CHAPTER 8 SUMMARY OF GUIDELINES FOR ROAD SLOPE DISASTER MANAGEMENT

Guidelines for Road Slope Disaster Management was studied and proposed in a separate volume of the final report.

The objective of preparation of the guidelines is to be a guide for JKR staff at headquarters and local offices to implement the new slope management system in managerial and technical aspect. However, we believe that some portions of the guidelines may be useful for people in private sector who will be involved with some works in slope management program.

It consists five (5) of Guides as listed below:

Guide I: Guide to Road Slope Maintenance and Disaster Management
Guide II: Guide to slope Inspection
Guide III: Guide to Early Warning and Site Investigation
Guide IV: Guide to Countermeasure Selection and Cost Estimation
Guide V: Guide to Slope Information Management System (SIMS)

The contents of each Guide are summarized in Table 8.1.1 as below. As shown in the Table, Guide I has two functions; first to offer overview of road slope management, *including its basic concept and flow of various works for slope management.*

On the other hand, other Guides from II to IV handles of each specific technical area, offering technical guide including suggested specification and procedures. And Guide V is prepared to be the user's reference of the newly developed slope information management system (SIMS).

Table 8.1.1 The Contents of Each Guide

Name of Guide		Contents
Guide I:	Guide to Road Slope Maintenance and Disaster Management	Overview of slope disaster management (Ch 1-5)
		Procedures of slope maintenance and disaster management (Ch 6-8)
Guide II:	Guide to slope Inspection	Technical guide; suggested specification and procedures of each technical area.
Guide III:	Guide to Early Warning and Site Investigation	
Guide IV:	Guide to Countermeasure Selection and Cost Estimation	
Guide V	Guide to Slope Information Management System (SIMS)	User's reference of SIMS.

8.1 Guide I: Guide to Road Slope Maintenance and Disaster Management

8.1.1 Preface

As mentioned in the previous page, Guide I describes the overview of slope disaster management in Chapter 1 to 5, and actual procedure of slope maintenance and disaster management in Chapter 6 to 8.

In preparation of this Guidelines, many of preceding literatures in Malaysia and overseas including Japan, have been carefully reviewed. And lots of efforts were made so that suggested methods and criteria should be suitable as much as possible to the application to federal roads in Malaysia.

It is suggested for JKR to make necessary modification through actual application to be best fit to local conditions. It is desired that these Guidelines would be the starting point of establishment of a management handbook, "Manual of Road Slope Disaster Management, Malaysia".

8.1.2 Outline of Road Slope Disaster Management

The mission, basic concept and workflow of road slope management are described.

(1) Basic Component of Road Disaster Management

Figure 8.1.1 shows the basic concept of road slope disaster management, which can be divided into three (3) stages as below:

Stage I: Evaluation of Slope Disaster Risk(Slope inspection and risk rating)
Stage II: Prevention of Slope Disaster Risk (Planning and implementation of countermeasure and other slope maintenance works)
Stage III: Emergency Management (Preparedness plan and response action)

(2) Categorization of Slope Management Level

According to the risk rating score, all the target slopes are divided into four (4) categories of management level as shown in Table 8.1.2.

Table 8.1.2 Category of Slope Management Level in terms of Risk Rating value

Slope Management Level	Value of Risk Rating	Basic Policy of the Slope management
Level I	Very High	Implementation of countermeasure
Level II	High	Regular patrol and monitoring
Level III	Moderate	Periodical inspection
Level IV	Low	Screening out of slope follow- up list

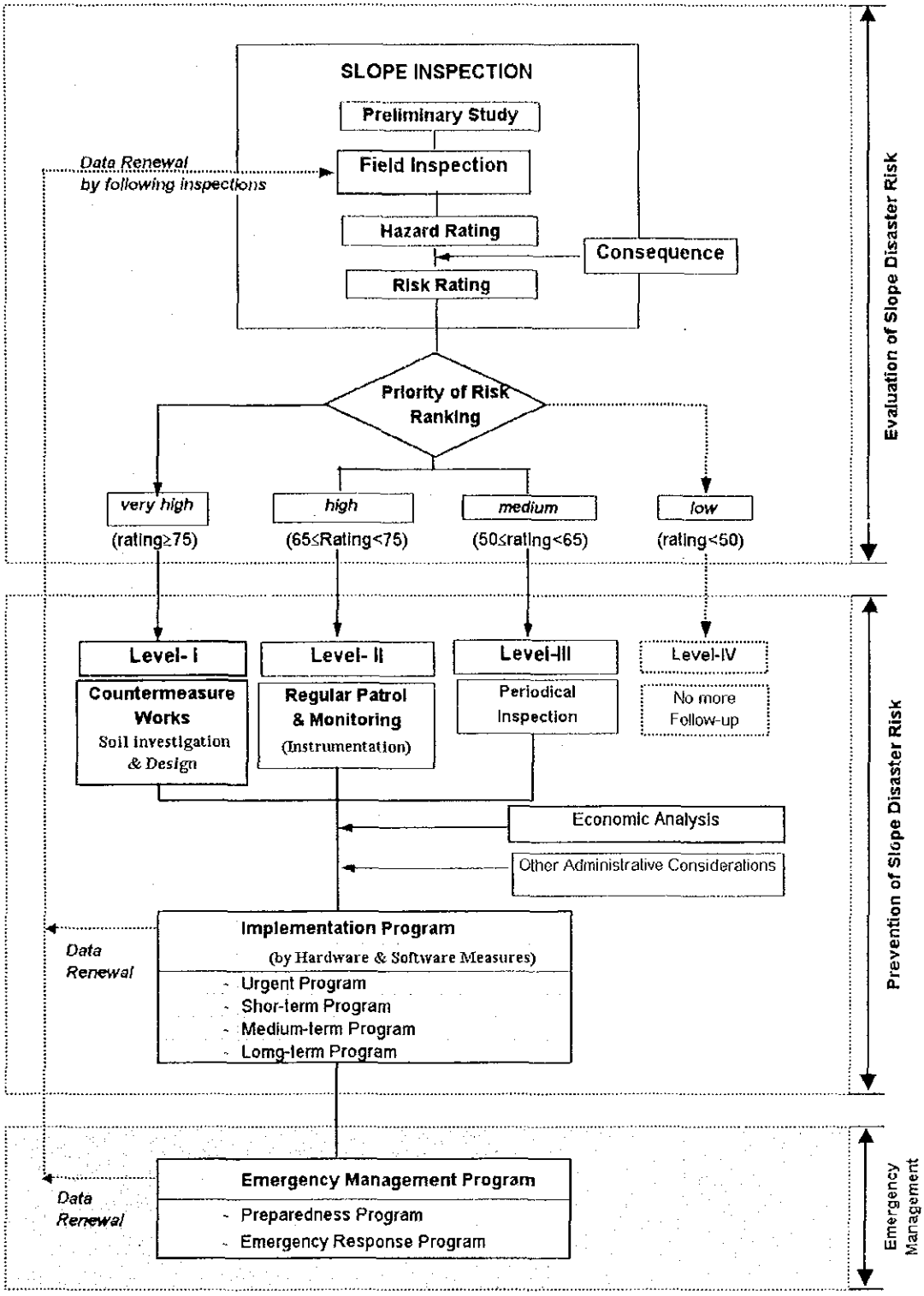


Figure 8.1.1 Basic Concept of Road Slope Disaster Management

8.1.3 Organization for Road Slope Disaster Management

Since February 2001 routine road maintenance was transferred from JKR offices to private maintenance companies along the government's privatisation policy. However the responsibility of slope maintenance still remains in the hand of JKR offices.

