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Our Ref: APPBCA-2026-23

19 October 2026

Dear Sir/Madam

JOINT BCA / ACES / IES / GEOSS CIRCULAR 2026

RISK-BASED GUIDELINES ON ERSS SHAFTS FOR UTILITY WORKS

Objective

This circular informs the industry of the risk-based guidelines for the design and construction of Earth Retaining or Stabilising Structure (“ERSS”) shafts for building works in respect of sewer, water and other utility pipes (“utility works”). These measures aim to prevent ground loss or water ingress associated with shaft excavation, particularly in soft, reclaimed, or highly permeable soils. The guidelines are applicable to ERSS shafts for utility works that require structural plan submission to the Commissioner of Building Control (“CBC”) under the Building Control Act. Project parties involved in the construction of ERSS shafts which are classified as insignificant building works according to the First Schedule in Building Control Regulations may also refer to this Circular as guidelines and best practices.

Background

2 Cases of ground loss and water ingress during shaft excavation, particularly in challenging ground conditions such as reclaimed sand and soft clays, have underscored the need for a risk-based approach to ensure the safety of ERSS shafts for utility works. In addition, cast-in-situ caisson shafts in soft ground with circular perimeter ground improvement columns to support the excavation prior to the casting of the caisson wall require high-quality ground improvement to provide effective initial support for the excavation. Good construction plays a crucial role in successful implementation of such ERSS scheme.

3 Over the past months, BCA has gathered feedback on good practices from the Association of Consulting Engineers Singapore (ACES), The Institution of Engineers, Singapore (IES), Geotechnical Society of Singapore (GeoSS), and industry practitioners including specialist builders, developers, and government agencies. This circular, which has incorporated inputs from the professional institutions

and industry, is to guide Qualified Persons ("QPs"), Accredited Checkers ("ACs"), builders and developers that are submitting plans in respect of ERSS shafts for utility works.

4 We would like to reiterate the importance of having a single QP(D) and a single QP(S) for all building works, including ERSS within the same project, to ensure effective coordination and enhance the safety of ERSS works, as set out in the joint circulars issued to the industry by BCA, ACES, IES, SCAL and REDAS on 23 October 2023 and 20 December 2024. For geotechnical building works ("GBW") where the ERSS is independent from the permanent structure, QP(D)(Geo) may also be appointed as the QP(D)(ST) for the ERSS works. Where separate QP(D)s or QP(S)s are appointed, for GBW, it is encouraged for QP(S)(Geo) to appoint the same site supervision team as other building works in the project to ensure continuity of supervision and to avoid any gaps from the separate appointments. Similarly, where Accredited Checker (AC) is required, the same AC or AC(Geo) should be appointed for all relevant works within the projects. Developers are also advised to engage QP(S) and Builders who are competent and have sufficient knowledge in ERSS shaft design and construction when the proposed building works involve shaft excavation in difficult ground conditions.

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 through the online feedback form (<https://www2.bca.gov.sg/feedback/>) should you need any clarification. Thank you.

Yours faithfully,



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The authors and working committee members shall not bear any liability for claims or disputes arising from the use or application of information contained herein.

Project professionals shall conduct their own independent assessment and verification to determine the applicability and sufficiency of the information provided for their specific project requirements.

This guide supplements and does not supersede the statutory requirements under the Building Control Act and Regulations. All stakeholders, including developers, Qualified Persons, site supervisors, and builders, remain bound by their statutory obligations to ensure that building works are designed and carried out in full compliance with the Building Control Act and Regulations, exercising due diligence throughout the project lifecycle.

Compliance with this Circular does not relieve any developer, QP, AC, site-supervisor or builder of their statutory duties under the Building Control Act and Building Regulations.

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Annex A

Risk-Based Guidelines on ERSS Shafts for Utility Works

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Risk-Based Guidelines on ERSS Shafts for Utility Works

Section 1. Introduction

1.1 Shaft excavation is commonly carried out in Singapore to construct underground infrastructure such as manholes, pump stations, and access shafts for sewerage and drainage systems. As Singapore's urban environment becomes increasingly dense and its land area expands through reclamation, shaft construction activities are more frequently encountering difficult ground conditions, including soft clays, reclaimed sand, fluvial sand, and complex geological formations associated with the Kallang Group.

1.2 Several construction methods are available for ERSS shaft. These range from lower-risk methods involving a physical retaining wall installed prior to excavation (such as sheet pile walls or secant bored pile walls), to higher-risk methods such as cast-in-situ (CIS) caisson shafts, which rely on the inherent stand-up time of the soil face and, in challenging ground, on the quality of ground improvement works to maintain face stability during excavation and casting of the caisson ring.

1.3 The integrity of the ERSS shaft is paramount to preventing ground loss incidents that can result in sinkholes, significant project delays, substantial remedial costs, and most critically, threats to worker and public safety. Recent incidents have demonstrated that for cast-in-situ caisson shafts with ground improvement to provide face support, the ground improvement quality assurance, effective construction supervision, and prompt response to early warning signs are key factors to ensure safe construction.

1.4 This guide introduces a risk-based approach to the design and construction of ERSS shafts for utility works. It categorises risk levels based on ground conditions and proximity to existing buildings and structures and provides targeted requirements for each risk category.

1.5 **Section 2** provides the risk matrix and default construction methods for various risk categories. It also describes the common shaft construction methods and their associated risk levels. **Section 3** to **Section 8** address the detailed requirements for each of the areas listed below:

- Section 3: Requirements of site investigation;
- Section 4: Specific design considerations for cast-in-situ caisson shafts;
- Section 5: Specific requirements for cast-in-situ caisson shafts with ground improvement;
- Section 6: Verification of ground improvement quality;
- Section 7: Instrumentation and monitoring; and
- Section 8: Construction control and supervision.

