# Master Specification
# Part ST-PI-C4

## Diaphragm Walls

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Government of South Australia
Department for Infrastructure and Transport

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# Document Management

# Contents

# ST-PI-C4 Diaphragm Walls

## 1 General

a) This Master Specification Part sets out the requirements for the installation of diaphragm walls as either retaining walls or cut-off walls including:

i) the documentation requirements, as set out in section 2;

ii) the materials requirements, as set out in section 3;

iii) the trench and guide wall stability requirements, as set out in section 4;

iv) the excavation requirements, as set out in section 5;

v) the placement of concrete requirements, as set out in section 6;

vi) the placement of reinforcement requirements, as set out in section 7;

vii) the tolerances requirements, as set out in section 8;

viii) the joints requirements, as set out in section 9;

ix) the waterproofing and concrete Defect requirements, as set out in section 10;

x) the cleaning requirements, as set out in section 11;

xi) the monitoring requirements, as set out in section 12; and

xii) the Hold Point and Witness Point requirements, as set out in section 13.

b) The installation of diaphragm walls must comply with the Reference Documents, including:

i) API-RP-13B Recommended Practice Standard Procedure for Field Testing Drilling Fluids;

ii) AS/NZS 1170 Structural design actions;

iii) AS 3600 Concrete structures;

iv) AS 3610 Formwork for concrete;

v) AS 4678 Earth-retaining structures;

vi) AS 5100 Bridge design;

vii) BS EN 1538 Execution of special geotechnical works - Diaphragm walls;

viii) BS 2571 Specification for General Purpose Flexible PVC compounds for Moulding and Extrusion; and

ix) BS 2782 Method of Testing Plastic.

c) The following guidance documents must be considered and applied to the extent required by Law and to meet the Contractor's Best Industry Practice obligations:

i) CIRIA C760 - Guidance on embedded retaining wall design; and

ii) ICE Specification for Piling and Embedded Retaining Walls (3rd edition).

d) This Master Specification Part also applies to barrettes (where applicable).

# 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) detailed methodology and procedures for the construction of:

   i) diaphragm wall panels; and

   ii) the guide wall;

b) the concrete mix designs, including test results for mix designs, verifying the ability to achieve specified requirements;

c) details of proposed plant and equipment to be used and evidence of its capacity to carry out the work in accordance with the requirements of this Master Specification Part;

d) details of methodology to control dust and stormwater contamination from bentonite and bentonite slurry;

e) construction sequence of excavation and concreting panels;

f) methodology for removing obstructions, taking into account the necessity to avoid excessive overbreak or over-excavation and unacceptable settlement, vibration of the adjacent ground, structures and Utility Services;

g) proposed recording forms to be used during construction and testing;

h) methodology for verifying the assumed bearing capacity of the soil below the guide wall;

i) methodology to check and ensure diaphragm wall location and verticality tolerances are met;

j) procedure for ensuring that each diaphragm wall panel achieves the required design founding conditions;

k) details of the wheels (cover spacers) to be employed and evidence that the wheels are robust enough not to be damaged during handling and installation of the pile cage and ensure that the minimum cover to steel reinforcement is maintained;

l) procedure for installation of the reinforcement cage, including spacer details and fixing, and the method of ensuring minimum cover to reinforcement;

m) clear and unambiguous methods of ensuring the correct pile cage is used in the correct diaphragm wall panel and in the correct orientation;

n) methodology for placing diaphragm wall concrete;

o) procedure for measurement and monitoring of the level of the concrete during concreting including recording and charting of the volume of concrete placed;

p) procedures to be implemented should a concrete pour be interrupted;

q) methodology for tremie tube placement and procedure for monitoring that the tremie tube is sufficiently below the top of concrete at all stages during the concrete pour;

r) the corrective action procedure to be taken if the tremie tube separates from the concrete during a concrete pour;

s) methodology for the cutting and breaking back of diaphragm wall panels;

t) details of the proposed integrity test and dynamic load test methods, including:

   i) the name and qualifications of any independent specialist Subcontractors to be used; and

   ii) a method statement of how the integrity test and dynamic load test will be carried out;

u) methodology to monitor and prevent contamination by ingress of loose material, ground water, or mud during diaphragm wall construction;