Thus it is emphasized that close relationship should be established between JKR offices and the private maintenance companies, in respect of close and timely information exchange and cooperation for slope maintenance and management.

Figure 8.1.2 shows the organization chart for road management of federal roads in Malaysia, which makes contrast between the work by private maintenance companies and those by JKR offices themselves.

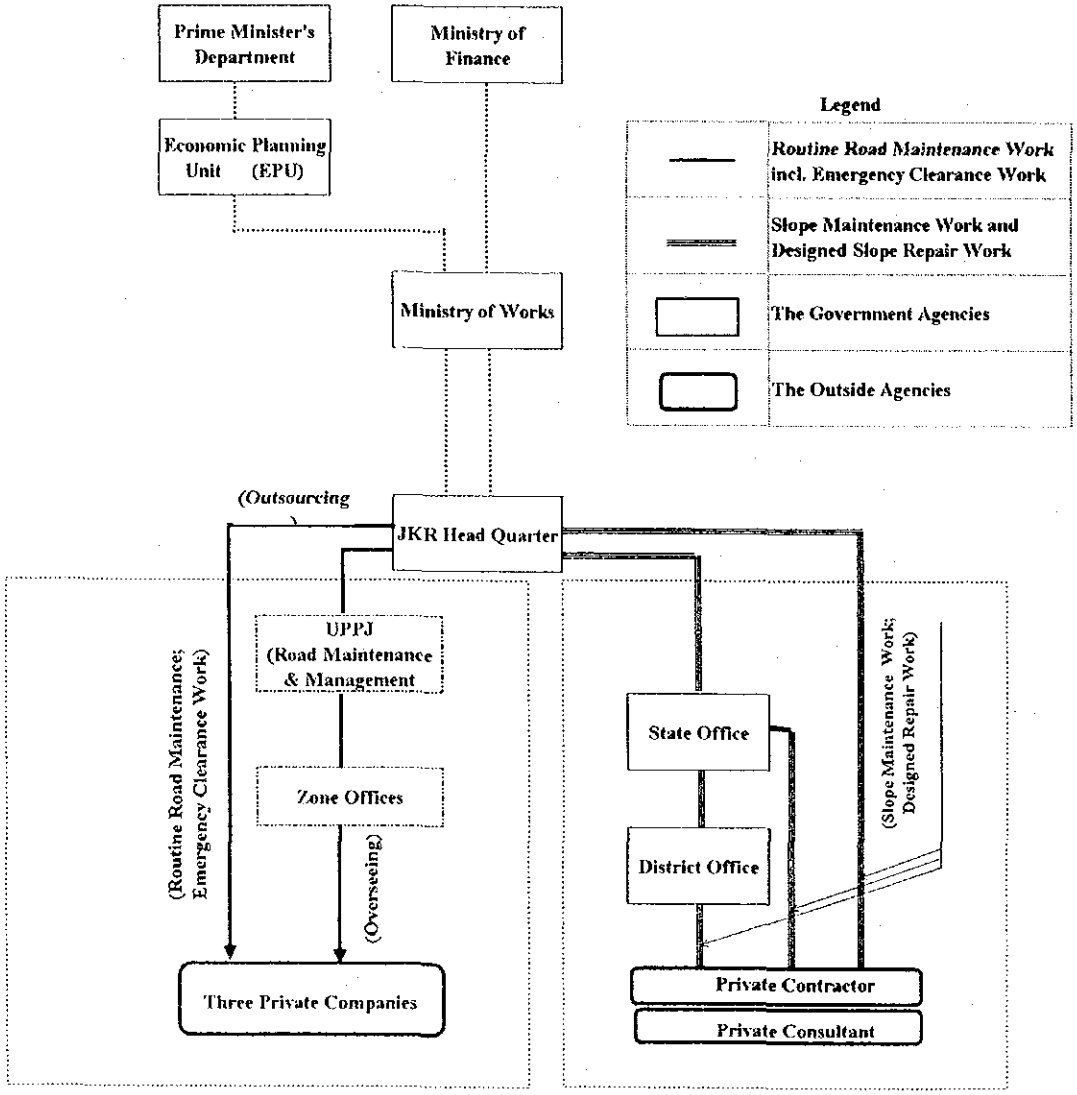


Figure 8.1.2 Organization for Road Slope Management

8.1.4 Slope Inspection and Risk Rating

The concept and technical specification of slope inspection and risk rating are described, while the detail is explained in Guide II: Slope Inspection.

The slope inspection and risk rating is essential jobs for effective and efficient planning of countermeasure and other slope maintenance and disaster management.

Following the existing slope management system such as SMS and SPRS, the risk rating score (R) of each slope is calculated from Hazard rating (H), stability of slope, and Consequence score (C), factors to evaluate the socio-economic influence by slope failure.

To improve the reliability of risk rating, more precise inspection system was introduced in the new system, in reference to the methodology that have been employed in Japan for many years. Special features in the proposed slope inspection methodology are;

1) Slope inspection is carried out based on the slope failure type (Table 8.1.3)
2) Slope inspection is carried out by trained geologist or geotechnical engineer, not by technician at local offices.

Table 8.1.3 Classification of Slope Failure

Type of Slope	Type of Slope Failure
Cut & Natural Slope	1 Collapse (CL)
	2 Rock Fall (RF)
	3 Rock Mass Failure (RM)
	4 Landslide (LS)
Stream & River	5 Debris Flow (DB)
Embankment Slope	6 Embankment Failure (EB)

8.1.5 Implementation of Countermeasure

(1) Implementation of Slope Management Plan

Priority risk ranking list is prepared based on the risk rating score. Final decision of slope management plan is established taking into consideration the cost of countermeasure, economic indicator, and other administrative consideration. Table 8.1.4 show an example of priority risk ranking list for the case study.

Basically the slopes identified as of very high risk is categorized into Level-I and countermeasure work will be constructed, as soon as necessary budget was allocated. The slopes categorized as Level-II and some of the slopes of Level-I which are on the waiting list of countermeasure implementation will be monitored by way of regular slope patrol and instrumentation.

