Development manual planning scheme policy (PSP)
SC6.4.16 Geotechnical investigations

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SC6.4.16 1 Introduction

(1) Purpose

This policy section provides advice and guidance and assists applications:

(a) on the preparation and assessment of geotechnical investigation reports;

(b) on the expected level of geotechnical investigation required for development based on the level of risk or hazard identified; and

(c) information Council may request for a development application.

(2) Background

Development on steep lands presents a unique set of design and engineering challenges, often requiring a greater degree of detail in the design and approval of allotments, earthworks, roads, services and built form.

There is a growing awareness of the risks, environmental values, and ongoing costs associated with development on steep slopes, which has resulted in an expectation of an improved standard of design in these environmentally and geologically sensitive areas. This is supplemented by an increased mindfulness of the risks and financial cost to construct and maintain the servicing in these areas and the need to consider these factors in the assessment of applications involving a landslide hazard.

Editor's Note - certain existing steep land or hillside developments have demonstrated how inappropriate forms of land use and servicing can permanently damage local environmental features and diminish valued natural assets, particularly scenic qualities. In addition, it has been noted how the costs to maintain associated infrastructure can become a burden on the wider community due to the specialist nature of this infrastructure and the generally lower density in these areas. Whilst these areas do contribute to the diversity of housing choice, the pricing of lot and housing prices usually exceed the ability for the local economy to include these as affordable housing options.

(3) Application

This section applies to development affected by SC2.5 Overlay maps Landslide hazard overlay maps OM-07.1 and OM- 07.2, and geotechnical investigations associated with road pavements, bridge foundations, culverts foundations, retaining walls, acoustic fences foundations, fence foundations, sign support structures, and temporary works.

SC6.4.16.2 Geotechnical investigations – steep land

(1) Requirements for site specific investigations

(a) Where development is subject to assessment against the Townsville City Plan - Part 8.2.7 Landslide hazard overlay code, an applicant will be required to undertake a geotechnical investigation of the likely impacts of the proposed development and to determine the measures to avoid or mitigate unacceptable risk and other adverse impacts.

(b) Table SC6.4.16.1 Guidelines for Applicability of Geotechnical Assessment Techniques in landslide hazard categories specifies the level of investigation required for the hazard level affecting the subject land. Where the subject land has more than one hazard level mapped, the assessment technique shall be for the higher hazard level mapped. Table SC6.4.16.2 Applicability of Site Investigation Methods to Slope Classes should be considered in conjunction with Table SC6.4.16.1.

(c) The planning and design of future development should consider the level of professional geotechnical input commensurate to the landslide hazard category which the development is subject to.

In general, it is appropriate that geotechnical input for development be carried out in accordance with the reporting standards proposed by the AGS, 2007c Landslide Risk Management (Reference 8). This requires the practitioner to consider not only the issues surrounding the landslide hazard (if one exists) but also the consequences if a landslide were to occur (I.e., the assessment needs to be couched in a risk assessment context).

(d) The extent and detail of the investigation will vary dependent upon the level of hazard identified on SC2.5 Overlay maps Landslide hazard overlay maps OM-07.1 and OM-07.2 and the nature of the development being proposed. Council will require each report to demonstrate a scope and depth of investigation appropriate to the level of hazard identified, for the specific site characteristics and the proposed development and works.

(e) Geotechnical reporting needs to clearly indicate whether the risk assessment is based on existing slope conditions or with risk treatment measures implemented (or both).

(2) Preparation of site specific geotechnical investigations report

(a) A geotechnical investigation report must document the following:

(i) introduction to the proposal including a description of the subject land, locality, and proposed development;

(ii) description and investigation of existing conditions of the development site, including assessment of land stability and geotechnical constraints to development (see Clause SC6.4.16.2 (3) Investigation Information Requirements);

(iii) assessment of the suitability of the site for the development. This should include an assessment of the likely effects and impacts of the development upon slope stability or landslide hazard (see Clause SC6.4.16.2 (3) Investigation information requirements);

Editor's Note - Assessments should be undertaken and give sufficient consideration of the final intended development outcomes for the subject site, including staging of development and associated works.