v) methodology to clean and check the base of the excavation;

w) details of the bentonite to be used;

x) details relevant to the bentonite slurry including details of the bentonite plant and methods for the production, cleaning, management and disposal of the bentonite slurry (including the removal and replacement of contaminated slurry);

y) additional or alternative testing equipment for bentonite slurry testing, in accordance with section 3.3.2c);

z) where appliable, details of the proposed additional or alternative ingredients and admixtures to the diaphragm wall support slurry, in accordance with section 3.3.5a) and 3.3.5b);

aa) methodology to remove any excessive filter cake layer, including evidence of successful field trials of the methodology, in accordance with section 5d) and 5e);

bb) methodology to maintain the required slurry levels in the excavation;

cc) details of the proposed spacers, in accordance with section 7c);

dd) methodology to clean the completed diaphragm wall;

ee) methodology to remove protrusions, in accordance with section 8.3a);

ff) details of the waterbars, including details of designed profiled forms as required by section 9.1a);

gg) where applicable, details of the proposed alternative waterbars, in accordance with section 9.1b);

hh) details of the joints and stop ends including details of any proposed shutter release agent, as required by section 9.2d);

ii) methodology for the monitoring and checking of the stability of diaphragm wall trench, neighbouring properties, roadways, Utility Services and underground structures;

jj) a monitoring plan with a proposed methodology for the monitoring of diaphragm retaining walls and checking of tolerances, as required by section 12;

kk) groundwater ingress measuring methodology, as required by section 12e);

ll) details of the inclinometers or other relevant monitoring instrumentation; and

mm) site layout plan indicating the safe allowable boundary for crane sitting and movement, especially for tunnel boring machine portals (for Projects that include a Tunnel).

## 2.2 Quality Management Records

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:

a) certification stating the properties of bentonite tested, as required by section 3.3.1d); and

b) the following records which must be kept for each diaphragm wall panel and which must be submitted to the Principal within 24 hours of the completion of each panel:

   i) key plan showing the panel location and number;

   ii) dates and times of start and finish of panel excavation;

   iii) details of any obstructions encountered and the time spent in dealing with obstructions;

   iv) date and time of completion of reinforcement cage placement;

v) date and time of start and completion of panel concreting;

vi) length, width, and depth of panel from top of guide wall level;

vii) a log of soil type encountered from start to finish of excavation and water levels;

viii) volume of concrete used and time of any interruptions recorded in concrete supply where these exceed 15 minutes;

ix) volumes of normal and lean mix concrete used;

x) cut-off level of concrete below top of guide wall level;

xi) date, place and time of bentonite slurry control tests and results recorded;

xii) results of the bentonite testing, including all supporting information, as required by section 3.3.1c);

xiii) concrete test cylinders, markings, date, and results obtained on testing;

xiv) details of reinforcement cage type;

xv) verticality checks of each diaphragm wall trench excavation using a continuous scanning device, producing a scanning graphical output, as required by section 5c);

xvi) records of tremie pipe length at regular intervals corresponding to each batch of concrete, as required by section 6.2e);

xvii) waterbar product testing certification, as required by section 9.1a);

xviii) waterbar testing results, as required by section 9.1e);

xix) quantity of slurry removed from Site and spoil removed from the Site recorded by date;

xx) chart of volume of concrete poured versus the depth of concrete in each diaphragm wall panel;

xxi) trench verticality record scanning graph; and

xxii) details of any trench collapse incident encountered.

# 3 Materials

## 3.1 Concrete

a) Concrete must be special-class concrete complying with the requirements of ST-SC-S7 “Supply of Concrete”.

b) Cast in situ concrete must be composed to minimise segregation during placing, to flow easily around the reinforcement, and when set, to provide a dense and low permeability material.

c) The concrete must comply with the requirements related to strength and durability in the hardened state as well as with the requirements related to consistency in the fresh state.

## 3.2 Reinforcement

Reinforcement must comply with ST-SC-S6 “Steel Reinforcement”.

