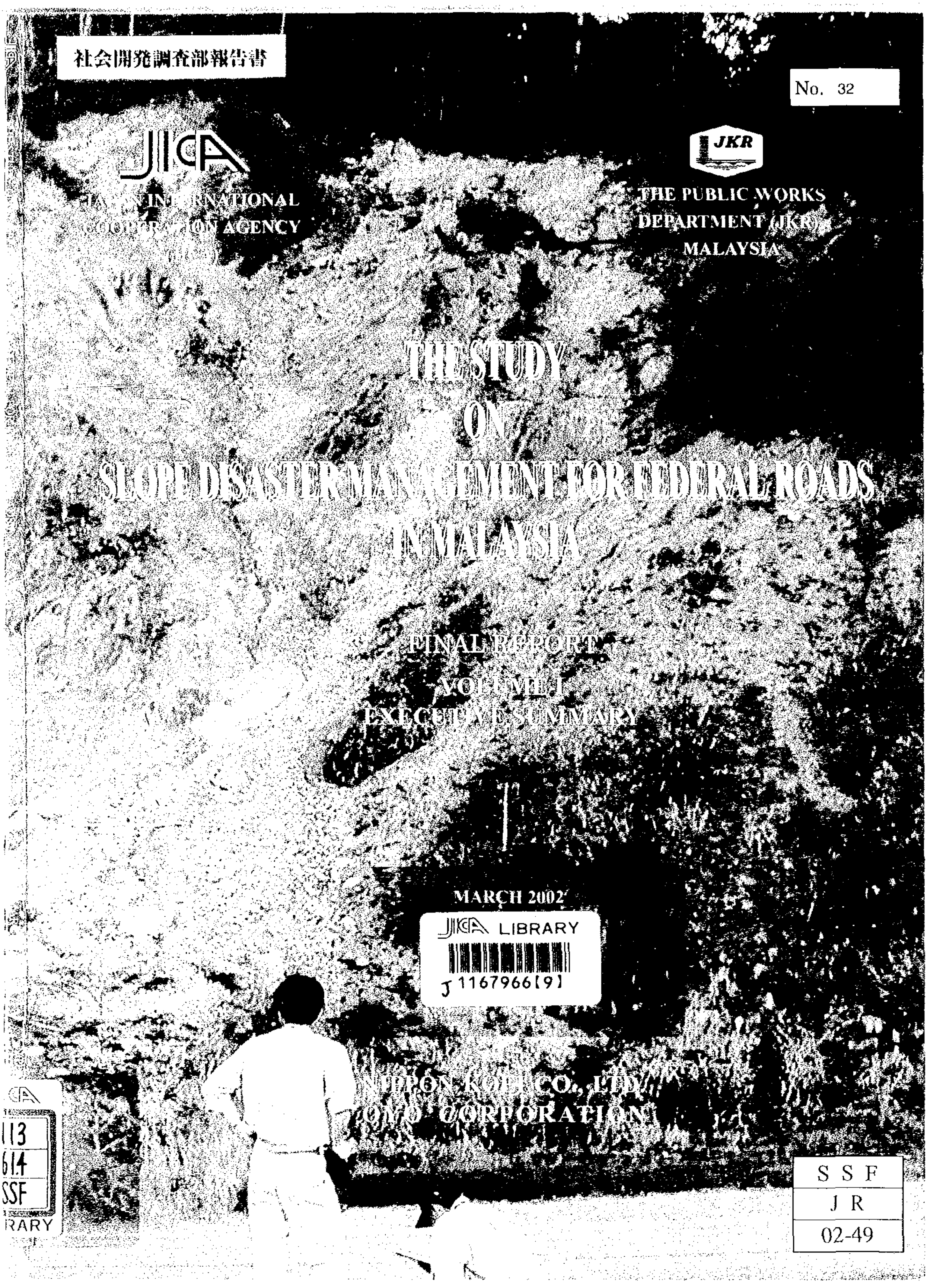


JAPAN INTERNATIONAL COOPERATION AGENCY

THE PUBLIC WORKS DEPARTMENT (JKR) MALAYSIA

THE STUDY ON SLOPE DISASTER MANAGEMENT FOR FEDERAL ROADS IN MALAYSIA

FINAL REPORT

VOLUME I EXECUTIVE SUMMARY

MARCH 2002

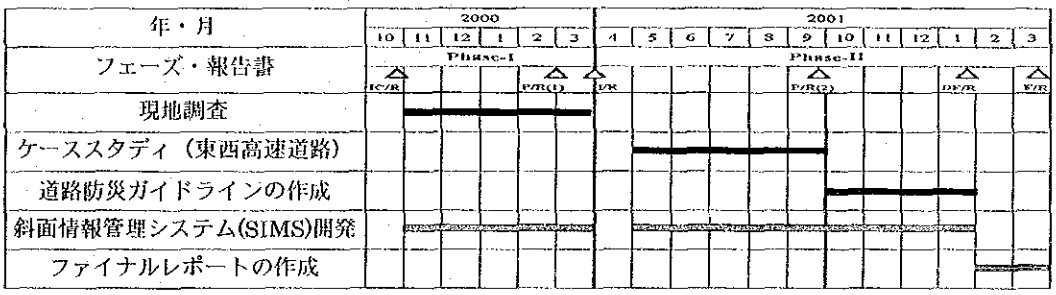
NIPPON KOEI CO., LTD.
OYO CORPORATION

マレイシア国道路防災管理調査概要

1．調査の概要

1. 国名	マレイシア国		
2. 調査名称	マレイシア国道路防災管理調査		
3. 受入機関	公共事業省　公共事業総局(JKR)　道路局		
4. 調査目的	・道路防災管理のガイドライン作成 ・道路斜面防災管理のための情報システム作成 ・技術移転と組織・人材開発の提案		
5. 対象地域	マレイシア半島、ならびに東マレイシアの６つの国道（総延長 425km）		
6. 調査の内容	1年次（フェーズI）		データ収集（自然、経済、技術分野）
			国道６路線での現地調査およびケース・スタディ路線の選定
			防災ガイドラインの基本方針策定
			情報管理システムの基本設計
	2年次（フェーズII）	A	東西高速道路での現地調査（斜面点検・地質調査・モニタリング・対策工概略設計）
			斜面情報管理システム(SIMS)の開発
			人材および組織のレビュー
			斜面管理計画の策定
			斜面情報管理システム(SIMS)の適用確認
		B	道路斜面管理システム(SIMS)の作成
			道路防災ガイドラインの作成
			組織および人材開発の提案

2．実施工程



3．調査の成果

1. ガイドラインの作成	ガイドI：道路斜面維持防災管理ガイド ガイドII：斜面点検ガイド ガイドIII：早期警戒および地質調査ガイド ガイドIV：対策工選定および工費概算ガイド ガイドV：斜面情報管理システム(SIMS)ガイド
2. 斜面情報管理システム(SIMS)の作成・適用性の確認	斜面危険度評価、経済分析、GIS 機能を備えたシステムを作成した。作成した本システムを実際の道路斜面で試験運用し、適用性を確認した。
3. 技術移転・人材開発	道路防災、斜面点検、およびシステム管理を主題とした２回のワークショップ、３回のセミナー、３回の情報システム講習会、カウンターパート受入研修、斜面点検 OJT を開催し、カウンターパート側への技術移転を行った。また、マレイシア国の道路防災管理の実施体制について提案を行った。

4．導入計画（提言）

- 新システムの全国展開計画作成
- JKR 本部維持管理部門への斜面防災、および情報管理専門家の導入
- 斜面防災関連担当者の教育訓練制度の新設
- 斜面点検などハード業務の外部委託化の推進

＜以　上＞

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

THE PUBLIC WORKS
DEPARTMENT (JKR)
MALAYSIA

THE STUDY ON SLOPE DISASTER MANAGEMENT FOR FEDERAL ROADS IN MALAYSIA

FINAL REPORT

VOLUME I
EXECUTIVE SUMMARY

MARCH 2002

NIPPON KOEI CO., LTD.
OYO CORPORATION

PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct a study on "Slope Disaster Management for Federal Roads in Malaysia" and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team, consisting of Nippon Koei Co., Ltd. and OYO Corporation, headed by Mr. Hiroki Shinkai of Nippon Koei Co., Ltd., three times between November 2000 and February 2002. In addition, JICA set up an advisory committee headed by Dr. Toshihiko Naganuma, Manager of Design Division, Construction Department, Hanshin Expressway Public Corporation, between November 2000 and February 2002, which examined the study from technical points of view.