Table 8.1.4 Example of Priority Risk Ranking List

No	Slope ID	New Score ID	Type of Slope	Type of Failure	Hazard Score	Conse-quence	Risk Rating	Risk Level	Estimated Cost (RM)	Economic Indicator (V_T/C)	Final Decision
1	-	0004/071/500RC	1	4	86	8	85	V.H	2,427,500		
2	1091	0004/081/150LC	1	4	85	7	84	V.H	727,000		
3	385	0004/031/460RC	1	1	82	7	81	V.H	356,935		
4	396	0004/032/080RC	1	1	79	7	78	V.H	995,000		
5	-	0004/072/680LC	1	4	77	8	77	V.H	674,606		
6	415	0004/033/300RC	1	1	79	6	77	V.H	120,755		
7	392	0004/031/920RC	1	3	77	7	76	V.H	309,600		
8	-	0004/069/520LC	1	1	77	7	76	V.H	2,108,267		
9	647	0004/050/900RC	2	6	75	8	76	V.H	206,988		
10	432	0004/035/530LC	1	3	74	6	73	H	1,312,314		
11	441	0004/036/140LC	1	4	69	8	70	H	1,426,400		
12	332	0004/027/350RC	1	1	70	7	70	H	191,267		
13	433	0004/027/910RC	1	1	71	6	70	H	214,812		
14	474	0004/038/800RC	1	1	72	6	70	H	264,318		
15	442	0004/032/950RC	1	1	71	5	69	H	152,143		
16	468	0004/038/530LE	2	6	68	7	68	H	422,521		
17	533	0004/042/380LC	1	1	69	6	68	H	130,023		
18	1083	0004/080/700RE	2	6	70	5	68	H	115,800		
19	345	0004/028/240RC	1	1	69	5	67	H	356,250		
20	628	0004/049/680RE	2	6	65	7	66	H	95,338		

Note: The boundary risk rating value may be determined flexibly for each road, taking the importance of the road, volume and type of likely slope failure, allocation of budget for slope disaster management, and so on. (In the SIMS, the boundary values between each risk level are set as 80, 60, and 40, respectively)

(2) Site Investigation and design of Countermeasure Work

When implementation of countermeasure was confirmed, detailed investigation for proper design should be carried out. The location and scope of site investigation should be carried out with careful attention to the type of likely slope failure. Guide-III explains the detailed procedure of investigation planning.

The most appropriate methods of countermeasures should be carefully selected taken into consideration site conditions, in particular the types of slope failure. Guide III explains the detailed procedure of selection of countermeasure method.

(3) Cost Estimation of Countermeasure Work

The approximate cost of slope countermeasure can be estimated using SIMS (Slope Information System) based on the scope and number suggested in slope inspection. The typical rate table was prepared through careful study with JKR and consulting companies.

8.1.6 Slope Maintenance

The importance of slope maintenance cannot be overestimated as many of risky slopes will be left as unimplemented due to shortage of countermeasure budget. In another view if slope maintenance is properly carried out, it can work effectively for avoiding slope disaster with limited cost.

From technical aspect, deterioration of slope ground by natural and artificial effects is considered as another reason for necessity of slope maintenance, even the slope where some countermeasure was implemented.

In the Guide-I, importance of two (2) items are emphasized as below:

(1) Regular patrol with special attention to slope

As routine road maintenance is taken over by maintenance companies, JKR staff for regular road patrol should give special attention to the stability of slopes, particularly rated as of Very-high-risk and of High-risk. It is recommended to make best use of slope database operated by SIMS. Any unusual phenomenon related to slope stability is suggested to take note and report for quick action, when necessary.

(2) Recording system of Patrol, Disaster and Countermeasure Work

Unfortunately there is no official recording system for slope maintenance and disaster management at JKR local offices. Record of historical events on slope is quite useful for further slope maintenance, similar to medical record on human body. Simple recording formats were proposed in the Guide-I in connection with:

- Record of regular slope patrol
- Record of slope disaster occurrence, and
- Record of slope countermeasure work (repair work).

8.1.7 Early Warning and Traffic Control

Early warning and traffic control can be thought as very effective measures to avoid occurrence of slope disaster, particularly at slopes where effective countermeasure work has not yet constructed.

There are two ways for early warning and traffic control:

(1) Based on slope monitoring data
(2) Based on rainfall data

The early warning for (1) will be done for specific slope, while (2) will be done for the road or a portion of it represented by the rain gauge data.

(1) Early warning using Monitoring Instrument

The applicability of various monitoring instrument is summarized in Table 8.1.5. Rain gauge, wire-extensometer and rock fall detector are applicable for early warning and traffic control, after proper criteria has established in local conditions.

Table 8.1.5 Applicability of Monitoring Instrument for Early Warning

Instrument	Measuring Item	Criteria for Early Warning	Applicability
1) Rain gauge	Rainfall (Hourly rain & accumulated rain)	Warning can be issued on basis of criteria, which preferably be established by local data..	Applicable
2) Wire-extensometer	Slope surface movement (strain)	Warning can be issued on basis of common criteria (effective for landslide and rock mass failure).	Applicable
3) Rock fall detector	Detection of rock fall	Warning can be issued by detection of actual fall.	Applicable
4) Other instrument: -borehole inclinometer, tilt meter, crack gauge, piezometer etc.		Useful for detailed slope study, but hard to fix the criteria for warning.	Not applicable

(2) Traffic Control under Heavy Rain Conditions

In case there are some possibilities of failure at many slopes along the road section, traffic control or warning is useful measure under heavy rain conditions. In Japan big efforts have been made for years to establish proper criteria for traffic control.

Several methods for determination of criteria were introduced in the Guide. However, it should be noted that proper criteria should be established on the basis of historical data for each of local region.

Thus it is proposed that JKR should make best efforts to accumulate the local data about the rainfall (hourly rain and accumulated rain) and occurrence of slope failure, so that most effective and reliable criteria for control could be materialized.

8.1.8 Road Disaster Emergency Plan

Study of emergency plan is one of essential components in road disaster management, because any of well-prepared disaster plan cannot be perfect in avoiding occurrence of slope disaster due to technical and financial limitation.

The emergency plan should consist of two (2) portions;

- Emergency preparedness plan, and
- Emergency response plan

The above plans should describe the objective, organization, function of each concerned organization and staff, reporting and communication, cooperation with concerned parties, procurement/mobilization of necessary personnel and equipment, and so on. After establishment of the plan, the contents should be announced to all the concerned people. Training and field demo operation should be arranged for a preparation of emergency event.

In this version of the Guide, the concept of basic items was presented. It is suggested for JKR to complete concrete plan defining actual procedures and person/organization.

Appendix 8.1 Examples of Supporting Tools to Disaster Management

In the appendix, some hardware and software types of tool for road disaster management is introduced. Making use of latest information technology, disaster prevention and provision of services to road user has been developed. Those systems are combination of GPS based car navigation, mobile phone, internet, radio beacon and FM wave broadcasting, electronic announcement board and various kinds of monitoring instrument.. VICS (Vehicle Information Communication System) is one of those traffic service systems.

Also Japanese government has been arranging some schemes of support from private sectors for better traffic control and disaster management. Here are some of such examples.

1) Registration scheme of expert in disaster management

   Registered technical experts give investigation and advice to government when requested for preparation of disaster management program and emergency action after disaster occurrence.

2) Registration scheme of road monitor

   Registered local residents cooperate in monitoring the road traffic conditions and providing real time information for traffic and disaster management.

8.2 Guide II: Guide to Slope Inspection

(1) Contents of Guide II

Guide II consists of five (5) chapters as below:

Ch. 1 General
Ch 2 Preparatory Work
Ch 3 Selection of Slope
Ch 4 Method of Slope Inspection
Ch 5 Database Creation and Reporting

8.2.1 General

(1) Purpose

Guide II: Guide to Slope Inspection has been prepared to standardise the method and procedures of slope inspection and risk rating method, as these works provide essential information to slope disaster management plan. . Data obtained by the slope inspection constitutes an important portion of slope database that is managed by Slope Information Management System (SIMS).

