The New Priority Ranking Systems for Man-made Slopes and Retaining Walls

GEO Report No. 284

P.F.K. Cheng

Geotechnical Engineering Office
Civil Engineering and Development Department
The Government of the Hong Kong
Special Administrative Region

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Preface

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (http://www.cedd.gov.hk) on the Internet. Printed copies are also available for some GEO Reports. For printed copies, a charge is made to cover the cost of printing.

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H.N. Wong
Head, Geotechnical Engineering Office
August 2013

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Foreword

The Government has launched the Landslip Prevention and Mitigation Programme (LPMitP) on a rolling basis to dovetail with the Landslip Preventive Measures (LPM) Programme upon its completion in 2010, to deal with landslide risks associated with the remaining man-made slope features and vulnerable natural hillside catchments.

This report documents the risk-based New Priority Ranking Systems (NPRS) which have been developed by the Geotechnical Engineering Office (GEO) to allow the ranking of both pre-1978 and post-1978 man-made slopes and retaining walls for priority attention under the LPMitP. The NPRS supersede the New Priority Classification Systems (NPCS), which were previously developed by the GEO for dealing with the high-risk old (i.e. pre-1978) man-made slope features under the 10-year (2000-2010) Extended LPM Programme.

The NPRS were jointly developed by Dr Dominic O.K. Lo, Ms Patty F.K. Cheng, Mr W.K. Pun and Mr Anthony Y.T. Lam.

A draft of the NPRS was reviewed by the Slope Safety Technical Review Board (SSTRB) comprising Dr Suzanne Lacasse, Professor Oldrich Hungr and Professor Wang Si-Jing, and their comments and suggestions were incorporated into the NPRS.

This report was compiled by Ms Patty F.K. Cheng under the supervision of Mr Anthony Y.T. Lam.

Ken. K.S. Ho
Chief Geotechnical Engineer/Standards & Testing

Abstract

This report documents the New Priority Ranking Systems (NPRS) for man-made slopes and retaining walls. The NPRS are risk-based ranking systems that consider both the likelihood and consequence of slope failures. The NPRS have been developed by the Geotechnical Engineering Office for the individual feature types (viz. soil cut slopes, rock cut slopes, fill slopes and retaining walls) to allow the priority ranking of both pre-1978 and post-1978 man-made slope features under the post-2010 Landslip Prevention and Mitigation Programme (LPMitP).

The likelihood of slope failures is reflected by an Instability Score, while the consequence of failure is reflected by a Consequence Score. The risk of slope failures is reflected by a Total Score, which is computed as the product of the Instability Score and the Consequence Score.

Instability Score accounts for the instability potential of a slope feature and its actual performance. The instability potential is assessed by considering the key factors that affect the likelihood of failure. The actual slope performance is manifested as signs of distress where present and records of instability after the slope feature has been formed or treated to its present configuration.

Consequence Score considers the facilities affected in the event of a slope failure. It takes due account of the type and proximity of the affected facilities, scale and mechanism of failure, together with the topography adjacent to the slope features.

A methodology for combining the Total Score computed by the individual NPRS is formulated based on the overall risk distribution of the four respective types of slope features, namely soil cut slopes, rock cut slopes, fill slopes and retaining walls. The resultant Ranking Score is unique for each slope feature and can be used for selection of deserving man-made slope features for follow-up action under the LPMitP.

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1 Introduction

This report documents the New Priority Ranking Systems (NPRS) which have been developed by the Geotechnical Engineering Office (GEO) for slope selection under the Landslip Prevention and Mitigation Programme (LPMitP). With the completion of the Landslip Preventive Measures (LPM) Programme by 2010, all the high-risk old (i.e. pre-1978) man-made slope features affecting major roads and developments will have been dealt with. To dovetail with the LPM Programme, the Government has launched the LPMitP on a rolling basis, in order to contain the landslide risks associated with the remaining man-made slope features and vulnerable natural hillside catchments.

Apart from vulnerable natural hillsides, the LPMitP primarily targets man-made slope features that are of moderate risk, viz. old slopes affecting frequently used road, footpaths, public waiting areas, etc. and post-1978 slopes formed or treated over 20 years ago with non-robust technology, which are denoted as "old technology" slopes[1]. The NPRS have been formulated for the respective feature types (viz. soil cut slopes, rock cut slopes, fill slopes and retaining walls) to allow the ranking of both pre-1978 and post-1978 man-made slope features for priority attention under the LPMitP. The priority ranking system for vulnerable natural hillside catchments is outside the scope of this report.

This report presents the methodology of the NPRS and gives guidance on collection of field data and computation of scores for man-made slope features. Worked examples are also provided in this report.

2 New Priority Ranking Systems

2.1 The Systems

The LPM Programme primarily targets high-risk pre-1978 man-made slope features, for which the New Priority Classification Systems (NPCS) were developed by the GEO for priority ranking (Wong, 1998). The LPMitP primarily targets moderate-risk pre-1978 and selected post-1978 man-made slope features. The resolution of the NPCS is not adequate to distinguish the relative risks of a large number of moderate-risk man-made slope features and that the degree of past geotechnical engineering input to post-1978 slopes is not accounted for. Also, further insights have been obtained through GEO’s systematic landslide investigation programme (Ho & Pappin, 2007), which have proved useful for refining selected factors and their weightings in the priority ranking systems. In light of the above, new NPRS were developed by the GEO primarily for use under the post-2010 LPMitP.

The NPRS are risk-based ranking systems that consider both the likelihood and the consequence of slope failures. The likelihood of failure is reflected by an Instability Score (*IS*) while the consequence of failure is reflected by a Consequence Score (*CS*). Each system for the four types of slope feature is based on the same equation, which computes a Total Score (*TS*). The *TS* is the product of *IS* and *CS*, i.e.

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[1] Old technology slopes are formed or treated from 1977 to late 1980s based on knowledge and technology at the time, typically comprise slopes trimmed back to a less steep gradient without the provision of reinforcement or structural support. These slopes are prone to degradation and less robust than those treated with modern technology such as soil nails.

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$$TS = IS \times CS \quad (2.1)$$

IS accounts for the instability potential of a slope feature and its actual performance. The assessment of Instability Potential (*IP*) is based on the consideration of a number of key factors that affect the likelihood of failure. The NPRS place due emphasis on the Actual Performance (*AP*) of a man-made slope feature, which is manifested as signs of distress where present and records of instability after the slope feature has been formed or treated to its present configuration. *IS* is the product of *IP* and *AP*, i.e.

$$IS = IP \times AP \quad (2.2)$$

Factors contributing to the *IP* are different for the individual feature types due to the fact that their failure mechanisms, together with the causes and triggering factors of failure, are not the same. Factors considered in each system are addressed in Sections 3 to 6.

Signs of distress of a slope feature are classified into three levels (i.e. severe, moderate and minor). Guidelines on the classification of signs of distress for the individual ranking systems are given in Appendices A to D.

CS reflects the severity of the consequence of a slope failure in terms of the potential loss of life. It takes due account of the type and proximity of the affected facilities, scale and mechanism of failure, and the topography adjacent to the slope features. The proximity of the toe facilities and the topography adjacent to the slope feature is accounted for by the shadow angle (ω), see Figure 2.1.

In the NPRS, the types of facilities affected are subdivided into five facility groups, pursuant to GEO Technical Guidance Note (TGN) No. 15 (GEO, 2007). The consequence-to-life categories corresponding to the different facilities are presented in Table 2.1.

Roads should be classified as the appropriate facility groups based on the most recent Annual Average Daily Traffic (AADT) and the number of traffic lanes (see Figure 2.2). The AADT data for a vast majority of roads in Hong Kong are available in the Annual Traffic Census published by the Transport Department.

It should be noted that the NPRS take account of direct-risk-to-life only, i.e. the consideration of indirect risk-to-life is excluded. Also, the following categories of slope feature will not be ranked for action under the LPMitP:

(a) Government soil cut slopes that were formed/treated in or after year 2000, and processed and accepted by GEO.

(b) Government soil cut slopes that were treated with robust technology[2] (e.g. installed with soil nails), and processed and accepted by GEO.

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[2] Robust technology refers to those design solutions that are not unduly sensitive to uncertainties associated with locally adverse geological and hydrogeological conditions (Ho et al, 2003). For example, soil nailing is a robust technology in the case of soil cut slopes.

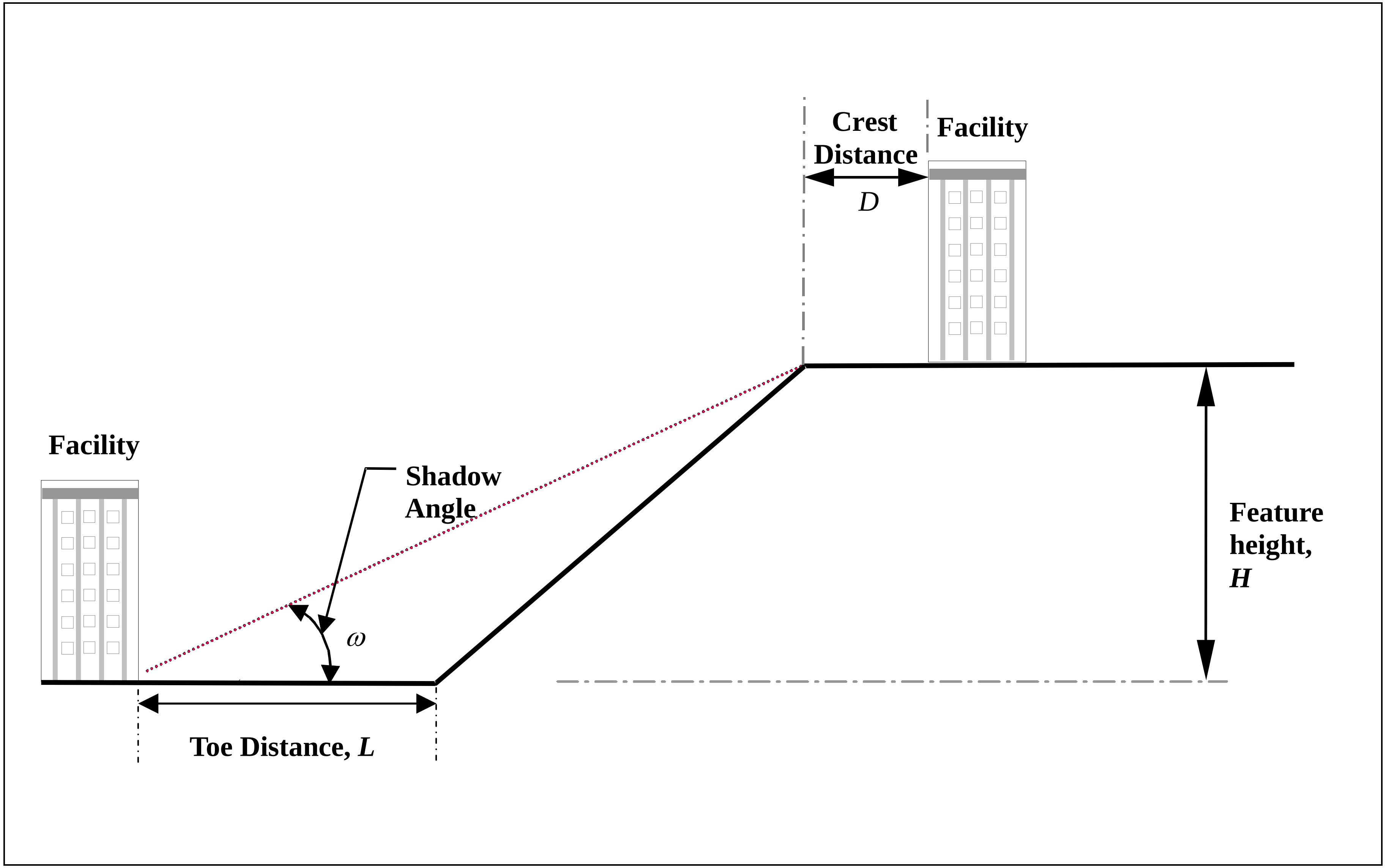

Figure 2.1 Crest and Toe Facilities Affected by a Slope Feature

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Table 2.1 Typical Examples of Facilities under Different Facility Groups Affected by Landslides

Facility Group	Facilities	Consequence-to-life Category
1	(a) Heavily Used Buildings – residential building, commercial office, store and shop, hotel, factory, school, power station, ambulance depot, market, hospital, polyclinic, clinic, welfare centre	1
	(b) Others – cottage, licensed and squatter areas – bus shelter, railway platform and other sheltered public waiting area – dangerous goods storage site (e.g. petrol stations) – road with very heavy vehicular or pedestrian traffic density	
2	(a) Lightly Used Buildings – indoor car park, building within barracks, abattoir, incinerator, indoor games' sport hall, sewage treatment plant, refuse transfer station, church, temple, monastery, civic centre, manned substation	
	(b) Others – major infrastructure facility (e.g. railway, tramway, flyover, subway, tunnel portal, service reservoir) – construction site (if future use not certain)[3] – road[4] with heavy vehicular or pedestrian traffic density	2
3	– heavily used open space and public waiting area (e.g. heavily used playground, open car park, heavily used sitting out area, horticulture garden) – road with moderate vehicular or pedestrian traffic density	
4	– lightly used open-air recreation area (e.g. district open space, lightly used playground, cemetery, columbarium – non-dangerous goods storage site – road with low vehicular or pedestrian traffic density	3
5	– remote area (e.g. country park, undeveloped green belt, abandoned quarry) – road with very low vehicular or pedestrian traffic density	

Note: The consequence-to-life category refers to the situation where the facilities are located within the expected travel distance of landslide debris or the expected crest influence zone of a failure. Situations where the CTL category can be downgraded are given in GEO TGN No.15 (GEO, 2007).

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[3] If the intended future use is known, the Facility Group should be based on the facility that corresponds to the intended future use of the site.

[4] For footpaths alongside roads, it may be assumed that footpaths are within the same group as the adjoining roads, except for Expressway (EX), Urban Trunk Roads (UT) and Rural Trunk Road (RT). Footpaths alongside EX, UT and RT roads may be taken, by default, as a Group 5 facility, unless dictated otherwise by site-specific conditions.

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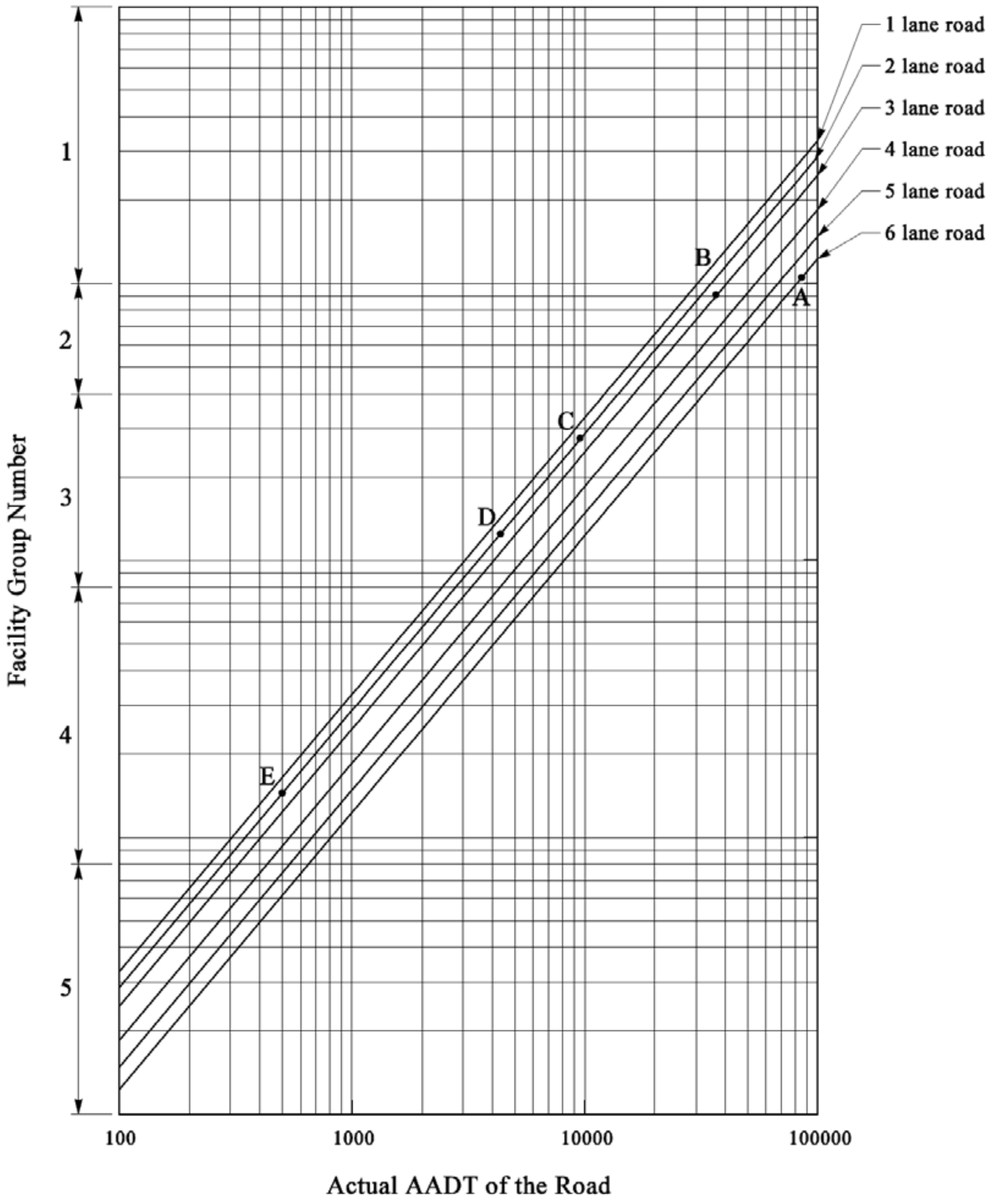

Legend:

AADT	Annual Average Daily Traffic based on the most recent Annual Traffic Census carried out by the Transport Department
A	Princess Margaret Road (from Wylie Road to Pui Ching Road)
B	Pokfulam Road (from Pokfield Road to Mount Davies Road)
C	Castle Peak Road (from Sham Tseng to Siu Lam)
D	Borrett Road
E	Shouson Hill Road West

Note: Figure extracted from GEO Report No. 68 (Wong, 1998).

Figure 2.2 Relationship between Facility Groups, Actual AADT and Number of Traffic Lanes

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(c) Government rock cut slopes, fill slopes and retaining walls that were processed and accepted by GEO.

(d) Private slopes and retaining walls that have been subjected to GEO Stage 2 studies after 2000, checked by GEO after 2000, checked and upgraded with robust technology, or subjected to DH orders.

Should severe signs of distress or instability be observed on the above slope features, safety nets (e.g. Engineer Inspections (EI), systematic landslide investigation programme, etc.) are available to initiate actions, e.g. urgent repairs and injection into the LPMitP.

Similar to NPCS, NPRS are essentially expert formulation systems (Wong, 2005), except for that on rock cut slopes which is an expert judgment system. In the latter system, the inspecting engineers need to exercise judgment in assessing the potential modes of instability and the corresponding probable scale of failures.

GEO has developed a database with standard templates for computation of ranking scores under NPRS. The database can be accessed and downloaded through the following link: (http://hkss.cedd.gov.hk/hkss/eng/nprs.aspx).

2.2 Selection of Cross-sections of Slope Features

In calculating the *TS*, the cross section corresponding to the worst-consequence (denoted as Section 1-1) should be considered. Where several facilities exist, either at the same section or at different sections across a slope feature, the potential consequence of failure in relation to each facility should be assessed to determine which facility and section would give rise to the most severe consequence. The section with the combination of crest and toe facilities which gives the highest *CS* should be selected as the worst-consequence section.

If the cross section with the maximum feature height (denoted as Section 2-2) is not the worst-consequence section, and the feature height at Section 1-1 is less than 75% of the feature height at Section 2-2, then the *TS* corresponding to both sections (i.e. Sections 1-1 and 2-2) should be computed and the higher *TS* value is taken to be representative of the slope feature.

2.3 Composite Slope Features

For composite slope features, i.e. with more than one type of slope feature present, the criteria for computation of the appropriate *TS* are given in Figures 2.3 and 2.4.

A methodology to combine the *TS* as calculated by the individual NPRS is presented in Section 7.

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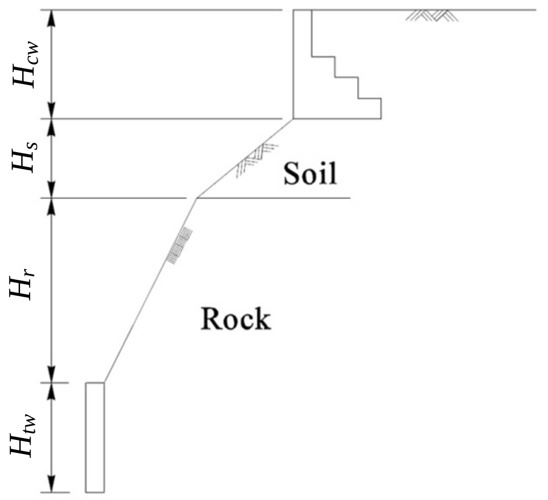
(1) General



Compute TS_{cw} if $H_{cw} \geq 3$ m

Compute TS_s if $H_s \geq 3$ m

Compute TS_r if $H_r \geq 3$ m

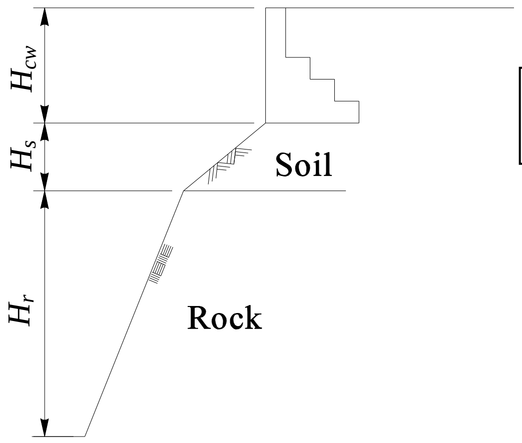
Compute TS_{tw} if $H_{tw} \geq 3$ m

(2) Special Cases

(a) If H_{cw}, H_s, H_r and $H_{tw} < 3$ m

Compute *TS* for the individual slope features, and take the highest *TS* as representative *TS* for the entire composite feature (i.e. $H_{cw} + H_s + H_r + H_{tw}$)

(b)



For $H_r \geq 3$ m :

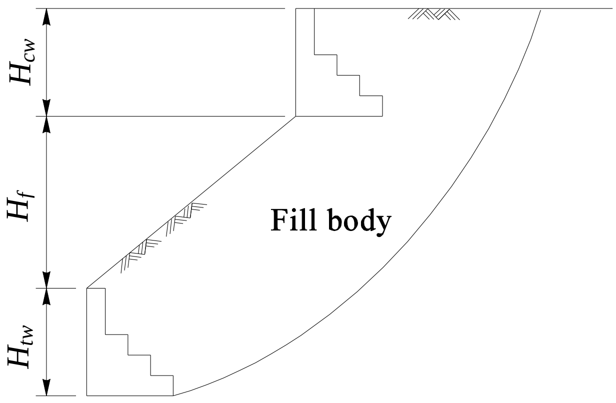
If $H_{cw} < 3$ m and $H_s \geq 1.5$ m,
or $H_s \geq 1$ m and $H_{cw} \geq 1$ m,

Compute both TS_r and TS_s

Notes:
(1) *TS* denotes Total Score.
(2) Compute the Ranking Score for the composite features under Cases 1 and 2(b) using the methodology given in Appendix E.

Figure 2.3 Computation of Ranking Scores for Composite Features Comprising Soil Cut Slope, Rock Cut Slope and Retaining Walls

(1) General



Compute TS_{cw} if $H_{cw} \geq 3$ m

Compute TS_f if $H_f \geq 5$ m

Compute TS_{tw} if $H_{tw} \geq 3$ m

(2) Special Cases

(a) If H_{cw} & $H_{tw} < 3$ m, and $H_f < 5$ m, and if $H_f + H_{cw} \geq 5$ m

Compute TS_f and TS_{cw} and take the higher TS as the representative score for the entire composite feature (i.e. $H_{cw} + H_f + H_{tw}$)

(b) If H_{cw} & $H_{tw} < 3$ m, and $H_f < 5$ m, and if $H_f + H_{tw} \geq 5$ m

Compute TS_f and TS_{tw} and take the higher TS as the representative score for the entire composite feature (i.e. $H_{cw} + H_f + H_{tw}$)

Notes:
(1) *TS* denotes Total Score.
(2) Compute the Ranking Scores for the composite features under Case 1 using the methodology given in Appendix E.

Figure 2.4 Computation of Ranking Scores for Composite Features Comprising Fill Slope and Retaining Walls

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2.4 A Stack of Slope Features

The overall stability of a stack of slope features that are close to each other vertically may be more critical than the individual slope feature, and is related to the proximity of the slope features relative to one another as well as the failure mechanisms. The influence of the lower slope feature on the upper slope feature has been assessed by the past landslide records.

Based on past landslide records, it was established that the back scarp of a typical slope failure in Hong Kong would generally extend beyond the slope crest to a horizontal distance of less than 0.4 times the feature height (GEO, 2007). Figure 2.5 addresses the *TS* calculation for slope features close to each other vertically. The separation limits L_{AB} and L_{BC} shown in Figure 2.5 are for guidance only. Depending on the actual site conditions, possible nature of instability and interaction between the slope features, some slope features may have to be assessed as a stack even when the crest to toe distance is wider than the separation limits. The guidance given in Figure 2.5 is applicable to a stack of slope features consisting of slope features of the same type, or cut slopes and retaining walls, or fill slopes and retaining walls. For multiple retaining walls in terraced ground, reference should be made to the guidance on multiple walls given in Appendix D.

2.5 Slope Features Requiring Immediate Action

Where there are significant signs of distress, or visual or documented evidence of continuous hazardous movement of slope features, or boulders or rock fragments, immediate follow-up action is recommended to be taken to remove or reduce the risk.

3 NPRS for Soil Cut Slopes

3.1 The System

The system considers sliding and washout failures of soil cut slopes and computes a (*TS*) based on the likelihood of failure (*IS*) and the consequence of failure (*CS*), i.e.

$$TS = IS \times CS$$

Details of the system and the guidelines, together with sample data collection sheets and a worked example, are presented in Appendix A.

3.2 Instability Score

The *IS* comprises two components, which account for the Instability Potential (*IP*) and Actual Performance (*AP*) of the slope, i.e.

$$IS = IP \times AP$$

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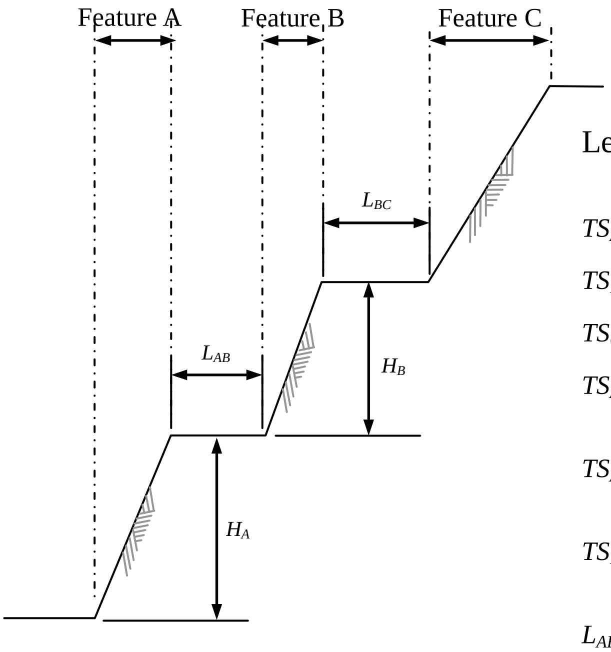

Legend

TS_A	Total Score for Feature A
TS_B	Total Score for Feature B
TS_C	Total Score for Feature C
TS_{ABC}	Total Score for a stack of slope features comprising Features A, B & C
TS_{AB}	Total Score for a stack of slope features comprising Features A & B
TS_{BC}	Total Score for a stack of slope features comprising Features B & C
L_{AB}	Separation Limit between Features A and B
L_{BC}	Separation Limit between Features B and C

1. For computing *TS* for the lowest slope feature:

   (a) If $L_{AB} \leq 0.4\ H_A$ and $L_{BC} \leq 0.4\ (H_A + H_B)$, consider a stack of features comprising Features A, B & C.

   If $TS_{ABC} > TS_A$, then $TS_A = TS_{ABC}$

   (b) If $L_{AB} \leq 0.4\ H_A$ and $L_{BC} > 0.4\ (H_A + H_B)$, consider a stack of slope features comprising Features A & B.

   If $TS_{AB} > TS_A$, then $TS_A = TS_{AB}$

2. For computing *TS* for the middle slope feature:

   (a) If $L_{BC} \leq 0.4\ H_B$, consider a stack of slope features comprising Features B & C.

   If $TS_{BC} > TS_B$, then $TS_B = TS_{BC}$

3. *TS* for the uppermost slope feature remains unchanged

Note: *TS* denotes Total Score.

Figure 2.5 Computation of Total Score for a Stack of Slope Features

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The *IP* is reflected by the age of the slope, level of geotechnical engineering input, slope geometry, provision of surface protection and surface drainage measures, and site characteristics, i.e. factors *A1* to *A5* in the equation below. The *AP* is manifested as signs of distress where present and records of instability after the slope has been formed or treated to its present configuration, i.e. factors *B1* and *B2*.

$$IS = A1 \text{ x } A2 \text{ x } A3 \text{ x } A4 \text{ x } A5 \text{ x } B1 \text{ x } B2 \quad (3.1)$$

where *A1* accounts for the age of slope since formation or treatment
A2 accounts for the level of geotechnical engineering input
A3 accounts for the slope geometry
A4 accounts for the adequacy of surface protection and surface drainage measures
A5 accounts for the site characteristics in respect of hydrogeological and geological settings
B1 accounts for signs of distress
B2 accounts for instability since slope formation or treatment

The weighting of individual factors in *IS* ranges between 1 and a value of less than or equal to 10, depending on their significance.

3.3 Consequence Score

The *CS*, which reflects the likely consequence of failure, is computed by the following equation:

$$CS = (C1 \text{ x } C2 + D1 \text{ x } D2) \text{ x } H \quad (3.2)$$

where *C1* accounts for the type of crest facility
C2 accounts for the vulnerability of the crest facility (see Table 3.1)
D1 accounts for the type of toe facility
D2 accounts for the vulnerability of the toe facility (see Table 3.2)
H represents the feature height

The vulnerability factors given in Tables 3.1 and 3.2, where reflect the chance of fatality given the landslide, account for the height of the slope and the nature of the affected facilities together with their proximity to the slope.

4 NPRS for Rock Cut Slopes

4.1 The System

The system considers potential ravelling, toppling, wedge and planar failures of rock cut slopes and computes a *TS* based on the likelihood of failure (*IS*) and the consequence of failure (*CS*), i.e.

$$TS = IS \text{ x } CS$$

Details of the system and the guidelines, together with sample data collection sheets and a worked example, are presented in Appendix B.

