CHAPTER 4 METHOD OF SLOPE INSPECTION

4.1 General

4.1.1 Inspection Sheet

Inspection Sheets (Form A to Form F) are prepared as mentioned in Chapter 1 and shown in the Tables 4.1. These Sheets shall be filled up while carrying out slope inspection fieldwork.(See Appendix 4.2)

4.1.2 Engineer in Charge of Slope Inspection

The Chief Engineer shall supervise the work of the Geologist, Geo-technical Engineer to obtain good results. The number of Geologists and Assistant Engineers involved depend on the magnitude of inspection work.
Qualification of Geologists is defined in Chapter 1 Table 1.3.1.
Geo- technical Engineer's responsibility is to estimate the cost of countermeasure works, with co-operation of the Geologist.

4.1.3 Field Work of Slope Inspection

Observations during fieldwork shall be done at the selected slope. The geologist has to use certain basic tools to record the surface conditions of slopes. Followings are the devices required for collecting field data.

(a) Tape measure
(b) Altimeter
(c) Clinometer
(d) Camera (Digital camera is recommended)
(e) G.P.S device
(f) Binocular

By using these devices, basic slope data can be collected and recorded on the Slope Inspection Sheet.

4.1.4 Evaluation of Slope Instability and Risk Rating

(1) Risk Rating
Risk rating is calculated automatically by the system after filling up the inspection sheets.

(2) Evaluation of Slope Instability

Comprehensive evaluation shall be done by the Chief Engineer and commented in Form F.

Table 4.1.1 Forms of Inspection Sheet

Form	Items to be Recorded	Remarks
A	General slope Data (a) Most Likely Failure Type, (b) Chainage, (c) Type of Slope, (d) Side of Road, (e) Distance from Road Centre-Line, (f) JKR Slope ID (g) Field ID, (h) Field ID, (i) Route Name, (j) District (State) Name, (k) Date Inspected, (l) Inspected by, (m) Date Checked, (n) Checked by, (o) Realignment Event, (p) Disaster Record, (q) Location Map (1/50,000), (r) Date Entered in SIMS, (s) Entered by	On SIMS
B	Slope Sketch (Plan and Cross Sections)	On SIMS
C	Photograph (Overall View and Special Features of Slope)	On SIMS
D	Slope Feature (a) Geometry, (b) Geology (c) Cover/Existing Countermeasure,(d) Drainage, (e) Pavement, (f) Instrumentation	After JKR USJ 1/2000 Not on SIMS (field data)
E	Slope Hazard Rating Sheets **E 1** : Collapse and Rock Fall(CL/RF), **E 2** : Rock Mass Failure(RM), **E 3** : Landslide(LS), **E 4** : Debris Flow(DB) **E 5** : Embankment Failure(EB)	On SIMS
F	Proposed Countermeasure Countermeasure, Amount, Remarks, and Comment Consequence Rating Local Information Building Type, Vegetation/Cultivation Rainfall Information	On SIMS

4.2 Completion of Inspection Sheet

As mentioned 4.1.1 the survey team shall complete the Inspection Sheets.

4.2.1 Form A: General Slope Data and Location Map

Please refer to Sections 3.2 and 3.6 for filling up the Form

(1) Distance from Road Centre-Line to Slope Toe

Distance from the centre of road to the toe of slope shown in Figure 4.2.1.

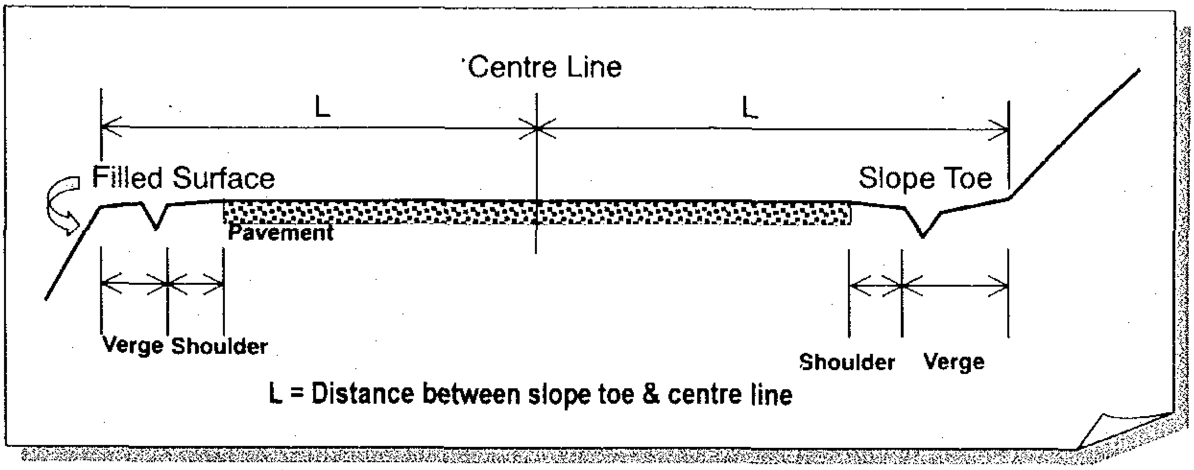


Figure 4.2.1 Distance of slope from road centre-line (Ref.*6)

(2) Date inspected and Inspected by

Date inspected and name of the Geologist should be entered in the Inspection Sheet.

(3) Date Checked and Checked by

Date inspected and name of the Chief Engineer should be entered in the Inspection Sheet.

(4) Realignment Event

Road alignment is sometime changed after slope disaster or other reason. When realigned, the following data should be recorded.

- Date of realignment, reason for realignment, and chainage of realignment section.

(5) Disaster Record

When the slope has disaster record, following data are entered.

- Date of disaster, Chainage of failure section, type of failure, Volume of failure, Traffic disasters, and Weather conditions. An example is shown in the Table 3.6.1.

4.2.2 Form B: Slope Sketch

In Form B (sheet of sketch), the condition of the slope surface under observation and measurements for recording purpose are required. The following data shall be recorded in Form B.

(1) Basic Structure of slope
- Distance from road centre to the toe of slope
- Geometry of the slope
- Facilities on the slope
- Countermeasure work on the slope

(2) Topography
- Topographic features
- Up- slope condition
- Down- slope condition
- Natural drainage

(3) Slope hazard condition
- Occurrence of collapse
- Deformation of slope
- Rock mass stability condition
- Boulder stability
- Gully erosion

(4) Countermeasure
- Features of countermeasure
- General layout of countermeasure

(5) Geological data
- Rock type
- Condition of surface soil
- Dip/strike of bed
- Condition and structure of discontinuity
- Weathering grade
- Pattern of rock discontinuity

(6) Location of photograph

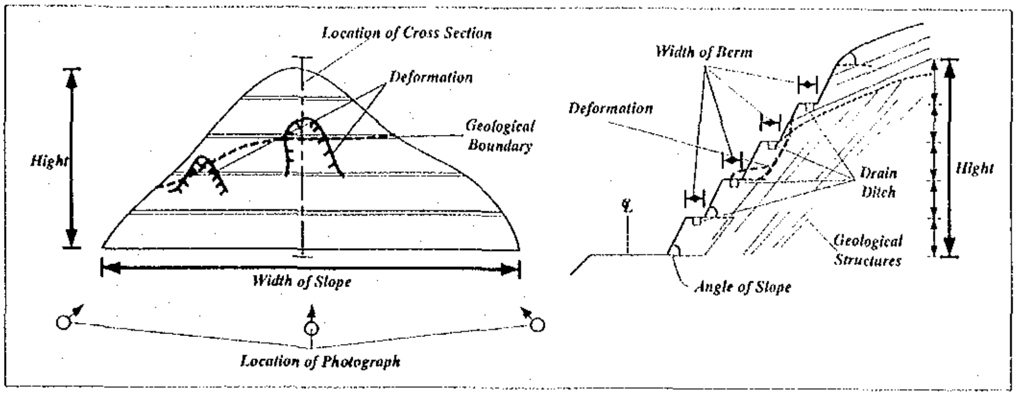


Figure 4.2.2 Basic slope information to be on the Form B (Sketch of Slope)

Recording standard shall conform to the British Standard that is used generally in Malaysia. Standards for weathering grade and pattern of discontinuity are shown in Figure 4.2.4 and Figure 4.2.5.

Sketch must be readable by everyone. It should be drawn clearly and highlighted by visible black line, because it will be displayed as a monochrome JPEG image in SIMS.

If a sketch is drawn using a pencil, it should be traced again on a new sheet or the drawing highlighted using a black pen without any dirt on the sheet.

An example of sketch is shown in the Figure 4.2.3.

SLOPE INSPECTION SHEET input **FORM B**

SLOPE SKETCH

JKR Slope ID :	Chainage: Start End 73.800km - 73.850km	Side of Road Right / Left	Date: 2001/8/14

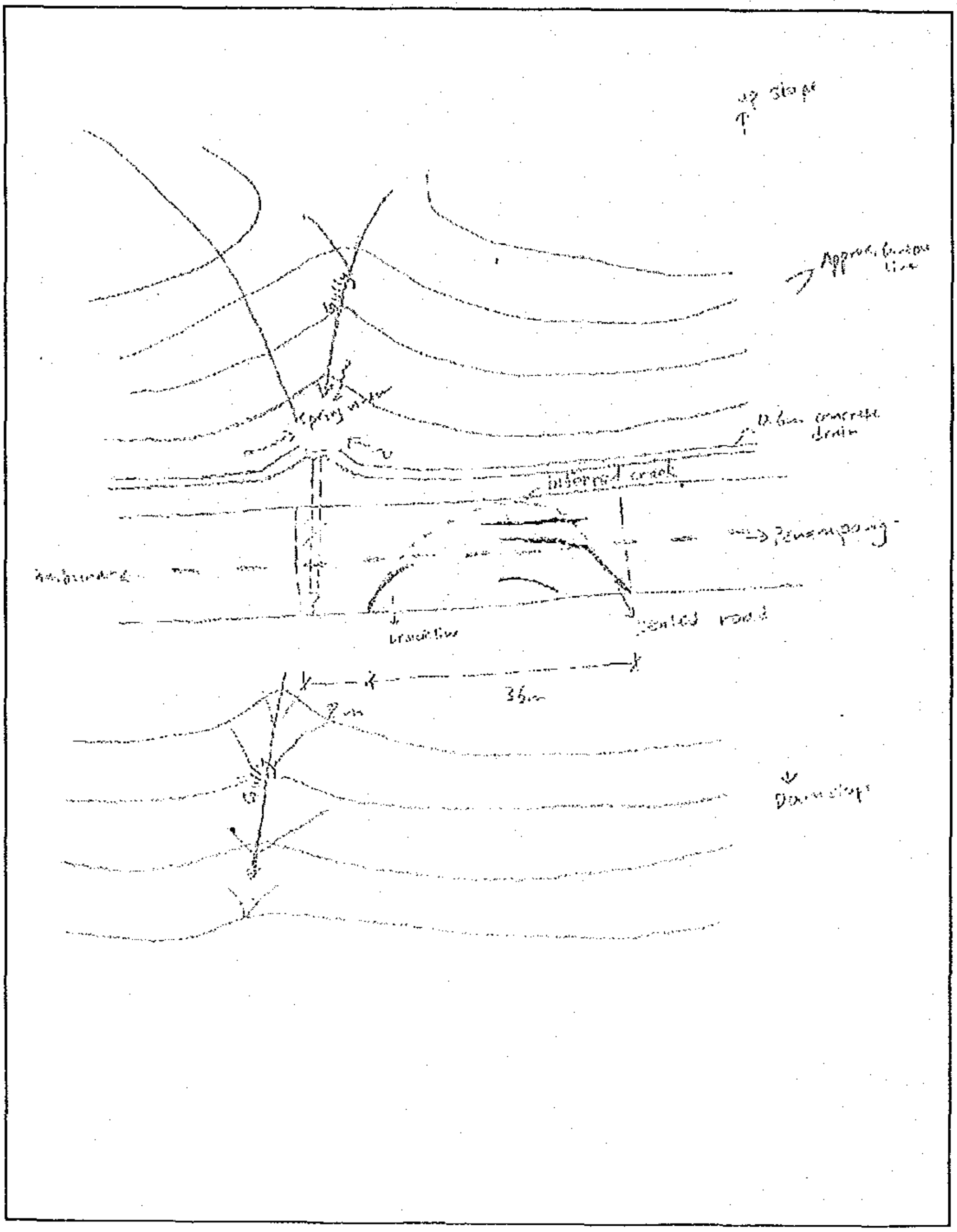


Figure 4.2.3 Example of Sketch (Penanpang-Tambunan Road, Sabah)

