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CONTINUOUS FLIGHT AUGER
(CFA) PILES

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IC-DC-B63

VERSION FOR:
DATE:
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FOREWORD

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BASE SPECIFICATION

This document is based on Specification RMS B63 Edition 2 Revision 1.
RMS SPECIFICATION D&C B63
CONTINUOUS FLIGHT AUGER (CFA) PILES

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the construction of reinforced cast-in-place concrete injected piles using continuous flight augers (CFA).

Materials and construction must conform to AS 5100.3 and this Specification.

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 (Not Used)

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure B63/C list the HOLD POINTS and WITNESS POINTS that must be observed. Refer to Specification RMS D&C Q6 for definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure B63/C are Identified Records for the purposes of RMS D&C Q6 Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B63/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 B63/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.

1.2.6 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 B63/M.
1.3 DEFINITIONS

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

The term “auger” refers to a hollow stem continuous flight auger.

The following definitions apply to this Specification:

**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 energy, pile integrity and stresses in the pile, determined immediately using electronic equipment (e.g. PDA) during pile testing.

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

**Integrity Testing**
A non-destructive test carried out on a concrete pile after its installation/construction to verify the quality of the concrete pile shaft in terms of its continuity, density, shape and length.

**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.

**Trial Pile**
Pile completed for the purpose of trialling the construction method for the site ground conditions, and must not be part of the permanent works.

**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 pile resistance.

2 MATERIALS

2.1 GENERAL

Concrete and reinforcement must conform to Specification RMS D&C B80 and any additional requirements necessitated by the CFA pile construction method.
2.2 **CONCRETE**

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

Select the concrete mix such that all loads of concrete remain workable throughout the time required to complete the pile construction including reinforcement cage insertion, allowing for delays and other unforeseen circumstances. Verify by calculation that the time to complete the pile is within the mix reversion time.

2.3 **STEEL REINFORCEMENT**

Reinforcement must extend over the full length of the piles.

Supply and fix reinforcement cages in conformity to RMS D&C B80.

Tying or welding of reinforcement cages must be sufficient to enable their placement in the correct position and to the full pile length.

Attach spacers with a minimum contact width of 35 mm to the reinforcement cage at locations and intervals not exceeding 3 m for the full length of the cage. Spacer depth (measured along the pile diameter) must be 25 mm less than the nominal cover specified on the Design Documentation drawings to facilitate insertion of the cage in the concreted pile hole.

3 **CONSTRUCTION – GENERAL REQUIREMENTS**

3.1 **WEEKLY PROGRAM**

Submit to the RMS Representative and Project Verifier each week a program showing your daily scheduled pile construction work for the week.

3.2 **SUPERVISION**

3.2.1 **Piling Supervisor**

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

3.2.2 **Attending Geotechnical Engineer**

During augering and concreting of the first pile of each pile group, a Geotechnical Engineer, engaged by you, must be in attendance.

For uniform or non-complex ground conditions, the attending Geotechnical Engineer must direct the Piling Supervisor to the single required depth that all piles within the pile group must reach.

For non-uniform or complex ground conditions, the attending Geotechnical Engineer must direct the Piling Supervisor to the specific depths that each individual pile must reach.

The attending Geotechnical Engineer must be a Chartered Professional Engineer with membership of Engineers Australia practising in the field of geotechnical engineering (or equivalent) and experienced in the geotechnical assessment of pile excavations. Submit for acceptance details of the qualifications and experience of the attending Geotechnical Engineer.
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 pile excavations.

### 3.3 PILING PLANT AND EQUIPMENT

#### HOLD POINT

**Process Held:** Delivery of piling plant and equipment to the Site.

**Submission Details:**

(a) Details of the proposed piling equipment together with certification, including calculations by a Chartered Professional Engineer, that the proposed piling equipment and working platforms or supports, complies with Clauses 3.3.1 and 3.4.1;

(b) Calibration records for piling rig monitoring instruments in accordance with Clause 3.3.2;

at least 5 working days before delivery of piling plant.