Table 3.1 Vulnerability Factors for Crest Facilities Involving Soil Cut Slopes, Rock Cut Slopes and Retaining Walls

(a) Vulnerability Factor (*C2*) for Crest Facility being Buildings

Feature Height, *H* (m)	Distance from Crest, *D* (m)		
	$10 > D \geq 6$	$6 > D \geq 3$	$D < 3$
$H < 5$	0	0.0000125	0.0003
$5 \leq H < 10$	0	0.0000625	0.0015
$10 \leq H < 15$	0	0.00025	0.006
$15 \leq H < 20$	0.0002	0.003	0.02
$H \geq 20$	0.0005	0.01	0.05

(b) Vulnerability Factor (*C2*) for Crest Facility other than Buildings

Feature Height, *H* (m)	Distance from Crest, *D* (m)		
	$10 > D \geq 6$	$6 > D \geq 3$	$D < 3$
$H < 5$	0	0.00025	0.0075
$5 \leq H < 10$	0	0.00125	0.0375
$10 \leq H < 15$	0	0.005	0.15
$15 \leq H < 20$	0.002	0.04	0.4
$H \geq 20$	0.002	0.074	0.54

Notes: (1) Refer to Figure 2.1 for definition of feature geometry *H* and *D*.
(2) For $D \geq 10$ m, accord $C2 = 0$ for all feature heights.

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Table 3.2 Vulnerability Factors for Toe Facilities Involving Soil Cut Slopes, Rock Cut Slopes and Retaining Walls

(a) Vulnerability Factor (*D2*) for Toe Facility being Buildings

Feature Height, H (m)	Shadow Angle, ω (degree)						
	$\omega > 50$	$50 \geq \omega > 45$	$45 \geq \omega > 40$	$40 \geq \omega > 35$	$35 \geq \omega > 30$	$30 \geq \omega > 25$	$25 \geq \omega > 20$
$H < 5$	0.0225	0.0225	0.0155	0.005	0.001	0.0001	0
$5 \leq H < 10$	0.1125	0.1125	0.0775	0.025	0.005	0.0005	0
$10 \leq H < 15$	0.45	0.45	0.31	0.10	0.02	0.002	0
$15 \leq H < 20$	0.95	0.92	0.70	0.35	0.11	0.02	0
$H \geq 20$	0.95	0.95	0.86	0.59	0.26	0.075	0.013

(b) Vulnerability Factor (*D2*) for Toe Facility other than Buildings

Feature Height, H (m)	Shadow Angle, ω (degree)						
	$\omega > 50$	$50 \geq \omega > 45$	$45 \geq \omega > 40$	$40 \geq \omega > 35$	$35 \geq \omega > 30$	$30 \geq \omega > 25$	$25 \geq \omega > 20$
$H < 5$	0.03	0.03	0.026	0.016	0.006	0.00075	0
$5 \leq H < 10$	0.150	0.150	0.130	0.08	0.030	0.00375	0
$10 \leq H < 15$	0.60	0.60	0.52	0.32	0.12	0.015	0
$15 \leq H < 20$	0.95	0.92	0.92	0.70	0.49	0.08	0
$H \geq 20$	0.95	0.95	0.95	0.86	0.59	0.25	0.03

Notes:
(1) Refer to Figure 2.1 for definition of feature geometry H and ω.
(2) For $\omega \leq 20^{\circ}$, accord $D2 = 0$ for all feature heights.

4.2 Instability Score

The *IS* comprises two components, which account for the Instability Potential (*IP*) and Actual Performance (*AP*) of the slope, i.e.

$$IS = IP \text{ x } AP$$

The *IP* is reflected by the level of geotechnical engineering input, slope geometry,

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mode and scale of instability, seepage and drainage conditions, i.e. factors $A1$ to $A4$ in the equation below. Similar to soil cut slopes, the AP is manifested as signs of distress where present and records of instability after the slope feature has been formed or treated to its present configuration, i.e. factors $B1$ and $B2$.

$$IS = A1 \text{ x } A2 \text{ x } A3 \text{ x } A4 \text{ x } B1 \text{ x } B2 \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.1)$$

where	$A1$	accounts for the level of geotechnical engineering input
	$A2$	accounts for slope geometry
	$A3$	accounts for mode and scale of instability
	$A4$	accounts for seepage and drainage conditions
	$B1$	accounts for signs of distress
	$B2$	accounts for instability since formation or treatment

The potential mode and scale of instability of a rock cut slope should be evaluated based on the inspecting engineer's site observations and documentary records on site geology, rock mass conditions, geological setting, and any relevant geological features. Reference should also be made to the previous failure incidents that occurred on the rock cut slope.

The weighting of individual factors in IS ranges between 1 and a value of less than or equal to 10, depending on their significance.

4.3 Consequence Score

The CS, which reflects the likely consequence of failure is computed by the following equation:

$$CS = (C1 \text{ x } C2 + D1 \text{ x } D2) \text{ x } K \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.2)$$

where	$C1$	accounts for the type of crest facility
	$C2$	accounts for the vulnerability of the crest facility (see Table 3.1)
	$D1$	accounts for the type of toe facility
	$D2$	accounts for the vulnerability of the toe facility (see Table 3.2)
	K	accounts for the probable scale of failure

The vulnerability factors given in Tables 3.1 and 3.2, where reflect the chance of fatality given the landslide, account for the height of the slope and the nature of the affected facilities together with their proximity to the slope. The weighting of K ranges between 1 and 5, depending on the scale of failure.

5 NPRS for Fill Slopes

5.1 The System

The system considers the following failure modes of fill slopes:

(a) sliding and minor washout: common slope failures which do

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not involve the build-up of excess pore water pressure and influence from a large amount of external water. The debris slides downslope and may involve disintegration of the soil mass, particle collision and minor erosion and washout action;

(b) liquefaction: mobile failure involving the generation of high positive excess pore water pressures during shearing and hence a substantial reduction of the effective stress and the shearing resistance; and

(c) major washout: mobile failure involving concentrated discharge of water (e.g. surface runoff from a road) resulting in scouring and erosion of the slope and the washing of debris downslope.

The system computes a *TS* based on the likelihood of the different failure modes (*IS*) and the consequence of different failure modes (*CS*), i.e.

$$TS = \sum_{i=1}^{3} IS_i \times CS_i \text{ .... } (5.1)$$

where IS_1 and CS_1 account for sliding and minor washout failure
IS_2 and CS_2 account for liquefaction failure
IS_3 and CS_3 account for major washout failure

Details of the system and the guidelines, together with sample data collection sheets and a worked example, are presented in Appendix C.

5.2 Instability Score

The *IS* comprises two components, which account for the Instability Potential (*IP*) and Actual Performance (*AP*) of the slope, i.e.

$$IS = IP \times AP$$

The *IP* is reflected by the level of geotechnical engineering input and potential of various modes of failure to occur. The *AP* is manifested as signs of distress where present and records of instability after the slope has been formed or treated to its present configuration.

$$IS_1 = A1 \times A2 \times B1 \times B2 \text{ .... } (5.2a)$$
$$IS_2 = A1 \times A3 \times B1 \times B2 \text{ .... } (5.2b)$$
$$IS_3 = A1 \times A4 \times B1 \times B2 \text{ .... } (5.2c)$$

where i 1, 2 and 3 correspond to "sliding and minor washout failure", "liquefaction failure" and "major washout failure" respectively
$A1$ accounts for the level of geotechnical engineering input

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$A2$	accounts for factors affecting sliding and minor washout failure
$A3$	accounts for factors affecting liquefaction failure
$A4$	accounts for factors affecting major washout failure
$B1$	accounts for signs of distress
$B2$	accounts for instability since formation or treatment

The weighting of individual factors in *IS* ranges between 0.05 and 32, depending on their significance.

5.3 Consequence Score

The *CS*, which reflects the likely consequence of different failure modes, is computed by the following equations:

$$CS_i = (C1 \times C2_i + D1 \times D2_i) \times H \ldots\ldots\ldots\ldots \quad (5.3)$$

where	i	1, 2 and 3 correspond to "sliding and minor washout failure", "liquefaction failure" and "major washout failure" respectively
	$C1$	accounts for the type of crest facility
	$C2$	accounts for the vulnerability of the crest facility (see Table 5.1)
	$D1$	accounts for the type of toe facility
	$D2$	accounts for the vulnerability of the toe facility (see Table 5.2)
	H	represents the feature height

The vulnerability factors given in Tables 5.1 and 5.2, where reflect the chance of fatality given the landslide, account for the height of the slope and the nature of the affected facilities together with their proximity to the slope.

6 NPRS for Retaining Walls

6.1 The System

The system considers partial and complete failure of retaining walls and computes a *TS* based on the likelihood of failure (*IS*) and the consequence of failure (*CS*), i.e.

$$TS = IS \times CS$$

Details of the system and the guidelines, together with sample data collection sheets and a worked example, are presented in Appendix D.

6.2 Instability Score

The *IS* comprises two components, which account for the Instability Potential (*IP*) and Actual Performance (*AP*) of the wall, i.e.

$$IS = IP \times AP$$

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Table 5.1 Vulnerability Factors for Crest Facilities Involving Fill Slopes

(a) Vulnerability Factor ($C2$) for Crest Facility being Buildings

Feature Height, H (m)		Distance from Crest, D (m)		
		$10 > D \geq 6$	$6 > D \geq 3$	$D < 3$
$H < 5$	$V_1=V_2$	0	0.0000125	0.0003
	V_3	0	0.00023	0.0023
$5 \leq H < 10$	$V_1=V_2$	0	0.0000625	0.0015
	V_3	0	0.00115	0.0115
$10 \leq H < 15$	$V_1=V_2$	0	0.00025	0.006
	V_3	0	0.00715	0.0375
$15 \leq H < 20$	$V_1=V_2$	0.0002	0.003	0.02
	V_3	0.008	0.0285	0.101
$H \geq 20$	$V_1=V_2$	0.0005	0.01	0.05
	V_3	0.015	0.045	0.15

(b) Vulnerability Factor ($C2$) for Crest Facility other than Buildings

Feature Height, H (m)		Distance from Crest, D (m)		
		$10 > D \geq 6$	$6 > D \geq 3$	$D < 3$
$H < 5$	$V_1=V_2$	0	0.00025	0.0075
	V_3	0	0.0022	0.011
$5 \leq H < 10$	$V_1=V_2$	0	0.00125	0.0375
	V_3	0	0.011	0.055
$10 \leq H < 15$	$V_1=V_2$	0	0.005	0.15
	V_3	0	0.043	0.18
$15 \leq H < 20$	$V_1=V_2$	0.002	0.04	0.4
	V_3	0.004	0.092	0.2825
$H \geq 20$	$V_1=V_2$	0.002	0.074	0.54
	V_3	0.006	0.12	0.315

Notes:
(1) Refer to Figure 2.1 for definition of slope geometry H and D.
(2) V_1 = Vulnerability factor for sliding and minor washout failure
V_2 = Vulnerability factor for liquefaction failure
V_3 = Vulnerability factor for major washout failure.
(3) For $D \geq 10$ m, accord $C2 = 0$ for all feature heights.

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Table 5.2 Vulnerability Factors for Toe Facilities Involving Fill Slopes

(a) Vulnerability Factor ($D2$) for Toe Facility being Buildings

Feature Height, H (m)		Shadow Angle, ω (degree)								
		$\omega > 50$	$50 \geq \omega > 45$	$45 \geq \omega > 40$	$40 \geq \omega > 35$	$35 \geq \omega > 30$	$30 \geq \omega > 25$	$25 \geq \omega > 20$	$20 \geq \omega > 15$	$15 \geq \omega > 10$
$H < 5$	V_1	0.0225	0.0225	0.0155	0.005	0.001	0.0001	0	0	0
	V_2	0.0225	0.0225	0.0225	0.0155	0.005	0.001	0.0001	0	0
	V_3	0.010	0.008	0.004	0.002	0.0005	0.00008	0.000005	0	0
$5 \leq H < 10$	V_1	0.1125	0.1125	0.0775	0.025	0.005	0.0005	0	0	0
	V_2	0.1125	0.1125	0.1125	0.0775	0.025	0.005	0.0005	0	0
	V_3	0.05	0.04	0.02	0.01	0.0025	0.0004	0.000025	0	0
$10 \leq H < 15$	V_1	0.45	0.45	0.31	0.10	0.02	0.002	0	0	0
	V_2	0.45	0.45	0.45	0.31	0.10	0.02	0.002	0	0
	V_3	0.25	0.24	0.18	0.10	0.0425	0.0104	0.001525	0	0
$15 \leq H < 20$	V_1	0.95	0.92	0.70	0.35	0.11	0.02	0	0	0
	V_2	0.95	0.95	0.95	0.8	0.48	0.18	0.045	0.005	0
	V_3	0.60	0.60	0.56	0.45	0.29	0.135	0.0435	0.0076	0
$H \geq 20$	V_1	0.95	0.95	0.86	0.59	0.26	0.075	0.013	0	0
	V_2	0.95	0.95	0.95	0.95	0.87	0.63	0.34	0.12	0.015
	V_3	0.80	0.80	0.80	0.72	0.50	0.25	0.084	0.015	0.001

(b) Vulnerability Factor ($D2$) for Toe Facility other than Buildings

Feature Height, H (m)		Shadow Angle, ω (degree)								
		$\omega > 50$	$50 \geq \omega > 45$	$45 \geq \omega > 40$	$40 \geq \omega > 35$	$35 \geq \omega > 30$	$30 \geq \omega > 25$	$25 \geq \omega > 20$	$20 \geq \omega > 15$	$15 \geq \omega > 10$
$H < 5$	V_1	0.03	0.03	0.026	0.016	0.006	0.00075	0	0	0
	V_2	0.03	0.03	0.03	0.026	0.016	0.006	0.00075	0	0
	V_3	0.040	0.036	0.025	0.013	0.004	0.001	0.0001	0	0
$5 \leq H < 10$	V_1	0.150	0.150	0.130	0.08	0.030	0.00375	0	0	0
	V_2	0.15	0.15	0.15	0.13	0.08	0.03	0.00375	0	0
	V_3	0.20	0.18	0.125	0.0625	0.02	0.005	0.0005	0	0
$10 \leq H < 15$	V_1	0.60	0.60	0.52	0.32	0.12	0.015	0	0	0
	V_2	0.6	0.60	0.6	0.52	0.32	0.12	0.015	0	0
	V_3	0.60	0.58	0.435	0.315	0.145	0.05	0.0105	0	0
$15 \leq H < 20$	V_1	0.95	0.92	0.92	0.70	0.49	0.08	0	0	0
	V_2	0.95	0.95	0.95	0.95	0.80	0.50	0.20	0.02	0
	V_3	0.875	0.875	0.835	0.725	0.530	0.285	0.1	0.0235	0
$H \geq 20$	V_1	0.95	0.95	0.95	0.86	0.59	0.25	0.03	0	0
	V_2	0.95	0.95	0.95	0.95	0.95	0.8	0.50	0.20	0.02
	V_3	0.95	0.95	0.95	0.95	0.81	0.48	0.18	0.045	0.005

Notes:

(1) Refer to Figure 2.1 for definition of slope geometry H and ω.

(2) V_1 = Vulnerability factor for sliding and minor washout failure
V_2 = Vulnerability factor for liquefaction failure
V_3 = Vulnerability factor for major washout failure.

(3) For $\omega \leq 10^{\circ}$, accord $D2 = 0$ for all feature heights.

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The *IP* is reflected by the level of geotechnical engineering input, wall slenderness, wall type, surface protection and surface drainage measures, seepage conditions and presence of leaky water-carrying services, i.e. factors *A1* to *A5* in the equation below. The *AP* is manifested as signs of distress where present and records of instability after the retaining wall has been formed or treated to its present configuration, i.e. factors *B1* and *B2*.

$$IS = A1 \text{ x } A2 \text{ x } A3 \text{ x } A4 \text{ x } A5 \text{ x } B1 \text{ x } B2 \ldots\ldots\ldots\ldots\ldots\ldots \tag{6.1}$$

where	*A1*	accounts for the level of geotechnical engineering input
	A2	accounts for wall slenderness ratio
	A3	accounts for wall type
	A4	accounts for adequacy of surface protection and surface drainage measures
	A5	accounts for seepage conditions and the presence of leaky water-carrying services
	B1	accounts for signs of distress
	B2	accounts for instability since formation or treatment

The weighting of individual factors in *IS* ranges between 1 and a value of less than or equal to 10, depending on their significance.

6.3 Consequence Score

The *CS*, which reflects the likely consequence of failure, is computed by the following equation:

$$CS = (C1 \text{ x } C2 + D1 \text{ x } D2) \text{ x } H \ldots\ldots\ldots\ldots\ldots\ldots \tag{6.2}$$

where	*C1*	accounts for the type of crest facility
	C2	accounts for the vulnerability of the crest facility (see Table 3.1)
	D1	accounts for the type of toe facility
	D2	accounts for the vulnerability of the toe facility (see Table 3.2)
	H	represents the feature height

The vulnerability factors given in Tables 3.1 and 3.2, where reflect the chance of fatality given the landslide, account for the height of the wall and the nature of the affected facilities together with their proximity to the wall.

7 Combined Ranking

A method which ranks all types of slope features in terms of the relative risk of each slope feature has been developed. Using this method, a "Ranking Score" (*RS*) is calculated for each slope feature based on its "Total Score" (*TS*) in the respective NPRS. Details of the derivation of the *RS* are given in Appendix E.

For composite features, except the special cases illustrated in Figures 2.3 and 2.4, the individual *RS* for each of the feature types are summed up to obtain the *RS* for the slope feature. A worked example on the computation of *RS* for a composite feature is also

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presented in Appendix E.

The *RS* is unique for each slope feature and can be used for priority ranking purposes under the post-2010 LPMitP. It can also be used by the Slope Maintenance Departments in the implementation of the post-2010 Preventive Maintenance Works.

8 References

GEO (2007). *GEO Technical Guidance Note No. 15 - Guidelines for Classification of Consequence-to-life Category for Slope Features.* Geotechnical Engineering Office, Hong Kong, 14 p.

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Appendix A

Details of NPRS for Soil Cut Slopes

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A.1 Total Score (*TS*) Computation Sheets for Soil Cut Slopes

FEATURE NO.	**SECTION :** ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Year of Formation/Treatment (*Y*)		
	A1	
(i) $Y \leq 1980$	6	
(ii) $1980 < Y \leq 1990$	4	
(iii) $1990 < Y \leq 1995$	2	*A1* ☐
(iv) $Y > 1995$	1	
For soil cut slopes excluded from ranking (see Note 8), denote $A1 = 0$		

(A2) Level of Geotechnical Engineering Input		
	A2	
(i) Slopes with none or little geotechnical engineering input	8	
(ii) Slopes with indication of some geotechnical engineering input	6	
(iii) Slopes with indication of substantial geotechnical engineering input	2	*A2* ☐
(iv) Slopes checked and accepted by GEO	1	

(A3) Geometry (refer to Figure A1)

(i) Soil Slope Height, H_s	m	(x) Feature Height, H $H = H_s + H_r + H_{cw} + H_{tw}$	m	
(ii) Rock Slope Height, H_r	m	(xi) $H_w = H_{cw} + H_{tw}$	m	
(iii) Crest Wall Height, H_{cw}	m	(xii) $H_c = H_s + H_r$	m	
(iv) Toe Wall Height, H_{tw}	m	(xiii) $H_o = H_s + H_{cw}\ (+ H_r')^*$	m	$^*H_r'$ = rock slope portion where a realistic slip surface daylights (see Note 14)
(v) Upslope Angle, β	°	(xiv) Effective Height, H_e $H_e = H_o(1 + 0.35 \tan \beta) + \frac{s}{\gamma_b}$	m	
(vi) Surcharge above the Slope Crest, s	kPa			
(vii) Soil Slope Angle, θ_s	°			
(viii) Average Slope Angle, θ	°			
(ix) Downslope Gradient, α	°			

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Geometry Classification (refer to Figure A2)

		<u>*A3*</u>
(i)	*S1*	8
(ii)	*S2*	4
(iii)	*S3*	2
(iv)	*S4*	1

A3

(A4) <u>Slope Protection and Surface Drainage</u>

Slope Protection Surface Drainage	Soil slope or crest area substantially unprotected	Soil slope or crest area partially protected	Soil slope or crest area substantially protected
Few or no channels, and potential for convergent flow of surface water above crest or located on a drainage line or depression	8	4	2
Few or no channels	4	2	1.5
Adequate channels	2	1.5	1

A4

(A5) <u>Site Characteristics</u>

Adverse hydrogeological settings Adverse geological feature	Significant	Moderate	Minor/None
Significant	10	8	5
Moderate	8	3	2
Minor/None	5	2	1

A5

(B) ACTUAL PERFORMANCE (*AP*)

(B1) <u>Signs of Distress</u>

		<u>*B1*</u>
(i)	Severe (signs of slope movement)	10
(ii)	Moderate (extensive minor defects)	4
(iii)	Minor/None (none or few isolated minor defects)	1

B1

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(B2) Instability after Slope Formation/Treatment

		B2
(i)	Massive failures (> 500 m^3)	10
(ii)	Major or repeated minor failures or records of previous severe signs of distress	5
(iii)	Minor failure or records of previous moderate signs of distress	2
(iv)	No failure or records of previous minor signs of distress	1

B2 ☐

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text) ☐

(ii) Facility Group ☐

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text) ☐ m

(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1 ☐

C2 ☐

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text) ☐

(ii) Facility Group ☐

(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text) ☐ m

(iv) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text) ☐ °

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

D1 ☐

D2 ☐

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CALCULATED SCORES	
INSTABILITY SCORE (*IS*) $IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$	IS ☐
CONSEQUENCE SCORE (*CS*) $CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$	CS ☐
TOTAL SCORE (*TS*) $TS = IS \text{ x } CS$	TS ☐

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A.2 Guidelines on Data Collection and Score Computation for Soil Cut Slopes

General

(1) For composite features, i.e. with more than one type of slope feature, the criteria for computation of the Total Score (*TS*) are presented in Figure 2.3 of the main text.

(2) If H of Section 1-1 ≥ 75% of H of Section 2-2, consider Section 1-1 (i.e. in terms of most severe consequence) in calculating the scores. Otherwise, both Sections 1-1 and 2-2 (in terms of maximum feature height, H) shall be considered.

(3) Geometric parameters of the feature (e.g. H_s, H_r, H_{cw}, H_{tw}, β, θ_s, θ and α) (see Figure A1) may be obtained from survey plans and site measurements.

(4) Detailed physical inspection on the features should be carried out using all available access/route.

(5) Unless stated otherwise, “distance” refers to horizontal distance and “height” refers to vertical height.

(6) Details of field mapping and site observation should be recorded using data collection sheets. Sample data collection sheets for soil cut slopes are appended for reference. Inspecting engineers may modify the sheets to suit their specific use. Provide photographic records of the overview of the features and facilities affected. The photographic records shall also include details of site observations to substantiate the factors adopted in the calculation.

Factor *A1*

(7) Years of formation/treatment refers to the year that the formation or substantial modification works completed on the subject slope. Substantial modification works refer to the engineering works to bring substandard slopes to the safety standards at that time.

(8) Slopes that were formed/treated in or after year 2000 or treated with robust technology (i.e. installed with structural support, e.g. soil nails), and processed and accepted by GEO, will not be ranked. Denote these features with $A1 = 0$. Data on these slopes should still be collected.

Factor *A2*

(9) The level of geotechnical engineering input should be inferred from databases, files and documentary records kept by GEO and other relevant government departments and organizations, or interpretation of aerial photographs if necessary.

(10) Slopes with none or little geotechnical engineering input, e.g.

- pre-1978 slopes

- post-1978 slopes formed by unauthorized works
- post-1978 slopes falling outside any engineering project boundary

(11) Slopes with indication of some geotechnical engineering input, e.g.

- post-1978 slopes without GEO checking records but falling within the boundary of engineering projects
- slopes assessed as being upto the required safety standard without site-specific ground investigation and laboratory testing

(12) Slopes with indication of substantial geotechnical engineering input, e.g.

- slopes checked by GEO but with outstanding comments

(13) Slopes checked and accepted by GEO, e.g.

- slopes checked by GEO without outstanding comments
- slopes designed by GEO

Factor *A3*

(14) Definition of geometric parameters are given in Figure A1. H_o is the difference in elevations between the crest of the feature and the lowest daylighting point of realistic slip surfaces. In the case where the lowest daylighting point is at the toe of the soil portion of the slope, H_o should be calculated as $H_s + H_{cw}$. Otherwise, H_o should be taken to include the portion of the rock slope (H_r') where a realistic failure surface can daylight. The definition of effective height, H_e, takes into account the equivalent surcharging effect due to the uphill slope and applied vertical loading. An assessment of the surcharge (s) above the slope crest may be made by reference to Table 16 of the second edition of Geoguide 1 (GEO, 1993).

(15) The factor *A3* involves combined consideration of the effective height, H_e, and average slope angle (θ) as defined in Figure A2.

Factor *A4*

(16) Both hard cover and vegetation cover are considered as slope protection. As a general guideline, "substantially protected" refers to more than 75% area covered, "partially protected" refers to between 25% and 75% area protected and "substantially unprotected" refers to less than 25% area covered.

(17) Crest area refers to the area within a horizontal distance of $H/2$ beyond the crest of the slope.

(18) Where there is potential for ponding above the slope crest, the score for the next higher category in respect of slope protection should be adopted.

(19) In assessing the adequacy of surface drainage provisions, the overall setting including the site topography, catchment area and environmental factors that are liable to give rise to convergent flow of surface water should be considered.

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(20) The potential for convergent flow of surface water above crest and whether the slope is located on a drainage line or depression shall be determined from topographic plan and/or aerial photographs.

Factor *A5*

(21) As a general guideline, adverse hydrogeological settings are as follows:

Significant - observable or recorded adverse groundwater conditions, e.g. high permanent groundwater over a significant area of the slope; complex groundwater conditions with a significant storm response or delayed response; seepage at or above mid-height of slope

Moderate - seepage below mid-height of slope

Minor/None - no signs of seepage

(22) As a general guideline, adverse geological features are as follows:

Significant - sites with relict massive failures; observable or recorded adverse discontinuities (e.g. adversely oriented, persistent, clay- or silt-infilled discontinuities, pre-existing shear surfaces or zones, and well developed discontinuities that are slickensided or heavily coated with dark minerals or kaolinite)

Moderate - observable or recorded adverse geological materials (e.g. significantly kaolinised granite and volcanics, weathered dykes, and sedimentary layers within volcanic formations)

Minor/None - none of the above

Factors *B1* and *B2*

(23) Signs of distress are based on site observations, and relevant inspection and maintenance records kept by the maintenance departments.

(24) Severe signs of distress refer to signs of slope movement, e.g. large tension cracks behind crest, significant distortion of channels and berms, severe cracking and bulging, subsidence of slope crest or slope surface. These tell-tale signs should be examined in a holistic manner to determine if they are indicative of slope movement. Where there are severe signs of distress or documented evidence of continuing hazardous movement, immediate action should be taken. Examples of severe signs of distress are attached in Appendix F of this report.

(25) Moderate signs of distress refer to signs of extensive minor defects, e.g. cracking of slope cover and damaged channels.

(26) Judgment should be made in assessing whether cracked slope cover, damaged channels, etc. are due to inadequate maintenance. If these are due to inadequate maintenance, they should not be regarded as signs of distress. In case of doubt, a conservative

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assessment should be made.

(27) Instability after treatment accounts for landslide incidents that occurred after the slope was formed or substantially modified to its present configuration, and upgrading works have not been carried out on the slope subsequent to the incidents.

Factors *C* and *D*

(28) Shadow angle (ω) as shown in Figure 2.1 of the main text should be determined by site measurements and/or from survey plans and sections.

References

GEO (1993). *Guide to Retaining Wall Design (Geoguide 1), 2nd Edition.* Geotechnical Engineering Office, Hong Kong, 258 p.

