

Structures

Master Specification

ST-PI-C1 Driven Piles

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ST-PI-C1 Driven Piles

1 General

- 1.1 This Part specifies the requirements for the supply and installation of driven piles, which includes prestressed concrete piles, steel piles and driven cast in situ concrete piles. These piles may be either end bearing or friction piles.
- 1.2 The Contractor is responsible for:
 - a) providing the detailed design of the piles to achieve the specified Design Geotechnical Strength (unless a detailed design has been specified by the Principal);
 - b) the installation of piles that achieve the Design Geotechnical Strength and design durability; and
 - c) verifying that the Design Geotechnical Strength has been achieved in practice.
- 1.3 Unless specified otherwise in the Contract Documents or on the drawings, piles must be designed and constructed in accordance with the methods specified in AS 2159 and AS5100.3.
- 1.4 Documents referenced in this Part are listed below:
 - a) AS 1554.3 Welding of Reinforcing Steel.
 - b) AS 2159 Piling – Design and Installation.
 - c) AS 5100.3 Bridge Design – Foundations and Soil Supporting Structures.

2 Quality Requirements

- 2.1 The Contractor must prepare and implement a Quality Plan that at a minimum includes the documents, procedures and / or instructions listed in the clauses below. If not provided beforehand, the procedures must be submitted at least 28 days prior to the commencement of tensioning.
- 2.2 Provision of the procedures listed in this Clause shall constitute a **Hold Point**.

Pile Design

- 2.3 Detailed design of the piles and supporting calculations.

Installation

- 2.4 Method of transporting, storing and lifting piles so as to prevent damage to the pile or any protective coating.
- 2.5 Details of proposed driving equipment including:
 - a) Pile hammer;
 - b) Pile helmet and cushion assembly;
 - c) Pile driving rig, crane, leaders and / or other equipment proposed for pile driving operations.
- 2.6 Method of driving so as to prevent damage to the pile.
- 2.7 Method of controlling noise.
- 2.8 Details of the equipment and methods to be used for any pre-boring and / or jetting.
- 2.9 Details of approval from the appropriate regulatory authority for any temporary filling in waterway areas during construction.
- 2.10 Methods of monitoring adjacent infrastructure during pile driving.
- 2.11 Methods of pre-boring and backfilling.
- 2.12 Method of cutting and breaking back of piles.

Records and Testing

- 2.13 Details of procedure to record pile driving, including example recording sheet.
- 2.14 Details of the proposed third party dynamic and integrity testing specialist subcontractor, system and field testing personnel.
- 2.15 Details of the testing regime and methodology to demonstrate that the required Design Geotechnical Strength and pile integrity is achieved in practice and supporting calculations.
- 2.16 The Contractor's attention is drawn to PC-QA1 "Quality Management Requirements", Clause 3 "Quality Management Plan in the event that the Contractor changes the pile design or installation methodology as a result of unforeseen ground conditions or any other reason.

3 Definitions

- 3.1 Except for the following definitions, the definitions in AS 2159 apply:

Term	Definitions
Calculated Set	The calculated average penetration per blow from 10 consecutive blows with the net driving energy of the proposed driving rig.
Dynamic Analysis	Determination of pile resistance, hammer energy, net driving energy, pile integrity, accelerations and stresses in the pile from Dynamic Testing in a wave equation analysis. e.g. CAPWAP, TNOWAVE.
Dynamic Testing	Determination of pile resistance, hammer energy, net driving energy, pile integrity, accelerations and stresses in the pile by the use of electronic equipment (e.g. Pile Driving Analyser) during driving and restrike testing.
Maximum Net Driving Energy	Net driving energy which must not be exceeded at any time during driving.
Minimum Penetration Depth	Minimum length of pile below existing surface or other specified surface level at pile location.
Nominal Driving Energy	Driving energy nominally imparted by the hammer. i.e. Before hammer, helmet and cushion losses are accounted for.
Net Driving Energy	Driving energy at the top of the pile. i.e. After hammer, helmet and cushion losses.
Nominal Refusal	A penetration of not more than 13 mm from 10 consecutive blows with the net driving energy calculated or piles driven to rock.
Test Piles	Piles manufactured and driven prior to the manufacture of other piles to enable the pile lengths to be confirmed or altered as necessary.
Wave Equation Analysis	Determination of theoretical resistance versus set of a pile using computer modelling. e.g. GRLWEAP.

