

# Structures

## Master Specification

### ST-PI-C3 Continuous Flight Auger (CFA) Piles

#### Document Information

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## ST-PI-C3 Continuous Flight Auger (CFA) Piles

### 1 General

- 1.1 This Part specifies the requirements for the installation of Continuous Flight Auger (CFA) piles. CFA piles are constructed by using a hollow flight auger to bore the hole, which is filled with concrete or cement grout injected under pressure as the auger is progressively withdrawn.
- 1.2 The Contractor is responsible for:
- a) providing the detailed design of the piles to achieve the specified design load (unless a detailed design has been specified by the Principal);
  - b) the installation of piles that achieve the design load capacity and design durability; and
  - c) verifying that the design load capacity and durability 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 AS 5100.3.
- 1.4 Documents referenced in this Part are listed below:
- a) AS 1012      Methods of testing concrete.
  - b) AS 1478.2    Chemical admixtures for concrete, mortar and grout – Methods of sampling and testing admixtures for concrete, mortar and grout.
  - c) AS 2159      Piling – Design and Installation.
  - d) AS 2701.2    Methods of sampling and testing mortar for masonry constructions - Methods of sampling.
  - e) AS 3972      Portland and blended cements.
  - f) AS 5100.3    Bridge Design – Foundations and Soil Supporting Structures.
- 1.5 When AS 5100 and AS 2159 requirements differ, then Contract Documents take precedence.

### 2 Quality Requirements

- 2.1 At a minimum, the Contractor's Quality Plan must include the following documents, procedures and instructions:
- a) the concrete and / or grout mix design(s), including test results for mix designs, verifying the ability to achieve specified requirements;
  - b) details of proposed boring equipment to be used and evidence of its capacity to carry out the work;
  - c) proposed recording forms to be used during construction and testing;
  - d) methodology to ensure pile location and verticality tolerances are met;
  - e) methodology for measuring penetration rate and torque during augering;
  - f) procedure for ensuring that each pile has achieved the required design founding conditions;
  - g) procedure for monitoring the extraction rate of the auger over the full length of the pile shaft;
  - h) procedure for measurement and monitoring of pressure in the delivery line to ensure that positive pressure is maintained at all times during concreting or grouting;
  - i) methodology and equipment to provide a continuous record of concrete or grout flow rate and auger extraction rate to ensure that no section of pile contains less than the theoretical volume of concrete or grout;
  - j) the corrective action procedure to be taken if supply pressure and / or flow rate is not maintained during concreting or grouting, or the construction process is interrupted;

- k) procedure for installation of the reinforcement cage, including spacer details and fixing and the method of ensuring minimum cover to reinforcement;
  - l) method of cutting and breaking back of piles;
  - m) details of the proposed integrity test and load test methods, including the name and qualifications of the third-party specialist sub-contractors and a method statement of how the test will be carried out and details of the record sheets proposed for monitoring results; and
  - n) a suitably qualified and experienced civil / geotechnical engineer or Engineering Geologist fully conversant with piling operations, must be present to supervise piling works.
- 2.2 If not provided beforehand, the documentation must be submitted at least 28 days prior to the commencement of piling works.
- 2.3 Provision of the documentation listed in this Clause shall constitute a **Hold Point**.

### 3 Materials

- 3.1 Concrete must be in accordance with ST-SC-S7 "Supply of Concrete" and reinforcement must be in accordance with ST-SC-S6 "Steel Reinforcement". Longitudinal reinforcement must be supplied in full lengths.
- 3.2 Grout must consist of cement, water and an admixture to reduce shrinkage and bleeding. Cement must conform to the requirements of AS 3972 for normal Portland cement and must be free from calcium chloride.
- 3.3 Admixtures must not contain chlorides, nitrates or similar electrolytic conducting materials and may only be used where they will increase workability or reduce shrinkage and bleeding.
- 3.4 The design strength of grout piles must be calculated using the additional strength reduction factors given in AS 2159 and based on the suitability of the grout mix for the soil conditions.
- 3.5 The Contractor must provide a Quality Plan that at a minimum must include the following documents, procedures and instructions:
- a) the concrete mix design(s), including test results for mix designs, verifying the ability to achieve specified requirements;
  - b) details of proposed boring equipment to be used and evidence of its capacity to carry out the work;
  - c) proposed recording forms to be used during construction and testing;
  - d) methodology to ensure pile location and verticality tolerances are met;
  - e) methodology for boring and verifying the ground conditions as per the design assumptions;
  - f) safety requirements to ensure that fall protection is in place whenever an open excavation exists;
  - g) where appropriate, the type of drilling mud and the means of maintaining head levels;
  - h) methodology to monitor and prevent contamination by ingress of loose material, ground water or mud during pile construction;
  - i) methodology for placing shaft concrete;
  - j) method of cutting and breaking back of piles; and
  - k) details of the proposed integrity test and load test methods, including the name and qualifications of the third party specialist sub-contractors and a method statement of how the test will be carried out and details of the record sheets proposed for monitoring results.
- 3.6 Provision of the documentation listed in this Clause must be provided at least 28 days prior to commencement of piling works and shall constitute a **Hold Point**.

