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Our Ref : APPBCA-2024-23

2 December 2024

Dear Sir/Madam

JOINT BCA / ACES / IES / GEOSS CIRCULAR 2024

REQUIREMENTS TO MITIGATE RISK ASSOCIATED WITH UTILITY GAP WITHIN ERSS

Objective

This circular is to inform the industry the requirements to mitigate risk associated with utility gap within the Earth Retaining or Stabilizing Structures (ERSS). By adopting a risk-based approach, this document aims to specify requirements for managing utility gaps effectively and safely during excavation. The requirements are applicable for major building works with excavation depth greater than 4m.

Background

2 In Singapore, there are many underground utilities (for example, sewer pipes, water pipes, power and telecommunication cables) within the road. Upcoming underground infrastructures such as new underground MRT lines or underground roads within the road will require deep excavation and there will be some existing utilities at the excavation areas. When the existing utilities cannot be diverted, they will create gaps within the ERSS wall ("utility gap"). Utility gaps within the ERSS wall form potential weak points within the ERSS system and hence proper measures are required to mitigate the risk of ERSS failure or sinkhole behind the utility gaps during construction.

3 Over the past months, BCA has gathered feedback on the framework from The Institution of Engineers, Singapore, Association of Consulting Engineers Singapore, and Geotechnical Society of Singapore. This circular, which has incorporated inputs from the professional institutions, is for compliance by Qualified Persons ("QPs"), Accredited Checkers ("ACs"), builders and developers that are submitting plans for ERSS with gaps due to utility or other underground obstructions. The requirements in this Circular are also applicable to gaps due to other underground obstructions.

4 Developers/ builders are advised to engage QPs and ACs who are competent and have sufficient knowledge in ERSS design when utility gaps are encountered within the ERSS wall. Highly skilled and experienced QPs and ACs should be able to provide a safe and optimised treatment of utility gap within ERSS wall.

5 **Nothing contained in this circular is meant to replace or negate the need to comply with the provisions of the Building Control Act 1989 and the subsidiary building regulations in all aspects. QPs are to note that they have duties under the Building Control Act, amongst others, to take all reasonable steps and exercise due diligence to ensure that building works are designed in accordance with the provisions of the Building Control Act and the subsidiary building regulations.**

6 We would appreciate if you could disseminate the contents of this circular to your members. Please contact us at Tel 1800-3425222 or through the online feedback form (https://www.bca.gov.sg/feedbackform/) should you need any clarification. Thank you.

Yours faithfully

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Annex A

Requirements to Mitigate Risk associated with Utility Gap within ERSS

Section 1. Introduction

1.1 In the rapidly developing urban landscape of Singapore, the integration of existing underground utilities with new underground infrastructures presents significant engineering challenges. The construction of major underground infrastructures such as the North-South Corridor and Cross-Island-Line face constraints from many existing utilities which could not be diverted. The existing utilities which cannot be diverted create gaps within the ERSS wall ("utility gap"). Utility gaps within the Earth Retaining or Stabilizing Structures (ERSS) form potential weak points within the ERSS system and hence proper measures are required to mitigate the risk of ERSS failure or sinkhole behind the utility gaps during construction.

1.2 This framework on utility gap provides basic concepts and requirements to mitigate risk associated with utility gap within ERSS. The framework outlines two approaches to comply with the requirements, namely 1) "Deemed-to-Satisfy Approach", and 2) an alternative "Engineering Approach". During structural plan submission, QPs should state the approach that will be adopted for the project. Regardless of the approach adopted, QPs must substantiate that the ERSS containing the utility gap is robust and stable until the completion of ERSS works.

1.3 This framework aims to provide guidelines to the industry for robust design and safety outcome in managing risk associated with utilities crossing. This is to set industry norms with mitigation measures to be consistently applied according to the risk categories.

1.4 During the planning stage for major underground construction works, the planner shall consult the utility agencies on the feasibility to divert the utilities that clash with the ERSS wall. Where the utilities cannot or are not practical be diverted (e.g. due to congestion or space constraints), the utility gap within ERSS wall shall be limited to a maximum of 3m width. For multiple 'side-by-side' utilities with combined gap width greater than 3m, the designer can provide intermediate supports to limit the clear gap within 3m. If necessary, staged diversion should be considered to mitigate the risks upfront prior to the construction stage.

1.5 **Section 2** provides definition and basic concepts of treatment of utility gap within ERSS. **Section 3** introduces the risk categories based on ground type and the presence of adjacent buildings. **Section 4** specifies the requirements for site investigation, instrumentation and monitoring, construction supervision, ground improvement, structural lagging, return wall. **Section 5** presents two approaches to comply with the requirements, namely Deemed-to-Satisfy Approach and Engineering Approach. **Section 6** discusses special measures required for High-risk category in densely populated area or for gap width exceeding 3m.