## 3.3 Supporting fluids

### 3.3.1 Bentonite

a) Bentonite for use in the diaphragm wall support slurry must be in accordance with BS EN 1538 Execution of special geotechnical work - Diaphragm walls.

b) Samples of the bentonite to be used for use in the diaphragm wall support and the initial set of test results required by section 3.3.1c) must be submitted to the Principal prior to use. The

submission of the bentonite sample constitutes a **Hold Point**. The bentonite from which the sample was taken must not be used in the diaphragm wall support slurry until this Hold Point has been released.

c) The supplied bentonite must be tested in accordance with this section 3.3.1. Samples must be taken so that at least one test is carried out for every 10 t of bentonite supplied.

d) A certificate must be provided as part of the Quality Management Records, with each consignment of supplied bentonite, stating the properties of samples tested.

e) The tests required by section 3.3.1c) must be carried out to provide the following information:

   i) apparent viscosity and gel strength of a suspension of bentonite in water; and

   ii) moisture content of the bentonite powder and wet screen residue on US 200 mesh sieve.

f) Results of the testing required by section 3.3.1c) must be provided as part of the Quality Management Records, together with a statement of the conditions of test, including:

   i) any results of water analysis;

   ii) mixer type;

   iii) mixer speed during testing; and

   iv) time of stirring and time of testing after initial addition of bentonite to the water.

g) For any 100 t of bentonite, moisture content must not deviate by more than ±2%, apparent viscosity by more than ±2 cps and gel strength measured at 10 minutes by more than ±0.023 N/m.

h) The Contractor must undertake one additional sample of bentonite powder per panel on the date that work on the panel commences. The sample must be prepared and tested under the same conditions as those under which testing was carried out pursuant to section 3.3.1e).

i) Water used for dispersion of bentonite must be as nearly neutral in pH as practicable and care must be taken to exclude saline water or water contaminated by salts.

j) Bentonite powder must be mixed thoroughly into the water using a suitable high shearing action mixer until all lumps have been broken up and dispersed within the mix.

### 3.3.2 Bentonite slurry testing

a) Bentonite slurry must be tested for compliance with BS EN 1538 Execution of special geotechnical work - Diaphragm walls.

b) The testing procedure and equipment employed for the purposes of section 3.3.2a) must be as specified in API-RP-13B Recommended Practice Standard Procedure for Field Testing Drilling Fluids, unless additional or alternative equipment is approved by the Principal as part of the Construction Documentation.

c) Where the Contractor proposes to use additional or alternative testing equipment than that specified in API-RP-13B Recommended Practice Standard Procedure for Field Testing Drilling Fluids, the Construction Documentation must include details of such additional or alternative testing equipment, including evidence that the additional or alternative equipment has equal or better accuracy and otherwise covers the same parameters as that testing equipment specified in API-RP-13B Recommended Practice Standard Procedure for Field Testing Drilling Fluids.

d) The Contractor must test the bentonite slurry for:

   i) density using a mud balance;

   ii) viscosity, yield stress and gel strength using a Fann viscometer;

   iii) viscosity using a Marsh funnel;

iv) pH with an electric pH meter;

v) sand content;

vi) fluid loss and residue using Baroid filter press; and

vii) filter cake thickness by Baroid filter press.

e) A sample of bentonite slurry must be obtained from the panel during excavation for every 5 m depth.

f) The full range of tests required by section 3.3.2d) must be taken when additional wall support materials are added to the slurry.

g) The pattern of relationship between gel strength, viscosity, and density of the bentonite slurry must be established on site so that:

i) the gel strength / viscosity relationship does not produce excessive combined values likely to produce slurry entrapment;

ii) no flocculation of the bentonite occurs;

iii) no settlement of the solids within the slurry occurs; and

iv) the range of values for slurry properties conform to BS EN 1538 Execution of special geotechnical work - Diaphragm walls.

h) Density, viscosity and gel strength must be measured together with sand content from a sample of bentonite slurry taken at the base of the trench immediately before concreting. The Contractor must invite the Principal to witness the sample testing required by this section 3.3.2, which constitutes a **Witness Point**.

i) The Contractor must rectify the bentonite slurry if the sample taken pursuant to section 3.3.2h) fails to meet the required characteristics.

### 3.3.3 Bentonite storage

a) Bentonite powder must be stored in cool dry conditions with a raised floor.

b) Bulk storage of bentonite must prevent:

i) balling of bentonite powder due to dampness; and

ii) deterioration of properties due to dampness and heat.