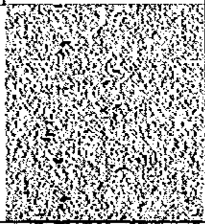
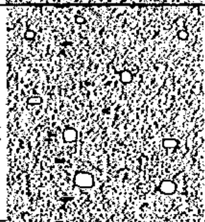
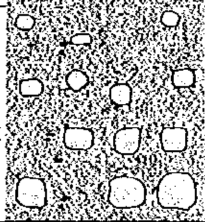
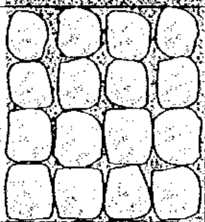
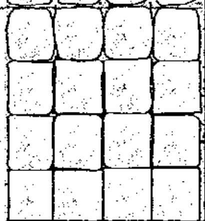
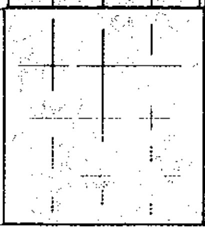
Grade	Description	Examples	Typical Characteristics
VI	Residual Soil		A soil mixture with the original texture and mineralogy of the rock completely destroyed by weathering.
V	Completely Decomposed Rock		Rock is wholly decomposed and in a friable condition but the rock texture is preserved. Geological pick easily indents when pushed into the surface. Usually slakes readily in water.
IV	Highly Decomposed Rock		Large rock pieces are broken by hand due to weathering. Individual grains may be plucked from the surface. Does not slake readily in water. Hard penetrometer strength index generally greater than $250 KN/m^2$.
III	Moderately Decomposed Rock		Considerably weathered throughout but possessing strength such that pieces 55mm in diameter cannot be broken by hand. Rock material not friable.
II	Slightly Decomposed Rock		Strength approaches that of fresh rock. More than one blow of the geological hammer to break specimen.
I	Fresh Rock		Unweathered. Rarely encountered in surface exposures.

Figure 4.2.4 Standard of Weathering Grade

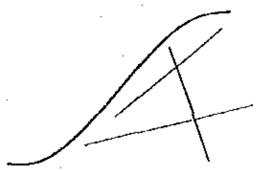
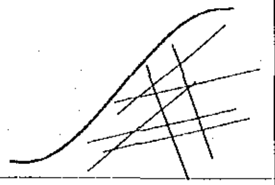
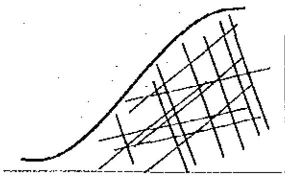
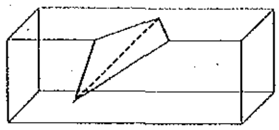
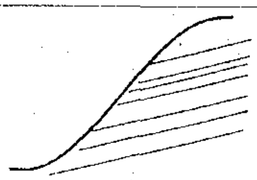
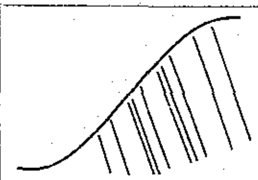
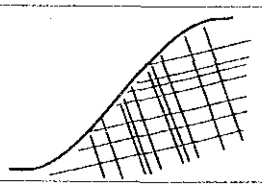
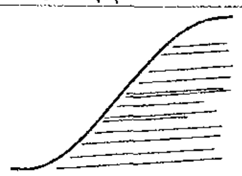
Joint Pattern	**Examples**	***Description***
1		No adverse discontinuities. Widely spaced, single set or absent.
2		Many discontinuities, blocky. Spacing generally greater than 500mm. No significant daylighting wedge or planar joints.
3		Many discontinuities, blocky. Spacing generally less than 500mm. No significant daylighting wedge or planar joints.
4		Two or more joints forming daylighting wedge.
5		Planar, daylighting joint or joints.
6		Toppling
7		Toppling and planar modes.
8		Many discontinuities, fissile. No significant daylighting wedge or planar joints.

Figure 4.2.5 Pattern of Discontinuity

4.2.3 Form C: Photograph

Followings are important guide lines to take a photograph.

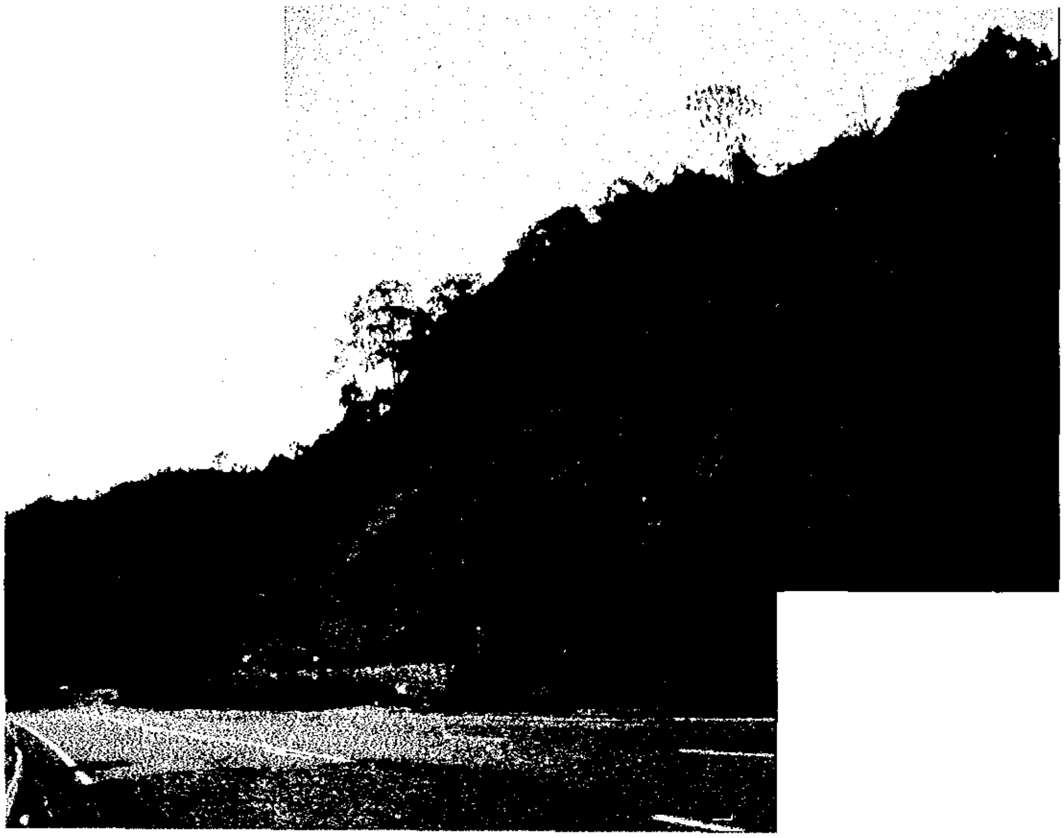
(1) View point of photograph
(a) General view of the slope
(b) Features of slope condition

(2) Numbers of photograph
One or two photographs of general view required and two or three photographs of features of slope condition are required. A total of three to five shots is recommended as an adequate number of photographs.

(3) Camera
It is better to take pictures with a digital camera. If a digital camera is not available, developed and printed photographs should be scanned and save as JPEG's images on digital media.

(4) Location of photograph
Location of photograph shall be recorded in the Form B Sketch.

An example of photograph is shown in Figure 4.2.6.



(a) General View

(b) Feature of Slope Condition

Figure 4.2.6 Example of Photograph(CH27.0km East- West Highway)

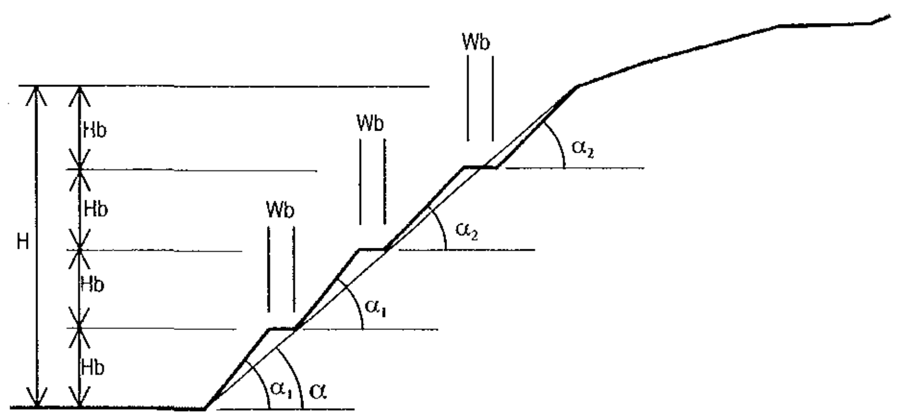
4.2.4 Form D: Slope Feature

Same as JKR Slope ID, Chainage, Side of Road and Date are required to be filled up in Form D followed by slope features as shown below:

(1) Geometry
(2) Geology
(3) Erosion
(4) Cover/Exiting Countermeasure
(5) Drainage
(6) Pavement
(7) Instrumentation

(1) Geometry

As shown in Figure 4.2.7, the Basic Elements of Slope, following fundamental data of slope shall be entered in the table. Maximum and minimum berm height (Hb) and width shall be entered.



H: Height of Slope, Hb: Berm Height, α_1,α_2: Angle of Slope(range; α_1-α_2),
α: Average Angle of Slope, Wb: Width of Berm

Figure 4.2.7 Basic Element of Slope

Number of berm

Number of berms on the given slope from the road level up to the highest point.

(2) Geology

(a) Geological Name
The main rock genetic type, sedimentary, igneous or metamorphic, is shown on the table. Tick on individual rock names that are seen on the slope. If not in the table, the rock name shall be entered in "OTHERS".
When the slope consists of soil, the appropriate soil name(s) shown in the table shall be ticked

(b) Weathering grade and type of discontinuities
Refer to Figures 4.2.4 and 4.2.5.

(c) Composition of Rock: Soil
Ratio of rock area to soil area shall be entered as a percentage.

(3) Erosion

(a) Sheet Erosion
Firstly, estimate the percentage of erosion by area.
Severe: more than 40%, Moderate: 10-40%, minor: less than 10%

(b) Rill Erosion
Severe: 0.2-0.5 m in depth, Moderate: less than 0.2 m in depth, Minor: newly formed rills

(c) Gully Erosion
Severe: Depth of gully is more than 0.5 m and spread over more than one berm,
Moderate: Depth of gully is over 0.5 m and spread over one berm
Minor: Depth of Gully is around 0.5 m and spread over one berm

(d) Fretting
Estimate the percentage of erosion by area.
Severe: more than 40%, Moderate: 10-40%, minor: less than 10%

(4) Cover/Existing Countermeasure
Following main countermeasure types are prepared in the table for recording height and length or area.

(a) Gabion
(b) Crib Wall
(c) Concrete Wall
(d) Masonry
(e) Rock Bolts
(f) Netting
(g) Soil Nail
(h) Piles

When any other countermeasure is applied, it shall be described in the column "OTHERS".

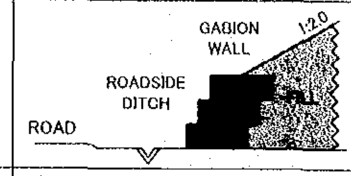
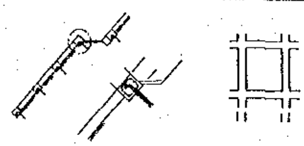
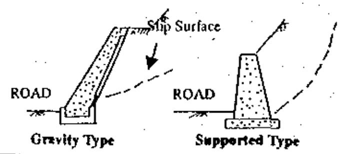
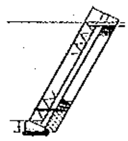
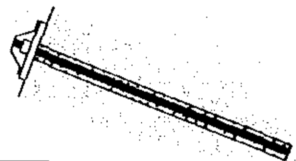
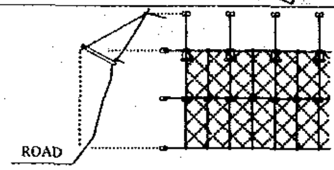
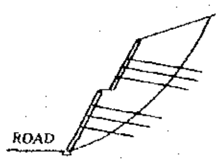
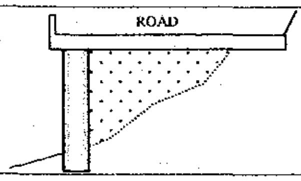
In the column "COMMENTS" effectiveness of countermeasure shall be described.