Section 2. Basic Concepts of Utility Gap within ERSS wall

2.1 In this framework, gap width refers to the clear width between the ERSS wall as illustrated **Figure 2.1**.

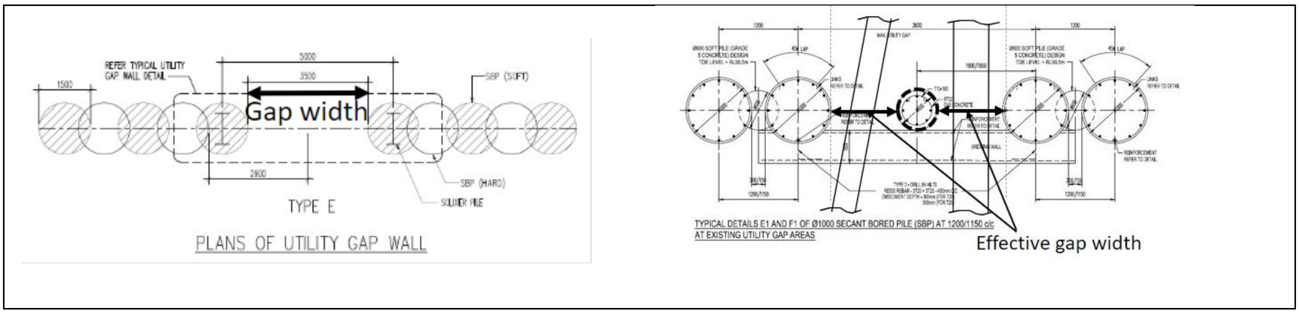


Figure 2.1: Definition of Gap Width

2.2 A larger gap within the ERSS wall poses higher risk of potential sinkhole behind the utility gap. Where the utilities cannot be diverted, the utility gap within the ERSS wall shall be limited to a maximum of 3m width to manage the risk. For larger gaps, QP to provide intermediate support to limit the effective gap width within 3m.

2.3 In general cases, ERSS wall is installed before excavation and serves to retain the soil during excavation. At a utility gap, ERSS wall cannot be installed. The ERSS at a utility gap must be designed so that it is equally robust to the ERSS with wall. At a utility gap, the lack of ERSS wall may be compensated by three components, namely:

a) Ground improvement block, which serves as a temporary measure to prevent water and soil ingress before the structural lagging is installed;
b) Structural lagging, which serves to resist the lateral earth pressure and transfer the load to the ERSS wall at the gap edges; and
c) Strengthened ERSS wall at the gap edges, which serves to strengthen the weak point and to resist the additional force from the gap.

Figure 2.2 illustrates the three components of ERSS at a utility gap.

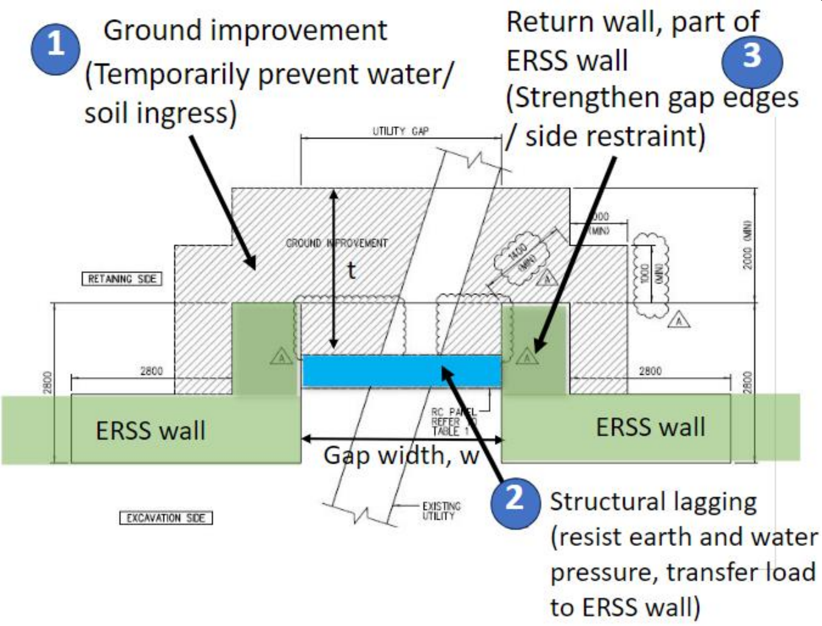


Figure 2.2: Components of ERSS at Utility Gap

Section 3. Risk Category

3.1 In this framework, utility gaps within ERSS wall are categorized into “Low”, “Medium” and “High” risk based on the ground condition and the presence of existing buildings within the zone of influence of the utility gap, as given in **Table 3.1** and illustrated in **Figure 3.2** and **Figure 3.3** below.

Table 3.1: Classification of Utility Gap Risk Categories

	No Ground Type B below 3m from ground level	**Ground Type B below 3m from ground level**	
		No buildings, structures, critical utilities* within influence zone	**Buildings, structures, critical utilities* within influence zone**
Risk Categories	Low	Medium	High

*Critical utilities refer to utilities with internal diameter > 1m, excluding the utilities crossing the gap which are typically supported and protected.

