METROLINK

Integrated Transport. Integrated Life.

A5.12 Piling

Contents

List of Figures and Tables

1. Introduction

This appendix provides a general description of:

- The Diaphragm Wall (D-wall) technique - including the sequence of activity, plant used and spatial requirements during construction.
- The Secant Piling technique - including the sequence of activity, plant used and spatial requirements during construction.
- Sequence of excavation, support and construction of the remainder of the civil engineering works (station first approach) for both techniques, highlighting any differences.

The preliminary design for the project has been developed and is based on the use of diaphragm wall techniques for deep stations however other techniques may be used if they meet or improve on the health and safety, technical, consenting and programme assessments.

It has been assumed that piles and D-walls will be installed into the following geological sequence for the excavation of the station box:

- 50% (of excavation depth) soft ground
- 50% hard rock

Further assumptions for the different construction methods are noted in relevant sections.

2. Diaphragm Walling

2.1 Introduction

Diaphragm walls are classed as rigid retaining walls and their purpose is to provide lateral ground support prior to the main excavation being carried out. They can be temporary works only or incorporated into the permanent structure, as is the case with the MetroLink stations.

2.2 General Description

Diaphragm Walls, often referred to as 'D-walls', are continuous, reinforced (steel or fibre glass) concrete walls placed in the ground as individual panels, prior to the excavation of the station/basement structure. A typical site with D-wall operations is illustrated in Figure 2-1.

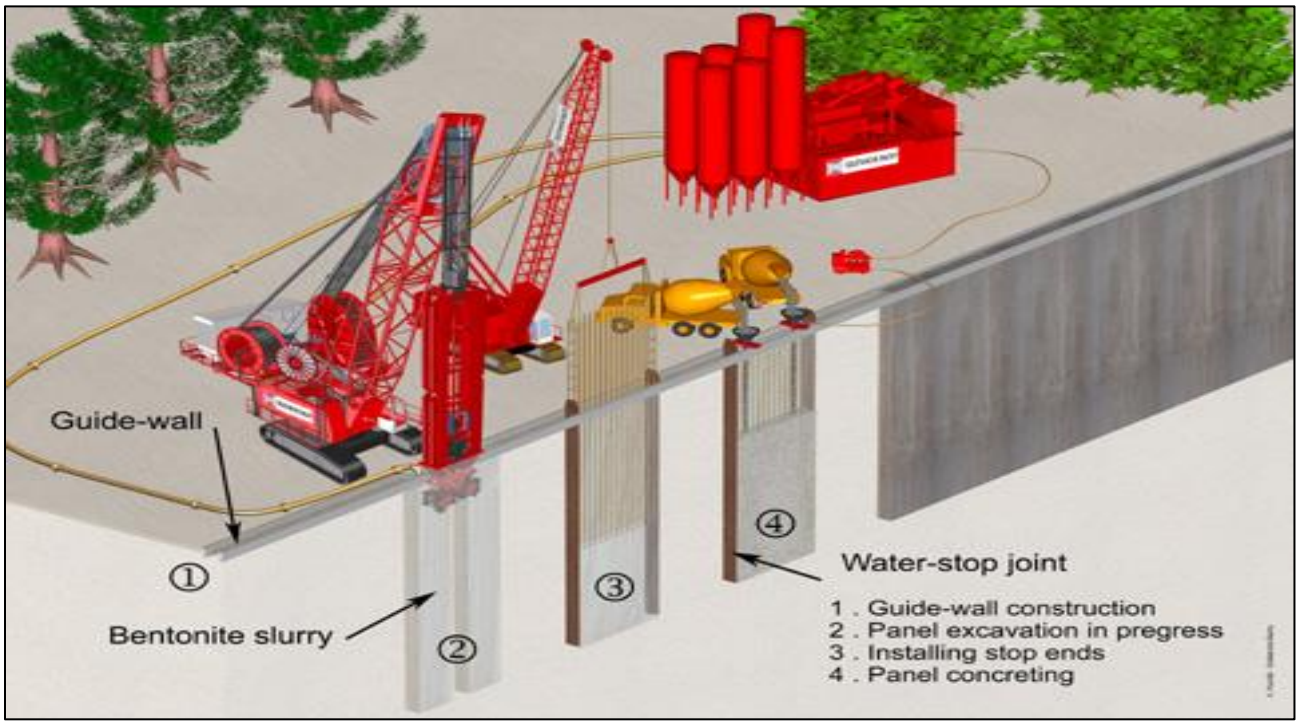

Figure 2-1: Typical D-wall Operations

Construction starts with the casting of guide walls into the ground parallel to the location of the D-wall panels.