**Release of Hold Point:** The Nominated Authority will consider the submitted information prior to authorising the release of the Hold Point.

#### 3.3.1 Capacity and Auger Length

The piling equipment must have the capacity to excavate the pile shaft and socket (where applicable) in the founding material to the diameter and depth shown on the Design Documentation drawings, and the capacity to excavate an additional 20% of the design pile length.

The auger length must also exceed the design pile length by at least an additional 20%, to allow continuous augering without breaking or unscrewing the auger in the event that the pile length need to be increased by an additional 20%.

#### 3.3.2 Piling Rig Instrumentation

Fit the CFA piling rig with on-board instruments to monitor the piling operations in real-time. The on-board instruments must be capable of accurately measuring the parameters listed in Clause 5.7.

Provide evidence verifying that the piling rig monitoring instruments have been calibrated within the six months before the date of pile construction.

### 3.4 WORK HEALTH AND SAFETY REQUIREMENTS

#### 3.4.1 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), verifying that under the proposed set up and site conditions, the proposed piling equipment and working platforms or supports will operate safely.

#### 3.4.2 Daily Checks

Prior to the commencement of each day’s piling, carry out a safety check on the piling equipment to ensure safe working conditions.
Check the entire concreting line for leakages.

3.5 ENVIRONMENTAL REQUIREMENTS

Remove all excavated material, excess concrete and waste from the site, unless otherwise specified.

Collect, treat and dispose of the water resulting from your piling operations in accordance with Specification RMS D&C G36.

3.6 SET OUT

Set out the site with adequate recovery pegs and survey markers so that the drilling rig can be set up accurately on the pile locations and be aligned correctly.

4 ADDITIONAL SITE INVESTIGATION AND TRIAL PILES

4.1 ADDITIONAL SITE INVESTIGATION

4.1.1 General

When required by site conditions, take additional boreholes and/or cores prior to augering the pile holes to confirm the adequacy of the ground conditions for the pile shaft and the depth of the pile base.

4.1.2 Standard Penetration Test

When taking boreholes, carry out Standard Penetration Test (SPT) to AS 1289.6.3.1 at 1.5 m intervals starting from one metre below the ground level to the pile toe level.

4.1.3 Cores

For piles founded on rock, take 50 mm diameter core samples commencing at one metre above the top of the rock socket shown on the Design Documentation drawings to a depth that is at least 3 m or 3 pile diameters, whichever is the greater, below Design Toe Level.

4.1.4 Logging

Log the boreholes and/or cores in conformity to AS 1726. Place the cores in suitable core boxes and make them available for inspection as required.

4.1.5 Backfilling Boreholes

Fill all boreholes upon completion using flowable cement-stabilised sand.

4.2 TRIAL PILES

Where specified on the Design Documentation drawings, construct trial piles in conformity to Clauses 5.2 to 5.5.

Submit installation records as specified in Clause 5.7.
5 CONSTRUCTION – CFA PILING

5.1 PRIOR TO AUGERING

HOLD POINT

Process Held: Augering and concreting of the first pile in each pile group.

Submission Details: Certification of pile location set out (refer to Clause 3.6) and, where required, additional site investigation (refer to Clause 4.1) and trial piles test results (refer to Clause 4.2), at least one working day before commencing.

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

WITNESS POINT

Process to be Witnessed: Augering, concreting and placing of reinforcement cage for each pile.

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

5.1.1 Calibration of Concrete Volume Measuring System

Determine the calibration factor for concrete pump efficiency, based on the make, model and previous experience with the specific concrete pump.

Prior to commencement of piling on site, confirm or adjust the calibration factor to suit the concrete mix and pump. The calibration factor is calculated as the ratio of the concrete volume delivered to the pump to the actual corresponding volume discharged. Enter that factor into the on-board monitoring instrument.

5.1.2 Other Checks and Preparatory Measures

Clearly mark the drilling frame at 0.5 m intervals for independent visual verification of the auger depth in addition to the automated depth monitoring unless a secondary depth recorder is present.

