Technical Note

Risk Management of Roadside Geotechnical Hazards

TN 96

Introduction

The purpose of this technical note is to provide an overview of the process adopted by VicRoads to undertake risk management of roadside geotechnical hazards in accordance with the Australian Geomechanics Society Practice Note Guidelines for Landslide Risk Management 2007 (AGS 2007). The process of risk management of roadside geotechnical hazards is illustrated in Figure 1.

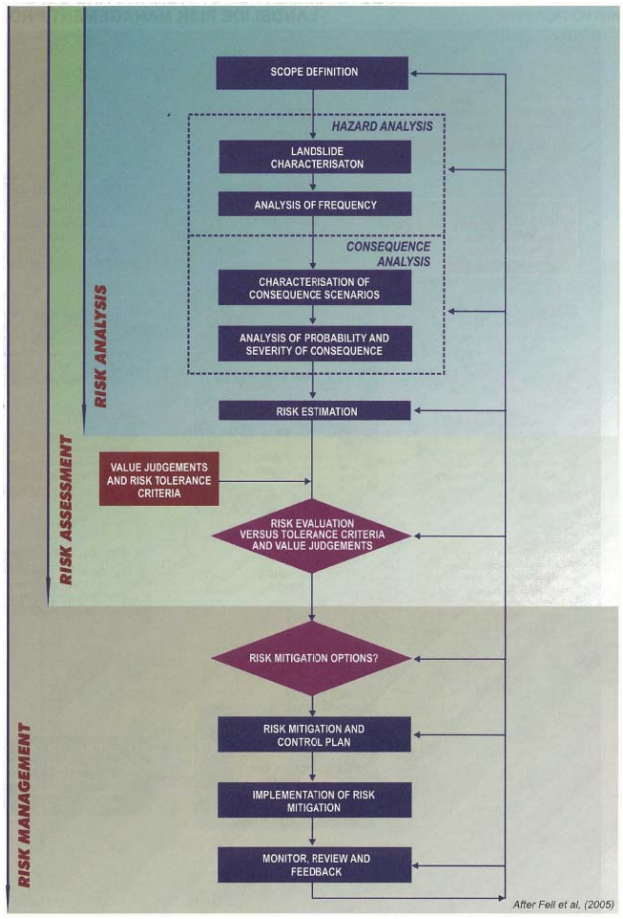

Figure 1: Risk management of roadside geotechnical hazards (AGS 2007).

Definition of a Roadside Geotechnical Hazard

VicRoads defines a roadside geotechnical hazard as a landslide (the movement of a mass of rock, debris or soil down a slope) or erosion (the loss of soil by the action of water) that either originates inside a road reserve and affects road users, roadside assets and/or people and assets outside of the road reserve, or originates outside a road reserve and affects road users and/or roadside assets. Roadside geotechnical hazards can occur on cut batters, fill batters, natural slopes and where geotechnical treatments have been constructed and include:

- Rockfalls
- Rotational failures
- Slumping of soil and rock
- Avalanches, debris flows and mud flows
- Cavities created by piping
- Erosion of river and creek banks and at culvert outlets
- Embankment fills acting as dams
- Failure of geotechnical treatments e.g. rockfall netting, minor retaining walls

Refer to Appendix A for examples.

The following are not considered to be roadside geotechnical hazards:

- Slopes, both natural and made, that show no visual evidence of current landslide activity or erosion, or potential for future landslide activity or erosion
- Pavement failures (cracking, rutting or other deformation limited to the pavement only, not extending through the subgrade)
- Tree fall (by itself, but not where it is part of a roadside geotechnical hazard)
- Failure of a retaining structure with a SR structure number
- Failure of a reinforced soil structure, spill through abutment or approach embankment within 5 m of the abutment of

a bridge with an SN structure number (5 m is the typical extent of Type A Structural Material)

- A landslide or erosion in fill within 3 m of a major culvert with an SN structure number (3 m is the typical extent of Type A Structural Material)

The following are not considered to be roadside geotechnical hazards if they do not affect road users, roadside assets (with the exception of table drains), and/or people and assets outside of the road reserve:

- Rockfalls less than 100 mm minimum dimension
- Slumping less than 2 m^3 total volume or 1 m^3/lineal m
- Surface erosion

Identification of Roadside Geotechnical Hazards

Roadside geotechnical hazards are identified through the following inspection program undertaken by trained geotechnical engineers:

- Kerbside stability assessments of targeted road sections to allow prioritisation of multiple sites in terms of the need for a more detailed assessment, scheduled every 7-10 years
- Specific inspections at the request of VicRoads Regions where a new roadside geotechnical hazard has been identified or a previously identified roadside geotechnical hazard has developed or occurred

Risk Analysis

Scope Definition

VicRoads has developed a procedure specifically for the risk assessment of roadside geotechnical hazards on the Victorian freeway and arterial road network. The procedure was developed from the results of a series of trials between 2000 and 2006 and is a three level quantitative assessment of risk based on field observations and an analysis of the likelihood of a hazard occurring and the consequences of the hazard occurring.

A Level 1 risk assessment requires the completion of a checklist and the calculation of a score. Separate checklists have been prepared for cut batters, fill batters, natural slopes and geotechnical treatments. Based on the score achieved, sites are assessed as being either LOW PRIORITY or HIGH PRIORITY. No further action is required for a LOW PRIORITY site; for a HIGH PRIORITY site a Level 2 risk assessment is undertaken.