## 4 Pile construction

### Protection of Adjacent Piles or Structures

#### 4.1 The Contractor must:

- a) minimise vibration during construction;
- b) ensure that services, adjacent structures or newly cast piles are not damaged during pile construction;
- c) not commence pile construction within 2.0 metres clear distance of a newly cast pile (or within three pile diameters, whichever is the greater) until the concrete or grout in the pile has attained a strength of 15 MPa; and
- d) locate construction equipment at sufficient distance from the pile being drilled and from recently constructed piles to avoid displacement of the column of concrete or grout.

### Pile Construction

- 4.2 The piling rig and length of flights on the auger must be sufficient to allow construction of the pile in a single pass of the auger to the design depth of the pile shown on the drawing. Splitting the auger during drilling is not permitted.
- 4.3 The rotation of the auger during drilling should only be in the drilling direction. Reversing the auger and / or pulling the auger out to clear the drilling head during drilling is not permitted.
- 4.4 The concrete delivery hose shall be primed above ground level; priming the concrete delivery hose down the hole is not permitted.
- 4.5 The introduction of air under pressure through the hollow stem of the auger during installation of the pile is not permitted.
- 4.6 When the auger has reached the design toe level the foundation material must be confirmed after concreting is completed, by sampling the material on the drilling head of the auger, in accordance with the Contractor's installation procedure, including reference to soils data, penetration rate of the auger and torque, or the toe level adjusted in accordance with the design requirements.
- 4.7 Where piles are founded on rock, they must extend the specified minimum distance into rock of the type and quality shown on the drawings.
- 4.8 Pile shafts must be formed by injecting concrete or grout in an uninterrupted operation as the auger is progressively extracted; splitting the auger during concreting is not permitted.
- 4.9 The concrete must be discharged into the pile within 2 hours from the batching time of the concrete load shown on the concrete delivery docket.
- 4.10 When the auger has reached the design toe level, the concrete delivery hose shall be pressurised to achieve a sufficient pressure before the auger is progressively withdrawn.
- 4.11 The method of maintaining positive pressure in the pumping equipment, and the method of maintaining an oversupply rate for concrete or grout must be in accordance with the Contractor's installation procedure.
- 4.12 Positive concrete pressure and rate of concrete delivery shall be maintained as the auger is withdrawn to reduce the risk of the formation of voids and inclusions.
- 4.13 The Contractor must ensure that earth and rock do not dislodge from the side of the hole or from the ground around the top of the pile and contaminating the concrete or grout and reducing the minimum cover to reinforcement.
- 4.14 All piles must be fully concreted up to the Piling Platform to ensure sound concrete free of any spoil at the Piling Platform level before installing the reinforcement cage. Pile break back must not be attempted for a minimum of 24 hours post concrete pour.

- 4.15 The reinforcement cage shall be placed and centralised in the pile as soon as is practicable after the pile has been concreted and while the concrete is still plastic. The reinforcement shall then be allowed to descend under its own weight until the correct level is reached.
- 4.16 If the reinforcement cage cannot be installed to the required level under the effects of gravity, a small vibratory drive head may be used to complete the installation of the cage provided the Contractor is able to demonstrate that such vibration will not cause segregation or bleeding in the concrete, nor adversely affect the integrity of the steel cage.
- 4.17 Pushing the reinforcement cage down using other means, other than cage vibrator, such as excavator bucket is not permitted.
- 4.18 Spacers and supports for CFA pile steel reinforcement shall be placed at intervals of no more than 2.0 m along the full length of the steel reinforcement cage to ensure that the specified concrete cover to the steel reinforcement is maintained.