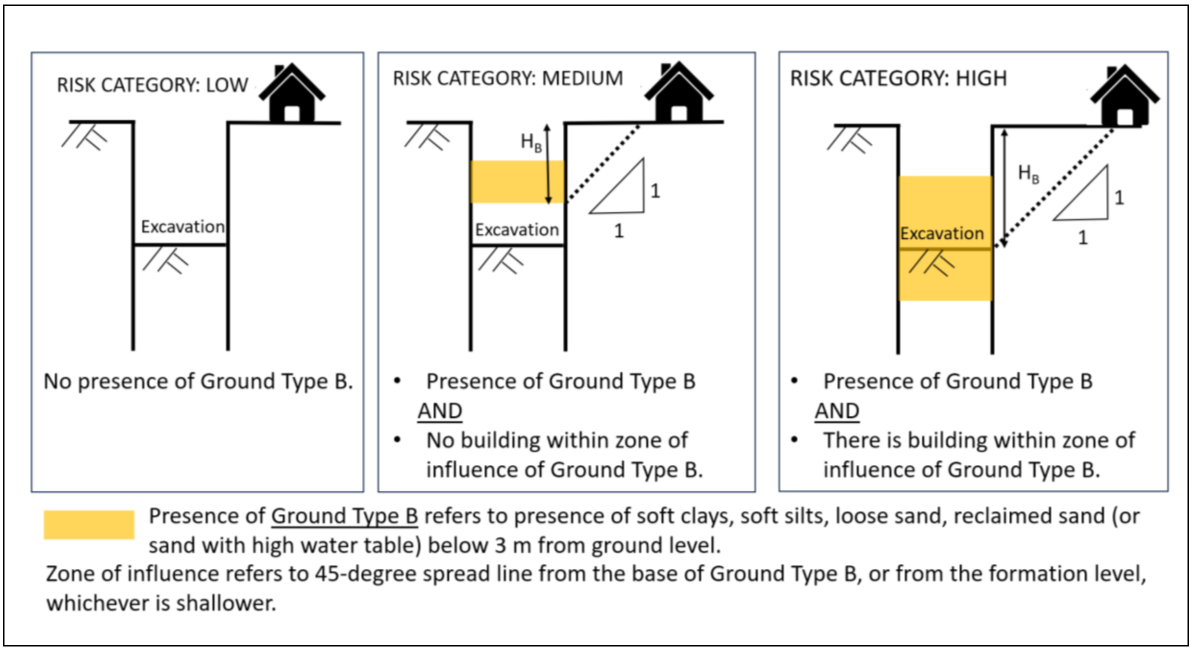
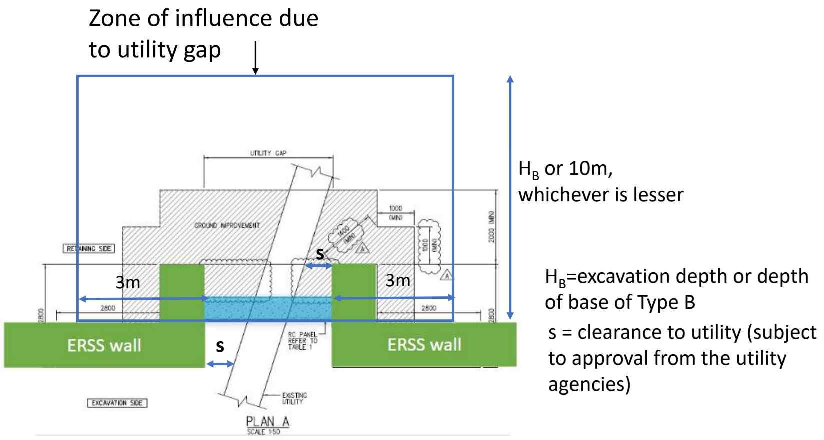


Figure 3.2: Risk Category for Utility Gap within ERSS



Plan View

Notes:

a) A larger gap within the ERSS wall poses higher risk of potential sinkhole. Where the utilities cannot be diverted, the utility gap within the ERSS wall shall be limited to a maximum of 3m width to manage the risk.

b) To comply with the maximum gap width of 3m, project parties are required to seek waiver from respective utility agencies (for example, PUB for water and sewer pipes) on the clearance to the utility.

c) Project parties shall work with the utility agencies on the necessary protection measures for the utility to ensure no damage to the utility during ERSS works, including during installation of ground improvement and the ERSS wall.

d) In designing the utility gap, project parties are to consider designing the ERSS to cater for the utility gap as well as the future maintenance of the utility.

Figure 3.3: Definition of Zone of Influence due to Utility Gap.

3.2 The required mitigation measures correspond to the utility gap risk category, where higher risk will require more mitigation measures to manage the risk.

Section 4. Requirements for Utility Gap

4.1 This section summarizes the requirements to be complied with for utility gap, including requirements on site investigation, instrumentation and monitoring, contingency measures and construction supervision. This section also summarizes the requirements for each component of the utility gap, namely ground improvement, structural lagging and ERSS wall at gap edges / return wall.

Site Investigation

4.2 Site investigation shall be carried out prior to ERSS design. The site investigation is to provide sufficient data to profile the ground and ground water conditions for a reliable assessment of the characteristic values of the parameters adopted for ERSS design. The site investigation shall comply with GeoSS (2015) guidelines (Guide on Ground Investigation and Geotechnical Characteristic Values to Eurocode).

4.3 As the utility gaps form a risk to the stability of the ERSS, more certainty on the ground information at the utility gap location is required, such that appropriate mitigation measures could be provided based on the risk categories. There shall be borehole information within 15m from the utility gap location. Additional boreholes and in-situ tests (e.g. permeability) should be carried out where the designer deems necessary.