### 3.3.4 Cleaning and recycling of support fluid

a) The Contractor must arrange for and dispose of used bentonite or contaminated slurry that is not suitable for re-use.

b) All disposal of materials and fluid must comply with:

i) all relevant environmental Laws;

ii) the requirements of SA EPA; and

iii) the requirements of PC-ENV1 “Environmental Management” and PC-ENV2 “Environmental Protection Requirements”.

### 3.3.5 Alternative support fluids

a) The Contractor may propose additional or alternative ingredients and admixtures to the diaphragm wall support slurry as part of the Construction Documentation.

b) Where section 3.3.5a) applies, the Construction Documentation must include:

i) samples and details of the proposed alternative ingredients and admixtures;

ii) supplier and manufacturer details of such ingredients;

iii) evidence that any additional or alternative ingredients and admixtures will not detrimentally affect the concreting or formed concrete; and

iv) test results of the alternative materials in accordance with section 3.3.5c)i).

c) After the additional or alternative ingredients and admixtures are approved as part of the Construction Documentation:

i) the alternative materials must be tested:

A. in the same manner as for bentonite (as required by sections 3.3.1 and 3.3.2), where appropriate; or

B. using alternative tests proposed by the Contractor to demonstrate the required properties;

ii) the alternative materials must be stored in conditions recommended by the ingredient supplier;

iii) used materials or contaminated slurry that is not suitable for re-use must be disposed of in accordance with section 3.3.4; and

iv) references to the bentonite slurry throughout this Master Specification Part are to be read as references to the alternative materials.

# 4 Trench and guide wall stability

a) A suitable guide wall complying with the Design Documentation must be used in conjunction with the excavation of the diaphragm wall trench.

b) The Contractor must ensure stability of the ground near ground surface level of the diaphragm wall trench until concrete and any backfill material has been placed.

c) Support fluid must be kept as close as possible to the top of the guide walls to reduce the risk of guide walls undermining.

d) Where panels are left open between work shifts, measures must be put in place to ensure support fluid levels are maintained.

e) Support fluid levels must be suitably maintained above external groundwater level to adequately resist hydraulic forces causing instability.

f) Where external groundwater is near the surface and is unable to be dewatered or the ground level raised, the guide walls must be extended to maintain adequate levels of support fluid.

# 5 Excavation

a) The Contractor must carry out verticality checks of each diaphragm wall trench excavation using a continuous scanning device, producing a scanning graphical printout on site.

b) The excavation scanning required by section 5a) must be carried out for the entire depth of the diaphragm wall trench excavation at the near and far faces of the excavated trench, including both ends.

c) The Quality Management Records must include the graphical output produced pursuant to section 5a).

d) During excavation and prior to concreting, a thick filter cake layer must not be allowed to form which could affect wall friction or concrete cover, unless the Contractor can demonstrate in the Construction Documentation an effective method of removing any such excessive filter cake layer.

e) Where the Contractor proposes a method of removing any excessive filter cake layer pursuant to section 5d), the Construction Documentation must include details of the proposed method and evidence of successful field trials of the proposed methodology.

f) The Contractor must ensure that a sufficient quantity of slurry is maintained on site to allow for any sudden slurry loss.

g) In the event of a loss of support fluid from an excavation, the Contractor must take such immediate remedial action as is necessary to preserve the stability of the trench and ensure the safety of neighbouring structures and services.

h) The verification of founding level, base cleanliness, and panel verticality constitutes a **Hold Point**. Placement of the concrete must not occur until this Hold Point is released.

i) The Contractor must not excavate any panel within 10 m of any other panels which have recently been cast and contain workable or unset concrete, where a flow of concrete or instability could be induced, or damage could be caused to any panel.

j) The Contractor must ensure that the base of the diaphragm wall trench excavation is free from loose and disturbed materials prior to placement of concrete.

