SC6.10 City Plan policy – Geotechnical stability assessment guidelines

1 Purpose

This City Plan policy provides advice and guidance on how to prepare a geotechnical stability assessment report when the development:

(a) is located on any lot partially or completely subject to the **landslide hazard overlay map**; and/or

(b) proposes the use of batters and/or retaining structures.

2 Application

This City Plan policy assists with satisfying the assessment benchmarks in the City Plan for developments with geotechnical stability issues as outlined in the table below:

Table 1: Application – Geotechnical stability assessment guidelines

Section or table in the code	Assessment benchmark reference	Section in policy
Change to ground level and creation of new waterways code		
Overall outcome	2(a)	~~Section 4~~ All
Landslide hazard overlay code		
Table 8.2.11-1 – Landslide hazard overlay code – for accepted development subject to requirements	Site slope constraints RO1	Section 5 and 6
Table 8.2.11-2 – Landslide hazard overlay code – for assessable development	Site slope constraints PO1	Section 5 and 6
Table 8.2.11-2 – Landslide hazard overlay code – for assessable development	Slope constraints and stability PO5	Section 5, 6 and 8.

3 Developments with geotechnical stability issues

This policy identifies two (2) types of developments involving geotechnical stability issues, these are:

(a) developments within landslide hazard areas; and

(b) developments involving batters and/or retaining structures.

4 Geotechnical stability assessment report requirements

The following sections describe the extent of geotechnical stability issues, assessments and certifications that may need to be included in the geotechnical stability assessment report.

5 Developments within landslide hazard areas

For any proposed development on land within landslide hazard areas, as identified on the **Landslide hazard overlay map**, there is a risk of landslide that must be assessed by a qualified expert and submitted to the City for assessment.

The level of landslide risk depends on a number of factors including, but not limited to the following:

(a) ground slope angle and shape;

(b) characteristic geology;

(c) strength of geomaterials and its distribution within the subsurface;

(d) landslide history;

(e) presence of existing or recent past instability i.e. slips, slumps, hummocky ground etc;

(f) emergent seepages and depth of groundwater table; and

(g) potential for surface run-off concentration, orientation of rock mass defects etc.

The applicant needs to assess the risk of landslide which may adversely affect the subject site, adjoining properties and the proposed development.

5.1 Landslide risk assessment

This section outlines:

(a) the details of landslide risk assessment; and

(b) geotechnical certifications required by the City for any proposed development within landslide hazard areas.

5.1.1 Details of landslide risk assessment

The landslide risk assessment for the proposed development site should be conducted by a Registered Professional Engineer of Queensland (RPEQ) specialising in geotechnical engineering, particularly experienced in landslide risk assessment and management.

The landslide risk assessment should be carried out using the following:

(a) site-specific geotechnical information;

(b) site slope gradient and shape;

(c) surface features;

(d) historical landslide information, where available;

(e) emergent seepages and groundwater table;

(f) drainage conditions; and

(g) any other relevant information of the site.

The landslide risk assessment results should be included in the geotechnical stability assessment report.

For any proposed development or re-development on any site/lot mapped on the **Landslide hazard overlay map**, a 'landslide relative susceptibility' analysis should be carried out first using the Landslide Susceptibility Analysis Form attached in **Appendix 1**.

The calculated relative susceptibility should then be correlated to susceptibility rating using the table given in **Appendix 2**.

5.1.2 Landslide susceptibility rating analysis is 'low' or 'very low'

If the result of the landslide susceptibility rating analysis is 'low' or 'very low', then the following is required:

(a) undertake a further risk assessment of the proposed development impacting any adjoining buildings/properties; and

(b) certification from a RPEQ specialising in geotechnical engineering. This certification needs to confirm:

  (i) the proposed development site/lot has been assessed with a landslide risk rating of 'low' or 'very low'; and

  (ii) the proposed development will not cause any adverse impact on any adjoining buildings, properties and infrastructure.

5.1.3 Landslide susceptibility rating analysis is 'moderate','high' or 'very high'

If the result of the landslide susceptibility rating analysis is 'moderate', 'high' or 'very high', a detailed landslide risk assessment following the *Australian Geomechanics Society (AGS) 'Landslide Risk Management Guideline 2007'* should be carried out in order to determine whether the risk to life and property is acceptable.

