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See **Distribution**

Dear Sir/Madam

ADVISORY NOTE 1/09 ON EARTH RETAINING OR STABILISING STRUCTURES (ERSS)

BCA is embarking on a comprehensive review all building control rules and regulations on a 3-year cycle basis with priority given to those rules that have significant impact on construction costs and those that have attracted frequent feedback from the industry. A review of BCA's requirements covering the design and construction of ERSS was recently carried out.

2 This circular is to inform you of the Advisory Note 1/09 which incorporates these changes that primarily relate to more relaxed allowable wall deflection limit for greenfield sites but subject to additional inspection, monitoring and checking procedures. The main changes include:

- a) Allowable wall deflection limits (Para 9 and 10)
- b) Ground improvement (Para 18, 19 and 20)
- c) Control Strategies (Para 22 and 23)
- d) Instrumentation and monitoring (Para 29)

3 This Advisory Note 1/09 will replace the Advisory Note 1/05 on Deep Excavation which was issued on 5 May 2005 with immediate effect.

4 The requirements of this Advisory Note are for compliance by QPs, ACs, site supervisors, builders and developers, where appropriate, in the design and construction of ERSS. I would appreciate it if you would disseminate the contents of this circular to your members' attention. The attached Advisory Note is also available on our website: www.bca.gov.sg.

5 Please contact me or Dr Poh Teoh Yaw at 63255181 or Mr Kiefer Chiam at Tel 63257492 if you need any clarification. Thank you.

Yours faithfully



YANG KIN SENG
DEPUTY DIRECTOR
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For COMMISSIONER OF BUILDING CONTROL

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ADVISORY NOTE 1/09 ON EARTH RETAINING OR STABILISING STRUCTURES

1 The safety of earth-retaining or stabilising structures (ERSS), whether they are temporary or permanent, is paramount, and all parties involved, namely Qualified Person (QP), QP(Geotechnical), AC, AC(Geotechnical), site supervisors, builders and developers should play their role in ensuring that all ERSS are structurally safe and robust. This Advisory Note provides the minimum requirements on the following key aspects pertaining to the design and construction of ERSS which shall be complied with by the appropriate persons:

- Section A: Site Investigation
 - Codes and standards
 - Extent of investigation
 - Ground water conditions
 - Existing building/structure conditions

- Section B: Design
 - Design considerations
 - Factor of safety
 - Structural steel
 - Allowable wall deflection limits
 - Soil parameters
 - Water pressures for design
 - Seepage control
 - Robustness of design
 - Numerical modelling
 - Sensitivity analysis
 - Ground improvement

- Section C: Construction
 - Multi-tier level monitoring
 - Control strategies
 - Comprehensive design review
 - Site inspection and construction controls

- Section D: Instrumentation and Monitoring

Section A: Site Investigation

Codes and standards

2 Proper site investigation shall be carried out for the design and construction of ERSS so as to give a thorough understanding, and to establish and determine the type and character of the ground conditions, and ground water conditions. It is guided by current codes and standards including:

- *BS 5930 Code of Practice for Site Investigations*
- *BS 1377 Methods of Test for Soils for Civil Engineering Purposes*
- *BS 8002 Code of Practice for Earth Retaining Structures*
- *BS 8081 Code of Practice for Ground Anchorages*
- *CP4:2003 Code of Practice for Foundations*

Extent of investigation

3 The site investigation including boreholes and tests shall be carried out to establish adequately the ground characteristics and conditions, and its variability for purposes of ERSS design and construction. At critical areas and excavation in difficult or complex ground conditions e.g. poor or mixed soils, the spacing and location of investigation or exploration points or boreholes shall appropriately be closer. Additional boreholes/cone penetration tests should be conducted between boreholes to establish ground variability, and to determine and delineate the penetration depth of the retaining walls. For ground anchorages, the locations should also be sited along the line of the probable fixed anchor zone.

Ground water conditions

4 Water levels encountered during boring operations are known to be unreliable and they seldom represent equilibrium conditions. Standpipes and piezometers should be installed to determine the ground water conditions and pore water pressures. Establishment of ground water conditions should include tidal and flood conditions.

Existing building/structure conditions

5 Pre-construction surveys shall be carried out to establish the condition of surrounding properties including obtaining the plans of existing buildings and structures. Special attention shall be paid to those buildings or structures that are sensitive to ground deformation, especially differential movements.

Section B: Design

Design considerations

6 The design of ERSS shall take into account the key design considerations tabulated in the forms *Exc_erss_Annex A* and *Exc_UBW_Annex A* (for ERSS which are classified as Underground Building Work) on "Design Considerations for Earth Retaining or Stabilising Structures (ERSS)" shown in Appendix.