1.6 This guide is applicable to all ERSS shafts constructed for utility works requiring structural plan approval under the Building Control Act. The Design QP [QP(D)] and Supervising QP [QP(S)] are to apply the requirements and good practices set out in this guide in the design and supervision of shaft construction, and to specify the relevant requirements in the ERSS structural plans submitted for approval.

Section 2. Risk Matrix and Default Construction Methods

2.1 The following common shaft construction methods are listed in order of increasing risk:

- a) **Shaft construction using a physical wall installed before excavation** (e.g. sheet pile wall, secant bored pile wall). This is a low-risk method. The physical wall provides a structural cut-off, preventing soil and water ingress into the shaft during excavation. If utility gap is present, project parties are to refer to Joint BCA/ACES/IES/GeoSS Circular 2024 "Requirements to mitigate risk associated with utility gaps within ERSS".
- b) **Cast-in-situ caisson shaft in competent ground.** This is a method of moderate risk. The shaft is constructed ring-by-ring, with each excavation stage followed by casting of a reinforced concrete caisson ring. The soil face is temporarily self-supported during excavation, and the soil must remain self-supported until the caisson ring is cast. Additional risks that must be addressed for this method include: (1) weak pockets within otherwise competent ground may cause localised soil collapse before the ring is cast, and (2) soil becoming unstable if the exposed soil face remains beyond its stand-up time.
- c) **Hybrid of (a) and (b) above, namely shaft construction using a physical wall in challenging ground followed by cast-in-situ caisson shaft in competent ground.** This is also a method of moderate risk. While the upper portion of the shaft adopts a safe physical wall in challenging ground such as soft clays or reclaimed sand, the lower portion uses cast-in-situ caisson shaft in competent ground. This method carries the same additional risks as listed in b). For this method, QP is to provide adequate wall embedment into competent soil for groundwater seepage cut-off and to prevent hydraulic failure.
- d) **Cast-in-situ caisson shaft in challenging ground with ground improvement.** This is a high-risk method. Since the challenging ground (e.g. soft clays, reclaimed sand, fluvial sand) cannot stand unsupported on its own, ground improvement such as jet grouted piles (JGP) or Deep Cement Mixing (DCM) is provided at the shaft perimeter to provide support during excavation before the caisson ring is cast. This method is critically dependent on the quality of the ground improvement works. Uncertainty / variability of the ground improvement quality is an additional risk that must be addressed for this method.

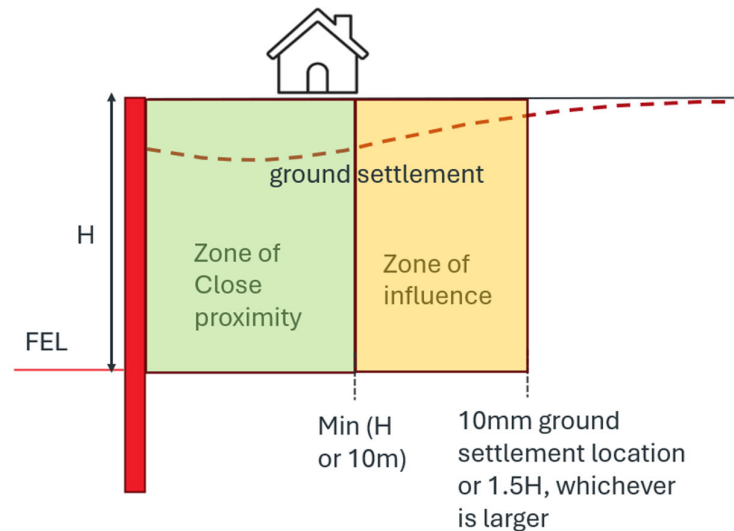
2.2 In this guide, "challenging ground" refers to soft to firm soils with SPT-N less than 8, and any soil with permeability $k \geq 5 \times 10^{-7}$ m/s, including reclaimed sand and fluvial sand. In the absence of permeability test results, a fines content of less than 35% may be taken as an indication of high permeability.

Risk Matrix

2.3 The risk for ERSS shaft construction is categorised into "Low", "Medium", and "High" based on the ground type and the proximity of the shaft to existing buildings and structures, as given in **Table 2.1** below.

Table 2.1: Risk Matrix for ERSS Shaft Construction

Ground type / Proximity to building	Very Stiff to Hard soils (SPT-N > 15 and $k < 5 \times 10^{-7}$ m/s)	Stiff soils (SPT-N = 8 to 15 and $k < 5 \times 10^{-7}$ m/s)	Soft to firm soils (SPT-N < 8) and any soil with $k \geq 5 \times 10^{-7}$ m/s
Greenfield	Low	Low	Medium
Zone of influence	Low	Medium	Medium
Close proximity	Medium	High	High



Notes:

- "Close proximity" means presence of buildings or structures within a horizontal distance of 1H from the shaft, up to a maximum of 10m, where H is the shaft excavation depth.
- "Zone of influence" means presence of buildings or structures beyond the close proximity boundary, up to the boundary of the 10mm ground settlement zone or 1.5H from the shaft, whichever is larger.
- "Greenfield" means areas other than those defined in Notes (1) and (2) above.
- Roads, utilities, and boundary walls are not included in the determination of close proximity and zone of influence, as the impact on these features is generally less significant than on buildings.
- Granular soils with high permeability are indicated by the presence of a soil/rock interface or a measured soil permeability $k \geq 5 \times 10^{-7}$ m/s, regardless of SPT-N value. In the absence of permeability test results, a fines content of less than 35% may be taken as an indication of high permeability.

Default Construction Method

2.4 **Table 2.2** provides the default construction method for each risk category. For shafts located in close proximity to buildings or structures, a physical retaining wall installed prior to excavation is required as the default construction method, given the higher consequence of ground movement on adjacent structures, unless otherwise agreed by the Commissioner of Building Control through pre-consultation based on project-specific justification.