(2) Main Output of Slope Inspection

The following information is the output of slope inspection.

1) Slope Stability Status
2) Effectiveness of Existing Countermeasure
3) Hazard Rating Score
4) Consequence Score
5) Risk Rating Score
6) Proposed Type of Countermeasure and it Approximate Cost

(3) Basic Policy of Preparation of Guide II

Guide-II was prepared as the combination of existing slope management systems in Malaysia and those in Malaysia. After the review of existing Malaysian slope systems, such as SPRS (Slope Priority Ranking System), similarities were found in many points between the slope systems of both countries. The basic flow of slope inspection and risk rating is basically the same between both systems. As there is no description of preparatory work in Malaysian system, the procedure of Japanese system was adopted in the new system.

Here are brief comments on some of main items as below:

(i) Taking into consideration the importance of slope failure categorization in slope disaster management study, likely slope failure was classified into Six-Failure Type; Collapse (CL), Rock Fall (RF), Rock Mass Failure (RM), Landslide (LS), Debris Flow (DB), Embankment Failure. These were determined in accordance with current Japanese Manual.

(ii) Items of observation and rating in slope inspection were carefully selected in reference with Japanese Manual. The weighting of each factor influencing stability of slope is defined in accordance with that defined in the Japanese manual although some modification was applied taking in considerations of geological condition in Malaysia.

(iii) Hazard rating is determined by the same method of exiting Malaysian manual, from the rating of slope status and the effectiveness of existing countermeasure.

(iv) Consequential evaluation is much the same as SPRS method that is modified by discussion with engineer of JKR and Study team.

(v) Risk Priority Rating Method of SPRS is changed as follows.

Risk Rating Score(R) = Hazard Score (H)* 0.9 + Consequence Score (C)

Note: In SPRS the formula R=H * C has been applied. The adoption of the above formula was approved by the Steering Committee with the judgement that hazard rating score should be evaluated more highly than consequential score, which is quite a rough indicator in this moment.

(4) Six (6) Slope Failure Types:

As mentioned in the above, the existing Malaysian system handles only two categories for slope, embankment slope and cut/natural slope. Taking into consideration the importance of slope failure classification, slope failure types were defined as six (6) groups, five groups for cut/natural slope and another one for embankment slope.

Table 8.2.1 shows the summarized description of each failure type with sketches.

(5) Study Team for Slope Inspection

It is suggested that slope inspection should be carried out by the study team organised by private geotechnical consultants, under the supervision by JKR staff. The reasons are the limited human resources at JKR and technical requirements for professional knowledge and experience in slope inspection.

(Note: In the case study in East-West Highway and trial application in Sabah, slope inspection was carried out satisfactorily by local geotechnical consultants' team under guidance of JICA Study Team).

(6) Improvement of Manual

This Guide was prepared for application to federal roads in Malaysia. Based on the present Malaysia Manual, some of technical expertise was introduced from current Japanese Manual with some modification to fit to conditions in Malaysia. It is expected that further improvement should be continued through the application to nationwide federal roads.

For example, even though mainframe of slope hazard rating system may remain, items of observation and their weighting may be modified in accordance with the local conditions. (In case of Japan, amendments have been applied five times on the slope inspection manual).

(7) Training Program for Slope Inspection

Training programme shall be arranged to obtain result of satisfactory quality level. It is required that all the engineers who are engaged in slope inspection should take the training course, the detail of which is proposed in the Chapter 7.

8.2.2 Preparatory Work

Prior to slope inspection on the site, existing data should be collected. The following materials are required to collect for good results of slope inspection.

1) Topographical map
2) Aerial photograph
3) Geological map
4) Slope disaster records, etc.

By analysing the above materials, slopes having risk of landslide (LS) and debris flow (DF) will be picked up for slope inspection. This is because only the site survey along road cannot tell the location and risk level of landslide and debris flow of large scale or on the upper slope.

8.2.3 Selection of Slope

At first all the slopes along study route shall be listed. Then the target slope for inspection shall be selected in accordance with the defined criteria. As this is a key step in the slope inspection, chief engineer should take charge supported by engineering geologist.

(1) Criteria for selection of slope

In general, a cut or natural slope of over 15 m high is selected for slope inspection. Also a natural slope with a gradient of over 45 degrees is selected.

Embankment slopes that are over 5m in height will be selected. Also embankment slopes that may be unstable due to the following conditions are selected for detailed inspection.

- Embankment on the landslide slope, talus slope, or step slope over 40°
- Embankment near the river
- Embankment of steep geometry (over 1:1.6)
- Embankment with malfunctioning drainage or culvert

The slopes picked up as suspected slope of landslide or debris flow should be selected as target of slope inspection, regardless the above criteria.

(2) Identification of failure type for each slope

On the basis of result of preparatory work and route survey, chief engineer should make preliminary identification of failure type for each target slope. This is necessary for selection of inspection sheet Form B (to be selected by slope failure type).

8.2.4 Method of Slope Inspection

Slope inspection is carried out by inspection study team, each member of that is required to be familiar with the method through training course.

The result of observation and rating during slope inspection is recorded on Inspection Sheet, Form A, B, C,and F. Form E has five types of form, depending on the type of slope failure.

The contents of each form are summarized in Table 8.2.2. And some examples of Form A, location map and Form B, sketch of slope are shown Figure 8.2.1 and 8.2.3, respectively.

8.2.5 Database Creation and Reporting

The result of slope inspection is input to Slope Information Management System (SIMS), being kept and used as the database for slope disaster management.

Table 8.2.1 Classification of Slope Failure

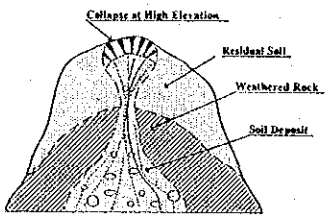
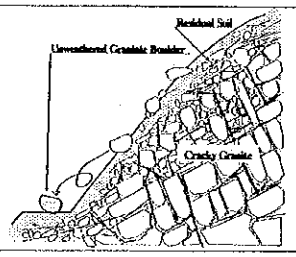
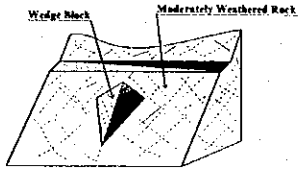
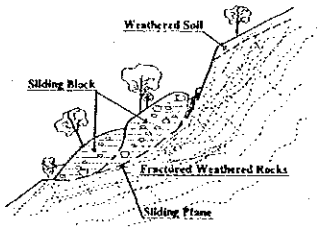
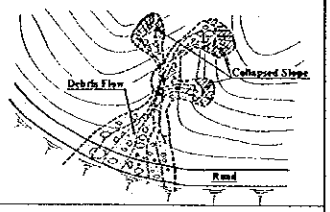
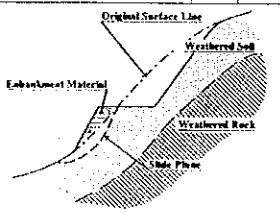
FAILURE TYPE (Inspection Sheet to be applied)	Characteristics	SCHEMATIC ILLUSTRATION
1. Collapse (CL)	- Collapsing materials are residual soils and highly weathered or jointed rocks. - Prone to occur on steep slopes. - Mostly triggered by rainfall infiltrating - Similar to slump failure in some cases. - Size is generally less than1,000 m^3	
2. Rock Fall (RF)	- Free fall or rolling down hard rocks and boulders in the slope. - Occur on steep slope and cliff. - Falls occur due to gravity and are controlled by the distribution of joints. - Size is generally less than 5 m^3.	
3. Rock Mass Failure (RM)	- Materials are hard jointed rocks. - Failure modes include wedge slide, plane slide and toppling. - Size is generally more than 2-3 m^3.	
4. Landslide (LS)	- Materials are clayey soils and highly weathered rocks. - Marked by topographic features that is gentle and deformed -Chiefly influenced by increased pore-water pressure by infiltration of heavy rainfall. -Size is generally more than 5,000 m^3.	
5. Debris Flow (DB)	- Rapid flow of boulder, gravel, sand, silt and clay mixed with big amount of water. - Occurs in a contributory areas that contains collapsible slopes	
6. Embank-ment Failure (EB)	All type of slope failure in embankment - Slump or collapse of slope, - settlement of road surface - Scouring of toe part	