Instrumentation and Monitoring

4.4 Instrumentation and monitoring provide crucial performance and warning signs to the effectiveness of the treatment of utility gaps during construction stage. Where there are utility gaps within ERSS wall, a set of geotechnical instruments consisting of inclinometer, piezometer and water standpipes shall be provided at the vicinity of the utility gaps.

4.5 Where there are structures sensitive to ground water lowering, recharge wells shall be specified on the structural plans. The recharge wells are to be installed before excavation commences.

Ground Improvement

4.6 Unsupported cuts in incompetent soil and/or adjacent to buildings/structures is not acceptable. Therefore, ground improvement (GI) is to be provided for soil with SPT-N<30. For soil with SPT-N≥30, ground improvement is to be provided for water cut-off.

4.7 On the structural plans, QP is to specify the details of the ground improvement, including but not limited to the followings:

a. Minimum strength, stiffness, maximum permeability
b. Execution standard. Execution of ground improvement must comply with the relevant BS EN standards, e.g. BS-EN-12716 for jet grouting, BS-EN-14679 for deep mixing.
c. Testing requirements to verify the ground improvement quality and parameters
d. Minimum depth, dimension of the ground improvement block and other details adopted as design requirements.
e. Measures to address the area / wedge which could not be grouted due to required clearance from utilities, e.g. inclined grouting, permeation grouting.

4.8 For area around the utility, due to geometry constraints, QP and Builder to adopt appropriate grouting method such as inclined grouting or permeation grouting to seal up potential weak zone.

4.9 Ground improvement shall be limited to soil improvement work and shall not be used as a retaining wall especially in acting as a cantilever retaining wall (refer to BCA Advisory Note 01/09).

410 The designers are to ensure that the ERSS system has adequate stability against basal heave, uplift and seepage forces.

4.11 The designers are to ensure that the improved ground has adequate unsupported face stability before the structural lagging is applied. Notwithstanding this, for all cases of ERSS with ground improvement, ULS and SLS requirements based on EC7 must be satisfied. Worst credible values of ground improvement parameters are to be adopted in design calculations.

4.12 To verify the ground improvement quality, the Builder is to carry out coring through the full depth of the ground improvement columns/ piles. A guideline is provided below. QP Design/ QP Design (Geotechnical) is to specify additional tests where necessary.

a. The numbers of cores at each utility gap should be at least 1 for Low-risk, 2 for Medium-risk and 3 for High-risk. The cores shall not be less than 50mm in diameter.
b. The quality of the ground improvement shall be determined from the total core recovery (TCR) and the strength and stiffness of the recovered core. The TCR shall not be less than 85%. Where TCR is found to be less than 85%, two additional cores to the adjacent ground improvement columns/ piles shall be carried out. In the event that either of the additional coring fails to conform with the requirement, the ground improvement is deemed to have failed.
c. A minimum of 1 sample shall be taken from top and middle and bottom of each core for strength and stiffness testing at an accredited laboratory. The selection of coring locations shall be determined by the QP Supervision/ QP Supervision (Geotechnical).
d. The strength and stiffness shall comply with the design requirements. If either the strength or stiffness test fails to achieve its target value, two additional samples in the same core shall be tested for strength and stiffness. In the event that either of the additional samples fails to conform with the requirement, the ground improvement work is deemed to have failed.

e. If the ground improvement work is deemed to have failed, the Builder shall propose rectification. Alternatively, QP Design / QP Design (Geotechnical) are to re-assess the design parameters of the ground improvement and review their ERSS design.

Structural Lagging

4.13 Structural lagging serves to resist the lateral earth and water pressure at the gap and to transfer the load to the ERSS wall at the gap edges. Soil face shall not be left unsupported at the utility gap location for a prolonged period. The structural lagging shall comply with the followings:

a. Structural lagging (e.g. shotcrete wall, cast in-situ reinforced concrete (RC) wall) is to be provided for all soil types, except when ERSS wall is provided below the utility gap.

b. Structural lagging shall be constructed in small excavation lift (in 1m or 1.5m as appropriate). QP to design the allowable excavation lift before installation of the structural lagging based on the soil type.

c. On the structural plans, QP to specify that structural lagging must be installed by "*x*" days after each excavation stage. Project parties to ensure that the lagging materials is ready on site before the excavation. For hard soils without ground improvement, structural lagging is to be installed within the same day. For the improved ground and where the water flow rate is within the specified limit, "*x*" is up to 2 days for High-risk, up to 3 days for Medium and Low-risk. The QP shall assess that the ground improvement does not deteriorate before the structural lagging is installed.

d. Connection between structural lagging and ERSS wall must be effective and robust to ensure proper load transfer.

Refer to **Figures 4.1** to **4.3** for some examples of structural lagging.