Table 2.2: Default Construction Method for Various Risk Categories

Ground type / Proximity to building	Very Stiff to Hard soils (SPT-N > 15 and $k < 5 \times 10^{-7}$ m/s)	Stiff soils (SPT-N = 8 to 15 and $k < 5 \times 10^{-7}$ m/s)	Soft to firm soils (SPT-N < 8) and any soil with $k \geq 5 \times 10^{-7}$ m/s
Greenfield	QP to decide	QP to decide	QP to decide
Zone of influence	QP to decide	QP to decide	QP to decide
Close proximity	Physical wall required; hybrid method with cast-in-situ caisson may be adopted for SPT-N > 30 (see Note 2)	Physical wall required	Physical wall required

Notes:

- 1) For shafts located in close proximity, if the QP has strong justification that a cast-in-situ caisson method can be adopted and the risk of damage to adjacent buildings can be adequately mitigated, the QP may pre-consult with BCA on a case-by-case basis prior to plan submission.
- 2) For shafts located in close proximity, a hybrid shaft construction method (combining a physical wall for the upper portion and cast-in-situ caisson for the lower portion for soil with SPT-N>30) is permitted, subject to the QP demonstrating that the overall design satisfies the applicable risk category requirements.
- 3) Shafts constructed by Vertical Shaft Sinking Machine (VSM) or sink-in caisson under submerged conditions (i.e. maintaining the groundwater table during excavation) may be considered for the High-risk category. Sink-in caisson construction not carried out under submerged conditions shall only be adopted for Low and Medium risk categories.

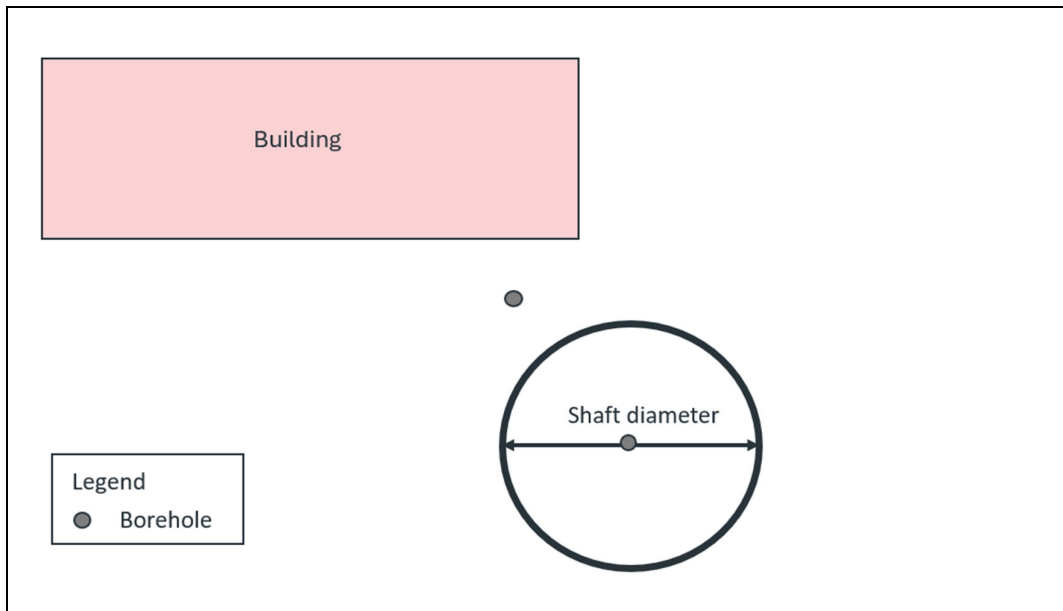
Section 3. Site Investigation Requirements

3.1 Projects must conduct borehole investigations to an adequate extent and depth as per Eurocode 7 requirements. These geotechnical investigations shall yield sufficient data on ground and groundwater conditions to enable a proper characterisation of essential ground properties and a reliable assessment of the characteristic values of ground parameters for use in design calculations. The number of investigation boreholes shall comply with the requirements stipulated in **Table 3.1**.

Table 3.1: Site Investigation Requirements for ERSS Shaft for Utility Works

Shaft inner diameter	Minimum number of boreholes	
	Shaft with no buildings within close proximity	Shaft with buildings within close proximity
< 6m	1	2*
6 – 12m	2	2*
> 12m	2	3*

* One of the boreholes must be at the building side



Section 4. Specific Design Considerations for Cast-In-Situ Caisson Shafts

4.1 Design of ERSS shall be carried out in accordance with the current version of SS EN 1997-1 Eurocode 7: Geotechnical design – Part 1: General rules, in conjunction with the Singapore National Annex to Eurocode 7, NA to SS EN 1997-1. The design code requires, among others, that the EQU, STR, GEO ultimate limit states (ULS) be satisfied for all excavations. For excavations in sand or highly permeable soils, piping checks in accordance with Eurocode Clause 2.4.7 are to be carried out to verify that the ERSS wall toe embedment is adequate for basal heave stability, hydraulic stability and resistance to piping.

4.2 Besides the design standard, BCA's Approved Document, Advisory Notes and guidelines jointly issued with the professional societies (GeoSS, IES, ACES, etc) and academia are useful resources. Qualified Persons should be guided by such resources as they contain requirements and good practices specific to ERSS design in the local context. Some of the key design considerations are summarised in **Table 4.1**.