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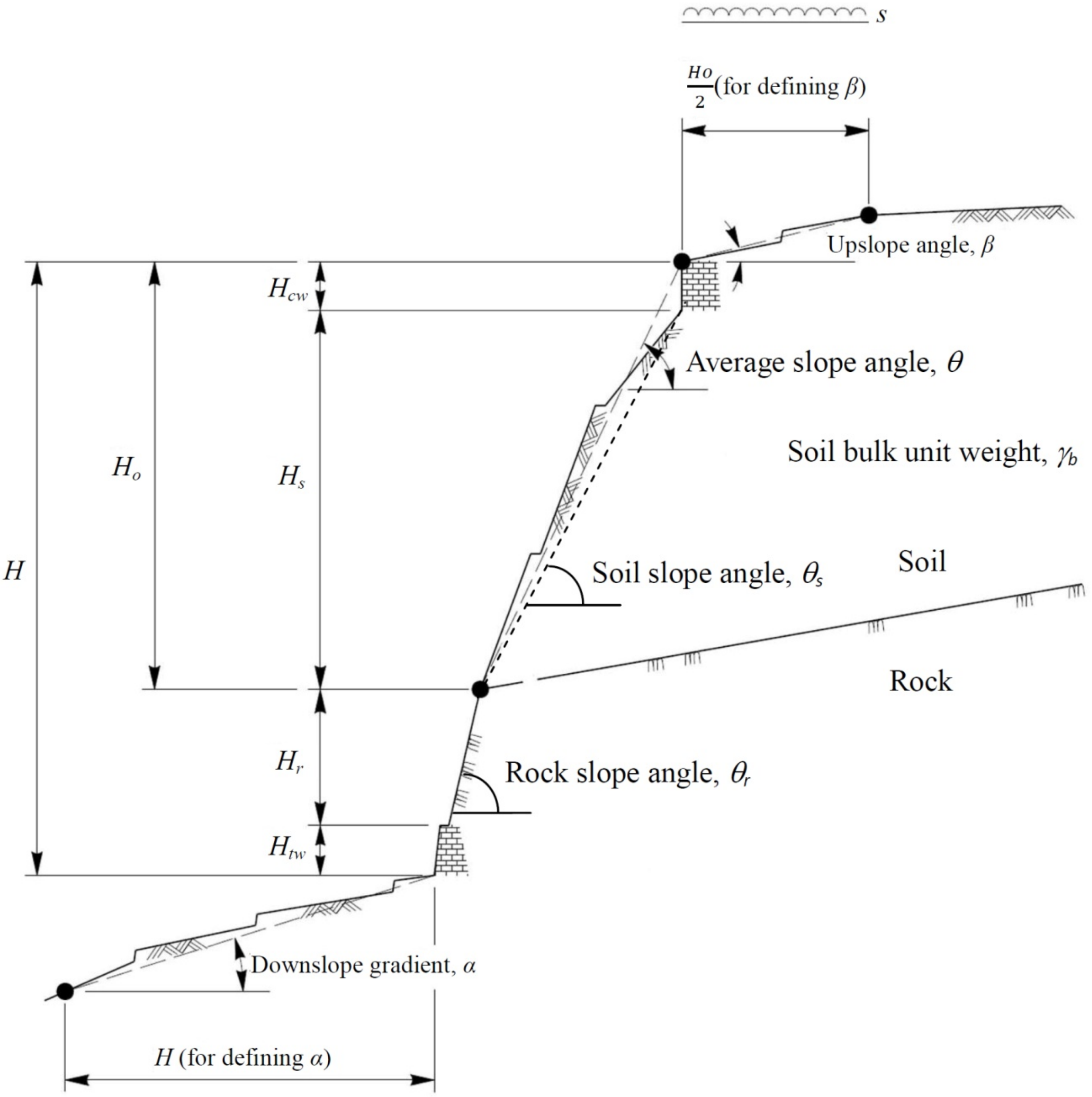

$H_w = H_{cw} + H_{tw}$

Figure A1 Geometry of Soil and Rock Cut Slopes

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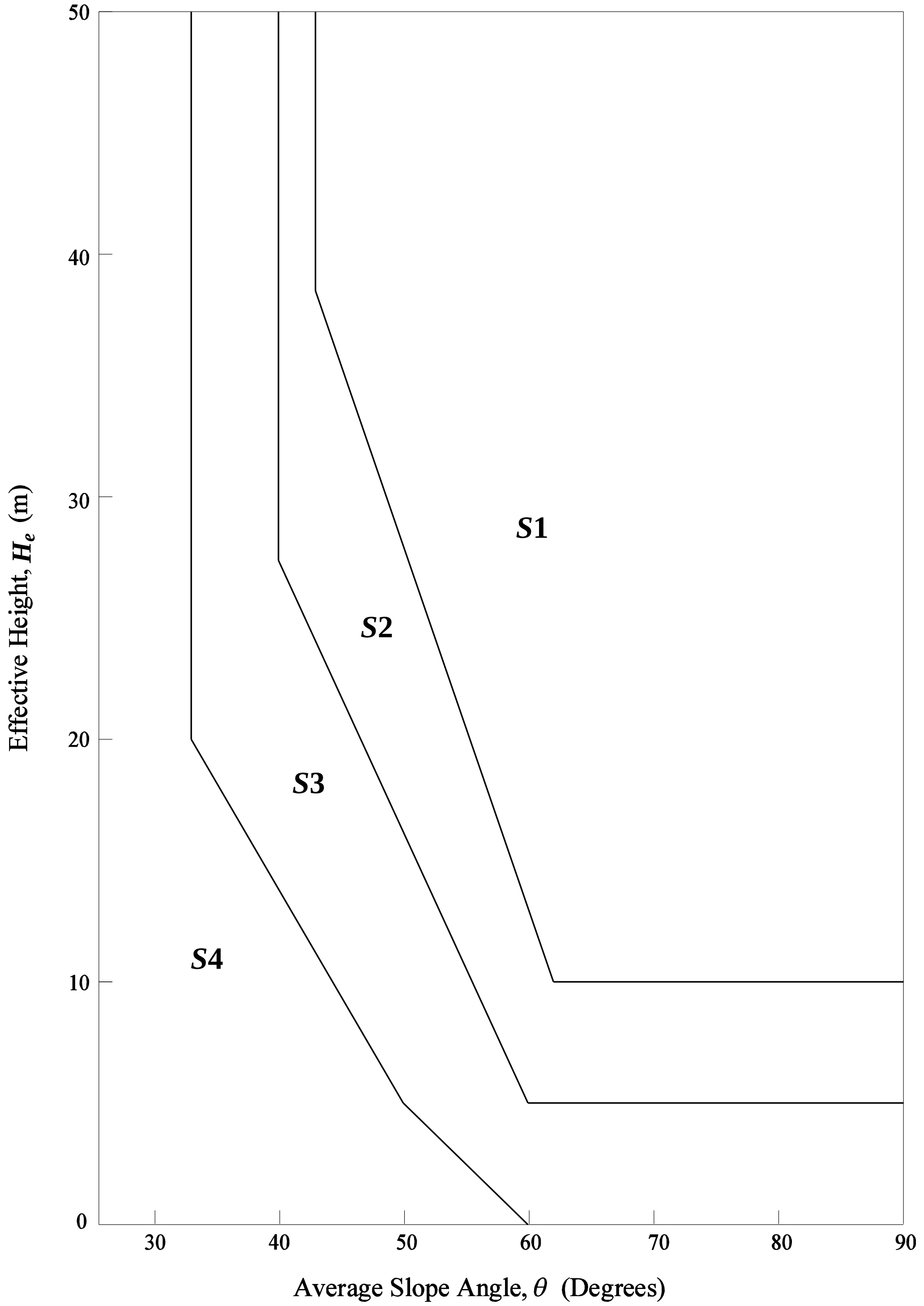

Figure A2 Geometry Classification for Soil Cut Slopes

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A.3 Sample Data Collection Sheets for Soil Cut Slopes

FEATURE NO. (Page 1 of)

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\% \times H_2$. If yes, consider Section 1-1 only; If No, consider both Sections 1-1 and 2-2

Geometry (refer to Figure A1)

	Section 1-1	2-2		Section 1-1	2-2
Soil Slope Height, H_s	m	m	Feature Height, $H = H_s + H_r + H_{cw} + H_{tw}$	m	m
Rock Slope Height, H_r	m	m	$H_w = H_{cw} + H_{tw}$	m	m
Crest Wall Height, H_{cw}	m	m	$H_c = H_s + H_r$	m	m
Toe Wall Height, H_{tw}	m	m	$H_o = H_s + H_{cw}\ (+ H_r')^{\#}$	m	m
Upslope Angle, β	°	°	$^{\#}$ H_o should include the portion of the underlying rock slope where a realistic slip surface can daylight (Hr')		
			H_r'	m	m
Surcharge above the Slope Crest, s	kPa	kPa			
Soil Slope Angle, θ_s	°	°	Effective Height, H_e $H_e = H_o(1 + 0.35 \tan\beta) + \dfrac{s}{\gamma_b}$	m	m
Average Slope Angle, θ	°	°			
Downslope Gradient, α	°	°	where γ_b = soil bulk unit weight		$\frac{kN}{m^3}$

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figure 2.3 of the main text?

○ Yes ○ No If yes, number of data collection sheets required for this section : ☐

Affected Facilities (Refer to Figure 2.1 and Table 2.1 of the main text)

Section 1-1	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe			L = m ω= °
Crest			D= m

Section 2-2	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe			L = m ω= °
Crest			D= m

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FEATURE NO. (Page 2 of)

PLAN AND CROSS-SECTION

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and revised feature boundary (if applicable)
2. Section mark
3. Photograph location and direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. soil nails, shotcrete & buttress)

CROSS-SECTIONS
1. Fully dimensioned
2. Engineering measures (e.g. soil nails, shotcrete & buttress)

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FEATURE NO. (Page 3 of)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**

Slope Protection

Surface cover with

- o Vegetation_____________% (including grass/shrubs/trees)
- o Hard cover_____________% (including concrete/chunam)
- o Bare surface____________%
- o Others_________________%

1. Based on the above, slope surface is
   - ○ Substantially protected (> 75%)
   - ○ Partially protected (25% - 75%)
   - ○ Substantially unprotected (< 25%)
2. Zone(s) of depression or potential ponding exist within the crest area (within *H*/2)

   o Yes o No

   If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest					
Berm					
On Slope					
Toe					

- o Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
- o Slope located on a drainage line/zone of depression
- o Inadequate surface drainage evident by surface erosion or erosion gully, etc.
- o Others observations/records : ____

Hydrogeological Settings

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? o Yes o No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

- o Others observations/records: ____

Geological Features

(Provide photographic records of the site observations)

Presence of the following based on site observations or available records (please tick):

- o No potential adverse geological features observed or recorded
- o Possible relict failure (concave shaped profile)
- o Shear surfaces/zone
- o Clay or silt filled discontinuities
- o Slickensided discontinuities
- o Discontinuities heavily coated with dark minerals or kaolinite
- o Significantly kaolinised granite or volcanics
- o Weathered dykes/sedimentary layers within volcanic formations
- o Others: ____

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FEATURE NO. (Page 4 of)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**

Signs of Distress
(Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)
	○ No indication of any signs of distress
	○ Reported signs of distress in inspection or maintenance records
	____
	○ Observed signs of distress (please tick)
	  ○ Large tension cracks behind crest (approx. ________ mm wide)
	  ○ Significant distortion/damage of channels and berms
	  ○ Severe cracking and bulging of hard surfacing
	  ○ Subsidence within crest area or on slope
	  ○ Extensive cracking of slope cover
	  ○ Isolated minor cracking of slope cover/isolated cracking of channels
	  ○ Others: _______________________________________
	1. Where severe signs of distress or hazardous movements are noted, appropriate follow-up action should be taken immediately.
	2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance; if so, they should not be regarded as signs of distress.

Instability after Slope Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	○ No indication of any failure occurred after formation or treatment ○ Reported failure ___________________________________ ○ Possible failure scar observed at _____________ of the slope Estimated failure volume = _________________ m^3 ○ Debris observed on site/Other observations: ____

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OTHER OBSERVATIONS/REMARKS

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INSPECTION DATE: / / (dd/mm/yyyy) BY:

FEATURE NO.	(Page 5 of)

PHOTOGRAPHIC RECORDS

[Caption]

PHOTOGRAPHIC RECORDS

[Caption]

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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A.4 Worked Example (Data Collection Sheets)

FEATURE NO. **"Worked Example 1"** (Page 1 of 6)

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\%$ x H_2. If yes, consider Section 1-1 only; If No, consider both Sections 1-1 and 2-2

Geometry (refer to Figure A1)

	Section 1-1	2-2		Section 1-1	2-2
Soil Slope Height, H_s	**12 m**	— m	Feature Height, $H = H_s + H_r + H_{cw} + H_{tw}$	**12 m**	— m
Rock Slope Height, H_r	**0 m**	— m	$H_w = H_{cw} + H_{tw}$	**0**	— m
Crest Wall Height, H_{cw}	**0 m**	— m	$H_c = H_s + H_r$	**12 m**	— m
Toe Wall Height, H_{tw}	**0 m**	— m	$H_o = H_s + H_{cw}\ (+ H_r')^{\#}$	**12 m**	— m
Upslope Angle, β	**20 °**	— °	# H_o should include the portion of the underlying rock slope where a realistic slip surface can daylight (H_r')		
Surcharge above the Slope Crest, s	**0 kPa**	— kPa	H_r'	**0 m**	— m
Soil Slope Angle, θ_s	**60 °**	— °	Effective Height, H_e $H_e = H_o\,(1 + 0.35 \tan\beta) + \dfrac{s}{\gamma_b}$	**13.5 m**	— m
Average Slope Angle, θ	**60 °**	— °			
Downslope Gradient, α	**0 °**	— °	where γ_b = soil bulk unit weight		**20 $\frac{\text{kN}}{\text{m}^3}$**

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figure 2.3 of the main text ?

☑ Yes ○ No If yes, number of data collection sheets required for this section : ☐

Affected Facilities (refer to Figure 2.1 and Table 2.1 of the main text)

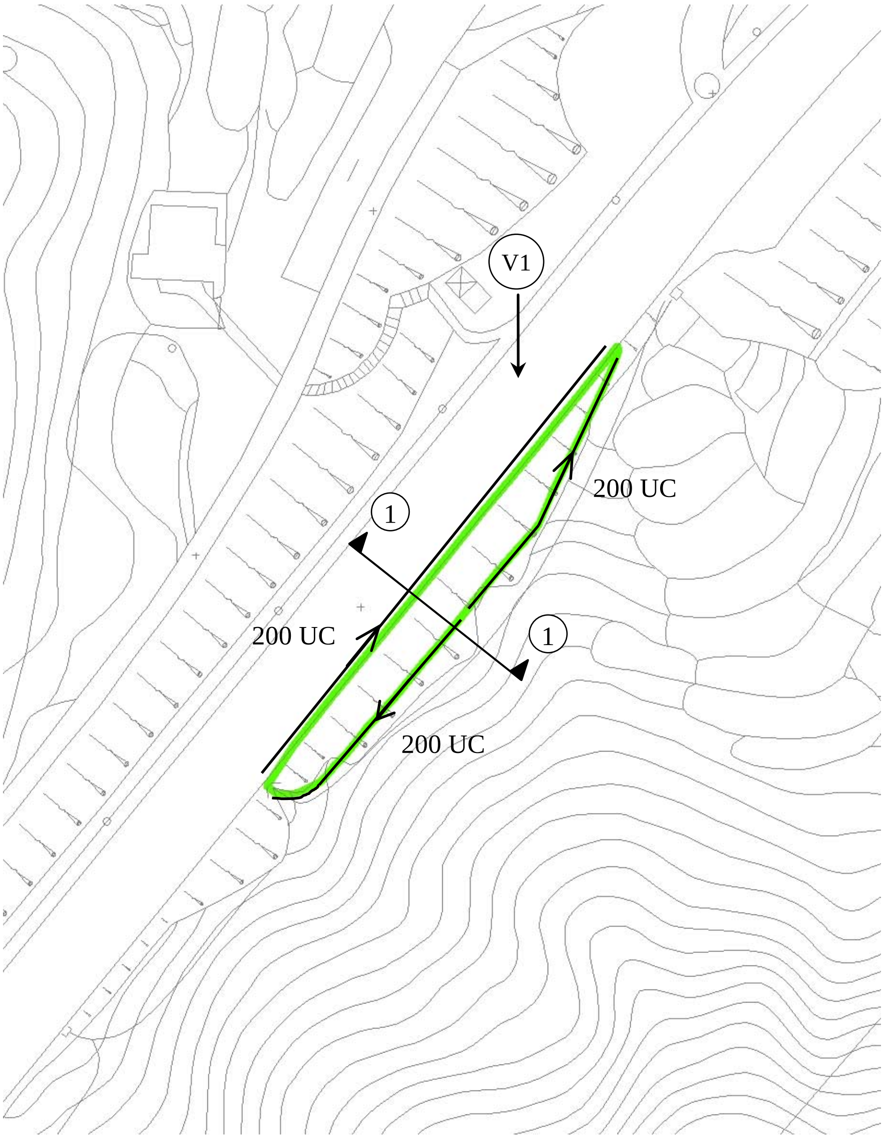
Section 1-1	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe	**Road with heavy traffic density**	**2(b)**	L = **0 m** ω = **60 °**
Crest	**Undeveloped green belt**	**5**	D = **0** m

Section 2-2	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

FEATURE NO. **"Worked Example 1"** (Page 2 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Plan
(Not to scale)

Notes:

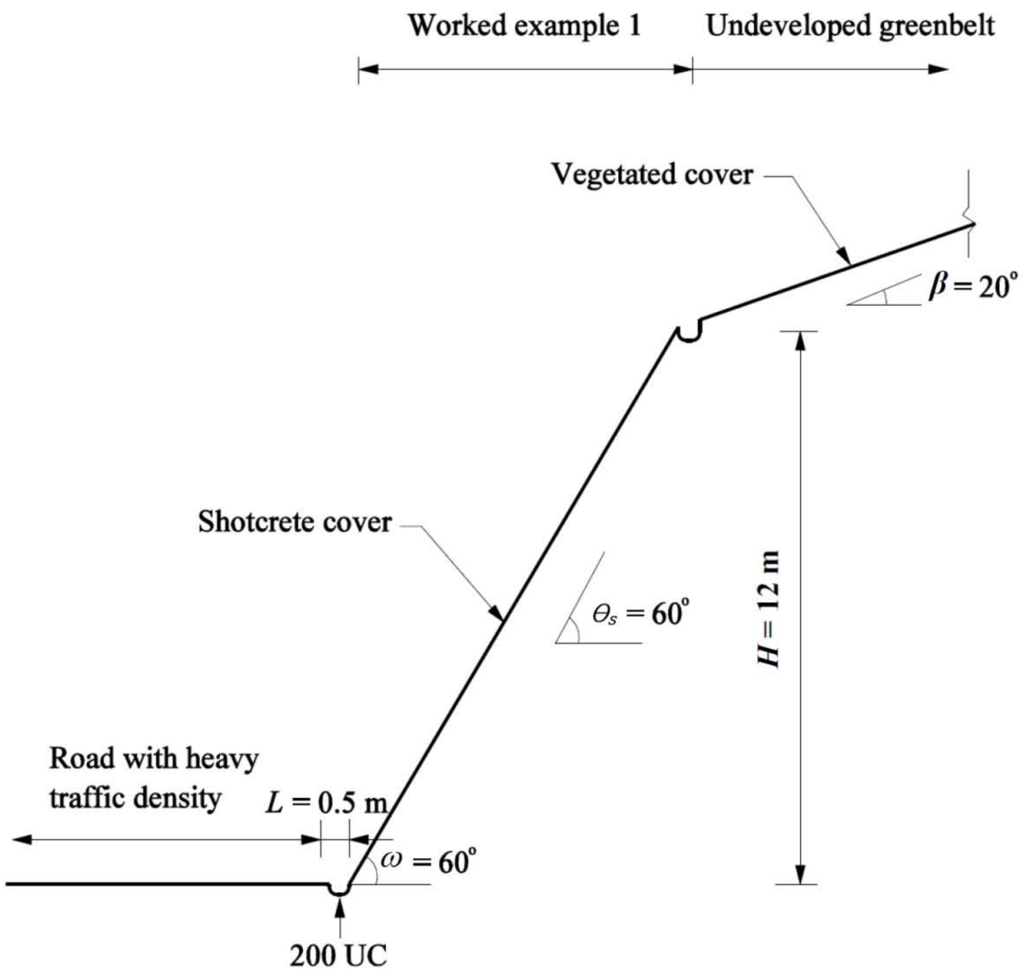
PLAN (1:1000)
1. Feature boundary (SIS) and revised feature boundary (if applicable)
2. Section mark
3. Photograph location and direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. soil nails, shotcrete & buttress)

CROSS-SECTIONS
1. Fully dimensioned
2. Engineering measures (e.g. soil nails, shotcrete & buttress)

FEATURE NO. **"Worked Example 1"** (Page 3 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note : No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and revised feature boundary (if applicable)
2. Section mark
3. Photograph location and direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. soil nails, shotcrete & buttress)

CROSS-SECTIONS
1. Fully dimensioned
2. Engineering measures (e.g. soil nails, shotcrete & buttress)

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FEATURE NO. **"Worked Example 1"** (Page 4 of 6)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Slope Protection	Surface cover with ○ Vegetation____________% (including grass/shrubs/trees) ☑ Hard cover___**100**_____% (including concrete/chunam) ○ Bare surface___________% ○ Others________________% 1. Based on above, slope surface is ☑ Substantially protected (> 75%) ○ Partially protected (25% - 75%) ○ Substantially unprotected (< 25%) 2. Zone(s) of depression or potential ponding exist within the crest area (within H/2) ○ Yes ☑ No If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection
Surface Drainage Provision	(see table below)
Hydrogeological Settings (Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)	(see below)
Geological Features (Provide photographic records of the site observations)	(see below)

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest	**200**	—	**U-channel**	**Y**	**Lined**
Berm	—	—	—	—	—
On Slope	—	—	—	—	—
Toe	**200**	—	**U-channel**	**Y**	**Lined**

○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)

○ Slope located on a drainage line/zone of depression

○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.

○ Others observations/records :_______________________________________

Hydrogeological Settings

Signs of Seepage? ○ Yes ☑ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

○ Others observations/records: _______________________________________

Geological Features

Presence of the following based on site observations & available records (please tick) :

☑ No potential adverse geological features observed or recorded

○ Possible relict failure (concave shaped profile)

○ Shear surfaces/zone

○ Clay or silt filled discontinuities

○ Slickensided discontinuities

○ Discontinuities heavily coated with dark minerals or kaolinite

○ Significantly kaolinised granite or volcanics

○ Weathered dykes/sedimentary layers within volcanic formations

○ Others: ____

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FEATURE NO. **"Worked Example 1"** (Page 5 of 6)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Signs of Distress (Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)	☑ No indication of any signs of distress ○ Reported signs of distress in inspection or maintenance records ____________________ ○ Observed signs of distress (please tick) ○ Large tension cracks behind crest (approx. ________ mm wide) ○ Significant distortion/damage of channels and berms ○ Severe cracking and bulging of hard surfacing ○ Subsidence inside crest area or on slope surface ○ Extensive cracking of slope cover ○ Isolated minor cracking of slope cover/Isolated cracking of channels ○ Others: ____________________ 1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately. 2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.
Instability after Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	○ No indication of any failure occurred after formation or treatment ☑ Reported failure **Minor inferred past instability recorded in SIRST in 1999** ○ Possible failure scar observed at _____________ of the slope Estimated failure volume = _________________ m^3 ○ Debris observed on site/Other observations: ____________________

OTHER OBSERVATIONS/REMARKS

1. **According to the SIFT report, the slope was formed pre-1963. No record of any development or modification works carried out on the feature.**
2. **No signs of distress were recorded in SIRST in 1999.**

INSPECTION DATE: **25 / 1 / 2009** (dd/mm/yyyy) BY: **PAJ**

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FEATURE NO. **"Worked Example 1"** (Page 6 of 6)

PHOTOGRAPHIC RECORDS

V1 General View of the Feature

Notes:

(1) Indicate photograph vantage points on plan

(2) Add more pages for additional photographic records/sketches

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A.5 Worked Example (*TS* Computation Sheets)

FEATURE NO. **"Worked Example 1"**

SECTION :
☑ 1-1 (Most Severe Consequence)
○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Year of Formation/Treatment (*Y*)

		A1
(i)	$Y \leq 1980$	6
(ii)	$1980 < Y \leq 1990$	4
(iii)	$1990 < Y \leq 1995$	2
(iv)	$Y > 1995$	1

For soil cut slopes excluded from ranking (see Note 8), denote $A1 = 0$

A1 **6**

(A2) Level of Geotechnical Engineering Input

		A2
(i)	Slopes with none or little geotechnical engineering input	8
(ii)	Slopes with indication of some geotechnical engineering input	6
(iii)	Slopes with indication of substantial geotechnical engineering input	2
(iv)	Slopes checked and accepted by GEO	1

A2 **8**

(A3) Geometry (refer to Figure A1)

(i)	Soil Slope Height, H_s	**12 m**	(x)	Feature Height, H $H = H_s + H_r + H_{cw} + H_{tw}$	**12 m**
(ii)	Rock Slope Height, H_r	**0 m**	(xi)	$H_w = H_{cw} + H_{tw}$	**0 m**
(iii)	Crest Wall Height, H_{cw}	**0 m**	(xii)	$H_c = H_s + H_r$	**0 m**
(iv)	Toe Wall Height, H_{tw}	**0 m**	(xiii)	$H_o = H_s + H_{cw}$ $(+ H_r')$*	**12 m**
(v)	Upslope Angle, β	**20 °**	(xiv)	Effective Height, H_e $H_e = H_o(1 + 0.35 \tan\beta) + \frac{s}{\gamma_b}$	**13.5 m**
(vi)	Surcharge above the Slope Crest, s	**0 kPa**			
(vii)	Soil Slope Angle, θ_s	**60 °**			
(viii)	Average Slope Angle, θ	**60 °**			
(ix)	Downslope Gradient, α	**0 °**			

* H_r' = rock slope portion where a realistic slip surface daylights (see Note 14)

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Geometry Classification (refer to Figure A2)

		<u>A3</u>
(i)	*S1*	8
(ii)	*S2*	4
(iii)	*S3*	2
(iv)	*S4*	1

A3 **4**

(A4) <u>Slope Protection and Surface Drainage</u>

Slope Protection Surface Drainage	Soil slope or crest area substantially unprotected	Soil slope or crest area partially protected	Soil slope or crest area substantially protected
Few or no channels, and potential for convergent flow of surface water above crest or located on a drainage line or depression	8	4	2
Few or no channels	4	2	[✓ 1.5]
Adequate channels	2	1.5	1

A4 **1.5**

(A5) <u>Site Characteristics</u>

Adverse hydrogeological settings Adverse geological feature	Significant	Moderate	Minor/None
Significant	10	8	5
Moderate	8	3	2
Minor/None	5	2	[✓ 1]

A5 **1**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) <u>Signs of Distress</u>

		<u>B1</u>
(i)	Severe (signs of slope movement)	10
(ii)	Moderate (extensive minor defects)	4
(iii)	Minor/None (none or few isolated minor defects)	1

B1 **1**

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(B2) Instability after Slope Formation/Treatment

		B2
(i)	Massive failures (> 500 m^3)	10
(ii)	Major or repeated minor failures or records of previous severe signs of distress	5
(iii)	Minor failure or records of previous moderate signs of distress	2
(iv)	No failure or records of previous minor signs of distress	1

B2 **2**

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text): **Undeveloped green belt**

(ii) Facility Group: **5**

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text): **0 m**

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1 **0.0002**

(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)

C2 **0.15**

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text): **Road/footpath with heavy traffic density**

(ii) Facility Group: **2(b)**

(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text): **0.5 m**

(iv) Shadow angle (*ω*) from crest of feature to toe facility (refer to Figure 2.1 of the main text): **60 º**

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

D1 **1**

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

D2 **0.6**

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CALCULATED SCORES	
INSTABILITY SCORE (*IS*) $IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$	IS **576**
CONSEQUENCE SCORE (*CS*) $CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$	CS **7.20**
TOTAL SCORE (*TS*) $TS = IS \text{ x } CS$	TS **4147.2**

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Appendix B

Details of NPRS for Rock Cut Slopes

Contents

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B.1 Total Score (*TS*) Computation Sheets for Rock Cut Slopes

FEATURE NO.

(refer to Figure B1)

(i) Rock Slope Height, H_r =______________m

(ii) Soil Slope Height, H_s =______________m

(iii) Crest Wall Height, H_{cw} =______________m

(iv) Toe Wall Height, H_{tw} =______________m

(v) Feature Height, H $= H_r + H_s + H_{cw} + H_{tw}$

= ______________m

(vi) Rock Slope Angle, θ_r = ______________$^{\circ}$

(vii) Soil Slope Angle, θ_s = ______________$^{\circ}$

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

		A1
(i)	Slopes with none or little geotechnical engineering input	10
(ii)	Slopes with indication of some geotechnical engineering input	3
(iii)	Slopes with indication of substantial geotechnical engineering input	1

For rock cut slopes excluded from ranking (see Note 7), denote $A1 = 0$

A1 ☐

(A2) Geometry

Rock Slope Angle (θ_r) / Feature Height (H)	$\theta_r >$ 80°	70$^{\circ} < \theta_r \leq$ 80°	60$^{\circ} < \theta_r \leq$ 70°	45$^{\circ} < \theta_r \leq$ 60°	$\theta_r \leq 45^{\circ}$
$H \geq 20$ m	8	7	6	5	4
15 m $\leq H <$ 20 m	7	6	5	4	3
10 m $\leq H <$ 15 m	6	5	4	3	2
5 m $\leq H <$ 10 m	5	4	3	2	2
$H <$ 5 m	4	3	2	2	1

A2 ☐

(A3) Instability Classification

$A3_a$ – Mode and scale of failure

Mode of failure / Scale of failure (volume)	Ravelling	Toppling	Wedge	Planar
Large (> 50 m^3)	6	10	10	10
Medium (5 – 50 m^3)	3	6	6	6
Small (< 5 m^3)	2	3	3	3
None	1	1	1	1

$A3_b$ – Potential for failure to occur

Low potential for failure	0.5
High potential for failure	1.0

$A3 = A3_a \times A3_b$

A3 ☐

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(A4) Seepage and Drainage Conditions

Drainage Provision \ Seepage	Heavy	Moderate	Slight or none
Potential for convergence of runoff at crest area and/or potential for water ingress into open discontinuities	8	6	4
Insufficient or no drainage measures in place to direct water away from the crest area and face of the slope	6	4	2
Drainage measures adequately direct water away from the crest area and face of the slope	4	2	1

A4 ☐

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

		B1
(i)	Severe	10
(ii)	Moderate	4
(iii)	Minor/None	1

B1 ☐

(B2) Instability after Slope Treatment/Formation

		B2
(i)	Documented evidence of past instability (failure volume ≥ 50 m^3)	10
(ii)	Documented evidence of past instability (failure volume < 50 m^3)	5
(iii)	Observed evidence of past instability	2
(iv)	No recorded or observed evidence of past instability	1

B2 ☐

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(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

(ii) Facility Group

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text) m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1

(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)

C2

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

(ii) Facility Group

(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text) m

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

(iv) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text) °

D1

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

D2

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CALCULATED SCORES

INSTABILITY SCORE (*IS*)

$IS = A1 \times A2 \times A3 \times A4 \times B1 \times B2$

IS

CONSEQUENCE SCORE (*CS*)

$CS = [C1 \times C2 + D1 \times D2] \times K$

Probable Scale of Failure Volume	*K*
< 5 m^3	1
5 to 50 m^3	3
> 50 m^3	5

CS

TOTAL SCORE (*TS*)

$TS = IS \times CS$

TS

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B.2 Guidelines on Data Collection and Score Computation for Rock Cut Slopes

General

(1) For composite features, i.e. with more than one type of slope feature, the criteria for computation of the Total Score (*TS*) are presented in Figure 2.3 of the main text.

(2) Geometric parameters of the feature (e.g. H_s, H_r, H_{cw}, H_{tw}, and θ_r) (see Figure B1) may be obtained from survey plans and site measurements.

(3) Detailed physical inspection of the features should be carried out using all available access/route.

(4) Unless stated otherwise, "distance" refers to horizontal distance and "height" refers to vertical height.

(5) Compute *TS* for each section where there is a potential for a particular mode of failure. If more than one mode of failure is kinematically possible, compute *TS* for each section, and adopt the highest one as the score for the entire feature.

(6) Details of field mapping and site observation should be recorded using data collection sheets. Sample data collection sheets for rock cut slopes are appended for reference. Inspecting engineers may modify the sheets to suit their specific use. Provide photographic records at each cross-section identified as having potential for a particular mode of failure. The photographs should show the discontinuities characteristics which render the failure mode possible. Provide sketches or overlays to highlight the relevant discontinuity set(s).

Factor *A1*

(7) Rock slopes that were processed and accepted by GEO (e.g. slopes checked by GEO without outstanding comments and slopes designed by GEO) will not be ranked. Denote these features with $A1 = 0$. Data on these slopes should still be collected.

(8) The level of geotechnical engineering input should be inferred from databases, files and documentary records kept by GEO and other relevant government departments and organizations, or aerial photographs if necessary.

(9) Rock slopes with none or little geotechnical engineering input, e.g.
- pre-1978 slopes
- post-1978 slopes formed by unauthorized works
- post-1978 slopes falling outside any engineering project boundary

(10) Rock slopes with indication of some geotechnical engineering input, e.g.
- post-1978 slopes without GEO checking records but falling within the boundary of engineering projects
- slopes assessed as being upto the required safety standard without detailed discontinuity mapping and assessment

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(11) Rock slopes with indication of substantial geotechnical engineering input, e.g.

- slopes checked by GEO but with outstanding comments

Factor *A2*

(12) Feature height (*H*) and rock slope angle (θ_r) of the section at which a potential mode of instability exists.

Factor *A3*

(13) A detailed field inspection is required to identify the probable mode and scale of failure, e.g. ravelling, toppling, planar and wedge failures. In determining the probable mode and scale of failure, due consideration should be given to the characteristics of the discontinuities, i.e. orientation, spacing, roughness and persistence, which render a particular mode of failure kinematically possible.

(14) Choose "Scale of failure" = "None" if there is no adversely oriented discontinuity set that may lead to instability; or the existing engineering measures in place can effectively mitigate a particular mode of failure, e.g. installation of wire mesh to prevent ravelling failure, or installation of patterned rock bolts to prevent toppling/planar/wedge failure.

(15) If the slope is concealed by shotcrete/chunam, or some part of the slope is inaccessible for detailed inspection, the characteristics of the discontinuities may be inferred from inspection of adjoining or nearby man-made features and rock exposures. If none of the discontinuity is accessible for inspection, relate the slope performance to the instability classification where appropriate, e.g. if the slope has records of severe signs of distress (*B1* = 10) or a large scale failure (*B2* = 10), adopt a high score in the instability classification.

(16) Judgment on the potential for failure to occur should be based on an overall assessment of the rock mass and the related environmental factors:

- high potential for failure to occur, e.g. with steeply dipping and daylighted discontinuities, evidence of progressive deterioration of the slope or the joint conditions, potential build-up of cleft water pressure, or growth of undesirable vegetation, etc.

- low potential for failure to occur, e.g. with shallow dipping discontinuities, or release surface not present

Factor *A4*

(17) Crest area refers to the area within a horizontal distance of *H*/2 beyond the crest of the slope.