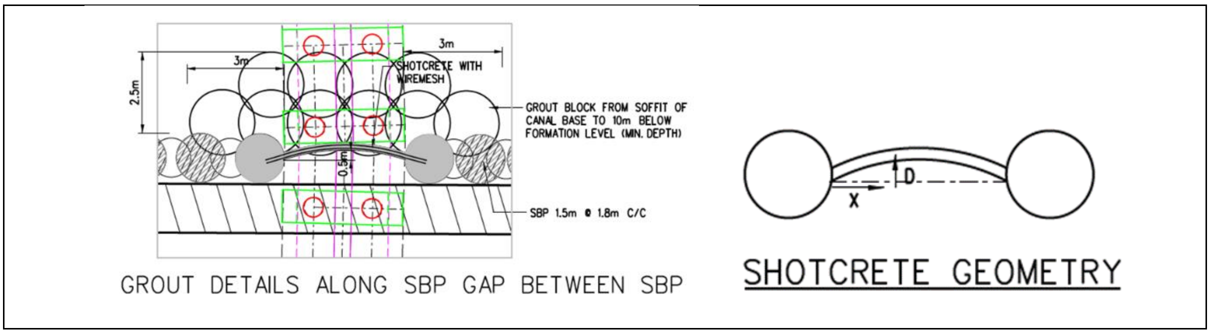


Figure 4.1: Example of Shotcrete with Arched Shape for Increased Load Resistance

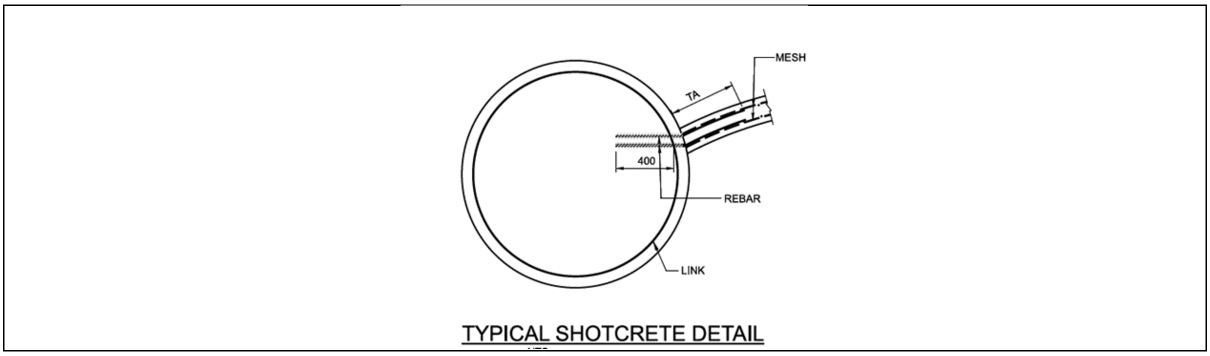


Figure 4.2: Example of Connection between Shotcrete and the ERSS Wall

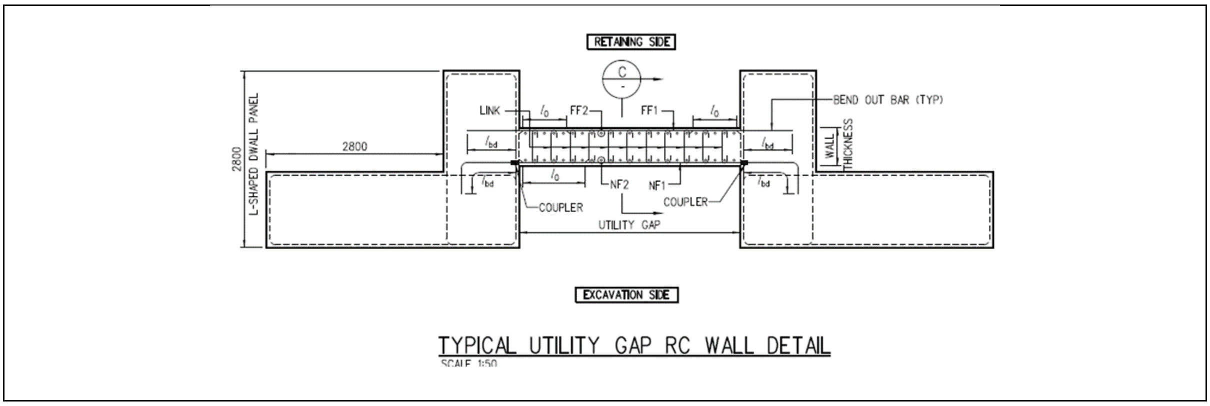


Figure 4.3: Example of Reinforced Concrete (RC) Lagging

ERSS wall at Gap Edges / Return Wall

4.14 The ERSS wall at the gap edges must be designed to take the higher force transferred from the gap. One way is to provide return wall at the gap edges. The purpose of return wall is to strengthen the wall at the gap edges to resist the additional forces transferred from the gap through the structural lagging. The return wall also serves as side restraint at the weak point.

Special Measures for High-risk Category for Densely Populated Area

4.15 For High-risk category at densely populated area (there are adjacent buildings within influence zone which are 4-storey and above/ office building/ shopping mall/ major infrastructure), special measures are required to achieve a more robust system. This is because if excessive movement or damage occurs to these buildings, the consequences may be more severe.

There are 3 options for the special measures, namely:

Option a) to provide intermediate support to reduce the span of the utility gap to less than 2m.

Option b) to provide micropiles below utility.
Option c) to install diaphragm wall below utility by pendulum swing method.

Contingency Measures and Construction Supervision

4.16 On the structural plans, QP Design is to specify the contingency measures to be carried out if soil and/or water ingress is observed. The measures may include, but not limited to:-

a) sealing the gap by polyurethane (PU) grouting or hydraulic cement,

b) backfilling and further grouting,

c) flooding of cofferdam,

d) activation of recharge well,

e) underpinning / compensation grouting of affected structure.

