 6.1	Marking requirements relaxed for other than Test Piles. Limits apply to permanent cracks.  Rewritten to be performance based.  Verification of pile resistance by Dynamic Testing permitted.  New Item (d) facilitates testing conforming to AS 5100.3.  Clarification of intent in regards to restrike test.	GM, IC	18.11.08

<b>Ed/Rev Number</b>	<b>Clause Number</b>	<b>Description of Revision</b>	<b>Authorised By</b>	<b>Date</b>
Ed 3/Rev 1 (cont'd)	7	Relaxation of extent of Dynamic Testing. Clarification of intent in regards to restrrike test.		
	8, 8.1	New Subclause 8.1 added for piling plant and equipment. Other subclauses renumbered.		
	8.2	Steam hammers deleted. Hammer combinations permitted.		
	8.3, 11	Corporate Member changed to chartered professional engineer.		
	8.3.1	Assignment of costs of pre-boring clarified.		
	8.3.2	Jetting subclause deleted.		
	9	Flexibility on age at driving introduced.		
	10, 10.1	New Subclause 10.1 introduced and other subclauses renumbered.		
	10.3	Limits apply to permanent cracks. Reference to Pay Item reworded to refer to Annexure B50/B.		
	11.1	Dynamic testing of spliced piles relaxed.		
	11.2	Lapping of reinforcement amended to conform to AS 5100.5.		
	14.4	Clarification of assignment of costs for Dynamic Testing reports.		
	14.5	Reporting requirements relaxed.		
	14.6 (c)	Reporting requirements relaxed.		
	Annex B (a), (b)	Modified to include provisional quantities for pile lengths.		
	Annex B (g)	Heading amended for clarity.		
	Annex B (h)	New Pay Item added.		
	Annex D	Edited.		
Annex F	Testing organisations (x) and (xi) and mechanical pile splice (f) added.			
Annex M	AS 5100 Parts 3 and 5 added.			
Ed 3/Rev 2	1.3	Definitions of “you” and “your” added.	GM, IC  Bernie Chellingworth	15.01.10
	8.1	Added: NPER registration as equivalent to CPEng, Engrs Aust, for certification purposes.		
	8.3			
	Annex M	Reference documents updated.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 4/Rev 0	Global	<p>Minor editing and rewording to improve clarity.</p> <p>“Driving Supervisor” changed to “Piling Supervisor”.</p> <p>1.2.4 Reference to spec Q on frequency of testing added.</p> <p>1.3 Clarification added that “Dynamic Testing” is same as “High-Strain Dynamic Testing”.</p> <p>2 Headings added to form sub-clauses 2.1 to 2.4.</p> <p>2.3 Requirement for submission of crack maps and proposals for repair to Principal added.</p> <p>4 Where bottom level of pile cap is more than 2 m below existing surface level, requirements for excavation clarified.</p> <p>5.3.1 Clause on pile resistance reworded to improve clarity.</p> <p>6.1, 7 Minimum period before restrike test increased to 24 hrs to accord with AS 2159.</p> <p>6.1 Statement on piling hammer mass and height of drop moved to clause 8.2.</p> <p>8.2 Statement on piling hammer mass and height of drop moved here from clause 6.1.</p> <p>8.4 Previously clause 8.3.1.</p> <p>Responsibility for cost of pre-boring under various situations clarified.</p> <p>Details of proposed pre-boring equipment and methods to be included in PQP.</p> <p>Pre-boring to nominated depths clarified.</p> <p>9 Minimum age of piles before driving of 14 days added.</p> <p>11.1 Requirement to demonstrate the structural capacity of mechanical pile splice added.</p> <p>11.2 “mechanical pile splice” replaced with “pile splice” to include epoxy type splice.</p> <p>Reference to list of approved mechanical pile splices in Annex F deleted and replaced by url reference for list of approved bridge components on internet.</p> <p>Minimum pile length for splicing added.</p> <p>Use of mechanical splices in high corrosive environments restricted.</p>	GM, CPS	18.12.13