Factor of safety

7 ERSS shall be designed with adequate safety factor that is not less than that of permanent works and the calculations shall take full account of the tolerances adopted. Temporary ERSS shall not have lower factor of safety and no material overstress is allowed. Among other considerations, the factor of safety shall take into account abnormal risks or unusual or difficult ground or loading conditions, soil characteristics, extreme soil and groundwater conditions, need to restrict deformation, the consequence of failure and the impact of surrounding properties.

Structural steel

8 For structural steelwork of ERSS, BS 5950 on Structural Use of Steelwork in Building and BS 5950:2008 on Design Guide on Use of Alternative Steel Materials to BS 5950 shall be followed. Where re-used structural steel is used, the structural design shall fully consider any imperfections and conditions of such materials.

Allowable wall deflection limits

9 One of the key considerations in the design and construction of ERSS is to achieve structural serviceability by limiting the wall movement of ERSS so as to ensure that the design strength of the soil does not mobilise excessive ground strains. Table 1 shows the allowable maximum wall deflection limits for different zones. Where there are existing structures within a distance of H from the edge of the excavation (where H is the excavation depth), denoted as Zone 1, the allowable limit should not exceed 0.5%H. Where there are existing structures within a zone of between H and 2H from the edge of the excavation, denoted as Zone 2, the allowable limit should not exceed 0.7%H. In Zone 3 where existing structures are more than 2H from the edge of the excavation, the allowable limit should not exceed 0.7%H for ground Type A, and 1.0%H for ground Type B. Ground Type A refers to over-consolidated stiff clays and silts, residual soils, and medium to dense sands; and Ground Type B refers to soft clays, silts or organic soils extending to or below formation level (e.g. Kallang Formation) and loose fills. The allowable wall deflection limits for Ground Type B in Table 1 also apply for cases where Ground Type B is treated with ground improvement techniques such as JGP, etc.

10 In any case, the allowable wall deflection limits shall also be determined by the prevention of structural damage to neighbouring buildings or structures arising from ground deformations.

Table 1: Allowable maximum ERSS wall deflection limits

Wall deflection limits/Zones where x = distance from excavation face; H = excavation depth δ_w = wall deflection	Locations of buildings, structures and critical utilities			
	Zone 1 ($x/H < 1$)	Zone 2 ($1 \leq x/H \leq 2$)	Zone 3 ($x/H > 2$)	
			Ground Type A	Ground Type B
Allowable maximum ERSS wall deflection limits (δ_w/H)	0.5%	0.7%	0.7%	1.0%

Soil parameters

11 In assessing the shear strength, influence due to factors such as stress level imposed on the soil, strain rate effects, large strain situation, time effects, and sensitivity shall be considered. The values for the representative strength values shall make due allowance for the influence of sampling and the method of testing as well as for likely softening on excavation.

Water pressures for design

12 Water pressure regime used in the design shall be the most onerous that is considered to be reasonably possible for both active pressure and passive resistance. This includes the potentially high pore water pressures on the passive side.

Seepage control

13 Design of ERSS should provide for adequate seepage cutoff, and where appropriate, re-charge wells, to minimize damage to surrounding structures caused by settlements arising from the lowering of ground water or piezometric levels.

Robustness of design

14 ERSS shall be robust and incorporate sufficient redundancy to avoid catastrophic collapse of support system resulting from an isolated case of overloading or failure of any particular element. In addition to the earth pressures under all identifiable conditions and surcharge/building loads, the design and construction of ERSS shall also consider

- accidental load
- one-strut failure
- material deficiencies and construction imperfections
- abnormal loads, particularly from construction surcharges, and higher groundwater levels caused by flooding or water-filled tension cracks; and
- eccentric loads or out-of-balance forces and reactions from the support systems, both temporary and permanent e.g. due to inclined anchors or struts

Numerical modelling

15 Experienced users with fundamental understanding of soil mechanics and clear understanding of numerical modelling, particularly the limitations, shall supervise the use of advanced numerical analyses e.g. use of finite element method in geotechnical design. On the use of computer software, the users are advised to follow the guidelines in "*The use of computers for engineering calculations*" published by The Institution of Structural Engineers, UK (Mar 2002); and "*Guidelines for the use of advanced numerical analysis*" edited by David Potts, Kennet Axelsson, Lars Grande, Helmut Schweiger and Michael Long (Thomas Telford, 2002).

Sensitivity analyses

16 For the design of ERSS, especially in difficult or poor ground conditions or for deeper excavations, the designer shall not rely merely on 'one-off' analysis, in which a single set of geotechnical parameters is used, and the results of the analysis then taken as 'the prediction' of deformations, loads and stresses. The analyses should include variations in the input parameters within a reasonable range corresponding to those actually determined from the site investigation and ground conditions, and to examine critically the effects of such variations on the computed deformations, loads and stresses.