4.17 During excavation at the utility gaps, if water ingress is observed, site supervisors shall inform the QP Supervision. Builder and QP Supervision shall stop the excavation and implement immediate contingency / remedial measures as specified on the approved structural plans. QP Supervision is to include this in site supervision plan and brief the site supervisors.

Section 5. Deemed-to-Satisfy Approach and Engineering Approach

5.1 There are two approaches to comply with the requirements, namely Deemed-to-Satisfy (DTS) Approach and Engineering Approach. The DTS Approach should cater for commonly-encountered circumstances on site. However, there might be site specific conditions or abnormal situations where the DTS Approach may not be appropriate. As an alternative to the DTS approach, QPs may adopt the Engineering Approach to determine the ground improvement thickness, excavation lift and requirements of return wall.

Regardless of the approach adopted, the performance standard is the same, namely the ERSS at the utility gap shall be equally robust to the ERSS with wall.

Deemed-to-Satisfy (DTS) Approach

5.2 This approach is suitable for simple utility crossings which can comply with the requirements in **Table 5.1**. In the DTS Approach, the proposed ERSS at the utility gap may be justified by analytical, empirical or numerical calculations. The Deemed-to-Satisfy Approach for various risk categories are summarized in **Table 5.1**.

Table 5.1: Requirements for Deemed-to-Satisfy Approach

Risk Category for Gap within ERSS	Risk Mitigation Measures			
	Min. Ground improvement thickness (t), t/w (where w is the gap width)	**Excavation lift for structural lagging installation**	**Return wall**	**Special Measures**
Low	1	1.5m as there is no Ground Type B	QP may design the ERSS wall at the gap edges to cater for the gap.	No
Medium	1	1m for excavation in Ground Type B, 1.5m for excavation in others	Yes. QP may adopt flexible return wall, e.g. sheet piles.	No
High	1	Prior to the installation of the structural lagging, shotcrete or temporary steel plate or equivalent to be installed every ≤1m excavation lift.	Yes. To adopt return wall with similar stiffness with the main ERSS wall.	Yes, for densely populated area (there are adjacent buildings within influence zone which are 4-storey and above/ office building/ shopping mall / major infrastructure) To adopt Option a), b) or c)
Requirements for High-risk category at densely populated area (there are adjacent buildings within influence zone which are 4 storey and above/office building/ shopping mall / major infrastructure): Option a) to provide intermediate support to reduce the 3m span of the utility gap to < 2m. Option b) to provide micropiles below utility Option c) to install diaphragm wall below utility by pendulum swing method				
Refer to **Section 4** for requirements on site investigation, instrumentation and monitoring, contingency measures.				

Engineering Approach

5.3 When adopting Engineering Approach, the QP's design calculations should include, but not limited to, a finite element analysis to demonstrate the followings.

Table 5.2: Requirements for Engineering Approach

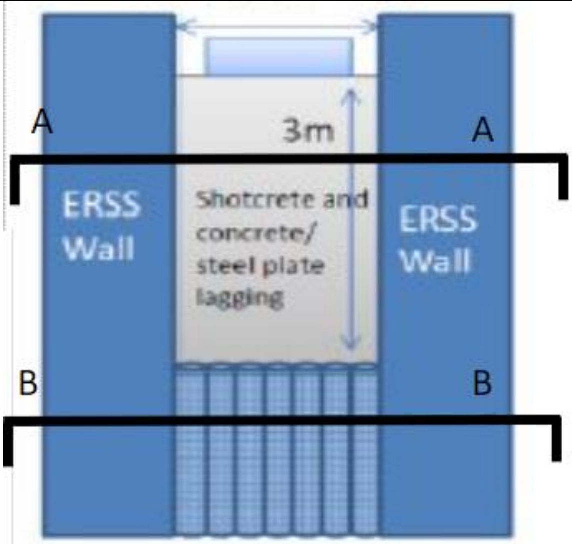
Component of utility gap	**QP to demonstrate by appropriate calculations, including finite element analysis:**
Ground improvement (GI) dimension	• The GI has adequate unsupported face stability before the structural lagging is installed. • The ERSS satisfies EC7 requirements. • To adopt "worst credible" values of GI parameters in the design calculations. • To carry out additional check for SLS case, to demonstrate that the Factor of Safety for stability at the gap is not less than 2.0.
Excavation lift	• The GI has adequate unsupported face stability before the structural lagging is applied. • QP to review the needs for temporary shotcrete before structural lagging is installed.
Design of ERSS wall at the gap edges / return wall.	• QP to assess the needs for return wall. • To design the ERSS wall at the gap edges to resist additional forces transferred from the gap. The forces to design the ERSS wall at the gap edges must be derived from a finite element analysis with full ERSS wall without gap.
The special measures for High-risk category for densely populated area (refer to **Section 4**) are also applicable to Engineering Approach**.**	
Refer to **Section 4** for requirements on site investigation, instrumentation and monitoring, contingency measures.	