A slot/panel is dug between the guide walls into the ground using an excavating grab in soft ground or a Hydrofraise (hydromilling) excavator in soft ground or rock, as shown in Figure 2-2. The slots/panels are commonly 800mm to 1,500mm thick, depending on the design of the wall, and up to 100m in depth, although they can go deeper.

Figure 2-2: Example Photos of a Grab and Hydrofraise

These slots/panels are dug to form a panel of typically 3m to 7m in width. During excavation, the slots/panels are filled with a support fluid (typically a bentonite slurry) to provide support to the ground and prevent ground collapse of the walls of the trench.

Once the panel is complete, a reinforcement cage, as shown in Figure 2-3, is placed into the panel, and this is then filled with concrete using a tremie pipe at the base of the panel.

Figure 2-3: Typical Reinforcement Cage for a D-wall Panel

The introduction of the concrete displaces the support fluid, allowing it to be pumped into tanks for future use. Adjacent panels are then constructed to form a continuous wall.

Once the wall is complete and the required concrete strength attained, excavation inside the wall can proceed, with further support from lateral propping and anchoring if and when required as the excavation progresses to depth.

2.3 Typical Plant Required

Typical construction plant used for the construction of D-walls are listed below. The exact requirements will depend on the site configuration, geology, the construction programme and the number of grabs or hydromills being utilised.

- Hydraulic grab;
- Hydromill (Hydrofraise);
- Cranes for lifting cages, tremies etc.;
- Concrete pump(s);
- Desander(s);
- Mixing plant(s);
- Bentonite silos;
- Dehydration unit;

- Backhoe excavator;
- Jet wash;
- Dumper(s);
- Compressor(s);
- Remixer(s);
- Tipper(s); and
- Wheel wash.

2.4 Spatial Requirements During Construction

A typical site layout for the duration of the D-wall installation works has been developed for the MetroLink sites. An example layout for Griffith Park Station is shown in Figure 2-4:.