4 Manufacture of piles

General

- 4.1 This Clause applies to steel piles and prestressed concrete piles.
- 4.2 Piles must not be deformed, damaged or have the integrity of any protective coating compromised during transportation, handling and storage.

Steel Piles

- 4.3 Piles must be manufactured in accordance with ST-SS-S1 "Fabrication and Erection of Structural Steelwork".
- 4.4 Protective treatment of steel piles, where specified, must be carried out in accordance with ST-SS-S2 "Protective Treatment of Structural Steelwork".
- 4.5 Those portions of the piles which are to be embedded or encased in concrete must be thoroughly cleaned in accordance with ST-SS-S2 "Protective Treatment of Structural Steelwork", Clause 8

"Surface Preparation Requirements". All piles must be clearly and indelibly marked at 1.0 m intervals commencing from the toe to show penetration depths attained during driving.

Prestressed Concrete Piles

- 4.6 Concerning the concreting and prestressing operations for prestressed concrete piles and subject to any other requirements of this P, piles must be manufactured in accordance with ST-SC "Concrete". ST-SS-C2 "Prestressed Concrete Work" applies to operations
- 4.7 Piles must be lifted, supported and pitched at the positions as shown on the Drawings. The minimum strength of concrete prior to lifting must be 75% of its 28 day characteristic compressive strength.
- 4.8 All piles must be clearly and indelibly marked at 1.0 m intervals commencing from the toe to show penetration depths attained during driving.

5 Site works

Site Preparation

- 5.1 Local excavation must be completed before driving of piles is commenced. Excavations must be trimmed after driving is completed to remove any material forced up between the piles during driving.
- 5.2 Unless specified otherwise, any over excavation in the vicinity of the piles must be backfilled with lean mix concrete after completion of the pile driving.
- 5.3 Where piles are to penetrate through a new embankment, the new embankment must be placed and compacted to the specified requirements prior to driving the piles. Piles must not be driven through an embankment until any settlement that may adversely affect the pile performance has occurred.

Temporary Filling of a Waterway

- 5.4 Where temporary filling of a waterway is proposed, the Contractor must verify that the addition of the fill will not cause any adverse ground movements either short term or long term.
- 5.5 Prior to commencing temporary filling, the Contractor must produce evidence that the methods of filling and restoration, and any proposed reduction in waterway area during construction, have the approval of the appropriate regulatory authorities.

6 Driving Operation

General Requirements

- 6.1 The net driving energy must not exceed the maximum net driving energy specified at any time during driving, including testing and restriking of the piles. Piles must not be damaged during driving.
- 6.2 At all times during the driving operation, the driving equipment must be adjusted such that the blow of the hammer is directed centrally and axially on the pile head.
- 6.3 For each pile, the Contractor must provide at least one working day's notice of intention to drive.

Driving of Piles

- 6.4 Piles must not be bent or sprung into position but must be effectively guided and held during the initial stages of driving. Frequent checks must be made during all stages of driving to ensure that the pile frame does not exert any undue lateral force on the pile. A significant horizontal force must not be used to correct any tendency for the pile to run off line.
- 6.5 The Contractor must ensure at all times that the pile is not restrained against rotation about its longitudinal axis.
- 6.6 If during driving the head of a pile is damaged to the extent that further driving is not possible the head must be cut off and driving continued. Where, as a result of such cutting off of the head, the

pile is too short, the Contractor must supply and splice on sufficient length of pile to restore the pile to its correct length and repair any damaged protective treatment.