The team held discussions with the officials concerned of the Government of Malaysia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the study team.

March 2002

Takao Kawakami
President
Japan International Cooperation Agency

March, 2002

Mr. Takao Kawakami

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We have the pleasure of submitting to you the Final Report of "The Study on Slope Disaster Management for Federal Roads in Malaysia", in accordance with the Scope of Work agreed upon between The Public Works Department (JKR) Malaysia and Japan International Cooperation Agency (JICA).

The report and product consists of three volumes as bellow.

1. Main Report
2. Guideline Volume
3. Program of the Slope Information Management System(SIMS)

In the Main Report the process of establishing the management system and the outline of the Guideline and the Slope Information Management System are described. The procedure and methodology for road slope disaster management are compiled in the Guideline Volume. The Slope Information Management System (SIMS) was prepared as the core tool for the management system.

The study team sincerely hopes that the study result would contribute to the effective management for road slope disaster in Malaysia

We wish to express our deep appreciation and gratitude to all the personnel concerned of your Agency and Office in Malaysia, the Embassy of Japan in Malaysia, as well as officials concerned of the Public Works Department (JKR) Malaysia.

Sincerely yours,

新開弘毅

Hiroki Shinkai

Team Leader

The study on Slope Disaster Management

for Federal Roads in Malaysia

LIST OF REPORT

FINAL REPORT

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GUIDELINE

GUIDE I: Guide to Slope Maintenance and Road 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 STUDY
ON
SLOPE DISASTER MANAGEMENT FOR FEDERAL ROADS IN MALAYSIA

Study Period : October 2000- March 2000
Counterpart Agency: The Public Works Department (JKR), Malaysia

OUTLINE OF THE STUDY

1. Background of the Study

Along with the development of a nationwide road network, the construction of new roads in hilly and mountainous areas has been increased in recent years. Under the climatic and geological conditions in the region, road slope disasters have been reported from time to time. Since the early 1990's, JKR has started to develop and implement several slope management systems like SMS, MEHMES and SPRS. Although those systems are in operation, it is required to develop a more reliable slope management system for disaster mitigation with limited resources.

In these circumstances, the Malaysian Government requested the Japanese Government to provide technical and financial co-operation to establish an effective slope management system. In July 2000, both governments came to agreement in signing the scope of work of this development study project, "The Study on Road Slope Disaster Management in Federal Roads in Malaysia".

2. The Objectives of the Study

This project was planned and carried out with the five objectives as below:

1.Clarification and analysis of the present situation of road slope and its management
2.Development of a new Slope Information Management System
3.Preparation of Guideline of road slope disaster management, consisting of five guides.
4.Preparation of Implementation Plan
5.Technical transfer

3. The Study Area

Fundamental data was collected in six federal roads (total length:425 km) and the case study was carried out in East-West Highway. The check study was carried out in Penampang-Tambunan Road.

4. Study Period and Phasing

The study was from carried out October 2000 through March 2002.

The work was divided into two phases and three (3) distinct components;

Phase I: Reconnaissance Survey
Phase II: (A) The Case Study
(B) The Study on Road Slope Management System

5. Present Condition of Road Network

During the Sixth Plan (1991-1995) period, road development was increasing the road network, particularly to improve inter-urban linkages, alleviate capacity constraints and increase the road network to open up new growth centres and rural areas. Several major projects such as the East-West Highway were initiated in this period.

The total length of federal and state roads has been extended from 21,914 km in 1980 to 67,627 km in 1998 at 6.46 % average annual growth rate. The Federal Roads have extended from 6,377 km to 16,081 km with the average growth rate of 5.27%.

6. Reconnaissance Survey of Six Study Roads

(1) Objective of The Survey

Field reconnaissance of six federal roads was carried out for about 2 weeks in the Phase I Study in December 2000. The reconnaissance was carried out with the objective to grasp the general conditions of road slopes in the country and to analyse the mechanisms and typical classification of slope failure.

(2) Classification of Slope Failure Type

Based on the Reconnaissance Survey and other literature study, road slope failure in Malaysia is classified into six (6) types depending on the failure mechanism. These are listed in Table 6.1.

Table 6.1 Classification 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)

(3) Condition of Slope Failure

Condition of slope disaster was found as Table 6.2. Collapse type of slope failure is common in federal roads. Big scale failure types of Landslides are occurring in Penampang-Tambunan Road in Sabah.

Table 6.2 Summary of Slope Failures along Six Routes

Disaster Type & Symbol		R4		R59		R56		R55		R6		R500	
		no	%	no.	%	no	%	no.	%	no	%	no	%
Collapse	**Total**	**23**	**44**	**128**	**93**	**12**	**86**	**92**	**80**	**23**	**67**	**32**	**35**
	Surface Failure	17	32	128	93	12	86	92	80	23	67	27	30
	Gully	6	12	0	0	0	0	0	0	0	0	5	5
Rock Fall	Rock Fall	**6**	**12**	**0**	**0**	**2**	**14**	**7**	**6**	**6**	**18**	**1**	**1**
Rock Mass Failure	Wedge Slip	**6**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Landslide	**Total**	**11**	**20**	**2**	**1**	**0**	**0**	**10**	**8**	**1**	**3**	**37**	**41**
	Landslide	11	20	2	1	0	0	10	8	1	3	17	19
	Settlement of Road	0	0	0	0	0	0	0	0	0	0	20	22
Debris Flow	Debris Flow	**2**	**4**	**1**	**1**	**0**	**0**	**3**	**3**	**2**	**6**	**13**	**14**
Embankment Failure	**Total**	**4**	**8**	**7**	**5**	**0**	**0**	**3**	**3**	**2**	**6**	**2**	**9**
	Embankment Failure	2	4	0	0	0	0	0	0	0	0	1	1
	Surface Failure - below shoulder	2	4	7	5	0	0	3	3	2	6	7	8
	Total	**52**	**100**	**138**	**100**	**14**	**100**	**115**	**100**	**34**	**100**	**91**	**100**

R4 : East-West Highway
R59 : Cameron Highlands Road
R56 : Gap-Fraser's Hill Road
R55 : Kuala Kubu B.-Gap- Teranum Raod
R6 : Penang Road
R500 (State Road) : Penampang-Tambnan Road(Sabah)

7. Selection of Case Study Route

The East–West Highway (Federal Route 04) is recommended as the most suitable route for the case study, as it satisfies almost all requirements for the case study. And, the Penampang-Tambunang-Keningau Road (Sabah) is recommended as the trial testing site of new information system.

8. Review of Existing Slope Information Systems

Following existing information systems are reviewed for planning new system.

(1) Slope Management System (SMS)

(2) Malaysian Engineered Highway Management System (MEHMS)

(3)Slope Priority Ranking System (SPRS)

Result of review is show in Table 8.1.

