

Master Specification

Part ST-PI-C3

Continuous Flight Auger (CFA) Piles

September 2024



Government of South Australia
Department for Infrastructure
and Transport

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Document Information

Document Information	
K Net Number:	13523415
Document Version:	1
Document Date:	30/09/2024

Document Amendment Record

Version	Change Description	Date
0	Initial issue	31/08/2023
1	Updated cover page	30/09/2024

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

1 General

- a) This Master Specification Part specifies the requirements for continuous flight auger (CFA) piles, including:
 - i) the documentation requirements, as set out in section 2;
 - ii) the material requirements, as set out in section 3;
 - iii) the pile construction requirements, as set out in section 4;
 - iv) the pile tolerance requirements, as set out in section 5;
 - v) the testing requirements, as set out in section 6;
 - vi) the construction monitoring requirements, as set out in section 7; and
 - vii) the Hold Point requirements, as set out in section 8.
- b) CFA piles must comply with the Reference Documents, including:
 - i) AS 1012 Methods of testing concrete;
 - ii) AS 1478.2 Chemical admixtures for concrete, mortar and grout, Part 2: Methods of sampling and testing admixtures for concrete, mortar and grout;
 - iii) AS 2159 Piling - Design and installation;
 - iv) AS 2701 Methods of sampling and testing mortar for masonry construction;
 - v) AS 3972 General purpose and blended cements; and
 - vi) AS 5100.3 Bridge design, Part 3: Foundations and soil-supporting structures.
- c) The Contractor is responsible for:
 - i) providing the design of the piles to achieve the specified design load (unless a design has been provided by the Principal);
 - ii) the installation of piles that achieve the design load capacity and durability; and
 - iii) verifying that the design load capacity and durability has been achieved in practice.

2 Documentation

2.1 Construction Documentation

In addition to the requirements of PC-CN3 "Construction Management", the Construction Documentation must include the following documents, procedures, and instructions:

- a) the concrete or grout mix designs, 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, including the information required by section 4.3j);
- 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 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, evidence that the spacers are robust enough not to be damaged during handling and installation of the pile cage, and the method of ensuring minimum cover to reinforcement;
- l) method of cutting and breaking back of piles;
- m) details of the proposed test methods, including:
 - i) the name and qualifications of the independent specialist Subcontractors nominated in section 6.2;
 - ii) a method statement of how the test will be carried out;
 - iii) details of the record sheets proposed for monitoring results; and
 - iv) details of the software to be used for the analysis of testing, where CAPWAP or TNOWAVE is not proposed to be used by the Contractor, in accordance with section 6.4a)v);
- n) methodology for boring and verifying the ground conditions as per the design assumptions, including how the Contractor will confirm the foundation material as required by section 4.3e);
- o) safety requirements to ensure that there is an exclusion zone around the piling rig at all times while in operation;
- p) evidence that the piling rig is of sufficient capacity such that drilling occurs in a continuous manner without the need to withdraw the auger or pause to add and remove additional auger lengths to achieve the target depth; and
- q) where CFA piles of the same diameter are used with differing reinforcement arrangements, clear and unambiguous methods of ensuring the correct pile cage is used in the correct orientation for each pile.

2.2 Quality Management Records

- a) In addition to the requirements of PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable), the Quality Management Records must include continuous records for each CFA pile, including the following data:
 - i) in relation to the installation of the piles:
 - A. diameter, length, location, type of pile, date of boring and construction duration;
 - B. concrete or grout batch details, properties, and slump;
 - C. hardened concrete test results (in accordance with ST-SC-S7 “Supply of Concrete”);
 - D. data recorded during installation of piles as specified in the Construction Documentation;
 - E. all information regarding obstructions, delays, and other interruptions to the sequence of work;
 - F. the continuous torque and penetration rate readings during pile installation, in accordance with section 7a); and

- G. the pump and delivery hose pressures, in accordance with section 7b); and
- ii) in relation to the testing:
 - A. integrity testing results, in accordance with section 6.3;
 - B. load testing results, in accordance with section 6.4;
 - C. where applicable, static load testing results, in accordance with section 6.5; and
 - D. 2 copies of a report showing the measured field parameters and the results of analysis to determine pile capacity, in accordance with section 6.4a)vii).
- b) Records for the installation of each CFA pile must be made available as part of the Quality Management Records within 12 hours of the completion of each pile.