(iv) measures recommended to mitigate impacts including siting, design, engineering, and any other necessary mitigation measures; and

Editor's Note - Applicants may also refer to Section SC6.4.15 Steep land development for further information.

(v) conclusion and recommendations (see Clause SC6.4.16.2 (3) Investigation information requirements).

(b) Geotechnical investigation reports are to reference Australian Geomechanics Society (AGS) Volume 42 No 1 March 2007, or any later guideline of the AGS as agreed by Council.

(c) Geotechnical investigations are to be undertaken and certified by an appropriately qualified and experienced engineering geologist, geotechnical engineer or registered professional engineer appropriately experienced in slope stability investigations in accordance with Australian Geomechanics Society (AGS) Volume 42 No 1 March 2007.

(d) The findings, recommendations and specific works of the geotechnical investigation report must be implemented and complied with to ensure that the risk level for the development will be no more than "low". If works required to achieve a risk level of "low', such works must be certified by a suitably qualified person.

(e) Laboratory testing is required to be undertaken by a National Association of Testing Authority (NATA) certificated laboratory. All investigations, testing and design should be undertaken in accordance with industry practice and the provisions of relevant Australian Standards.

(3) Investigation information requirements

(a) Geotechnical investigations should cover the matters set out below, and may include, but need not be limited to:

(i) review of existing data sources including regional geology, topographic maps, and geotechnical reports;

Editor's Note - where a geotechnical investigation has been previously undertaken and the report provided as supporting documentation to Council for a previous application over the subject land, these documents must be clearly referenced in the report prepared for the subsequent application. Such supporting documentation must be made available to Council and be current and specifically relevant to the proposed development.

(ii) preparation of site plan showing results of geomorphic and engineering geological mapping (to scale);

(iii) subsurface investigations including drill holes, auger holes, shafts and test pits with locations shown on a to scale site plan;

(iv) results of laboratory testing of samples recovered from subsurface investigations;

Editor's Note - the results of all laboratory tests must be included in the geotechnical report, including the location and level ((including datum).

(v) groundwater and surface water studies including recording of groundwater conditions in sub surface investigation and mapping of surface seepages;

(vi) preparation of cross section(s) showing interpreted geotechnical and groundwater conditions with cross section location identified on site plan;

(vii) evidence of past slope stability performance;

(viii) evidence of history of slope instability with assessed trigger events, including in relation to adjoining land;

(ix) identification of landslides, shown in plan and on section, and discussed in terms of the site geomorphology and slope forming process;

(x) assessment of consequences to property and life for each landslide and or type of landslide;

(xi) assessment of risk for each landslide and or type of landslide;

(xii) assessment of landslide frequency (probability) and or type of landslide;

(xiii) risk assessment in relation to tolerable risk criteria (e.g., published criteria where appropriate); and

(xiv) risk mitigation measures and options, including revised risk assessment following implementation.

(4) Guidelines for applicability of geotechnical assessment techniques

Guidelines for applicability of geotechnical assessment techniques in landslide hazard categories Table SC6.4.16.1has been prepared for the standard geotechnical techniques identified in AGS, 2007c which are applicable for the assessment of landslide risk. The various investigation techniques have different levels of applicability for the different hazard categories shown on SC2.5 Overlay maps Development constraints overlay map – Landslide hazard OM-07.1 and OM-07.2. Table SC6.4.16.1 should therefore be considered as a guideline as to the applicability of professional geotechnical input for any hazard category.

Table SC6.4.16.1 - Guidelines for Applicability of Geotechnical Assessment Techniques in Landslide Hazard Categories

