

GUIDE TO PLANNING GEOTECHNICAL SITE INVESTIGATIONS

1. INTRODUCTION

The purpose of this technical note is to provide a simple and practical guide for planning geotechnical site investigations to allow completion on time, to the required quality and to budget.

The information collected during a geotechnical site investigation is used to design road formations and structure foundations, and is also issued in Site Conditions Information (SCI) documents as part of contract documentation. The SCI document is a factual report, containing only data from the geotechnical site investigation and other relevant sources, which enables tenderers to assess geotechnical risks associated with design and construction before submitting their tender.

2. PRELIMINARIES

Before commencing the planning of a geotechnical site investigation, the following preliminaries should be completed:

- feature survey of the site
- preparation of drawings illustrating the proposed road alignment, grade line and general arrangement of structures
- arrange access to the site, including obtaining landowner consent to access private property
- identify any areas of restricted access (Aboriginal cultural sites, heritage protected sites, areas of significant or protected flora or fauna, etc)
- decide on the type of roadworks contract to be used (this will determine the level of investigation required), and
- collate all existing geotechnical data relating to the site (planning investigation reports, previous geotechnical investigations, flood data, earthquake and landslide data, known contaminated sites, etc).

3. GEOTECHNICAL SITE INVESTIGATION METHODS AND LABORATORY TESTING

Common geotechnical site investigation methods and typical times required to complete each activity are described in Table 1. Site investigation results provide inferred material properties only. Samples of soil, rock and groundwater collected during the site investigation are required to be tested in NATA registered laboratories to accurately determine their physical properties. Common laboratory tests and applications are listed in Table 2. Other types of tests may be required where complex geological conditions are encountered during the initial investigation.

Table 1: Common Geotechnical Site Investigation Methods

Method	Application	Quantity/ Day
Borehole	Undertaken on alignments in cut and at structures, to assess the soil and rock profile. Samples are recovered and insitu testing is undertaken.	10-15 m
Cone Penetration Test (CPT)	Undertaken on alignments on soft ground and on fill and at structures in areas of deep soil coverage only, to assess soil strength properties.	30-60 m
Test Pit	Excavated with backhoes or excavators on alignments in cut, at grade and on fill to assess the soil and rock profile. Excavation faces are logged and bulk samples are collected.	5-8 no.
Bulldozer Trench	Excavated on alignments in deep cut to assess the rippability of rock. Excavation faces are logged and bulk samples are collected.	4 m
Dynamic Cone Penetration Test (DCPT)	Undertaken in areas at grade to assess subgrade strength.	20-30 no.

Method	Application	Quantity/Day
Seismic Survey	Undertaken on alignments in cut to assess the soil and rock profile and the rippability of rock.	Consult with geotechnical consultant.
Standpipe	Installed in completed boreholes to measure ground water level and to collect groundwater samples.	
Inclinometer	Installed in completed boreholes to monitor rate and direction of movement of unstable slopes.	

It is advisable to confirm that the scope of a geotechnical site investigation is adequate with a geotechnical consultant at the earliest opportunity, to ensure that the relevant geotechnical issues for the proposed roadworks have been addressed.

Table 2: Common Laboratory Tests

Method	Application	Quantity
Soil classification	Tests conducted on bulk soil samples of potential fill and subgrade materials	1 per test pit
Standard Compaction		
Soaked CBR		
Swell		
Emerson		
Triaxial testing	Soil at structures and in cut batters	2 per site
Consolidation testing	Soil under fill embankments	2 per abutment
Point Load Index	Rock core at structures	1 every 1.5 m
Groundwater quality	Alignments in cut	1 per standpipe
Acid sulfate soil	Alignments near coastlines	Consult with geotechnical consultant
Chemical testing	Potentially contaminated sites	

4. SCOPING GEOTECHNICAL SITE INVESTIGATIONS

The scope of a geotechnical site investigation may be adjusted to suit different planning stages of a road project, such as:

1. initial (e.g. desk top study)
2. preliminary (e.g. identification of potential routes)
3. general (e.g. assessment of route options), and
4. detailed (e.g. SCI document preparation)

Table 3 lists the level of geotechnical site investigation in respect of various planning stages.

Table 3: Level of Geotechnical Investigations

Geotechnical Site Investigation Level	Detail of Investigation
Level 1 (initial)	Generally, no geotechnical site investigation work is undertaken. A desktop study, kerbside (drive through) inspection, discussion with relevant departments, local government and service authorities would be undertaken.
Level 2 (preliminary)	Limited geotechnical site investigation work is normally undertaken, targeting specific locations to assess potential geotechnical issues identified during the initial planning stage.
Level 3 (general)	Undertaken to assist evaluation of road alignment options and structure types. The level of geotechnical site investigation varies and depends on the significance of the geotechnical issues identified during the initial and preliminary stages. Detailed geotechnical site investigations may need to be carried out for structures. Installation of standpipes to monitor groundwater and assessment of potentially contaminated sites may also be required at this level.