- 6.7 If driving operations cease for any reason than to perform a restrike test, then driving must recommence after striking a minimum of 30 blows at the required net driving energy before assessing whether the pile has met the required driving criteria.

Tolerances

- 6.8 Piles must be driven with tolerances not exceeding the positional tolerance requirements specified in AS 2159.

7 Splicing and stripping of piles

Steel Piles

- 7.1 A pile may be extended by splicing on an additional length of identical steel pile section prior to, during and / or after driving.
- 7.2 Unless specified otherwise, piles must be spliced using full penetration butt welds over the whole cross section. Pile welds must be ground smooth after splicing.

Prestressed Concrete Piles

- 7.3 A pile may be extended prior to or during driving by splicing on an additional length of precast prestressed concrete pile.
- 7.4 Piles must be spliced as detailed on the drawings. If no details of the splice are shown on the drawings the piles must be spliced used mechanical pile splices.
- 7.5 Unless otherwise shown on the drawings, all mechanical pile splices must be located at least 5 m below the lowest natural or existing ground surface after the completion of driving.
- 7.6 A pile may be extended after completion of driving (but not prior to or during driving) by casting a cast-in-place reinforced concrete extension to it.
- 7.7 The connection and the extension must be capable of developing the full structural capacity of the whole pile, including the bending capacity and durability classification shown on the drawings.
- 7.8 Any welding of reinforcement carried out as part of the extension must be in accordance with AS 1554.3 and to the manufacturer's recommendations. Tendons must not be welded.

Stripping Of Concrete Piles

- 7.9 Explosives must not be used for the stripping operation.
- 7.10 Only hand held equipment may be used for stripping of the pile head.
- 7.11 Prior to stripping heads of piles, a circumferential saw cut must be carried out. The saw cut must be to a depth of 13.0 mm less than the minimum clear cover to the longitudinal steel bars or the prestressing strands whichever has the least cover.
- 7.12 The method used to strip the pile must ensure that spalling, cracking and / or scoring of the face of the pile below the cut-off level does not occur and that reinforcement and stressing tendons are not damaged for their full final length.
- 7.13 The stripping must expose the longitudinal reinforcement and / or strands for the bond lengths shown on the drawings.
- 7.14 Any excess length of pile must be cut off and removed.

8 Driving records and testing

Driving Records

- 8.1 The Contractor must complete a pile driving record sheet for each pile and provide a copy of each sheet. The driving record must contain the following information at a minimum:
- date of driving pile;
 - design location of pile;
 - final natural surface level and toe level;
 - pile penetration (blows verses displacement) and the corresponding energy input at all stages of the driving;
 - type and size of hammer and its stroke, or for double acting hammers the number of blows per minute;
 - type and condition of packing on the pile head, and of the dolly or follower;
 - sequence of driving in the pile groups;
 - actual location and any apparent deviation from design location and inclination; and
 - details of piles that are re-driven due to the effect of ground movements.

Testing

- 8.2 The Contractor must undertake all testing necessary to demonstrate conformance with the requirements of this specification, including strength testing and pile integrity testing. Testing for Design Geotechnical Strength must be carried out after all piles in a group have been installed. At least one dynamic load test must be performed at each bridge abutment and pier location, and at least one for every 30 piles or 10% of pile, whichever results in a greater number of tests being undertaken.
- 8.3 Submission of the test results and driving records shall constitute a **Hold Point**.

9 Hold points

- 9.1 The following is a summary of Hold Points referenced in this Part:

Document Ref.	Hold points	Response time
2.2	Submission of documentation or amendments	7 days
8.3	Submission of records and test results following the driving of a group of piles	6 hours

10 Verification requirements and records

- 10.1 The following is a summary of records to be supplied by the Contractor to demonstrate compliance with this Part:

Table ST-PI-C1 10-1 Verification requirements

Document Ref.	Record
8.1	Pile Driving Records
8.2	Pile Test Results