Table 8.2.2 Forms of Inspection Sheet

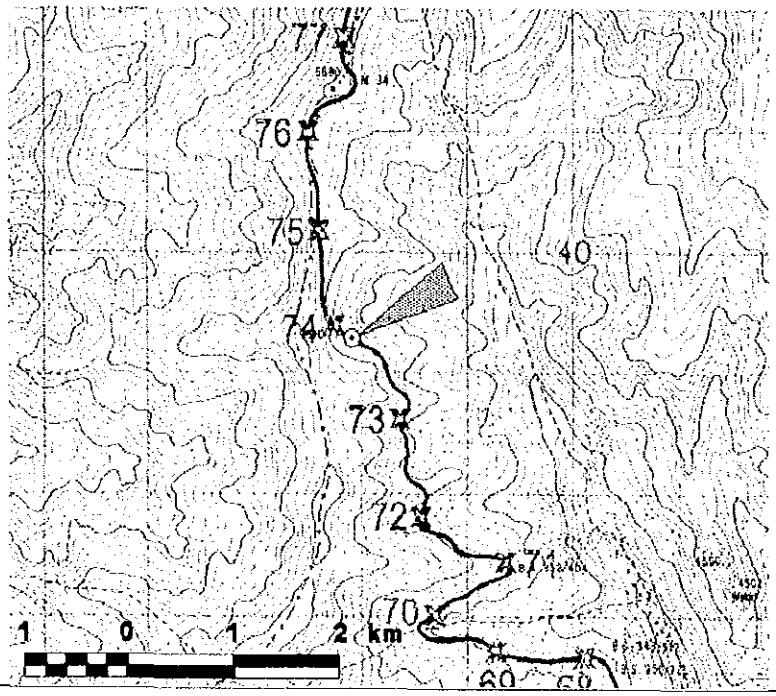
Form		Items to be Recorded
A		**General Slope Data** Failure Type, Route name, Chainage, Slope ID, Location Map, etc.
B		**Sketch of Slope** Plan and Cross Sections
C		**Photograph of Slope** Overall View and Special Feature of Slope)
D		**Slope Feature** Geometry, Geology, Existing Countermeasure, Conditions of Drainage and Pavement, Instrumentation
E	E 1: CL/RF	**Slope Hazard Rating** Rating sheet based on the observation of geometry, geology, surface conditions, existing countermeasures, etc. The form corresponding the failure type is selected.
	E 2: RM	
	E 3: LS	
	E 4: DF	
	E 5: EB	
F		**Proposed Countermeasure** Type of works, Quantity, etc. **Consequence Rating** **Other Local Information** Building, Cultivation, Rainfall data, etc.

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

General Slope Data

Type of Slope Failure	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 73.800km - End 73.850km	Type of Slope	Cut (Embankment) Natural
Side of Road	(Right) Left	Distance from Road Centre-Line	10 m
JKR Slope ID		Date Inspected	14-Aug-01
Field ID	S01	Inspected by	WATIN m. (JWGC)
Route Name	Tambunan - Penampang Road	Date Checked	19-Oct-01
District Name / State Name	Tambunan / Sabah	Checked by	TANAKA k. (JICA Study Team)
Realignment Event (Description)	Yes (No) (If 'yes', describe)		
Disaster Record			

Location Map (1:50,000)



Date Entered in SIMS	/ /
Entered by	

Figure 8.2.1 An Example of Inspection Form A (General Slope Data)