Table 4.1: Design Consideration for ERSS

Aspects	Design considerations
Ground, soil and Site Characterization	Adequate and appropriate site investigation
Characteristic value	Proper evaluation and selection of the soil parameters for design in accordance with EC7
Water pressures and seepage force	Effects due to onerous water pressures and seepage forces
Drained, Undrained or time dependent soil drainage conditions	Effects due to onerous soil loading conditions from both undrained and drained/time dependent soil drainage conditions
Surcharge/ Unbalanced load	Effects of surcharge loads (at least 10 kPa), including incidental loads, construction loads, adjacent slope, load from adjacent existing structures and usage, etc;
Varying load conditions during stages of the construction	Varying load conditions during stages of the construction including removal stages;
Robustness/ redundancy	Design robustness and redundancy considerations include one-strut failure, accidental loads, unplanned excavation, etc.
Wall toe stability and seepage control	Adequacy of wall embedment for toe stability and seepage control, etc.
Basal heave/ hydraulic uplift/ piping stability	Adequate factor of safety for overall wall stability and basal heave/hydraulic uplift/piping
Structural adequacy	- Structural adequacy of wall and supporting system e.g. walers, struts, anchors etc. considering temperature effect and stiffeners; - Provision of continuous concrete packing between waler and wall, preloading of struts, adequate stiffeners and temperature effect;

Aspects	Design considerations
	Design for adequate effective length of kingpost and struts considering construction sequences;
Impact due to ground water lowering	Effects of ground water lowering and ground deformation on neighbouring properties
Design Factor of safety similar to permanent works	Factor of safety for the design shall not be less than that for permanent works.

Characteristic Value for Geotechnical Parameters of Soil and Improved Soil in ERSS

4.3 EC7 introduces the concept of characteristic values, to which partial factors are applied to obtain suitably safe design values of soil parameters. SS EN1997-1 C.2.4.5.2(2) defines the characteristic value as being "selected as cautious estimate of the value affecting the occurrence of the limit state".

4.4 Designers shall remain guided by GeoSS guideline 2015 in the determination of characteristic value. Where a large volume of ground is involved (i.e. overall/ global failure), the characteristic value should be determined such that a cautious estimate of the mean value is a selection of the mean value with a confidence limit of 95% (moderately conservative estimate), reflecting the reduced likelihood of simultaneous failure across the entire volume due to spatial averaging. Where a small volume of ground is involved (i.e. localized failure such as face stability), a cautious estimate of the low failure is a 5% fractile (inferior parameter).

Exposed Soil Face Stability and Stand-up Time Prior to Casting of Caisson Ring

4.7 In embedded wall systems, the wall is installed to its full depth first, providing structural support for the entire construction stages.

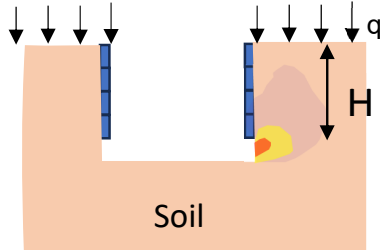
4.8 In cast-in-situ caisson shaft construction, there is no pre-installed wall to retain the soil. The excavation is done in stages, each stage typically 1 to 1.2 m deep. During each excavation stage, the exposed face is either self-supporting (in firm to hard ground) or supported by ground improvement column (in soft ground) prior to the casting of the reinforced concrete caisson ring.

4.9 This means the critical design and construction consideration is the stand-up time of the exposed face during each excavation stage. The exposed face must remain stable long enough for the concrete ring to be cast and achieve sufficient strength to carry load before the next excavation stage begins. For the assessment of face stability and stand-up, designers could either adopt the method of deemed-to-satisfy or the engineering analysis approach as described in the **Table 4.2**.

Table 4.2: Deemed-to-Satisfy Approach and Engineering Approach to Estimate Ground Stand-up Time

Deemed-to-Satisfy Approach

- i. In this approach, the underlying assumption is that the ground is a relatively homogeneous, low permeability soil mass and the loading rate (time duration) is fast for the undrained (suction) behaviour in the soil to prevail such that the soil cohesion could maintain to provide temporary face stability.
- ii. The height of each excavation stage directly controls the exposed face geometry, so keeping each excavation stage shallow reduces the risk of face collapse. Groundwater conditions are also critical. If the water table is above the excavation level, seepage pressure acts against face stability and can cause rapid deterioration of stand-up time, potentially requiring ground improvement.
- iii. The practical implication is that even when adopting the deemed-to-satisfy approach, there should be a degree of vigilance during construction — monitoring the exposed face carefully during each excavation stage, being alert to any signs of seepage, ravelling, or unexpected material changes, and having contingency measures ready if anomalous ground is encountered.
- iv. Designer may adopt the following empirical method to substantiate the allowable stand-up time is within the deemed-to-satisfy value listed in this Table. As a cautious reminder, designer should critically assess if the assumption underpinning the empirical method remains valid and applicable for the entire cast-in-situ shaft construction.



$$\text{Stability Number, } N = \frac{\gamma H + q}{c_u} < N_c$$

where:

γ is the unit weight of soil; q is the surcharge; H is the retained height;

c_u is 0.85 of design undrained shear strength, or the 5% fractile value (inferior parameter) of undrained shear strength as determined by the Design QP; and

N_c is the critical stability number (4 to 6)

Non-sandy soil	Recommended soil face exposure time until RC caisson is cast (to be substantiated with empirical calculations)
SPT-N $\leq$ 15	Within a day
15 < SPT-N $\leq$ 50	Within 2 days
SPT-N > 50	Within 3 days

The recommended soil face exposure periods are guidance values and do not replace the Design QP's responsibility to verify face stability and allowable stand-up time based on the actual site conditions and construction sequence.

Table 4.2: Deemed-to-Satisfy Approach and Engineering Approach to Estimate Ground Stand-up Time (continued)

Engineering Approach

Designer could adopt engineering approach using detailed analysis (i.e. finite element method) to obtain stand-up time as an alternative to the recommended value. The analysis simultaneously solves for both the mechanical stress-strain behaviour of the soil, and the pore water pressure changes due to seepage, recognising that the two are interdependent and commonly known as fully coupled flow-deformation analysis. The procedures are listed below for reference.

Step 1 — Set up a detailed numerical model that could analyse model both mechanical stress-strain behaviour of the soil and the pore water pressure change due to seepage (i.e. effects of time-dependent seepage) since the two interact over time. The analysis shall include detailed steps covering the activities such as excavation, installation of support and foreseeable delay.