17 Sensitivity analyses should be performed as part of the design to demonstrate that the design and the models are not unduly sensitive to variations in any of the input parameters such as shear strength, soil stiffness and reduced wall stiffness due to cracking. It should also cover the effect of time on the soil conditions and its impact on the performance of ERSS.

Ground improvement

18 The use of ground improvement measures such as jet-grouted piles (JGP), or deep soil/cement mixing (DSM or DCM) shall be restricted to ground strengthening or soil improvement works. It shall not be used as part of the ERSS structural support system or compressive strutting system for ERSS.

19 When ground improvement layer is used as a base shear plug below the formation level, continuous monitoring of deformation should be in place to validate ERSS design to ensure that ERSS is performing in accordance to design. If ground improvement layer is used to control basal heave and or where the design of ERSS relies on the interface shear resistance between the improved ground mass and the piles which are used to anchor the ground improvement layer, continuous monitoring of basal heave and pore pressures should be implemented to provide continuous checks on the stability of the entire system.

20 The design of ground improvement mass as gravity retaining structure shall comply with BS8002.

Section C: Construction

Multi-tier level monitoring

21 The performance of ERSS shall be monitored at all stages. In addition to the allowable limits based on the predicted maximum values for monitoring, corresponding pre-determined values shall be determined for each construction stage, support or strutting level. If the monitoring results exceed the corresponding pre-determined values, the design should be reviewed and assessed, and the design adequacy for all remaining stages should be evaluated. The design should also be checked independently.

Control strategies

22 The performance of ERSS shall be monitored and checked throughout the construction. Table 2 shows the control strategies guide which should be put in place as a control procedure by the QP and the builder for monitoring and checking the performance of ERSS during construction stage.

- a) Check Level. For excavation where buildings, structures or critical utilities are located in Zone 2 and Zone 3, check level is at 50% of allowable maximum wall deflection value given in Table 1. When check level is reached, the designer shall confirm or recalibrate the design assumptions made with appropriate corrective actions to be taken by the QP and the builder.
- b) Alert Level. Alert level is at 70% of allowable maximum wall deflection value given in Table 1. When the alert level is reached, updated predictions of future performance should then be made to consider whether to re-engineer the remaining excavation works.
- c) Work Suspension Level. Work suspension level is given by the allowable maximum wall deflection value in Table 1. When the work suspension level is reached, work must be stopped and immediate measures shall be implemented to remove any danger that is likely to cause a risk of injury or damage to adjoining properties.

Table 2: Control strategies guides for ERSS.

Zone 1	Allowable limits		
	Alert level	Work suspension level	
	70% WSL	Allowable wall deflection limit	
Zones 2 and 3	Allowable limits		
	Check level	Alert level	Work suspension level
	50% WSL	70%WSL	Allowable wall deflection limit

23 QP is required to inform BCA monthly of the results of the monitoring of the ground movements using form Exc_Annex E or Exc_UBW_Annex E (for ERSS which are classified as Underground Building Works). When the alert level or work suspension level is exceeded, QP is required to inform BCA immediately.

Comprehensive design review

24 A comprehensive design review shall be carried out when wall deflection has exceeded work suspension level or any structural element of ERSS has exceeded the design level or where there is structural distress. The works shall be stopped and made safe pending the outcome of the review. Construction shall not proceed until proper remedial actions have been put in place. As a minimum, the review shall include full analyses with justifications and validation for the design to be performed to assess and check on the stability requirements and to ensure that all minimum mobilisation factors, load factors and safety factors including robustness considerations are adequately met. The design and its assumptions shall be reviewed based on observed performance with recommendation on design modifications, preventive/contingency or protective measures and working procedures to ensure safety of the excavation and to prevent unacceptable impacts on the surrounding buildings and properties.

Site inspection and construction controls

25 Form “Certification by QP and the builder” shown in Annex B shall be used in conjunction with the permit of building works for ERSS. During construction, the builder shall obtain approvals, in a form on “Site Inspection & Approval Records and Ground Movement Assessment” shown in Annex C, from the appropriate QP/AC that the ERSS is in accordance to design, before proceeding with any excavation at critical stages and at every support or strut level. For ground movement monitoring control at every support or strut level, the form on “Ground Movement Assessment Record” shown in Annex D should be used.