Check the depth sensors to ensure accurate measurements.

Prior to augering of the first pile of the day, prime the concrete supply line with a cement/water mix or equivalent and pump concrete through the full length of the line.

Keep the concrete hose length to a minimum to facilitate pumping.

Prior to augering of each pile, use an end cap or temporary plug to close off the auger tip and prevent soil and water ingress into the hollow shaft of the auger during augering. Clean and grease the plug prior to sealing the auger.
Check the position and verticality of the auger prior to the commencement of augering of each pile.

5.2 AUGERING

5.2.1 Sequence and Timing

Carry out the pile construction in such a sequence that the integrity of previously constructed piles is not compromised.

Do not construct piles within a centre-to-centre distance of less than 3 times the pile diameters from adjacent piles cast within the previous 24 hours. If required because of unfavourable ground conditions, such as in saturated granular soils or soft clays, increase this minimum distance to 7 times the pile diameter.

Prevent delays during augering. Do not leave pile holes partially drilled.

5.2.2 Depth

Auger to the Design Toe Level unless otherwise directed by the attending Geotechnical Engineer.

5.2.3 Control and Monitoring

Control the auger drilling rate against the penetration rate to minimise “draw-in” of surrounding ground. Do not allow the auger stem to rotate without penetration or extraction. Do not lift the auger stem during augering.

Monitor the penetration rate, the drilling rate and the torque over the full length of the piles.

5.3 CONCRETING AND AUGER EXTRACTION

5.3.1 General

Commence concreting immediately after completion of augering and proceed with injecting the concrete without delays.

Verify from the concrete delivery docket prior to the discharge from the agitator that the specified concrete mix has been delivered. Visually check the concrete mix and carry out testing in conformity to Specification RMS D&C B80.

5.3.2 Concrete Oversupply

The actual volume of concrete placed in the pile shaft must not be less than the nominal volume multiplied by the concrete oversupply factor.

The concrete oversupply factor varies for different ground conditions, but must not be less than 105% except for pile sockets in rock where the factor may be reduced to 100%.

The oversupply factor must replicate values derived from trial piles where used.

5.3.3 Prior to Auger Extraction

Prior to auger extraction, pre-charge the concreting line and the auger stem with concrete under pressure.
Should the plug closing off the auger tip not open immediately following commencement of extraction, raise the auger 200 mm and blow the plug free. Re-auger to the original depth and recommence extraction.

Use a multi-pass drilling technique in the base of the pile hole to ensure that the concrete is not contaminated. Withdraw the auger 500 mm while discharging concrete and then drill back down to toe of the pile to pick up any contaminated concrete before re-commencing concreting of the pile. The auger depth in the second or subsequent pass must not be less than the depth of the previous pass by more than 50 mm.

Verify the use of the multi-pass drilling technique from the pile monitoring records.

5.3.4 Auger Extraction and Concrete Pumping

During extraction, provide an uninterrupted supply of concrete for each pile to produce a monolithically concreted pile with the specified dimensions and that is free of entrapped air and debris.

Extract the auger smoothly, without jerks. Where required, the auger stem may rotate slowly on extraction to facilitate the auger cleaning. Care must be taken to ensure soil draw-in will not occur.

Maintain positive concrete pressure during extraction over the length of the pile. If the concrete pressure becomes negative at a certain depth, redrill to 500 mm below that depth and resume extraction and concreting. Ensure that the auger tip remains embedded in concrete at all times during extraction by injecting sufficient concrete oversupply.

During extraction, clean the auger of all rising ground materials. Progressively remove spoil accumulating around the top of the pile hole.

5.3.5 Completion of Concrete Placement

Continue concrete pumping until the auger tip rises to 300 mm above the ground level. Remove all spoil from around the pile hole.

On completion of concrete placement, and removal of spoil around the top of the pile hole, clean the top of the pile manually. Where necessitated by the site conditions, insert a temporary form in the pile top and remove contaminated concrete at the top and replace with good concrete as required.