## Sampling and Testing

- 4.19 Concrete must be sampled and tested in accordance with ST-SC-S7 "Supply of Concrete".
- 4.20 Grout must be sampled from each truckload of grout supplied during pile installation. Cube samples of grout must be taken in accordance with AS 2701.2 and must be tested in accordance with AS 1012 to determine the compressive strength.
- 4.21 Bleeding must be tested in accordance with the requirements of AS 1478.2 and must not exceed 2% of the volume three hours after mixing and must not exceed 4% of the volume at any time. All separated water must be reabsorbed within 24 hours. Shrinkage must not exceed 750 micro strain.
- 4.22 Any additional water added to the concrete load on site must not exceed the maximum allowed water specified on the concrete docket. Spread slump test must be repeated after the addition of water on site to confirm the spread slump remains within the project specifications.
- 4.23 Inspection of Pile location, verticality (i.e. general piles setting out) and reinforcement cages shall constitute a **Hold Point**.

## 5 Tolerances

- 5.1 Piles must be constructed to within the following tolerances:
  - a) pile head must finish within 75 mm of the specified plan position;
  - b) variation from the vertical must not be more than 1 in 50; and
  - c) minimum cover to reinforcement must be 75 mm.

## 6 Testing of piles

### Integrity Testing

- 6.1 Integrity testing must be carried out by a third-party specialist sub-contractor approved by DPTI.
- 6.2 Integrity testing must be carried out on the piles in accordance with integrity test methods specified in AS 2159. Integrity testing equipment must be capable of checking cross-sectional irregularities in piles and identifying the location and characteristics of any significant anomalies such as voids or contaminants.
- 6.3 Acceptance criteria, supervision and reporting of integrity testing must be in accordance with the requirements of AS 2159.
- 6.4 Unless specified otherwise, integrity testing must be carried out on all piles.

## Load testing

- 6.5 Dynamic load testing of piles must be carried out by a third-party specialist sub-contractor approved by DPTI. Alternatively, DPTI may approve that the Raw Data be supplied to DPTI for Independent Review by a third Party.
- 6.6 The Contractor must carry out dynamic testing of piles to confirm that design pile capacity has been achieved. 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 total number of piles, as appropriate. Additional dynamic load testing must also be carried out on piles in the event that pile toe levels vary by more than 2 metres from the test pile.
- 6.7 Testing must be carried out by use of a Pile Driving Analyser (PDA) and the data obtained from each pile must be analysed using CAPWAP, TNO WAVE or other approved equivalent software.
- 6.8 Additional load testing requirements (including static load tests) may be specified in the Contract Documents or on the drawings.
- 6.9 The test procedure and test reports must conform with the requirements of AS 2159, and two copies of a report showing the measured field parameters and the results of analysis to determine pile capacity must be provided to the Superintendent.
- 6.10 The measured ultimate capacity of test piles must be equal to or greater than the pile test load specified in the Contract Documents or on the drawings.
- 6.11 Where a defective pile is detected or a pile isn't within tolerances, follow AS 2159 and / or Contract Documents as appropriate.

## Test Results

- 6.12 Submission of the test results shall constitute a **Hold Point**.

## 7 Construction Monitoring

- 7.1 Continuous torque and penetration rate readings must be recorded during pile installation. The torque readings shall be compared to those recorded previously at the test pile sites. Where lower than anticipated torque readings are recorded, particularly at the founding depth, a further assessment must be undertaken by the Design Geotechnical Engineer.

## 8 Hold points

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

| Document Ref. | Hold point   | Response time   |
|---------------|--|-----------------|
| 2.3           | Submission of Quality Documentation                            | 14 working days |
| 3.6           | Provision of documentation                                     | 14 working days |
| 4.23          | Pile location, verticality and reinforcement cages             | TBD             |
| 6.12          | Submission of test results following the installation of piles | 6 hours         |

## 9 Records

- 9.1 The Contractor must provide continuous records for each pile. The data recorded must include the following:
  - a) diameter, length, location, type of pile, date of boring and construction duration;
  - b) concrete or grout batch details, properties and slump;
  - c) data recorded during installation of piles as specified in the Quality Plan;
  - d) all information regarding obstructions, delays and other interruptions to the sequence of work;
  - e) integrity testing results; and



- f) load testing results.
  - 9.2 Records for CFA piling shall be submitted within 12 hours of the completion of each pile.
  - 9.3 All piling rigs must employ a real time monitoring system which provides relevant stakeholders including the Commissioner real time access to piling records at local computers within the site office and remotely via remote access.
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