Section 6. Examples of Special Measures for High-risk Category for Densely Populated Area or for Gap Width Exceeding 3m

6.1 For High-risk category where the adjacent buildings are 4-storey and above/ office building/ shopping mall/ major infrastructure), movement or damage to the adjacent buildings may have more severe consequences. Similarly, gap exceeding 3m-width pose a higher risk. Therefore, special measures/ a more robust ERSS system are required to mitigate the risk in such cases.

Micropile Installed Below Utility

6.2 One way to achieve a more robust ERSS system at the gap is by providing a structural wall below the utility before further excavation. Example 1 (**Figure 6.1**) shows a case where row(s) of closely-spaced micropiles are provided below the utility. A low headroom machine can be brought down to the excavation level when sufficient clearance from the utility is available. The location or position of the micropiles should take into consideration the interface with any permanent wall such that internal basement space is not compromised.



Source: Kumarasamy (2022)

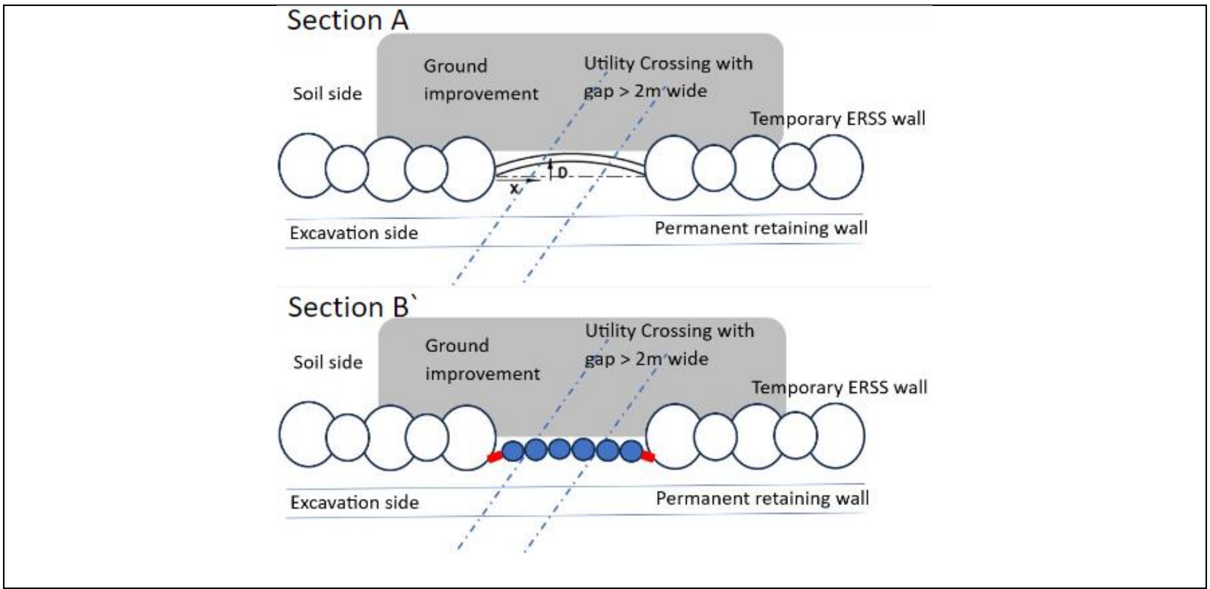
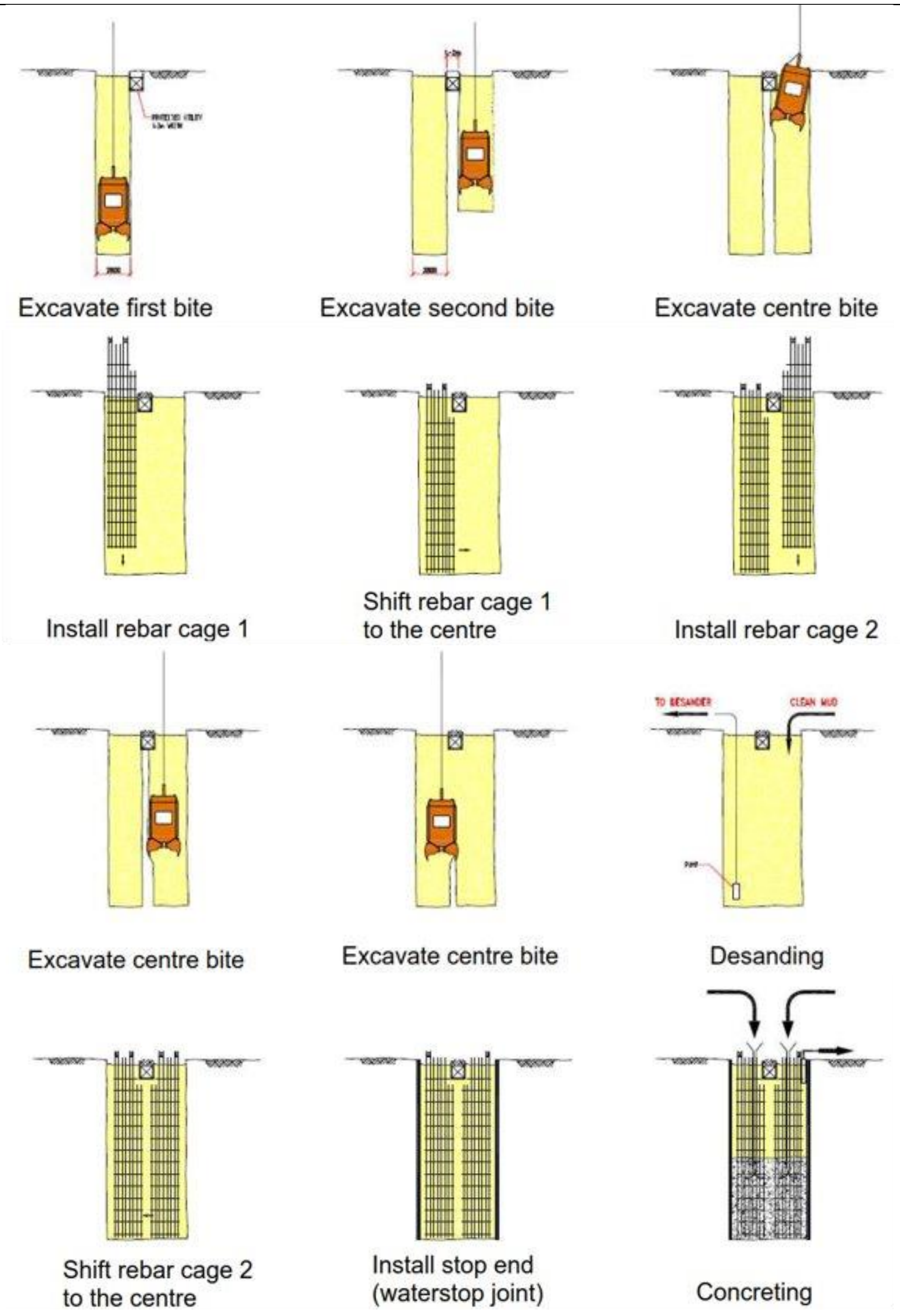