5.4 Plug Failure

If the plug opens prematurely during drilling, or if all attempts to blow out the plug after completion of drilling are unsuccessful, wind out the auger in conformity to the manufacturer's recommendations and clean and refit the end plug. Then redrill the same pile hole to the specified depth or to an increased depth as required.

If redrilling the pile at the same position cannot be achieved, seek the Designer’s direction. Drilling the pile at a new position which is within a short distance from the original pile position may be acceptable.

5.5 Placement of Reinforcement Cage

Prior to placement, ensure that the reinforcement cage is clean and straight.
Place the reinforcement cage into the centre of the concreted pile hole immediately after concreting and while the concrete is still fluid. Keep the cage vertical during insertion. Prior to lowering the reinforcement cage, adjust the cage orientation to avoid clashing with the pile cap reinforcement.

Secure the reinforcement cage in place to obtain the specified projection above final pile cut-off level.

If the reinforcement cage cannot be placed to the specified depth, withdraw the cage and clean it thoroughly before re-augering and re-concreting the pile prior to re-inserting the cage.

5.6 INSTALLATION TOLERANCES

Tolerances on pile installation must conform to Section 7 of AS 2159 except that the inclination tolerance for vertical piles must be 2%.

Demonstrate that the inclination tolerance has been achieved.

5.7 INSTALLATION RECORDS

Monitor and record the following parameters in real-time over the full length of each pile to verify conformity of the pile installation:

(a) penetration rate (m/min) during augering;
(b) drilling rate (rev/mm) during augering;
(c) drilling torque (% of maximum available) during augering;
(d) extraction rate of auger (m/min) during concreting;
(e) concreting pressure (bar); and
(f) amount of concrete oversupply (% above nominal) recorded at half metre intervals of the pile depth.

Provide to the RMS Representative and Project Verifier a copy of the pile monitoring records, signed by the Piling Supervisor, demonstrating that the pile position, size, depth, verticality and other design parameters, shown on the Design Documentation drawings, or in conformity to the directions of the attending Geotechnical Engineer, have been achieved within 24 hours of the completion of the pile where mobile phone reception is available at the site, and within 48 hours otherwise.

6 TESTING

6.1 PILE INTEGRITY TESTING

Unless specified otherwise on the Design Documentation drawings, carry out integrity testing of all piles in conformity to AS 2159. Testing must not result in the allowable concrete stresses being exceeded.

The integrity testing must confirm that the pile is sound over its full length.
HOLD POINT

Process Held: Integrity testing of all piles.
Submission Details: Method of integrity testing and personnel proposed for the testing.
Release of Hold Point: The Nominated Authority will consider the submitted information prior to authorising the release of the Hold Point.

6.2 PILE LOAD TESTING - GENERAL

Carry out load testing to the piles designated on the Design Documentation drawings (such as for trial piles if applicable) to the test load specified on the Design Documentation drawings or required by the Designer.

Unless specified otherwise, perform static or high-strain dynamic testing in conformity to AS 2159 and Clause 6.3 as applicable.

You may use other types of pile load testing in conformity to AS 2159, where accepted by the RMS Representative.

6.3 HIGH-STRAIN DYNAMIC TESTING

6.3.1 General

Where high-strain dynamic pile testing is to be carried out, prepare the pile as required to allow the attachment of transducers or similar testing instruments.

Carry out high-strain dynamic testing in conformity to AS 2159 and this Clause 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: http://www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/tenders-contracts/listofapprovedbridgecomponentsystems.pdf

Testing must not result in the allowable concrete stresses being exceeded.

6.3.2 Testing Procedure

Use the following procedure for the testing:

(a) Attach at least four bolt-on transducers below the head of the pile.
(b) Connect the transducers to the analyzer and strike the pile with sufficient energy to verify the required resistance.