A Level 2 risk assessment is an expanded version of a Level 1 risk assessment. Separate checklists have been prepared for cut batters, fill batters, natural slopes and geotechnical treatments and separate scores are calculated for likelihood, consequences to people and economic consequences of hazard occurrence. Based on the likelihood and higher consequence score, sites are assigned an assessed risk level of VERY LOW, VERY LOW-LOW, LOW, LOW-MODERATE, MODERATE, MODERATE-HIGH, HIGH or VERY HIGH. For sites with an assessed risk level of HIGH and VERY HIGH a Level 3 risk assessment is undertaken.

A Level 3 risk assessment requires a detailed inspection of a site, the identification of each hazard present at the site and the identification of each element at risk from each hazard. The likelihood, consequences to people and economic consequences of hazard occurrence are then rated for each combination of hazard and element at risk. Based on the worst case combination of likelihood and higher consequence rating sites are assigned the same range of assessed risk levels as a Level 2 risk assessment.

Hazard Analysis

When a roadside geotechnical hazard is identified, the type of hazard and the volume and extent of the hazard are characterised.

For Level 1 and 2 risk assessments, the likelihood of hazard occurrence is scored based on quantitative site characteristics.

For Level 3 risk assessments, the likelihood of hazard occurrence is specifically estimated based on records of previous hazard occurrences and an assessment of the likelihood of future hazard occurrence. The likelihood of hazard occurrence is expressed as an annual probability of occurrence, e.g. a 1:10 year event.

Consequence Analysis

When a roadside geotechnical hazard is identified, the elements at risk (people and assets) and their location are characterised.

For Level 1 and 2 risk assessments, the consequence of hazard occurrence is scored based on quantitative site characteristics.

For Level 3 risk assessments, the consequences of hazard occurrence are specifically estimated for both the consequences to people and the economic consequences of direct costs for remedial works and indirect costs from traffic disruption. The consequences of the hazard occurring are expressed as a scale of injury and a scale of economic loss, e.g. minor injuries and direct costs and economic losses of $0.5M.

Table 1: Risk estimation matrix for roadside geotechnical hazards.

Likelihood	Consequences				
	1 or C1 CATASTROPHIC	2 or C2 MAJOR	3 or C3 MEDIUM	4 or C4 MINOR	5 or C5 INSIGNIFICANT
A or L1 ALMOST CERTAIN	VH	VH	H	H	M
B or L2 LIKELY	VH	H	H	M	L-M
C or L3 POSSIBLE	H	M-H	M	L-M	VL-L
D or L4 UNLIKELY	M-H	M	L-M	L	VL
E or L5 RARE	M	L-M	L	VL	VL
F or L6 NOT CREDIBLE	VL	VL	VL	VL	VL

Risk Estimation

The matrix shown in Table 1 is used to assign the assessed risk level of a roadside geotechnical hazard based on the results of the hazard and consequence analyses.

Risk Assessment

Risk assessment of roadside geotechnical hazards is the process of applying risk tolerance criteria to risk estimations. VicRoads has adopted the following risk tolerance criteria for roadside geotechnical hazards:

- No injuries or deaths shall occur
- No roadside assets shall be destroyed
- Disruption to traffic should be minimised
- Where medium-long term remedial works are undertaken at the site of an existing roadside geotechnical hazard, the remediated site should have an assessed risk level no greater than LOW-MODERATE
- For new road construction projects, no new roadside geotechnical hazards with an assessed risk level greater than LOW-MODERATE should be created

VicRoads has adopted the minimum risk mitigation measures for roadside geotechnical hazards shown in Table 2 to achieve these risk tolerance criteria.

Risk Management

Risk management of roadside geotechnical hazards is the process of determining and undertaking appropriate remedial works for roadside geotechnical hazards based on the assessed risk level of the roadside geotechnical hazard, VicRoads' risk tolerance criteria and VicRoads' minimum risk mitigation measures for roadside geotechnical hazards.

The process adopted by VicRoads to undertake risk management of roadside geotechnical hazards, summarised in this Technical Note, is described in full in the VicRoads Roadside Asset Management Guideline - S1 Geotechnical Hazards which forms part of VicRoads' Roadside Management Strategy 2011.

Table 2: Risk mitigation measures based on assessed risk level.

Assessed Risk Level	Risk Mitigation Measures
VL, VL-L, L, L-M	No further action required.
M	Regional staff to monitor further development of failure.
M-H	Trained geotechnical engineer to reinspect every 24 months. Short term remedial works to be undertaken as required.
H	Trained geotechnical engineer to reinspect every 12 months. Monitoring instrumentation to be installed. Short term remedial works to be undertaken as required. Planning of medium-long term remedial works to be undertaken and implemented within 3 years.
VH	Trained geotechnical engineer to reinspect every 6 months. Monitoring instrumentation to be installed. Planning of medium-long term remedial works to be undertaken and implemented within 1 year.

References

1. 'Practice note guidelines for landslide risk management 2007' 2007, *Journal and News of the Australian Geomechanics Society*, vol. 42 no. 1, p63

2. VicRoads Roadside Asset Management Guideline - S1 Geotechnical Hazards

3. VicRoads' Roadside Management Strategy 2011

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Appendix A: Examples of Roadside Geotechnical Hazards

Figure A1: Rockfall.

Figure A2: Rotational failure.

Figure A3: Slumping of soil.

Figure A4: Debris flow.

Figure A5: Cavity created by piping.

Figure A6: Erosion at culvert outlet

Figure A7: Embankment fill acting as a dam.

Figure A8: Failure of minor retaining wall.

VicRoads believes this publication to be correct at the time of printing and does not accept responsibility for any consequences arising from the use of the information herein. Readers should rely on individual judgment and skill to apply information to particular issues.

Technical Note - Revision Summary

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Date	Clause Number	Description of Revision	Authorised by
March 2013	Full document	Major corrections made	PA – P&M