Section D: Instrumentation and Monitoring

26 As a minimum, monitoring of wall and ground deformation, anchor/strut loads and piezometric pressures shall be carried out within and outside the excavation to provide data for design review on the performance. Control sections of ERSS shall be identified and adequately instrumented with the validation or calibration between the design/predicted and actual values to be verified as early as possible during the construction stage.

27 The strain gauges for member forces shall be properly installed, calibrated and checked for meaningful interpretation and monitoring as the readings could be affected by many factors such as non-uniform stresses, temperature, joints, strut installation and pre-loading.

28 Caution shall be exercised when evaluating strut force by hydraulic jacking. In addition to the use of calibrated jacks, the loads shall be independently confirmed by calibrated load cell.

29 Movement of adjacent ground shall be monitored with appropriate allowable limits to safeguard against any adverse construction effects to neighbouring properties during the installation or construction of jet grout piles (JGP), deep soil/cement mixing etc and trenching of the ground e.g. to form diaphragm walls.

References

- 30 References include the following:
- BS 5930:1999 *Code of Practice for Site Investigations*
 - BS 1377:1990 *Methods of Test for Soils for Civil Engineering Purposes*
 - BS 8002:1994 *Code of Practice for Earth Retaining Structures*
 - BS 5950-1:2000 *Structural Use of Steelwork in Building*
 - BS 8081:1989 *Code of Practice for Ground Anchorages*
 - BS EN 12716:2001 *Execution of Special Geotechnical Works - Jet Grouting*
 - *Temporary Propping of Deep Excavations - Guidance on Design*, CIRIA C517, 1999
 - *Design and Construction of Deep Basements including Cut-and-Cover Structures*, IstructE Publication, UK, 2004
 - *Guidelines of Engineering Practice for Braced and Tied-back Excavations*, Geotechnical Special Publication No. 74, ASCE
 - *Review of Design Methods for Excavation*, Geotechnical Engineering Office, Civil Engineering Department, GCO Publication, Hong Kong
 - *The Use of Computers for Engineering Calculations* by The Institution of Structural Engineers (Mar 2002)
 - *Guidelines for the Use of Advanced Numerical Analysis*, David Potts, Kennet Axelsson, Lars Grande, Helmut Schweiger and Michael Long, Thomas Telford, 2002
 - *Forms Annex A, B, C and D* can be obtained from http://www.bca.gov.sg/StructuralPlan/structural_plan_appInforms.html

Appendix

a) Annexes for ERSS

DESIGN CONSIDERATIONS FOR EARTH RETAINING OR STABILISING STRUCTURES (ERSS)

Project Ref: _____ Project Name: _____

(note : this form is to be completed and attached to the design calculations)

SECTION I (to be completed by the QP(D) for ERSS)**1** Key design considerations

I have designed ERSS in accordance with the building codes and regulations. I confirm that the ERSS design is structurally safe and robust. As a minimum, I have taken into account the following aspects:

- Adequate and appropriate site investigation;
- Proper evaluation and selection of the soil parameters for design;
- Effects due to onerous water pressures and seepage forces;
- Effects due to onerous soil loading conditions from both drained and undrained conditions of the soils, as well as the effect of time on soil drainage conditions;
- 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 including removal stages;
- Design robustness and redundancy considerations which shall include one-strut failure, accidental loads etc;
- Adequacy of wall embedment against toe kick-out and seepage control, etc;
- Adequate factor of safety against overall wall stability and basal heave/hydraulic uplift/piping;
- Structural adequacy of wall and supporting system e.g walers, struts, anchors etc;
- Provision of proper continuous concrete packing between waler and wall, preloading of struts, adequate stiffeners and temperature effect;
- Provision of restraints in structural members' connections, ties and bracings;
- Sensitivity analyses and impact on the performance of ERSS;
- Effects due to ground water lowering;
- Effects of ground deformation on neighbouring properties.

2 Other specific controls on design

I have also allowed in my design the following:-

- Construction tolerances and material imperfections; and no allowance for any material overstress;
- Full water table level or onerous water conditions and seepage pressures acting on both sides on the wall;
- Factor of safety for the design shall not be less than that for permanent works;
- Mobilization factors of not less than 1.2 and 1.5 for effective stress and total stress parameters respectively for limit equilibrium calculations; and
- Unplanned excavation.

Name, stamp & signature of QP(D)

Date: _____

SECTION II* (to be completed by the AC for ERSS)

I have independently reviewed and checked the design and construction methodology of ERSS to satisfy that the ERSS is structurally safe and robust and the measures are also adequate to safeguard the neighbouring properties, and is in accordance to the building codes and regulations.

Name, stamp & signature of AC*

Date: _____

Note:

* Only applicable for AC application.