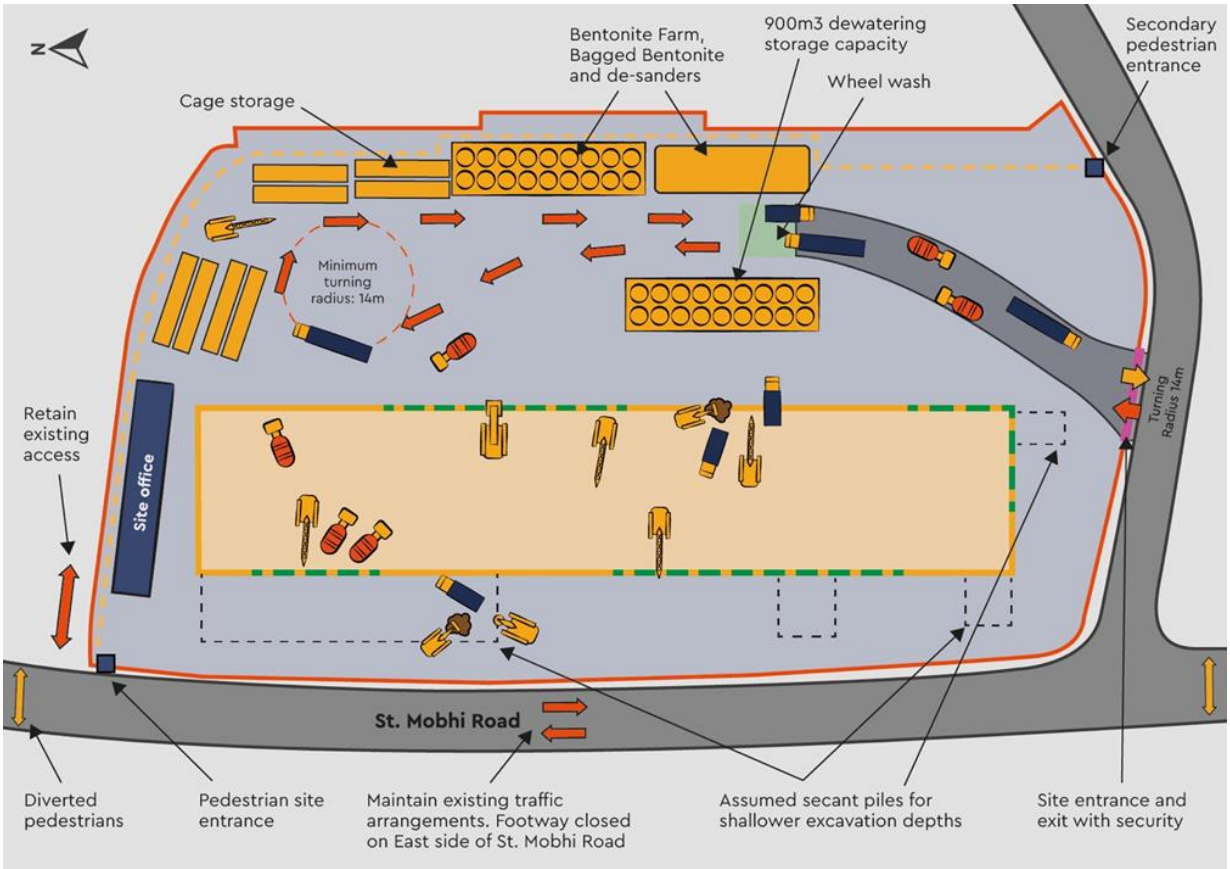

Figure 2-4: Site layout: Diaphragm Wall Installation Works

2.5 Minimum Site Dimensions

It is envisaged that the D-walls will all be placed from a level at (or just below) the existing ground surface, and that the guide walls will be constructed at the level of the piling mat.

The D-wall will be cast to the top of the proposed roof slab level (with the rebar in reservation tubes above the base of roof slab level), and the section above this will be backfilled with pea gravel to ground surface. After the walls have been completed, the D-wall panels will be broken down to the underside of roof slab level so that the roof slab reinforcing cage can be tied into the D-wall reinforcement.

The two sections shown in Figure 2-5 reflect different details to be used dependent on the available site dimensions. For the Griffith Park Station layout presented in Figure 2-4:, the majority of the capping beam Section B-B is sufficient. Section A-A is required along the western side of the station along St Mobhi Road adjacent to the vent shafts.