6.3.3 Dynamic Analysis

Analyse the dynamic data for each pile tested. Analyses must include full Dynamic Analysis using measured field parameters of the test data (e.g. CAPWAP).
6.3.4 Report

Provide to the RMS Representative and Project Verifier a report for each pile tested, including the following:

(a) Complete PDA (or approved equivalent) output for all blows.
(b) CAPWAP (or approved equivalent) analyses for selected blows.
(c) Certification that the pile has been dynamically tested in conformity to this Specification. If it is not possible for this certification to be provided due to nonconformities in the testing or the pile tested, provide instead an itemised nonconformity report together with the proposed disposition.
ANNEXURES B63/A AND B63/B – (NOT USED)

ANNEXURE B63/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

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<td>Hold</td>
<td>Submission of details of piling plant and equipment before delivery to Site</td>
</tr>
<tr>
<td>5.1</td>
<td>Hold</td>
<td>Submission of pile set out, and site investigation and trial pile test results, for each pile group</td>
</tr>
<tr>
<td>5.1</td>
<td>Witness</td>
<td>Augering, concreting and placing of the reinforcement for each pile</td>
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<tr>
<td>6.1</td>
<td>Hold</td>
<td>Proposed method of pile integrity testing and personnel to carry out the testing</td>
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C2 SCHEDULE OF IDENTIFIED RECORDS

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

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<th>Clause</th>
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<td>Qualifications and experience of Geotechnical Engineer</td>
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<td>3.3.2</td>
<td>Calibration records for drilling monitoring instruments</td>
</tr>
<tr>
<td>4.1</td>
<td>Borehole logs and SPT results from additional site investigation</td>
</tr>
<tr>
<td>5.7</td>
<td>Certified installation records for each pile</td>
</tr>
<tr>
<td>6.1</td>
<td>Integrity test report for each pile tested</td>
</tr>
<tr>
<td>6.3.4</td>
<td>Load test report for each load tested pile</td>
</tr>
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ANNEXURE B63/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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<th>Clause</th>
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<td>Details of approved nominated concrete mix</td>
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<td>3.3.2</td>
<td>Details of proposed CFA piling rig and on-board monitoring instruments together with recent calibration records</td>
</tr>
<tr>
<td>5.1.1</td>
<td>Evidence that on-board monitoring instruments accurately measure the concrete volume discharged</td>
</tr>
<tr>
<td>5.2 &amp; 5.3</td>
<td>Procedures for auguring, auger extraction and concreting</td>
</tr>
<tr>
<td>5.5</td>
<td>Procedure for placing reinforcement cage</td>
</tr>
<tr>
<td>6.1</td>
<td>Procedure for Integrity Testing</td>
</tr>
<tr>
<td>6.3</td>
<td>Procedures for load testing and details of proposed approved dynamic testing organisation and system and testing personnel</td>
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ANNEXURES B63/E TO B63/K – (NOT USED)

ANNEXURE B63/L – FREQUENCY OF TESTING

Refer to Clause 1.2.5.

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<thead>
<tr>
<th>Clause</th>
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<td>Concrete for piles</td>
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<td>2.3</td>
<td>Reinforcement for piles</td>
<td>As specified in RMS D&amp;C B80</td>
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<td>5.6</td>
<td>Pile position and verticality</td>
<td>Each pile</td>
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<td>6.1</td>
<td>Pile Integrity Testing</td>
<td>All piles</td>
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<td>6.3</td>
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<td>Piles specified on Design Documentation drawings</td>
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ANNEXURE B63/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.6.

RMS Specifications

RMS D&C B80  Concrete Work for Bridges
RMS D&C G22  Work Health and Safety (Construction Works)
RMS D&C G36  Environmental Protection
RMS D&C Q6   Quality Management System (Type 6)

Australian Standards

AS 1289.6.3.1  Methods of testing soils for engineering purposes – Soil strength and consolidation tests – Determination of the penetration resistance of a soil - Standard penetration test (SPT)
AS 1726        Geotechnical site investigations
AS 2159        Piling – Design and installation
AS 5100.3      Bridge design. Part 3: Foundations and soil-supporting structures