Table 8.1 Summary of the Existing Slope Information Systems

Module	Function	SMS	MEHMS	SPRS
Slope Information	Slope Inventory	Yes	Yes (but no data entry form)	Yes
	Slope Inspection	Yes	Not designed	Yes, but not professional
	Slope Maintenance	Yes	Not designed	Not designed
	Countermeasure	Not designed	Using CHASM Module	Yes, but quite simple
Rating Analysis	Hazard Rating	Yes	by slope stability analysis, CHASM	Yes, but not professional
	Consequence of Slope Failure	Yes	Not designed	Yes
	Risk Rating	Yes	Factor of Safety by CHASM	Yes
	Economic Analysis	Not designed	Not designed	Yes, but rough cost estimation only
Disaster Support	Emergency Response	Not designed	Not designed	Not designed
GIS Application	Location Map	Yes	Not designed	Not designed
	Thematic Mapping	Yes	Not designed	Not designed
	Spatial Analysis	Not designed	Not designed	Not designed
Administrative Functions	Data management	Yes	Yes	Not designed
	User management	Not designed	Not Available	Not designed

9. Method of Slope Risk Rating

The following items were carefully studied in the design of the new system.

1) Objective
2) Target Road
3) Personnel for Inspection
4) Slope Failure Type
5) Risk Rating Formula
6) Hazard Score factors
7) Hazard Score distribution
8) Consequence Score
9) Economic Analysis
10) Countermeasure Selection and Cost Estimation

10. Case Study

The Case Study was carried out as a model study prior to establishment of a nationwide slope management system. By carrying out various kinds of field study, actual data could be collected and subjected to analysis for detailed study on a certain road. The case study allowed any problems encountered to be carefully considered and reflected in the nationwide management system.

10.1 The Scope of Case Study

The Scope of Case Study is summarised in Table 10.1.

Table 10.1 Scope of the Case Study

	Scope
Field	Aerial Photograph Survey Slope Inspection Geological Investigation (drilling/ geophysics) Instrumentation/Monitoring Land survey, Hydrological Survey, etc.
Office	Slope Database/ Development of SIMS Preliminary Countermeasure Design/ Cost Estimation Program of Slope Management Organization/ Human Resources Development Study

10.2 Slope Inspection

Slope inspection was carried out along the case study route to evaluate the risk of each slope against slope failure. The target section of survey was between Chainage 25.00 km to 82.30 km of Federal Road No.4, the East–West Highway. The JICA study team in accordance with specifications established the methodology of slope inspection, which are described in detail in Guide II of the set of guidelines prepared in this study.

767 slopes in total were checked on site, and 471 slopes were inspected and recorded on the inspection sheets. The other 296 were not inspected in detail because of low height slope (less than 15 m cut slope or less than 5 m embankment).

Nine (9) slopes recorded a hazard score over 75, and 18 slopes were between 74 and 65 in Risk Rate. There are one hundred seven (107) slopes with the mark over 50 in risk rate.

The inspection result was input to SIMS, the newly developed Slope Information Management System, calculating the risk rating and fixing the priority ranking for an implementation plan of disaster management.

10.3 Geological Investigation

Three slopes were selected for detailed geological investigation along the E-W Highway that could represent the typical types of slope failure; namely, collapse at CH27.0 km, Landslide at CH 30.32 km, and Embankment at CH 81.3 km.

<Investigation Method>

Boring and geophysical survey were employed as the recommended standard techniques to aid slope design. The boring investigation was carried out to estimate the area, depth, and shape of failure zone, and to study the mechanism of the slope failure.

Geophysical survey is regarded as a useful technique for investigation of slope design work, combined with investigation boring. Two kinds of geophysical methods, Seismic Refraction Survey and Resistivity Image Profile, were applied in the study. These methods are expected to delineate the subsurface structure quite efficiently for slope design, using the difference in characteristics of each zone in seismic wave velocity and electrical resistivity, respectively.

10.4 Instrumentation and Monitoring

The purpose of the instrumentation and monitoring in this case study was to collect necessary information to develop a road slope disaster management system applicable to nationwide federal roads.

Several kinds of instrument were installed as shown in Table 10.2 and monitoring was carried out.

Table 10.2 List of Instruments Installed in the Case Study

	Number of Instrument			Utilization of Monitoring Result
	81.3km LS	27.0km EB	30.4km CL/LS	
Rain Gauge	1	1	1	**Traffic control**; Failure mechanism
Extensometer	2	1	0	***Traffic control***; *Moving speed, Failure area*
Inclinometer	2	1	1	Failure depth, Failure mechanism
Piezometer	2	0	1	Failure mechanism using pore water pressure fluctuation and other data

10.5 Preliminary Design of Countermeasure

Preliminary design of countermeasure was carried out as model study at following 5 slopes along E-W Highway and Penanpang-Tambunan Road.

1) East-West Highway

   CH 27.00 km for Collapse and Landslide, at CH 30.32 km for Embankment Failure, and at CH 81.30 km for Landslide.

2) Penanpang-Tambunan Road

   Slope No. S05 (Landslide) and S19 (Rock Fall).

Some alternative countermeasure method was studied for each slope to select reasonable countermeasure work.

10.6 Case Study of Slope Disaster Management

10.6.1 Flow of Slope Disaster Management

The procedures of road slope disaster management can be divided into three steps as shown in Table 10.3. The most important process in the slope management is: Slope Inspection, Risk Rating and Prioritisation of Implementation.

Table 10.3 Three Steps of Road Slope Disaster Management

Step	Function	Actual Procedures
1st Step	Evaluation of Slope Disaster Risk	Historical Review, Aerial Photograph Observation, Site Reconnaissance, Slope Inspection, Risk Rating
2nd Step	Prevention of Slope Disaster Risk	Prioritisation of Implementation, Countermeasure, Regular Patrol, Monitoring, Traffic Control, etc.
3rd Step	Emergency Management	Preparedness Plan, Emergency Response Action

10.6.2 Disaster Management

(1) Categorisation based on the Slope Risk Rating

Table 10.4 shows a summary of Risk Rating score of slopes in the Case Study. All slopes were categorised into four groups according to the score of the risk rating (R), which correspond to different level of slope management, or different type of management program.

Table 10.4 Slope Management Level for Slope in Case Study

Level of Slope Management	Risk Rating Grade	Risk Rating (R)	Number of Slopes (Case Study)	Management Program
Level I	Very High	$R \geq 75$	9 slopes	Slope Countermeasure Work
Level II	High	$65 \leq R < 75$	18 slopes	Regular Patrol, monitoring
Level III	Moderate	$50 \leq R < 65$	80 slopes	Periodical Inspection
Level IV	Low	$R < 50$	660 slopes	No follow up
Total			767 slopes	

(2) Suggested Priority of Preventive Countermeasure Implementation

1) Priority Risk Ranking List

Table 10.5 shows a Priority Risk Ranking List for the slopes rated as Very High Risk and High Risk. Besides the value of Risk Rating (R), some of the other figures that can be used to support decision-making of implementation planning; such as the Hazard Rating (H), Consequence (C), Approximate Countermeasure Cost and Simple Economic Indicator (from traffic volume and countermeasure cost).

Table 10.5 Priority Risk Ranking List (Case Study)

No	Slope ID	New Score ID	Type of Slope	Type of Failure	Hazard Score	Consequence Attribute	Risk Rating	Risk Level	Estimated Cost (RM)	Economic Indicator (V_T/C)	Final Decision
1	-	0004/071/500RC	1	4	85	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	1,428,400		
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	5	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		

2) Proposed Concept of Priority in Implementation Program

To prevent or mitigate possible damage by occurrence of slope failure, it is recommended to implement appropriate countermeasure work on the slopes rated as VERY HIGH to HIGH risk, as soon as possible. However there is actually a certain limitation in budget for countermeasure implementation. It is therefore necessary to prioritise the implementation of works in consideration of consequence score, and administrative requirements.

3) Definition of Importance of Road

To evaluate the feasibility of the road disaster prevention work, a simpler economic indicator was studied and applied to the SIMS as below. Because, it was found that some of the necessary data was not easy to collect and that some assumption in the economic analysis was not accurate enough from the viewpoint of practical use of the economic analysis

$E = V_T/C$

Where,

E : Rate of V_T to C

V_T: AADT (Annual Average Traffic Volume (No. of Vehicles of Each Route)

C : Cost for Countermeasures (RM 1,000)

"V_T" could be interpreted as a substitute of "benefits" tentatively. Because "V_T" as traffic volume of the route in the number of vehicles is assumed to represent the socio-economic activities of the regions as the beneficiaries of countermeasure works for slopes along side the route. The data of "V_T" in this calculation is ADT Annual Daily Traffic of the East-West Highways.