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(18) In assessing the adequacy of drainage provisions, the overall setting including the site topography, catchment area and environmental factors that are liable to give rise to convergent flow of surface water should be considered.

(19) The potential for convergent flow of surface water above crest should be determined from topographic plan and/or aerial photographs.

(20) Staining on or below joints often indicates seepage. When seepage or staining is noted from joints on the slope, its location should be marked on the feature plan.

(21) If the inspection is being done in the dry season, seepage conditions could be assessed based on water staining on the slope surface.

Factors *B1* and *B2*

(22) Signs of distress are based on site observations, and relevant inspection and maintenance records kept by the maintenance departments.

(23) Severe signs of distress refer to surficial loosening and small overhanging blocks in several areas of slope, or tension cracks exist along crest of slope, or large overhanging blocks with potential release surfaces visible.

(24) Moderate signs of distress refer to localised surficial loosening, or small overhanging blocks.

(25) Minor signs of distress refer to no evidence of surficial loosening.

(26) Judgment should be made in assessing whether cracked slope cover, damaged channels, etc. are due to inadequate maintenance. If these are due to inadequate maintenance, they should not be regarded as signs of distress. In case of doubt, a conservative assessment should be made.

(27) Instability after treatment accounts for landslide incidents occurred after the slope was formed or substantially modified to its present configuration and upgrading works have not been carried out on the slope subsequent to the incidents.

Factors *C* and *D*

(28) Shadow angle (ω) as shown in Figure 2.1 of the main text should be determined by site measurements and/or from survey plans and sections.

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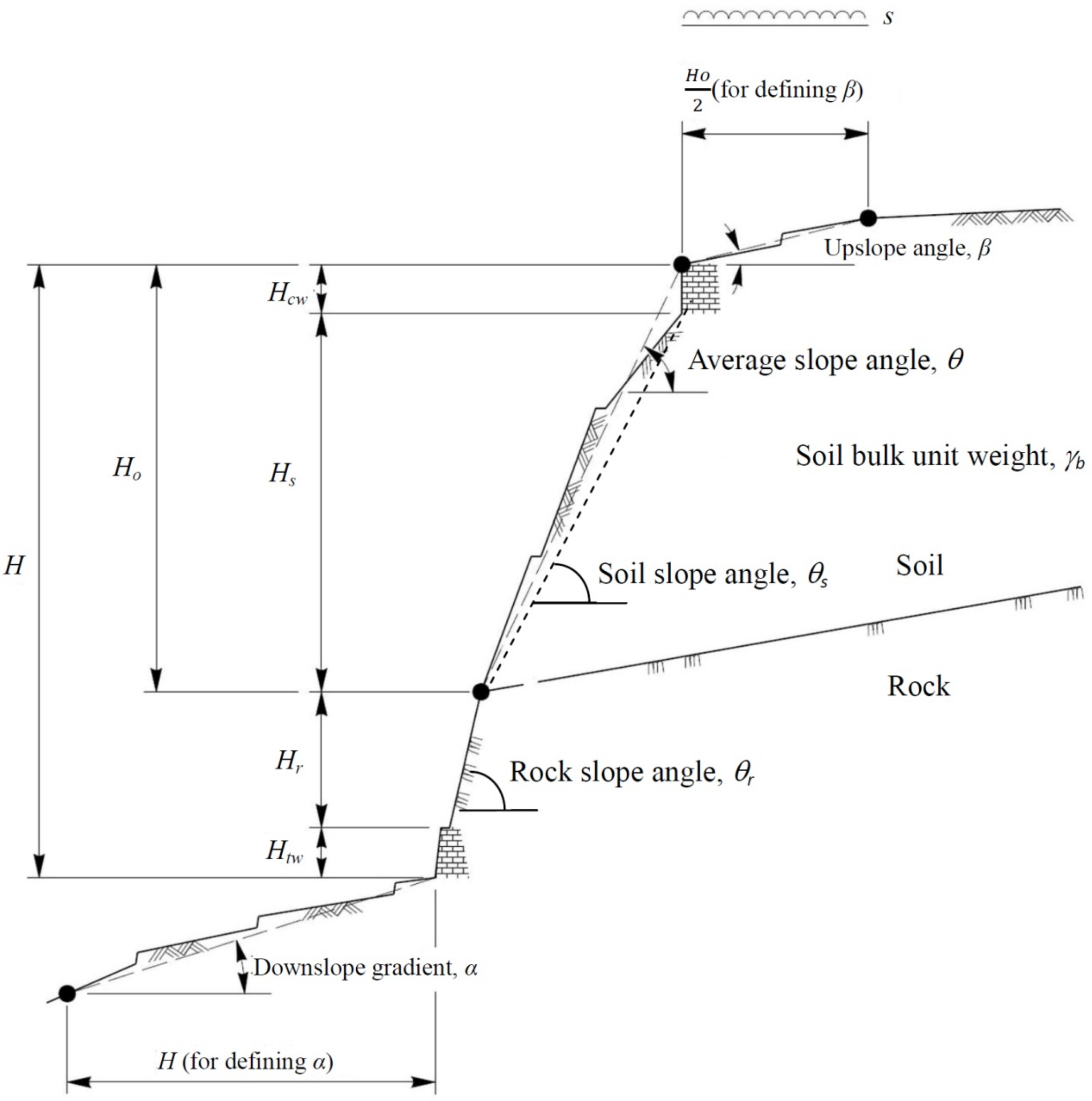


$H_w = H_{cw} + H_{tw}$

Figure B1 Geometry of Soil and Rock Cut Slopes

B.3 Sample Data Collection Sheets for Rock Cut Slopes

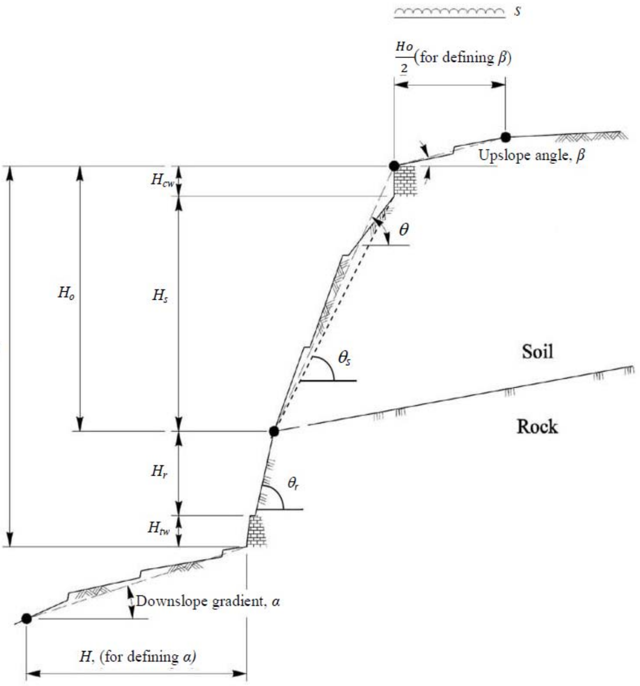
FEATURE NO. (Page 1 of)

SECTION :

Note: Total Score should be computed for each section where there is a potential for a particular mode of failure, i.e. ravelling, toppling, wedge and planar, and adopt the highest one as the score for the entire feature

Geometry (Figure B1)

Feature Height, H (m)	
Rock Slope Height, H_r (m)	
Soil Slope Height, H_s (m)	
Crest Wall Height, H_{cw} (m)	
Toe Wall Height, H_{tw} (m)	
Rock Slope Angle, θ_r (°)	
Soil Slope Angle, θ_s (°)	
Average Slope Angle, θ (°)	



Do the dimensions of individual feature types at this section satisfy the requirement of separate Total Score as shown in Figure 2.3 of the main text?

○ Yes ○ No

If yes, number of data collection sheets required for this section : ☐

Affected Facilities (Figure 2.1 and Table 2.1 of the main text)

Section 1-1	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

Section 2-2	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

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FEATURE NO. (Page 2 of)

PLAN AND CROSS-SECTION

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Notes:

PLAN (1:1000)

1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. rock bolts/dowels, shotcrete, buttress & wire mesh)

CROSS-SECTIONS

1. Fully dimensioned
2. Individual sections shall be provided for each probable mode of failure
3. Engineering measures. (e.g. rock bolts/dowels, shotcrete, buttress & wire mesh)

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(Page 3 of)	SITE OBSERVATIONS/FINDINGS			
FEATURE NO.	**RAVELLING**	**TOPPLING**	**WEDGE**	**PLANAR**
Rock lithology and nature of discontinuity *(see Remark A)*				
Dips of discontinuities/line of intersection of discontinuities (^{o})				
Persistence of discontinuity (m) *(i.e. max. dimension of trace length exposed)*				
Discontinuity spacing (m)				
Discontinuity roughness and infilling *(see Remarks B and C)*				
Width of discontinuity aperture *(see Remark D)*				
Probable scale of failure volume (m^3)				

Remarks

A. Nature of Discontinuity	**B. Roughness of Discontinuities**	**C. Infilling Materials**	**D. Aperture**
1. Joint 2. Fault 3. Tension crack 4. Shear Plane 5. Foliation 6. Bedding	1. Rough 2. Smooth 3. Slickensided	1. Clean/staining 2. Strong/Firm materials *e.g. decomposed/disintegrated rock* 3. Weak/Soft materials *e.g. soil/koalin* 4. Others	1. Wide (> 200 mm) 2. Moderate (20 – 200 mm) 3. Narrow (0 – 20 mm) 4. Tight (zero)

Note: If slope face is concealed or part of the slope inaccessible, the characteristics or discontinuities should be inferred from inspection of adjoining/nearby exposed slope areas.

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FEATURE NO. (Page 4 of)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**

Seepage Condition

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? ○ Yes ○ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

○ Other observations/records:____

Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest					
Berm					
On Slope					
Toe					

○ Potential surface runoff or flow converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)

○ Slope located on a drainage line/zone of depression

○ Inadequate surface drainage provision

○ Other observations/records

Instability after Slope Formation/Treatment

(Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)

○ No indication of any failure occurred after formation or treatment

○ Reported failure ____

○ Possible failure scar observed at ______________ of the slope

○ Estimated failure volume = __________________ m^3

○ Debris observed on site/Other observations:

____

FEATURE NO.	(Page 5 of)
SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**
Signs of Distress (Provide photographic records of signs of distress and indicate location & extent on plan & cross-section)	○ No indication of any signs of distress ○ Reported signs of distress in inspection or maintenance records ______________________________________ ○ Observed signs of distress (please tick) ○ Tension crack(s) along crest of slope (approx. ________ mm wide max) ○ Surficial loosening and small overhanging blocks in several areas ○ Large overhanging block with visible release surface ○ Localised surficial loosening of blocks or small overhanging blocks ○ No noticeable surficial loosening blocks ○ Others: ______________________________ 1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately. 2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.

OTHER OBSERVATIONS/REMARKS

INSPECTION DATE: / / (dd/mm/yyyy) BY:

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FEATURE NO. (Page 6 of)

PHOTOGRAPHIC RECORDS

[Caption]

PHOTOGRAPHIC RECORDS

[Caption]

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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B.4 Worked Example (Data Collection Sheets)

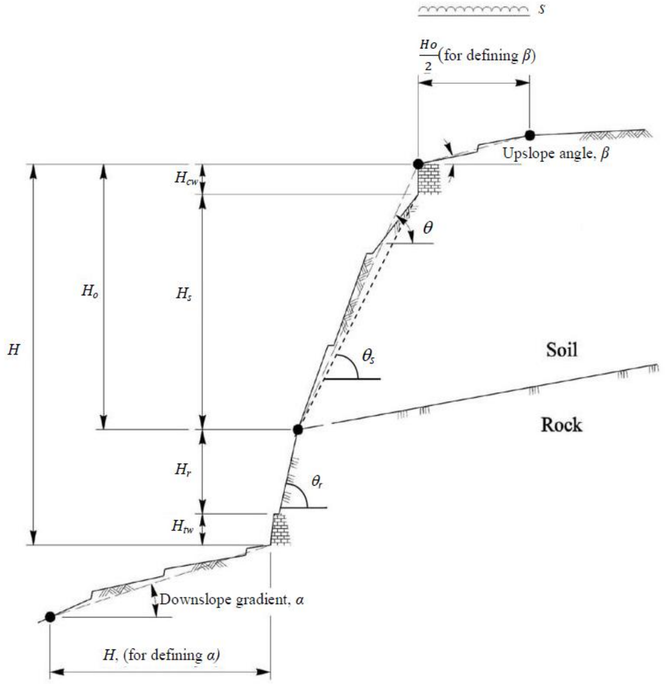
FEATURE NO. **"Worked Example 2"** (Page 1 of 7)

SECTION : 1-1 (Most Severe Consequence)

Note: Total Score should be computed for each section where there is a potential for a particular mode of failure, i.e. ravelling, toppling, wedge and planar, and adopt the highest one as the score for the entire feature

Geometry (Figure B1)

Feature Height, H (m)	**10 m**
Rock Slope Height, H_r (m)	**10 m**
Soil Slope Height, H_s (m)	—
Crest Wall Height, H_{cw} (m)	—
Toe Wall Height, H_{tw} (m)	—
Rock Slope Angle, θ_r (°)	**75 °**
Soil Slope Angle, θ_s (°)	—
Average Slope Angle, θ (°)	**75 °**



Do the dimensions of individual feature types at this section satisfy the requirement of separate Total Score as shown in Figure 2.3 of the main text?

○ Yes ☑ No

If yes, number of data collection sheets required for this section : ☐

Affected Facilities (Figure 2.1 and Table 2.1 of the main text)

Section 1 - 1	Facility Type	Facility Group	Proximity
Toe	**Residential**	**1(a)**	L = **2 m** ω = **70°**
Crest	**Undeveloped Green Belt**	**5**	D = **0 m**

Section 2 - 2	Facility Type	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

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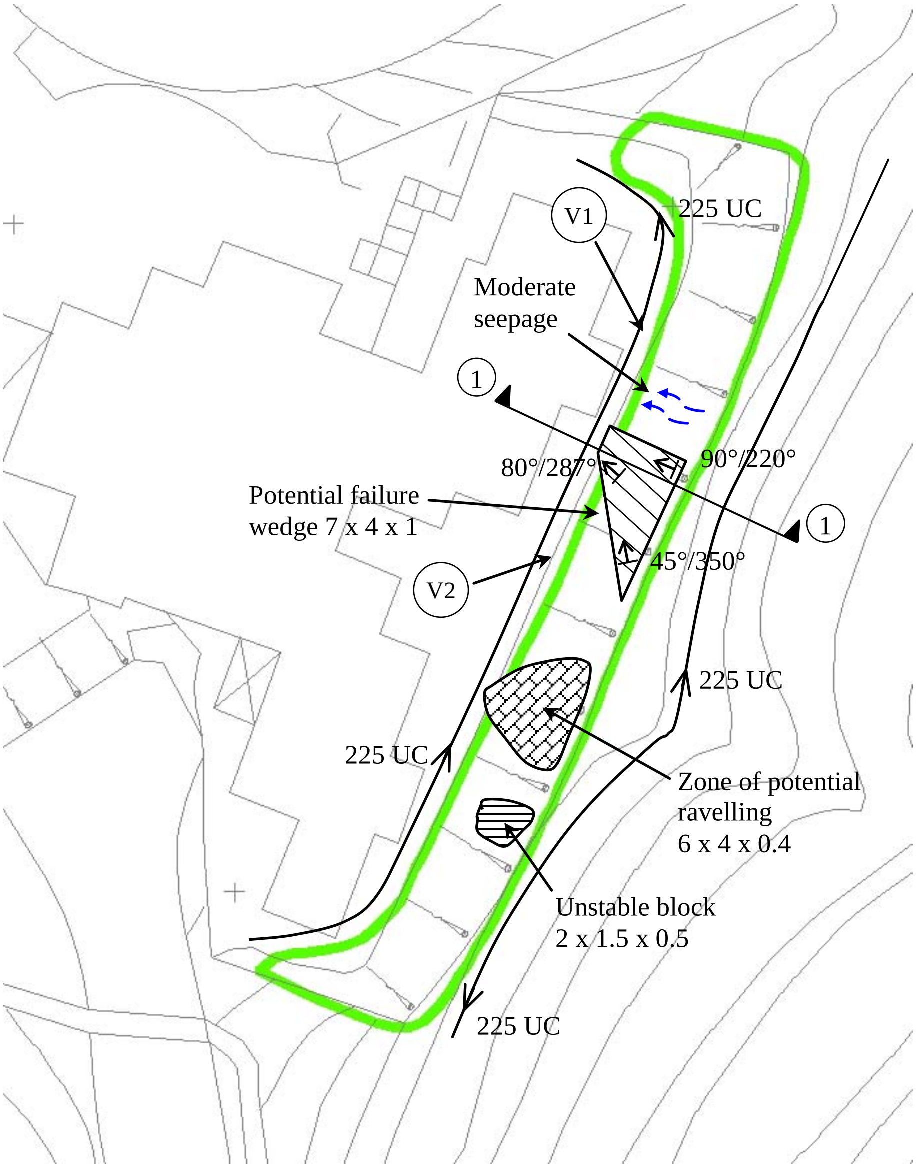
FEATURE NO. **"Worked Example 2"** (Page 2 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Plan
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. rock bolts/dowels, shotcrete, buttress & wire mesh)

CROSS-SECTIONS
1. Fully dimensioned
2. Individual sections shall be provided for each probable mode of failure
3. Engineering measures. (e.g. rock bolts/dowels, shotcrete, buttress & wire mesh)

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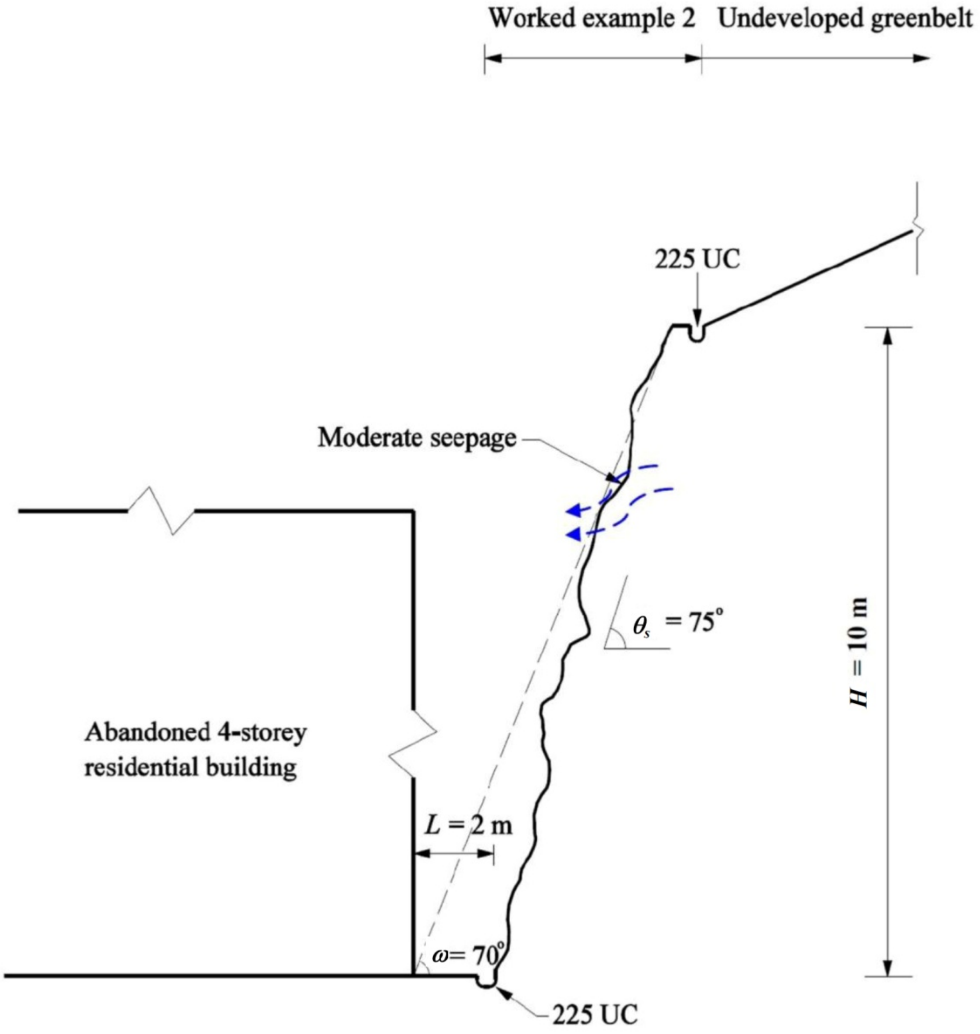
FEATURE NO. **"Worked Example 2"** (Page 3 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note: No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. rock bolts/dowels, shotcrete, buttress & wire mesh)

CROSS-SECTIONS
1. Fully dimensioned
2. Individual sections shall be provided for each probable mode of failure
3. Engineering measures. (e.g. rock bolts/dowels, shotcrete,, buttress & wire mesh)

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(Page 4 of 7) **FEATURE NO. "Worked Example 2"**	**SITE OBSERVATIONS/FINDINGS**			
	RAVELLING	**TOPPLING**	**WEDGE**	**PLANAR**
Rock lithology and nature of discontinuity *(see Remark A)*	**Volcanic Rock with Joints**	—	**Volcanic Rock with Joints**	—
Dips of discontinuities/line of intersection of discontinuities (^{o})	**Multiple sets of sub-vertical joints**	—	**45^{o} / 350^{o}, 50^{o} / 340^{o} 90^{o} / 220^{o}, 80^{o} / 287^{o}**	—
Persistence of discontinuity (m) *(i.e. max. dimension of trace length exposed)*	**0.1 – 0.4 m**	—	**1 – 7 m**	—
Discontinuity spacing (m)	**0.1 – 0.4 m**	—	**1 – 5 m**	—
Discontinuity roughness and infilling *(see Remarks B and C)*	**Rough and staining**	—	**Rough and staining**	—
Width of discontinuity aperture *(see Remark D)*	**0 – 20 mm**	—	**Narrow to tight**	—
Probable scale of failure volume (m^3)	**6 × 4 × 0.4 = 9.6 m^3 (H) (W) (D)**	—	**7 × 4 × 1 = 28 m^3 (H) (W) (D)**	—

Remarks

A. Nature of Discontinuity	**B. Roughness of Discontinuities**	**C. Infilling Materials**	**D. Aperture**
1. Joint 2. Fault 3. Tension crack 4. Shear Plane 5. Foliation 6. Bedding	1. Rough 2. Smooth 3. Slickensided	1. Clean/staining 2. Strong/Firm materials *e.g. decomposed/disintegrated rock* 3. Weak/Soft materials *e.g. soil/koalin* 4. Others	1. Wide (> 200 mm) 2. Moderate (20 – 200 mm) 3. Narrow (0-20 mm) 4. Tight (zero)

Note: If slope face is concealed or part of the slope inaccessible, the characteristics or discontinuities should be inferred from inspection of adjoining/nearby exposed slope areas.

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FEATURE NO. **"Worked Example 2"** (Page 5 of 7)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS

Seepage Condition

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? ✓Yes ○ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height	–	–	–
Below mid-height	–	✓	–

○ Other observations/records:____

Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest	**225**	•	**U-channel**	**N**	**Lined**
Berm	•	•	•	•	•
On Slope	•	•	•	•	•
Toe	**225**	•	**U-channel**	**N**	**Lined**

○ Potential surface runoff or flow converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)

○ Slope located on a drainage line/zone of depression

✓ Inadequate surface drainage provision

✓ Others observations/records

Remarks : Due to a large catchment exist above the rock slope, the 225 UC at crest and toe are considered inadequate

Instability after Slope Formation/Treatment

(Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)

○ No indication of any failure occurred after formation or treatment

○ Reported failure ____

○ Possible failure scar observed at ______________ of the slope

Estimated failure volume = __________________ m^3

✓ Debris observed on site/Other observations:

A small amount (< 1 m^3) of rock fragments found at slope toe

FEATURE NO. **"Worked Example 2"** (Page 6 of 7)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**

Signs of Distress
(Provide photographic records of signs of distress and indicate location & extent on plan & cross-section)
	○ No indication of any signs of distress
	○ Reported signs of distress in inspection or maintenance records ____
	✓ Observed signs of distress (please tick)
	  ○ Tension crack(s) along crest of slope (approx. ________ mm wide max)
	  ✓ Surficial loosening and small overhanging blocks in several areas
	  ○ Large overhanging block with visible release surface
	  ○ Localised surficial loosening of blocks or small overhanging blocks
	  ○ No noticeable surficial loosening blocks
	  ✓ Others: **The slope was in poor maintenance conditions, and potentially unstable blocks and wedges noted in several areas**
	1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately.
	2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.

OTHER OBSERVATIONS/REMARKS

1. **According to SIFT Report, the slope was formed pre-1978. A GEO Stage 1 study was carried out in 1986.**
2. **The residential building at the toe was abandoned at the time of inspection and the whole site was pending redevelopment.**

INSPECTION DATE: **05 / 04 / 2009** (dd/mm/yyyy) BY: **PAJ**

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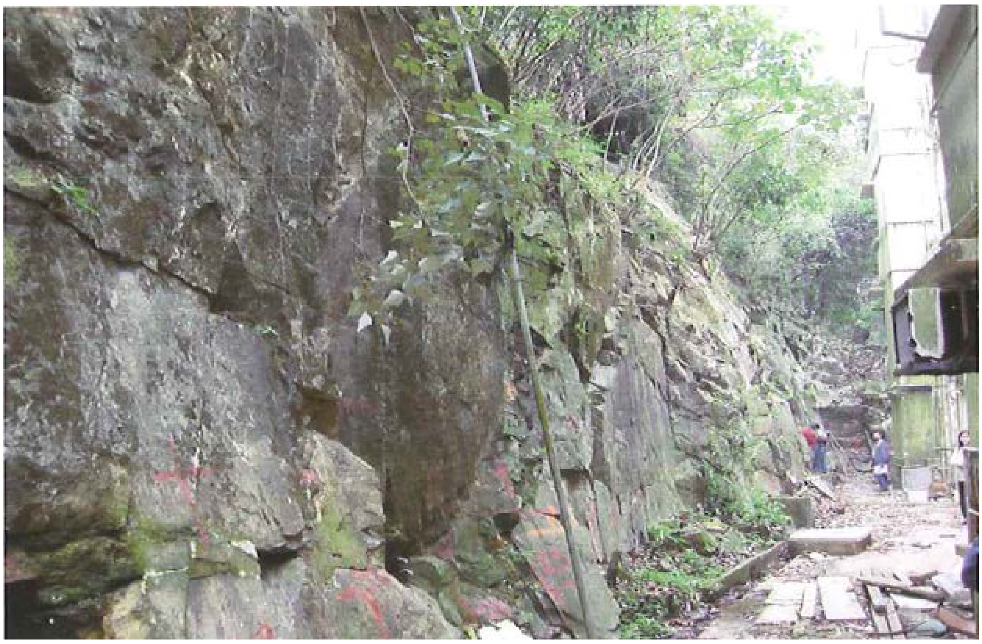
FEATURE NO. **"Worked Example 2"** (Page 7 of 7)

PHOTOGRAPHIC RECORDS



V1 General View of the Feature

PHOTOGRAPHIC RECORDS

V2 Potential Wedge Failure of the Rock Mass

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

B.5 Worked Example (*TS* Computation Sheets)

FEATURE NO. **"Worked Example 2"**

(refer to Figure B1)

(i) Rock Slope Height, H_r = **10** m

(ii) Soil Slope Height, H_s = **-** m

(iii) Crest Wall Height, H_{cw} = **-** m

(iv) Toe Wall Height, H_{tw} = **-** m

(v) Feature Height, H = $H_r + H_s + H_{cw} + H_{tw}$

= **10** m

(vi) Rock Slope Angle, θ_r = **75 °**

(vii) Soil Slope Angle, θ_s = **-**

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

		A1
(i)	Slopes with none or little geotechnical engineering input	10
(ii)	Slopes with indication of some geotechnical engineering input	3
(iii)	Slopes with indication of substantial geotechnical engineering input	1

For rock cut slopes excluded from ranking (see Note 7), denote *A1* = 0

A1 **10**

(A2) Geometry

Rock Slope Angle (θ_r) / Feature Height (H)	$\theta_r > 80^o$	$70^o < \theta_r \le 80^o$	$60^o < \theta_r \le 70^o$	$45^o < \theta_r \le 60^o$	$\theta_r \le 45^o$
$H \ge 20$ m	8	7	6	5	4
15 m $\le H <$ 20 m	7	6	5	4	3
10 m $\le H <$ 15 m	6	[✓ 5]	4	3	2
5 m $\le H <$ 10 m	5	4	3	2	2
$H <$ 5 m	4	3	2	2	1

A2 **5**

(A3) Instability Classification

$A3_a$ – Mode and scale of failure

Mode of failure / Scale of failure (volume)	Ravelling	Toppling	Wedge	Planar
Large (> 50 m^3)	6	10	10	10
Medium (5 – 50 m^3)	3	6	[✓ 6]	6
Small (< 5 m^3)	2	3	3	3
None	1	1	1	1

$A3_b$ – Potential for failure to occur

Low potential for failure	0.5
High potential for failure	[✓ 1.0]

$A3 = A3_a \times A3_b$

A3 **6**

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(A4) Seepage and Drainage Conditions

Drainage Provision \ Seepage	Heavy	Moderate	Slight or none
Potential for convergence of runoff at crest area and/or potential for water ingress into open discontinuities	8	6	4
Insufficient or no drainage measures in place to direct water away from the crest area and face of the slope	6	[✓ 4]	2
Drainage measures adequately direct water away from the crest area and face of the slope	4	2	1

A4 **4**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

	B1
(i) Severe	10
(ii) Moderate	4
(iii) Minor/None	1

B1 **10**

(B2) Instability after Slope Treatment/Formation

	B2
(i) Documented evidence of past instability (failure volume ≥ 50 m^3)	10
(ii) Documented evidence of past instability (failure volume < 50 m^3)	5
(iii) Observed evidence of past instability	2
(iv) No recorded or observed evidence of past instability	1

B2 **2**

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(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

Undeveloped green belt

(ii) Facility Group

5

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text)

0 m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1 **0.0002**

(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)

C2 **0.15**

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

Residential

(ii) Facility Group

1(a)

(iii) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text)

70 °

(iv) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text)

2 m

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

D1 **9**

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

D2 **0.45**

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CALCULATED SCORES

INSTABILITY SCORE (*IS*)

$IS = A1 \times A2 \times A3 \times A4 \times B1 \times B2$

IS **24000**

CONSEQUENCE SCORE (*CS*)

$CS = [C1 \times C2 + D1 \times D2] \times K$

Probable Scale of Failure Volume	*K*
< 5 m^3	1
5 to 50 m^3	3
> 50 m^3	5

$K = 3$

CS **12.15**

TOTAL SCORE (*TS*)

$TS = IS \times CS$

TS **291600**

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Appendix C

Details of NPRS for Fill Slopes

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Contents

List of Figure

C.1 Total Score (*TS*) Computation Sheets for Fill Slopes

FEATURE NO.