3 Materials

- a) Concrete and grout must be in accordance with ST-SC-S7 "Supply of Concrete".
- b) Reinforcement must be in accordance with ST-SC-S6 "Steel Reinforcement".
- c) Unless otherwise shown on the Design Drawings and subject to section 3d), splicing of piles must not be undertaken.
- d) Reinforcement cages must be supplied in full lengths with the number of splices minimised.
- e) Grout must include an admixture to reduce shrinkage and bleeding.
- f) The design strength of grout piles must be calculated using the additional strength reduction factors in accordance with AS 2159 Piling - Design and installation and based on the suitability of the grout mix for the soil conditions.

4 Pile construction

4.1 General

- a) CFA piles must be constructed in accordance with the methods specified in AS 2159 Piling - Design and installation and AS 5100.3 Bridge design, Part 3: Foundations and soil-supporting structures.
- b) A suitably qualified and experienced civil/geotechnical engineer or engineering geologist, fully conversant with CFA piling operations, must be present to supervise all piling works.

4.2 Protection of adjacent piles or structures

In relation to the protection of adjacent piles or structures during the installation of CFA piles, the Contractor must:

- a) minimise vibration during construction;
- b) ensure that Utility Services, adjacent structures, or newly cast piles are not damaged during pile construction;
- c) not commence pile construction within 2.5 m clear distance of a newly cast pile, or within 3 pile diameters (whichever is the greater), until the concrete or grout in the newly cast 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.

4.3 Pile construction

- a) 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 CFA pile. Splitting the auger during drilling is not permitted.
- b) The rotation of the auger during drilling must only be in the drilling direction. Reversing the auger or pulling the auger out to clear the drilling head during drilling is not permitted.
- c) The concrete delivery hose must be primed above ground level. Priming the concrete delivery hose down the hole is not permitted.
- d) The introduction of air under pressure through the hollow stem of the auger during installation of the pile is not permitted.
- e) 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 specified in the Construction Documentation, including reference to soils data, penetration rate of the auger and torque, or the toe level confirmed in accordance with the design requirements.
- f) Where piles are founded on rock, they must extend the minimum distance into rock of the type and quality as specified in the Design Drawings.
- g) 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.
- h) 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.
- i) When the auger has reached the design toe level, the concrete delivery hose must be pressurised to achieve a sufficient pressure before the auger is progressively withdrawn.
- j) 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 and provided as part of the Construction Documentation.
- k) Positive concrete pressure and rate of concrete delivery must be maintained as the auger is withdrawn to reduce the risk of the formation of voids and inclusions.
- l) 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, contaminating the concrete or grout and reducing the minimum cover to reinforcement.
- m) All piles must be fully concreted up to the piling platform, as a minimum, to ensure sound concrete, free of any spoil at the piling platform level, before installing the reinforcement cage. In addition, a minimum of 400 mm of sound concrete or grout must be constructed above the final level of the pile. Any space between the top of the pile and the ground surface must be filled with sand within 30 minutes of placing the shaft concrete or grout. Pile break back must not be attempted within 24 hours of completion of concrete pour.
- n) The reinforcement cage must 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 must then be allowed to descend under its own weight until the correct level is reached.
- o) 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.
- p) Pushing the reinforcement cage down using other means, other than cage vibrator, such as excavator bucket, is not permitted.
- q) Spacers and supports for CFA pile steel reinforcement must 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.

4.4 Sampling and testing

- a) Concrete must be sampled and tested in accordance with ST-SC-S7 "Supply of Concrete".
- b) 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 Methods of sampling and testing mortar for masonry construction and tested in accordance with AS 1012 Methods of testing concrete to determine the compressive strength.
- c) Bleeding must be tested in accordance with the requirements of AS 1478.2 Chemical admixtures for concrete, mortar and grout, Part 2: Methods of sampling and testing admixtures for concrete, mortar and grout, and must not exceed 2% of the volume 3 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.
- d) Any additional water added to the concrete load on Site must not exceed the maximum allowed water specified on the concrete docket. A spread slump test must be repeated after the addition of water on site to confirm the spread slump meets the requirements of the Contract Documents.
- e) Inspection of pile location, verticality (i.e., general piles setting out), and reinforcement cages will constitute a **Hold Point**. The drilling of piles must not commence until the Hold Point has been released by the Principal.