4) Framework of Implementation Plan

Based on the concept of slope risk categorisation and the concept of priority in implementation, the implementation plan of countermeasure can be prepared. Table 10.6 shows a suggested implementation plan framework in respect of urgency of implementation. The actual plan shall be set as a combination of scheduled countermeasure program and other maintenance measures such as regular patrol and instrument monitoring etc.

Table 10.6 Framework of Implementation Plan

Time Frame	Time Period	Slope Criteria		Note: Refer to Fig.3.7.1
		Risk Rating	Road Importance	
a) Urgent Plan	Urgent	VERY HIGH risk	(extremely) high	
b) Short-term Plan	1 to 2 years	VERY HIGH risk	high	Zone A
c) Medium-term Plan	3 to 5 years	VERY HIGH risk	moderate	Zone B
		HIGH risk	high	
d) Long-term Plan	6 to 10 years	HIGH risk	moderate	Zone C

(3) Implementation of Countermeasures

1) Priority in Implementation in Case Study

For the case study route, nine (9) slopes were identified as Very High risk. The total cost of countermeasures is estimated as RM7,881,921. Taking into account the importance of the East-West Highway, the countermeasures are recommended to be implemented as soon as the necessary funds are secured. (Notes: Just for information, at present, a two-year contract for countermeasure work is in progress along the East-West Highway for 15 slopes with a value of RM 11 million).

2) Selection of Countermeasure

The recommended types of countermeasure were proposed during slope inspection. These should be reviewed at the time of detailed design with reference to the Guidelines: Guide IV.

(4) Slope Maintenance Program

Countermeasure work will be implemented for Very High-risk slopes first, while slopes of lower risk will be managed by a slope maintenance program.

Table 10.7 Main Points for Slope Maintenance

Item	Outline
1) Regular Patrol (2-3 times/week)	Target: Very High-risk slopes (9) and High-risk slopes (18), until the completion of countermeasure.
2) Periodical Inspection (1-2 times/year)	Target: Medium-risk slopes (80), in addition to the above slopes.
3) Recording System	A) Database of patrol, disaster and countermeasure work

(5) Early Warning and Traffic Control

Early warning system and traffic control are useful measures for disaster management on risky slopes where countermeasures are not yet completed due to financial and time restrictions.

1) Early Warning System (Monitoring by Instruments)

Among the many types of instruments available, monitoring by extensometer is a very useful method, particularly against large-scale failure of landslide and rock mass failure. This is because the extensometer not only detects the ground movement before the occurrence of failure, but can also forecast the time of failure based on the level of strain of the ground surface.

2) Traffic Control under Heavy Rain Condition

To establish reliable rainfall criteria (or thresholds), it is necessary to accumulate and analyse actual historical rainfall data of each district in connection with disaster occurrence. In the report, tentative thresholds for traffic control are suggested, along with additional establishment of rain gauge stations by JKR and collection and analysis of rainfall data from other organization like MMS and DID.

(6) Emergency Plan

As countermeasure work and maintenance work cannot be perfect to prevent disaster, proper emergency plans should be carefully prepared to limit the possible damage to a minimum. Together with defining the actual procedures of quick response action, a preparedness plan should be studied including organization, logistics, training program and so on. The reference material is presented in Guide I.

11. Design Concept of SIMS

Development of the application was coordinated with the field-based slope inspection methodology prescribed by the JICA Study Team. Using a combination of a relational database and a Geographic Information System, SIMS brings together the required functionality for Slope Information Management into a user-friendly, windows-based application.

11.1 Program Design and Development

To address the functionality required, the deployment of the application at multiple locations, and the possible extent of data to be managed for Slope Disaster Management for Federal Roads, the selection of software was determined as:

- Development Environment: Visual Basic
- Operating System: Windows 2000
- Database: Microsoft SQL Server
- GIS: ESRI's MapObjects
- Internet Connectivity: None essential

This software configuration was discussed with JKR and after approval was confirmed as the technology for the development of SIMS.

The application functionality desired was organized into modules as shown in Figure 11.1.

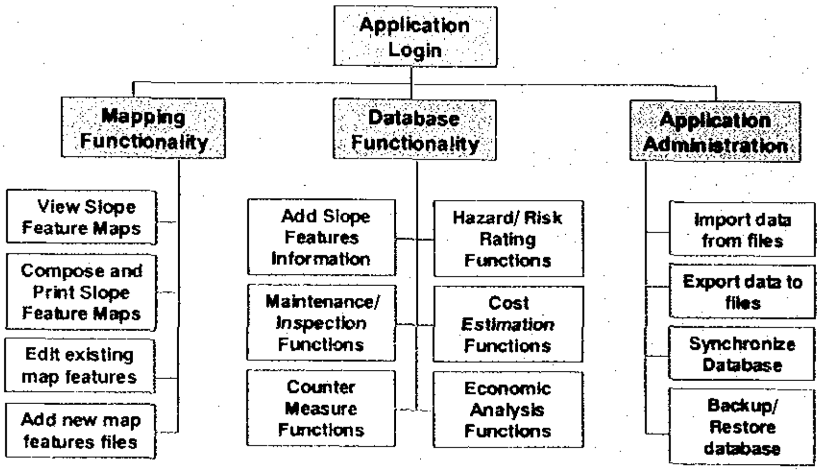


Figure 11.1 Summarized Application Functionality

11.2 Managing Slope Disaster Using SIMS

This application provides a unified system for use all across Malaysia. With information collected on the field inspection forms providing the basis for Slope Disaster Management using SIMS, the input data is organized, managed, and assigned values for hazard and consequence of slope failure. These values are uniformly applied to all the slopes. This standardization of assigning values forms the basis of a Risk Rating System that provides an identical scale for comparative evaluation of all slopes for which information is provided in the system.

The application also provides for guidance in design and costing for development of countermeasures for identified slopes. Using this system, a rough design cost estimate can be prepared based on the countermeasures selected, quantities input, and standard rates pre-defined. Capturing information on the consequences of slope failure and comparing them against the cost of executing countermeasures, the application also guides the user in performing an economic analysis to compare the cost to benefit of slope management alternatives.

The application also facilitates the review of slope information by major evaluative criteria such as slope type, most likely failure type, hazard score, risk rating, countermeasure design cost, and economic analysis. The mapping functions will also generate standard map compositions making it easier to generate map-based reports and to review the required information in a more graphic and spatial manner. Within each module, a reporting function provides for the creation of standard reports appropriate to the module. Embedded mapping functionality in each module also allows the display of maps based on the context of the module.

11.3 Technical and Technological Aspects of SIMS

The administrative functions essential for the effective functioning of SIMS can be categorized as (a) administrative functions for managing standard data required in the application (scoring ranges, master tables, lookup tables), and (b) administrative function for defining and managing users of the application, managing the database installation, importing data from district/zonal offices and integrating it into a master database at the headquarters, and exporting relevant data for re-distribution to the district/ zonal offices.

These administrative functions need to be addressed by appropriately skilled and trained persons for the smooth and effective functioning of SIMS at the Headquarters, and at the district/zonal offices.

11.4 Application of SIMS to Case Study Route

Slope Inspection work was conducted along the East-West Highway during the period from June to August 2001. Based on the experience of the field work, some revision was made to inspection forms and SIMS for easier data entry and data processing. These changes included reorganizing of the input screens.

The field inspections were conducted using Slope ID's designated in the field, but according to JKR's suggestion, all of the application and the data forms were revised to primarily follow the JKR slope ID, which is clearly defined for consistency with other types of structures along federal roads.