Following comments can be used.

(a) Effective
(b) Effective but needs repair
(c) Not effective needs additional work

Outline of features of each countermeasure as shown in Table 4.2.2. Further explanation is described in the Guide IV; Guide to Countermeasure Selection.

Table 4.2.2 Engineering Features of Countermeasure Type

Countermeasure Type	Engineering Features	Schematic Structure
(a) Gabion	Wire netting or cellular steel lattice to support rocks and soils.	
(b) Crib Wall	Interlocking pre-cast concrete structure arranged overlapping and filled with earth or stones. Similar to gravity retaining wall.	
(c) Concrete Wall	Concrete retaining wall either cantilever or fixed.	
(d) Masonry	Stone wall bonded with concrete acting as free wall or gravity retaining wall	
(e) Rock Bolt	A method or equipment used as an anchor on possible loose rock slopes	
(f) Netting	Netting used to cover slope surface	
(g) Soil Nail	A method used to hold slope earth	
(f) Piles	Pile wall to support slope earth	

(5) Drainage

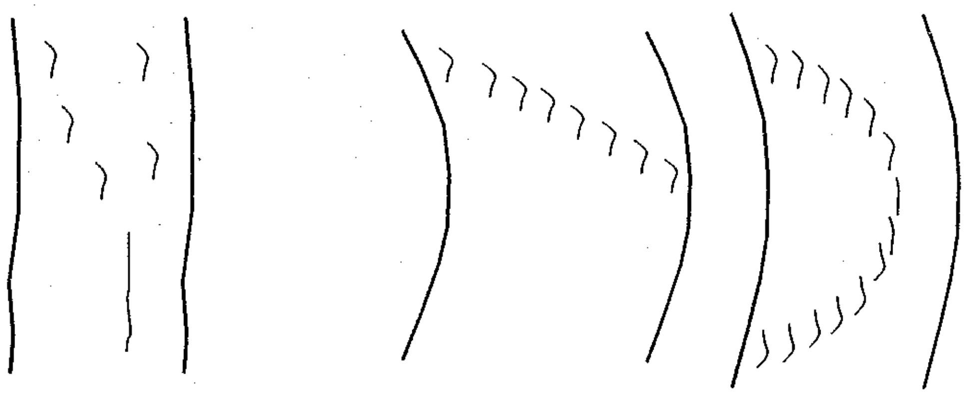
(a) Culvert ID: According to bridge inventory number.
(b) Drainage

Drainage condition can be ticked on more than one item prepared in the table.
Good condition/Need Desilting/Need Repair/Not present

(6) Pavement

Following cracks or deformation on the pavement shall checked.
(a) Cracks: Yes/No
(b) Cracks sealed: Yes/No
(c) Depression: Yes/No
(d) Shoulder depression: Yes/No
(e) Cause of Cracks: Pavement/ Slope failure

Evaluation on Cause of Cracks (e) is most important procedure. When cracks are due to fatigue, they have no continuous relationship and depression. When a slope failure is taking place, cracks are continuous and some depression is found. (Figure 4.2.8)



(a) Pavement cracks
(Random fabric)

(b) Cracks caused by slope failure
(Linear structure)

Figure 4.2.8 Pavement Cracks and Cracks caused by Slope Failure

(7) Instrumentation

Condition of the slope can be checked by installation of certain monitoring devices into the slope.

4.2.5 Form E1: Collapse (CL)/Rock Fall(RF)

Form E 1 is the sheet for Slope Hazard Rating of Collapse (CL) and Rock Fall (RF). The following six items are main factors for hazard evaluation.

(1) Topography
(2) Geometry
(3) Material
(4) Geological Structure
(5) Deformation
(6) Surface Condition
(7) Countermeasure

(1) Topography

To evaluate slope stability following sub-items are selected.

(a) Alluvium slope

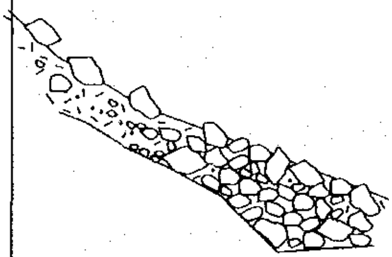
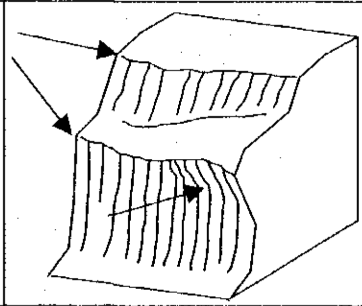
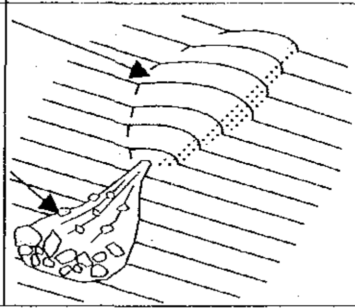
(b) Trace of collapse

(c) Clear knick point or overhang

(d) Concave slope or debris slope.

These types of slope topographies are prone to collapse or rock fall. Definition of sub-items is shown in the Table 4.2.3.

Table 4.2.3 Definition of Sub-item of Topography

Hazard Evaluation Item	Definition	Schematic diagram
Alluvial Slope	Detritus deposit resulting from the operation of modern river. Including fallen disintegrated material which has formed a slope at the toe of steep slope. (Talus)	
Trace of Collapse	Slightly hollowed part of slope that had been made by a collapse in the past. Surface of it denuded or covered by grass or young tree.	
Clear Knick Point Or Overhang	Knick point: The point on a slope where the where the slope gradient is abruptly steeper below the point than above it. Overhang: A condition of soil or rock slope that is overhanging.	
Concave Slope Or Debris	Concave slope: The slope with a surface that has spoon-like shape Debris slope: The slope that is composed of debris deposits.	

(2) Geometry

Generally, steeper and higher slopes are more unstable. The gradient and height of slope are important items for evaluating the stability of collapse and rock fall. The combination of height and gradient of the slope is an important determinant of stability of soil and rock slope.

Geometric stability factor is classified as follows. When the slope consists of (a) soil slope and (b) rock slope, higher points shall be ticked in the table.

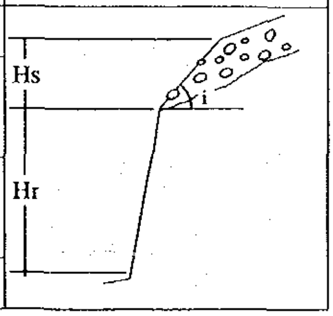
(a) Soil slope

- The height is over 30 m (H > 30 m),
- The height is less than 30 m, and the gradient is larger than 45°.
- The height is between 15 m and 30 m and the gradient is less 45°.
- The height is less than 15 m and the gradient is under 45°.

(b) Rock slope

- The height is larger than 50 m ($H \geqq 50$ m),
- The height is between 30 m and 50 m ($30 \leqq H < 50$ m),
- The height is over 15 m and less than 30 m ($15 \leqq H < 30$ m), and
- The height is below 15 m (H < 15 m).

Table 4.2.4 Selection of Evaluation Item

Rock / Soil	$Hr \geqq 50$	$30 \leqq Hr < 50$	$15 \leqq Hr < 30$	$Hr < 15$	Height and Angle of Slope
$Hs \geq 30$	**R**	**S**	**S**	**S**	
$Hs < 30$, $i \geq 45$	**R**	**R**	**S**	**S**	
$15 \leq Hs, < 30$ $i < 45$	**R**	**R**	**R/S**	**S**	
$Hs < 15$	**R**	**R**	**R**	**R/S**	

R: Rock Slope, S: Soil Slope

(3) Material

Material means character of soil or soundness of rock slope. It can be classified as follows.

(a) Soil slope

Soil slope is classified into three grade of soil condition
- The soil contains swelling clay: Conspicuous
- The soil contains a small amount of swelling clay: Slightly
- The soil is does not contain swelling clay: No swelling clay

Generally, residual soil formed from the following parent materials contains conspicuous swelling clay minerals
- Serpentinite;
- Tuff;
- Mudstone;
- Phyllite;
- Graphite schist;
- Granite and
- Altered rocks.

(b) Rock slope

Sheared or weathered condition is classified into following three grades.

(i) Conspicuous: The rock is obviously and heavily sheared or weathered
Weathering grade; IV and Discontinuity pattern; 3, 7, 8

(ii) Slightly: The rock is slightly sheared or weathered slightly
Weathering grade; III and Discontinuity pattern; 3,4,5,6

(iii) Not available: The rock is sound.
Weathering grade; II, I and Discontinuity pattern; 1

(4) Geological Structure

Following three geological structures shall be checked.

(a) Daylight Structure (planar and wedge) : Yes or No
(b) Soft Soil over Base Rock : Yes or No
(c) Hard Rock over Soft Rock :Yes or No
(d) Others

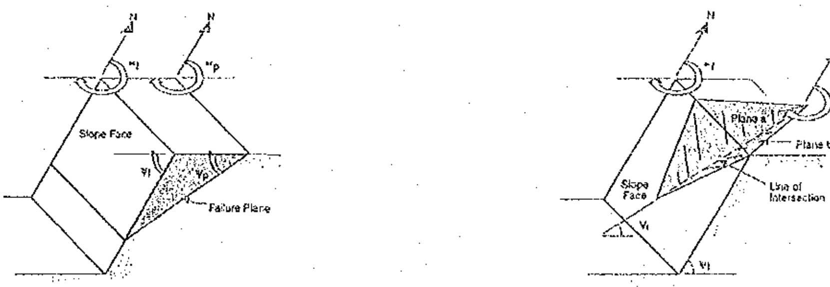


Figure 4.2.9 Daylight Structure (Planar and Wedge)

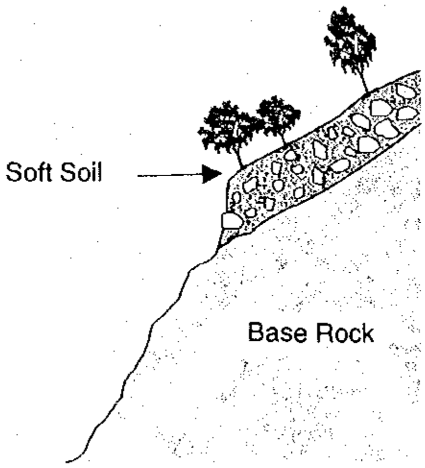


Figure 4.2.10 Soft Soil over Base Rock

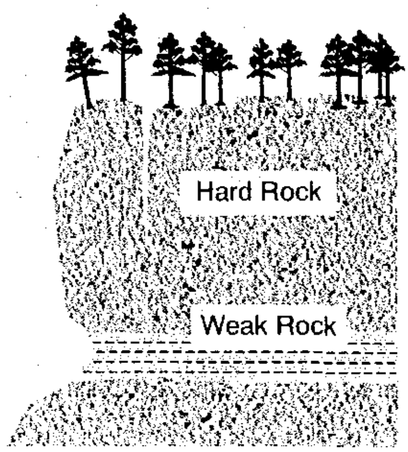


Figure 4.2.11 Hard Rock over Weak Rock

(5) Deformation

(a) Slope Deformation

Occurrence of following slope failure, deformation and erosion shall be checked.

- Rock Fall and Exfoliation (small slope failure)
- Swelling (deformation)
- Gully, Rill, Sheet, Fretting, Sheet Erosion (erosion)

Occurrence of these "deformations" implies unstable condition of slope that is classified into three grades.

(i) Visible; Deformation is occurring in the slope
(ii) Obscure; Trace of deformation is found in the slope
(iii) No Slope Deformation; No deformation is found in the slope

(b) Deformation at Adjacent Slope

Same evaluation as (5) is carried out in the adjacent slopes.