# 6 Placement of concrete

## 6.1 Tremie pipe requirements

a) Tremie pipes must be clean, water-tight and with a minimum internal diameter of 250 mm.

b) The outer diameter of tremie pipes must be such that it passes freely through the reinforcement cage.

c) The tremie pipe must have a plug of suitable material or other means to separate concrete in the tremie pipe from bentonite slurry at the start of concreting.

d) The tremie pipe must extend to the bottom of the diaphragm wall trench excavation prior to concreting. All bentonite slurry must be expelled from the tube during the initial charging operation.

e) The tremie pipe must be maintained with a minimum embedment of 3 m into the concrete to prevent the re-entry of bentonite slurry into the tremie pipe.

f) The Contractor must ensure that an adequate supply of concrete to the tremie pipe is available at all times so that placement is continuous.

g) Tremie pipes must be provided such that the maximum horizontal distance concrete has to travel is less than 3 m.

h) Where more than one tremie pipe is employed during concrete pouring to any one panel, the charging of concrete in the tremie pipes must be evenly distributed between the tremie pipes to ensure that no differential head exists at the concrete / bentonite slurry interface over the length of the panel. The distribution level between the tremie pipes must be confirmed by soundings taken during the concrete pour.

## 6.2 Placement of concrete

a) The placement of concrete as part of the diaphragm walls must comply with ST-SC-C7 “Placement of Concrete”.

b) The Contractor must commence the placing of concrete within 2 hours of the installation and verification of the reinforcement cage(s).

c) In order to ensure concrete integrity, the rate of concrete rising over the full height of the panel must not be less than 3 m/h.

d) The Contractor must produce a chart of the concrete volume placed versus the depth of concrete for every batch of concrete placed in the wall panel. This chart must be produced during the concrete pour and made available to the Principal and Construction Verifier upon request.

e) Records of tremie pipe length must be recorded at regular intervals corresponding to each batch of concrete. The actual depths measured, and volumes placed at each depth must be recorded and compared with the theoretical volumes at each corresponding depth. These records must form part of the Quality Management Records.

f) If the measured volume of concrete placed is different to the theoretical value this will be deemed as a Non-Conformance, and subject to the processes as detailed in PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable).

## 6.3 Trimming to cut off level

a) Concrete must be cast to such a level that only sound concrete remains below the specified levels.

b) Diaphragm walls must be over-cast by a minimum of 600 mm where only sound concrete remains below the specified levels. The concrete must be cut down to sound concrete that is free of contaminants, or to such a level as is required by the Design Documentation.

c) Where the cutting down extends to within 2 m of any waterproofing membrane, the cutting down must be completed before the waterproofing membrane is laid.

d) If the arrangement includes a roof waterproofing membrane and it has been laid, any cutting down must be carried out by non-percussive means.

# 7 Placement of reinforcement

a) Front and rear of reinforcement cages must be marked on site to identify them during placement.

b) The reinforcement must be adequately fixed to avoid damage or displacement during handling and lifting operations and to maintain the minimum specified cover during concreting.

c) Non-metallic spacers must be incorporated in the reinforcement cage construction to ensure correct cover is maintained to all reinforcements and couplers. The spacers must be capable of resisting deformation during reinforcement cage placement within the trench and must not entrap slurry during concreting. The Contractor must include details of the proposed spacers in the Construction Documentation.

d) Inspection of the reinforcement cages constitutes a **Hold Point**. Placement of the reinforcement cages must not occur until this Hold Point is released.

e) Inspection of embedded items including couplers, starter bars and waterstops at construction joints will constitute a **Hold Point**. Any further works in relation to the embedded item or construction joint must not occur until the Hold Point has been released.

# 8 Tolerances

## 8.1 Guide wall

a) The guide wall tolerances must be sufficient to achieve the permanent Works requirements.

b) Unless otherwise stated in the Construction Documentation, the clear distance between the inside faces of the guide wall must be the required diaphragm wall thickness plus 20 mm with a tolerance of +10 mm.

## 8.2 Diaphragm wall

a) Diaphragm walls must have a plan positioning tolerance of ±25 mm at the top of the guide walls.

b) The plane of the diaphragm wall face to be exposed must be vertical with a tolerance of 1:200.

c) The diaphragm wall plan position tolerance at the cut off level must include the tolerances in both section 8.2a) and section 8.2b). Where recesses and inserts are formed within the diaphragm wall, they must be positioned within a horizontal and vertical tolerance of ±70 mm.