Data for all the slope inspections carried out on the case study route have been entered using SIMS. The slope inspection information and hazard/ risk information are complete for this study section and the hazard scores and SIMS has computed risk ratings. The countermeasure module is now available for data entry and design/ costing of countermeasures. Once this data is complete, the economic analysis results can also be generated from the application.

11.5 Application to Penampang-Tambunan Road

(1) Background of the Work

The development of SIMS was based on slope analysis of the East–West Highway. As a verification exercise, a prototype of SIMS was applied to a federal road in Sabah State with the intention of checking the operation of the prototype. Slope inspection was carried out by a geologist of a local consulting firm based in Kota Kinabaru, with technical instruction and guidance by a JICA study team member. Inspection was made in accordance with the same specifications as used on East-West highway.
The test section was about 5 km long, located on the federal road No. 500, leading from Penampang to Tambunan (CH74-CH79). Slope inspection was carried out on 23 slopes. Detailed results of the slope inspections were input to the SIMS and submitted as electronic file.

(2) Applicability of the Newly Developed System

Evaluating the result and performance of the trial test in Sabah, it can be confirmed that SIMS and the related slope inspection methodology are applicable not only to the E-W Highway but also to the Penampang–Tambunan Road. From this experience, it is expected that SIMS will be also applicable to other federal roads in Malaysia.

Through the field work and data compilation by a local geologist, it was confirmed that technical training and guidance by experts (engineering geology, slope engineering and system engineer) is essential to obtain reliable result of slope inspection and further road slope disaster management.

12. Implementation to Nationwide Federal Road

12.1 Priority in Implementation

Table12.1 shows a list of 12 selected federal roads identified as prone to slope disaster, based on the result of SPRS. Thus, it is recommended to first implement the new system for these 12 roads as Phase I (their total length is 1,068 km, corresponding to about 7 % of the current federal road network). The remaining roads should be implemented as Phase II, III and so on.

Table 12.1 Federal Roads Identified as Prone to Slope Failure

No.	Brief Description of Route	Route No.	Design Standard	Route Distance (km)	Percentage in hilly and mountainous area (%)	Distance in hilly or mountainous area (km)	Number of Past Slope Failure			
							Year 1998	Year 1999	Year 2000	3 years total
	A. WEST MALAYSIA									
1	Gerik - Pasir Putih (East-West Highway)	No. 4	R5	203	90%	183	8	5	5	18
2	Jalan Mengelilingi Pulau Pinang (Pulau Pinang)	No. 6	R1	62	40%	25	3	3	3	9
3	Bentong - Gua Musang - Kota Bharu	No. 8	R2	407	40%	163	2	2	2	6
4	Kuala Kubu Bharu - Gap - Teranum	No.55	R1	53	80%	43	10	8	8	26
5	Gap - Faser Hill	No.56	R2	8	100%	8	20	10	10	40
6	Tapah - Cameron Highlands	No.59	R2	65	95%	61	10	10	10	30
7	Kuala Lumpur - Bentong (Jalan Bentong Lama)	No.68	R2	60	70%	42	5	4	4	13
8	Baling - Kuala Kangsar	No.76	R3	164	80%	131	5	3	3	11
9	Seremban - Kuala Klawang - Simpang Pertang	No.86	R2	63	40%	25	3	3	7	13
10	Simpang Pulai-Lojin (The 2nd East-West Highway)	(*1)	R3	49	90%	44	(*1)	(*1)	(*1)	(*1)
	B. SABAH									
11	Tamparulli - Sandakan	No.22	R2	298	95%	283	10	10	8	28
12	Penampang-Tambunan-Keningau	No.500	R4	120	50%	60	(*2)	(*2)	(*2)	(*2)
	GRAND TOTAL			1,551	69%	1,068	76	58	60	194

(*1) As being State Road under construction, no record is available.
(*2) State Road until December 2000, then no record is available.
(Compiled in Decemebr 2001 by JKR)

12.2 Proposed Implementation Plan of Phase-I

Outline:

Outline:	Target Roads:	Twelve (12) roads, 1,068 km in total length
	Number of slopes:	10,000 slopes (10 slopes/km in average)
	Period:	Two (2) years
	Estimated Budget:	RM 10 million

Table 12.2 General Schedule of Implementation of Phase-I (for twelve (12) selected roads with total length of 1,068 km)

	Time Schedule								Remarks
	The 1st Year				The 2nd Year				
Slope Inspection		━━━	━━━		━━━	━━━			
SIMS		= = =	━━━	━━━		= = =	━━━	━━━	
Training									
Management	═══	= = =			═══	= = =			
Slope inspection	═══	= = =			═══	= = =			
System maintenance			= = =	═══			= = =	═══	

12.3 Recommendation for Implementation

It is recommended for implementation work.

(1) Arrangement of Specialist in JKR

It is recommended that JKR should arrange the specialists at Headquarters in two (2) areas: engineering geology and system development and maintenance. They are expected to support the JKR staff in planning, supervision, and technical guidance in connection with the new slope management system.

(2) Outsourcing

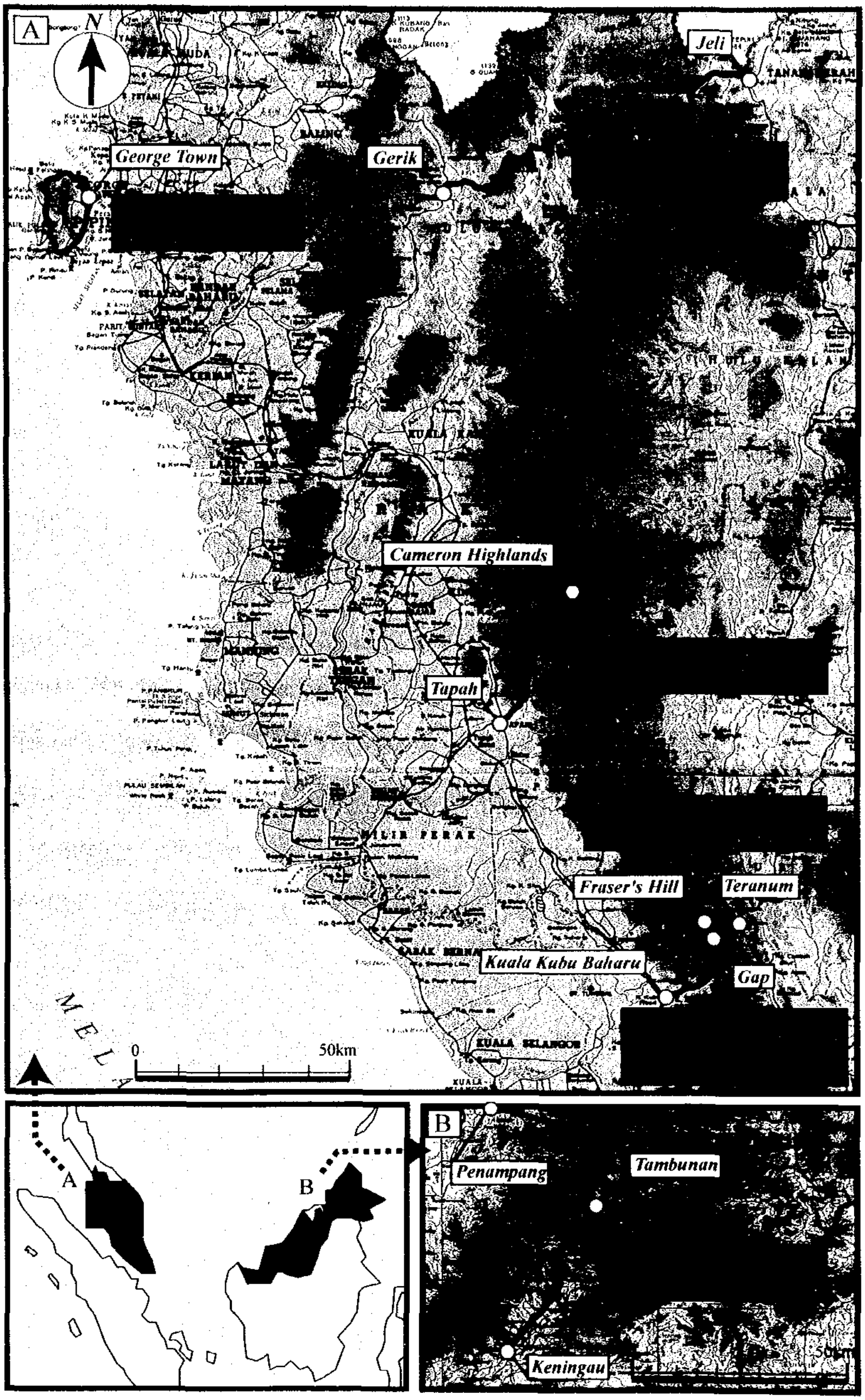
Outsourcing should be arranged in three areas; slope inspection, system maintenance, and optionally aerial survey and digital mapping.