SECTION :
○ 1-1 (Most Severe Consequence)
○ 2-2 (Maximum Feature Height)

(refer to Figure C1)

(i) Fill Slope Height, H_f = ______________ m

(ii) Crest Wall Height, H_{cw} = ______________ m

(iii) Toe Wall Height, H_{tw} = ______________ m

(iv) Feature Height, H = ______________ m

(v) Fill Slope Angle, θ_f = ______________ ^{o}

(vi) Average Slope Angle, θ = ______________ ^{o}

INSTABILITY SCORE (*IS*)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

	A1
(i) Slopes with none or little geotechnical engineering input	10
(ii) Slopes with indication of some geotechnical engineering input	3
(iii) Slopes with indication of substantial geotechnical engineering input	1

For fill slopes excluded from ranking (see Note 7), denote $A1 = 0$

A1 ☐

(A2) Sliding and Minor Washout Failure

$A2 = A2_a \times A2_b \times A2_c \times A2_d \times A2_e =$

($A2_a$) Geometry (From Figure C1)
$S1 = 32$
$S2 = 16$
$S3 = 8$
$S4 = 4$
$S5 = 2$
$S6 = 1$

($A2_b$) Type of Surface Cover
Bare = 4
Vegetated = 3
Chunam = 1.5
Shotcrete = 1

($A2_c$) Surface Drainage Provision
No = 2
Yes = 1

($A2_d$) Signs of Seepage
Yes = 2
No = 1

($A2_e$) Potential Leaking Water-carrying Services
Leaking = 2
Presence = 1.5
None = 1

(A3) Liquefaction Failure

$A3 = ¼ \times A2 \times A3_a \times A3_b =$

($A3_a$) Feature Height, H (m)
$H \geq 30 = 4$
$20 \geq H < 30 = 3$
$10 \geq H < 20 = 1$
$H < 10 = 0.5$

($A3_b$) Type of Surface Cover
Bare = 1.3
Vegetated = 1.1
Chunam = 0.5
Shotcrete = 0.25

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(A4) Major Washout Failure $A4 = (A2)^{1/3} \times A4_a \times A4_b \times A4_c \times A4_d \times A4_e \times A4_f \times A4_g \times A4_h =$

($A4_a$) Catchment Characteristics : Topographic Setting and Size of Catchment

Topographic Setting	Size of Catchment (m^2)				
	≤ 100	100 - 500	500 - 1000	1000- 10000	>10000
Traverse Drainage Line	2	4	8	16	32
Adjacent to Drainage Line	2	3	6	12	24
Traverse Topographic Depression	1	2	4	8	16
Adjacent to Topographic Depression	1	2	3	6	12
Planar Slope	0.5	1	3	5	10
Spur	0.5	1	2	4	8

($A4_b$) Type of Crest Facility

Road	Platform & Urban Development	Catch-Water	Minor Development e.g. Rural Footpath	Natural Hillside
1.0	0.5	0.25	0.10	0.05

($A4_c$) Volume of Fill Body (m^3)

≤ 100	100 –500	500 -1000	1000 - 10000	>10000
0.10	0.25	0.5	1	2

($A4_d$) Channelisation of Debris Yes = 2.0
No = 0.5

($A4_e$) Erosion and Entrainment along Debris Trail Yes = 2.0
No = 1.0

($A4_f$) Spread of Debris Yes = 0.5
No = 1.0

($A4_g$) Unstable Terrain Yes = 2.0
No = 1.0

($A4_h$) Masonry Wall at Crest

Wall Height ≥ 3 m	2.0
Wall Height < 3 m	1.5
No Masonry Wall	1.0

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

	B1
(i) Severe	10
(ii) Moderate	4
(iii) Minor/None	1

B1 ☐

(B2) Instability after Slope Formation/Treatment

	B2
(i) Massive failures (> 500 m^3)	10
(ii) Major or repeated minor failures or records of previous severe signs of distress	5
(iii) Minor failure or records of previous moderate signs of distress	2
(iv) No failure or records of previous minor signs of distress	1

B2 ☐

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INSTABILITY SCORE (*IS*)

IS_1 = Instability Score for Sliding and Minor Washout
= $A1 \times A2 \times B1 \times B2$

IS_2 = Instability Score for Liquefaction
= $A1 \times A3 \times B1 \times B2$

IS_3 = Instability Score for Major Washout
= $A1 \times A4 \times B1 \times B2$

IS_1	
IS_2	
IS_3	

CONSEQUENCE SCORE (*CS*)

(C) FACILITY ABOVE CREST OF FEATURE

(i) Type of crest facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

(ii) Facility Group

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text) m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1	

(iv) Vulnerability Factor, *C2* (refer to Table 5.1 of the main text)

$C2_1$	
$C2_2$	
$C2_3$	

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

(ii) Facility Group

(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text) m

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

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(iv) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text)	°	$D1$
(v) Vulnerability Factor, $D2$ (refer to Table 5.2 of the main text)		$D2_1$ $D2_2$ $D2_3$
CONSEQUENCE SCORE (CS) $CS_i = (C1 \times C2_i + D1 \times D2_i) \times H$ Sliding and minor washout failure, $i = 1$ Liquefaction failure, $i = 2$ Major washout failure, $i = 3$		CS_1 CS_2 CS_3

CALCULATED SCORES	
TOTAL SCORE (TS) $TS = \sum_{i=1}^{3} IS_i \times CS_i$	TS

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C.2 Guidelines on Data Collection and Score Computation for Fill Slopes

General

(1) For composite features, i.e. with more than one type of slope feature, the criteria for computation of the Total Score (*TS*) are presented in Figure 2.4 of the main text.

(2) If H of Section 1-1 ≥ 75% of H of Section 2-2, consider Section 1-1 (i.e. in terms of most severe consequence) in calculating the scores. Otherwise, both Sections 1-1 and 2-2 (in terms of maximum feature height, H) should be considered.

(3) Geometric parameters of the feature (e.g. H_f, H_{cw}, H_{tw} and θ_f) (see Figure C1) may be obtained from survey plans and site measurements.

(4) Detailed physical inspection on the features should be carried out using all available access/route.

(5) Unless stated otherwise, "distance" refers to horizontal distance and "height" refers to vertical height.

(6) Details of field mapping and site observation should be recorded using data collection sheets. Sample data collection sheets for fill slopes are appended for reference. Inspecting engineers may modify the sheets to suit their specific use. Provide photographic records of the overview of the features and facilities affected. The photographic records should also include details of site observations to substantiate the factors adopted in the calculation.

Factor *A1*

(7) Fill slopes that were processed and accepted by GEO (e.g. slopes checked by GEO without outstanding comments and slopes designed by GEO) will not be ranked. Denote these features with $A1 = 0$. Data on these slopes should still be collected.

(8) The level of geotechnical engineering input should be inferred from databases, files and documentary records kept by GEO and other relevant government departments and organizations, or aerial photographs if necessary.

(9) Fill slopes with none or little geotechnical engineering input, e.g.
- pre-1978 slopes
- post-1978 slopes formed by unauthorized works
- post-1978 slopes falling outside any engineering project boundary

(10) Fill slopes with indication of some geotechnical engineering input, e.g.
- post-1978 slopes without GEO checking records but falling within the boundary of engineering projects
- slopes assessed as being upto the required safety standard without site specific ground investigation and laboratory testing

(11) Fill slopes with indication of substantial geotechnical engineering input, e.g.

- slopes checked by GEO but with outstanding comments

<u>Factors *A2* to *A3*</u>

(12) Feature Height (*H*) refers to the height of a fill slope including the height of the crest wall and half of the height of the toe wall (refer to Figure C1).

<u>Factor *A4*</u>

(13) Catchment Characteristics - Topographic Setting and Size of Catchment, should be based on SIFT Report. If data are not available, default value 32 for type of crest facility being a road or a catchwater; and 12 for other types of crest facility are suggested.

(14) Volume of Fill Body should be estimated from survey map, field measurement, or aerial photos. Information from SIFT Report may be used, if available.

(15) Channelisation of Debris should be based on SIFT Report. If data are not available, default value 0.5 is suggested.

(16) Erosion and Entrainment along Debris Trail should be based on SIFT Report. If data are not available, default value 1.0 is suggested.

(17) Spread of Debris should be based on SIFT Report. If data are not available, default value 1.0 is suggested.

(18) Unstable Terrain should be based on GASP Reports. Unstable terrain refers to the presence of the following between the fill feature and toe facilities: (i) zones of general instability associated with predominantly colluvial terrain or insitu terrain, and (ii) instability on disturbed terrain.

<u>Factors *B1* and *B2*</u>

(19) Signs of distress are based on site observations, and relevant inspection and maintenance records.

(20) Severe signs of distress refer to signs of slope movement, e.g. large tension cracks behind crest, significant distortion of channels and berms, severe cracking and bulging, subsidence of slope crest or slope surface. These tell-tale signs should be examined in a holistic manner to determine if they are indicative of slope movement. Where there are severe signs of distress or documented evidence of continuing hazardous movement, immediate action should be taken. Examples of severe signs of distress are attached in Appendix F of this report.

(21) Moderate signs of distress refer to signs of extensive minor defects, e.g. cracking of slope cover and damaged channels.

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(22) Judgment should be made in assessing whether cracked slope cover, damaged channels, etc. are due to inadequate maintenance. If these are due to inadequate maintenance, they should not be regarded as signs of distress. In case of doubt, a conservative assessment should be made.

(23) Instability after treatment accounts for landslide incidents occurred after the slope was formed or substantially modified to its present configuration and upgrading works have not been carried out on the slope subsequent to the incidents.

Factors *C* and *D*

(24) Shadow angle (ω) as shown in Figure 2.1 of the main text should be determined by site measurements and/or from survey plans and sections.

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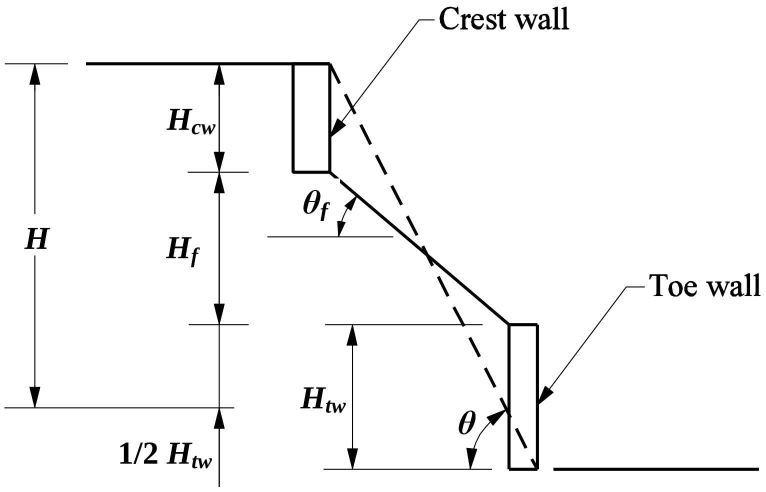
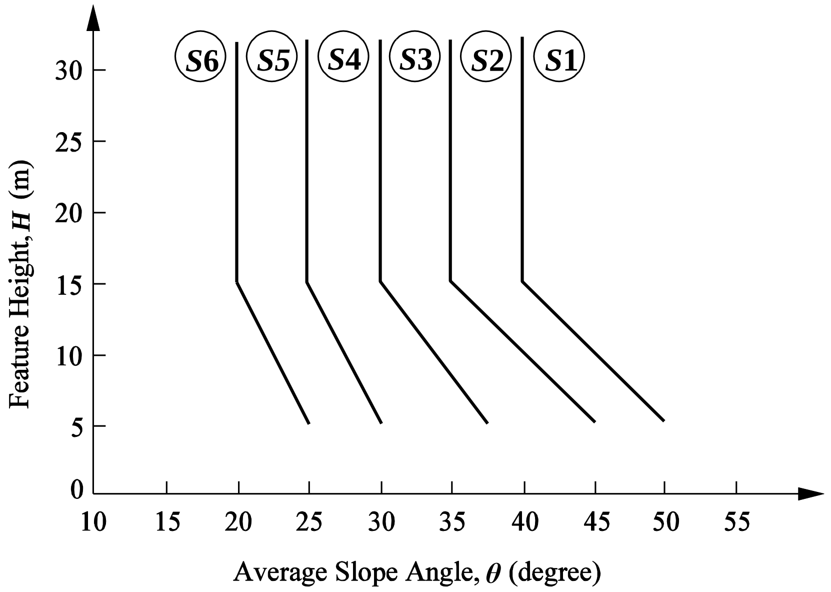


(a) Slope Geometry



(b) Geometry Grouping

Notes:
(1) For a slope with geometry at the dividing line between two categories, the slope is taken to be within the less severe category.
(2) If the toe wall is not retaining the fill body, use $H = H_{cw} + H_f$.

Figure C1 Geometry Classification for Fill Slopes

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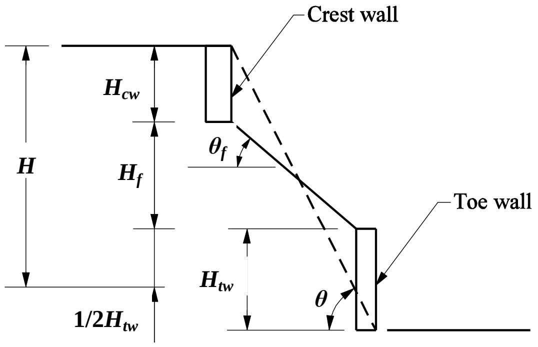
C.3 Sample Data Collection Sheets for Fill Slopes

FEATURE NO. (Page 1 of)

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\% \times H_2$. If yes, consider Section 1-1 only; If No, consider both Section 1-1 and 2-2

Geometry (Figure C1)



Geometrical Data	Section 1-1	Section 2-2
Fill Height, H_f (m)		
Crest Wall Height, H_{cw} (m)		
Toe Wall Height, H_{tw} (m)		
Feature Height, H (m)		
Fill Slope Angle, θ_f (°)		
Average Slope Angle, θ (°)		

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figure 2.4 of the main text?

○ Yes ○ No

If yes, number of data collection sheets required for this section ☐

Affected Facilities (Figure 2.1 and Table 2.1 of the main text)

Section 1-1	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

Section 2-2	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

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FEATURE NO. (Page 2 of)

PLAN AND CROSS-SECTION

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. recompaction, soil nails, grillage beams & shotcrete)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures
   (e.g. recompaction, soil nails, grillage beams & shotcrete)

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FEATURE NO. (Page 3 of)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS

Surface Cover

Surface cover with

○ Vegetation ____________% (including grass/shrubs/trees)
○ Chunam ______________%
○ Concrete _____________% (including shotcrete or other hard material)
○ Bare surface ___________%
○ Others _______________%

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest					
Berm					
On Slope					
Toe					

○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
○ Slope located on a drainage line/zone of depression
○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.
○ Other observations/records

Signs of Seepage

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? ○ Yes ○ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

○ Other observations/records: ____

Water-carrying Services

Indication of presence of water-carrying services :

○ Exposed water main within crest area/on slope
○ Valve(s) of water main within crest area/on slope
○ Manhole cover(s) within crest area/on slope
○ None of the above
○ Others: ____

Signs of leakage ?

○ Yes ○ No

If Yes, indicate location and condition of leakage

____

FEATURE NO. (Page 4 of)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Catchment Characteristics	Provide the following data based on SIFT Report on the slope: Size of Catchment: ___________ m^2 Topographic Setting: ○ Traverse drainage line ○ Adjacent to drainage line ○ Traverse topographic depression ○ Adjacent to topographic depression ○ Planar slope ○ Spur If the required data are not available in SIFT report, adopt the following default values: 1. A maximum score of 32 should be taken for factor *A4a* if crest facility is a road or a catchwater. 2. Otherwise, a score of 12 should be adopted.
Volume of Fill Body	Volume of fill body estimated by : ○ SIFT Report ○ Field measurement (if SIFT data are not available) ○ API Estimated volume of fill body : ___________________ m^3
Channelisation of Debris	Provide data based on SIFT Report on the slope: In case of failure, channelization of debris flow is possible: ○ Yes ○ No If the required data are not available in SIFT report, then **No** should be assumed.
Erosion and Entrainment along Debris Trail	Provide data based on SIFT Report on the slope: In case of failure, erosion and entrainment is possible along the run-out path of the debris flow: ○ Yes ○ No If the required data are not available in SIFT report, then **No** should be assumed.
Spread of Debris	Provide data based on SIFT Report on the slope: In case of failure, spread of debris is possible: ○ Yes ○ No If the required data are not available in SIFT report, then **No** should be assumed.
Unstable Terrain	Obtain terrain classification for the area(s) between the slope and toe facilities based on relevant GASP Reports ○ Zones of general instability associated with predominantly colluvial terrain or in-situ terrain, and ○ Instability on disturbed terrain If terrain between the slope and toe facilities meets both of the above criteria, the terrain should be classified as “Unstable”.

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FEATURE NO. (Page 5 of)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**
Signs of Distress (Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)	○ No indication of any signs of distress ○ Reported signs of distress in inspection or maintenance records ____ ○ Observed signs of distress (please tick) ○ Large tension cracks behind crest (approx. ________ mm wide) ○ Significant distortion/damage of channels and berms ○ Severe cracking and bulging of hard surfacing ○ Subsidence inside crest area or on slope surface ○ Extensive cracking of slope cover ○ Isolated minor cracking of slope cover/Isolated cracking of channels ○ Others: ____ 1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately. 2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.
Instability after Slope Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	○ No indication of any failure occurred after formation or treatment ○ Reported failure ____ ○ Possible failure scar observed at ______________ of the slope Estimated failure volume = __________________ m^3 ○ Debris observed on site/Other observations: ____

OTHER OBSERVATIONS/REMARKS

INSPECTION DATE: / / (dd/mm/yyyy) BY:

FEATURE NO.	(Page 6 of)

PHOTOGRAPHIC RECORDS

[Caption]

PHOTOGRAPHIC RECORDS

[Caption]

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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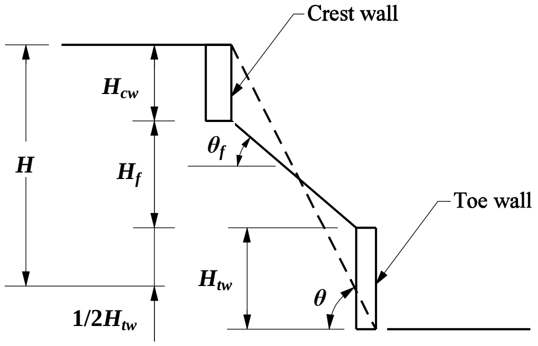
C.4 Worked Example (Data Collection Sheets)

FEATURE NO. **"Worked Example 3"** (Page 1 of 7)

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\% \text{ x } H_2$. If yes, consider Section 1-1 only; If No, consider both Section 1-1 and 2-2

Geometry (refer to Figure C1)



Geometrical Data	Section 1-1	Section 2-2
Fill Height, H_f (m)	**13 m**	—
Crest Wall Height, H_{cw} (m)	—	—
Toe Wall Height, H_{tw} (m)	—	—
Feature Height, H (m)	**13 m**	—
Fill Slope Angle, θ_f (°)	**40 °**	—
Average Slope Angle, θ (°)	**40 °**	—

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figure 2.4 of the main text?

○ Yes ☑ No

If yes, number of data collection sheets required for this section —

Affected Facilities (refer to Figure 2.1 and Table 2.1 of the main text)

Section 1-1	Facility Type	Facility Group	Proximity
Toe	**Densely-used Playground**	**3**	L = **0 m** ω = **40 °**
Crest	**Open Car Park**	**3**	D = **1 m**

Section 2-2	Facility Type	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

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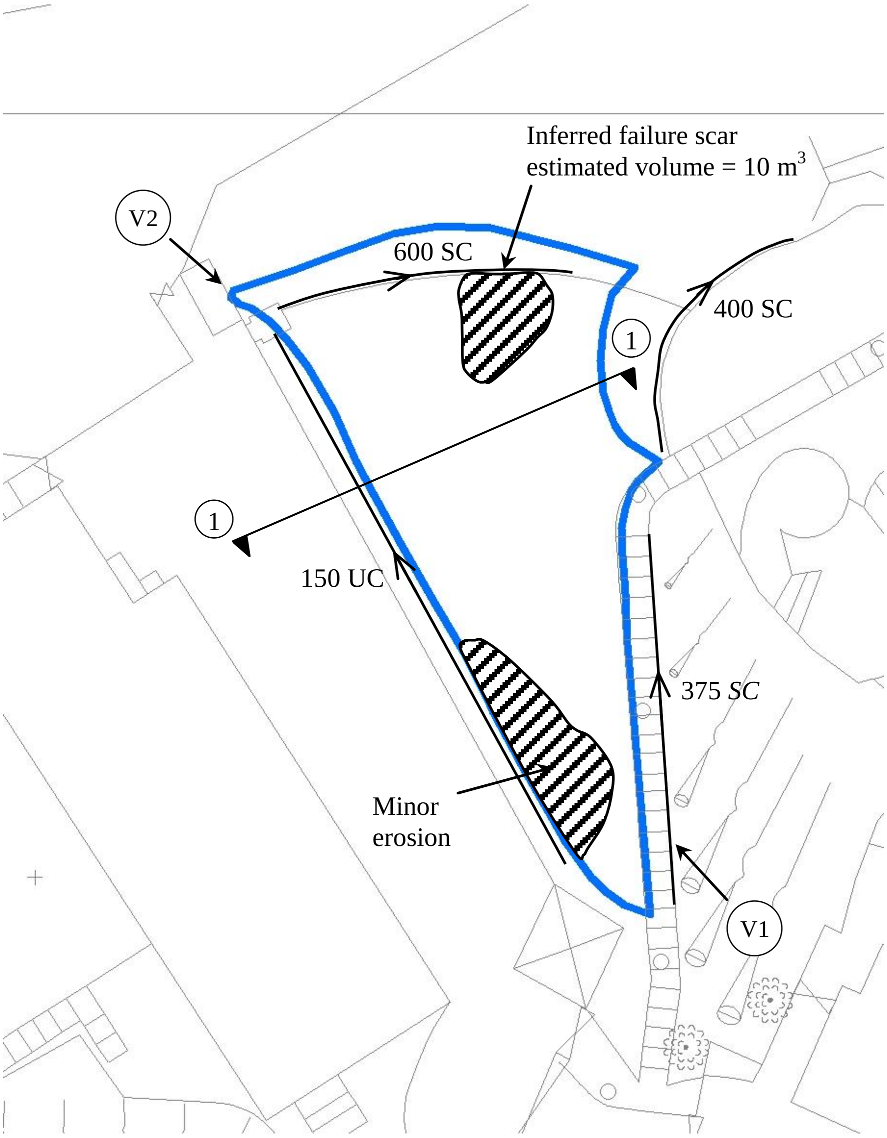
FEATURE NO. **"Worked Example 3"** (Page 2 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Plan
(Not to scale)

Notes:
PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. recompaction, soil nails, grillage beams & shotcrete)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures
(e.g. recompaction, soil nails, grillage beams & shotcrete)

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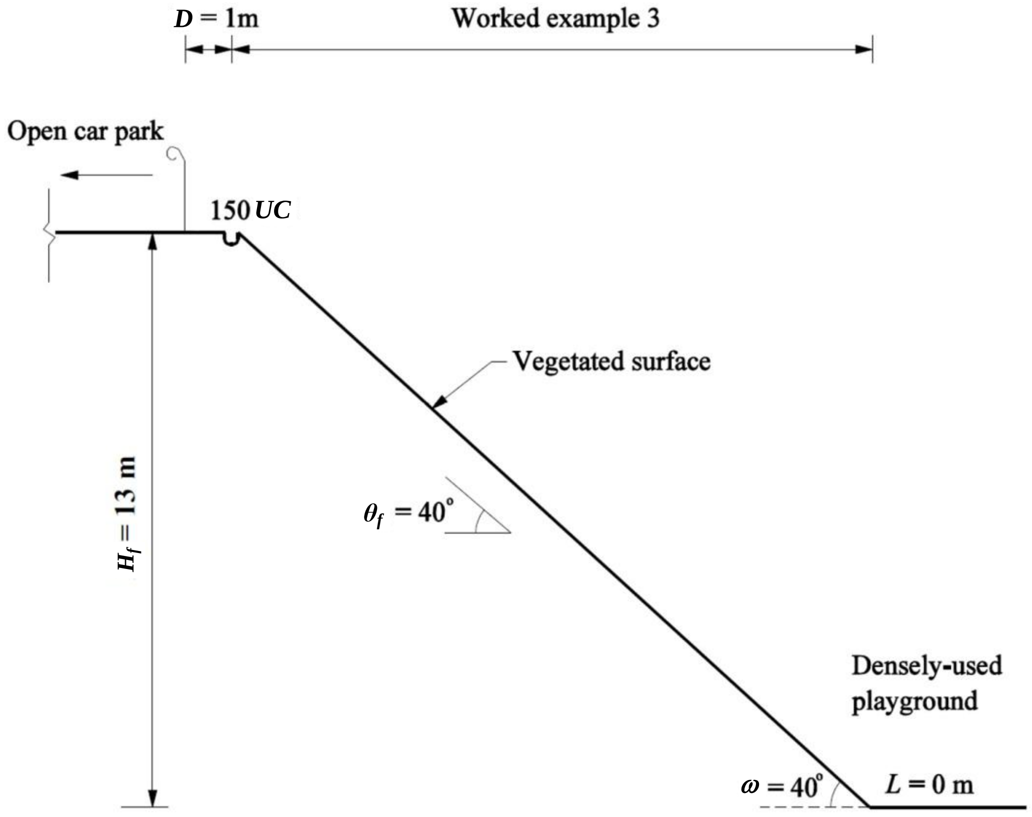
FEATURE NO. **"Worked Example 3"** (Page 3 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note: No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:
PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. recompaction, soil nails, grillage beams & shotcrete)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures
(e.g. recompaction, soil nails, grillage beams & shotcrete)

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FEATURE NO. **"Worked Example 3"** (Page 4 of 7)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS

Surface Cover

Surface cover with

☑ Vegetation **90** % (including grass/shrubs/trees)
☑ Chunam **10** %
○ Concrete ________________% (including shotcrete or other hard material)
○ Bare surface _____________%
○ Others _________________%

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest	**150**	—	**U-channel**	**Y**	**Lined**
Berm	—	—	—	—	—
On Slope	**600**	—	**Step-channel**	**Y**	**Lined**
Toe	**350**	—	**U-channel**	**Y**	**Lined**

○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
○ Slope located on a drainage line/zone of depression
○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.
○ Other observations/records

Signs of Seepage

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? ○ Yes ☑ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

○ Other observations/records: ____

Water-carrying Services

Indication of presence of water-carrying services :

○ Exposed water main within crest area/on slope
○ Valve(s) of water main within crest area/on slope
☑ Manhole cover(s) within crest area/on slope
○ None of the above
○ Others: ____

Signs of leakage?

○ Yes ☑ No

If Yes, indicate location and condition of leakage

____

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FEATURE NO. **"Worked Example 3"** (Page 5 of 7)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Catchment Characteristics	Provide the following data based on SIFT Report on the slope: Size of Catchment: **< 100** m^2 Topographic Setting: ○ Traverse drainage line ☑ Adjacent to drainage line ○ Traverse topographic depression ○ Adjacent to topographic depression ○ Planar slope ○ Spur If the required data are not available in SIFT report, adopt the following default values: 1. A maximum score of 32 should be taken for factor A4a if crest facility is a road or a catchwater. 2. Otherwise, a score of 12 should be adopted.
Volume of Fill Body	Volume of fill body estimated by : ☑ SIFT Report ○ Field measurement (if SIFT data are not available) ○ API Estimated volume of fill body : **750** m^3
Channelisation of Debris	Provide data based on SIFT Report on the slope: In case of failure, channelization of debris flow is possible: ○ Yes ☑ No If the required data are not available in SIFT report, then **<u>No</u>** should be assumed.
Erosion and Entrainment along Debris Trail	Provide data based on SIFT Report on the slope: In case of failure, erosion and entrainment is possible along the run-out path of the debris flow: ○ Yes ☑ No If the required data are not available in SIFT report, then **<u>No</u>** should be assumed.
Spread of Debris	Provide data based on SIFT Report on the slope: In case of failure, spread of debris is possible: ☑ Yes ○ No If the required data are not available in SIFT report, then **<u>No</u>** should be assumed.
Unstable Terrain	Obtain terrain classification for the area(s) between the slope and toe facilities based on relevant GASP Reports ○ Zones of general instability associated with predominantly colluvial terrain or in-situ terrain, and ○ Instability on disturbed terrain If terrain between the slope and toe facilities meets both of the above criteria, the terrain should be classified as “Unstable”.

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FEATURE NO. **"Worked Example 3"** (Page 6 of 7)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Signs of Distress (Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)	○ No indication of any signs of distress ○ Reported signs of distress in inspection or maintenance records ____ ☑ Observed signs of distress (please tick) ○ Large tension cracks behind crest (approx. ________ mm wide) ○ Significant distortion/damage of channels and berms ○ Severe cracking and bulging of hard surfacing ○ Subsidence inside crest area or on slope surface ○ Extensive cracking of slope cover ☑ Isolated minor cracking of slope cover/Isolated cracking of channels ○ Others: ________________________________ 1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately. 2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.
Instability after Slope Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	○ No indication of any failure occurred after formation or treatment ○ Reported failure ________________________________ ☑ Possible failure scar observed at **northern toe** of the slope Estimated failure volume = **10** m^3 ○ Debris observed on site/Other observations: ____

OTHER OBSERVATIONS/REMARKS

According to SIFT Report, the slope was formed before 1949 and was modified between 1963 and 1968.