<b>Ed/Rev Number</b>	<b>Clause Number</b>	<b>Description of Revision</b>	<b>Authorised By</b>	<b>Date</b>
Ed 4/Rev 0 (cont'd)	11.3	Requirements for lap lengths of reinforcing bars amended.		
	13	Hold Point on cutting off and stripping of pile moved here from clause 10.3. Requirements for development lengths of reinforcing bars amended.		
	14.1	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.		
	14.2	New heading "Procedure" inserted to form clause 14.2. Subsequent clauses renumbered.		
	Annex B	Jetting removed from costs of pile driving to be included in Item (b). Statement added that payment for pre-boring to be in accordance with clause 8.3.1.		
	Annex F	Previous lists of approved mechanical pile splices and Dynamic Testing systems in Annex F deleted.		
	Annex M	Reference documents updated.		
Ed 4/Rev 1	11.3	Reference to "B204" replaced by "B203".	DCS	27.10.17
	Annex M	Referenced documents updated.		
Ed 4/Rev 2	Global	References to "Roads and Maritime Services" or "RMS" changed to "Transport for NSW" or "TfNSW".	DCS	22.06.20





# DRIVEN REINFORCED CONCRETE PILES

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VERSION FOR: DATE:
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## FOREWORD

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### REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW B50 Edition 4 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~~.



# TfNSW QA SPECIFICATION B50

## DRIVEN REINFORCED CONCRETE PILES

### 1 GENERAL

#### 1.1 SCOPE

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

#### 1.2 STRUCTURE OF THE SPECIFICATION

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

##### 1.2.1 Payment

The method of measurement and payment must conform to Annexure B50/B.

Work and materials will be rejected if they do not conform to the requirements of this Specification.

##### 1.2.2 Schedules of **HOLD POINTS**, **WITNESS POINTS** and **Identified Records**

The schedules in Annexure B50/C list the **HOLD POINTS** and **WITNESS POINTS** that must be observed. Refer to Specification TfNSW Q for the definitions of **HOLD POINTS** and **WITNESS POINTS**.

The records listed in Annexure B50/C are **Identified Records** for the purposes of TfNSW Q Annexure Q/E.

##### 1.2.3 Planning Documents

The **PROJECT QUALITY PLAN** must include each of the documents and requirements listed in Annexure B50/D and must be implemented.

##### 1.2.4 Frequency of Testing

The Inspection and Test Plan must nominate the proposed testing frequency to verify conformity of the item, which must not be less than the frequency specified in Annexure B50/L. Where a minimum frequency is not specified, nominate an appropriate frequency. Frequency of testing must conform to the requirements of TfNSW 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.

### **1.2.5 Referenced Documents**

Unless otherwise specified, the applicable issue of a referenced document, other than a TfNSW 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 B50/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 pile 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 20 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.

**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 MANUFACTURE OF PILES**

### **2.1 GENERAL**

The materials for and manufacture of the piles must be in accordance with the Drawings, and Specifications TfNSW B80 and B115.

### **2.2 PILE LENGTHS FOR MANUFACTURE**

Manufacture Test Piles to the lengths shown on the Drawings. Do not manufacture any piles, other than Test Piles, until driving of the Test Piles is completed. Following submission of the driving records and Dynamic Testing reports of the Test Piles, the Principal will instruct the lengths to be manufactured for the remainder of the piles, in accordance with Clause 6.2.

If you propose to the Principal, and the Principal has accepted your proposal, to manufacture all of the piles prior to completion of the Test Piles to lengths other than those instructed, any costs or delays arising out of the length of piles instructed after completion of the driving of the Test Piles being different to those manufactured by you, must be borne by you. Acceptance of such a proposal is at the absolute discretion of the Principal.

### **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 Principal's approval. Piles with such cracks that are repaired to the Principal'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 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 TfNSW 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 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 Drawings as being driven to Nominal Refusal in rock.

##### **5.2.1 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 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 Drawings.

### **5.3 PILES DRIVEN TO A RESISTANCE**

Apply this Clause where piles are NOT shown on the Drawings as being 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.

#### **5.3.1 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, 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.

The acceptance of a proposal for Dynamic Testing of an individual pile will be at the absolute discretion of the Principal. Payment for such testing when accepted by the Principal must be in accordance with Item (h) in Annexure B50/B.

### **5.4 MINIMUM PENETRATION DEPTH**

Apply driving methods that ensure 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.

### **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**

Drive Test Piles at locations nominated on the Drawings 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.

#### **HOLD POINT**

Process Held:	Driving of each Test Pile.
Submission Details:	Notification of the time and location of the driving of each Test Pile at least one working day prior to commencing.
Release of Hold Point:	The Principal will attend the site of each Test Pile and may inspect arrangements for monitoring prior to authorising the release of the Hold Point.

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, 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.

## **6.2 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 piles to be manufactured.

### **HOLD POINT**

Process Held: Manufacture of 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.