Project Ref: _____

Project Name: _____

SECTION I (to be completed by the QP(S) for ERSS)	
1	Construction Sequence
a	I append below the construction plans and work sequence. I confirm that the builder's detailed excavation plan is fully in accordance to the ERSS design, and shall instruct the builder to seek my approval before proceeding with any excavation at every strut level.
2	Inspection of erected works
a	I shall check that ERSS are constructed in accordance to my design and assess its performance at every strut level before giving approval to the builder for further excavation.
b	I shall carry out site inspections, including but not limited to the following:- <ul style="list-style-type: none"> • Check that the as-constructed embedded piled wall sizes and penetration depths are in accordance to my design • Check that the structural sections, connections and bracings are structurally adequate and robust; and they are timely installed in accordance to my design • Check that the structural supporting elements used on site are in accordance to the drawings, free from defects, not damaged or deformed, and all are within the tolerances allowed for in my design. • Check that the actual soil and water conditions, loads and pressures do not exceed design limits and assumptions.
3	Ground movement monitoring
a	I shall ensure that an adequate instrumentation and monitoring plan is executed and in place on site before the commencement of ERSS. (The locations, number and types of instruments as well as the frequency of taking readings and other instrumentation measures are shown on the plans).
b	I shall closely monitor the site to inspect and ensure that all deformations, loads and pressures do not exceed critical limits. I shall take necessary preventive, protective and remedial actions on site in consultation with appropriate QP and AC, the builder and the client/developer, in order to remove danger immediately and prevent damage to surrounding properties.
4	Monitoring and Inspections
a	I shall ensure that the monitoring readings are properly and timely taken and assessed.
b	I shall conduct regular site inspections and assess the actual performance of ERSS to ensure that the safe condition of ERSS is maintained at all times as long as the excavations remain.
c	I shall instruct the builder to take corrective action immediately and notify BCA if any of the critical limits is reached or if there is damage to the neighbouring properties.
d	I shall ensure that copies of "Site Inspection & Approval Records" and "Ground Movement Assessment Records" are kept on site.
<p>_____</p> <p>Name, stamp & signature of QP(S)</p> <p>Date: _____</p>	
SECTION II (to be completed by the builder)	
1	Erection of ERSS
a	I shall comply with the endorsed construction plans and sequence stipulated by the QP and accordingly produce a detailed excavation plan. All excavation works shall be executed in accordance with the QPs' endorsed plans. I shall have obtained the QPs' approval before proceeding with any excavation.
b	I shall implement and maintain the QPs' endorsed instrumentation and monitoring plan.
c	I shall ensure that the monitoring readings are properly taken by trained persons and to be overseen by the site supervisor, or the QP.
d	I shall ensure that all ERSS works are executed within the critical limits. If any of the allowable limits of ground movement is reached or there is damage to neighbouring properties, I shall take corrective actions, remove danger immediately and notify BCA, QP for ERSS, and QP(S).
2	Contingency measures
a	I have prepared a contingency plan in consultation with the QP(S) and ensure that adequate resources are on standby to implement the plan when needed.
<p>_____</p> <p>Name & signature of builder Date: _____</p>	

SITE INSPECTION & APPROVAL RECORDS

Project Ref.: _____ Project Name: _____

(This report is to be promptly updated by the QP(S) for ERSS and builder at every strut level and timely submitted to the QP(S). The QP(S) must ensure that a copy of each of these completed reports is kept on site)

Location/Section: _____

Stage of ERSS Erection and Removal of Strut/anchors	Depth of strut level* from ground surface	Dates of QP's site inspections of embedded walls/piling/ ERSS**	Grid references of areas inspected	QP's approval given to builder to proceed with excavation or strut removal to next level. (Sign & Date)	Comments
Installation of embedded walls for ERSS	N.A				
At Strut level no. 1					
At Strut level no. 2					
At Strut level no.()					

Notes: * Strut level is measured from the ground surface downwards.

** ERSS refers to the earth retaining or stabilising structures or system including embedded walls, earth berms, struts, walers, connections, kingposts, all structural components and measures which are integral in ensuring stability and structural integrity.

I confirm that the above information is accurate and correct and I am satisfied that ERSS as constructed are fully in accordance with the design calculations and construction plans. I have given the approval to the builder to proceed excavation or strut/anchor to the next level/stage.

Name, stamp & signature of QP(S)

Date: _____

I confirm that I have constructed the ERSS according to the QPs' plans and design calculations; and upon the completion of each and every strut level, I have obtained the QPs' approval before further excavation or strut/anchor to the next level.

Name, stamp & signature of builder

Date : _____

Review by the AC* :-

I have reviewed the as-installed key structural elements of the building works and earth retaining structures and am satisfied that they do not show any inadequacy. I agree with the QP's approval for the builder to proceed excavation or removal of strut/anchor to the next level/stage.