Step 2 —The analysis must use advanced soil models that capture the realistic ground behaviour and calibrated to site-specific soil condition.

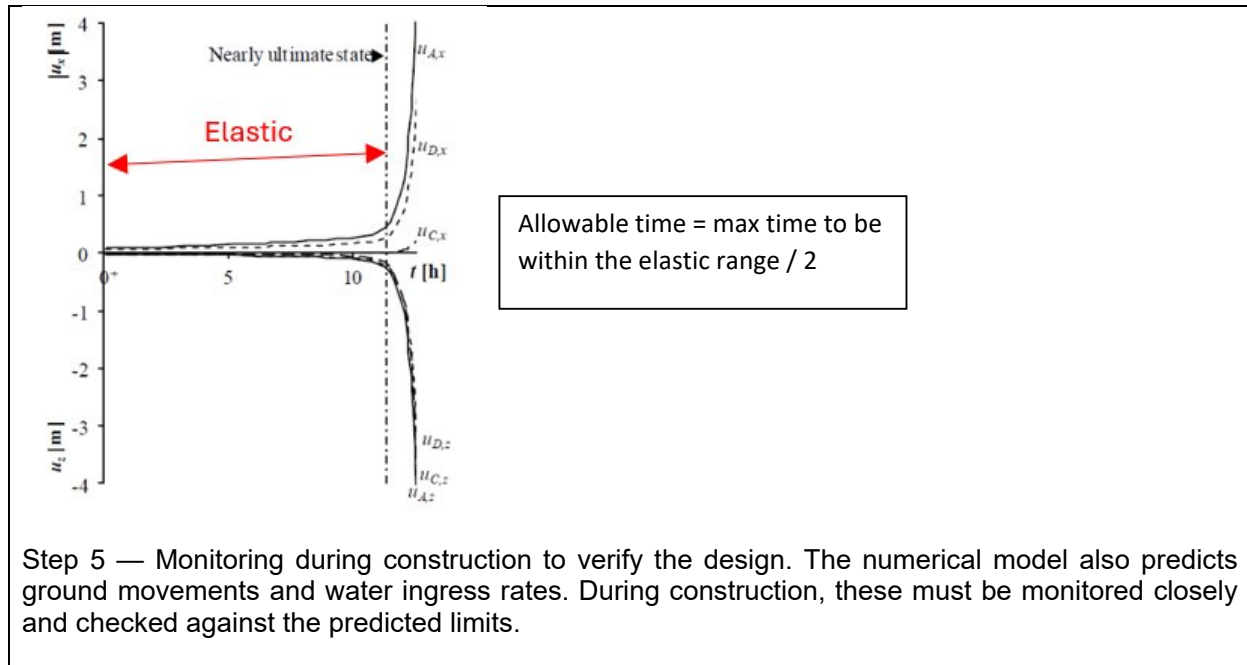
Step 3 — Full step-by-step analyses from ground level to completion of the shaft shall be carried out to assess the ground behaviour and construction impact to the surrounding ground and structures. For stability checks, critical excavation stage for each of different ground layer shall be carried out.

Step 4 — Determine allowable stand-up time from the displacement-time graph. The allowable standup time should be the maximum time for the ground behaviour to remain within the elastic range with a factor of safety (minimum FOS = 2) applied against the onset of instability.

If this time is shorter than what the construction cycle needs (including any stoppages or delay), the designer should either

- (i) reduce the excavation depth for each stage so that the construction cycle falls within the allowable stand-up time; or
- (ii) pre-install ground improvement; or
- (iii) install a retaining wall.

Table 4.2: Deemed-to-Satisfy Approach and Engineering Approach to Estimate Ground Stand-up Time (continued)



Asymmetrical (Unbalanced) Loading Conditions

4.10 Caisson ERSS walls are circular in shape and self-supporting, resisting lateral soil and water pressure through hoop (circumferential) compression; thus, they take advantage of concrete's high compressive strength. This works effectively when the loading is uniform around the ring.

4.11 However, asymmetric loading conditions, such as uneven surcharge, sloping ground, or variable soil layers, cause non-uniform stress distribution around the caisson ring. This leads to ring squatting (i.e. the ring being pushed into an oval or egg-like shape, flattening in one direction and widening in the other) and distortion, where the ring deforms out of its intended circular shape. Once the ring loses its circularity, it can no longer distribute stress evenly around its perimeter, and bending stresses develop in the concrete wall — something a circular ring is not designed to handle efficiently, compromising its structural efficiency and potentially its integrity. Where applicable, QPs/ACs are to design and check for such design loadings.

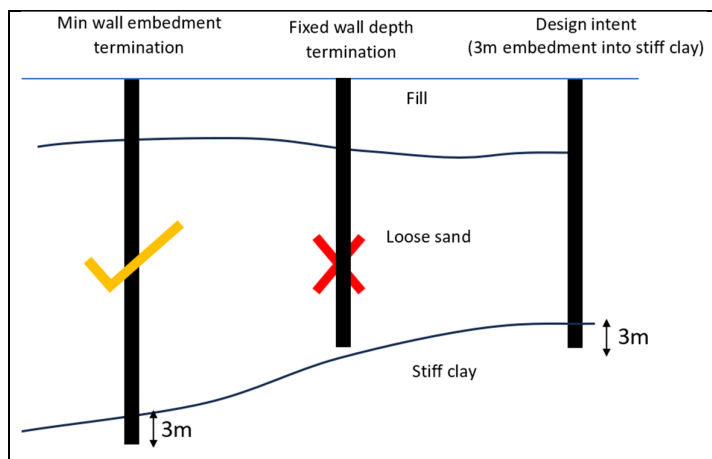
Specifying Minimum Embedment Length of ERSS Wall in Competent Soil as Termination Criteria in Approval Plan

4.12 Physical ERSS wall must achieve adequate embedment into a competent low-permeability soil layer to provide effective seepage cut-off. In variable ground, by specifying minimum embedment length

instead of a fixed wall toe, the wall installation can adapt to the actual soil profile encountered during construction in ensuring the termination criterion is met regardless of where the soil layer boundary is found. With clear minimum termination criteria, the ERSS wall would be installed to terminate in competent soil as per the design intent and ensuring the excavation susceptibility to seepage, piping, or base instability is mitigated.