In this regard a 'low' or 'very low' risk to property and life is acceptable to Council. If the result of the landslide risk assessment following the AGS 2007 method is still 'moderate', 'high' or 'very high', then the following is required to be included in the report:

(a) detailed risk mitigation measures and engineering recommendations to reduce the landslide risk to 'low' or 'very low'; and

(b) certification from a RPEQ specialising in geotechnical engineering. This certification needs to confirm:

(i) the proposed development site/lot will achieve a landslide risk rating of 'low' or 'very low'; and

(ii) will not cause any adverse impact on any adjoining buildings, properties and infrastructures, providing the risk mitigation measures and engineering recommendations (if any) of the report are followed.

5.1.4 On-site effluent disposal (if applicable)

The report should generally examine feasibility and suitability of the proposed development with regard to landslide risk issues for the site. If the proposed development involves on-site effluent disposal system, the risk assessment should consider potential saturation and softening of the soils within the effluent disposal areas and their impacts on the long-term stability of the site.

Table ~~1~~2 describes the details of landslide risk issues for different types of development applications that should be addressed in a geotechnical stability assessment report.

Table ~~1~~2: Details of landslide risk issues for various development applications

Details of landslide risk issues for various development applications
Material change of use (MCU) For any MCU development application on any site/lot identified on the **Landslide hazard overlay map**, the application needs to be supported by a landslide risk assessment and included in the geotechnical stability assessment report. The landslide risk assessment should assess the risk of landslide on the subject site as well as any risk of landslide on any upslope and downslope external properties which may impact the proposed development. If any risk of landslide on any upslope and downslope external properties impacting the proposed development is identified, the risk assessment should provide suitable risk mitigation measures including appropriate buffers to protect the proposed development. If the proposed development is on a portion of a large allotment, the landslide risk assessment may be limited to the proposed development footprint only. In this case, the risk assessment for the proposed building envelope and effluent disposal area of the site may be sufficient, rather than for the entire allotment. The risk assessment should take into account availability of a suitable driveway access to the proposed building envelope. If the proposed development is associated with any significant excavation/cutting and/or filling on the site, the landslide risk assessment should take into account the proposed bulk earthworks and finished levels, and determine the overall risk of landslide including the proposed bulk earthworks. The assessment of the earthworks should be carried out in the form of a global stability assessment. The landslide risk assessment should provide any restrictions on any earthworks including excavation/cutting and filling in order to achieve and maintain acceptable risk of landslide in the long-term conditions. The landslide risk assessment report should confirm the risk of landslide on the subject site/lot adversely impacting the proposed development and adjoining properties/structures and the risk of landslide on any upslope and downslope external properties impacting the proposed development is 'low' or 'very low'.
Reconfiguring a lot (ROL) For any ROL development application on any site/lot identified on the **Landslide hazard overlay map**, the application needs to be supported by a landslide risk assessment and included in the geotechnical stability assessment report. The landslide risk assessment should assess the risk of landslide for each of the proposed lots. If the proposed lots are large allotments, the landslide risk assessment for each proposed lot may be limited to the nominated building envelope and effluent disposal area only, rather than for the entire allotment. The risk assessment should take into account availability of a suitable driveway access to the proposed building envelope of the lot. The landslide risk assessment should identify any clear exclusion zone (if any) which is deemed not suitable for any future development due to unacceptable risk to life and/or property. In this case, the report should recommend a suitable buffer zone outside the exclusion zone. If the proposed development is associated with any significant excavation/cutting and/or filling on the site/lots, the risk assessment should take into account the proposed bulk earthworks and finished levels, and determine the risk of landslide for each of the proposed lots at their proposed finished levels. The assessment of the earthworks should be carried out in the form of a global stability assessment. The landslide risk assessment should confirm the risk of landslide adversely affecting each of the proposed lots (or their nominated building envelopes and effluent disposal areas) is 'low' or 'very low'. The report should include a completed and signed subdivision landslide encumbrance form (attached in **Appendix 3**) for each of the proposed lots.

Details of landslide risk issues for various development applications

Operational works (OPW)

For any OPW development application (for change to ground level or infrastructure works) on any site/lot identified on the **Landslide hazard overlay map**, the application needs to be supported by a landslide risk assessment and included in the geotechnical stability assessment report.