Name, stamp & signature of AC*

Date: _____

*Only applicable for AC application

GROUND MOVEMENT ASSESSMENT RECORD

Project Ref.: _____ Project Name: _____

(This record is to be completed by the QP(S) promptly upon the completion of every strut level and a copy must be kept on site)

Location/Section: _____

1 Assessment of ground movements:

a I have assessed the results taken from the monitoring instrumentation and site observations. The maximum measured movements are:

Wall lateral deflection : _____ mm

Ground settlement reading : _____ mm

b I have inspected the site and its neighbouring areas, and assessed the performance of ERSS as constructed; and I am satisfied that ERSS is structurally adequate and the works can safely proceed to the next excavation stage.

2 Actions taken

a # I am not satisfied with ERSS as installed and its performance, and its shortcomings are as follows:

b # I have taken the following immediate actions:

Name, stamp & signature of QP(S)

Date:

3 Taking of monitoring readings:

a I confirm that the ERSS have been constructed according to the construction plans and design calculations endorsed by the QP.

b I confirm that the readings of the monitoring instruments from _____ to _____ (dates) are properly taken by instrumentation specialist. I have kept a record of the dates and times of these events including the construction/excavation activities.

Other comments:

Name & signature of Site Supervisor(s)

Date: _____

Note: # delete if not applicable

Monthly Instrumentation and Monitoring for Excavation Works

(This form shall be completed and submitted to CBC/BCA by 7th day of the following month. The form shall be duly signed and endorsed by the QP(Supervision) appointed under Section 8(1)(b) or 11(1)(d)(ii) of the Bldg Control Act)

For the month of _____ Year _____

Project Ref. No.	
Project Title	

Site Location: _____

Instrumentation Monitoring (fill in this section only if the critical levels are exceeded)

Ground lateral movement					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

Ground/building settlement/vertical movement					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

Other Instruments : e.g. strut force, ground water level, pressures etc (if available)					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

I declare that for the month of _____

- *a) none of the instrumentation movement readings has exceeded the critical levels.
- *b) monitoring readings have exceeded the alert level as shown above. My follow-up action is in the attached report.
- *c) monitoring readings have exceeded the work suspension level and work at site has been suspended. I have directed the builder to take corrective action to ensure safety as shown in the attached report.
- *d) The basement structure or backfilling works have been completed. I declare that I have inspected the site and its surroundings and confirm that they are stable and there are no safety issues anticipated. This is the last monthly declaration on instrumentation and monitoring for excavation works.

*Delete as appropriate

QP(S): _____ Name/PE's Stamp/Signature	
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Note: Critical level means either alert level or work suspension level.

(Under Section 20 of the Building Control Act, any person who makes or produces any declaration, report, record, document etc which is false in a material particular, shall be guilty of an offence.)

b) Annexes for ERSS

(For ERSS which are classified as Underground Building Works i.e. when geotechnical aspects of the ERSS require checking by a specialist accredited checker)

DESIGN CONSIDERATIONS FOR EARTH RETAINING OR STABILISING STRUCTURES (ERSS)

Project Ref: _____ **Project Name:** _____

(note : this form is to be completed and attached to the design calculations)

SECTION I (to be completed by the QP(D) and QP(Geo)(D) for ERSS)

1 **Key design considerations**
 I have designed ERSS in accordance with the building codes and regulations. I confirm that the ERSS design is structurally safe and robust. As a minimum, I have taken into account the following aspects:

- Adequate and appropriate site investigation;
- Proper evaluation and selection of the soil parameters for design;
- Effects due to onerous water pressures and seepage forces;
- Effects due to onerous soil loading conditions from both drained and undrained conditions of the soils, as well as the effect of time on soil drainage conditions;
- 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 including removal stages;
- Design robustness and redundancy considerations which shall include one-strut failure, accidental loads etc;
- Adequacy of wall embedment against toe kick-out and seepage control, etc;
- Adequate factor of safety against overall wall stability and basal heave/hydraulic uplift/piping;
- Structural adequacy of wall and supporting system e.g walers, struts, anchors etc;
- Provision of proper continuous concrete packing between waler and wall, preloading of struts, adequate stiffeners and temperature effect;
- Provision of restraints in structural members' connections, ties and bracings;
- Sensitivity analyses and impact on the performance of ERSS;
- Effects due to ground water lowering;
- Effects of ground deformation on neighbouring properties.