## **7 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 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 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 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, submit the driving records to the Principal and take such action as directed by the Principal.

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 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.

Notwithstanding that a Representative Pile may have achieved the required pile resistance and the required Minimum Penetration Depth, the Principal may require further driving of the Representative Pile.

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, the Principal may 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 TfNSW 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 rigs 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 or approved 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**

Process Held: Setting up of piling frame and driving of all piles, including Test Piles and Representative Piles.

Submission Details: 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.

Release of Hold Point: The Principal will consider the details and certification submitted, prior to authorising the release of the Hold Point.

### **8.4 USE OF PRE-BORING**

Pre-boring may be used 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 (b) in Annexure B50/B. Where pre-boring is not shown on the Drawings but is directed by the Principal, the costs of the pre-boring will be borne by the Principal.

Pre-boring may be carried out at your discretion in a manner 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.

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, at your cost, any pile which, in the Principal's opinion, 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 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, 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 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. 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 (g) in Annexure B50/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.

<b>HOLD POINT</b>	(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.

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 14, with payment in accordance with Item (g) in Annexure B50/B.

## **11 EXTENDING PILES PRIOR TO OR DURING DRIVING**

### **11.1 GENERAL**

A pile may be extended prior to or during driving either by splicing on an additional length of precast reinforced concrete pile or by casting a cast-in-place reinforced concrete extension to it. This extension must conform to all the requirements for the pile.

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 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), verifying that the extension and connection conform to the requirements of this Clause.

### **11.2 PRECAST EXTENSIONS**

For precast extensions, if details of the splice are shown on the Drawings, splice the piles in accordance with the splice details shown. If no details of the splice are shown on the Drawings, splice the piles using pile splices acceptable to the Principal.

TfNSW approved types of pile splices are listed in the “Lists of TfNSW Approved Bridge Components and Systems” at:

<http://www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/tenders-contracts/listofapprovedbridgecomponentssystems.pdf>.

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

Unless noted otherwise on the Drawings or approved by the Principal, 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.

### **11.3 CAST-IN-PLACE EXTENSIONS**

Cast-in-place extensions must conform to the requirements of Specification TfNSW B80 and the additional requirements below.

Any welding of reinforcement carried out as part of the extension must be in accordance with Specification TfNSW B203 and to the manufacturer's recommendations.

Unless shown otherwise on the Drawings, lap lengths must conform to AS 5100.5.

## **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 the requirements of Clause 11 for cast-in-place extensions.

If a pile is extended by extending the reinforcement only and does not require casting of a cast-in-place reinforced concrete extension, payment will be valued as an adjustment to the Contract Price not exceeding Item (e)(i) in Annexure B50/B.

## **13 CUTTING OFF AND STRIPPING OF PILES**

### **HOLD POINT**

(On the completion of the driving of each pile)

Process Held: Cutting off and stripping or extending a pile after completion of driving.

Submission Details: 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.

Release of Hold Point: The Principal will consider the details submitted, prior to authorising the release of the Hold Point.

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 along its 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 for the stress development lengths shown on the Drawings. Where they are not shown on the Drawings, the stress development lengths must conform to AS 5100.5 for the development of the yield strength of bars in tension.

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

## **14 DYNAMIC TESTING**

### **14.1 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 TfNSW Approved Bridge Components and Systems" at:

<http://www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/tenders-contracts/listofapprovedbridgecomponentssystems.pdf>.

### **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, submit the driving records to the Principal and take such action as directed by the Principal at the Principal's cost.

#### **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), when requested by the Principal, showing a minimum of six (6) different resistances and the corresponding blowcounts.

#### **14.5 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 B50/A – (NOT USED)**

## **ANNEXURE B50/B – PAYMENT**

Refer to Clause 1.2.1.

The Lump Sum must cover 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) Manufacture of Piles**

This item includes the cost of manufacture (including splicing, if required), delivery and storage on site of precast reinforced concrete piles of the 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 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 6.2. If the individual pile lengths are altered under Clause 6.2 to exceed 22 metres, the Principal may include in the adjustments to the Contract Price a splice at the rate submitted as per Item (d)(i) below.

### **(b) Driving of Piles**

This item includes all costs associated with driving precast reinforced concrete 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 8.4.

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 6.2.

### **(c) Cutting Off and Stripping of Piles**

This item includes all costs associated with the cutting off and stripping of piles in accordance with Clause 13, including disposal of cut off pile lengths and stripped materials. The unit is per pile.