## 8.3 Protrusions

a) Protrusions of more than 75 mm beyond the design surface, or as otherwise nominated in the Design Documentation, must be removed in accordance with the approved methodology included in the Construction Documentation.

b) At completion of removal of the protrusions in accordance with section 8.3a), the diaphragm wall must be inspected for conformity to design surface flatness. This inspection constitutes a **Hold Point**. Any further activities in relation to the diaphragm wall panel must not occur until the Hold Point has been released.

c) The Contractor must ensure that there are no depressions below the design surface.

## 8.4 Tolerance on reinforcement cage placement

a) The tolerance on the total width of the reinforcement cage is ±10 mm.

b) The tolerance on the elevation of the top of the reinforcement cage after concrete has been placed is ±50 mm.

c) The tolerance on the horizontal position of the reinforcement cage along the axis of the diaphragm wall after concrete has been placed is ±70 mm within a panel.

# 9 Joints

## 9.1 Waterbar requirements

a) PVC waterbars, that have been tested to BS 2571 Specification for General Purpose Flexible PVC compounds for Moulding and Extrusion and BS 2782 Method of Testing Plastic, must be provided and held in place by suitably designed profiled forms (details of which must be provided as part of the Construction Documentation). The Contractor must provide waterbar product testing certification as part of the Quality Management Records.

b) The Contractor may propose alternative waterbars as part of the Construction Documentation.

c) The width of the waterbars required by section 9.1a) must be not less than 200 mm.

d) The PVC waterbars must be extruded from an elastomeric plastic material of which the basic resin is pure virgin polyvinyl chloride. The PVC compound must not contain any scrapped or reclaimed material.

e) The waterbars must be tested to confirm compliance with the performance requirements set out in Table ST-PI-C4 9-1. The test results must form part of the Quality Management Records.

**Table ST-PI-C4 9-1 Waterbar performance requirements**

| Property | Test method | Required limits |
|---|---|---|
| Water absorption | ASTM D570 Standard Test Method for Water Absorption of Plastics | 0.15% max. |
| Tear resistance | ASTM D624 Plastics and Elastomers - Tension Testing | 35 KN/m min. |
| Ultimate elongation | ASTM D638 Plastic Tensile Strength Test | 300% min. |
| Tensile strength | ASTM D638 Plastic Tensile Strength Test | 14 MPa |
| Specific gravity | ASTM D792 Specific Gravity and density | 1.45 max. |
| Hardness, Shore A | ASTM D2240 Standard Test Method for Rubber Property - Durometer Hardness | To manufacturer's specifications |

## 9.2 Joints and stop ends

a) Joints must be formed in accordance with BS EN 1538 Execution of special geotechnical works - Diaphragm walls.

b) Joints between diaphragm wall panels must include waterbars in accordance with section 9.1 unless shown otherwise in the Design Documentation.

c) Stop ends, inserted before placement of concrete in the panel, must be clean and have a smooth regular surface.

d) The Contractor must provide details of any proposed shutter release agent as part of the Construction Documentation.

e) Where stop ends are inserted in sections, adequate joint connections must be provided to ensure verticality of the complete tube.

f) The extraction of stop ends must be carried out such that no damage is caused to the panels or adjacent soil and structures.

g) Where concrete is cast against previously completed diaphragm wall panels, the previously formed concrete must be cleaned so that solid substances are removed before the joint is formed.

h) When the diaphragm wall is exposed, joints with any Defects including jetting, spraying or leakage will be deemed as a Non-Conformance, and subject to the processes as detailed in PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable).

# 10 Waterproofing and concrete Defects

a) The diaphragm wall must meet Haack Tightness Class 3 or such higher requirement specified in the Design Documentation or Contract Documents and must not have any groundwater seepage through the pavement and floors (0 l/s).

b) Crack in the diaphragm wall must:

   i) not exceed the allowable crack width limits set out in Table ST-PI-C4 10-1; and

   ii) not impact the ability of the diaphragm wall to achieve the water tightness requirement set out in section 10a).