5 Tolerances

All CFA piles must be constructed in accordance with the tolerances specified in AS 2159 Piling - Design and installation, except that:

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

6 Testing of piles

6.1 General

The results of the testing of CFA piles required in section 6.3 and 6.4, and where applicable, section 6.5, must be submitted as part of the Quality Management Records. The submission of the test results will constitute a **Hold Point**. Breakback of the pile and any construction work on the pile cap or abutment, must not occur until this Hold Point has been released.

6.2 Independent specialist Subcontractor

- a) Testing of CFA piles must be carried out by an independent specialist Subcontractor approved by the Principal.
- b) The Contractor must nominate the independent specialist Subcontractor which will constitute a **Hold Point**. Testing of CFA piles must not occur until this Hold Point has been released.

6.3 Integrity testing

- a) Integrity testing for CFA piles must be carried out:
 - i) by the independent specialist Subcontractor nominated in the section 6.2;
 - ii) on all piles; and
 - iii) in accordance with integrity test methods specified in AS 2159 Piling - Design and installation.

- b) Integrity testing equipment must be capable of checking cross-sectional irregularities in CFA piles and identifying the location and characteristics of any significant anomalies, such as voids or contaminants, throughout the full length of the pile.
- c) Acceptance criteria, supervision, and reporting of integrity testing must be in accordance with the requirements of AS 2159 Piling - Design and installation.

6.4 Dynamic load testing

- a) Subject to section 6.4b), the following requirements apply to load testing for CFA piles:
 - i) dynamic load testing of CFA piles must be carried out by the independent specialist Subcontractor nominated in the section 6.2;
 - ii) where requested by the Principal, the Contractor must provide the raw data, collected from the testing in accordance with this section 6.4, to the Principal within 1 day of such request, which may be used for independent review by a third party;
 - iii) the Contractor must carry out dynamic load testing of CFA piles to confirm that the design pile capacity has been achieved, including:
 - A. at least one dynamic load test at each bridge abutment and pier location, and
 - B. dynamic load testing of at least 10% of the total number of CFA piles;
 - iv) if a test pile has been constructed, additional dynamic load testing (in addition to section 6.4a)iii)) must be carried out on the CFA piles where the toe level varies by more than 2 m from the test pile toe level;
 - v) testing must be carried out by use of a pile driving analyser and the data obtained from each pile must be analysed using CAPWAP, TNOWAVE or equivalent software as nominated in the Construction Documentation;
 - vi) the test procedure and test reports must conform with the requirements of AS 2159 Piling - Design and installation;
 - vii) 2 copies of a report showing the measured field parameters and the results of analysis to determine pile capacity must be provided as part of the Quality Management Records; and
 - viii) the measured ultimate capacity of test piles must be equal to or greater than the pile test load.
- b) Dynamic load testing is not required for CFA piles where the primary load effect on the CFA pile is lateral loading and which have no vertical load capacity requirement.

6.5 Static load testing

- a) Where nominated in the Contract Documents or on the Design Documentation, static load testing for CFA piles must be carried out:
 - i) by the independent specialist Subcontractor nominated in the section 6.2;
 - ii) on the nominated piles;
 - iii) where requested by the Principal, the Contractor must provide the raw data, collected from the testing in accordance with this section 6.5, to the Principal within 1 day of such request, which may be used for independent review by a third party; and
 - iv) in accordance with static load test methods specified in AS 2159 Piling - Design and installation.
- b) Acceptance criteria, supervision, and reporting of static load testing must be in accordance with the requirements of AS 2159 Piling - Design and installation.

7 Construction monitoring

- a) Continuous torque and penetration rate readings must be recorded during pile installation and provided as part of the Quality Management Records. The torque readings must be compared to those recorded previously at the test pile sites (where applicable). Where lower than anticipated torque readings are recorded, particularly at the founding depth, a further assessment must be undertaken by the Contractor's civil/geotechnical engineer or engineering geologist, engaged in accordance with section 4.1b).
- b) Pump and delivery hose pressures must be monitored and recorded and provided as part of the Quality Management Records.
- c) All CFA piling rigs must employ a real time monitoring system which provides the Principal real time access to piling records at local computers within the site office and remotely via remote access.

8 Hold Points

Table ST-PI-C3 8-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.

Table ST-PI-C3 8-1 Hold Points

Section reference	Hold Point	Documentation or construction quality	Review period or notification period
4.4e)	Inspection of pile location, verticality, and reinforcement cages	Construction quality	24 hours notification
6.1	Submission of test results	Documentation	5 Business Days review
6.2b)	Details of the independent specialist Subcontractor	Documentation	10 Business Days review