(3) Procurement

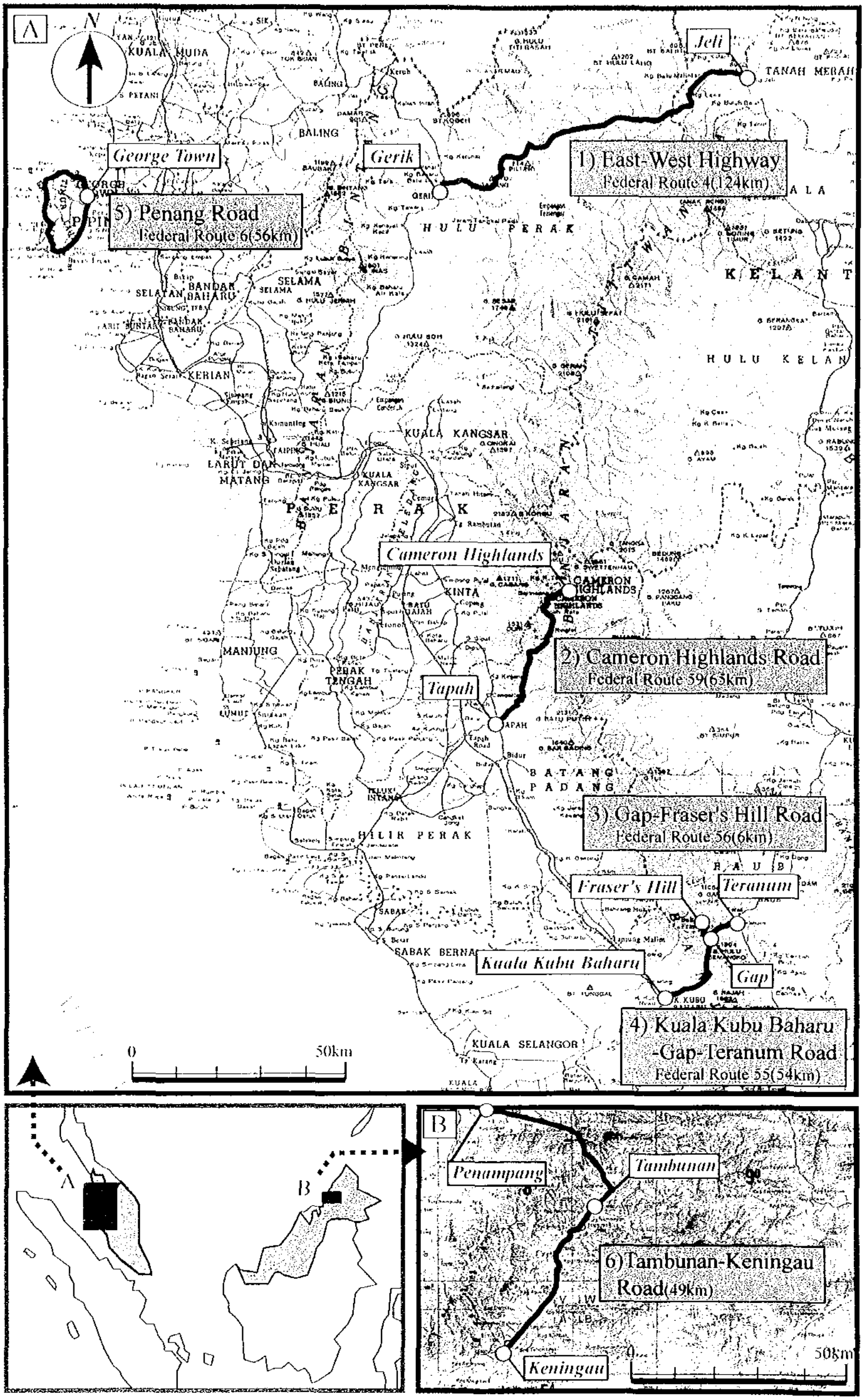
In connection with implementation of SIMS, it is required to procure hardware and software in each of the concerned offices of JKR. The necessary hardware and software are described in Chapter 5 of the main report.

(4) Training

Training is one of the essential elements of implementation and effective operation of the new slope management system. The training program shall be carried out in three categories; slope management, slope inspection and system maintenance.



Location Map



Location Map

THE STUDY
ON
SLOPE DISASTER MANAGEMENT FOR FEDERAL ROADS
IN MALAYSIA

FINAL REPORT
VOLUME I
EXECUTIVE SUMMARY

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Exchange Rate (Nov.2001)
1.00 US$ = RM 3.80 = ¥ 124.00

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Abbreviations

_², m² square e.g. square meter(s)
AE *Acoustic Emission*
Bbl barrel(s)
B/C Benefit Cost Ratio
BEM Board of Engineering Malaysia
BH Borehole
bn or 10^9 Billion
C Consequence
C & F Cost and Freight
CH Chainage
CIF Cost, Insurance and Freight
CL Collapse
CT Computed Tomography
DB Debris
Db decibel
DF Debris Flow
DID Department of Irrigation and Drainage
DPW Digital Photogrammetric Workstation
DTM Digital Terrain Model
dw deadweight
dwt deadweight tons
EA Experts Environmental Assessment Expert
EB Embankment Failure
EIRR Economic Internal Rate of Return
EW Highway East-West Highway
FEM Finite Element Method
FOB Free on Board
g gram(s)
GCPs Ground Control Points
GIS Geographical Information System
GNI Gross National Income
GNP Gross National Product
GPS Global Positioning System
GRM Generalized Reciprocal Method
gt gross ton(s)
GWh gigawatt-hour(s)
H Hazard Score
ha hectare(s)
hp horsepower
hr or h hour(s)
hz hertz
IEM Institute of Engineering Malaysia
in. inch(es)
kA kilo-ampere
kg kilogram
kl kiloliter(s)
km kilometer(s)
kt knot(s)
kV kilovolt
kVA kilovolt-ampere
kVAr reactive kilovolt-ampere
kW kilowatt(s)
kWh kilowatt-hour(s)
l liter(s)
LS Landslide
Lt long ton
m meter(s)
m^3/s or cu.m/sec cubic meter(s) per second
M or 10^6 million
MAF million acre-feet(=1,235 MCM)
MARRIS The Malaysia Road Record Information System
MCM *million cubic meter*
mgd million gallons per day
min minute(s)

mg	milligram(s)
mm	millimeter(s)
MMS	Malaysia Meteorological Service
mt or t	metric ton(s) or tonne(s)
MVA	megavolt-ampere
MVAr	reactive megavolt-ampere
MW	megawatt(s)
MWh	megawatt-hour(s)
nm	nautical mile(s)
N/mm²	newton per square millimeter(=Pa)
No.	number(serial number)
no(s).	unit(s)
NPV	Net Percent Value
OJT	On the Job Training
P	Primary
Pa	pascals
PAMS	Pavement Appraisal Management Suite
pf	power factor
ppm	parts per million
psi	pound per square inch
R	Risk Rating
RF	Rock Fall
RIP	Resistivity Image Profiling
RM	Rock Mass Failure
rpm	revolutions
RQD	Rock Quality Designation
RSO	Rectified Skew Orthomorphic
S	Secondary
s	seconds
SIMS	Slope Information Management System
SIRT	Simultaneous Reconstruction Technique
SPT	Standard Penetration Test
SPRS	Slope Priority Ranking System
t	ton(s) or tonne(s)
TWIMs	Tropical Weathered in-situ Materials
UPPJ	Road Maintenance and Management Unit
V	volt
VA	volt-ampere
VHF radio modem	Very High Frequency radio modem
VW	Vibrating Wire
VWP	Vibrating Wire Piezometer
W	watt(s)
Wh	watt-hour(s)