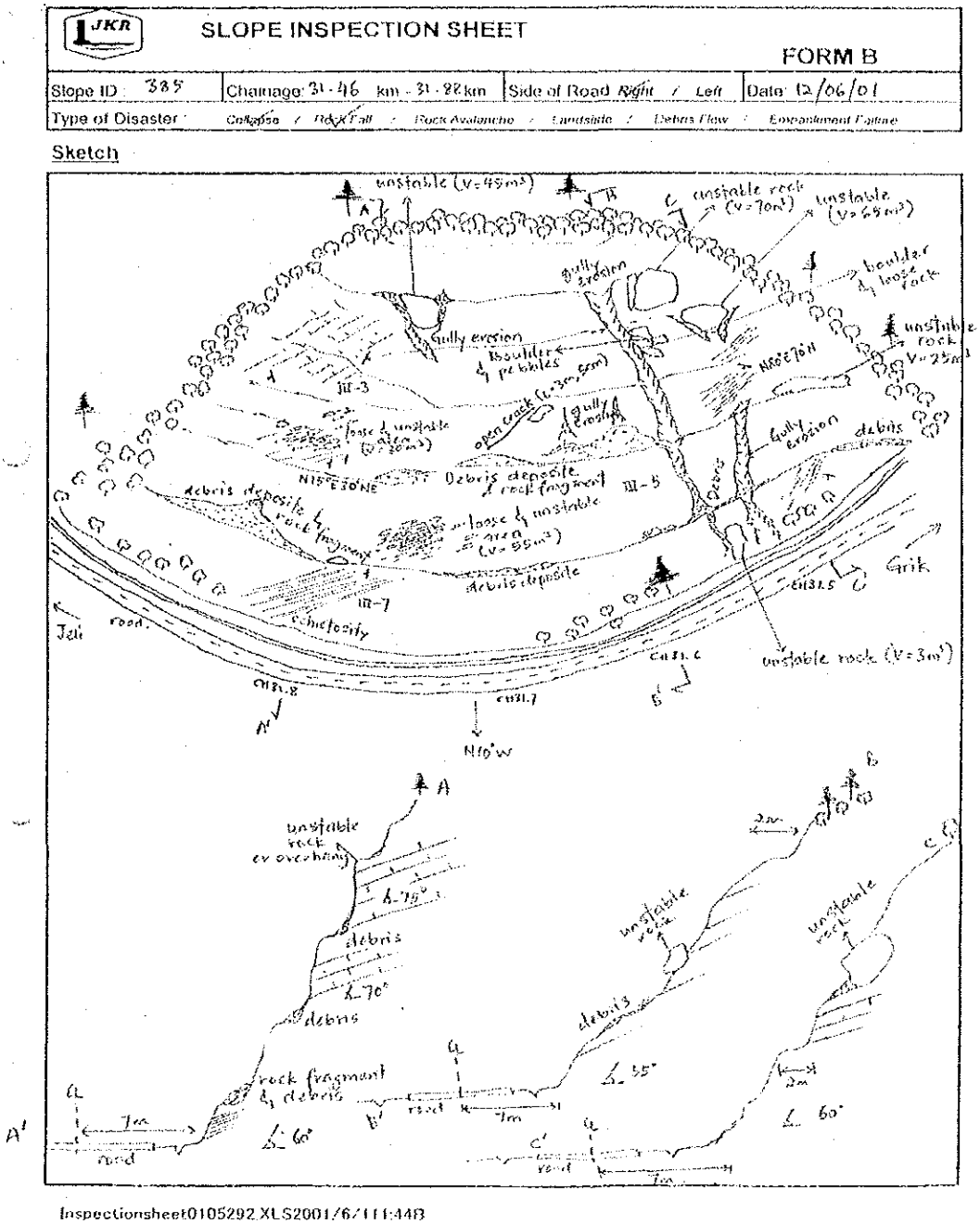


Figure 8.2.2 An Example of Inspection B (Sketch of Slope)

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		6
			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		

Figure 8.2.3 An Example of Inspection Form E (Slope Hazard Rating)

8.3 Guide III: Guide to Early Warning System and Site Investigation

Guide III consists of two parts:

Guide III-1: Early Warning System
Guide III-2: Site Investigation for Road Slope

Guide III-1 describes the early warning and traffic control system to prevent the slope disaster, by using the monitoring data of slope behaviour and rainfall. It is recommended to make best use of these techniques, as effective measures for the slopes at which necessary countermeasure works are not yet implemented due to the financial limitation.

Guide III-2 describes the method of site investigation for design of countermeasure work after implementation was confirmed. The main point of this guide is that proper program of site investigation can be prepared in accordance with likely types of failure at each slope. Proper site investigation can make it possible to prepare most effective and economical design and implementation of slope countermeasure, fitting the site conditions and mechanism of likely slope failure.

Here is the brief outline of the contents of Guide III as below:

8.3.1 Early Warning System

To prevent and minimise the road slope disasters, the primary task is to evaluate the risk of all the slope and to implement the countermeasure according to the priority in risk ranking. However, due to the limitation of budget of countermeasure, many of risky slopes are forced to leave without any of major slope civil works. Early warning and traffic control system is useful measures to minimize the chance of slope disaster.

There are two kinds of Early Warning System:

1) Early Warning based on monitoring slope behaviour, with target of individual slope of high risk
2) Early Warning and traffic control based on monitoring of rainfall, with target of wider area, such as certain road, or road section.

Table 8.3.1 summarizes monitoring instrument for slope behaviour and rainfall which can be used in slope disaster management.

Table 8.3.1 Monitoring Instruments for Early Warning

Measuring Items	Typical Instrument	Objective of Monitoring	Suitable Failure Type
a) Rock Fall Detection	Rock Fall Detector	For direct information on actual occurrence of rock fall or failure	RF/ RM/ DF
b) Slope Surface Movement	Wire Extensometer, Electro-Optical Distance Meter	For early warning based on large displacement exceeding the criteria generally accepted.	CL/ RF/ RM/ LS/ EB
c) Slope Surface Behaviour	Crack Gauge Surface Tilt-meter	For information for detailed slope study. (Criteria for early warning needs to be defined for each slope.)	CL/ RF/ RM/ LS/ EB
d) Subsurface Movement	Borehole Inclinometer Borehole *Extensometer*		LS
e) Groundwater Level (Pore Pressure)	Water Level Meter Piezometer		LS/ CL
f) Rainfall <hourly & accumulated rainfall>	Rain Gage	*For early warning and traffic* control (To be used for analysis between occurrence of failure and rainfall/slope monitoring data.)	*For any failure type*

For the early warning based on the slope monitoring, the first two measuring items, a) Rock Fall Detection and b) Slope Surface Movement can give the useful and practical information. Other items of slope monitoring can give supporting data for slope stability conditions and mechanism of possible slope failure.

For the early warning and traffic control based on rainfall monitoring, lots of researches and application have been made in Japan for many years. Among several methods proposed by past researches and applications, the criteria using the data of hourly rainfall and accumulated rainfall is recommended to apply to federal roads in Malaysia.

It should be stressed that, for reliable and practical operation system, reliable criteria of slope behaviour and rainfall for early warning and traffic control should be established after accumulation of local data on rainfall and slope disaster occurrence.

8.3.2 Site Investigation for countermeasure Design

Guide III-1: Guide to Site Investigation describes the standard method for investigation and instrumentation for design of countermeasure work against high-risk slope. It is emphasized that the investigation program should be prepared in accordance with the likely type of slope failure for the target slope.

The investigation for slope work design can be divided into two (2) stages:

1) Preliminary Study
2) Detailed Study

Although many kinds of technique of investigation is available, the method being most suitable to the site conditions should be selected, taking into consideration:

- the stage of slope study,
- size of likely failure,
- positional relationship between the risky slope and road concerned,
- mechanism of slope failure assumed from the likely type of failure, etc.

Table 8.3.2shows the technique of site investigation for slope study, to be selected in preliminary study and detailed study.

Table 8.3.2 Site Investigation Techniques Generally Adopted for Each Stage

	Stage of Preliminary Slope Study	Stage of Detailed Slope Study
Standard technique	Site reconnaissance Topographical survey	Geophysical survey Boring investigation Monitoring using Instrument
Optional technique	----------	Borehole logging In-situ test and sampling

In the Guide III-2, detailed information on various kinds of investigation techniques are explained as technical supporting material. Also some of latest techniques for slope study are introduced. Investigation program carefully prepared and executed could give tremendous benefit to the effectiveness of countermeasure and economical utilization of allocated budget.

8.4 Guide IV: Countermeasure Selections and Cost Estimation

Guide IV consists of 10 chapters::

Chapter 1 describes basic concept of countermeasure works against slope failure.
Chapter 2 describes the general principle in selection of appropriate countermeasure.
Chapter 3 to 8 describes detailed approach of selection of countermeasure appropriate to each of slope failure types, CL/RF, RM, LS, DF and EB, respectively.
Chapter 9 describes approximate cost estimation of countermeasure.
Chapter 10 introduces some examples of slope countermeasure design in Malaysia and in Japan.

Here are some of the main points in countermeasure selection and cost estimation.

8.4.1 Countermeasure Selection

(1) General Principle in Countermeasure Design

Implementation of countermeasure work is thought as the most important part in the road slope disaster management program. The reasons is that it is the most effective way to prevent occurrence of slope failure. But at the same time, it arises the problem of its high cost of implementation comparing to other slope maintenance measures, such as routine maintenance, regular patrol, monitoring, etc.