### **(d) Extending Piles Prior to or During Driving - Provisional Quantity**

Where this item is included in the Schedule of Estimated Quantities, payment for all activities under Clause 11 (including the construction of splices, supply of precast reinforced concrete pile lengths, casting of cast-in-place extensions and additional Dynamic Testing for integrity) and the further driving of the extended piles, will be made at the tendered rates for this item (except where pile is extended as a result of excessive pre-boring).

The units of measurement and payment are:

- (i) per pile extended. and
- (ii) per metre of extended pile length.

**(e) Extending Piles after Completion of Driving - Provisional Quantity**

Where this item is included in the Schedule of Estimated Quantities, payment for all activities under Clause 12, including supply of all materials, will be made at the tendered rates for this item (except where the pile is extended as a result of excessive pre-boring). The units of measurement and payment are:

- (i) per pile extended. and
- (ii) per metre of extended pile length.

**(f) Dynamic Testing of Test Piles/Representative Piles for Resistance**

This item includes mobilisation and Dynamic Testing in accordance with Clause 14 for each Test Pile/Representative Pile to determine the Net Driving Energy and Set at the required pile resistance. The unit of measurement is per pile tested.

**(g) Dynamic Testing of Piles to Verify Dynamic Data - Provisional Quantity**

This item includes Dynamic Testing or restrike testing in accordance with Clause 14 when testing is instructed by the Principal to verify the Net Driving Energy delivered by the driving equipment in accordance with Clauses 5.2, 7 or 10.3. The unit of measurement is per pile tested.

Payment is subject to the provisions of Clause 10.3.

**(h) Dynamic Testing of Individual Piles for Resistance - Provisional Quantity**

This item includes the cost of Dynamic Testing in accordance with Clause 14 of individual piles in accordance with Clause 5.3.1(c), the cost of which will be borne by you if pile lengths supplied differ from those instructed under Clause 6.2, but otherwise this testing must be paid for at the tendered rate for this item.

## **ANNEXURE B50/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS**

Refer to Clause 1.2.2.

### **C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS**

<b>Clause</b>	<b>Type</b>	<b>Description</b>
6.1	Hold	Driving of each Test Pile
6.2	Hold	Manufacture of all piles other than Test Piles
7	Hold	Driving of each Representative Pile
8.3	Hold	Setting up of driving frame and driving of all piles, including Test Piles and Representative Piles
10.3	Witness	Driving of each pile
10.3	Hold	Driving of any further piles (for piles not founded in rock and Minimum Penetration Depth is not achieved)
13	Hold	Cutting off and stripping or extending a pile after completion of driving

### **C2 SCHEDULE OF IDENTIFIED RECORDS**

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

<b>Clause</b>	<b>Description of Identified Record</b>
5.6	Driving records and survey report for each pile
6.2	Driving records of each Test Pile
7	Driving records for each Representative Pile
11	Engineer's certification of conformity of pile extension and connection
14.5	Dynamic Testing report for each tested pile

**ANNEXURE B50/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 pre-boring 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 & 12).
- (g) details of additional corrosion protection measures adopted for mechanical pile splices in aggressive environment, where applicable (refer to Clause 11.2). and
- (h) Dynamic Testing organisation and system, and field testing personnel (refer to Clause 14).

**ANNEXURES B50/E TO B50/K – (NOT USED)****ANNEXURE B50/L – FREQUENCY OF TESTING**

Refer to Clause 1.2.4.

<b>Clause</b>	<b>Characteristic analysed</b>	<b>Test Method</b>	<b>Minimum Frequency of Testing</b>
2	Concrete for piles	TfNSW B80	TfNSW B80
5.5	Pile position	TfNSW Q, Annexure Q/K	Each pile
6, 7	Pile resistance by Dynamic Testing	Clause 14	Each Test Pile or Representative Pile

## **ANNEXURE B50/M – REFERENCED DOCUMENTS**

Refer to Clause 1.2.5.

### **TfNSW Specifications**

TfNSW G22	Work Health and Safety (Construction Work)
TfNSW Q	Quality Management System
TfNSW B30	Excavation and Backfill for Bridgeworks
TfNSW B80	Concrete Work for Bridges
TfNSW B115	Precast Concrete Members (Not Pretensioned)
TfNSW B203	Welding of Steel Reinforcement

### **Australian Standards**

AS 2159	Piling - Design and installation
AS 5100 (Set)	Bridge Design
AS 5100.5	Concrete