(6) Surface Condition

Surface condition consists of:

(a) Condition of Surface
(b) Ground Water
(c) Cover
(d) Surface Drainage

(a) Condition of surface is classified into following three grades:
   (i) Unstable: Unstable rock is found or deformation is occurring
   (ii) Moderate: Partly found in the slope
   (iii) Stable: No unstable rock or deformation is found

(b) Ground Water;
Influence of ground water is evaluated by existence of "Natural Water Spring". It is divided into three conditions.
   (i) Natural spring: Natural springs are almost permanently evident in the slope.
   (ii) Water seepage: Trace of spring or small amount of seepage is found in the slope.
   (iii) Dry: No spring and seepage is found in the slope.

(c) Cover
Slope cover is evaluated by following condition.
   (i) No vegetation, grass: No cover on the slope.
   (ii) Complex (Grass + Structures): Grass with some kind of structures is covering the slope.
   (iii) Structure: Slope is covered by stable structure like crib with rock bolts.

(d) Surface Drainage
Condition of surface drainage is evaluated as following three conditions
   (i) Available (good): In a good condition to drain surface water.
   (ii) Available (need repair): In a good condition to drain surface water, but some repair is needed.
   (iii) Not available: Poor surface water drainage and in need of improvement.

(8) Countermeasure

The evaluation of the effect of the existing countermeasure work depends on the deterioration or shortcomings of the existing structures. The effects of the existing countermeasures are evaluated as follows.

(a) Effective

The existing countermeasures are implemented to meet the proposed safety factor, and are also effective enough to prevent the slope failure predicted in the inspection.

(b) Partly effective

The proposed countermeasures are partly implemented, and hence are not enough to prevent the probable disaster.

(c) Not effective or no countermeasure

The existing countermeasures are not expected to be effective against the possible disaster or no countermeasure work is applied.

4.2.6 Form E2: Rock Mass Failure(RM)

Rock mass failure occurrence is closely related to conditions of cracks or joints, rock character, topography. In addition, some signs of small rock slope failure such as rock fall and small collapses are important sign of Rock Mass Failure.

(1) Topography

(a) Slope Type

Slopes are subdivided into four types by its shape. (Figure 4.2.1)

(i) Convex Slope;

(ii) Debris Sediment;

(iii) Concave Slope and

(iv) Others

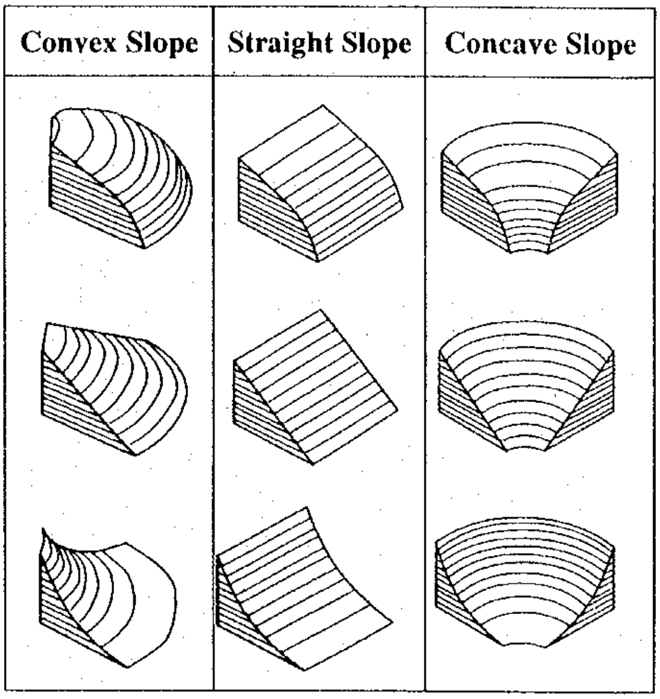


Figure 4.2.12 Schematic Classification of Slope Shape (Ref. *1)

Knick Point

Knick line is an abrupt transition from the gentler upper slope to a steeper lower slope (Figure 4.2.13).

Steep slopes or cliff surface below the knick line are prone to erosion and this is called the erosion front.

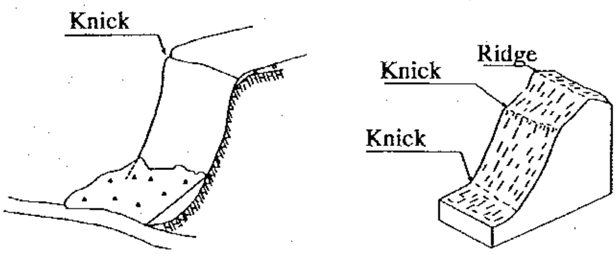


Figure 4.2.13 Definition of Knick line

In the table of the sheet, one of the following three grades is used for evaluation.

(i) Clear: An abrupt change of slope gradient is clear.

(ii) Moderate: Knick line is found, but change of gradient in the slope is not so clear

(iii) No Knick Point: Slope gradually gets gentle without a remarkable change in gradient.

(2) Geometry

(a) Angle of Slope

Steep slope overhang has a high degree of instability. In addition, when failure occurs in such steep slope, the impact of rock mass fall would be too large to control.

In measuring the average gradient of slope from a road or the toe of a slope up to the knick line, Figure 4.2.15, the average gradients of the upper slope A and the lower slope B correspond to angle α and β, respectively. Compared to the gentle slope B, the steep slope A is often a site of rock mass failure. Therefore, the gradient of slope A is used as the gradient of slope.

In general, slope of over 60° has higher probability of rock mass failure. Therefore, the 60° value is used to divide steep slopes into the following grades.

(i) Overhanging slope,

(ii) Slope of over 60° and

(iii) Slope of less than 60°.

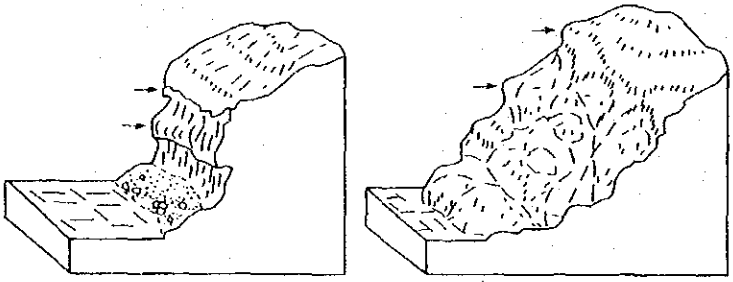


Figure 4.2.14 Overhang (arrow) (Ref. *1)

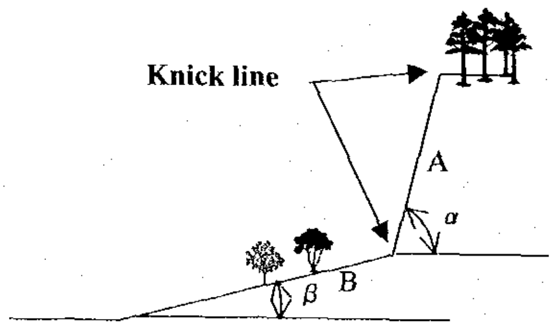


Figure 4.2.15 Measurement of Slope Gradient

(b) Height of Slope

Height of cliff is from a road or the toe of a slope up to the knick line.

As in Figure 4.2.16, when the width of the lower gentle slope B is smaller than that of the road (W), the height of cliff should be evaluated by the sum of the height H1 of the upper steep slope and the height H2 of the lower gentle slope. Where the knick line is recognizable, the height of cliff is considered to be that from the foot up to the ridge.

Height of cliffs is divided into four grades.

(i) Over 100 m

(ii) Between 50m and 100 m

(iii) Between 30m and 50 m

(iv) Less than 30 m

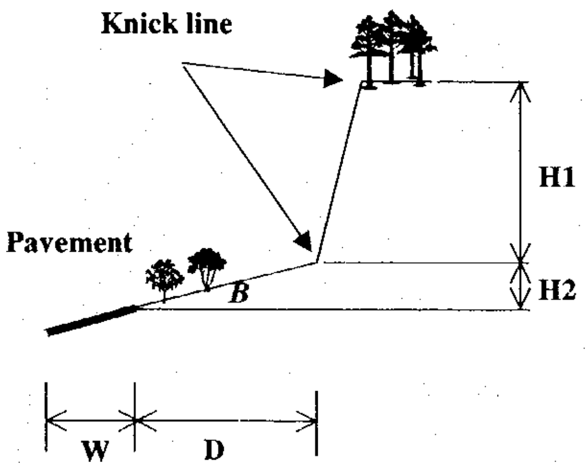


Figure 4.2.16 Measurement of height of slope

(3) Geological Condition

(a) Scale of open cracks

Condition of open crack is an important item to evaluate instability of slope in Slope Inspection Sheet Form. Condition of open crack is divided into three conditions.

(i) Large: Open crack larger than 20 mm

(ii) Small: Open crack smaller than 20 mm

(iii) No crack: Crack width is less than 5 mm

(b) Combination of Rock Condition

There are following five combinations of rock type

(i) Upper Part: Hard Rock/Lower Part: Soft Rock

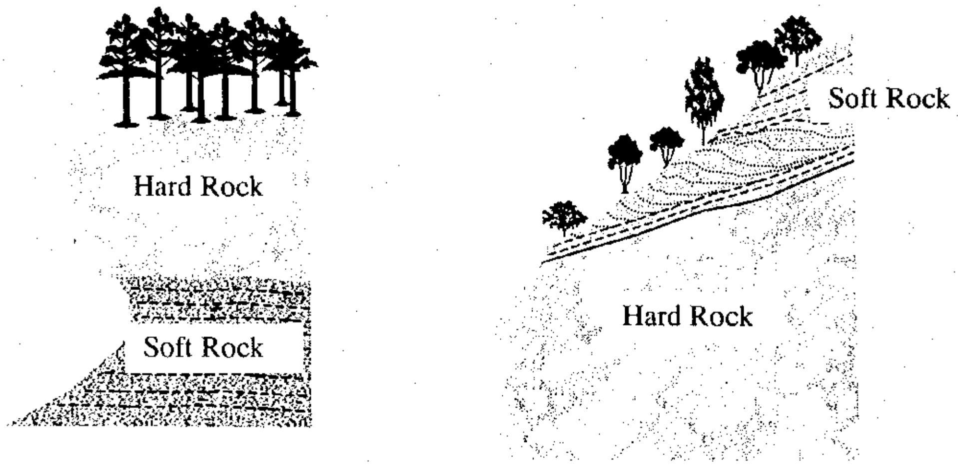
(ii) Upper Part: Soft Rock/Lower Part: Hard Rock

(iii) Wholly Soft Rock

(iv) Wholly Hard Rock

(v) Others

Generally, slopes of hard or soft homogeneous rocks are stable. On the other hand, a combination of hard and soft rock sometimes produces conditions that are prone to large rock mass failure. Especially in the case of (i), lower soft rock is easily eroded and the slope often becomes an overhang cliff.



(i) Upper Part: Hard Rock/
Lower Part: Soft Rock

(ii) Upper Part: Soft Rock/
Lower Part: Hard Rock

Figure 4.2.17 Combination of Hard and Soft Rock

(4) Geological Structure

Geological structure regulates scale of rock mass and probability of rock mass failure.

(a) Crack (Joint pattern and its interval

Joint pattern is divided into three categories.

(i) Regular cracks: interval $>$ 1m

(ii) Regular cracks : interval $\leqq$ 1m

(iii) Irregular

(b) Relationship of slope/ joint structure

Relationship between joint and slope plane

(i) Daylight: Line of intersection of two rock joint plane is gentler than the slope angle, including planar structure.

(ii) Non-daylight: Not daylight structure

(iii) No plane: Large scale fault, joint, crack, bedding are not developed

Schematic diagram of daylight structure is shown in the Figure 4.2.18.