Investigation Techniques	**Landslide Hazard**				
	Landslide hazard Map OM-07.1				**OM-07.2**
	Very Low	**Low**	**Medium**	**High**	**>23degrees**
1. Review of existing data sources including regional geology, topographic maps, and geotechnical reports.	B	A	A	A	A
2. Stereoscopic viewing of vertical air photo pairs to facilitate terrain mapping.	B	B	A	A	A
3. Preparation of site plan showing results of geomorphic and engineering geological mapping (to scale).	B	B	A	A	A
4. Subsurface investigations including drill holes, auger holes, shafts, and test pits with locations shown on the site plan.	C	B	A	A	A
5. Results of laboratory testing of samples recovered from the subsurface investigation.	D	C	B	A	A
6. Groundwater and surface water studies including recording of groundwater conditions in sub surface investigation and mapping of surface seepages.	C	B	B	A	A
7. Preparation of cross section (s) showing interpreted geotechnical and groundwater conditions with cross section location identified on the site plan.	C	B	B	A	A
8. Evidence of past slope stability performance.	B	B	B	A	A
9. Evidence of history of slope instability with assessed trigger events, including in relation to adjoining land.	B	B	B	A	A

10. Identification of landslides, shown in plan and on section, and discussed in terms of the site geomorphology and slope forming process.	C	B	B	A	A
11. Assessment of landslide frequency (probability) and or type of landslide.	C	B	B	A	A
12. Assessment of consequences to property and life for each landslide and or type of landslide.	C	B	B	A	A
13. Assessment of risk for each landslide and or type of landslide.	C	B	B	A	A
14. Risk assessment in relation to tolerable risk criteria (E.g., published criteria where appropriate).	D	C	C	B	A
15. Risk mitigation measures and options, including revised risk assessment following implementation.	C	B	B	A	A

Editor's Note - A – Strongly Applicable, B – Applicable, C – May be applicable, D – Seldom applicable.

(5) Applicability of site investigation methods to slope class

Table SC6.4.16.2 summarises the applicability of various site investigation techniques for natural and constructed slopes of various scales. The requirements for site investigations shown in Table SC6.4.16.1 should be considered in the context of the hazard categories given in Table SC6.4.16.2.

Editor's Note:

1. A – Strongly applicable, B – Applicable, C – May be applicable, D – Seldom applicable.
2. In similar areas.
3. SPT, CPT, CPTU.
4. Permeability.
5. During construction.

Table SC6.4.16.2 Applicability of Site Investigation Methods to Slope Classes

Site Investigation Method	Natural Slopes				Constructed Slopes			
	Small/ Shallow	Medium	Large	Existing Cut	New Fill	New Cut	New Fill	Soft Clay
Topographicmapping and survey	A	A	A	A	A	A	A	A
Regional geology	A	A	A	A	A	A	A	A
Geological mapping of project Area	B	B	A	A	B	A	B	C
Geomorphological mapping	A	A	A	B	B	B	B	D
Satellite imagery interpretation	D	D	C	D	D	D	D	D

Air photograph interpretation	A	B	A	C	C	C	C	C
Historic record	A	B	B	A	B	B (2)	B (2)	B (2)
Dating past movements	B	C	B	D	D	D	D	D
Geological methods	C	C	B	C	C	C	D	C
Trenches and pits	B	A	B	B	B	B	B	C
Drilling/boring	C	A	A	C	B	B	B	A
Downhole inspection	C	B	B	C	D	C	D	D
Shafts and tunnels	D	C	B	D	D	D	D	D
In situ testing of strength Permeability	C (3)	C (3)	C (4)	D	B (3)	C	C	A (3)
Strength and permeability monitoring pore pressures, rainfall, etc.	C	A	A	A	A	C	C	A (5)
Monitoring of displacements	C	B	A	B	B	B (5)	C (5)	A (5)
Laboratory testing	C	A	B	B	B	B	C	A
Back analysis of stability	C	B	A	C	B	B (2)	C (2)	C (2)

Source: (Fell, Hungr, Leroueil and Reimer, 2000)

SC6.4.16.3 Geotechnical evaluation – pavements

(1) General

The designer must arrange a detailed geotechnical investigation of the naturally occurring material along the alignment of the proposed roads prior to the commencement of the design process to permit adequate pavement depths to be determined to ensure sufficient cover is achieved to the stormwater infrastructure. The extent of any areas of filling and cutting must be determined including the strength of the underlying materials and considered in the overall pavement design.