Geotechnical Site Investigation Level	Detail of Investigation
Level 4 (detailed)	Undertaken after the final road alignment has been chosen. A comprehensive geotechnical site investigation program building on the results of the initial, preliminary and general geotechnical site investigations is undertaken to confirm the extent and implication of key geotechnical issues. The results of a detailed geotechnical site investigation are compiled into a Site Conditions Information (SCI) document, and the scope of a detailed geotechnical site investigation must be sufficient to allow design and construction to proceed with a low level of risk. For Design and Construct contracts, an SCI document provides an appraisal of the geotechnical features of the site and is adequate for tenderers to cost the work based on the functional design contained in the contract specifications. However, the information contained in an SCI document may not be sufficient for detailed geotechnical design, in particular where subsequent changes have been made to the original functional design.

The results of a level 1, 2 or 3 geotechnical site investigation may be published as a planning study or appended to an Environmental Effects Statement. Only the results of a detailed (level 4) geotechnical site investigation may be published as an SCI document.

The minimum numbers of test sites for a detailed (level 4) geotechnical site investigation are listed in Table 4.

Table 4: Minimum Test Site Requirements for Detailed (Level 4) Geotechnical Site Investigations

Method	Application	Test Sites	Potential use of Information
Borehole or CPT	Structure	Every 7 m width at each abutment and pier	Provide adequate geotechnical information along the centreline of structural support (e.g. pier, abutment, retaining wall, etc). Borehole depths should be to a level where adequate geotechnical information has been obtained for conventional foundation design (e.g. piling, spread footing, etc)
	Alignment in cut <5 m	Every 100 m, to below gradeline	Cut batter slope angle consideration, rippability of material (e.g. basalt exists at shallow depth), suitability of material for use as filling, groundwater consideration, etc.
	Alignment in cut <10 m	Every 50 m, to below gradeline	As above.
	Alignment in cut >10 m	Every 50 m, 2 min., to below gradeline	As above.
	Alignment on soft ground	Every 50 m	Short and long term settlement issues, constructability of road formation (potential problem in achieving proof rolling), stability of fill embankment (slope instability and bearing failure), groundwater, ground heaving issues, etc.
Test Pit and DCPT	Alignment at grade or on fill	Every 50-150 m, to below gradeline	Obtain bulk samples for determination of subgrade strength (e.g. laboratory soak CBR, compaction testing and soil classification)
Bulldozer Trench	Alignment in cut	Where trial excavations required	Rippability of insitu material, mapping of rock formation (e.g. strike and dip, faults, dykes, etc), cut batter slope angle consideration, suitability of material for use as filling, groundwater consideration, etc.
Seismic Survey	Alignment in cut through rock	Longitudinal and transverse	Rippability of insitu material. Determination of whether blasting hard rock through cutting is needed, etc.
Standpipe	Alignment in cut or known area of spring activity	Every 100 m and at selected locations	The requirement of drainage blankets, groundwater quality testing, hydrogeological analysis to determine the effects of change of groundwater table to the local amenity, environmental consideration such as disposal of low quality groundwater in accordance with EPA guidelines, etc.
Inclinometer	Alignment in cut	Where natural slopes are unstable	Geotechnical risk assessment, monitoring and management.

5. ESTIMATING DURATION OF GEOTECHNICAL SITE INVESTIGATIONS

The duration of a geotechnical site investigation may be estimated using the information listed in Tables 1 and 4. However, additional duration should be allowed for:

- inclement weather
- delays due to preliminaries not completed on time, which restrict access to the site
- laboratory testing, and
- preparation of logs and reports.

Many site investigation methods can also be scheduled concurrently to reduce the duration of a geotechnical site investigation. Indicative durations for detailed geotechnical site investigations are listed in Table 5.

Table 5: Duration of Detailed Geotechnical Site Investigations

Type of Site	Duration
New road*	6-9 months
Road duplication*	3-6 months
Road widening*	1-3 months
Bridge	1-4 months
Culvert/other structure	2-4 weeks

**Based on 5-15 km alignment with structures*

6. IMPORTANT CONSIDERATIONS FOR GEOTECHNICAL SITE INVESTIGATIONS

The following issues should be considered when scoping a geotechnical site investigation:

- the scope of a geotechnical site investigation should reflect the purpose and results should be used accordingly, e.g. results from a preliminary investigation of alignment options are insufficient for use as an SCI document
- if the final road alignment, gradeline or location of a structure is significantly changed, additional investigation may be required, and
- limiting the scope of a geotechnical site investigation to less than accepted good practice increases the risk of latent conditions.

7. REFERENCES

1. Institute of Engineers Australia 1987, Guidelines for the Provision of Geotechnical Information in Construction Contracts, I.E. Aust, Canberra.
2. Standards Association of Australia 2004, Bridge design - Part 3: Foundations and Soil Supporting Structures, (AS 5100.3), Standards Australia, North Sydney
3. Standards Association of Australia 1993, Geotechnical Site Investigations, (AS 1726), Standards Australia, North Sydney
4. VicRoads GeoPave 2001, Guide to Geotechnical Investigation Procedures, VicRoads, Kew

8. CONTACT OFFICER

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