In the circumstance it is requested for us to find how we can select and design the appropriate countermeasure that is effective to failure prevention in minimum cost. The purpose of preparation of this guide is to give the guidance for selection of appropriate countermeasure and cost estimation for budget planning.

One of the most highlighted points through this guide is that the characteristics and present conditions of the relevant slope should be carefully studied and put into the consideration in the investigation and design for countermeasure work. In this sense, the likely failure type of the slope is quite essential factor for the study. Thus, as mentioned in the above, detailed approach of selection of appropriate countermeasure was discussed in accordance with each of slope failure types, CL/RF, RM, LS, DF and EB, respectively.

(2) Review of Countermeasure Option

Countermeasure options against road slope failure can be classified into seven groups, in consideration of size, purpose, application, and design method. In general, any of slope countermeasures involve some or all of the objectives as below:

1. Preventing erosion and weathering of slope surface by the use of vegetation, shotcrete, cribwork, and surface drainage;

2. Reducing pore-water pressures in the slope by surface and subsurface drainage;
3. Reducing shear (or destabilizing) force by removing the unstable materials from the upper part of the unstable slope;
4. Increasing shear strength (or stabilizing force) by adding weight to the toe of an stable slope or by increasing shear strength along the failure surface;
5. Supporting the unstable area of slope by the construction of retaining Walls and similar structures;
6. Reducing or preventing the damages from slope failures by catch works, etc;
7. Avoiding the unstable area by relocating a route or by the construction of bridge and similar structures.

Table 8.4.1 summarizes most of applicable countermeasure option for road slope, with their applicability to each type of slope failure. The slope countermeasure are classified into seven (7) groups and fifteen (15) sub-groups in accordance with the character of each work:

1) Earth work
2) Vegetation
3) Water drainage
4) Slope work
5) Wall and resisting structures
6) Protection work
7) Other works

Detailed approach of selection of appropriate countermeasure are illustrated as flow charts for each of slope failure types, CL/RF, RM, LS, DF and EB, respectively. Figure 8.4.1 is an example of such flow charts for the type of collapse and rock fall.

8.4.2 Estimation of Approximate Cost of Countermeasure

(1) Basic principle of preparation of cost sheet

On the subject of slope disaster management for road, it is very important to grasp the cost of countermeasure.

Table 8.4.1 shows the types of works, specifications and approximate unit rate.

In the table, type of works and specification are listed as much as possible, so, the some types of works are listed, which are constructed in rear cases and isn't constructed in Malaysia.

There are many specifications in a type of works, and the cost of same type of works is different by the specification, so in the table, most important specification is listed and estimated the unit rate.

The unit rates are estimated only usage of slope disaster management, therefore at the time of construction of countermeasure, the detail investigation should be done, and expert engineer should decide the suitable countermeasure.

(2) Procedures of fixing of typical cost in the list

Unit rate of countermeasures are determined by the discussion with member of JICA study team and JKR staffs. And JICA study team also investigate the unit rate from some of engineers in Malaysia.

Unit rate include every cost, such as labour coat, material cost, machinery cost, temporary work cost, over head cost, benefit cost, etc.

Unit rate is local cost in Malaysia, and at the year 2001.

It is difficult to estimate the unit rate of type of works, which has not been constructed in Malaysia. So we calculate the ratio of unit rate of works, which is known in Malaysia and Japan, and then we estimate the unit rate of these works.

(3) Suggested policy for future periodical review of pricing

These unit rates should be reviewed at least once a year to use SIMS.

The method of review should be depended on the ratio of a price index.

At this case it is advisable to separate the cost into labor costs and other costs, such as material costs, machinery costs, and to be review the unit rate.

Table 8.4.1 Applicability of Countermeasures against Slope Failures

Classification		Type of work	Type of slope failure					
			CL	RF	RM	LS	DF	EB
1. EARTH WORK	Earth Work	Removal	○	○	○	○	○	×
		Rock Cutting	○	○	○	○	○	×
		Rock Pre-Splitting	○	○	○	△	○	×
		Soil cutting	○	×	×	○	○	×
		Embankment	○	×	×	○	△	○
2. SURFACE COVER	Vegetation	Hydroseeding	○	△	×	○	○	○
		Vegetation	○	△	×	○	○	○
3. WATER DRAINAGE	Surface Drainage	Subsoil drain hole	○	△	×	○	×	○
		Berm or roadside drain	○	△	△	○	△	○
	Subsurface Drainage	Culverts	△	×	×	△	○	○
		Horizontal drain hole	○	×	○	○	△	○
		Drainage well	×	×	×	○	×	×
		Drainage tunnel	×	×	×	○	×	×
4. SLOPE WORK	Pitching Work	Stone pitching	○	○	△	×	×	○
		Block pitching	○	○	△	×	×	○
		Concrete pitching	○	○	○	×	×	○
	Shotcrete work	Mortar spraying	○	○	○	×	○	×
		Concrete spraying	○	○	○	×	○	×
	Crib work	Concrete block crib (Precast)	△	△	×	△	×	○
		Cast-in-place concrete crib	○	○	△	○	○	×
		Shotcrete crib	○	○	△	○	○	×
5. WALL AND RESISTING STRUCTURES	Anchoring	Soil nail	○	△	×	△	△	○
		Rock bolt	○	○	○	○	△	×
		Ground anchor	○	○	○	○	△	×
	Retaining Wall	Gabion Wall	○	○	×	○	○	○
		Stone masonry Wall	○	○	○	○	△	○
		Gravity type retaining Wall	○	○	○	○	△	○
		Concrete block Wall	○	○	○	○	△	○
		Supported type retaining Wall	○	○	○	△	△	○
	Catch Work	Catch Fill	△	○	△	×	×	×
		Catch gabion	△	○	△	×	○	×
		Catch concrete Wall	△	○	△	×	△	×
	Pilling Work	Precast reinforced concrete pile	△	×	×	△	×	×
		Steel Pile	△	×	×	○	×	×
		Cast in place reinforced concrete pile	△	×	×	○	×	×
6. PROTECTION WORK	Protection Work	Rock fall catch net	△	○	○	×	×	×
		Rock fall catch fence	△	○	○	×	×	×
	Rock Shed	Concrete (or Steel) shed	△	○	○	×	○	×
	Sabo (Check) Dam	Concrete (or Stone) dam	×	×	×	○	○	×
		Steel crib dam	×	×	×	○	○	×
		Slit dam	×	×	×	△	○	×
7. OTHERS	Avoiding Problem Work	Diversion (Shifting)	△	△	○	○	○	△
		Route relocation	△	△	○	○	○	△
		Tunnel, Bridge	△	×	×	○	○	○

○ : Applicable △ : Limited case × : Not applicable
CL : Collapse **RF** : Rock Fall **RM** : Rock Mass Failure **LS** : Land Slide **DF** : Debris Flow **EB** : Embankment Failure