The geotechnical investigation, including both field and laboratory testing must be undertaken in accordance with all relevant Australian Standards (e.g., AS 1289) and *Guide to Road Design* in particular *Road Design Part 2: Design Considerations.*

(2) Subgrade testing

(a) Except where a mechanistic design approach is employed using Austroads *Guide to Pavement Technology Part 2: Pavement Structural Design*, the measure of subgrade support

must be the California Bearing Ratio (CBR).

Where a mechanistic design approach using linear elastic theory is employed for flexible pavements, the measure of subgrade support must be in terms of the elastic parameters (modulus, Poisson's ratio), e.g., for use in CIRCLY computerised pavement design methods.

In conducting subgrade tests, the following approach must be adopted for new roads:

(i) test pits/holes along the alignment of the road must have a spacing between 60 m and 120 m as appropriate for each urban residential and industrial street or a minimum of three test locations per street in a stage, whichever is greater;

(ii) test pits/holes along the alignment of a rural area road must have a spacing of up to 300 m or a minimum of 3 test locations per road whichever is greater;

(iii) test holes must be excavated to a minimum depth of 1 m and must extend a minimum 500 mm below the proposed subgrade level;

(iv) if the depth of fill material over the natural subgrade is more than 500 mm, then the fill material is considered to be the new subgrade and it must be assessed; and

(v) if the depth of fill is less than 500 mm, investigation must assess the natural ground conditions, and the properties of the proposed fill material.

(b) The following factors must be considered in determining the design strength/stiffness of the subgrade:

(i) sequence of earthworks construction;

(ii) the compaction moisture content and field density specified for construction;

(iii) moisture changes during service life;

(iv) subgrade variability; and

(v) the presence or otherwise of weak layers below the design subgrade level.

(3) California Bearing Ratio (CBR)

(a) Notwithstanding the requirements of AS1289.6.1.1, this document specifies additional or differing requirements, including:

(i) CBR tests must be carried out with a maximum of 4.5 kg surcharge; and

(ii) maximum correction allowable to the applied force is 0.5 mm along the horizontal axis of the penetration curve.

(b) The calculation of the Design CBR must be based on either soaked or unsoaked conditions as appropriate.

(i) For boxed in pavements, soaked conditions must be adopted for the calculation of Design CBR and must be based on a minimum of three 4-day soaked CBR laboratory samples for each subgrade area compacted to 97% of maximum dry density, standard compaction at optimum moisture content (OMC).

(ii) If it can be demonstrated that the subgrade is well drained and not less than 300 mm above natural surface or table drain, e.g., Rural formation, in free draining material and not influenced by spring/seepage conditions, then the unsoaked condition will be considered for design by Council. When unsoaked conditions are to be adopted the calculation of Design CBR must be based on a minimum of three laboratory samples for each subgrade area compacted to 97% maximum dry density standard compaction at OMC and corrected to allow for the effects of subsurface drainage (or lack of), climatic

zone and soil type if appropriate (as per the guidelines in Austroads *Guide to Pavement Technology Part 2: Pavement Structural Design*) to give an estimate of equilibrium in-situ CBR.

(iii) The Design soaked CBR for each subgrade area is computed by using the appropriate formula as follows:

Design CBR = Least of estimated CBRs, for less than five results or

Design CBR = 10th percentile of all estimated CBRs, for five or more results.

Where practicable, the Design CBR obtained from laboratory testing should be confirmed by testing performed on existing road pavements near to the job site under equivalent conditions and displaying similar subgrades.

The pavement design must include a summary of all laboratory and field test results and assumptions and/or calculations made in the assessment of Design CBR.

SC6.4.16.4 Geotechnical investigations – bridges

(1) General

Such structures may be primarily constructed of concrete, steel, or other materials appropriate to the application. The design should always have a primary emphasis on safety, maintenance, and whole of life cycle costs. The structure/s should comply with current Safety in Design principles and guidelines, the *Bridge Design* Code (AS 5100), and Austroads *Guide to Bridge Technology Part 4.*

(2) Geotechnical assessment

An applicant will be required to undertake a geotechnical investigation of the subsurface conditions at the proposed site of the structure to determine the measures required to avoid or mitigate unacceptable risk and other adverse impacts of constructing the structure.