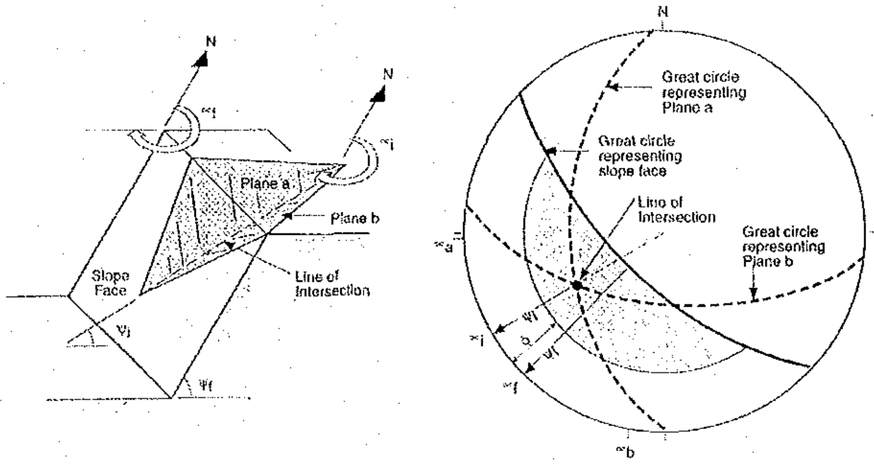


Figure 4.2.18 Probability of Rock Mass Failure by Daylight Wedge (Ref. *9)

(5) Deformation

Deformation of rock mass shall be ticked "Yes" or "No".

Signs of deformation can be identified by the following phenomenon in the slope.

(a) Small-scale collapse or rock falls

Small-scale collapse and rock fall often imply large rock mass failure that is deformed with a loose condition on the slope surface. These collapses and rock falls, present or previous, should be inspected. Talus observed at the foot of a slope is regarded as evidence of previous small-scale collapses or rock falls.

(b) Small movement of planar or daylight wedge (Figure 4.2.19)

Small amount of movement implies future large and rapid movement. When this phenomenon is found, condition of the rock mass shall be observed carefully.

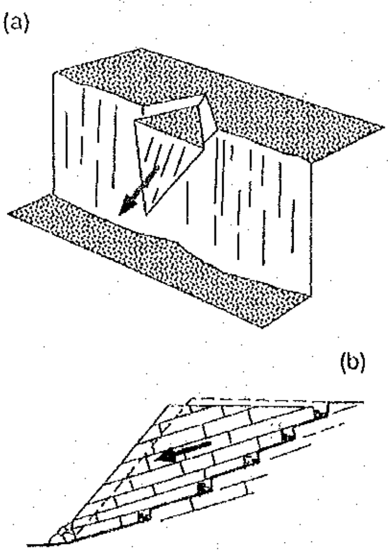


Figure 4.2.19 Small Movement of Planar or Daylight Plane (Ref. * 9)
(a) Wedge and (b) stepped translational slides

(c) Deformation or bending of original structure (Figure 4.2.20)

Deformation .or bending of original structure also implies future rock mass failure. When this phenomenon is found, the condition of the rock mass shall be observed carefully.

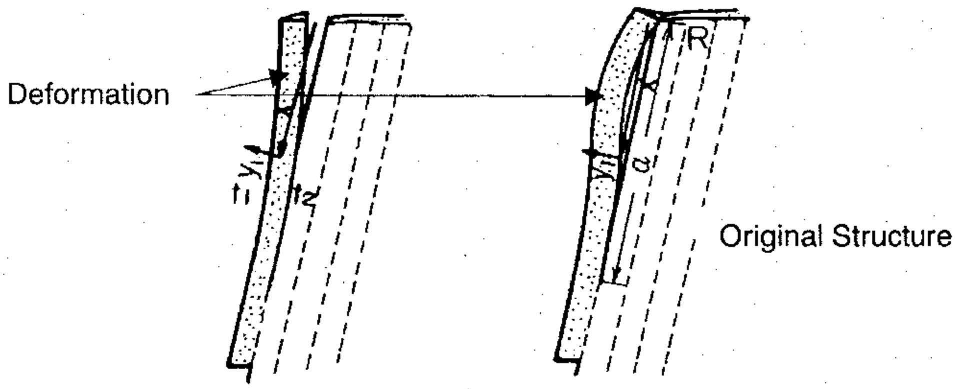


Figure 4.2.20 Schematic diagram shows the deformation of the original structure.(Ref. *10)

(6) Surface Condition

Following surface conditions shall be observed.

(a) Spring or seepage on slope ("Yes" or "No")

(b) Surface drainage

(i) Available (good)

(ii) Available (need repair)

(iii) Not Available

(7) Countermeasure

Effectiveness of countermeasure shall be judged into one of the following three grades. Criteria for judgement is same as Form E 1.

(a) Effective

(b) Partially Effective

(c) Not Effective or No countermeasure

4.2.7 Form E3: Landslide (LS)

Landslides are generally characterised by slow and repetitive movements, and consequently, have a characteristic landform. Such landform can be detected except in some, initial landslide areas that appear as a stable slope. Furthermore, landslides tend to be concentrated in certain regions with specific topographic and geologic features.

Stability evaluation for landslide is therefore, made in view of topographical and geological factors in landslide areas and historical disaster records. The total evaluation score is obtained by the sum of evaluation scores of main causes and disaster records and judging the effectiveness of the existing countermeasures.

(1) Topography

(a) History

Record of previous landslide occurrence shall be investigated. ("Yes" or "No")

(b) Topography

Natural landslide has topographical features mentioned in Section 3.5.

Evaluation on landslide is done not only by field survey but also by study of aerial photographs.

(i) Obvious

Topographical anomalies are found on aerial photograph and observed during field survey

(ii) Partially

Topographical features of landslides are suspected from study of aerial photograph, but clear topographic features of landslide are not found in the slope.

(iii) Uncertain

Topographical features are suspected from the study of aerial photographs, but topographical features of landslide are not found on the slope.

(2) Geological

Generally, natural landslides occur in areas that have geological defects, such as fractured zone, alteration zone, and clayey formation. Geological hazard items are as follows:

(a) Fault, Sheared Zone

Part of a fault surface forms surface of rupture or scarp to border the landslide area. Furthermore, a fault surface or a fractured zone may become a route of groundwater flow. Fault clay may cut off groundwater flow, leading to landslide due to the rise of pore water pressure.

Folding area is also included in this category.

(b) Alteration Zone

Hydrothermal alteration in the geological stage and hot spring water causes chemical alteration of surrounding rocks in volcanic and geothermal areas. Swelling clay minerals are made by chemical alteration, the slope is prone to slide.

(c) Daylight Structure

Large-scale daylight structure that is regulated by fault or planar (monoclinic) structure often cause landslides.

(d) Non-Daylight Structure

No daylight geological structure is exists.

(e) Intrusive Structure, Cap Rock Structure

Landslides sometime occur around intrusive rocks. Rocks are often fractured in the areas surrounding intrusive rock and are liable to cause landslide.

Cap rock structure means lava flow on soft sedimentary layers.

(3) Geological Condition

Landslides always consists of concentrate mud and silt stones, shale, graphite schist. For this evaluation item, development of "Shale" or "Schist" is inquired. This means clayey rock or schistose rock.

(4) Deformation

An active landslide shows small deformation on ground surface of the landslide block, such as bulge, depression, cracks and so on. These features are generally considered as signs of an impending landslide. They provide information for determining or identifying landslide activity, shapes of surface of rupture, and direction of movement.

The following phenomena of deformation shall be checked on the slope.

(a) Bulging at Toe

(b) Depression or Subsidence

(c) Cracks on Surface (Diagonal Tension Crack, Shear Cracking)

(d) Deformation of Countermeasure

(5) Surface Condition

(a) Spring, Natural Water Path

Groundwater is a major factor that accelerates landslides. Groundwater enters by inflow or infiltration from the slope above the landslide site or landslide slope. The inflow or infiltration frequently emerges as spring water or near the lower end of the surface of rupture, especially around the lower end of both sides of the landslide block.

In inspecting landslide areas, spring water should be considered as present if spring scar is found.

(b) Surface Drainage

Condition of surface drainage shall be checked and evaluated by the same method as E 2.

(6) Countermeasure

Effectiveness of countermeasure work shall be judged by field observation.

Criteria of judgement are same as Form E1 (Collapse/Rock Fall).

4.2.8 Form E4: Debris Flow (DB)

Road disaster caused by a debris flow is related not only to debris flow (size, velocity), but also to the degree of connection between the road facilities and the crossing stream. Stability evaluation for debris flow is carried out in view of topographical factors, the effects of the existing countermeasures and road facility. The total evaluation score is obtained by the sum of evaluation scores of main causes, countermeasure works and road facilities, after correction for evaluation score of disaster records.

(1) Topography

The following causes (factors) related to torrent are basically investigated by deskwork.

(a) Contributory Area of Occurrence

This is contributory area of over 15 degrees-stream gradient at debris flow vulnerable area. This area is divided into the following three grades.

(i) Over 0.50 km^2,

(ii) Between 0.15 km^2 and 0.50 km^2, and

(iii) Less than 0.15 km^2.

(b) Extreme Steep Gradient more than 30°

The gradient of the steepest stream part is divided into the following three grades.

(i) Over 40°,

(ii) Between 30° and 40°, and

(iii) Less than 30°.

(c) Area of slope of over 30^0 gradient

This is the area of slope of which the gradient is over 30°. The area is divided into the following three grades.

(i) Over 0.20 km^2,

(ii) Between 0.08 km^2 and 0.20 km^2, and

(iii) Less than 0.08 km^2.

(2) Cover in Source Area

(a) Area of Grassland and Bush

This item is evaluated by the areas covered by grass and shrub (less than 10 m) and the presence of countermeasure against the unstable soils.

(i) Over 0.20 km^2,

(ii) Between 0.02 km^2 and 0.20 km^2,

(iii) Less than 0.02 km^2, and

(b) Existence of Earth Works /Ponds/ Logging activity Seepage

When earth work, ponds, seepage from a pond, or logging activity exist, tick "Yes".

(3) Deformation in Source Area

(a) Existence of New Crack, Scarp

This means presence of newly formed cracks and scarps in the upstream contributory. These deformations are identified by interpretation of topographic maps and aerial photographs.

(b) History of Collapse

Trace of Large-scale collapse in the upstream contributory. These collapses can be recognised by interpretation of aerial photographs.

(4) Trace

The purpose of disaster history survey is to trace the occurrence frequency of debris flows. In this survey debris flow records shall be collected as soon as possible. When a record of debris flow is found, tick "Yes".

(5) Countermeasure

Effectiveness of countermeasure works shall be evaluated. Criteria of evaluation is same as Form E1 (Collapse/Rock Fall).

4.2.9 Form E5: Embankment(EB)

Followings are evaluation items for Embankment Failure.

(1) Geometry

Geometry of embankment is classified into following three grades.

(a) > 45°

(b) 33° < I < 45°

(c) < 33°

(2) Base Ground

Base ground of embankment is evaluated into four conditions;

(a) Unstable Toe: Toe part of fill slope is unstable due to bad condition of base ground

(b) Poor subsoil: Unconsolidated surface soil or removed soil

(c) Alluvium: Alluvial terrace deposits, talus deposits, debris deposits

(d) Stable basement: Consolidated soils, rock basement

(e) Uncertain: Difficult to judge the condition of base ground

(3) Fill Materials

Embankment materials are divided into the following four groups in consideration of their stability against erosion and weathering.

(a) Sandy soil

(b) Clayey Soil

(c) Gravel

(d) Unknown

(4) Groundwater and surface water

Infiltration of groundwater and surface water into embankment may increase pore water pressure inside the embankment, leading to a collapse at the shoulder of the embankment slope. Moreover, surface water may scour the surface of embankment. In inspecting, careful attention should be given to the following phenomena.

(a) Wet at Toe of Fill Slope

It is difficult to recognise the infiltration of groundwater into an embankment. Therefore, infiltration of groundwater is judged by wetness at the toe of an embankment including a retaining wall.

(b) Trace of Water Flow on Slope Surface

Gully and rill erosion implies that surface water from road or upper slope flow on the surface of embankment. This causes scouring of the surface and collapse of embankment.

(c) Seepage from Fill Slope

Where spring water exists at the adjacent ground around the embankment, the spring water may come out from the adjacent ground and is likely to infiltrate into the embankment.

(d) Surface Drainage

Surface drainage shall be evaluated by following three grade.

(i) Need Repair, (ii) Not Available, (iii) Good

(5) Condition of Culvert

Culverts will be evaluated in terms of the following four conditions.