Standard Conversions

acre	x	0.404	=ha
acre foot	x	1,235	=m^3
cusecs	x	0.02832	=m^3/s
feet	x	0.3048	=m
in.	x	25.4	=mm
psi	x	0.070307	=kg/cm^2

CHAPTER 1 INTRODUCTION

1.1 Background of The Study

Along with the development of a nationwide road network, the construction of new roads in hilly and mountainous areas has been increased in recent years. Under the climatic and geological conditions in the region, road disasters related to slope failure have been reported from time to time. The Genting Bypass disaster (June 1995) with 21 victims was one such tragedy. *Since the early 1990's, JKR has started to develop and implement* several slope management systems like SMS, MEHMS and SPRS. Although those systems are in operation, it is required to develop a more reliable slope management system for disaster mitigation with limited resources. On the other hand, the State Government Malaysia has vigorously proceeded with a strategic plan, The VISION 2020, which demands continuous development of nationwide road network for the economic and social development of the country.

In these circumstances, the Malaysian Government requested the Japanese Government to provide technical and financial cooperation to establish an effective slope management system. The Japanese Government was pleased to arrange a new cooperative project and to provide its professional personnel and expertise in this area as Japan has been making great efforts to develop and implement slope disaster management systems for the past forty years. In July 2000, both governments came to agreement in signing the scope of work of this development study project, "The Study on Slope Disaster Management in Federal Roads in Malaysia".

1.2 The Objectives of The Study

This project was planned and carried out with the five objectives as below:

1. Clarification and analysis of the present situation of road slope and its management, in connection with natural and socio-economic conditions.
2. Development of a slope database and management system named SIMS, which denotes Slope Information Management System.
3. Preparation of Guideline of road slope disaster management, consisting of five guides.
4. Preparation of Implementation Plan

   A practical plan for application to federal roads nationwide is proposed, including a training program, based on the results of institutional and human resources study.
5. Technical transfer

   Technical transfer was to be carefully evaluated through three seminars and two workshops, as well as collaboration between the Study Team and their Malaysian counterparts.

1.3 The Study Area

The study area is shown in Table 1.3.1.

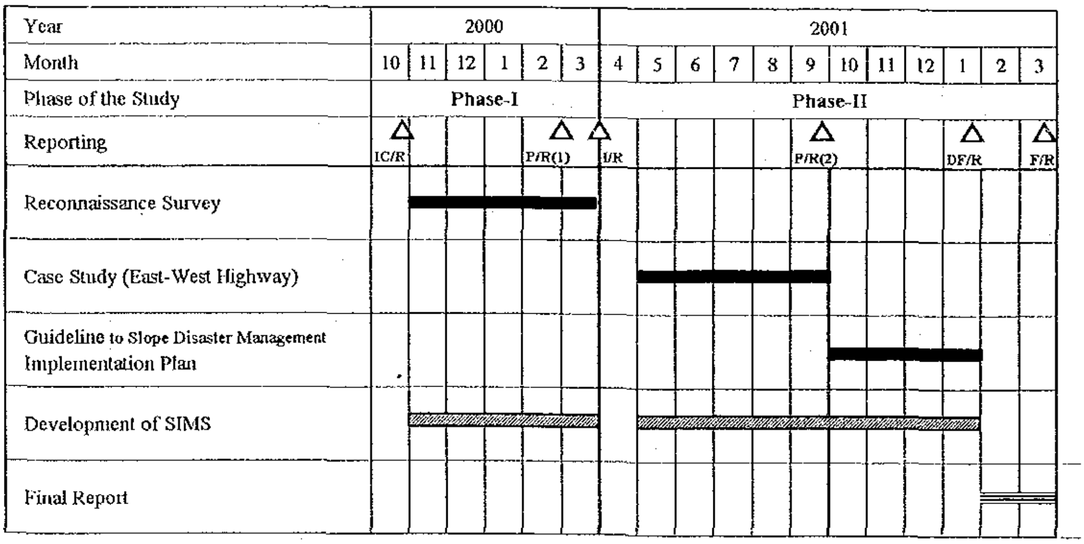
Table 1.3.1 The Study Area

Phase.		No.	Surveyed Route	Route No.	Length
Phase I:	Reconnaissance Survey	1	East-West Highway	Rt. 4	124 km
		2	Cameron Highlands Road	Rt. 59	65 km
		3	Gap-Fraser's Hill Road	Rt. 56	6 km
		4	Kuala Kubu Baharu-Gap-Teranum Road	Rt. 55	54 km
		5	Penang Road	Rt. 6	56 km
		6	Penampang-Tambunan-Keningau Road	Rt.500	120 km
			Total		425 km
Phase-II	Case Study		East-West Highway (Rt. 4) Chainage 25.0km to 82.3km (Perak)		55.3 km
	Check Study		Penampang-Tambunan Road		2.0 km
	Management System		Whole the Country (No field survey)		---

1.4 Period and Time Schedule of the Study

The contract period of this study was from October 2000 through March 2002. The actual progress schedule of performance is shown in Table 1.4.1.

Table 1.4.1 The Time Schedule



1.5 The Flow of the Study

The study was carried out in accordance with the flow chart as shown in Figure 1.5.1

As shown in the figure, the work can be divided into three (3) distinct components;

Phase I: Reconnaissance Survey
Phase II: (A) The Case Study
(B) The Study on Road Slope Management System

The major scope of each component is summarised as below:

Phase I:Reconnaissance Survey

1) To collect the information of the present situation of road slopes and management, in connection with natural and socio-economic conditions.
2) To survey six assigned federal roads and to grasp the general features of road slope in the country.
3) To analyse the mechanism of slope failure and to propose the classification of slope failure for slope disaster management.
4) To compare the various features of the six roads and select the most appropriate route for case study in Phase II.

Phase II: The Case Study

A Case Study was carried out along the East-West Highway, which include.

1) Slope Inspection with preliminary study, risk rating and priority risk ranking, and study of countermeasure implementation and road slope maintenance.
2) Development of a slope information management system (SIMS).
3) Study of the present organisation and human resource arrangements for slope management and to propose an improvement plan.

Phase II: The Study on Management System

1) To complete the SIMS for general application to federal roads nationwide.
2) To prepare Guidelines for road slope disaster management.
3) To test the proposed slope inspection/rating system in Penampang - Tambunan Road, Sabah for system verification.
4) To prepare an implementation plan based on the institution/human resource development study.