INSPECTION DATE: **02 / 05 / 2009** (dd/mm/yyyy) BY: **PAJ**

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FEATURE NO. **"Worked Example 3"** (Page 7 of 7)

PHOTOGRAPHIC RECORDS

V1 Overview of the Slope

PHOTOGRAPHIC RECORDS

V2 General View of the Crest Area

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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C.5 Worked Example (*TS* Computation Sheets)

FEATURE NO. **"Worked Example 3"**

SECTION :
☑ 1-1 (Most Severe Consequence)
○ 2-2 (Maximum Feature Height)

(refer to Figure C1)

(i) Fill Slope Height, H_f = **13** m

(ii) Crest Wall Height, H_{cw} = **0** m

(iii) Toe Wall Height, H_{tw} = **0** m

(iv) Feature Height, H = **13** m

(v) Fill Slope Angle, θ_f = **40 °**

(vi) Average Slope Angle, θ = **40 °**

INSTABILITY SCORE (*IS*)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Input

		A1
(i)	Slopes with none or little geotechnical engineering input	10
(ii)	Slopes with indication of some geotechnical engineering input	3
(iii)	Slopes with indication of substantial geotechnical engineering input	1

For fill slopes excluded from ranking (see Note 7), denote *A1* = 0

A1 **10**

(A2) Sliding and Minor Washout Failure $A2 = A2_a \times A2_b \times A2_c \times A2_d \times A2_e =$ **48**

($A2_a$) Geometry (From Figure C1)
$S1 = 32$
$S2 = 16$
$S3 = 8$
$S4 = 4$
$S5 = 2$
$S6 = 1$
$A2_a =$ **16**

($A2_b$) Type of Surface Cover
Bare = 4
Vegetated = 3
Chunam = 1.5
Shotcrete = 1
$A2_b =$ **3**

($A2_c$) Surface Drainage Provision
No = 2
Yes = 1
$A2_c =$ **1**

($A2_d$) Signs of Seepage
Yes = 2
No = 1
$A2_d =$ **1**

($A2_e$) Potential Leaking Water-carrying Services
Leaking = 2
Presence = 1.5
None = 1
$A2_e =$ **1**

(A3) Liquefaction Failure $A3 = \frac{1}{4} \times A2 \times A3_a \times A3_b =$ **13.2**

($A3_a$) Feature Height, H (m)
$H \geq 30 = 4$
$20 \geq H < 30 = 3$
$10 \geq H < 20 = 1$
$H < 10 \quad = 0.5$
$A3_a =$ **1**

($A3_b$) Type of Surface Cover
Bare = 1.3
Vegetated = 1.1
Chunam = 0.5
Shotcrete = 0.25
$A3_b =$ **1.1**

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(A4) Major Washout Failure $A4 = (A2)^{1/3} \times A4_a \times A4_b \times A4_c \times A4_d \times A4_e \times A4_f \times A4_g \times A4_h =$ **0.5**

($A4_a$) Catchment Characteristics : Topographic Setting and Size of Catchment

Topographic Setting	Size of Catchment (m^2)				
	≤ 100	100 - 500	500 - 1000	1000- 10000	>10000
Traverse Drainage Line	2	4	8	16	32
Adjacent to Drainage Line	[✓ 2]	3	6	12	24
Traverse Topographic Depression	1	2	4	8	16
Adjacent to Topographic Depression	1	2	3	6	12
Planar Slope	0.5	1	3	5	10
Spur	0.5	1	2	4	8

$A4_a =$ **2**

($A4_b$) Type of Crest Facility

Road	Platform & Urban Development	Catch-Water	Minor Development e.g. Rural Footpath	Natural Hillside
1.0	0.5	0.25	0.10	0.05

$A4_b =$ **0.5**

($A4_c$) Volume of Fill Body (m^3)

≤ 100	100 –500	500 -1000	1000 - 10000	>10000
0.10	0.25	0.5	1	2

$A4_c =$ **0.5**

($A4_d$) Channelisation of Debris
Yes = 2.0
No = 0.5

$A4_d =$ **0.5**

($A4_e$) Erosion and Entrainment along Debris Trail
Yes = 2.0
No = 1.0

$A4_e =$ **1**

($A4_f$) Spread of Debris
Yes = 0.5
No = 1.0

$A4_f =$ **0.5**

($A4_g$) Unstable Terrain
Yes = 2.0
No = 1.0

$A4_g =$ **1**

($A4_h$) Masonry Wall at Crest

Wall Height ≥ 3 m	2.0
Wall Height < 3 m	1.5
No Masonry Wall	1.0

$A4_h =$ **1**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

		B1
(i)	Severe	10
(ii)	Moderate	4
(iii)	Minor/None	1

B1 **1**

(B2) Instability after Slope Formation/Treatment

		B2
(i)	Massive failures (> 500 m^3)	10
(ii)	Major or repeated minor failures or records of previous severe signs of distress	5
(iii)	Minor failure or records of previous moderate signs of distress	2
(iv)	No failure or records of previous minor signs of distress	1

B2 **2**

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INSTABILITY SCORE (*IS*)

IS_1 = Instability Score for Sliding and Minor Washout
$= A1 \text{ x } A2 \text{ x } B1 \text{ x } B2$

IS_2 = Instability Score for Liquefaction
$= A1 \text{ x } A3 \text{ x } B1 \text{ x } B2$

IS_3 = Instability Score for Major Washout
$= A1 \text{ x } A4 \text{ x } B1 \text{ x } B2$

IS_1	**960**
IS_2	**264**
IS_3	**10**

CONSEQUENCE SCORE (*CS*)

(C) FACILITY ABOVE CREST OF FEATURE

(i) Type of crest facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text)	**Open car park**
(ii) Facility Group	**3**
(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text)	**1 m**

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1	**0.25**

(iv) Vulnerability Factor, *C2* (refer to Table 5.1 of the main text)

$C2_1$	**0.15**
$C2_2$	**0.15**
$C2_3$	**0.18**

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text)	**Densely-used playground**
(ii) Facility Group	**3**
(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text)	**0 m**

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

(iv) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text)	**40 ^{o}**	*D1*	**0.25**
(v) Vulnerability Factor, *D2* (refer to Table 5.2 of the main text)		$D2_1$ $D2_2$ $D2_3$	**0.32** **0.52** **0.315**

<u>CONSEQUENCE SCORE (*CS*)</u>

$CS_i = (C1 \times C2_i + D1 \times D2_i) \times H$

Sliding and minor washout failure, *i* = 1

Liquefaction failure, *i* = 2

Major washout failure, *i* = 3

CS_1	**1.52**
CS_2	**2.17**
CS_3	**1.60**

CALCULATED SCORES

<u>TOTAL SCORE (*TS*)</u>

$TS = \sum_{i=1}^{3} IS_i \times CS_i$

TS	**2057.3**

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Appendix D

Details of NPRS for Retaining Walls

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D.1 Total Score (*TS*) Computation Sheets for Retaining Walls

FEATURE NO.	**SECTION :** ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

		A1
(i)	Features with none or little geotechnical engineering input	10
(ii)	Features with indication of some geotechnical engineering input	3
(iii)	Features with indication of substantial geotechnical engineering input	1

For retaining walls excluded from ranking (see Note 7), denote *A1* = 0

A1 ☐

(A2) Geometry (refer to Figure D1)

	Section 1-1	2-2
(i) Wall Height, H_w	m	m
(ii) Rock Slope Height, H_r	m	m
(iii) Soil Slope Height, H_s	m	m
(iv) Upslope Angle, β	°	°
(v) Wall Face Angle, θ_w	°	°
(vi) Surcharge at crest of wall, s	kPa	kPa
(vii) Base width, B_w		
(viii) Average Wall Face Angle (in case of multiple walls), θ	°	°

(ix) Feature Height, H $H = H_s + H_r + H_w$	m
(x) Effective Height, H_e $H_e = H_w\,(1 + 0.35 \tan \beta) + \dfrac{s}{\gamma_b}$	m
where γ_b = soil bulk unit weight	$\frac{\text{kN}}{\text{m}^3}$
(xi) H_e/B_w =	

Classification

		A2
(i)	$H_e/B_w > 4.2$	8
(ii)	$3.5 < H_e/B_w \leq 4.2$	6
(iii)	$2.8 < H_e/B_w \leq 3.5$	4
(iv)	$2.0 < H_e/B_w \leq 2.8$	2
(v)	$H_e/B_w \leq 2.0$	1

A2 ☐

(A3) Wall Type (refer to Figure D2)

Type of Wall	*A3*
• Random rubble masonry wall (with or without pointing, ties or horizontal beams)	8
• Wall composed of lime-stabilised soils • Brick Wall • Dry packed dressed block/squared rubble wall without ties • Any type of masonry wall (except for random rubble walls) with horizontal beams made of lime-stabilised soil or brick	5
• Dry packed dressed block/squared rubble wall with ties • Any type of masonry wall (except for random rubble walls) with concrete horizontal beams	3
• Masonry facing to concrete wall • Concrete wall	1

Other Wall Type ____

A3 ☐

(A4) Surface Protection and Surface Drainage

Surface Protection / Surface Drainage	Crest area substantially unprotected	Crest area partially protected	Crest area substantially protected
Few or no channels above wall crest, and potential for convergent flow of surface water above crest	8	4	2
Few or no channels above wall crest	4	2	1.5
Adequate channels	2	1.5	1

A4 ☐

(A5) Signs of Seepage and Leaky Water-Carrying Services

Water-carrying Services / Signs of Seepage	Presence of potentially leaky services & signs of leakage noted	Presence of potentially leaky services but no signs of leakage noted	No potentially leaky services
Seepage at mid-height or above	8	4	2
Seepage below mid-height	4	2	1.5
No signs of seepage	2	1.5	1

A5 ☐

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

		B1
(i)	Severe (Advanced stage of severe deformation and/or distress or onset of severe deformation and/or distress)	10
(ii)	Moderate (Moderate deformation and/or distress)	4
(iii)	Minor/None (Minimal deformation and distress)	1

For a wall of the slenderness ratio, $H_e/B_w \geq 5$ or a dry packed random rubble wall with $H_w > 5$ m, accord $B1 = 10$

B1 ☐

(B2) Instability after Wall Formation/Treatment

		B2
(i)	Major (full-height failure)	10
(ii)	Multiple part-height or structural failures, or records of previous severe signs of distress	5
(iii)	Part-height or structural failures, or records of previous moderate signs of distress	2
(iv)	No failure nor records of previous signs of distress	1

B2 ☐

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text) ☐

(ii) Facility Group ☐

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text) ☐ m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

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(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)		*C1* ☐ *C2* ☐

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text) ☐

(ii) Facility Group ☐

(iii) Shadow angle (*ω*) from crest of feature to toe facility
(refer to Figure 2.1 of the main text) ☐ °

(iv) Distance (*L*) from toe of feature to toe facility
(refer to Figure 2.1 of the main text) ☐ m

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

D1 ☐

D2 ☐

CALCULATED SCORES

INSTABILITY SCORE (*IS*)

$IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$

IS ☐

CONSEQUENCE SCORE (*CS*)

$CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$

CS ☐

TOTAL SCORE (*TS*)

$TS = IS \text{ x } CS$

TS ☐

D.2 Guidelines on Data Collection and Score Computation for Retaining Walls

General

(1) For composite features, i.e. with more than one type of slope feature, the criteria for computation of the Total Score (*TS*) are presented in Figures 2.3 and 2.4 of the main text.

(2) If *H* of Section 1-1 ≥ 75% of *H* of Section 2-2, consider Section 1-1 (i.e. in terms of most severe consequence) in calculating the scores. Otherwise, both Sections 1-1 and 2-2 (in terms of maximum feature height, *H*) should be considered.

(3) Geometric parameters of the feature (e.g. H_s, H_r, H_w, β, and θ_w) (see Figure D1) may be obtained from survey plans and site measurements.

(4) Detailed physical inspection on the features should be carried out using all available access/route.

(5) Unless stated otherwise, "distance" refers to horizontal distance and "height" refers to vertical height.

(6) Details of field mapping and site observation should be recorded using the agreed data collection sheet. Sample data collection sheets for retaining walls are appended for reference. Inspecting engineers may modify the sheets to suit their specific use. Provide photographic records of the overview of the features and facilities affected. The photographic records should also include details of site observation to substantiate the factors adopted in the calculation.

Factor *A1*

(7) Retaining walls that were processed and accepted by GEO (e.g. retaining walls checked by GEO without outstanding comments, and retaining walls designed by GEO) will not be ranked. Denote these walls with *A1* = 0. Data on these walls should still be collected.

(8) The level of geotechnical engineering input should be inferred from databases, files and documentary records kept by GEO and other relevant government departments and organizations, or aerial photographs if necessary.

(9) Retaining walls with none or little geotechnical engineering input, e.g.
- pre-1978 walls
- post-walls formed by unauthorized works
- post-1978 walls falling outside any engineering project boundary

(10) Retaining walls with indication of some geotechnical engineering input, e.g.
- post-1978 walls without GEO checking records but falling within the boundary of engineering projects

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- walls assessed as being upto the required safety standard without site specific ground investigation and laboratory testing

(11) Retaining walls with indication of substantial geotechnical engineering input, e.g.

- walls checked by GEO but with outstanding comments

Factor *A2*

(12) A retaining wall is defined as one with an average face angle (θ_w) of 75^o or more. Where θ_w is less than 75^o, it would be considered as a rigid surface protection to a slope.

(13) An assessment of the surcharge (*s*) above the wall crest may be made by reference to Table 16 of the second edition of Geoguide 1 (GEO, 1993).

(14) In the case of a series of walls retaining a number of platforms, the walls should be considered as a single feature if the average angle (θ) of the line joining the toe of the lowermost wall and the top of the uppermost wall is ≥ 60^o (Figure D1). If $\theta \leq 60^o$, the individual walls should be considered as separate walls for data collection purposes if each wall is "registrable" based on the SIRST criteria. The criteria for features requiring registration should refer to GEO Circular No. 15 (GEO, 2004).

(15) The base width of a wall should be determined from the available records as far as possible. In case no record is available, the base width may be inferred from weephole probing. If the base width cannot be determined by the above means, accord the wall slenderness ratio, $H_e/B_w = 5$.

Factor *A3*

(16) Concrete walls sometimes have a decorative masonry facing which can give the impression of being a masonry wall. This type of wall can often be distinguished by the presence of vertical movement joints at a regular spacing, uniformity of the pointing and regular squared-shaped, well dressed blocks. Smaller squared blocks, not necessarily laid in horizontal courses, but arranged to create a regular pattern on the wall face, and often without pointing, have also been used as a decorative facing to concrete walls. Examples of common types of masonry walls and masonry facings are shown in Figures D2 and D3.

(17) If the wall type is not included in the table, specify the wall type and accord an appropriate weighting by benchmarking with the listed wall type of similar characteristics.

Factor *A4*

(18) Both hard cover and vegetation cover are considered as slope protection. As a general guideline, “substantially protected” refers to more than 75% area covered,

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"partially protected" refers to between 25% and 75% area protected and "substantially unprotected" refers to less than 25% area covered.

(19) Crest area refers to the area within a horizontal distance of $H/2$ beyond the crest of the wall.

(20) Where there is potential for ponding above the wall crest, the score for the next higher category in the surface protection should be adopted.

(21) In assessing the adequacy of surface drainage provisions, the overall setting including the site topography, catchment area and environmental factors that are liable to give rise to convergent flow of surface water should be considered.

(22) The potential for convergent flow of surface water above the wall crest should be determined from topographic plan and/or aerial photographs.

Factor *A5*

(23) Assessment of the seepage conditions should be based on site inspection.

(24) Any water-carrying services that could potentially affect the retaining wall in the event of leakage, typically water-carrying services within H from the crest of the retaining wall, should be considered. However, each case should be treated on its merits in determining the extent necessary for the assessment. If proper ducting provisions have been provided, the services may be taken as not "potentially leaky".

(25) Staining on the wall and erosion features often indicates seepage. When seepage is noted on the wall, the location of the seepage should be marked on plan and section. If the inspection is carried out during the dry season, a conservative assessment of the seepage condition should be made.

(26) Consideration should also be given to the overall setting of the retaining wall, e.g. whether the retaining wall is at the head of a valley, along the side of a valley or across the nose of a spur, presence of hydrogeological features (e.g. streamcourse) which might contribute water to the retained material, or evidence of a high water table upslope (e.g. an unusually rich vegetation cover).

Factors *B1* and *B2*

(27) Signs of distress are based on site observations, and relevant inspection and maintenance records. The inspecting engineers are required to exercise professional judgement in deciding whether the signs of distress are genuine indication of unsatisfactory performance of the feature. Examples of severe signs of distress are shown in Appendix F of this report.

(28) Minimal distress refers to wall fabric in good condition; moderate distress refers to the situation where much mortar is missing, or where there is minor dislocation of isolated

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wall blocks; onset of severe distress refers to the situation where some of the wall blocks are missing or dislocated; advanced stage of severe distress refers to the condition where many of the wall blocks are missing or subject to major dislocation. Some guidelines for evaluating the state of wall deformation are given in Table D1.

(29) Judgment should be made in assessing whether apparent signs of distress (such as cracking) are induced during wall construction or due to inadequate maintenance. In the latter circumstances, although maintenance work may be required, they should not be regarded as signs of distress. In case of doubt, a conservative assessment should be made.

(30) Instability after treatment accounts for landslide incidents occurred after the wall was formed or substantially modified to its present configuration and upgrading works have not been carried out on the wall subsequent to the incidents.

(31) Where there are severe signs of distress or documented evidence of continuing hazardous movement, immediate action should be taken.

Factors C and D

(32) Shadow angle (ω) as shown in Figure 2.1 of the main text should be determined by site measurements and/or from survey plans and sections.

References

GEO (1993). *Guide to Retaining Wall Design (Geoguide 1) 2nd Edition*. Geotechnical Engineering Office, Hong Kong, 258 p.

GEO (2004). *Registration and Updating of Records of Features (GEO Circular No, 15)*. Geotechnical Engineering Office, Hong Kong, 20 p.

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Table D1 Guidelines for Evaluation of the State of Wall Deformation

Observed State of Wall Deformation	Forward Movement	Bulging
(1) Minimal Deformation	Forward movement of wall as indicated by: (a) long continuous movement cracks at wall crest sub-parallel to wall, total width at any section < 0.1% of wall height or (b) sub-vertical through cracks in return wall of total width at each level < 0.1%*h* where *h* is height of measurement point from ground surface level in front of toe	Negligible bulging of wall
(2) Moderate Deformation	Forward movements as (1) except crack width totalling between 0.1% and 0.2%*h*	Minor bulging of wall face noticeable to naked eye
(3) Onset of Severe Deformation	Forward movements as (1) except crack width totalling between 0.2% and 0.6%*h*	Bulged profile of wall face sufficient to touch a vertical line drawn through wall toe, or maximum bulging of wall approaching or equal to 75 mm
(4) Advanced Stage of Severe Deformation	Forward movements as (1) except crack width totalling to a value > 0.6%*h*	Bulging as (3) but protruding beyond a vertical line drawn through toe, or maximum bulging of wall > 75 mm

Note: In using this table, engineering judgment is crucial since different wall types are likely to present different degrees of difficulty in deformation determination. The proposed deformation limits shown in this table shall not be regarded as absolute.

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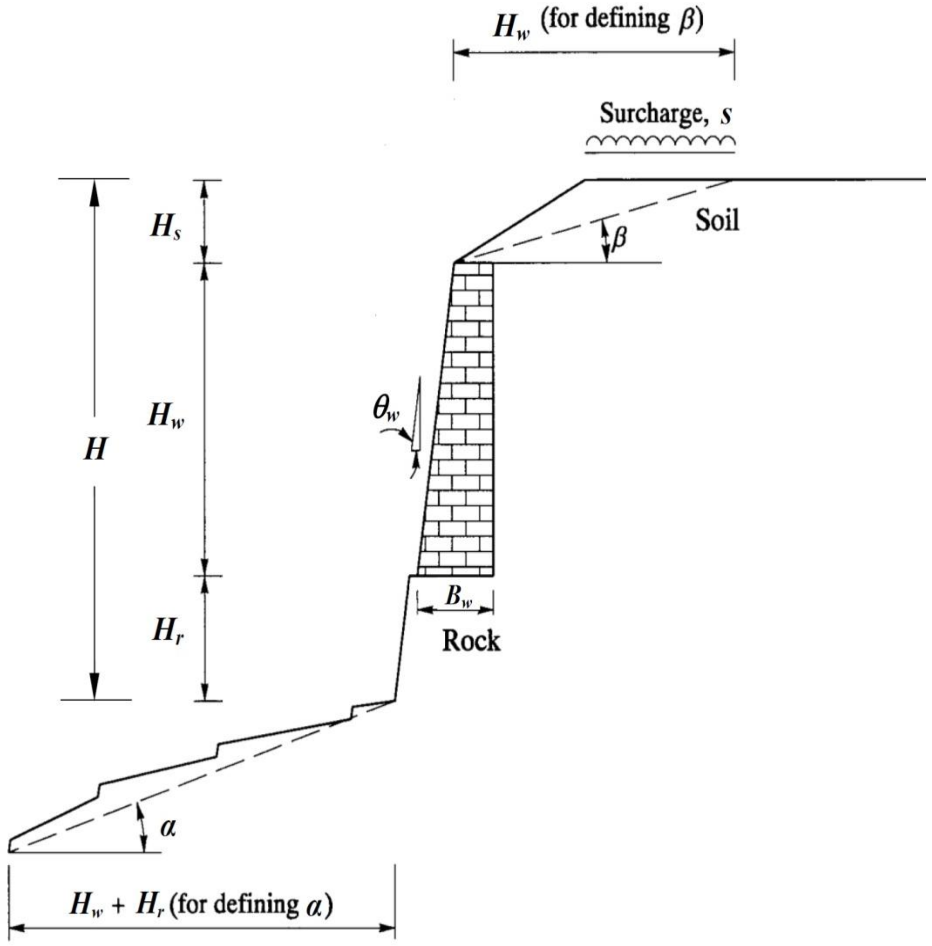
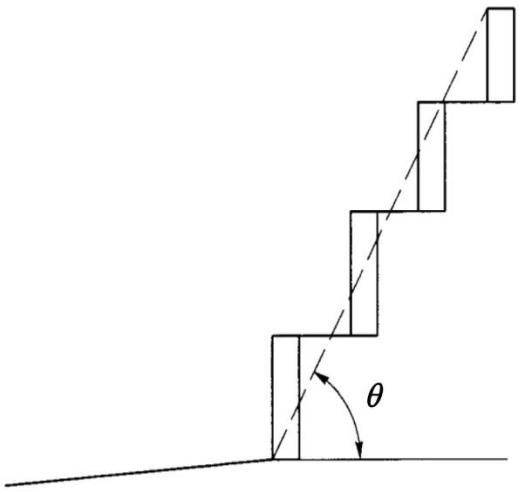


(a) Feature Geometry



(b) Multiple Walls

Figure D1 Geometry Classification for Retaining Walls

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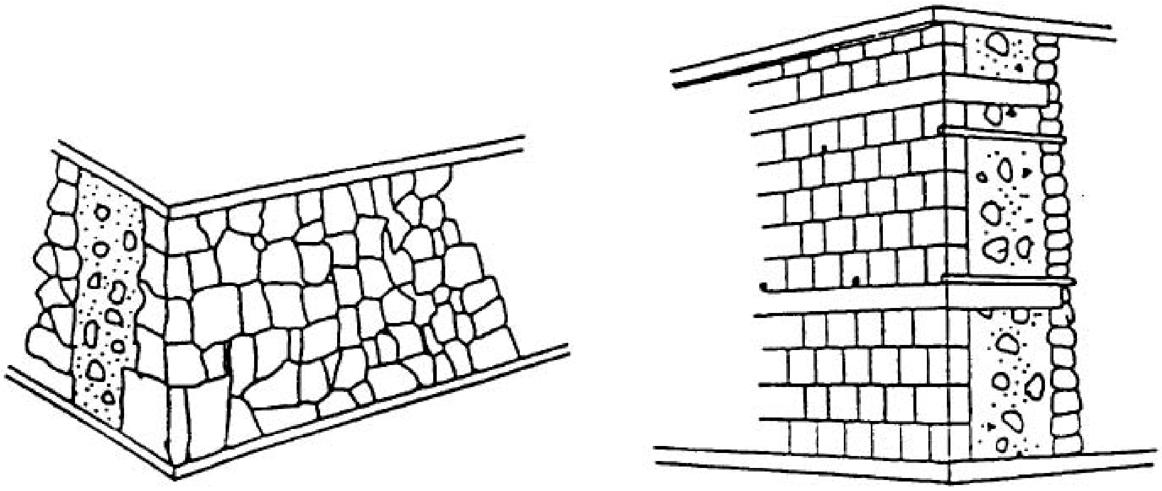
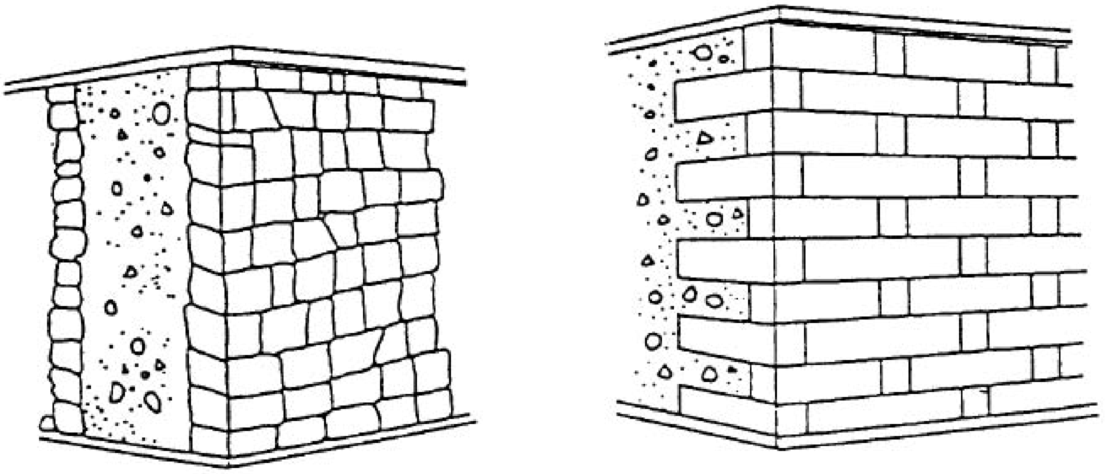


(a) Dry Packed Random Rubble Wall

(b) Dressed Block Wall
with Horizontal Beams



(c) Dry Packed Squared Rubble Wall

(d) Tied Face Wall

Figure D2 Typical Forms of Construction of Masonry Walls

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Dry Packed Random Rubble Wall
(11SW-A/R389)

Pointed Random Rubble Wall
(11SW-A/R116)

Dry Packed Squared Rubble Wall
(11SW-A/R109)

Dry Packed Squared Rubble Wall with Horizontal Beams (11SW-A/R163)

Pointed Squared Rubble Wall
(11SW-A/R295)

Pointed Squared Rubble Wall with Horizontal Beams (11SW-A/R194)

Figure D3 Common Types of Masonry Walls and Masonry Facings (Sheet 1 of 3)

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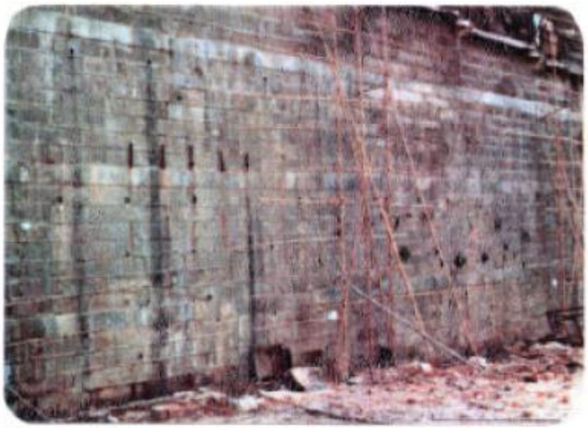
Dressed Block Wall
(11SW-A/R46)

Dressed Block Wall with Horizontal Beams
(11SW-A/R423)

Tied Face Wall
(11SW-A/R74)



Tied Face Wall with Horizontal Beams
(11SW-A/R45)

Random
Rubble
Wall with
Stone Ties

Recent
Masonry
Walls

Figure D3 Common Types of Masonry Walls and Masonry Facings (Sheet 2 of 3)

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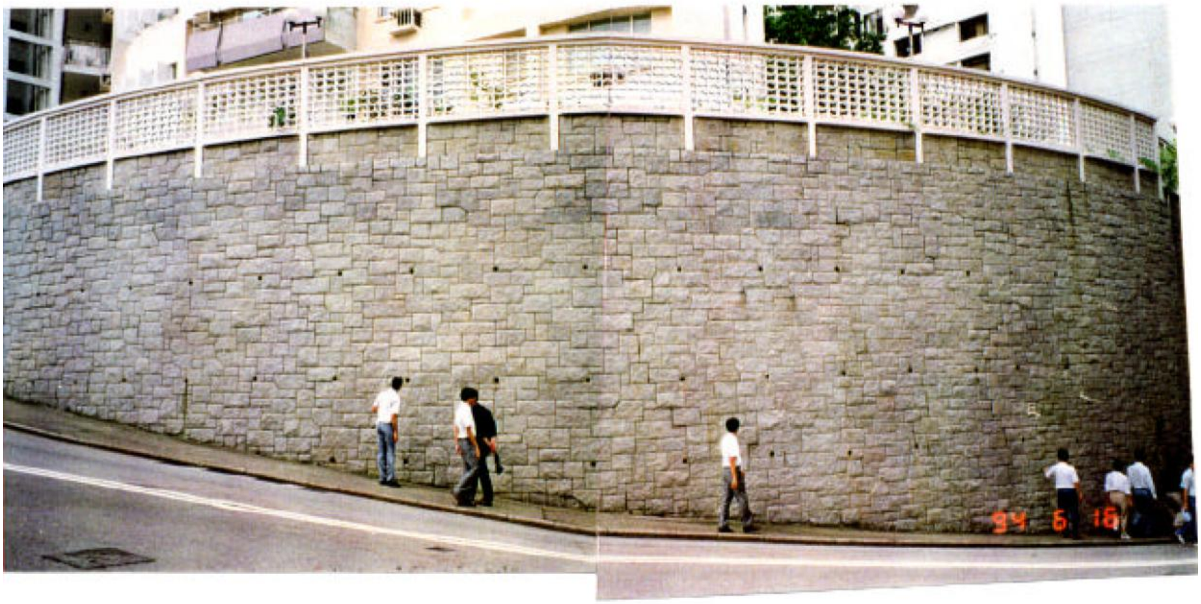
(a) Presence of expansion joints or similar construction joints



(b) Special architectural features, such as masonry blocks with irregular pattern

Figure D3 Common Types of Masonry Walls and Masonry Facings (Sheet 3 of 3)

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D.3 Sample Data Collection Sheets for Retaining Walls

FEATURE NO. (Page 1 of)

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\%$ x H_2. If yes, consider Section 1-1 only; If no, consider both Sections 1-1 and 2-2

Geometry (refer to Figure D1)

	Section 1-1	2-2
(i) Wall Height, H_w	m	m
(ii) Rock Slope Height, H_r	m	m
(iii) Soil Slope Height, H_s	m	m
(iv) Upslope Angle, β	°	°
(v) Wall Face Angle, θ_w	°	°
(vi) Surcharge at Crest of Wall, s	kPa	kPa
(vii) Base Width, B_w		
(viii) Average Wall Face Angle (in case of multiple walls), θ	°	°

	Section 1-1	2-2
(ix) Feature Height, H $H = H_s + H_r + H_w$		m
(x) Effective Height, H_e $H_e = H_w (1 + 0.35 \tan \beta) + \frac{s}{\gamma_b}$		m
where γ_b = soil bulk unit weight	$\frac{\text{kN}}{\text{m}^3}$	
(xi) H_e/B_w =		

Notes

If $\theta_w < 75^{\circ}$, the wall should be considered as a rigid surface protection to a slope. The feature should be treated as a soil cut slope in computation of the NPRS.

If $\theta \geq 60^{\circ}$, the walls should be considered as a single feature. Otherwise, individual wall should be registered separately if they are registrable.

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figures 2.3 & 2.4 of the main text ?