2 **Other specific controls on design**
 I have also allowed in my design the following:-

- Construction tolerances and material imperfections; and no allowance for any material overstress;
- Full water table level or onerous water conditions and seepage pressures acting on both sides on the wall;
- Factor of safety for the design shall not be less than that for permanent works;
- Mobilization factors of not less than 1.2 and 1.5 for effective stress and total stress parameters respectively for limit equilibrium calculations; and
- Unplanned excavation.

Name, stamp & signature of QP(D)
Date: _____

Name, stamp & signature of QP(Geo)(D)*
Date: _____

SECTION II (to be completed by the AC and AC(Geo) for ERSS)

I have independently reviewed and checked the design and construction methodology of ERSS to satisfy that the ERSS is structurally safe and robust and the measures are also adequate to safeguard the neighbouring properties, and is in accordance to the building codes and regulations.

Name, stamp & signature of AC
Date: _____

Name, stamp & signature of AC(Geo)*
Date: _____

* For geotechnical aspects of the UBW

CERTIFICATIONS BY QPs and BUILDER

Exc_UBW_Annex B

Project Ref: _____ **Project Name:** _____

SECTION I (to be completed by the QP(S) and QP(Geo)(S) for ERSS)	
1	Construction Sequence a I append below the construction plans and work sequence. I confirm that the builder's detailed excavation plan is fully in accordance to the ERSS design, and shall instruct the builder to seek my approval before proceeding with any excavation at every strut level.
2	Inspection of erected works a I shall check that ERSS are constructed in accordance to my design and assess its performance at every strut level before giving approval to the builder for further excavation. b I shall carry out site inspections, including but not limited to the following:- <ul style="list-style-type: none"> • Check that the as-constructed embedded piled wall sizes and penetration depths are in accordance to my design • Check that the structural sections, connections and bracings are structurally adequate and robust; and they are timely installed in accordance to my design • Check that the structural supporting elements used on site are in accordance to the drawings, free from defects, not damaged or deformed, and all are within the tolerances allowed for in my design. • Check that the actual soil and water conditions, loads and pressures do not exceed design limits and assumptions.
3	Ground movement monitoring a I shall ensure that an adequate instrumentation and monitoring plan is executed and in place on site before the commencement of ERSS. (The locations, number and types of instruments as well as the frequency of taking readings and other instrumentation measures are shown on the plans). b I shall closely monitor the site to inspect and ensure that all deformations, loads and pressures do not exceed critical limits. I shall take necessary preventive, protective and remedial actions on site in consultation with appropriate QP and AC, the builder and the client/developer, in order to remove danger immediately and prevent damage to surrounding properties.
4	Monitoring and Inspections a I shall ensure that the monitoring readings are properly and timely taken and assessed. b I shall conduct regular site inspections and assess the actual performance of ERSS to ensure that the safe condition of ERSS is maintained at all times as long as the excavations remain. c I shall instruct the builder to take corrective action immediately and notify BCA if any of the critical limits is reached or if there is damage to the neighbouring properties. d I shall ensure that copies of "Site Inspection & Approval Records" and "Ground Movement Assessment Records" are kept on site.
<p>_____ Name, stamp & signature of QP(S) Date: _____</p>	<p>_____ Name, stamp & signature of QP(Geo)(S)* Date: _____</p>
SECTION II (to be completed by the builder)	
1	Erection of ERSS a I shall comply with the endorsed construction plans and sequence stipulated by the QP and accordingly produce a detailed excavation plan. All excavation works shall be executed in accordance with the QPs' endorsed plans. I shall have obtained the QPs' approval before proceeding with any excavation. b I shall implement and maintain the QPs' endorsed instrumentation and monitoring plan. c I shall ensure that the monitoring readings are properly taken by trained persons and to be overseen by the site supervisor, or the QP. d I shall ensure that all ERSS works are executed within the critical limits. If any of the allowable limits of ground movement is reached or there is damage to neighbouring properties, I shall take corrective actions, remove danger immediately and notify BCA, QPs for ERSS, and QP(S).
2	Contingency measures a I have prepared a contingency plan in consultation with the QP(S) and ensure that adequate resources are on standby to implement the plan when needed.
<p>_____ Name & signature of builder Date: _____</p>	

*For geotechnical aspects of the underground building works

SITE INSPECTION & APPROVAL RECORDS

Project Ref.: _____ **Project Name:** _____
 (This report is to be promptly updated by the QP(S) and QP(Geo)(S) for ERSS and builder at every strut level and timely submitted to the QP(S). The QP(S) must ensure that a copy of each of these completed reports is kept on site)

Location/Section: _____

Stage of ERSS Erection and Removal of Strut/anchors	Depth of strut level* from ground surface	Dates of QP's site inspections of embedded walls/piling/ ERSS**	Grid references of areas inspected	QP's approval given to builder to proceed with excavation or strut removal to next level. (Sign & Date)	Comments
Installation of embedded walls for ERSS	N.A				
At Strut level no. 1					
At Strut level no. 2					
At Strut level no.()					

Notes: * Strut level is measured from the ground surface downwards.
 ** ERSS refers to the earth retaining or stabilising structures or system including embedded walls, earth berms, struts, walers, connections, kingposts, all structural components and measures which are integral in ensuring stability and structural integrity.

