

SEACAP 21/004
Mainstreaming Slope Stability Management – Hazard and Risk Assessment

Theme 5
Slope Instability Hazard and Risk Assessment

SEACAP 21/004

**Mainstreaming Slope Stability Management – Hazard and
Risk Assessment – to Laos Practitioners**

**Theme 5.1
Definitions**

Landslide Hazard

- A landslide hazard is a slope failure or slope movement that has the potential to cause damage.

It is defined by:

- Size and depth of failure
- Frequency and speed of movement

Landslide Risk

- Landslide risk is the actual or expected loss caused by a landslide hazard occurring.

It is defined by:

- Landslide hazard
- Location of the hazard in relation to the road (above, below or through)
- The vulnerability of the road structures to damage
- Their combined value
- Other related costs (maintenance costs, traffic delays & social costs)

An Assessment of Landslide Hazard and Risk is Required in Order to be Able to Prioritise Preventative or Remedial Works

- **This is preferably carried out using an objective and formal risk assessment approach via a Landslide or Damage Inventory**

Risk Computation in Landslide Inventory

R (risk) = Magnitude (M) x Probability (P) x Value (Va) x Vulnerability (Vu)

- **Magnitude is the size of the landslide or slope failure**
- **Probability is the likelihood of a ground movement or slope failure occurring within a given time, such as a road design life**
- **Value is the value of elements judged to be at risk (e.g. a retaining wall or a side drain)**
- **Vulnerability is the degree of damage considered likely to occur to a given element at potential risk should the ground movement or slope failure occur.**

Landslide Risk is therefore ultimately measured in terms of economic (and social) loss

- **Repairs/losses caused by landslide impacts to engineering assets**
- **Landslide debris clearance and access provision in landslide areas**
- **Traffic delays**
- **Social and environmental costs***

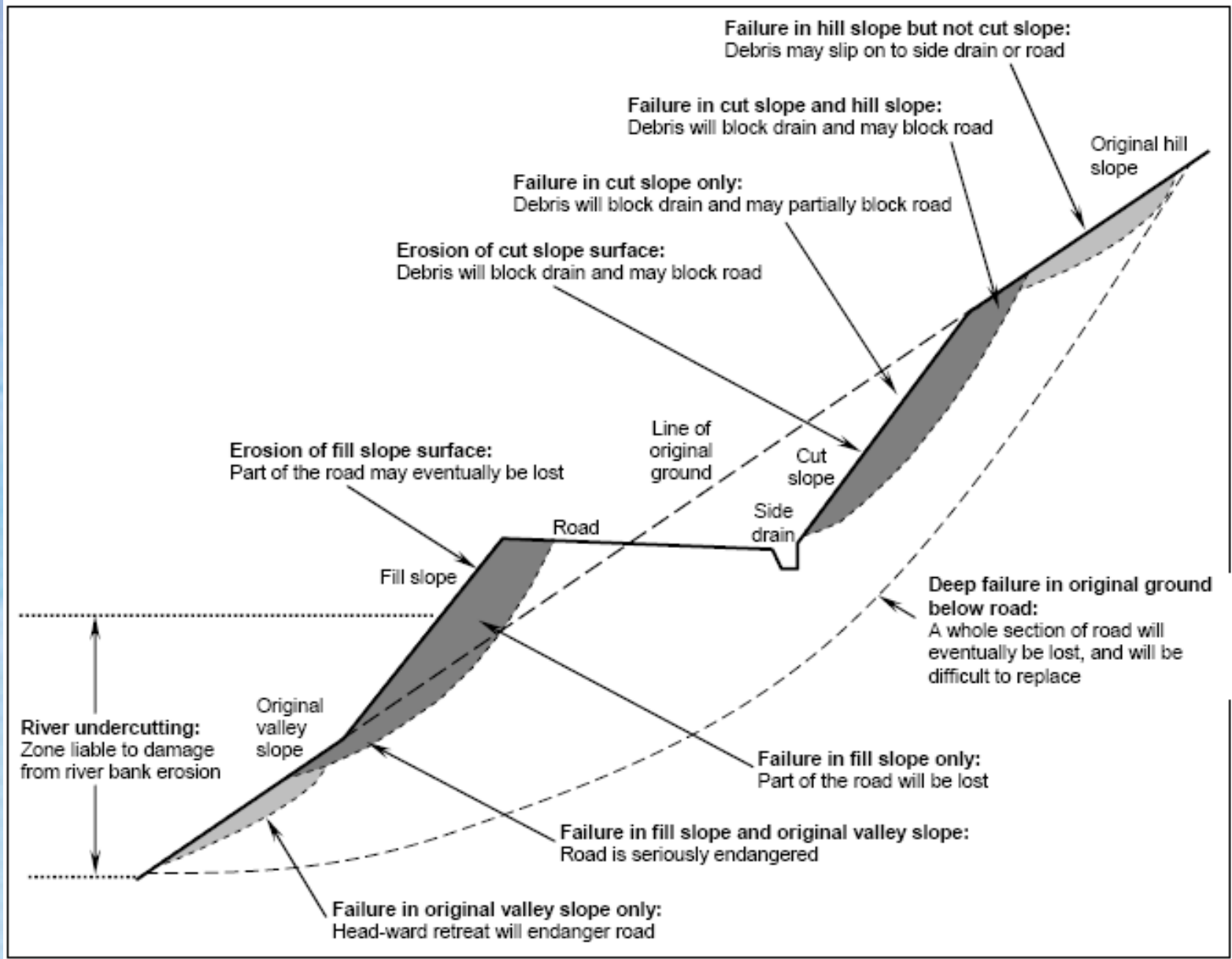
*considered to be comparatively low in Lao PDR

