Technical Note

Risk Management of Road 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 road 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 road geotechnical hazards is illustrated in Figure 1.

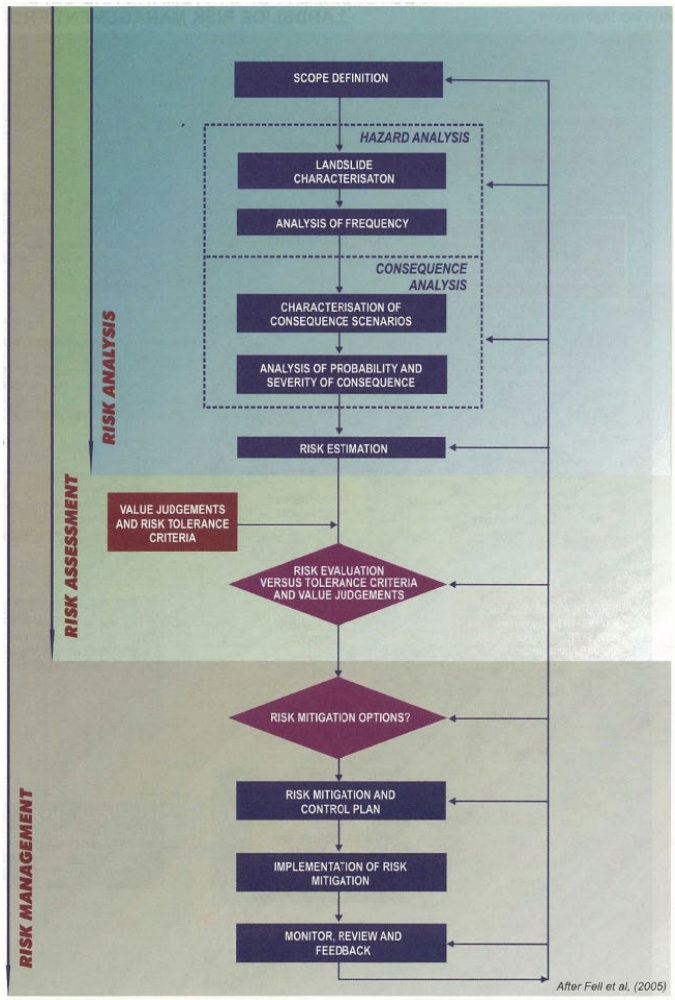

Figure 1: Risk management of road geotechnical hazards (AGS 2007).

Definition of a Road Geotechnical Hazard

VicRoads defines a road geotechnical hazard as ground movement inside a road reserve that affects road users, road infrastructure, non-road infrastructure and/or people and assets outside of the road reserve. Road geotechnical hazards can originate inside or outside a road reserve, can occur on cut batters, fill batters and/or natural slopes, and include:

- Landslides (including rockfalls, rotational failures, slumping of soil and rock, avalanches, debris flows and mud flows)
- Erosion (including erosion of river and creek banks, erosion at culvert outlets, cavities created by piping and embankment fills acting as dams)
- Coastal processes (including erosion by wave action, coastal cliff collapse and inundation from projected sea level rise)
- Subsidence (including pavement settlement)
- Expansive soil processes (including cracking extending through the pavement, capping layer and subgrade)

Refer to Appendix A for examples.

The following are not considered to be road geotechnical hazards:

- Batters and slopes that show no visual evidence of ongoing ground movement or potential for future ground movement
- Ground movement at dams, slope treatments and minor retaining walls (these assets are managed under separate asset management programs)
- Ground movement at structures (these assets are managed under separate asset management programs), including:
  - within 3 m of the start or end of a retaining structure, or within 3 m of the top of a toe retaining structure, with an SR structure number (3 m

is the typical extent of Type A Structural material)

- at a retained abutment, 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)
- within 3 m of a major culvert with an SN structure number (3 m is the typical extent of Type A Structural material)

- Potential for future ground movement from earthquake and tsunami (these are rare likelihood hazards and are considered a tolerable risk)
- Potential for future ground movement from works by others in road reserves or works by others on land adjacent to road reserves (these works are controlled by regulation)
- Pavement failures (cracking, rutting or other deformation limited to the pavement only, not extending through the subgrade; and cracking, rutting or other deformation extending through the pavement and subgrade where the subgrade is expansive soil and there is no capping layer)
- Drainage failures and tree falls (by themselves, but not where part of a road geotechnical hazard)

The following are not considered to be road geotechnical hazards if they do not affect road users, road infrastructure (with the exception of batters and table drains), non-road infrastructure 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
- Superficial erosion

Identification of Road Geotechnical Hazards

Road 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 12-15 years
- Specific inspections at the request of VicRoads Regions where a new road geotechnical hazard has been identified or a previously identified road geotechnical hazard has developed or occurred

Risk Analysis

Scope Definition

VicRoads has developed a procedure specifically for the risk assessment of road 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 continuously improved since, 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 and natural slopes. 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 and natural slopes 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 road 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 road geotechnical hazard is identified, the elements at risk (people, road infrastructure, non-road infrastructure 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.

Risk Estimation

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

Table 1: Risk estimation matrix for road 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 Assessment

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

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

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

The VicRoads Road Management Plan is available from the VicRoads website.

Further information on short term remedial works (routine maintenance) is provided in the following Technical Notes:

- Technical Note TN 36 Rock Slope Routine Maintenance
- Technical Note TN 80 Soil Slope Routine Maintenance

Further information on monitoring instrumentation is provided in Technical Note TN 79 Monitoring Slope Stability.

Risk Management

Risk management of road geotechnical hazards is the process of determining and undertaking appropriate remedial works for road geotechnical hazards based on the assessed risk level of the road geotechnical hazard, VicRoads' risk tolerance criteria and VicRoads' minimum risk mitigation measures for road 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	Regional staff to monitor during hazard inspections in accordance with the VicRoads Road Management Plan
M	Trained geotechnical engineer to reinspect at maximum 15 year intervals
M-H	Trained geotechnical engineer to reinspect at maximum 3 year intervals Short term remedial works (routine maintenance) to be undertaken as required
H	Trained geotechnical engineer to reinspect at maximum 2 year intervals Monitoring instrumentation to be installed Short term remedial works (routine maintenance) to be undertaken as required Planning of medium term (design life minimum 10 years) or long term (design life minimum 100 years) remedial works to be undertaken and implemented within 3 years
VH	Trained geotechnical engineer to reinspect at maximum 1 year intervals Monitoring instrumentation to be installed Planning of medium term (design life minimum 10 years) or long term (design life minimum 100 years) 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

Contact Officer

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Appendix A: Examples of Road Geotechnical Hazards

Figure A1: Landslide (rockfall).

Figure A2: Landslide (rotational failure).

Figure A3: Landslide (slumping of soil).

Figure A4: Landslide (debris flow).

Figure A5: Landslide (complex: sliding/lateral spread of shallow colluvial debris overlying rock).

Figure A6: Erosion (erosion at culvert outlet).

Figure A7: Erosion (cavity created by piping).

Figure A8: Erosion (embankment fill acting as a dam).

Figure A9: Coastal processes (erosion by wave action).

Figure A10: Subsidence (pavement settlement).

Figure A11: Expansive soil processes (cracking extending through the pavement, capping layer and subgrade).

Technical Note - Revision Summary

TN 96 Risk Management of Road Geotechnical Hazards

Date	Clause Number	Description of Revision	Authorised by
March 2013	Full document	Major corrections made	PA – P&M
April 2022	Full document	Major corrections made	M - GS