(a) Insufficient or no culvert

(b) Insufficient treatment at end of culvert

This can be judged by the condition of scouring at the slope toe part

(c) Bending or reduction of culvert

(6) Deformation

Following four items shall be checked.

(a) Cracks, Creeping

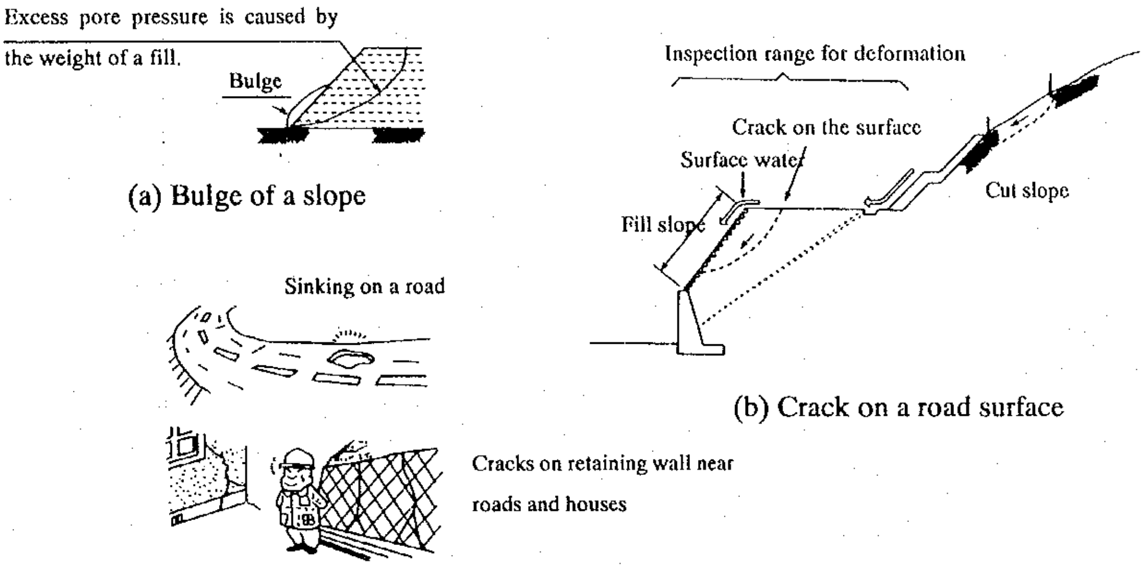
(b) Surface erosion

(c) Existence of repaired portion

(d) Exfoliation on slope

In general, deformation occurring at the surface of an embankment implies the presence of potentially unstable factors in the embankment or adjacent ground. Therefore, stability of embankment is evaluated by those deformations occurring at embankments.

Example of deformation of embankment in the Figure 4.2.21



(c) Depressions on a road surface and cracks on a retaining wall

Figure 4.2.21 Examples of Embankment Deformation

4.3 Form F: Proposed Countermeasure/Consequence Data/Local Information

The following Items are included in the Form F:

(1) Proposed Countermeasure

(2) Consequence Data

(3) Local Information

4.3.1 Proposed Countermeasure Work

This provides for basic planning and rough estimation of countermeasure work for unstable slopes.

As these data are used for road slope maintenance planning, proposed countermeasure work and cost estimation shall be reasonable. So, the chief engineer shall be responsible for final decision of all countermeasure planning

Detailed method of countermeasure selection is described in Guide IV "Guide to Countermeasure Selection and Cost Estimation".

Outline of countermeasure planning methods is mentioned in this section.

(1) Type of Countermeasure

Type of countermeasure can be selected from the following methods.

(a) Earth Work, (b) Vegetation, (c) Water Drainage, (d) Slope Work, (e) Anchoring,

(f) Wall, (g) Piling, (h) Protection Work, (i) Others

Detailed countermeasure type and their unit cost is shown in the Table 4.3.1

Table 4.3.1 Countermeasure Options

Work Item	ID	Countermeasure (Type of works)	Description (Specification)	Unit	Rate (RM)
1 Earthwork	11	Removal	--	m^3	2.00
	12	Rock Cutting	Rock Excavation	m^3	15.00
	13	Rock Pre-Splitting	Rock Blasting	m^2	70.00
	14	Soil Cutting	Soil Excavation (bulk quantity)	m^3	5.00
	15	*Embankment*	*Backfill & Import Suitable Fill*	m^3	*8.00*
2 Vegetation	21a	Re-Vegetation	Supply & lay spot turfing including 100mm thick top soil	m^2	3.00
	21b	Re-Vegetation	Close turfing	m^2	3.50
	22	Hydroseeding	--	--	2.50
3 Water Drainage	31	Drain Ditch and Cascade	Concrete G15 cast-in-situ at any inclination along the berm of slopes including excavation, BRC A7 joints with existing drain	m	160.00
	32a	Subsoil Drainage Hole	Layer of coarse sand as subsoil drainage blanket	m^3	35.00
	32b	Subsoil Drainage Hole	Approved filter media layer	m^3	45.00
	33a	Horizontal Drain Hole	Supply, drill & install ϕ 75mm perforated PVC pipe wrapped with a layer of Geotextile filter fabric of 3.0m into rock slopes	nos.	450.00
	33b	Horizontal Drain Hole	Supply, drill & install ϕ 50mm perforated PVC pipe wrapped with a layer of Geotextile filter fabric of 9.0m length including construct drain outlet to existing berm drain	nos.	600.00
	34	Drainage Well	(To be estimated each case)	--	--
	35	Drainage Tunnel	(To be estimated each case)	--	--
4 Slope work	41a	Shotcrete (Mortar)	Minimum 75mm thickness shotcrete facing c/w one layer welded steel mesh ; supply BRC, ϕ 50mm PVC pipe with geotextile	m^2	100.00
	41b	Shotcrete (Mortar)	Minimum 125mm thickness shotcrete facing c/w two layers welded steel mesh	m^2	150.00
	42	Shotcrete (Concrete)	--	m^2	300.00
	43	Cribwork (Precast)	--	m^2	200.00
	44	Stone Pitching	--	m^2	500.00
5 Anchoring	51a	Soil Nailing	60 kN working load with minimum required length of 6 m inclusive of 0.5 m fixed length into rock	nos.	600.00
	51b	Soil Nailing	--ditto--with minimum required length of 9m	nos.	850.00
	51c	Soil Nailing	--ditto--with minimum required length of 12m	nos.	1,200.00
	51d	Soil Nailing	--ditto--with minimum required length of 12m in soil	nos.	1,000.00
	52	Rock Bolt	200 kN working load with minimum required length of 4.0 m	nos.	1,500.00
	53	Ground Anchor	Design & construct post-tensioned trial permanent ground anchors ; 300 kN working load	nos.	5,000.00
6 Wall	61a	Gabion Wall	Galvanized (For dry application)	m^3	45.00
	61b	Gabion Wall	PVC coated (For wet condition)	m^3	65.00
	62	*Stone Pitching*	--	m^3	*70.00*
	63	Concrete Block Wall	Precast concrete block	m^3	280.00
	64	Retaining Wall (Supported Type)	Concrete + reinforcement	m	400.00
	65a	Crib Wall (Precast)	Single header (4.5 m – 5.0 m)	m	210.00
	65b	Crib Wall (Precast)	Double header (5.0 m – 8.0 m)	m	300.00
	65c	Crib Wall (Precast)	Triple header (8.0 m – 12.0 m)	m	500.00
	66	Pile Wall (PC / RC)	Spun pile ϕ 800 mm : Supply + install	m	260.00
	67	Pile Wall (PC/RC)	RC pile (400 x 400) : Supply + install	m	110.00
	68a	Pile Wall (in-place)	Bored pile ϕ 600 mm : Concrete + Reinforcement + Link + Boring	m	170.00
	68b	Pile Wall (in-place)	Bored pile ϕ 750 mm : Concrete + Reinforcement + Link + Boring	m	250.00
	68c	Pile Wall (in-place)	Bored pile ϕ 900 mm : Concrete + Reinforcement + Link + Boring	m	350.00
	68d	Pile Wall (in-place)	Bored pile ϕ 1,050mm: Concrete + Reinforcement + Link + Boring	m	450.00
	69a	Pile Wall (Steel Sheet Pile)	Supply & deliver to site Type FSP IIIA steel sheet pile	kg	2.10
	69b	Pile Wall (Steel Sheet Pile)	Handle, pitch and drive steel sheet pile	nos.	100.00
7 Pilling	71	Steel Pipe Pile	Steel pipe ϕ 400 mm	m	2,000.00
	72	H Steel Pile	H steel (400 x 400) --	m	2,000.00
	73	Shaft Work for Resistance Slide	(To be estimated each case)	--	--
8 Protection Work	81	Rock Fall Catch Net	--	m^2	100.00
	82	Rock Fall Catch Fence	Supply & erect PVC coated chain link fence including concrete kerbs, posts, structs, staining wires, barbed wires etc. (Reservoir compound)	m^2	200.00
	83	Rock Shed	--	m^3	400.00
	84	Debris Shed	--	m^3	400.00
	85	Slit Dam	--	m^3	300.00
	86	Check Dam (Sabo Dam)	--	m^3	300.00
9 Others	91	Diversion (Shifting)	(Earth work and structure work should be estimated each case)	m	300.00
	92	Route Relocation	(To be estimated each case)	m	

(2) Selection of Countermeasure Work

Selection method of countermeasure work is different, based on slope failure type described in Guide IV "Guide to Countermeasure Selection and Cost Estimation".

Following are basic procedure for countermeasure selection for unstable slopes.

(a) Collapse, Rock Mass Failure and Rock Fall (Cut Slope)

(i) *Stable Slope*

No measure countermeasure work is required. But, probability of small collapse or rock fall shall be checked. If small collapse or rock fall is suspected, preventive or protection work shall be planned. After that, treatment for surface protection shall be planned according to the condition.

(ii) Unstable Slope

Countermeasure work such as soil work or preventive structures shall be planned. In this planning, common countermeasure work shall be proposed. If the failure is large or mechanism of failure is not clear, investigations will have to be performed.

When the size of rock to be treated is smaller than 1 m^3, rock fall netting, rock catch fence, rock fall barrier (gabion), and rock fall shed are applicable, and by these facilities, safety of traffic can be maintained. If the size of rock to be treated is larger than 5 m^3, it will be necessary to plan rather expensive countermeasure work such as, for example, removal of large quantities of rock or rock anchoring.

(iii) Landslide

Basically, treatment of surface and underground water is recommended. This will be able to mitigate movement of the landslide and would bring a major disaster under control. The possibility of soil work such as cut or embankment can also be considered. This countermeasure work is considered to be the most reasonable method for large scale landslide in Malaysia. If it is not possible to apply the above-mentioned methods, rock anchoring or steel pile method shall be considered. But these countermeasure methods will be very expensive for preventing a large landslide. In this case, route relocation could be considered as an alternative plan.

In all cases selection of a suitable plan for countermeasure works for a large landslide is difficult, because it contains not only engineering problems but also traffic system issues.

(iv) Debris Flow

The following three steps are recommended for planning of treatment works for debris flow.

(a) Minor road relocation
(b) Improvement of road structure
(c) Prevention work of debris flow

(a) Minor road relocation and (b) Improvement of road structure are similar in terms of treatment method. When debris flow is considered probable for the site, the road structure shall be improved, which may include relocation of the road to prevent it being destroyed by debris flow. If it is not possible to improve the road structure, it will be required to plan constructing structures like "Sabo Dam" to guard the road facility and traffic safety.

(v) Embankment Failure

Failure of embankment has two aspects.
(a) Slope stability depending on strength of material and geometry of slope
(b) Drainage ability mainly through culvert

For the failure of embankment slope, suitable countermeasure work shall be planned according to the failure mechanism or size of failure. On the other hand drainage ability is a problem of road structures. Both, water flow ability and condition of the crossing channel shall be considered in planning treatment or improvement of road structure.

(vi) Amount

Amount of each countermeasure shall be entered. Cost is automatically in the system.

4.3.2 Consequence Data

The items for consequential attributes are as follows. These indicators are also used for judgement of priority.