The landslide risk assessment should assess the overall risk of landslide on the subject site/lot taking into account the proposed bulk earthworks, excavation/cutting, filling, retaining walls and the proposed finished level. If the proposed development is on a portion of a large allotment, the landslide risk assessment may be limited to the proposed development footprint only, rather than ~~for~~ the entire site/lot.

The landslide risk assessment should provide any restrictions on any earthworks including excavation/cutting and filling in order to achieve and maintain acceptable risk of landslide in the long-term conditions.

The landslide risk assessment should confirm the risk of landslide on the subject site/lot after completion of the proposed works is 'low' or 'very low' and will not cause any adverse impact on any adjoining properties/structures.

6 Geotechnical certifications

In addition to undertaking a landslide risk assessment, the applicant should provide a number of geotechnical certifications from a RPEQ specialising in geotechnical engineering for any proposed development within landslide hazard areas, as identified in **Table ~~2~~3.**

These certifications will provide assurance of geotechnical stability for the proposed development site and a summary of the complex landslide risk assessment process. These certifications should be prepared using the standard pro-forma provided in **Appendix 4** and should be included with the geotechnical stability assessment report.

Table ~~2~~3: Geotechnical certifications for developments within landslide hazard areas

Type of application	MCU	ROL	OPW
If the landslide risk assessment determines the site/lot/building envelope with a landslide risk rating of 'low' or 'very low'			
Certification from a RPEQ specialising in geotechnical engineering confirming the proposed development is appropriate for the sloping nature of the site, the risk of landslide on the subject site/lot (or each of the proposed lots for reconfiguring a lot development applications) adversely affecting the proposed development and adjoining properties/structures and the risk of landslide on any upslope and downslope external properties impacting the proposed development is 'low' or 'very low'.	✓	✓	✓
If the landslide risk assessment determines the site/lot/building envelope with a landslide risk rating of 'moderate', 'high' or 'very high'			
Certification from a RPEQ specialising in geotechnical engineering confirming the proposed development is appropriate for the sloping nature of the site, the risk of landslide on the subject site/lot (or each of the proposed lots for reconfiguring a lot development applications) adversely affecting the proposed development and adjoining properties/structures and the risk of landslide on any upslope and downslope external properties impacting the proposed development will be reduced to 'low' or 'very low', providing the risk mitigation measures and engineering recommendations of the report are followed.	✓	✓	✓

7 Developments involving batters and/or retaining structures

Where the proposed development requires significant bulk earthworks including cut/fill batters and/or retaining structures to achieve the desired finished levels, a geotechnical stability assessment is required to assess potential sliding, rotational and slip circle failure. The stability assessment of the proposed cut/fill batters and/or retaining structures should be included with the geotechnical stability assessment report.

This section provides guidance on the City's requirements for stability assessment of cut/fill batters and retaining structures associated with any proposed development.

7.1 Stability assessment of batters

The stability assessment of all proposed cut/fill batters should be carried out following a conventional slip circle failure analysis method. In this type of analysis, a number of potential slip circles are assumed, and the factor of safety for each of the assumed slip circles is calculated. The minimum factor of safety amongst those assumed slip circles is considered to be the factor of safety for that designed batter. The accuracy of the stability assessment depends on the number of slip circles analysed and the calculation method followed.

One very important issue in the stability assessment of batters is the estimation of representative shear strengths for the constituting soil layers. In stability analysis of batters, the worst credible shear strengths of the soil layers expected during the design life of the batters should be used, rather than using the existing shear strengths of the soil layers. If there is a prolonged and heavy rainfall, the highest estimated watertable and drainage conditions should be used. Another potential worst case scenario for the stability assessment of batters adjacent to any water body is sudden drawdown of the watertable. In this instance, the factor of safety for the sudden drawdown case should be calculated, rather than for the temporary or short term high water level condition.

The stability assessment of the cut/fill batters should achieve a long term factor of safety of at least 1.5 against geotechnical instability. For rapid drawdown temporary conditions, the stability assessment of the cut/fill batters should achieve a short term factor of safety of at least 1.3 against geotechnical instability.