Figure 6.1: Example 1 - Micropile Installed Below Utility

Diaphragm Walls Installation by Pendulum Swing Method

6.3 Example 2 shows a method of installing diaphragm walls (D-wall) below the utility using a specific pendulum swing method. In this method, the wall grab of the machine is tilted at a certain inclination below the utility. This process allows the grab to cut the soil below the utility and allow a structural wall to be formed. The inclination of the tilt will limit the gap width which can be bridged. Nevertheless, a reduction of utility gap width is helpful in mitigating risks associated with large unsupported gaps. The utility shall be protected and supported when the soil below the utility is removed.

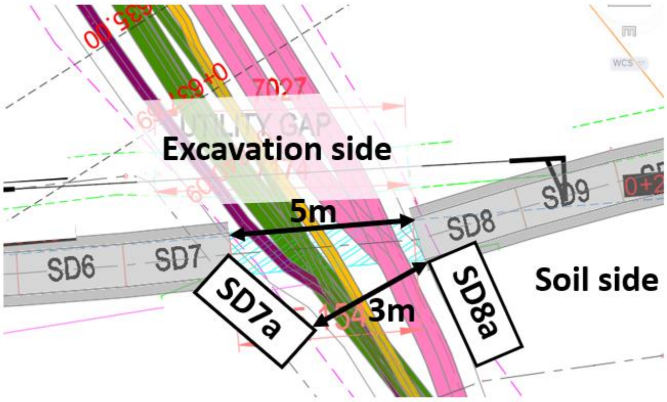


Source: Bachy Soletanche.

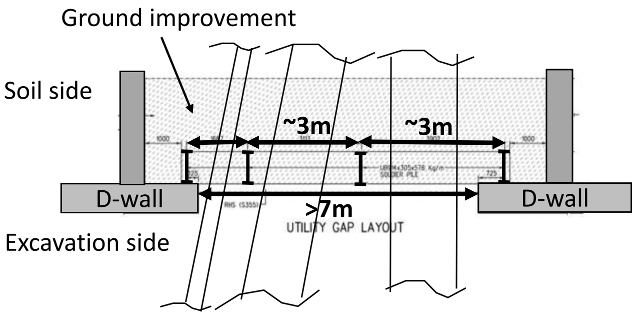
Figure 6.2: Example 2 - Diaphragm Wall Installation by Pendulum Swing Method

Examples of Measures for Gap Width > 3m

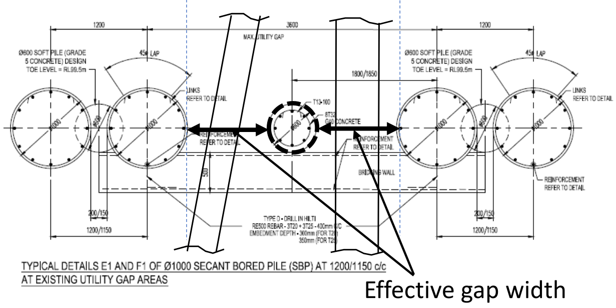
6.4 Two examples are provided here to illustrate measures for gap width exceeding 3m, namely provision of return wall or intermediate soldier piles to reduce the gap width to within 3m.



Provision of return wall to reduce the gap width



Provision of intermediate support (soldier pile) to reduce the gap width



Provision of intermediate support (micro pile) within available space of utilities to reduce the gap width

Figure 6.3: Example 3 – Measures to Reduce the Effective Gap Width

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