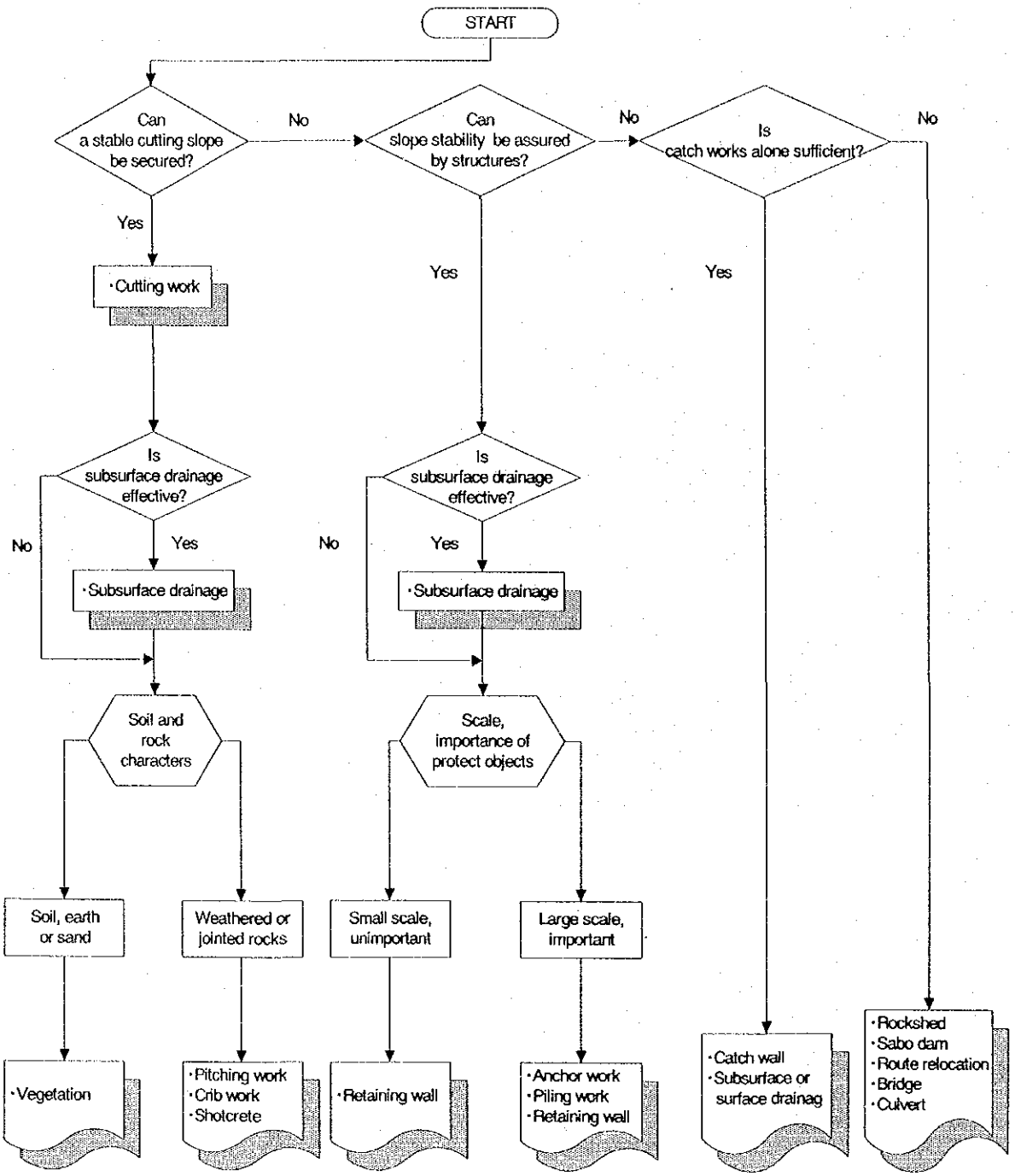


Figure 8.4.1 Flow chart for selection of countermeasures for collapse

Table 8.4.2 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 ϕ75mm 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 ϕ50mm 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, ϕ50mm 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 ϕ800 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 ϕ600 mm : Concrete + Reinforcement + Link + Boring	m	170.00
	68b	Pile Wall (in-place)	Bored pile ϕ750 mm : Concrete + Reinforcement + Link + Boring	m	250.00
	68c	Pile Wall (in-place)	Bored pile ϕ900 mm : Concrete + Reinforcement + Link + Boring	m	350.00
	68d	Pile Wall (in-place)	Bored pile ϕ1,050mm: 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 ϕ400 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	

8.5 Guide V: Guide of Slope Information Management System (SIMS)

8.5.1 Introduction

The SIMS application has been developed in coordination with the Slope Disaster Management program and the Slope Inspection Format developed by the JICA Study Team. Designed as a simple to use application, it is delivered as a product to be used in a networked environment, as conceived for the JKR Headquarters at Kuala Lampur, and multiple stand-alone installations for use at District Offices.

8.5.2 Overall Structure of SIMS User Guide

The SIMS Application Guide consists of the following sections:

(1) Design Guidelines and Considerations
(2) Hardware and Software Requirements for Application Operation
(3) Application Installation Instructions
(4) Application Modules
(5) Administrative Functions
(6) User Levels
(7) Help Function
(8) Lookup Tables and Standard Values

(1) Design Guidelines and Considerations

This section of the document outlines the design considerations and guidelines that were established at the outset of the development of this software application. It specifically describes the basis of developing the different versions of a Networked Application for use at JKR HQ and the stand-alone versions to be used in the districts.

(2) Hardware and Software Requirements for Application Operation

The Guide clearly identifies the technical specification of the hardware and software environment required for the use of this application. This will serve as a guide to the upgradation and procurement of additional equipment where necessary.

(3) Application Installation Instructions

The application will be available for installation from a CD-based product. Detailed, step-by-step instructions required for the installation will be provided under this section.

(4) Application Modules

The application functionality is organized into distinct modules, each addressing a specific set of functionality. The Guide provides details on the operation of the application, different functionalities provided by User Level Management, and Administrative Functions for the operation and coordination of this application at multiple districts and at the headquarter offices of JKR.

The main functionality for Slope Disaster Management are provided for in SIMS through the following modules:

- Slope Information
- Hazard/ Risk Rating
- Counter Measure
- Economic Analysis
- Integrated Reporting
- GIS Functions

This section of the Guide will provide the user with details and instructions on the above listed modules

(5) Administrative Functions

The administrative functions of the application address User Management, System Management, and activities of database management. This section of the guide will address the Administrative Functions in detail, especially those of creating and managing users, keeping the database updated and synchronized across all the installations, and tracking version changes of future upgrades of the application.

(6) User Levels

Access to the entire functionality of the application is restricted by a user level structure, organized as:

- General User
- Advanced User
- Administrative User

The details and control of the user levels will be described in detail in this section of the guide, providing an understanding of the need for the differing user levels, and the associated permissions/ restrictions based on each level.

(7) Help Function

The application includes within it a context/ subject relevant help file that is accessible through the main menu. This will help the user understand the application, its use, and the relationship of this to Slope Disaster Management activities. This section of the Guide will include explanations and descriptions for technical expressions used.

(8) Lookup Tables and Standard Values

The Lookup Tables and Standard values populate the application providing selection options to the user without having to key in the information. A listing of the details of each of these tables along with their original source will be provided in the Guide to assist the user in reviewing standard information.

Modification to this data may be required and guidance on the procedures to make such changes as considered necessary will be provided in this section of the guide.

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