Emergency Maintenance Expenditure (US\$M)

Fiscal Year	Landslide removal and repair	Carriageway repairs and road grading	Total emergency maintenance expenditure
2004-05	5.15	1.19	6.34
2005-06	3.17	3.43	6.59
2006-07	3.14	2.08	5.21

Between 50-80% of emergency maintenance costs are due to landslides

Basis for Inventory Hazard and Risk Rating



ard ~ Low - Mod
ue ~ High
nerability ~ Low
k ~ Low - Mod





Hazard ~ Low - Mod

Value ~ High

Vulnerability ~ High

Risk ~ High

SEACAP 21/002 Landslide Hazard and Risk Inventory

- Notes, photographs and hazard/risk rating for >150 landslides
- Over 1,100 km of National Road included in Inventory
- Selected Roads:
1E, 3, 4, 8, 12, 13N (as far as Chinese Border), 18

Road	Km	Grid Ref (E/N)	Geology	Hazard Type	Risk (without mitigation) $R = M \times P \times V_a \times V_u$	Measures Taken	Degree of Success/ Residual Effects	Risk (without mitigation) $R = M \times P \times V_a \times V_u$
8	128+800	105°09'00" 18°22'16"	Granite WG II	Deep seated rockslide in cut slope. Approx 40m road length, extends approx 80m upslope	M = 3 P = 2 V _a = 3 V _u = 1 R = 18	None, debris clearance only. Only other option would be large RW	OK, probable continued movement of debris into road	M = 3 P = 2 V _a = 3 V _u = 1 R = 18

Summary of Inventory Findings

- **Over 70% of recorded landslides had taken place above the road**
- **Approximately 60% of total recorded landslides were assigned low risk categories**
- **3% of recorded landslides had resulted in movement of the entire carriageway, i.e. high risk**
- **4% of recorded landslides were rock slope failures, i.e. almost all were in soil or weathered rock**