c) In the event that diaphragm wall cracks exceed the allowable values specified in section 10b), this will constitute a Non-Conformance and the Contractor must issue a Non-Conformance Notice in accordance with PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable) which must include:

   i) assessment report of the cracked concrete structure (assessment undertaken and report prepared by a technical specialist with a minimum of 5 years’ practical experience in the diagnostic assessment and investigation of concrete structures), evaluating the influence of cracks on the load bearing capacity, serviceability and durability;

   ii) details of the causes of the cracks, crack width, the moisture condition of the crack and whether a crack is active or inactive; and

   iii) a crack repair procedure or plan, which must set out how the Contractor proposes to repair the cracks.

d) Repair of the cracks must not occur until the associated Hold Point set out in PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable) has been released.

e) Depressions, blowholes, and contamination in the surface that reduces concrete cover to the reinforcement below the nominated minimum cover will constitute a Non-Conformance and be subject to the processes as detailed in PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable).

**Table ST-PI-C4 10-1 Allowable crack widths**

| Exposure classification (per AS5100.5 Bridge design) | Maximum acceptable crack widths (mm) |
|---|---|
| A | 0.2 |
| B1 | 0.2 |
| B2 | 0.15 |
| C1, C2, U | 0.1 |

# 11 Cleaning

a) The exposed surface of the diaphragm wall must be thoroughly cleaned to remove all traces of bentonite, soil, or other contaminating materials. This requirement applies irrespective of whether or not the exposed panel is to be subsequently covered by insitu concrete.

b) At completion of cleaning in accordance with section 11a), the diaphragm wall must be inspected for conformity to design surface flatness and cleanliness. This inspection constitutes a **Hold Point**. Any further works in relation to the diaphragm wall panel (such as covering, or pouring concrete against it) must not occur until the Hold Point has been released.

# 12 Monitoring

a) The Contractor must prepare and submit a monitoring plan with a proposed methodology for the monitoring of diaphragm walls and checking of tolerances as part of the Construction Documentation.

b) The monitoring plan required by section 12a) must be based upon the information contained in the Design Documentation, including:

i) the locations of monitoring points and inclinometers (or other relevant monitoring instruments);

ii) expected movements at the location of each monitoring point (both during excavation and post excavation); and

iii) assigned trigger movement levels.

c) Installation of inclinometers or other relevant monitoring instruments is required prior to excavation to achieve a baseline for future monitoring. The Contractor must submit details of such inclinometers or other monitoring instruments as part of the Construction Documentation.

d) Monitoring of the diaphragm wall must be undertaken in accordance with the monitoring plan approved as part of the Construction Documentation.

e) The Contractor must provide documented evidence that the specified limits for groundwater ingress in respect of the diaphragm walls are not exceeded in accordance with a measurement methodology approved by the Principal as part of the Construction Documentation at the following time periods:

i) within 3 months prior to Handover and as a condition precedent to Handover; and

ii) within 3 months prior to the end of the relevant Defects Liability Period.

# 13 Hold Points and Witness Points

a) Table ST-PI-C4 13-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.

b) Table ST-PI-C4 13-2 details the review period or notification period, and type (documentation or construction quality) for each Witness Point referred to in this Master Specification Part.

**Table ST-PI-C4 13-1 Hold Points**

| Section reference | Hold Point | Documentation or construction quality | Review period or notification period |
|---|---|---|---|
| 3.3.1b) | Provision of bentonite samples for use in the diaphragm wall support slurry and initial test results | Documentation | 10 Business Days review |
| 5h) | Verification of founding level and verticality | Construction quality | 4 hours notification |
| 7d) | Inspection of the reinforcement cages | Construction quality | 24 hours notification |
| 7e) | Inspection of embedded items including couplers, starter bars and waterstops at construction joints | Construction quality | 24 hours notification |
| 8.3b) | Inspection of diaphragm wall for conformity to design surface flatness following completion of removal of the protrusions | Construction quality | 24 hours notification |
| 11b) | Inspection of the diaphragm wall at the completion of cleaning for conformity to design surface flatness and cleanliness | Construction quality | 24 hours notification |

**Table ST-PI-C4 13-2 Witness Points**

| Section reference | Witness Point | Documentation or construction quality | Review period or notification period |
|---|---|---|---|
| 3.3.2h) | Bentonite slurry testing | Construction quality | 4 hours notification |