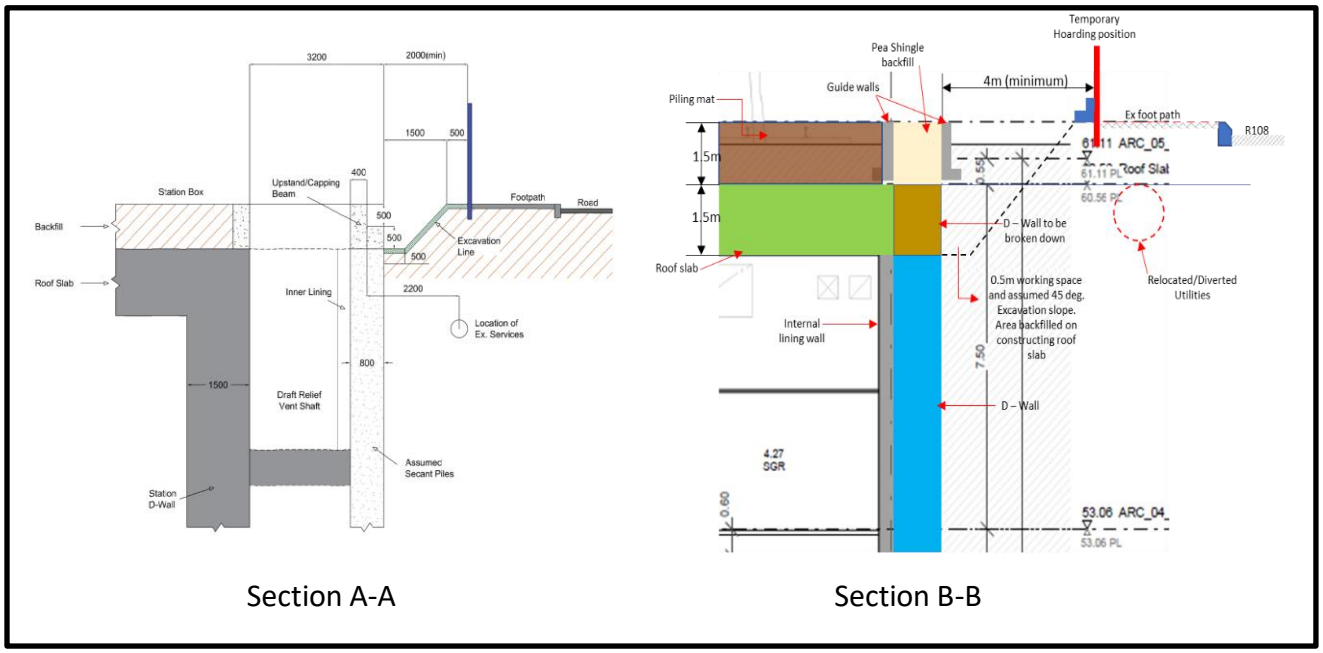

Figure 2-5: Top Slab to Diaphragm Wall Construction Detail

3. Secant Piling

3.1 General Description

Secant piled walls are essentially interlocking piles placed into the ground prior to bulk excavation. Figure 3-1 to Figure 3-4 show examples of the types of secant pile installations and the types of equipment (rigs) used in the process. There are three types of secant pile walls commonly used as set out below.

1. Hard/soft secant piled walls: softer female piles are installed first, followed by harder reinforced male piles, as shown in Figure 3-1.

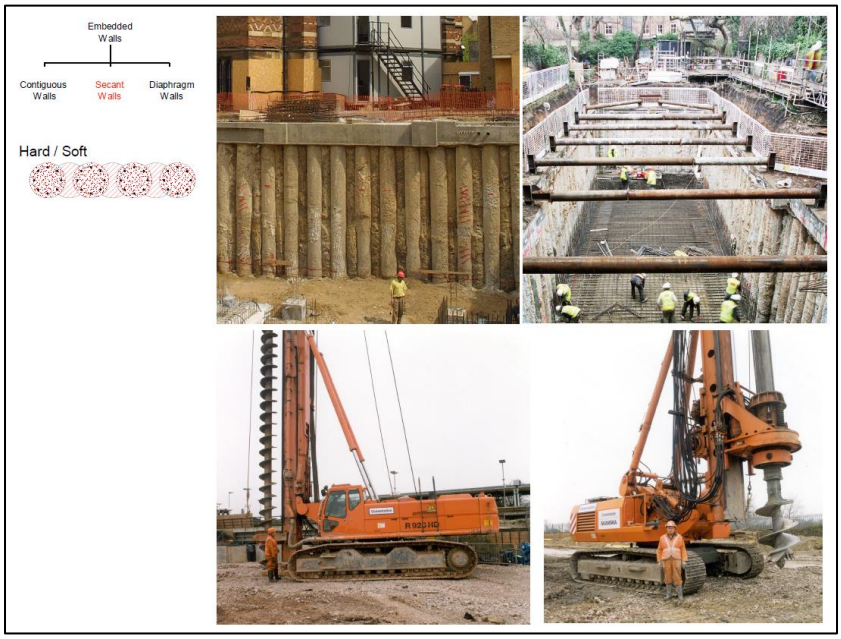

Figure 3-1: Example Secant Piling Works and Rigs

2. Hard/firm secant piled walls: un-reinforced female piles are installed first, followed by reinforced male piles, as shown in Figure 3-2.

Figure 3-2: Example Secant Piling Works and Rigs

3. Hard/hard secant piled walls: reinforced female piles are installed first, followed by reinforced male piles, as shown in Figure 3-3.

Figure 3-3: Example Secant Piling Works and Rigs

For the purposes of this study, it is assumed that hard/soft piles are utilised for the design of the secant piles.