(1) Services, Public Utilities

If gas, oil, telecommunications, electric, or water pipe line installations are within a distance of 2 H (H: height of slope), mark "Yes". (Figure 4.3.1)

(2) Danger to Building Occupants

Distance from the toe of slope to the building shall be measured. When the distance is less than two times of slope height, there is danger to the building. (Figure 4.3.1)

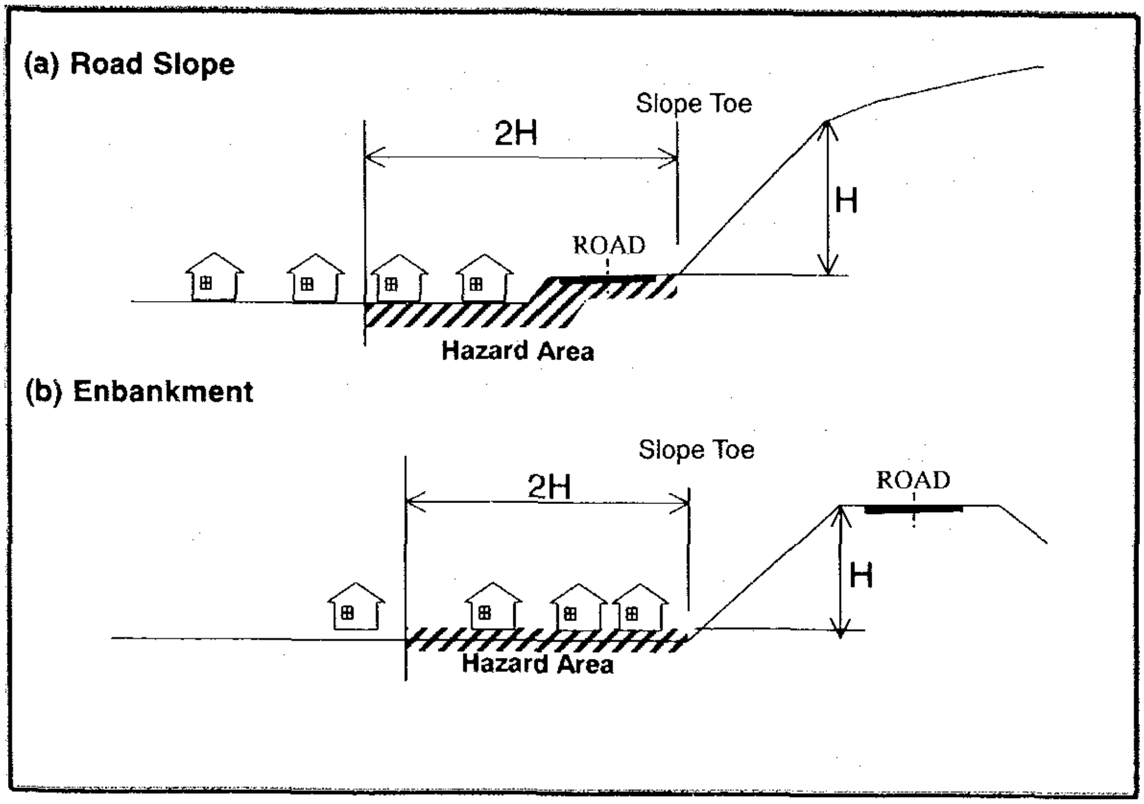


Figure 4.3.1 Distance of Services, Public Utilities and Building

(3) Volume of Traffic
Volume of traffic is available in "Road Traffic Volume Malaysia" which is published every year by Highway Planning Unit Ministry of Works. Annual Average Daily Traffic (AADT) is divided into following three grades.

(a) > 1,000 AADT
(b) 200 - 1,000 AADT
(c) < 200 AADT

(4) Failure size (volume)

Failure size could be estimated by the following formula.(Figure 4.3.2)

V = 1/3LWD
V: Volume of slope failure (m^3)
L: Length of failure (m)
W: Width of Failure (m)
D: Depth of maximum failure depth (m); Presumed depth

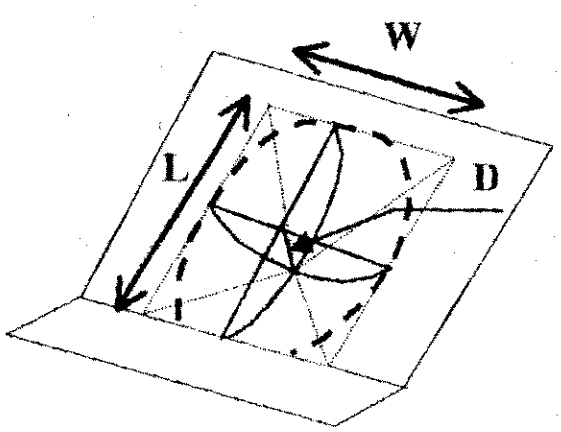


Figure 4.3.2 Estimation of Failure Volume

(5) Angle β (road at centre--line to crest or embankment toe)
Angle at the centre line to the top of slope shall be measured. (Figure 4.3.3)

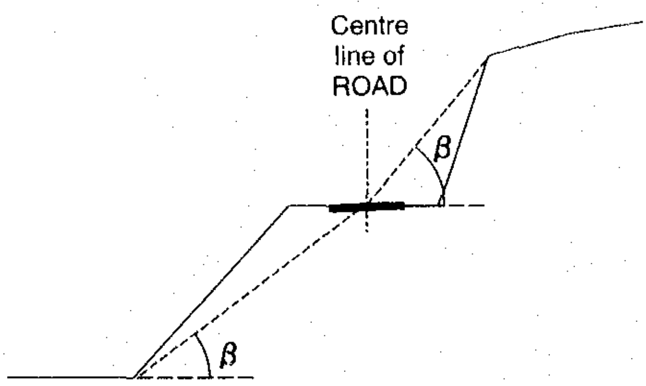


Figure 4.3.3 Definition of Angle β

(6) Construction Period of Temporary Diversion

If the road is likely to be destroyed by a failure, it is estimated whether the time to construct a temporary diversion will take more than one day or not.

(7) Length of Alternative Roads

Length of alternative roads shall be estimated by using maps.

4.3.3 Local Information

The following items shall be entered on the basis of field observations and data research.

(1) Building Types

(2) Vegetation and Cultivation

(3) Rainfall Information

Building type and vegetation/cultivation within the distance from the toe of slope to the building shall be investigated. These will be used for economic analysis.

Rainfall information of the nearest rain gauge station shall be collected and the following data shall be entered.

(a) Annual Average Rainfall

(b) Monthly Rainfall (maximum and month that it occurs/minimum and month)

(c) Daily Rainfall (maximum and month in which it occurs/minimum and month)

Rainfall data can be available from the records of MMS (Malaysia Meteorological Service) and DID (Department of Irrigation and Drainage).

CHAPTER 5 DATABASE CREATION AND REPORTING

The survey team shall create a database and prepare the report on slope inspection arranging results of the slope inspection.

5.1 Database Creation

The study team shall input all the data of slope inspection into the information system SIMS (Slope Information Management System). The entry method is described in the Guide V "User's Guide"

5.2 Reporting

Following matters shall be arranged in the hard copy report.

(1) Preparatory Work
- Disaster records in the study area
- Record of countermeasure work which is implemented for slope disaster rehabilitation
- Topographic maps (larger than 1:50,000)
- Map of road plan
- Geological information of the area
- Result of aerial photographs interpretation
- Others

(2) Selection of slope to be inspected
- Criteria for selection
- Result of selection

(3) Slope Inspection
- Method of slope inspection
- Record of each inspection Form (Form A to Form F)
- Table of summary
- Comments on the result

Comments on the results shall be reported including general recommendation for road slope maintenance.

References

1) Manual of slope inspection for road disaster management, 1996; Road Management Centre of Japan

2) East-West highway long term preventive measures and stability study project: completion report, 1996; JKR Malaysia

3) East-West highway long term preventive measures and stability study project: final risk analysis report, 1996; Road Branch, Public Works Malaysia

4) East-West highway long term preventive measures and stability study project: slope maintenance system (SMS) operational manual , 1996; JKR Malaysia

5) Assessment of hillslope stability, site investigation and design, case study, Gunung Raya, Langkawi, MEHMS user reference manual, 1998; JKR Malaysia

6) JKR slope inspection guideline and notes, 2000; JKR Malaysia

7) Slope management system in JKR, 2000; Kamar Kasim and Lai Khin Onn, Proceeding of 4th Malaysian Road Conference

8) Evaluation of slope stability against rock falls and slope failures, 199 1 ; Katuya Kutara and others: 126th Conference of The Japanese Geotechnical Society

9) Landslide-investigation and management, 1996; A.Keith and Robert L Schaster, Transportation Research Board, USA

10) Slope geology-Research trend and future prospect, 1999; T Fujita and Others, Japan Society of Engineering Geology

11) Site investigation and Stabilization Methods for Rock Slopes, 1999; Civil Engineering Society of Japan

12) Handbook for Rock Fall Countermeasure, 2000; Japan Road Association

Appendix 4.2

Slope Inspection Sheets

SLOPE INSPECTION SHEET	input **FORM A** GENERAL SLOPE DATA	

General Slope Data

Most Likely Failure Type	*1. Collapse / Rock Fall 2. Rock Mass Failure 3. Landslide 4. Debris Flow 5. Embankment Failure 6. No Action Needed (Form A only)*		
Chainage	*Start km - End km*	Type of Slope	*Cut / Embankment / Natural*
Side of Road	*Right / Left*	Distance from Road Centre-Line	*m*
JKR Slope ID		Date Inspected	/ /
Field ID		Inspected by	
Route Name		Date Checked	/ /
District Name / State Name	/	Checked by	
Realignment Event (Description)	*Yes / No (if 'yes', describe)*		
Disaster Record			

Location Map (1:50,000)

Date Entered in SIMS	/ /
Entered by	

A.Figure 4.2.1 Inspection Sheet Form A

SLOPE INSPECTION SHEET		input FORM B SLOPE SKETCH	
JKR Slope ID :	Chainage: Start km - End km	Side of Road : *Right / Left*	Date:

A.Figure 4.2.2 Inspection Sheet Form B

SLOPE INSPECTION SHEET		input FORM C PHOTOGRAPH	
JKR Slope ID :	Chainage: Start km - End km	Side of Road : *Right / Left*	Date:

A.Figure 4.2.3 Inspection Sheet Form C

SLOPE INSPECTION SHEET input **FORM D**
SLOPE FEATURE

JKR Slope ID :	Chainage: Start km - End km	Side of Road : *Right / Left*	Date:

GEOMETRY	Height of Slope	m	No. of Berms	
	Angle of Slope (range)	- deg	Width of Berms	m
	Average Angle of Slope	deg	Berm Height	m
GEOLOGY	Soil Name (if soil)	*Gravel / Sand / Silt / Clay / Peat / other ( )*		
	Geological Name – Sedimentary	*Sandstone / Mudstone / Siltstone / Conglomerate / Limestone / Chert / Shale / Alternation of Sandstone & Mudstone / other ( )*		
	Geological Name – Igneous	*Rhyolite / Dacite / Andesite / Basalt / Granite / Granodiorite / Diorite / Gabbro / Ultrabasic Rocks / Tuff / Pyroclastic / other ( )*		
	Geological Name – Metamorphic	*Slate / Phillite / Schist / Marble / Hornfels / Gneiss / other ( )*		
	Weathering Grade	*I, II, III, IV, V, VI*	Composition Ratio of Rock : Soil (%)	
	Discontinuities Type	*1, 2, 3, 4, 5, 6, 7, 8*	Rock : Soil = :	
EROSION	Sheet Erosion	*Severe (>40%) / Moderate (10%-40%) / Minor (<10%)*		
	Rill Erosion	*Severe (0.2-0.5m depth) / Moderate (<0.2m depth) / Minor*		
	Gully Erosion	*Severe (>one berm) / Moderate (one berm) / Minor*		
	Fretting Erosion	*Severe (>40%) / Moderate (10%-40%) / Minor (<10%)*		
COVER / EXISTING COUNTERMEASURE	Type	*Trees / Shrubs / Grass / Gunite / Dental Concrete / Others ( )*		
	Engineering Features		Percentage covered	%
	Gabions	*H= m, L= m*	*Rock Bolts*	m^2
	Crib Wall	*H= m, L= m*	*Netting*	m^2
	Concrete Wall	*H= m, L= m*	*Soil Nail*	m^2
	Masonry	*H= m, L= m*	*Piles*	*m interval, m extension*
	Others		*Comments*	
DRAINAGE	Roadside Drains	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Cascade Drains	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Berm Drains	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Cut-Off Drains	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Horizontal Drains	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Culvert Passageway	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Culvert Inlet	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Culvert Outlet	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Culvert Wingwalls	*Good Condition / Needs Desilting / Needs Repair / Not Present*		
	Culvert ID			
	Hydrological Condition	Seepage from Slope Face or Ground?: *Yes / No*		
		Natural Surface Runoff?: *Yes / No*	Ponding Water Nearby?: *Yes / No*	
	Comments			
PAVEMENT	Cracks?:	*Yes / No*	Depression?:	*Yes / No*
	Cracks Sealed?:	*Yes / No*	Shoulder Depression?:	*Yes / No*
	Shoulder Cracks?	*Yes / No*	Cause of Cracks?:	*Pavement / Slope failure*