○ Yes ○ No

If yes, number of data collection sheets required for this section : ☐

Affected Facilities (refer to Figure 2.1 and Table 2.1 of the main text)

Section 1-1	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

Section 2-2	Facility Type	Facility Group	Proximity
Toe			L = m ω = °
Crest			D = m

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FEATURE NO. (Page 2 of)

PLAN AND CROSS-SECTION

SECTION : ○ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. thickening & skin walls)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures. (e.g. thickening & skin walls)

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FEATURE NO. (Page 3 of)

WALL CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Wall Type	○ Random rubble masonry wall ○ Brickwall ○ Wall composed of lime stabilized soil ○ Dry-packed dressed block or squared rubble wall ☐ with ties ☐ without ties ○ Masonry wall other than random rubble wall ☐ with horizontal beam(s) made of concrete ☐ with horizontal beams(s) made of lime-soil or brick ☐ without horizontal beam(s) ○ Concrete wall (with or without masonry facing) ○ Others: ____
Base Width, B_W	Base Width ________________ mm as determined from ○ Documentary records (Thickness Gauging/EI/MM/As-built drawings) ○ Weephole Probing (Provide field weephole probing record on Page 5) ○ Others : _______________________________________
Surface Protection	Surface cover with ○ Vegetation____________% (including grass/shrubs/trees) ○ Hard cover____________% (including concrete/chunam) ○ Bare surface___________% ○ Others_______________% 1. Based on the above, slope surface is ○ Substantially protected (> 75%) ○ Partially protected (25% - 75%) ○ Substantially unprotected (< 25%) 2. Zone(s) of depression or potential ponding exist within the crest area $H/2$ ○ Yes ○ No If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest					
Berm					
On Slope					
Toe					

- ○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
- ○ Feature located on a drainage line/zone of depression
- ○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.
- ○ Other observations/records :__________________________________

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<table>
<tr><td>FEATURE NO.</td><td>(Page 4 of)</td></tr>
<tr><th>WALL CHARACTERISTICS</th><th>SITE OBSERVATIONS/FINDINGS</th></tr>
<tr><td>Signs of Seepage</td><td>Signs of Seepage? ○ Yes ○ No
If Yes, provide the following details
<table>
<tr><th rowspan="2">Seepage Location</th><th colspan="3">Condition of seepage</th></tr>
<tr><th>Copious</th><th>Trickling/damp</th><th>Stain</th></tr>
<tr><td>At or above mid-height</td><td></td><td></td><td></td></tr>
<tr><td>Below mid-height</td><td></td><td></td><td></td></tr>
</table>
○ Others: ____
Indicate seepage location on plan and sections</td></tr>
<tr><td>Water-carrying Services</td><td>Indication of presence of underground water-carrying services above or behind the wall:
○ Valve(s) of water main within crest area/on the wall
○ Manhole cover(s) within crest area/on the wall
○ Others: ____
Signs of leakage?
○ Yes ○ No
If Yes, indicate location and condition of leakage
____</td></tr>
<tr><td>Signs of Distress

(Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)</td><td>○ No indication of any signs of distress
○ Reported signs of distress during inspection or in maintenance records
____
○ Observed signs of distress (please tick)
Deformation of the Wall
○ Long continuous crack at wall crest sub-parallel to wall;
Crack width _______ mm, equivalent to ______ % of wall height
○ Sub-vertical through crack in return wall
Crack width _______ mm measured at _____ m above toe
○ Bulging of wall face
Horizontal distance between the vertical line from the peak of bulged profile and the wall toe = _______ mm

Fabric condition of rubble/masonry wall
○ General intact without signs of distress
○ Localised mortar/pointing missing
○ Missing mortar/pointing at several locations
○ Minor dislocation of isolated blocks
○ Some blocks missing or dislocated

1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately.
2. Judgment should be made in assessing whether apparent signs of distress (such as cracking) are induced during wall construction or due to inadequate maintenance. In the latter circumstances, they should not be regarded as signs of distress.</td></tr>
</table>

FEATURE NO.	(Page 5 of)

WALL CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**
Instability after Wall Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	o No indication of any failure occurred after formation or treatment o Reported failure ____ o Possible failure scar observed at ______________ of the wall Estimated failure volume = __________________ m^3 o Debris observed on site/Other observations: ____

OTHER OBSERVATIONS/REMARKS

INSPECTION DATE: / / (dd/mm/yyyy) BY:

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FEATURE NO. (Page 6 of)

PHOTOGRAPHIC RECORDS

[Caption]

PHOTOGRAPHIC RECORDS

[Caption]

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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D.4 Worked Example (Data Collection Sheets)

FEATURE NO. **"Worked Example 4"** (Page 1 of 7)

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\%$ x H_2. If yes, consider Section 1-1 only; If no, consider both Sections 1-1 and 2-2

Geometry (refer to Figure D1)

	Section 1-1	2-2
(i) Wall Height, H_w	**8.3 m**	— m
(ii) Rock Slope Height, H_r	— m	— m
(iii) Soil Slope Height, H_s	— m	— m
(iv) Upslope Angle, β	**0** °	— °
(v) Wall Face Angle, θ_w	**85** °	— °
(vi) Surcharge at Crest of Wall, s	**10 kPa**	— kPa
(vii) Base Width, B_w	**1.0 m**	—
(viii) Average Wall Face Angle (in case of multiple walls), θ	— °	— °

	Section 1-1	2-2
(ix) Feature Height, H $H = H_s + H_r + H_w$	**8.3 m**	— m
(x) Effective Height, H_e $H_e = H_w (1 + 0.35 \tan \beta) + \frac{s}{\gamma_b}$	**8.8 m**	— m
where γ_b = soil bulk unit weight	**20 $\frac{\text{kN}}{\text{m}^3}$**	
(xi) H_e/B_w =	**8.8**	—

since $H_e/B_w > 5$, accord $B1 = 10$

Notes

If $\theta_w < 75°$, the wall should be considered as a rigid surface protection to a slope. The feature should be treated as a soil cut slope in computation of the NPRS.

If $\theta \geq 60°$, the walls should be considered as a single feature. Otherwise, individual wall should be registered separately if they are registrable.

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figures 2.3 & 2.4 of the main text?

○ Yes ☑ No

If yes, number of data collection sheets required for this section : ☐

Affected Facilities (refer to Figure 2.1 and Table 2.1 of the main text)

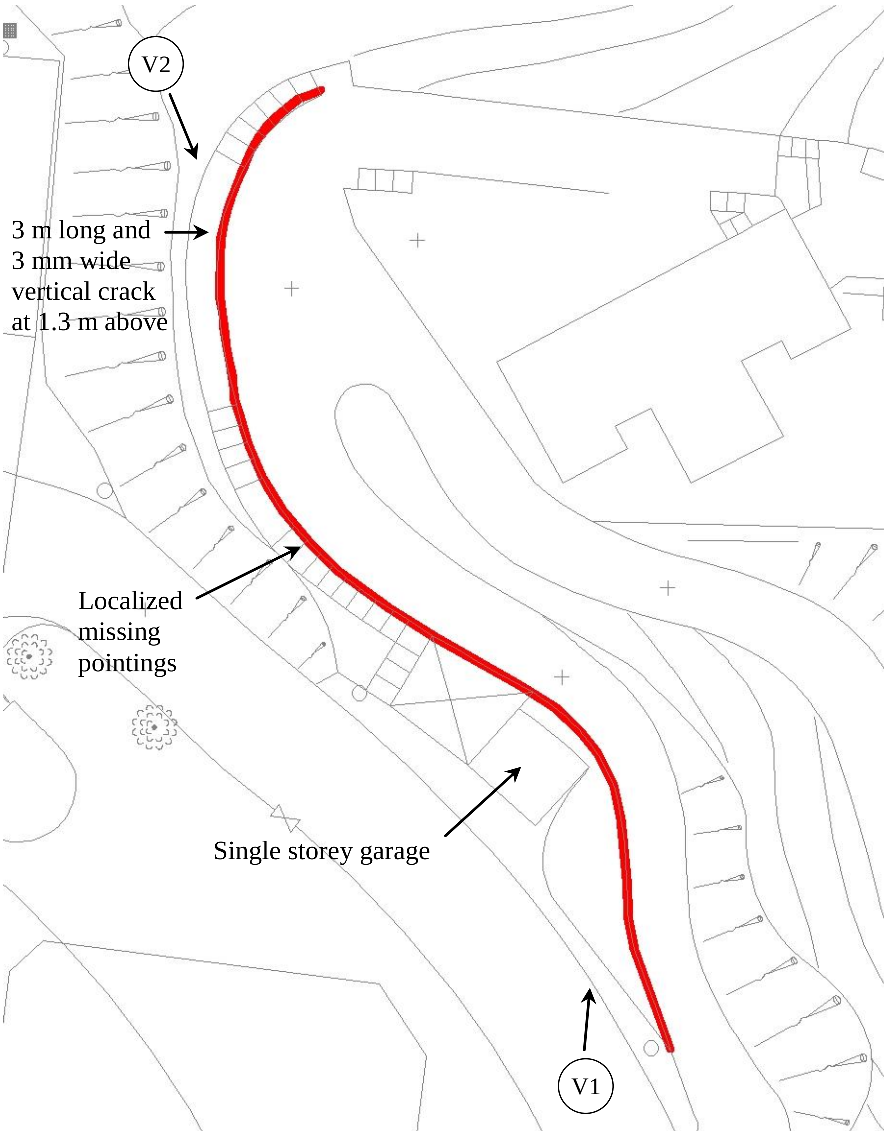
Section 1 - 1	Facility Type	Facility Group	Proximity
Toe	**Cottage, licensed and squatter area**	**1(b)**	L = **0 m** ω = **85** °
Crest	**Road with low traffic density**	**4**	D = **0** m

Section 2 - 2	Facility Type	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

FEATURE NO. **"Worked Example 4"** (Page 2 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



PLAN
(Not to scale)

Notes:
PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. thickening & skin walls)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures. (e.g. thickening & skin walls)

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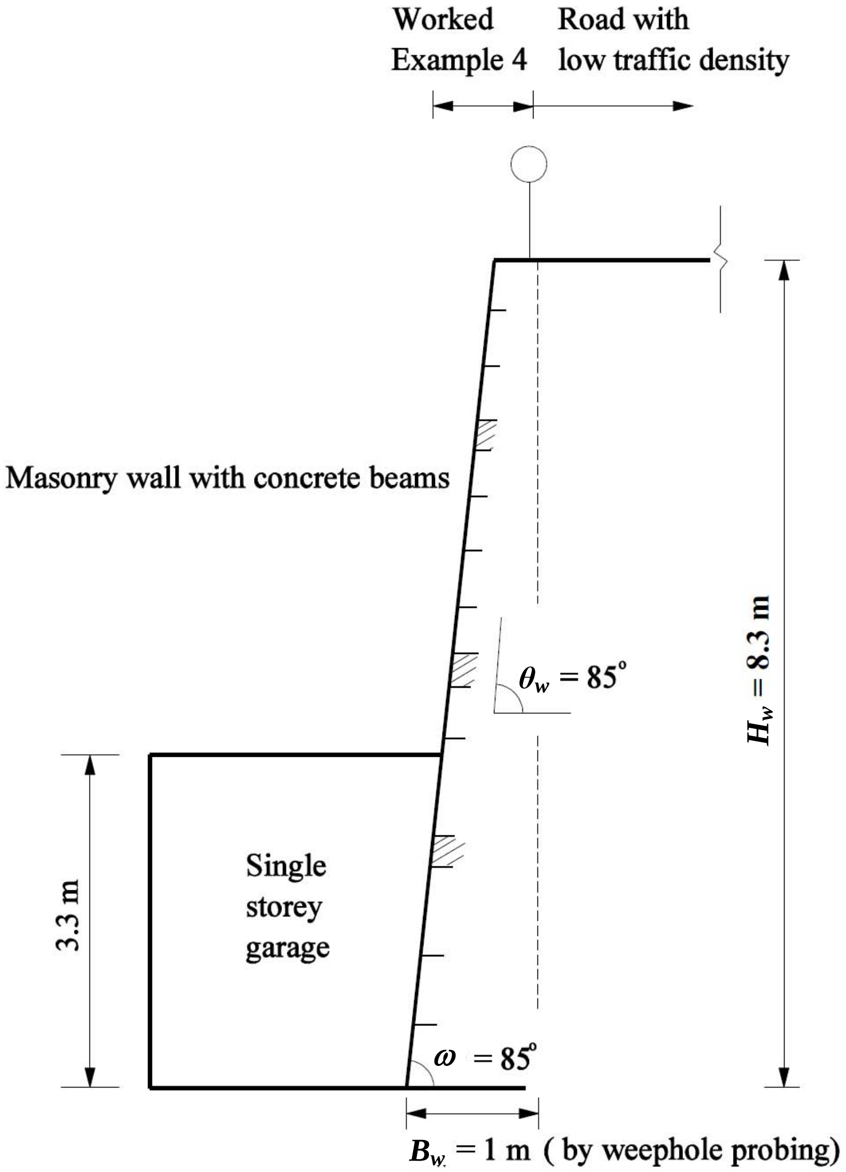
FEATURE NO. **"Worked Example 4"** (Page 3 of 7)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note: No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. thickening & skin walls)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures. (e.g. thickening & skin walls)

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FEATURE NO. **"Worked Example 4"** (Page 4 of 7)

WALL CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**
Wall Type	○ Random rubble masonry wall ○ Brickwall ○ Wall composed of lime stabilized soil ○ Dry-packed dressed block or squared rubble wall ☐ with ties ☐ without ties ✓ Masonry wall other than random rubble wall ☑ with horizontal beam(s) made of concrete ☐ with horizontal beams(s) made of lime-soil or brick ☐ without horizontal beam(s) ○ Concrete wall (with or without masonry facing) ○ Others: ____
Base Width, B_w	Base Width ______**1000**______ mm as determined from ○ Documentary records (Thickness Gauging/EI/MM/As-built drawings) ✓ Weephole Probing (Provide field weephole probing record on Page 6) ○ Others : ____
Surface Protection	Surface cover with ○ Vegetation_____________% (including grass/shrubs/trees) ✓ Hard cover______**100**_____% (including concrete/chunam) ○ Bare surface___________% ○ Others________________% 1. Based on the above, slope surface is ✓ Substantially protected (> 75%) ○ Partially protected (25% - 75%) ○ Substantially unprotected (< 25%) 2. Zone(s) of depression or potential ponding exist within the crest area H/2 ○ Yes ✓ No If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection
Surface Drainage Provision	(see below)

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest					
Berm					
On Slope					
Toe					

- ○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
- ○ Feature located on a drainage line/zone of depression
- ○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.
- ✓ Other observations/records : **No surface drainage system observed**

<table>
<tr><td colspan="2">**FEATURE NO.** **"Worked Example 4"** (Page 5 of 7)</td></tr>
<tr><th>WALL CHARACTERISTICS</th><th>SITE OBSERVATIONS/FINDINGS</th></tr>
<tr><td>Signs of Seepage</td><td>
Signs of Seepage? ○ Yes ✓ No
If Yes, provide the following details
<table>
<tr><th rowspan="2">Seepage Location</th><th colspan="3">Condition of seepage</th></tr>
<tr><th>Copious</th><th>Trickling/damp</th><th>Stain</th></tr>
<tr><td>At or above mid-height</td><td></td><td></td><td></td></tr>
<tr><td>Below mid-height</td><td></td><td></td><td></td></tr>
</table>
○ Others: ____
Indicate seepage location on plan and sections
</td></tr>
<tr><td>Water-carrying Services</td><td>
Indication of presence of underground water-carrying services above or behind the wall:
○ Valve(s) of water main within crest area/on the wall
✓ Manhole cover(s) within crest area/on the wall
○ Others: ____
Signs of leakage?
○ Yes ✓ No
If Yes, indicate location and condition of leakage
____
</td></tr>
<tr><td>Signs of Distress

(Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)</td><td>
○ No indication of any signs of distress
○ Reported signs of distress during inspection or in maintenance records
____
✓ Observed signs of distress (please tick)
Deformation of the Wall
○ Long continuous crack at wall crest sub-parallel to wall;
Crack width _______ mm, equivalent to ______ % of wall height
✓ Sub-vertical through crack in return wall
Crack width **3** mm measured at **0.5** m above toe
○ Bulging of wall face
Horizontal distance between the vertical line from the peak of bulged profile and the wall toe = _______ mm

Fabric condition of rubble/masonry wall
○ General intact without signs of distress
○ Localised mortar/pointing missing
✓ Missing mortar/pointing at several locations
○ Minor dislocation of isolated blocks
○ Some blocks missing or dislocated

1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately.
2. Judgment should be made in assessing whether apparent signs of distress (such as cracking) are induced during wall construction or due to inadequate maintenance. In the latter circumstances, they should not be regarded as signs of distress.
</td></tr>
</table>

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FEATURE NO. **"Worked Example 4"** (Page 6 of 7)

WALL CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Instability after Wall Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	✓ No indication of any failure occurred after formation or treatment ○ Reported failure ______________________________ ○ Possible failure scar observed at __________ of the wall Estimated failure volume = __________ m^3 ○ Debris observed on site/Other observations: ______________________________

OTHER OBSERVATIONS/REMARKS

1. **According to SIFT Report, this retaining wall was formed pre-1978.**

2. **The base width of the wall, B_w = 1 m was estimated by weephole probing on site. Three weepholes were probed (Length = 0.9 m, 0.95 m, and 1.1 m) and the wall face angle was considered in the estimation of the base width.**

INSPECTION DATE: **24 / 01 / 2009** (dd/mm/yyyy) BY: **PAJ**

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FEATURE NO. **"Worked Example 4"** (Page 7 of 7)

PHOTOGRAPHIC RECORDS

V1 General View of the Retaining Wall

PHOTOGRAPHIC RECORDS

V2 Crack and Missing Pointings

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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D.5 Worked Example (*TS* Computation Sheets)

FEATURE NO. **"Worked Example 4"**	**SECTION :** ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

		A1
(i)	Features with none or little geotechnical engineering input	10
(ii)	Features with indication of some geotechnical engineering input	3
(iii)	Features with indication of substantial geotechnical engineering input	1

For retaining walls excluded from ranking (see Note 7), denote $A1 = 0$

A1 $\boxed{\mathbf{10}}$

(A2) Geometry (refer to Figure D1)

		Section 1-1	2-2
(i)	Wall Height, H_w	**8.3 m**	— m
(ii)	Rock Slope Height, H_r	**0 m**	— m
(iii)	Soil Slope Height, H_s	**0 m**	— m
(iv)	Upslope Angle, β	**0 °**	— °
(v)	Wall Face Angle, θ_w	**85 °**	— °
(vi)	Surcharge at crest of wall, *s*	**10 kPa**	— kPa
(vii)	Base width, B_w	**1 m**	— m
(viii)	Average Wall Face Angle (in case of multiple walls), θ	— °	— °

(ix) Feature Height, *H*

$H = H_s + H_r + H_w$ $\boxed{\mathbf{8.3\ m}}$

(x) Effective Height, H_e

$$H_e = H_w\,(1 + 0.35 \tan \beta) + \frac{s}{\gamma_b} \quad \boxed{\mathbf{8.8\ m}}$$

where γ_b = soil bulk unit weight $\boxed{\mathbf{20\ \frac{kN}{m^3}}}$

(xi) $H_e/B_w =$ $\boxed{\mathbf{8.8}}$

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Classification	*A2*
(i) $H_e/B_w > 4.2$	8
(ii) $3.5 < H_e/B_w \leq 4.2$	6
(iii) $2.8 < H_e/B_w \leq 3.5$	4
(iv) $2.0 < H_e/B_w \leq 2.8$	2
(v) $H_e/B_w \leq 2.0$	1

A2 **8**

(A3) Wall Type (refer to Figure D2)

Type of Wall	*A3*
• Random rubble masonry wall (with or without pointing, ties or horizontal beams)	8
• Wall composed of lime-stabilised soils • Brick Wall • Dry packed dressed block/squared rubble wall without ties • Any type of masonry wall (except for random rubble walls) with horizontal beams made of lime-stabilised soil or brick	5
• Dry packed dressed block/squared rubble wall with ties • Any type of masonry wall (except for random rubble walls) with concrete horizontal beams	3
• Masonry facing to concrete wall • Concrete wall	1

Other Wall Type ____

A3 **3**

(A4) Surface Protection and Surface Drainage

Surface Protection Surface Drainage	Crest area substantially unprotected	Crest area partially protected	Crest area substantially protected
Few or no channels above wall crest, and potential for convergent flow of surface water above crest	8	4	2
Few or no channels above wall crest	4	2	[✓ 1.5]
Adequate channels	2	1.5	1

A4 **1.5**

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(A5) Signs of Seepage and Leaky Water-Carrying Services

Water-carrying Services / Signs of Seepage	Presence of potentially leaky services & signs of leakage noted	Presence of potentially leaky services but no signs of leakage noted	No potentially leaky services
Seepage at mid-height or above	8	4	2
Seepage below mid-height	4	2	1.5
No signs of seepage	2	[✓ 1.5]	1

A5 **1.5**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

	B1
(i) Severe (Advanced stage of severe deformation and/or distress or onset of severe deformation and/or distress)	10
(ii) Moderate (Moderate deformation and/or distress)	4
(iii) Minor/None (Minimal deformation and distress)	1

For a wall of the slenderness ratio, $H_e/B_w \geq 5$ or a dry packed random rubble wall with $H_w > 5$ m, accord *B1* = 10

B1 **10**

(B2) Instability after Slope Formation/Treatment

	B2
(i) Major (full-height failure)	10
(ii) Multiple part-height or structural failures, or records of previous severe signs of distress	5
(iii) Part-height or structural failures, or records of previous moderate signs of distress	2
(iv) No failure nor records of previous signs of distress	1

B2 **1**

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

Road/footpath with low traffic density

(ii) Facility Group

4

(iii) Distance (*D*) from crest of feature to crest facility
(refer to Figure 2.1 of the main text)

0 m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

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		C1	**0.002**
(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)		*C2*	**0.0375**

(D) FACILITY AT TOE OF FEATURE			
(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text)	**Cottage, licensed and squatter area**	Facility Group	*D1*
		1 (a)	9
		1 (b)	3
(ii) Facility Group	**1(b)**	2 (a)	2
		2 (b)	1
		3	0.25
(iii) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text)	**85 °**	4	0.002
		5	0.0002
(iv) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text)	**0 m**	*D1*	**3**
(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)		*D2*	**0.15**

CALCULATED SCORES		
INSTABILITY SCORE (*IS*) $IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$	*IS*	**5400**
CONSEQUENCE SCORE (*CS*) $CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$	*CS*	**3.74**
TOTAL SCORE (*TS*) $TS = IS \text{ x } CS$	*TS*	**20172.4**

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Appendix E

Combined Ranking Methodology

Contents

E.1 Combined Ranking Methodology

The Ranking Score (*RS*) for a man-made slope feature is determined by assigning a proportion of the total risk to a slope feature of a particular type according to the ratio of the Total Score (*TS*) to the summation of *TS* (Σ*TS*) of that feature type. It is assumed that the *TS* of each feature type is linearly related to the relative risk. A constant of 10^5 is applied to the computation of *RS* to make its value larger for easy reference.

The equation is as follows:

$$RS = \frac{TS}{\Sigma TS} \times \begin{matrix} Proportion\ \ of\ \ Total\ \ Risk\ \ for \\ a\ \ Particular\ \ Feature\ \ Type \end{matrix} \times 10^5 \ldots\ldots\ldots\ldots\ldots \quad (E.1)$$

According to an updated assessment of landslide risk posed by man-made slope features (Cheng & Ko, 2008), the proportions of the total risk associated with soil cut slopes, rock cut slopes, fill slopes and retaining walls are 66%, 10%, 11% and 13% respectively.

A combined ranking involving about 16,600 soil cut slopes, 1,600 rock cut slopes, 6,400 fill slopes and 4,300 retaining walls has been carried out by the GEO. The *TS*, and hence Σ*TS* of the individual feature types, were determined on the basis of available data in 2008, using default values where necessary.

Based on the findings of the above mentioned risk assessment and combined ranking, the respective proportion of total risk and Σ*TS* for each feature type have been substituted in the equation above to give the following equations for the computation of *RS*:

For soil cut slope	$RS = 0.063 \times TS$ (individual slope feature)
For rock cut slope	$RS = 0.022 \times TS$ (individual slope feature)
For fill slope	$RS = 0.006 \times TS$ (individual slope feature)
For retaining wall	$RS = 0.027 \times TS$ (individual slope feature)

References

Cheng, P.F.K. & Ko, F.W.Y. (2008). *An Updated Assessment of Landslide Risk Posed by Man-made Slopes and Natural Hillsides in Hong Kong (SPR 7/2008).* Geotechnical Engineering Office, Hong Kong, 44 p.

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E.2 Worked Example (Data Collection Sheets - Soil Cut Portion)

FEATURE NO. **"Worked Example 5"** (Page 1 of 6)

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\%$ x H_2. If yes, consider Section 1-1 only; If No, consider both Sections 1-1 and 2-2

Geometry (refer to Figure A1)

	Section 1-1	2-2		Section 1-1	2-2
Soil Slope Height, H_s	**14 m**	— m	Feature Height, $H = H_s + H_r + H_{cw} + H_{tw}$	**17 m**	— m
Rock Slope Height, H_r	— m	— m	$H_w = H_{cw} + H_{tw}$	**3 m**	— m
Crest Wall Height, H_{cw}	— m	— m	$H_c = H_s + H_r$	**14 m**	— m
Toe Wall Height, H_{tw}	**3 m**	— m	$H_o = H_s + H_{cw}\ (+ Hr')^{\#}$	**14 m**	— m
Upslope Angle, β	— °	— °	$^{\#}$ H_o should include the portion of the underlying rock slope where a realistic slip surface can daylight (Hr')		
Surcharge above the Slope Crest, s	**10 kPa**	— kPa	H_r'	m	m
Soil Slope Angle, θ_s	**45 °**	— °	Effective Height, H_e $H_e = H_o\,(1 + 0.35 \tan\beta) + \dfrac{s}{\gamma_b}$	**14.5 m**	— m
Average Slope Angle, θ	**45 °**	— °			
Downslope Gradient, α	— °	— °	where γ_b = soil bulk unit weight		**20 $\frac{\text{kN}}{\text{m}^3}$**

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figure 2.3 of the main text?

☑ Yes ○ No If yes, number of data collection sheets required for this section : **2**

Affected Facilities (refer to Figure 2.1 and Table 2.1)

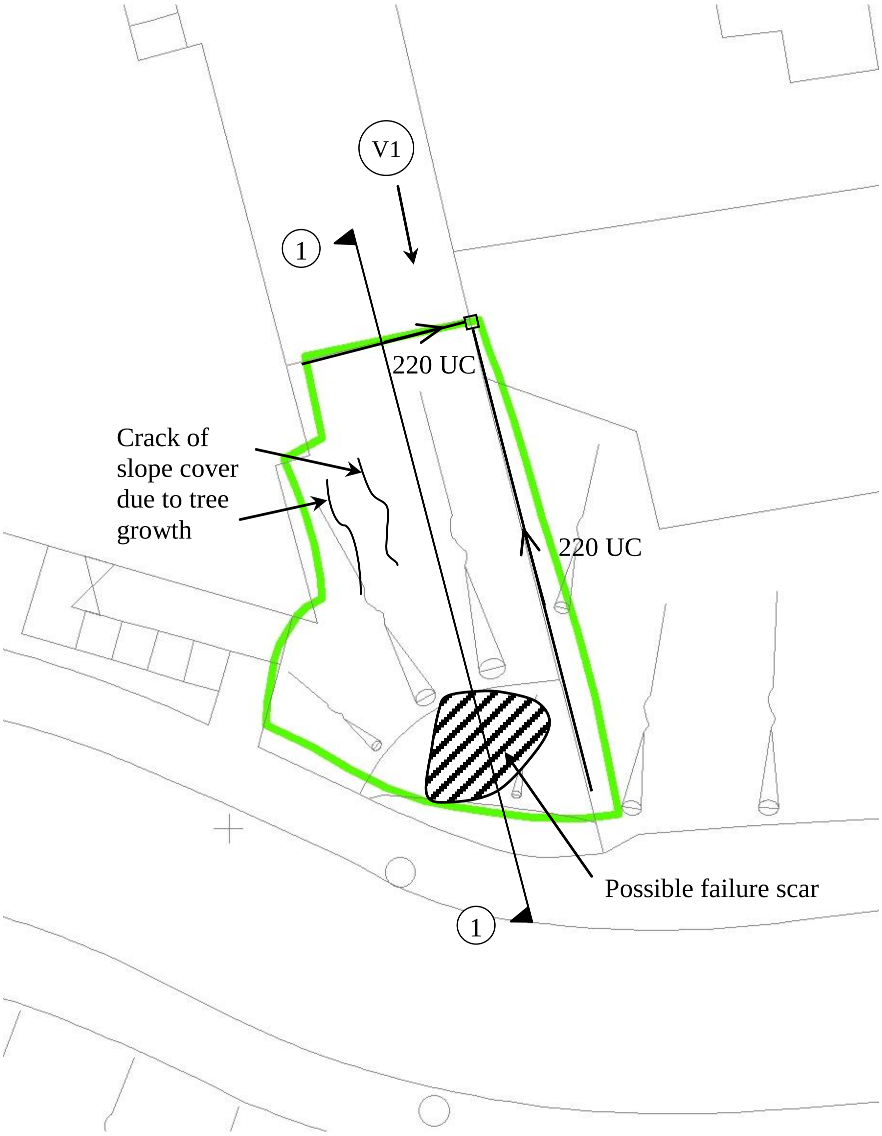
Section 1-1	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe	**Densely-used open area**	**3**	L = **0 m** ω = **49 °**
Crest	**Road with low traffic density**	**4**	D = **2** m

Section 2-2	Facility Type (for roads, please give name)	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

FEATURE NO. **"Worked Example 5"** (Page 2 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Plan
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and revised feature boundary (if applicable)
2. Section mark
3. Photograph location and direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. soil nails, shotcrete & buttress)

CROSS-SECTIONS
1. Fully dimensioned
2. Engineering measures (e.g. soil nails, shotcrete & buttress)

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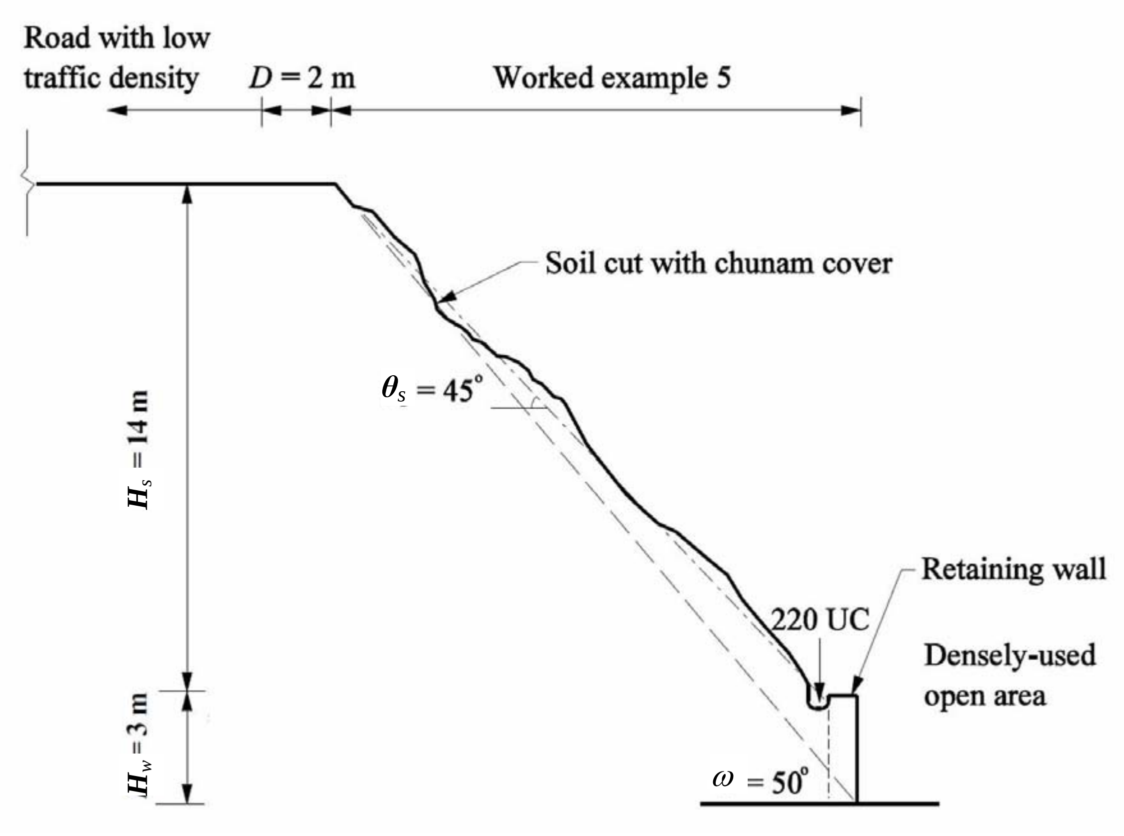
FEATURE NO. **"Worked Example 5"** (Page 3 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note: No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and revised feature boundary (if applicable)
2. Section mark
3. Photograph location and direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. soil nails, shotcrete & buttress)

CROSS-SECTIONS
1. Fully dimensioned
2. Engineering measures (e.g. soil nails, shotcrete & buttress)

FEATURE NO. **"Worked Example 5"** (Page 4 of 6)

SLOPE CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS

Slope Protection

Surface cover with
- ✓ Vegetation **5** % (including grass/shrubs/trees)
- ✓ Hard cover **95** % (including concrete/chunam)
- ○ Bare surface ____ %
- ○ Others ____ %

1. Based on the above, slope surface is
   - ✓ Substantially protected (> 75%)
   - ○ Partially protected (25% - 75%)
   - ○ Substantially unprotected (< 25%)
2. Zone(s) of depression or potential ponding exist within the crest area H/2

   ○ Yes ✓ No

   If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection

Surface Drainage Provision

Location	Size (mm)	Spacing (m)	Type (e.g. U-channel, step channel, downpipes or ditch)	Adequate Capacity (Y/N)	Remarks
Crest	—	—	—	—	—
Berm	—	—	—	—	—
On Slope	**220**	—	**Step-channel**	**Y**	**Lined**
Toe	**220**	—	**U-channel**	**Y**	**Lined**

- ○ Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
- ○ Slope located on a drainage line/zone of depression
- ○ Inadequate surface drainage evident by surface erosion or erosion gully, etc.
- ○ Others observations/records :____

Hydrogeological Settings

(Provide photographic records of signs of seepage and indicate location & extent on plan & cross-sections)

Signs of Seepage? ○ Yes ✓ No

If Yes, provide following details

Seepage Location	Condition of seepage		
	Copious	Trickling/damp	Stain
At or above mid-height			
Below mid-height			

- ○ Other observations/records: ____

Geological Features

(Provide photographic records of the site observations)

Presence of the following based on site observations & available records (please tick) :
- ○ No potential adverse geological features observed or recorded
- ✓ Possible relict failure (concave shaped profile)
- ○ Shear surfaces/zone
- ○ Clay or silt filled discontinuities
- ○ Slickensided discontinuities
- ○ Discontinuities heavily coated with dark minerals or kaolinite
- ○ Significantly kaolinised granite or volcanics
- ○ Weathered dykes / sedimentary layers within volcanic formations
- ○ Others: ____

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FEATURE NO. **"Worked Example 5"** (Page 5 of 6)

SLOPE CHARACTERISTICS	**SITE OBSERVATIONS/FINDINGS**

Signs of Distress
(Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)
	○ No indication of any signs of distress
	○ Reported signs of distress in inspection or maintenance records ________________________________
	✓ Observed signs of distress (please tick)
	  ○ Large tension cracks behind crest (approx. ________ mm wide)
	  ○ Significant distortion/damage of channels and berms
	  ○ Severe cracking and bulging of hard surfacing
	  ○ Subsidence inside crest area or on slope surface
	  ✓ Extensive cracking of slope cover
	  ✓ Isolated minor cracking of slope cover/Isolated cracking of channels
	  ○ Others: ________________________________
	1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately.
	2. Judgment should be made in assessing whether cracked slope cover, damaged channels etc. are due to inadequate maintenance, if so, they should not be regarded as signs of distress.