The stability analysis of batters may be carried out manually, however, the use of professional software, such as *SLOPE/W by Geoslope (www.geo-slope.com)* would be cost effective with much less computational efforts and time. **Figure 1** shows an example of slope stability analysis using *SLOPE/W*.

Material number 1:	Unit weight: 15	C: 5	Phi: 20	Model: MohrCoulomb
Material number 2:	Unit weight: 18	C: 10	Phi: 25	Model: MohrCoulomb

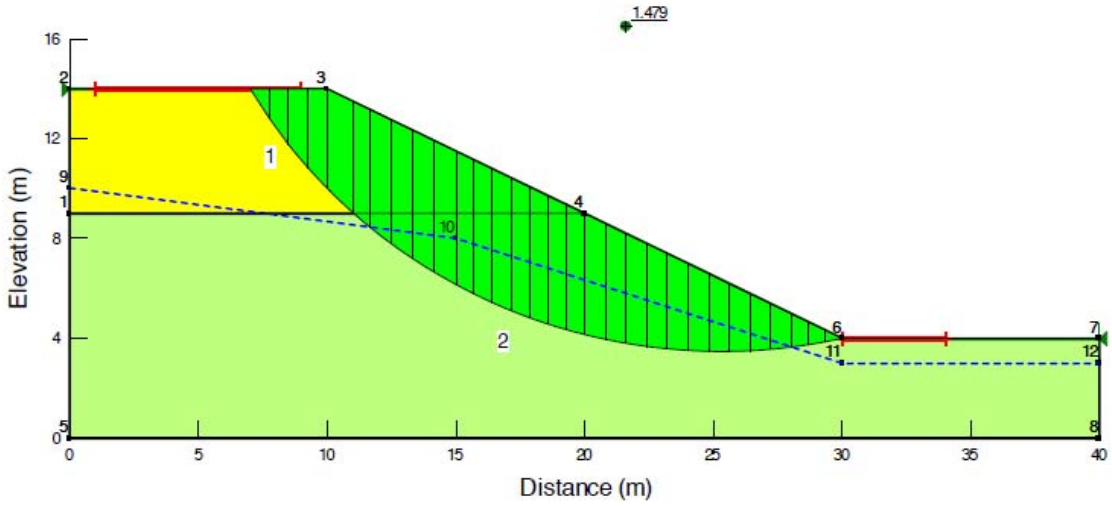

Figure 10-1
Typical slope stability analysis using SLOPE/W

7.2 Stability assessment of retaining structures

Geotechnical stability of all proposed retaining structures should be carried out against sliding, overturning and global slope instability through the geomaterials. The proposed retaining structures should also be checked against bearing capacity failure or excessive base settlements. Furthermore, the retaining structure itself must be adequately designed against any potential structural failure such as flexural failure or shear failure.

Figure 2 shows a typical retaining structure including lateral earth pressure distributions. The retained soil behind the retaining structure will exert active lateral earth pressure if the retaining structure allows lateral movement. Otherwise, lateral earth pressure at rest 'K_o *condition'* should be used during the design and stability assessments. The soil in front of the wall will provide passive earth pressure (resistance).

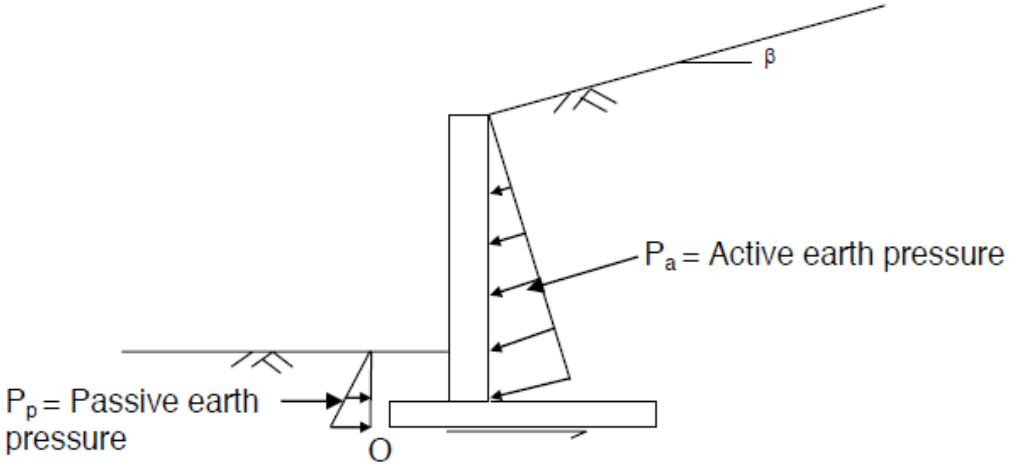

Figure 2
Typical retaining structure and lateral earth pressure distributions

For the proposed retaining structures, the applicant should assess the factor of safety against the following:

(a) sliding caused by the active earth pressure and resistance by passive earth pressure and frictional force at the base of the retaining structure;

(b) overturning about the toe *(point O in Figure SC6.10-2)* as a result of the driving moment caused by the active earth pressure and resisting moment caused by the passive earth pressure, the self-weight of the retaining structure and weight of the retained soils behind the structure; and

(c) global slope instability considering a number of large slip circles passing below the base of the retaining structure and the retained soils.

The stability assessment should ensure all retaining structures will achieve a factor of safety (FOS) greater than or equal to 1.5 against sliding, overturning and global slope instability. Alternatively, the sliding and overturning stability and global stability assessments for retaining structures can be carried out using Limit State Methods as described in *AS4678 – Earth Retaining Structures.*

The global stability analysis of retaining walls may be carried out manually, however, the use of professional software, such as *SLOPE/W by Geoslope: (www.geo-slope.com)* would be cost effective with much less computational efforts and time.

7.3 Geotechnical certifications

All development applications involving batters and/or retaining structures in excess of 1m in height should include a certification from a RPEQ specialising in geotechnical engineering confirming all cut/fill batters and/or retaining structures associated with the proposed development have been adequately designed to achieve a long-term factor of safety greater than or equal to 1.5 against geotechnical failure or demonstrate satisfactory compliance with *AS4678 – Earth Retaining Structures*. The certification should be prepared using the standard pro-forma given in **Appendix 4** and be included with the geotechnical stability assessment report.

8 Presentation of the report

The geotechnical stability assessment report is to be written as a self-contained document, which does not require the reader to refer to any other documents including the City's file number, maps, drawings, previous applications or other reports (if any). If the report does require the applicant to refer to any other documents, it should include a copy of those documents as attachments.

The report should include, but not necessarily limited to, the following:

(a) a cover page with a title of the report, revision number, property address, real property description (lot and plan numbers), report reference number, author's name and date;

(b) the body of the report including the context within which the report was commissioned, the purpose of the report, geotechnical site investigation results, landslide risk assessment results and slope stability assessment results for cut/fill batters and/or retaining walls;

(c) any maps, plans, drawings, cross-sections referred to in the report;

(d) any relevant borehole records, laboratory and field test results;

(e) landslide susceptibility rating calculations;

(f) slope stability calculations for batters and retaining walls; and

(g) geotechnical certifications.

Appendix 1: Landslide susceptibility analysis form

LANDSLIDE SUSCEPTIBILITY ANALYSIS

Analysis No. ____

Location: **Site No.** **Site Name:**

1 Natural Surface Slope

Site		Level	Factor
	Less than 5 degrees	L	0.1
	Between 5 and 15 degrees	M	0.5
	Between 15 and 30 degrees	M	0.8
	Between 30 and 45 degrees	H	1.2
	More than 45 degrees	M	0.8

2 Slope Shape

Site		Level	Factor
	Crest or ridge	L	0.7
	Planar / Convex	M	0.9
	Rough / Irregular	H	1.2
	Concave	H	1.5

3 Site geology

Site		Level	Factor
	Volcanic Extrusive rock	H	1.1
	Sedimentary rock	M	1
	Low grade metamorphic rock	M	1
	High grade metamorphic rock	L	0.9
	Volcanic Intrusive rock	M	1

4 Soils

Site		Level	Factor
	Rock at surface	VL	0.1
	Residual soil < 1m deep	L	0.5
	Residual soil 1-3m deep	M	0.9
	Residual soil > 3m deep	H	1.5
	Colluvial soil < 1m deep	H	1.5
	Colluvial soil 1-3m deep	VH	2
	Colluvial soil > 3m deep	VH	4