INSTRUMENTATION (type & condition, if any)	*Inclinometer*	*Piezometer*	*Tensiometer*	*Rain Gauge*	*Pressure G.*	*Others( )*
	Good / Bad	*Good / Bad*	*Good / Bad*	*Good / Bad*	*Good / Bad*	*Good / Bad*

A.Figure 4.2.4 Inspection Sheet Form D

SLOPE INSPECTION SHEET input **FORM E1**
COLLAPSE / ROCK FALL

JKR Slope ID :	Chainage: Start km - End km	Side of Road : *Right / Left*	Date:

Condition of Slope ✔ tick one

TOPOGRAPHY	Alluvium Slope	*Yes*		2
		No		0
	Trace of Collapse	*Yes*		1
		No		0
	Clear Knick Point or Overhang	*Yes*		1
		No		0
	Concave Slope or Debris Slope	*Yes*		1
		No		0
GEOMETRY *Select Higher Point of A or B*	A : Soil Slope H : Height of Soil i : Angle of Slope	*H > 30m*		30
		H ≤ 30m i > 45 deg		24
		15m ≤ H < 30m i ≤ 45 deg		20
		H < 15m i ≤ 45 deg		10
	B : Rock Slope H : Height of Rock	*H > 50m*		30
		30 m ≤ H < 50m		26
		15 m ≤ H < 30m		20
		H <15m		10
MATERIAL Select A and B	A : Soil Character Swelling Clay Contents	*Conspicuous*		8
		Slightly		4
		No Swelling Clay		0
	B : Rock Quality Sheared Rock, Weathered Rock	*Conspicuous*		8
		Slightly		4
		Not Available		0
GEOLOGICAL STRUCTURE	Daylight Structure (Planar, Wedge)	*Yes*		8
		No		0
	Soft Soil over Base Rock			6
	Hard Rock over Weak Rock			4
	Others			0
DEFORMATION	Slope Deformation Gully Erosion, Rill Erosion, Sheet Erosion, Fretting Erosion, Rock Fall, Exfoliation, Swelling	*Visible*		10
		Obscure		8
		No Slope Deformation		0
	Deformation at Adjacent Slope Rock Fall, Collapse, Crack, Swelling, Other deformation	*Visible*		5
		Obscure		3
		No Slope Deformation		0
SURFACE CONDITION	Condition of Surface	*Unstable*		8
		Moderate		6
		Stable		0
	Ground Water	*Natural Spring*		6
		Water Seepage		3
		Dry		0
	Cover	*No-vegetation, Grass*		4
		Complex (Grass + Structure)		3
		Structure		1
	Surface Drainage	*Available (good)*		0
		Available (need repair)		2
		Not Available		1
		Score		

Countermeasure ✔ tick one

Effective		-20
Partially Effective		-10
Not effective or No Countermeasure		±0
Hazard Score		

A.Figure 4.2.5 Inspection Sheet Form E1

JKR	**SLOPE INSPECTION SHEET**	*input* **FORM E2** ROCK MASS FAILURE	
JKR Slope ID :	Chainage: *Start* *km -* *End* *km*	Side of Road : *Right / Left*	Date:

Condition of Slope ✔ tick one

TOPOGRAPHY	Slope Type	*Convex Slope*		4
		Debris Sediment		3
		Concave Slope		1
		Other		0
	Knick Point	*Visible*		7
		Moderate		4
		No Knick Point		0
GEOMETRY	Angle of Slope	*Overhang*		4
		> 60°		2
		< 60°		0
	Height of Slope	*> 100m*		10
		50 < H ≤ 100m		7
		30< H ≤ 50m		4
		< 30m		2
GEOLOGICAL CONDITION	Scale of Open Crack	*Large* *≥ 20 mm*		25
		Small *< 20mm, ≥ 5mm*		15
		No Open Crack *< 5mm*		0
	Upper Part : Hard Rock / Lower Part :Soft Rock			6
	Upper Part : Soft Rock / Lower Part : Hard Rock			4
	Wholly Soft Rock			4
	Wholly Hard Rock			2
	Others			0
GEOLOGICAL STRUCTURE	Crack	*Regular Cracks : interval > 1 m*		18
		Regular Cracks : interval ≤ 1 m		12
		Irregular		6
	Daylight Structure or Non-Daylight Structure (Fault, Joint, Crack, Bedding)	*Daylight*		15
		Non-Daylight		5
		No Plane		0
DEFORMATION	Trace of Small Collapse or Small Rock Fall	*Yes*		7
		No		0
SURFACE CONDITION	Spring or Seepage on Slope	*Yes*		2
		No		0
	Surface Drainage	*Available (good)*		0
		Available (need repair)		2
		Not Available		1
			Score	

Countermeasure ✔ tick one

Effective		-20
Partially Effective		-10
Not effective or No Countermeasure		±0
	Hazard Score	

A.Figure 4.2.6 Inspection Sheet Form E2

SLOPE INSPECTION SHEET input **FORM E3**
LANDSLIDE

JKR Slope ID :	Chainage: Start km - End km	Side of Road : Right / Left	Date:

Condition of Slope ✔ tick one

TOPOGRAPHY	History of Landslide	Yes		10
		No		0
	Anomaly Disturbed Contour Lines Geographical Features like Scarp at Top of Slope	Obvious		40
		Partially		30
		Uncertain		10
GEOLOGICAL STRUCTURE	Fault, Sheared Zone			10
	Alteration Zone			10
	Daylight Structure			6
	Non-Daylight Structure			3
	Intrusive Structure, Cap Rock Structure			3
	Others			0
GEOLOGICAL CONDITION	Shale or Schist			3
	Others			2
DEFORMATION	Bulging at Toe	Yes		8
		No		0
	Depression or Subsidence	Yes		8
		No		0
	Cracks on Surface, Diagonal Tension, Shear Cracking	Yes		8
		No		0
	Deformation of Countermeasure	Yes		8
		No		0
SURFACE CONDITION	Spring, Natural Waterpath	Yes		3
		No		0
	Surface Drainage	Available (good)		0
		Available (need repair)		2
		Not Available		1
		Score		

Countermeasure ✔ tick one

Effective		-20
Partially Effective		-10
Not effective or No Countermeasure		±0
Hazard Score		

A.Figure 4.2.7 Inspection Sheet Form E3

SLOPE INSPECTION SHEET input **FORM E4**
DEBRIS FLOW

JKR Slope ID :	Chainage: Start km - End km	Side of Road : Right / Left	Date:

Condition of Slope ✔ tick one

TOPOGRAPHY	Contributory Area of Occurrence (Gradient of Stream ≥15deg)	$\geq 0.50\ km^2$		15
		$0.15 \leq A < 0.50\ km^2$		10
		$< 0.15\ km^2$		5
	Extreme Steep Gradient of Stream	$\geq 40°$		15
		$30° \leq \theta < 40°$		10
		$< 30°$		0
	Area of Slope Gradient more than 30° in Source Area	$\geq 0.20\ km^2$		13
		$0.08 \leq A < 0.20\ km^2$		8
		$< 0.08\ km^2$		4
COVER IN SOURCE AREA	Area of Grassland and Bush	$\geq 0.20\ km^2$		13
		$0.02 \leq A < 0.20\ km^2$		8
		$< 0.02\ km^2$		0
	Existence of Earth Works/ Ponds/ Logging activity/Seepage	Yes		10
		No		0
DEFORMATION IN SOURCE AREA	Existence of New Crack, Scarp	Yes		10
		No		0
	History of Collapse	Yes		15
		No		0
TRACE	Trace of Debris Flow	Yes		9
		No		0
		Score		

Countermeasure ✔ tick one

Effective		-20
Partially Effective		-10
Not effective or No Countermeasure		±0
Hazard Score		

A.Figure 4.2.8 Inspection Sheet Form E4

SLOPE INSPECTION SHEET input **FORM E5**
EMBANKMENT FAILURE

JKR Slope ID :	Chainage: Start km - End km	Side of Road : Right / Left	Date:

Condition of Slope ✔ tick one

GEOMETRY	Angle of Slope	> 45 deg		10
		> 33 deg, ≤ 45 deg		5
		≤ 33 deg		0
BASE GROUND	*Unstable Toe*			8
	Poor Subsoil			5
	Alluvium			5
	Stable Toe			0
	Uncertain			3
FILL MATERIAL	*Sandy Soil*			5
	Clayey Soil			0
	Gravel			0
	Unknown			3
GROUND WATER AND SURFACE WATER	Wet at Toe of Fill Slope	*Yes*		8
		No		0
	Trace of Water Flow on Slope Surface	*Yes*		8
		No		0
	Seepage from Fill Slope	*Yes*		8
		No		0
	Surface Drainage	*Need Repair*		5
		Not Available		3
		Good		0
CONDITION OF CULVERT	Insufficient or No Culvert	*Yes*		10
		No		0
	Insufficient Treatment at End of Culvert	*Yes*		7
		No		0
	Bending or Reduction of Culvert	*Yes*		5
		No		0
DEFORMATION	Cracks, Creeping	*Yes*		10
		No		0
	Surface Erosion	*Yes*		8
		No		0
	Existence of Repaired Portion	*Yes*		5
		No		0
	Swelling on Slope	*Yes*		3
		No		0
		Score		

Countermeasure ✔ tick one

Effective		-20
Partially Effective		-10
Not effective or No Countermeasure		±0
Hazard Score		

A.Figure 4.2.9 Inspection Sheet Form E5

SLOPE INSPECTION SHEET input **FORM F**

PROPOSED COUNTERMEASURE & CONSEQUENCE

JKR Slope ID :	Chainage: *Start* km - *End* km	Side of Road : *Right / Left*	Date:

Proposed Countermeasure

Countermeasure	Amount	Remarks

Comments

Consequence Data

✔ tick one

Services, Public Utilities if gas, oil, telecom, electric or water pipelines are available, mark "Yes"	*Yes*		2
	No		0
Danger to Building Occupants only mark "Yes", if distance from toe of slope ~ 2H (H : Height of Slope)	*Yes*		2
	No		0
Volume of Traffic (AADT = Annual Average Daily Traffic)	*> 1,000 AADT*		2
	200 - 1,000 AADT		1
	< 200 AADT		0
Angle β (road at centre-line to crest or embankment toe)	*> 30°*		1
	≤ 30°		0
Failure Size (a) Cut Slope (m^3)	*(a) > 3,000 or (b) > 1,000*		1
(b) Embankment (m^3)	*(a) ≤ 3,000 or (b) ≤ 1,000*		0
Construction Period of Temporary Diversion	*> 1 day*		1
	≤ 1 day		0
Length of Alternative Roads	*> 50km*		1
	≤ 50 km		0
	Consequence Score		

Local Information

Building Type	*Residential / Hotel / Commercial /Hospital / Factory / School / Others( )*			
Vegetation / Cultivation	*Primary Forest / Secondary Jungle / Grass / Rubber / Oil Palm / Coconut / Paddy Field / Others ( )*			
Rainfall Information	Annual Average		(mm)	
	Monthly Average	Maximum	(mm)	
			Month	
		Minimum	(mm)	
			Month	
	Daily	Maximum	(mm)	
			Month	
	Nearest Station			

A.Figure 4.2.10 Inspection Sheet Form F

JICA