3.2 Construction Sequence

The typical construction sequence is described below.

Guide walls are constructed to set out the position of the secant pile wall.

There are several different ways of creating the piles, depending on the ground conditions. A common method is to install a casing into the ground, and then an auger cuts and removes the soil from within the casing to form a primary borehole. The soil surrounding the borehole is supported by the casing. The casing will be socketed into the bedrock, and the pile will continue to be bored through the rock using rock drilling drill bits to the final toe levels.

Concrete is then poured into the borehole to form the primary (female) pile and the casing extracted. This process is then repeated adjacent to the existing bored pile but leaving a space between the two primary piles of slightly less than a primary pile diameter.

Once the primary (female) piles have gained sufficient strength, the auger cuts into and removes the remaining soil between the two primary piles to form a secondary borehole (male pile). The secondary borehole therefore intersects with the adjacent primary bored piles. A steel reinforcement cage is then placed into the secondary borehole which is subsequently filled with concrete to form the secondary bored pile.

The sequence of primary and secondary bored piles is repeated until the required length of the piled wall is complete. Bulk excavation can then take place between the walls with further support from lateral propping and anchoring if and when required as the excavation progresses to depth.

Figure 3-4: Typical Secant Pile Operation

3.2.1 Full Depth Female Piles into Rock

It has been assumed that the female piles are taken to full depth into the bedrock. The advice from a specialist contractor is that this will create issues when installing the male piles as there will be a tendency for the male piles to deviate towards the softer material (the female piles) when excavating the male piles through the rock.

It may be difficult to achieve a full secant effect in the rock, therefore an alternative methodology can be adopted. The female piles will terminate at the soil rock boundary zone and only the male piles will be taken to full depth. Holes will then be drilled through the female piles into the rock and the zone between the piles will be grouted to seal any fissure in the rock zone. In addition, during the excavation phase, shotcrete can be applied to seal any areas of seepage, as shown in Figure 3-5.

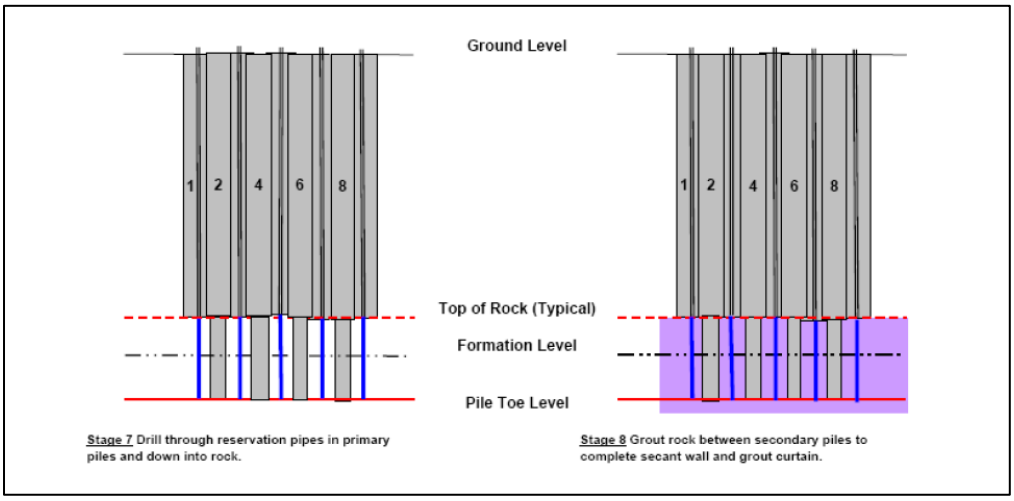

Figure 3-5: Curtain Grouting Below Secant Piles

3.3 Typical Plant Required

A typical list of the plant and equipment required is as follows:

- Piling rig(s) and associated tools;
- Concrete pump;
- $9m^3$ or $12m^3$ mixer drum;
- Compressor(s);
- Jet washer(s);
- Water bowser;
- Crane-suspended vibrator with power pack;
- Mobile Elevated Working Platform;
- Hand tools including power tools with small generator;
- 90 Tonne crawler crane or similar;
- Segmental casings;
- Casings, casing extractor, casing oscillator;
- Setting-out tools;

- Backhoe excavator;
- Tipper(s); and
- Remixer(s).