4.13 To manage ground variability effectively, the soil layer profile can be established by monitoring sheet pile or wall installation behaviour adjacent to known borehole locations. This allows the contractor to correlate driving resistance or installation response with the known stratigraphy, providing a practical means of verifying the required embedment into the target layer has been achieved at each location along the wall. **Table 4.3** compares the recommended minimum wall embedment termination criteria against the fixed wall depth.

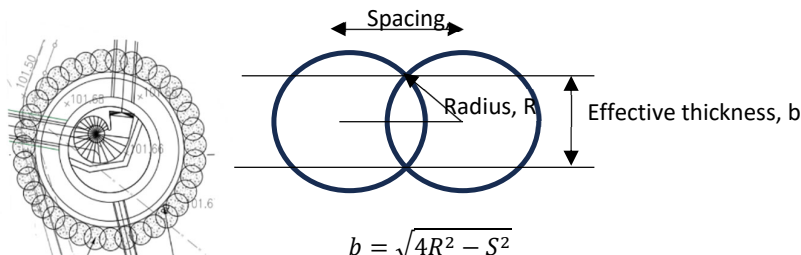
Table 4.3: ERSS wall Termination Criteria – Minimum Embedment in Competent Soil



Other considerations

4.14 There are other practical considerations for cast-in-situ caisson ERSS when used with ground improvement as face support. **Table 4.4** summarised some key considerations.

Table 4.4: Practical Design Considerations for Cast-in-Situ Caisson Shafts with Ground Improvement as Face Support

Use effective thickness of ground improvement in FEM analysis	
 $b = \sqrt{4R^2 - S^2}$	

Section 5 Specific Requirements for Cast-In-Situ Caisson Shafts with Ground Improvement as Face Support

Details to be Shown in Structural Plans for Cast-In-Situ Caisson Shafts with Ground Improvement

5.1 In addition to the requirements for ERSS submission, structural plan for cast-in-situ caisson shafts with ground improvement shall contain the following, where applicable:

- a) Layout, sections and details of the ERSS and the ground improvement;
- b) Minimum thickness, minimum depth or toe level of the ground improvement, the diameter / dimension of the ground improvement piles / columns and minimum overlap between the piles / columns, a note on the structural plans stating that the Supervising QP may allow variation in diameter and overlapping of the ground improvement (the perimeter jet grout piles) if the design effective thickness of the ground improvement (see **Table 4.4**) is fulfilled without a gap.
- c) Characteristic value of strength, stiffness and permeability of the ground improvement adopted in the design;
- d) Allowable soil face exposure time until RC caisson is cast (see **Table 4.2** for recommended values);
- e) Minimum time for RC ring to gain strength before subsequent excavation;
- f) Ground improvement execution standard;
- g) Requirements on ground improvement trial and verification of the ground improvement installation, testing frequency and acceptance criteria as stated in **Section 6** below;
- h) Instrumentation and monitoring plan (refer to **Section 7** for minimum requirements).

5.2 The operation parameters for the installation of ground improvement works should be included in the method statement and should not be included in the structural plans.

Requirements for Specialist Builder for Ground Improvement Works for Cast-In-Situ Caisson Shafts

5.3 For ERSS shafts for utility works which adopts cast-in-situ caisson method and ground improvement to provide support during excavation, ground improvement quality is crucial in ensuring adequate stability before the caisson ring is cast. Poor quality/ defective ground improvement may result in localised soil/ water ingress into the excavation shaft which may lead to a sinkhole if not mitigated properly.

5.4 For ERSS shafts for utility works which adopts cast-in-situ caisson method and ground improvement to provide support during excavation, the Supervising QP is to check that the Specialist Builder (SB) who will carry out the ground improvement works comply with the basic Quality Assurance / Quality Control requirements summarized in **Table 5.1**. Firms that are SAC accredited for specialist builders (ground stabilisation works for ERSS - ground improvement) are deemed to have satisfied the requirements in **Table 5.1**.

Table 5.1: Requirements for Specialist Builder (SB) for Ground Improvement Works Providing Face Support for Cast-in-Situ Caisson Shafts.

Category	Requirements
Code compliance	The SB shall have detailed procedures, method statements and instructions for the application of the appropriate regulations, codes of practice, standards, specifications, guidance documents and customer requirements. All products and its material shall meet the requirements set in the respective EN execution standards of special geotechnical works: A) Jet Grouting - BS EN 12716 B) Deep Mixing - BS EN 14679
Quality Management System	The SB shall operate a quality management system that complies with ISO 9001. The SB shall produce a quality plan for each structure, contract or project as appropriate and identifying specific details on which it is contracted to operate. This plan shall include method statements and inspection test plans for all key ground support and stabilisation works activities.
Report for ground support and stabilisation Works	The PE / Technical Controller shall review and endorse the list of records (those specified in EN standard) and shall ensure that the report contains the information listed below: 1. Identification of the document, i.e., date of issue and unique identification. 2. Identification of the client, consultants and subcontractors (if any). 3. Description of the project, products and the type of tests conducted. 4. Description of the machine/equipment, methods and procedures adopted for the installation of the products and the associated tests. 5. Name of the full staff members and supervisory team who installed the products and the associated tests. 6. Date of products installed. 7. Date of tests conducted. 8. The reports/results of tests, including field tests, laboratory tests, findings and issues encountered. 9. Print out record from real-time data logger.
Firms that are SAC accredited for specialist builders (ground stabilisation works for ERSS - ground improvement) are deemed to have satisfied the above requirements.	