The extent of geotechnical investigations required to be undertaken prior to the commencement of design of the structure are dependent on the size and value of the structure, site location, and associated risk.

Details of proposed geotechnical investigations to be undertaken by the applicant are to be discussed with Council prior to commencing design of the structure.

Geotechnical investigations are to be undertaken and certified by an appropriately qualified and experienced engineering geologist, geotechnical engineer or registered professional engineer appropriately experienced in bridge foundation investigations.

Laboratory testing is required to be undertaken by a National Association of Testing Authority (NATA) certificated laboratory. All investigations, testing and design should be undertaken in accordance with industry practice and the provisions of relevant Australian Standards.

SC6.4.16.5 Geotechnical investigations – structures other than bridges

(1) General

Public utility structures, major culverts, major sign support structures, retaining walls, and the like will be designed by a competent, practicing engineer (RPEQ certified) who is accredited in the design of such structures. The design must be in accordance with the SC6.4 Development manual planning scheme policy, relevant Austroads codes, all relevant Australian Standards, and the requirements of any utility owners that may be applicable.

The extent of geotechnical investigations required to be undertaken prior to the commencement of design of the structure are dependent on the size and value of the structure, site location, and associated risk.

Details of proposed geotechnical investigations to be undertaken by the applicant are to be discussed with Council prior to commencing design of the structure.

Geotechnical investigations are to be undertaken and certified by an appropriately qualified and experienced engineering geologist, geotechnical engineer or registered professional engineer appropriately experienced in foundation investigations.

Laboratory testing is required to be undertaken by a National Association of Testing Authority (NATA) certificated laboratory. All investigations, testing and design should be undertaken in accordance with industry practice and the provisions of relevant Australian Standards.

SC6.4.16.6 Geotechnical investigations – sewage pump stations

(1) General

Pump stations shall be planned and designed to optimise construction, operation, and maintenance costs for the total life cycle of the infrastructure and equipment.

The applicant will be required to undertake a geotechnical investigation of the subsurface conditions at the proposed site of the pump station to determine the measures required to avoid or mitigate unacceptable risk and other adverse impacts of constructing the pump station.

Geotechnical investigations are to be undertaken and certified by an appropriately qualified and experienced engineering geologist, geotechnical engineer, or registered professional engineer appropriately experienced.

The minimum investigations and geotechnical report shall include:

(a) a bore hole drilled to 1.5 m below the base of the pump station;

(b) a descriptive log of materials encountered and depths of each material;

(c) depth of water below surface if encountered; and

(d) suitability of materials encountered for use as backfilling around pump station where open excavation is used to install the pump station, to minimise backfill settlement that may damage connections between the pump station and other fixtures.

SC6.4.16.7 Reference and source documents

Reference and source documents that must be read in conjunction with this section are as follow:

Australian Geomechanics Society (AGS)	*Australian Geomechanics*, Volume 42 No 1 March 2007
AGS (2007c)	*Practice note guidelines for landslide risk management, Australian Geomechanics Society, Australian Geomechanics,* Vol 42 No 1, March 2007
Austroads	*Road Design Part 2: Design Considerations*
Austroads	*Guide to Pavement Technology Part 2: Pavement Structural Design*
Austroads	*Guide to Bridge Technology Part 4: Design Procurement and Concept Design*
Fell, R., Hungr, O., Leroueil, S. Riemer, W., 2000	*Keynote Lecture – Geotechnical engineering of the stability of natural slopes, and cuts and fills in soil*, GeoEng2000, 1, 21-120. Invited Papers, Technomic Publishing, Lancaster, ISBN:

	1-58716-067-7, November 2000
AS 1289	*Methods of testing soils for engineering purposes*
AS 1289.4.2.1	*Methods of testing soils for engineering purposes - Soil chemical tests - Determination of the sulphate content of a natural soil and the sulphate content of the groundwater - Normal method*
AS 1289.6..	*Methods of testing soils for engineering purposes - Soil strength and consolidation tests - Determination of the California Bearing Ratio of a soil – Standard laboratory method for a remoulded specimen*
AS 5100	*Bridge Design Code (set)*