Computation of Risk

Risk components	Assigned Relative Values			
	0	1	2	3
Magnitude of hazard (M)		Small (shallow and extending over up to 500m ²)	Moderate	Large (deep and extending over area of 5000m ² or more)
Probability of hazard occurring during 20 year period (P)	Not expected to happen	Possible	Expected to happen	Definite
Value of road elements at risk (Va)		Existing slope works and side drain	Existing slope works, side drain, and up to 50% of carriageway width (one lane)	Entire carriageway and adjacent structures
Vulnerability of elements to the hazard, should it occur (Vu)	No effect	Deformation or blockage	Partial loss	Total loss
Risk = M x P x Va x Vu				



Road 1E

Nam Theun

Road 1E	16+100	105°03'06" 17°47'24"	Sandstone mudstone WG II-III	Above Road: Rock slide in cut slope. 100m of road affected. Assume original failure blocked road.	Above Road: M = 2 P = 3 Va = 3 Vu = 1 R = 18	Above Road: Cut slope angle reduced to being slightly greater than angle of dip of strata. No other mitigation undertaken, though rock bolting is under consideration by the contractor.	Tension cracks continue to develop.	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
---------	--------	-------------------------	------------------------------------	--	---	---	---	---



Road 3

Road 3	64+500 (approx)	101°13'31" 20°46'38"	Not known WG IV?	Above Road: Failing rock mass forming cut slope. Original failure probably partially blocked road	Above Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36	Above Road: None, clearance only.	NA	Above Road: M = 2 P = 3 Va = 2 Vu = 3 R = 36
--------	--------------------	-------------------------	---------------------	--	---	---	----	---

Road 8



Road 8	128+800	105°09'00" 18°22'16"	Granite WG II	Above Road: Deep seated rockslide in cut slope. Approx 40m road length, extends approx 80m upslope	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12	Above Road: None, debris clearance only. Only other option would be large RW	OK, probable continued movement of debris into road	Above Road: M = 2 P = 2 Va = 3 Vu = 1 R = 12
--------	---------	-------------------------	------------------	---	---	--	--	---

Practical Guidelines

Assessing Hazard Based on Slope Angle & Height

Hazard ranking	Soil/highly weathered rock or colluvial slope		Rock slope, fresh to moderately weathered		Wall
	Height (m)	Angle (deg)	Height (m)	Angle (deg)	Height (m)
High	> 15	> 35	> 12	> 70	> 8
Moderate	5-15	25-35	7-12	50-70	3-8
Low	< 5	< 25	< 7	< 50	< 3

Notes: For slopes, use height or angle to derive highest category
Table based on average conditions

Practical Guidelines

Prioritising Investigation

Risk/hazard priority	Type of investigation		
	Detailed site inspection only	Intermediate geotechnical investigation	Detailed geotechnical investigation
Risk rating from Figure 3.3			
1			✓
2		✓	
3	✓		
4	✓		
5	✓		
Hazard rating from Figure 3.4			
High			✓
Moderate		✓	
Low	✓		

Practical Guidelines

Prioritising Mitigation Based on Expected Outcome

Actual or expected consequences	Risk ranking				
	1	2	3	4	5
Road completely lost (or road subsidence greater than 1m) or occupied buildings damaged or destroyed	✓				
Road partially lost		✓			
Road completely blocked		✓			
Road subsidence less than 1 metre		✓			
Road partially blocked			✓		
Productive agricultural or forest land lost or destroyed				✓	
Walls damaged or slope drainage blocked or damaged				✓	
Roadside drainage damaged or blocked					✓
Continued erosion without destroying vegetation cover					✓
Ranking and priority					
<ol style="list-style-type: none"> 1. Top priority, emergency measures required immediately; buildings may need to be evacuated. 2. High priority; realignment may be necessary. 3. Moderate priority, but some temporary remedial measures are required immediately, such as slip debris clearance, emergency road signing etc. 4. Low priority, but some actions are required quickly, such as slip debris clearance. 5. Least priority, but should be tackled as soon as possible under routine maintenance. 					