I confirm that the above information is accurate and correct and I am satisfied that ERSS as constructed are fully in accordance with the design calculations and construction plans. I have given the approval to the builder to proceed excavation or strut/anchor to the next level/stage.

Name, stamp & signature of QP(S)
Date: _____

Name, stamp & signature of QP(Geo)(S)*
Date: _____

*For geotechnical aspects of the underground building works

I confirm that I have constructed the ERSS according to the QPs' plans and design calculations; and upon the completion of each and every strut level, I have obtained the QPs' approval before further excavation or strut/anchor to the next level.

Name, stamp & signature of builder

Date : _____

Review by the AC and AC(Geo) :-	
I have reviewed the as-installed key structural elements of the building works and earth retaining structures and am satisfied that they do not show any inadequacy. I agree with the QP(s)'s approval for the builder to proceed excavation or removal of strut/anchor to the next level/stage.	
_____ Name, stamp & signature of AC Date: _____	_____ Name, stamp & signature of AC(Geo)* Date: _____
*For geotechnical aspects of the underground building works	

GROUND MOVEMENT ASSESSMENT RECORD

Project Ref.: _____ Project Name: _____

(This record is to be completed by the QP(S) and QP(Geo)(S) promptly upon the completion of every strut level and a copy must be kept on site)

Location/Section: _____

1 Assessment of ground movements:

a I have assessed the results taken from the monitoring instrumentation and site observations. The maximum measured movements are:

Wall lateral deflection : _____ mm

Ground settlement reading : _____ mm

b I have inspected the site and its neighbouring areas, and assessed the performance of ERSS as constructed; and I am satisfied that ERSS is structurally adequate and the works can safely proceed to the next excavation stage.

2 Actions taken

a # I am not satisfied with ERSS as installed and its performance, and its shortcomings are as follows:

b # I have taken the following immediate actions:

Name, stamp & signature of QP(S)

Date: _____

Name, stamp & signature of QP(Geo)(S)*

Date: _____

3 Taking of monitoring readings:

a I confirm that the ERSS have been constructed according to the construction plans and design calculations endorsed by the QP.

b I confirm that the readings of the monitoring instruments from _____ to _____ (dates) are properly taken by instrumentation specialist. I have kept a record of the dates and times of these events including the construction/excavation activities.

Other comments:

Name & signature of Site Supervisor(s)

Date: _____

Note: # delete if not applicable

*For geotechnical aspects of the underground building works

Monthly Instrumentation and Monitoring for Excavation Works

(This form shall be completed and submitted to CBC/BCA by 7th day of the following month. The form shall be duly signed and endorsed by the QP(Supervision) appointed under Section 8(1)(b) or 11((1)(d)(ii), and QP(Geo) (Supervision) appointed under Section 8(1)(d)(ii) or 11((1)(d)(iii) of the Bldg Control Act)

For the month of _____ Year _____

Project Ref. No.	
Project Title	

Site Location: _____

Instrumentation Monitoring (fill in this section only if the critical levels are exceeded)

Ground lateral movement					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

Ground/building settlement/vertical movement					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

Other Instruments : e.g. strut force, ground water level, pressures etc (if available)					
Instrument Ref.	Actual current reading exceeded critical level (mm)	Check level (mm)	Alert level (mm)	Work Suspension level (mm)	Date of Reading

I declare that for the month of _____

- *a) none of the instrumentation movement readings has exceeded the critical levels.
- *b) monitoring readings have exceeded the alert level as shown above. My follow-up action is in the attached report.
- *c) monitoring readings have exceeded the work suspension level and work at site has been suspended. I have directed the builder to take corrective action to ensure safety as shown in the attached report.
- *d) The basement structure or backfilling works have been completed. I declare that I have inspected the site and its surroundings and confirm that they are stable and there are no safety issues anticipated. This is the last monthly declaration on instrumentation and monitoring for excavation works.

*Delete as appropriate

QP(S): _____ Name/PE's Stamp/Signature	QP(Geo)(S): _____ Name/PE's Stamp/Signature
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Note: Critical level means either alert level or work suspension level.

(Under Section 20 of the Building Control Act, any person who makes or produces any declaration, report, record, document etc which is false in a material particular, shall be guilty of an offence.)