3.4 Spatial Requirements During Construction

A typical site layout for a Metrolink site utilising four piling rigs is shown in Figure 3-6.

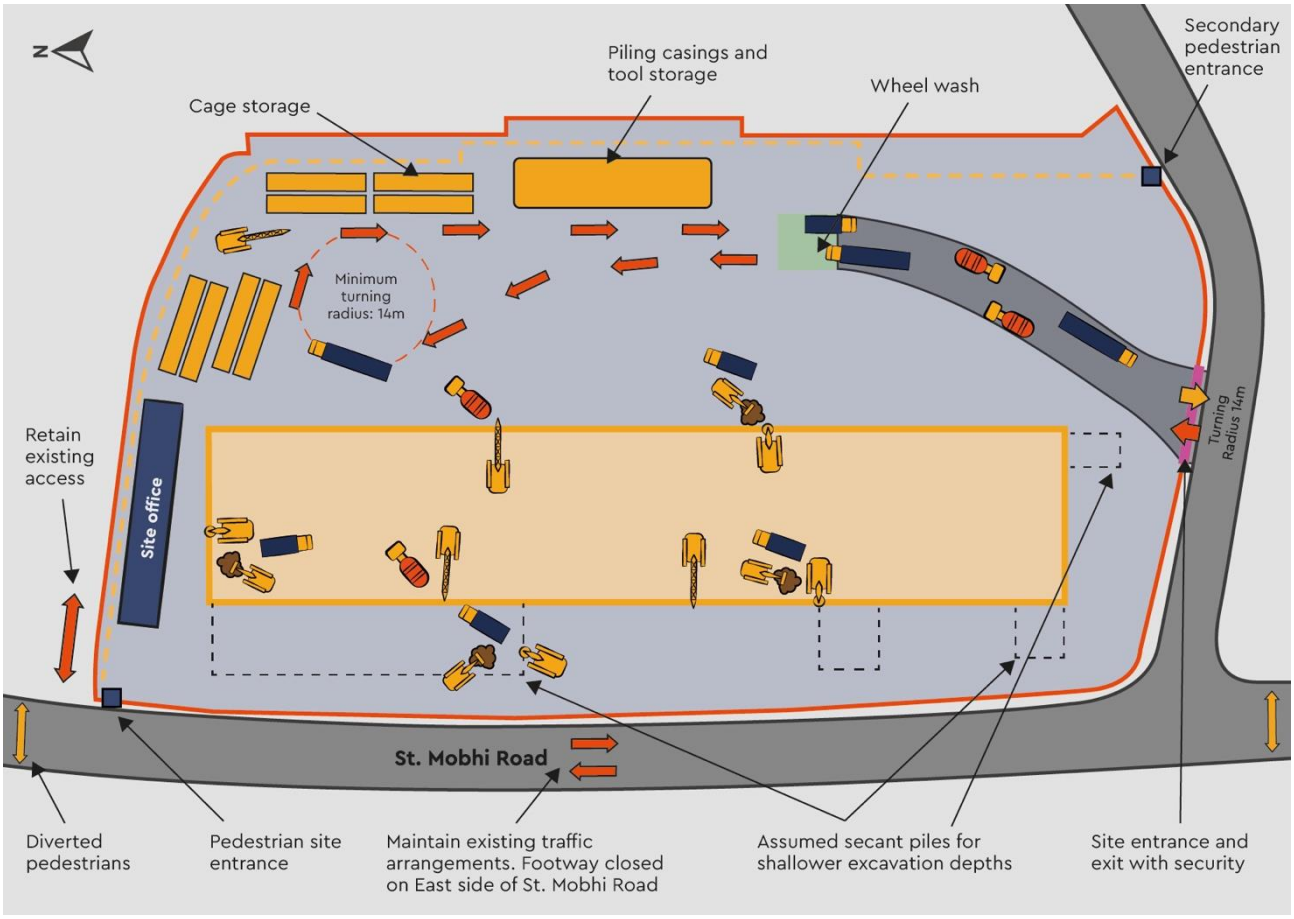

Figure 3-6: Typical Secant Piling Site Layout Drawing