Instability after Slope Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	○ No indication of any failure occurred after formation or treatment ○ Reported failure ________________________________ ✓ Possible failure scar observed at ___**top**___ of the slope ○ Estimated failure volume = _________________ m^3 ○ Debris observed on site/Other observations: ________________________________

OTHER OBSERVATIONS/REMARKS

According to the SIFT Report, the feature was formed pre-1963.

INSPECTION DATE: **02 / 06 / 2009** (dd/mm/yyyy) BY: **PAJ**

FEATURE NO. **"Worked Example 5"** (Page 6 of 6)

PHOTOGRAPHIC RECORDS

V1 General View of the Feature Comprising Soil Cut Slope and Retaining Wall

Notes:
(1) Indicate photograph vantage points on plan
(2) Add more pages for additional photographic records/sketches

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E.3 Worked Example (Data Collection Sheets - Retaining Wall Portion)

FEATURE NO. **"Worked Example 5"** (Page 1 of 6)

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)

Check if $H_1 \geq 75\%$ x H_2. If yes, consider Section 1-1 only; If no, consider both Sections 1-1 and 2-2

Geometry (refer to Figure D1)

	Section 1-1	2-2
(i) Wall Height, H_w	**3 m**	— m
(ii) Rock Slope Height, H_r	— m	— m
(iii) Soil Slope Height, H_s	**14 m**	— m
(iv) Upslope Angle, β	**45** °	— °
(v) Wall Face Angle, θ_w	**90** °	— °
(vi) Surcharge at Crest of Wall, s	**10 kPa**	— kPa
(vii) Base Width, B_w	**Unknown**	—
(viii) Average Wall Face Angle (in case of multiple walls), θ	— °	— °

	Section 1-1	2-2
(ix) Feature Height, H $H = H_s + H_r + H_w$	**17 m**	— m
(x) Effective Height, H_e $H_e = H_w\,(1 + 0.35 \tan\beta) + \frac{s}{\gamma_b}$	**4.55 m**	— m
where γ_b = soil bulk unit weight	**20** $\mathbf{\frac{kN}{m^3}}$	
(xi) H_e/B_w =	**5 ***	—

*** Since B_w cannot be determined from documentary record or probing, accord H_e/B_w = 5**

Notes

If $\theta_w < 75^{\circ}$, the wall should be considered as a rigid surface protection to a slope. The feature should be treated as a soil cut slope in computation of the NPRS.

If $\theta \geq 60°$, the walls should be considered as a single feature. Otherwise, individual wall should be registered separately if they are registrable.

Do the dimensions of individual feature types satisfy the requirement of separate Total Score as shown in Figures 2.3 & 2.4 of the main text?

☑ Yes ○ No

If yes, number of data collection sheets required for this section : **2**

Affected Facilities (refer to Figure 2.1 and Table 2.1 of the main text)

Section 1 - 1	Facility Type	Facility Group	Proximity
Toe	**Densely-used open area**	**3**	L = **0 m** ω = **49** °
Crest	**Road with low traffic density**	**4**	D = **16** m

Section 2 - 2	Facility Type	Facility Group	Proximity
Toe	—	—	L = — m ω = — °
Crest	—	—	D = — m

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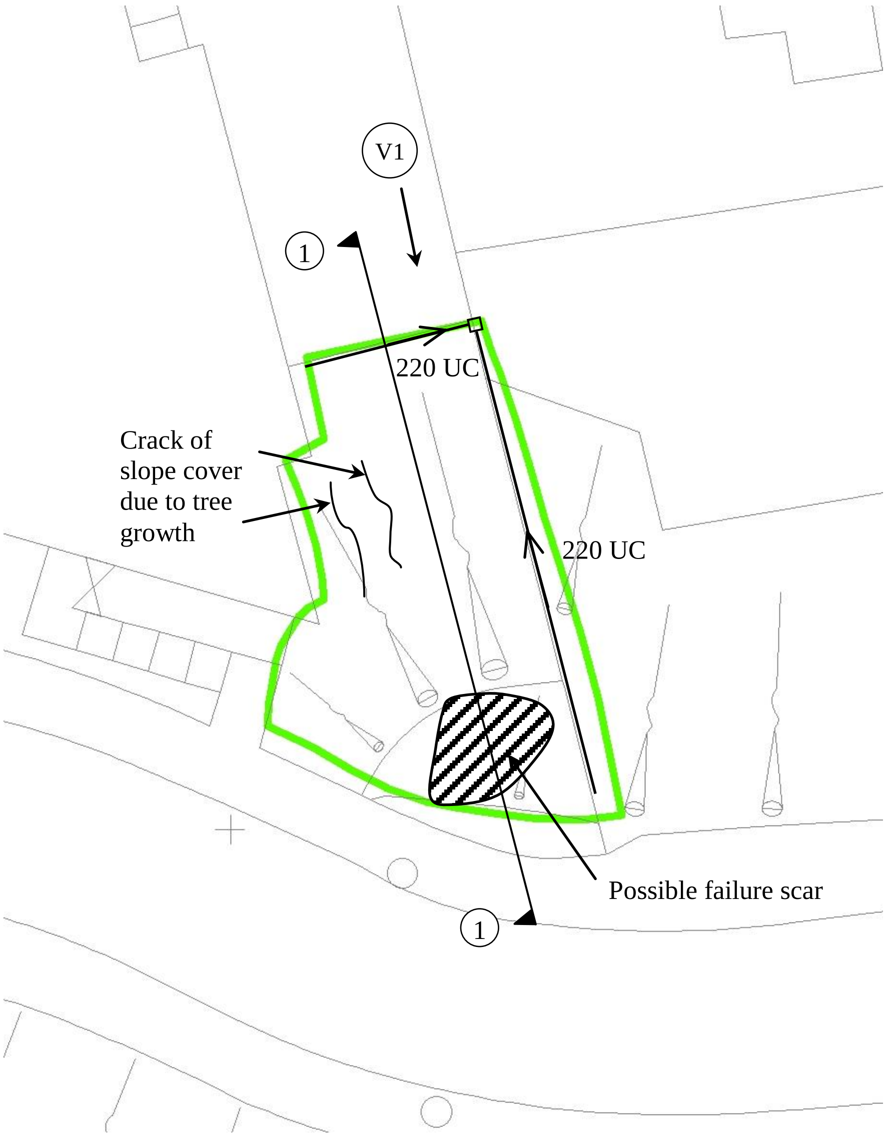
FEATURE NO. **"Worked Example 5"** (Page 2 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



PLAN
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. thickening & skin walls)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures. (e.g. thickening & skin walls)

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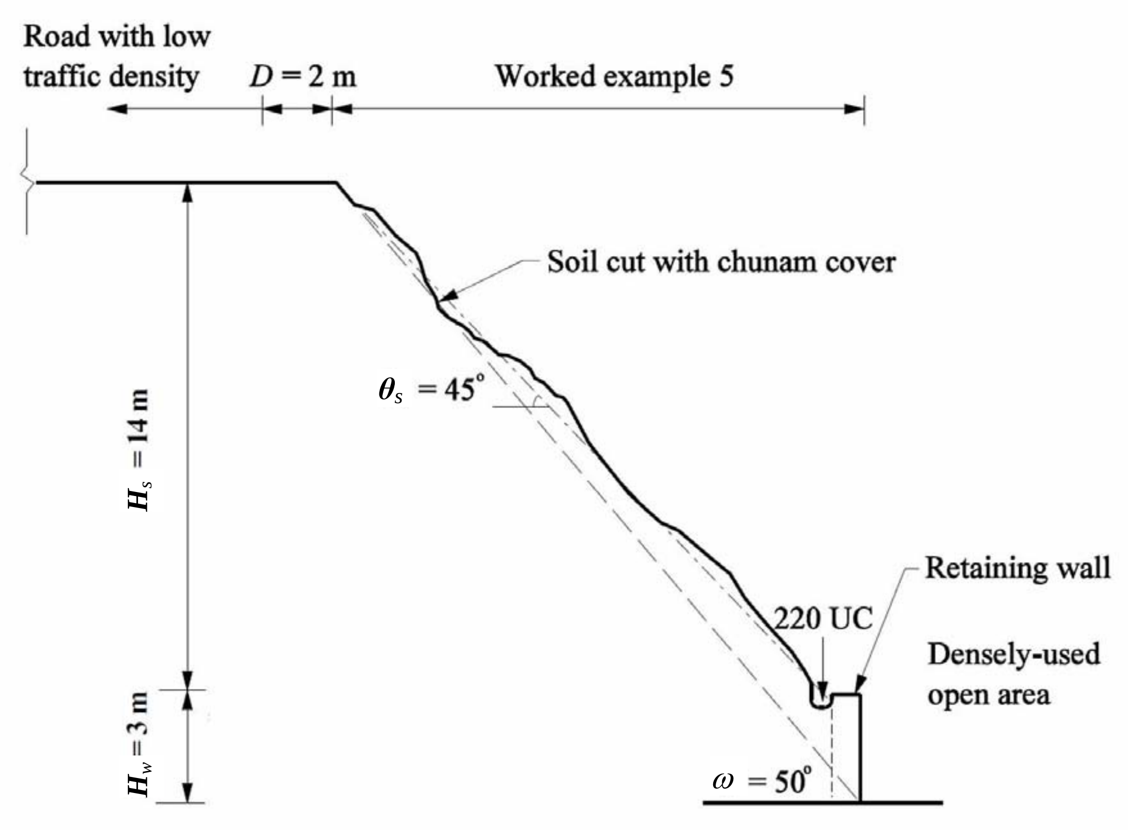
FEATURE NO. **"Worked Example 5"** (Page 3 of 6)

PLAN AND CROSS-SECTION

SECTION : ☑ 1-1 (Most Severe Consequence) ○ 2-2 (Maximum Feature Height)



Note: No reinforcement or structural support observed on site

Section 1-1
(Not to scale)

Notes:

PLAN (1:1000)
1. Feature boundary (SIS) and Revised Feature Boundary (if applicable)
2. Section Mark
3. Photo Location and Direction
4. Signs of distress, if any
5. Signs of seepage, if any
6. Engineering measures (e.g. thickening & skin walls)

CROSS-SECTIONS
1. Fully dimensioned
2. Existing engineering measures. (e.g. thickening & skin walls)

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FEATURE NO. **"Worked Example 5"** (Page 4 of 6)

<table>
<tr><th>WALL CHARACTERISTICS</th><th>SITE OBSERVATIONS/FINDINGS</th></tr>
<tr><td>Wall Type</td><td>o Random rubble masonry wall
o Brickwall
o Wall composed of lime stabilized soil
o Dry-packed dressed block or squared rubble wall
☐ with ties
☐ without ties
o Masonry wall other than random rubble wall
☐ with horizontal beam(s) made of concrete
☐ with horizontal beams(s) made of lime-soil or brick
☐ without horizontal beam(s)
✓ Concrete wall (~~with or~~ without masonry facing)
o Others: ____</td></tr>
<tr><td>Base Width, B_W</td><td>Base Width ___________________________ mm as determined from
○ Documentary records (Thickness Gauging/EI/MM/As-built drawings)
○ Weephole Probing (Provide field weephole probing record on Page 5)
✓ Others : cannot be determined from above, accord H_e/B_w = 5</td></tr>
<tr><td>Slope Protection</td><td>Surface cover with
o Vegetation____________% (including grass/shrubs/trees)
✓ Hard cover100% (including concrete/chunam)
o Bare surface___________%
o Others________________%
1. Based on the above, slope surface is
✓ Substantially protected (> 75%)
○ Partially protected (25% - 75%)
○ Substantially unprotected (< 25%)
2. Zone(s) of depression or potential ponding exist within the crest area $H/2$
o Yes ✓ No
If yes, mark the extent of depression or ponding zones on plan and adopt the score of the next higher category in slope protection</td></tr>
<tr><td>Surface Drainage Provision</td><td>
<table>
<tr><th>Location</th><th>Size (mm)</th><th>Spacing (m)</th><th>Type (e.g. U-channel, step channel, downpipes or ditch)</th><th>Adequate Capacity (Y/N)</th><th>Remarks</th></tr>
<tr><td>Crest</td><td>220</td><td></td><td>U-channel</td><td>Y</td><td></td></tr>
<tr><td>Berm</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>On Slope</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Toe</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
o Potential surface runoff converge onto the crest area due to topography (observed or inferred from topographic plan or aerial photos)
o Feature located on a drainage line/zone of depression
o Inadequate surface drainage evident by surface erosion or erosion gully, etc.
o Other observations/records : ______________________________________</td></tr>
</table>

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<table>
<tr><td colspan="2">FEATURE NO. "Worked Example 5" (Page 5 of 6)</td></tr>
<tr><th>WALL CHARACTERISTICS</th><th>SITE OBSERVATIONS/FINDINGS</th></tr>
<tr><td>Signs of Seepage</td><td>
Signs of Seepage? ○ Yes ✓ No
If Yes, provide following details
<table>
<tr><th rowspan="2">Seepage Location</th><th colspan="3">Condition of seepage</th></tr>
<tr><th>Copious</th><th>Trickling/damp</th><th>Stain</th></tr>
<tr><td>At or above mid-height</td><td></td><td></td><td></td></tr>
<tr><td>Below mid-height</td><td></td><td></td><td></td></tr>
</table>
○ Others: ____________________
Indicate seepage location on plan and sections
</td></tr>
<tr><td>Water-carrying Services</td><td>
Indication of presence of underground water-carrying services above or behind the wall:
○ Valve(s) of water main within crest area/on the wall
○ Manhole cover(s) within crest area/on the wall
○ Others: ____________________
Signs of leaking?
○ Yes ✓ No
If Yes, indicate location and condition of leakage
____
</td></tr>
<tr><td>Signs of Distress

(Provide photographic records of signs of distress and indicate location & extent on plan & cross-sections)</td><td>
○ No indication of any signs of distress
○ Reported signs of distress during inspection or in maintenance records
____
○ Observed signs of distress (please tick)
Deformation of the Wall
○ Long continuous crack at wall crest sub-parallel to wall;
Crack width _______ mm, equivalent to ______ % of wall height
○ Sub-vertical through crack in return wall
Crack width _______ mm measured at _____ m above toe
○ Bulging of wall face
Horizontal distance between the vertical line from the peak of bulged profile and the wall toe = _______ mm

Fabric condition of rubble/masonry wall
✓ General intact without signs of distress
○ Localised mortar/pointing missing
○ Missing mortar/pointing at several locations
○ Minor dislocation of isolated blocks
○ Some blocks missing or dislocated

1. Where severe signs of distress or hazardous movement is noted, appropriate follow-up action should be taken immediately.
2. Judgment should be made in assessing whether apparent signs of distress (such as cracking) are induced during wall construction or due to inadequate maintenance. In the latter circumstances, they should not be regarded as signs of distress.
</td></tr>
</table>

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FEATURE NO. **"Worked Example 5"** (Page 6 of 6)

WALL CHARACTERISTICS	SITE OBSERVATIONS/FINDINGS
Instability after Wall Formation/Treatment (Provide photographic records of the inferred failure scar and indicate location on plan & cross-sections)	✓ No indication of any failure occurred after formation or treatment o Reported failure ______________________________ o Possible failure scar observed at __________ of the wall Estimated failure volume = ____________ m^3 o Debris observed on site/Other observations: ______________________________

OTHER OBSERVATIONS/REMARKS

See the remarks on the data collection sheets for soil cut slope portion

INSPECTION DATE: **02 / 06 / 2009** (dd/mm/yyyy) BY: **PAJ**

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E.4 Worked Example (*TS* Computation Sheets - Soil Cut Portion)

FEATURE NO. **"Worked Example 5"**

SECTION :
☑ 1-1 (Most Severe Consequence)
○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Year of Formation/Treatment (*Y*)

		A1
(i)	$Y \leq 1980$	6
(ii)	$1980 < Y \leq 1990$	4
(iii)	$1990 < Y \leq 1995$	2
(iv)	$Y > 1995$	1

For soil cut slopes excluded from ranking (see Note 8), denote $A1 = 0$

A1 **6**

(A2) Level of Geotechnical Engineering Input

		A2
(i)	Slopes with none or little geotechnical engineering input	8
(ii)	Slopes with indication of some geotechnical engineering input	6
(iii)	Slopes with indication of substantial geotechnical engineering input	2
(iv)	Slopes checked and accepted by GEO	1

A2 **8**

(A3) Geometry (refer to Figure A1)

(i) Soil Slope Height, H_s **14 m**

(x) Feature Height, H $H = H_s + H_r + H_{cw} + H_{tw}$ **17 m**

(ii) Rock Slope Height, H_r **0 m**

(xi) $H_w = H_{cw} + H_{tw}$ **0 m**

(iii) Crest Wall Height, H_{cw} **0 m**

(xii) $H_c = H_s + H_r$ **0 m**

(iv) Toe Wall Height, H_{tw} **3 m**

(xiii) $H_o = H_s + H_{cw}$ $(+ H_r')^*$ (see Note 14) **14 m**

$^*H_r'$ = rock slope portion where a realistic slip surface daylights (see Note 14)

(v) Upslope Angle, β **0 °**

(xiv) Effective Height, H_e

$$H_e = H_o(1 + 0.35 \tan\beta) + \frac{s}{\gamma_b}$$

14.5 m

(vi) Surcharge above the Slope Crest, *s* **10 kPa**

(vii) Soil Slope Angle, θ_s **45 °**

(viii) Average Slope Angle, θ **45 °**

(ix) Downslope Gradient, α **0 °**

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Geometry Classification (refer to Figure A2)

		A3
(i)	*S1*	8
(ii)	*S2*	4
(iii)	*S3*	2
(iv)	*S4*	1

A3 **2**

(A4) Slope Protection and Surface Drainage

Slope Protection Surface Drainage	Soil slope or crest area substantially unprotected	Soil slope or crest area partially protected	Soil slope or crest area substantially protected
Few or no channels, and potential for convergent flow of surface water above crest or located on a drainage line or depression	8	4	2
Few or no channels	4	2	[✓ 1.5]
Adequate channels	2	1.5	1

A4 **1.5**

(A5) Site Characteristics

Adverse hydrogeological settings Adverse geological feature	Significant	Moderate	Minor/None
Significant	10	8	5
Moderate	8	3	2
Minor/None	5	2	[✓ 1]

A5 **1**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

		B1
(i)	Severe (signs of slope movement)	10
(ii)	Moderate (extensive minor defects)	4
(iii)	Minor/None (none or few isolated minor defects)	1

B1 **4**

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(B2) Instability after Slope Formation/Treatment

		B2
(i)	Massive failures (> 500 m^3)	10
(ii)	Major or repeated minor failures or records of previous severe signs of distress	5
(iii)	Minor failure or records of previous moderate signs of distress	2
(iv)	No failure or records of previous minor signs of distress	1

B2 **2**

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text) — **Road with low traffic density**

(ii) Facility Group — **4**

(iii) Distance (*D*) from crest of feature to crest facility (refer to Figure 2.1 of the main text) — **2.5 m**

(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

C1 **0.002**

C2 **0.4**

(D) FACILITY AT TOE OF FEATURE

(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text) — **Densely-used open area**

(ii) Facility Group — **3**

(iii) Distance (*L*) from toe of feature to toe facility (refer to Figure 2.1 of the main text) — **0 m**

(iv) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text) — **49 °**

(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)

Facility Group	*D1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

D1 **0.25**

D2 **0.92**

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CALCULATED SCORES		
<u>INSTABILITY SCORE (*IS*)</u> $IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$	IS	**1152**
<u>CONSEQUENCE SCORE (*CS*)</u> $CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$	CS	**3.9236**
<u>TOTAL SCORE (*TS*)</u> $TS = IS \text{ x } CS$	TS	**4520.0**

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E.5 Worked Example (*TS* Computation Sheets - Retaining Wall Portion)

FEATURE NO. **"Worked Example 5"**

SECTION :
☑ 1-1 (Most Severe Consequence)
○ 2-2 (Maximum Feature Height)

(A) INSTABILITY POTENTIAL (*IP*)

(A1) Level of Geotechnical Engineering Input

		A1
(i)	Features with none or little geotechnical engineering input	10
(ii)	Features with indication of some geotechnical engineering input	3
(iii)	Features with indication of substantial geotechnical engineering input	1

For retaining walls excluded from ranking (see Note 7), denote *A1* = 0

A1 **10**

(A2) Geometry (refer to Figure D1)

		Section 1-1	2-2
(i)	Wall Height, H_w	**3 m**	— m
(ii)	Rock Slope Height, H_r	**0 m**	— m
(iii)	Soil Slope Height, H_s	**14 m**	— m
(iv)	Upslope Angle, β	**45 °**	— °
(v)	Wall Face Angle, θ_w	**90 °**	— °
(vi)	Surcharge at crest of wall, *s*	**10 kPa**	— kPa
(vii)	Base width, B_w	— m	— m
(viii)	Average Wall Face Angle (in case of multiple walls), θ	— °	— °

(ix) Feature Height, *H*
$H = H_s + H_r + H_w$ **17 m**

(x) Effective Height, H_e
$H_e = H_w\,(1 + 0.35 \tan \beta) + \dfrac{s}{\gamma_b}$ **4.5 m**

where γ_b = soil bulk unit weight **20 $\mathbf{\dfrac{kN}{m^3}}$**

(xi) H_e/B_w = **5**

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Classification	A2
(i) $H_e/B_w > 4.2$	8
(ii) $3.5 < H_e/B_w \leq 4.2$	6
(iii) $2.8 < H_e/B_w \leq 3.5$	4
(iv) $2.0 < H_e/B_w \leq 2.8$	2
(v) $H_e/B_w \leq 2.0$	1

A2 **8**

(A3) Wall Type (refer to Figure D2)

Type of Wall	*A3*
• Random rubble masonry wall (with or without pointing, ties or horizontal beams)	8
• Wall composed of lime-stabilised soils • Brick Wall • Dry packed dressed block/squared rubble wall without ties • Any type of masonry wall (except for random rubble walls) with horizontal beams made of lime-stabilised soil or brick	5
• Dry packed dressed block/squared rubble wall with ties • Any type of masonry wall (except for random rubble walls) with concrete horizontal beams	3
• Masonry facing to concrete wall • Concrete wall	1

Other Wall Type ____

A3 **1**

(A4) Surface Protection and Surface Drainage

Surface Protection Surface Drainage	Crest area substantially unprotected	Crest area partially protected	Crest area substantially protected
Few or no channels above wall crest, and potential for convergent flow of surface water above crest	8	4	2
Few or no channels above wall crest	4	2	[✓ 1.5]
Adequate channels	2	1.5	1

A4 **1.5**

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(A5) Signs of Seepage and Leaky Water-Carrying Services

Water-carrying Services / Signs of Seepage	Presence of potentially leaky services & signs of leakage noted	Presence of potentially leaky services but no signs of leakage noted	No potentially leaky services
Seepage at mid-height or above	8	4	2
Seepage below mid-height	4	2	1.5
No signs of seepage	2	1.5	[✓ 1]

A5 **1**

(B) ACTUAL PERFORMANCE (*AP*)

(B1) Signs of Distress

		B1
(i)	Severe (Advanced stage of severe deformation and/or distress or onset of severe deformation and/or distress)	10
(ii)	Moderate (Moderate deformation and/or distress)	4
(iii)	Minor/None (Minimal deformation and distress)	1

For a wall of the slenderness ratio, $H_e/B_w \geq 5$ or a dry packed random rubble wall with $H_w > 5$ m, accord *B1* = 10

B1 **10**

(B2) Instability after Slope Formation/Treatment

		B2
(i)	Major (full-height failure)	10
(ii)	Multiple part-height or structural failures, or records of previous severe signs of distress	5
(iii)	Part-height or structural failures, or records of previous moderate signs of distress	2
(iv)	No failure nor records of previous signs of distress	1

B2 **1**

(C) FACILITIES ABOVE CREST OF FEATURE

(i) Type of crest facility
(for roads and footpaths, give also the name)
(refer to Table 2.1 of the main text)

Road/footpath with low traffic density

(ii) Facility Group

4

(iii) Distance (*D*) from crest of feature to the crest facility
(refer to Figure 2.1 of the main text)

16 m

Facility Group	*C1*
1 (a)	9
1 (b)	3
2 (a)	2
2 (b)	1
3	0.25
4	0.002
5	0.0002

		C1	**0.002**
(iv) Vulnerability Factor, *C2* (refer to Table 3.1 of the main text)		*C2*	**0**

(D) FACILITY AT TOE OF FEATURE			
(i) Type of toe facility (for roads and footpaths, give also the name) (refer to Table 2.1 of the main text)	**Densely-used open area**	Facility Group	*D1*
		1 (a)	9
		1 (b)	3
(ii) Facility Group	**3**	2 (a)	2
		2 (b)	1
		3	0.25
(iii) Shadow angle (ω) from crest of feature to toe facility (refer to Figure 2.1 of the main text)	**49 °**	4	0.002
		5	0.0002
(iv) Distance (L) from toe of feature to toe facility (refer to Figure 2.1 of the main text)	**0 m**	*D1*	**0.25**
(v) Vulnerability Factor, *D2* (refer to Table 3.2 of the main text)		*D2*	**0.92**

CALCULATED SCORES		
INSTABILITY SCORE (*IS*) $IS = A1 \times A2 \times A3 \times A4 \times A5 \times B1 \times B2$	*IS*	**1200**
CONSEQUENCE SCORE (*CS*) $CS = [C1 \text{ x } C2 + D1 \text{ x } D2] \text{ x } H$	*CS*	**3.91**
TOTAL SCORE (*TS*) $TS = IS \text{ x } CS$	*TS*	**4692.0**

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E.6 Worked Example (*RS* Computation)

"WORKED EXAMPLE 5"

(A) Soil Cut Portion

$TS = 4520.0$

According to the equation in Appendix E.1

$RS = 0.063 \text{ x } TS$

$= 284.8$

(B) Retaining Wall Portion

$TS = 4692.0$

According to the equation in Appendix E.1

$RS = 0.027 \text{ x } TS$

$= 126.7$

(C) Combined *RS*

RS (soil cut) + *RS* (retaining wall) = 284.8 + 126.7

= 411.5

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Appendix F

Examples of Severe Signs of Distress

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Example F1 Displaced Surface Channel

Example F2 Cracking of Berm

Example F3 Displaced U-channel

Example F4 Cracking and Bulging of Hard Cover

Example F5 Displaced Pipeline

Example F6 Displaced Surface Channel

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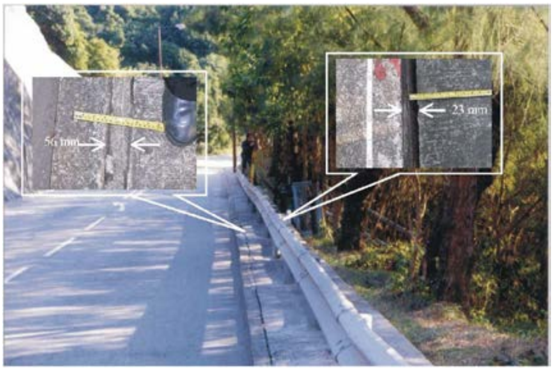
Example F7 Deformed Railings

Example F8 Detached Surface Channel



Example F9 Cracking at Slope Crest

Example F10 Sheared Concrete Steps

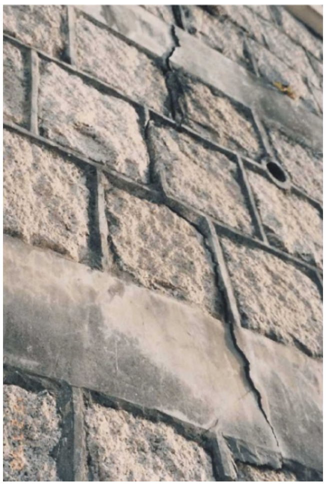
Example F11 Cracking of Hard Cover

Example F12 Extensive Cracking of Hard Cover

Example F13 Voids Underneath Hard Cover

Example F14 Subsidence and Extensive Cracking of Hard Cover

Example F15 Wall Tilting



Example F16 Wall Cracking

Example F17 Tension Cracks

Example F18 Extensive Tension Cracks

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土力工程處刊物及訂購資料

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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 302 p. (English Version), (Reprinted, 2011).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.
Geoguide 7	Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
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GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.
GEO Publication No. 1/2009	Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.
GEO Publication No. 1/2011	Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

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TGN 1	Technical Guidance Documents