5 Fill height

Site		Level	Factor
	None	L	1.0
	Less than 1m	M	1.1
	Between 1 and 3m	M	1.3
	Between 3 and 6m	H	1.7
	More than 6m	VH	2.5

6 Evidence of groundwater

Site		Level	Factor
	None apparent	L	0.7
	Minor moistness	M	0.9
	Generally wet	H	1.5
	Surface springs	VH	3

7 Cut height

Site		Level	Factor
	None (Go to section 11)	L	1.0.
	Less than 1m	M	1.1
	Between 1 and 3m	M	1.3
	Between 3 and 6m	H	1.7
	More than 6m	VH	2.5

8 Slope of cut face

Site		Level	Factor
	Less than 30 degrees	L	0.5
	Between 30 and 45 degrees	M	1
	Between 45 and 60 degrees	H	1.5
	More than 60 degrees	VH	3

9 Material in cutting

Site		Level	Factor
	High strength rock	L	0.5
	Medium strength rock	L	1
	Low strength rock	M	1.2
	Very low strength rock and soil	H	1.5
	Soil	VH	2

10 Cut slope support

Site		Level	Factor
	Concrete wall	L	0.5
	Crib wall	M	0.9
	Gabion wall	M	1
	Rock wall	H	1.5
	Unsupported	H	2

11 Concentration of surface water

Site		Level	Factor
	Ridge	L	0.7
	Crest	M	0.8
	Upper slope	M	0.9
	Mid slope	H	1.2
	Lower slope	H	1.5

12 Wastewater Disposal

Site		Level	Factor
	Fully Sewered	M	1
	Onsite disposal – Surface	M	1.2
	Onsite disposal – Soak Pit/Trenches	H	1.5

13 Stormwater Disposal

Site		Level	Factor
	All stormwater piped into road drainage	L	0.7
	Rain water tank with overflows	M	1
	Stormwater discharge on site	H	1.5

14 Evidence of instability

Site		Level	Factor
	No sign of instability	L	0.8
	Soil Creep	H	1.2
	Minor irregularity	VH	2
	Major irregularity	VH	5
	Active instability	VH	10

Summary

			Factor
1	Natural Surface Slope		
2	Slope Shape		
3	Site Geology		
4	Soils		
5	Fill Height		
6	Evidence of Groundwater		
7	Cut height		
8	Slope of Cut Face		
9	Material in Cutting		
10	Cut Slope Support		
11	Concentration of Surface Water		
12	Wastewater Disposal		
13	Stormwater Disposal		
14	Evidence of Instability		
Relative Susceptibility (1x2x3x4x5x6x7x8x9x10x11x12x13x14)			

Appendix 2: Correlation between relative susceptibility and susceptibility rating

Relative Susceptibility	Susceptibility Rating
Less than 0.2	Very Low
0.2 – 0.6	Low
0.6 – 2.0	Moderate
2.0 – 6.0	High
Greater than 6.0	Very High

Appendix 3: Subdivision landslide encumbrance form

Property details	
Address	
Estate name	
Estate stage	
Council reference	

Parent parcel of land	
Lot number	
Registered plan number	
Encumbrance	

Please use the following abbreviations to re-categorise the *SMEC* landslide susceptibility rating.

Encumbrances shall be defined in accordance with the following abbreviations for landslide susceptibility rating:

VH = Very high
H = High
M = Moderate
L = Low
VL = Very low

Proposed subdivided allotments					
Proposed Lot number	Plan number	Relative susceptibility	Final landslide susceptibility rating for:		
			Lot	Building pad	Effluent disposal area

Geotechnical engineer details	
Consulting engineering company	
Name of engineer	
Registered professional engineer of Queensland (RPEQ) number	
Signature	
Date	

Appendix 4: Standard pro-forma for geotechnical certification

Property details	
Lot number	
Registered plan number	
Property address	

Proposed works	
Description	

Proposed development	
Description	

Declaration			
I,		Registered professional engineer of Queensland (RPEQ) number	
of			(Consulting engineer's firm)
being duly authorised on this behalf, do certify that:			
I am aware that the Council of the City of Gold Coast will rely upon this certificate and any associated geotechnical reports, maps, graphs, tables, attachments, etc., produced as a consequence of commissioning this technical assessment.			
Signature		**Designation**	
Certified this		**Day of**	**20**