Section 6 Verification of Ground Improvement Quality

Execution Standards

6.1 The ground improvement works shall comply with the relevant BS EN execution standards, namely BS EN 12716 for jet grouting and BS EN 14679 for deep mixing.

Ground Improvement Trial

6.2 Before commencement of ground improvement works, the Builder/ Specialist Builder shall conduct a trial to demonstrate the suitability of the proposed method. This shall be carried out in accordance with the method statement. The trial ground improvement shall be carried out using the same type of machine and the same operation parameters (e.g. grout/water/air pressure and flow rate, rod withdrawal and rotation rate) as the actual ground improvement works. There should also be considerations for change in soil conditions (i.e. stiffness or soil type).

6.3 One minimum trial test shall be carried out at site for each soil type to be treated for a project site. The trial ground improvement shall consist of minimum three piles with overlapping (for jet grouted piles) or three columns with overlapping (for deep mixing) formed to the full depth and in similar ground conditions as the proposed ground improvement.

6.4 The effectiveness of the trial ground improvement shall be demonstrated with a minimum of two boreholes used to obtain cores through the full depth of the grouted block. The boreholes shall be targeted at the overlapping areas of the piles / columns.

6.5 The cores shall be fully logged. A minimum of 1 sample shall be taken every 2m depth of each core from 3m below ground level or the top of the ground improvement, whichever is lower, to 1m below formation level. The samples shall be sent for strength testing at an accredited laboratory. The strength refers to peak strength.

6.6 Acceptance criteria of the strength test results are as follows:-

The strength test results must satisfy the following criteria:

- a) Any individual test result > 85% of the design target value specified on the approved plans, and
- b) Mean value of test results > 100% of the design target value specified on the approved plans.

Alternatively, the Design QP / Design QP(Geotechnical) may adopt statistical methods accounting for an appropriate distribution of the test data, in compliance with Eurocodes.

6.7 The ground improvement trial is deemed to fail if the Total Core Recovery (TCR) fails to achieve 85% or the strength test results fail to comply with the acceptance criteria in 6.6. Further trial(s) with more appropriate operation parameters shall be carried out.

Verification of the Ground Improvement Installation

6.8 The actual ground improvement works shall be carried out with a machine equipped with a reliable electronic control and data recording system (data logger). The operating parameters in the ground improvement trial or ground improvement installation shall be checked and recorded continuously by the data logger in real time throughout the entire installation process. To minimise risk of ground heaving and flow into unplanned locations, continuous monitoring of spoil return using visual observation should be carried out. If there is unexpected reduction in spoil return, the Builder / Specialist Builder should stop the works and investigate.

6.9 The quality of the ground improvement shall be verified by coring. For perimeter ground improvement which provides face support before installation / casting of the caisson ring, the minimum coring requirements and passing criteria are listed below. The Design QP / Design QP (Geotechnical) shall specify additional coring and tests where necessary.

- a. Minimum one number of cores through the full depth of the ground improvement piles / columns every 6m perimeter length of the shaft and minimum four number of cores for each shaft.
- b. For ground improvement at the base of the shaft, there shall be minimum one number of cores through the full depth of the ground improvement piles / columns.
- c. The cores shall be taken from the overlapping areas of the ground improvement piles. The coring locations shall be determined by the Supervising QP / Supervising QP (Geotechnical). The cored holes shall be grouted with cement bentonite.
- d. The quality of the ground improvement shall be determined from the total core recovery (TCR) and the strength 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 jet grout piles shall be carried out. If either of the additional coring fails to conform with the requirement, the ground improvement work is deemed to have failed.
- e. In addition to the TCR, presence of non-improved ground / non-properly improved ground should be recorded in the site inspection record. Such samples should be sent for strength testing.
- f. Refer to 6.5 and 6.6 for the strength testing requirements and acceptance criteria.

6.10 The Supervising QP / Supervising QP (Geotechnical) and Builder are to notify the Commissioner Building Control (CBC) where any individual strength test result fails to achieve 85% of the target value specified on the approved plans.

6.11 The strength shall comply with the design requirements. If any individual test result fails to achieve 85% of the characteristic value specified on the approved plans, two additional samples in the same core shall be tested. If either of the additional samples fails to conform with the requirement, the ground improvement is deemed to have failed.

6.12 If the ground improvement work is deemed to have failed, the Builder shall propose rectification measures for the Design QP / Design QP (Geotechnical)'s acceptance.

Summary of Coring and Testing Requirements for Ground Improvement Trial and Ground Improvement Installation

6.13 **Table 6.1** summarizes the minimum requirements for coring and testing to verify ground improvement quality.

Table 6.1: Coring and Testing Requirements for Ground Improvement in Cast-in-situ Caisson Shafts

Aspect	Requirements
Minimum number of trials	One number of ground improvement trial for each soil type to be treated for a project site. The trial ground improvement shall consist of a minimum three overlapping piles (for jet grouted piles) or three overlapping columns (for deep mixing) formed to the full depth and in similar ground conditions as the proposed ground improvement. The trial ground improvement shall be carried out using the same type of machine and the same operation parameters as the actual ground improvement works.
Minimum number of full depth coring and coring requirements	Two number of cores at overlapping areas of the JGP columns for the ground improvement trial. For perimeter ground improvement which provides temporary support during excavation: One number of cores every 6m perimeter length of the shaft at overlapping areas of the JGP columns, and minimum four number of cores for each shaft. A minimum of 1 test sample every 2m depth of each core from 3m below ground level or the top of the ground improvement, whichever is lower, to 1m below formation level. For ground improvement at the base of the shaft: Minimum one number of cores with minimum 1 test sample. Note: The cored holes shall be grouted with cement bentonite.
Acceptance criteria for strength	The strength test results must satisfy the following criteria: (a) Any individual test result > 85% of the design target value specified on the approved plans, and (b) Mean value of test results > 100% of the design target value specified on the approved plans. Alternatively, the Design QP / Design QP(Geotechnical) may adopt statistical methods accounting for an appropriate distribution of the test data, in compliance with Eurocodes.
Acceptance criteria for TCR	TCR > 85%. In addition to the TCR, presence of non-improved ground / non-properly improved ground should be recorded in the site inspection record, and samples should be sent for strength testing.

Section 7 Instrumentation and Monitoring Requirements

7.1 In the approved plans, the Design QP/ Design QP(Geotechnical) is to specify appropriate instrumentation and monitoring. The QP should assess that the provided instrumentation is able to provide early warning of excessive ground movement. Where possible, the instruments should be placed within 1~2m from the shaft.

7.2 **Table 7.1** summarizes the minimum requirements for instrumentation and monitoring of ERSS shafts for utility works. The QP shall specify additional instrumentation where necessary.

Table 7.1: Minimum Requirements for Instrumentation and Monitoring of ERSS Shafts for Utility Works.

Type of instruments (or equivalent)	Objective	Minimum requirements
Inclinometer	To measure lateral movement or wall deflection	Minimum 1 set of inclinometer and piezometer or water standpipe.
Piezometer, water standpipe	To measure groundwater pressure or groundwater level	To provide inclinometer at every potential weak point (e.g. utility gap) and higher risk location (e.g. near existing building). Example: A shaft contains 1 utility gap and there is 1 adjacent building next to the shaft. Provide 1 set of inclinometer and piezometer or water standpipe at the utility gap, and 1 inclinometer between the shaft and the adjacent building.
Rod-type ground settlement markers	To measure subsurface ground movement	Provide adequate number of markers at 3m interval along the shaft perimeter (for caisson shaft or partial caisson shaft) or at 5m interval along the shaft (for shaft with physical ERSS wall). Specify appropriate Work Suspension Level for ground settlement around the shaft.

Section 8. Construction Control and Supervision

8.1 For every critical construction stage or excavation stage for a caisson ring, the Supervising QP [QP(S)] shall check that the retaining wall system and its supports are constructed and performing in accordance with plans approved by the Commissioner of Building Control, before completing the Site Inspection and Approval Records (ERSS_Annex C) form and before allowing further building works or excavation work to proceed. Areas of check by QP(S) include the construction record and the testing result of the ground improvement and the caisson ring, the shape of the as-constructed caisson ring, e.g. circular shape, signs of visible soil ingress or significant water ingress (including water gushing), and instrumentation and monitoring results. Where appropriate, QP(S) may conduct remote supervision.

8.2 For caisson construction using perimeter ground improvement to support the excavation work, before construction of the 1st caisson ring, QP(S) is to complete checklist of Annex C-GI (see **Table 8.1**). The checklist is to verify that the ground improvement works are done according to approved plans and satisfy the required design parameters for shaft construction using cast-in-situ caisson with ground improvement.

8.3 During the construction of each caisson ring, site supervisors are to inspect and verify that there is no visible soil ingress or significant water ingress (including water gushing). If there is visible soil ingress or significant water ingress (including water gushing), QP(S) and Builder are to implement immediate measures to stop the ingress such as backfill or flood the shaft. In addition, the Builder shall immediately implement all necessary measures to maintain the property or building works in a safe condition. These measures include immediately notifying QP(S) of the incident and seeking QP(S)' advice and instruction on appropriate follow-up actions to be taken. The Builder and QP(S) shall notify the Commissioner of Building Control immediately of the incident of visible soil ingress or significant water ingress (including water gushing).

8.4 After construction of formwork and before casting, site supervisors are to measure that the design thickness of caisson ring shall be achieved.

8.5 For each caisson ring, immediately after excavation, site supervisors are to identify soft pockets / poorly formed GI through visual inspection and the use of pocket penetrometer (or equivalent means) every 3m interval along the shaft perimeter.

Note: For the purpose of this Circular, significant water ingress refers to water inflow that indicates the ERSS is not performing as intended and requires immediate remedial measures.

Table 8.1: Annex C-GI

CHECKLIST FOR SHAFT CONSTRUCTION USING CAST-IN-SITU CAISSON WITH GROUND IMPROVEMENT (GI) This checklist is to be prepared and certified before allowing excavation work for the next caisson ring to proceed. The checklist is to be attached as an attachment to form ERSS_Annex C. Project Ref: _____ Project Name: _____	
SECTION I <i>by the QP(S) (for non-GBW) and QP(S)(Geo) (for GBW) (please tick box when applicable)</i>	
I am satisfied that the constructed ERSS is in accordance with the approved plans: ☐ Ground improvement trial had been conducted. The core and test results of the GI meet the requirements of the design GI as per approved plans (to attach assessment report with the test records) ☐ Ground improvement installation had been completed. As-constructed GI records meet the design requirements. The core and test results of the GI meet the requirements of the design GI as per approved plans (to attach assessment report with the test records) ☐ For the construction of caisson ring no # _____, the exposed ground improvement surface was inspected, results of pocket penetrometer are satisfactory, thickness and shape of caisson ring are satisfactory.	
Name, stamp & signature of QP(S) Date: _____	☐ (tick for GBW) Name, stamp & signature of QP(Geo)(S) for GBW Date: _____

References

Building and Construction Authority. (2025). *Approved Document – Acceptable Solutions*.

Building and Construction Authority. (2009). *Advisory Note 01/09 on Earth Retaining or Stabilising Structures (ERSS)*.

BC1: 2023. Design Guide on Use of Alternative Structural Steel to Eurocode 3.

Geotechnical Society of Singapore. (2015). *Guide on Ground Investigation and Geotechnical Characteristic Values to Eurocode 7*.

Joint BCA/ ACES/ IES/ GeoSS Circular. (2024). *Requirements to Mitigate Risk Associated with Utility Gap within ERSS*.