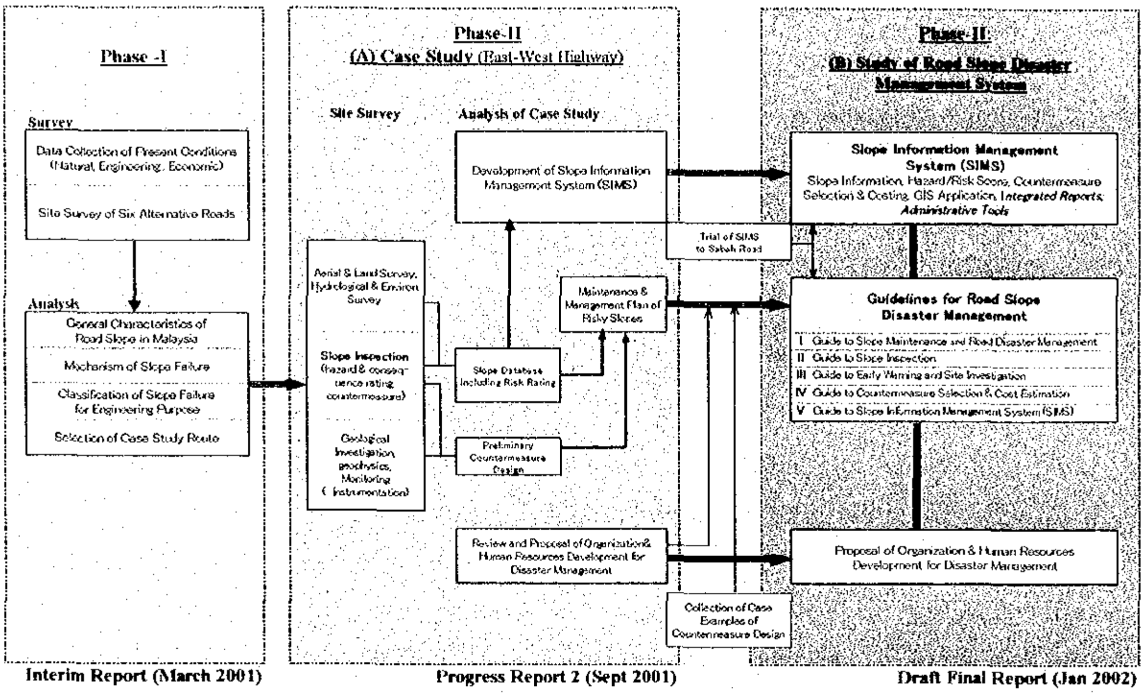


Figure 1.5.1 The Flow of the Study

1.6 Components of Draft Final Report

This draft final report consists of two (2) volumes as below:

<u>(1) Main Report Volume</u>

Executive Summary

Main Report — Chapter 1 to Chapter 8 with Appendices

<u>(2) Guideline Volume</u> Guidelines for Road Slope Disaster Management

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)

CHAPTER 2 THE PRESENT CONDITIONS OF MALAYSIA

Chapter 2 consists of nine sections from 2.1 to 2.9 as shown below.

2.1 Present Condition of Socio-Economy of Malaysia
2.2 Present Conditions of Road Network and Its Management Organization
2.3 Natural Conditions of Malaysia
2.4 Reconnaissance Survey of Six (6) Routes
2.5 Selection of The Case Study Route
2.6 Current Status of Countermeasure Works
2.7 Classification and Mechanism of Slope Failure
2.8 Existing Slope Information System
2.9 Method of Slope Risk Rating

2.1 Present Condition of Socio-Economy of Malaysia

(1) Population

The total population of Malaysia increased from 13.7 million to 23.3 million at an average annual growth rate of 2.67% over the twenty years from 1980 to 2000. (As total area of the country is 330,113 km^2, the population density in 2000 reached 70.5 person/km^2).

(2) Gross Domestic Product (GDP)

The Malaysian economy performed better than expected during the Sixth and Seventh Malaysian Plan period (1991-2000) despite the severe contraction in 1998 arising from the East Asian financial crisis. Thanks to the Government's monetary policy and fiscal stimulus to domestic demand and international trade, Gross Domestic Product (GDP) in constant price has recovered above the pre-crisis level in 2000. During the Eighth Plan Period (2001-2005), it is expected that GDP will grow at 7.5 % per annum and GDP Per Capita at 5.6 % in constant prices respectively.

(3) Road Transport

The total number of motor vehicles registered increased from 3.5 million to 9.9 million in the thirteen years from 1986 to 1999 at a rate of increase of 8.3 % per annum on average. It can be assumed that the increase of the number of motor vehicles reflects the development of road transportation including the road network and traffic volume.

2.2 Present Conditions of Road Network

(1) Progress of Road Development in Malaysia

During the Sixth Plan (1991-1995) period, emphasis was placed on further expansion, upgrading and improvement of the country's network of infrastructure. Road development was to increase the road network, particularly to improve inter-urban linkages, alleviate capacity constraints and increase the road network to open up new growth centres and rural areas. Several major projects such as the East-West Highway were initiated in this period.

(2) Seventh Development Plan

During the Seventh Plan (1996-2000) period, the road sub sector accounted for nearly 60% of the total allocation to the infrastructure sector, with total expenditure of RM12.3 billion. In addition, the private sector also expended a total of RM7.9 billion for the development of privatised highways. The slowdown in private road sector due to the financial crisis, was mitigated by increased Government expenditure on road construction and improvement projects during the last two years of the Seventh Plan period.

The total length of federal and state roads has been extended from 21,914 km in 1980 to 67,627 km in 1998 at 6.46 % average annual growth rate. The Federal Roads have extended from 6,377 km to 16,081 km with the average growth rate of 5.27% (See Fig. 2.2.1).

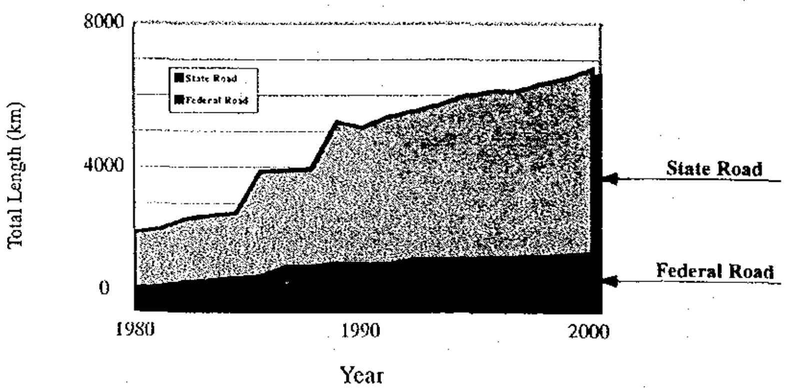


Figure 2.2.1 Historical Performance of Road Length in Malaysia

During the Eighth Plan (2001-2005) period, the road development programme will be continued with emphasis on quality and safety. New road construction will focus on opening up corridors for development as well as improving accessibility to rural areas. Construction of roads through privatization and deferred payment method will be continued on a selective basis, thereby sustaining road project implementation.

2.3 Natural Conditions of Malaysia

(1) Location

Malaysia is located in the heart of Southeast Asia. Consisting of 329,735 km^2, Malaysia is divided into two main regions: Peninsular Malaysia and East Malaysia.

(2) Climate

The climate of Malaysia is characterized as tropical, with high temperature and high humidity. Periodic changes in the wind flow patterns can be observed over the country, namely, the southwest monsoon, northeast monsoon and two shorter inter-monsoon seasons. The southwest monsoon, with prevailing wind flow from the southwest, usually occurs in the latter half of May or early June and ends in September. The northeast monsoon, with prevailing wind flow from the northeast, usually commences in early November and ends in March. The more severely affected area is the east coast states of Peninsular Malaysia.

The seasonal wind flow patterns determine the rainfall distribution over the country. Although several patterns of seasonal variation of rainfall can be observed in the country, in general, the rainy season can be seen during October to January, while a relatively dry season occurs during April to July every year.

(3) Topography

The backbone of Peninsular Malaysia, the Main Range, is located on the western flank of the peninsula and is about 480 km in length from the Malaysia-Thai border to the southern state, rising to more than 2,100 m above sea level in places. In Sabah, the most prominent highlands occur in the Crocker Range with average heights ranging from 457 to 914 meters.

(4) Geology

Malaysia is comprised of a broad range of rock types.

1) Peninsula Malaysia

In Peninsular Malaysia, all geological systems ranging from the Cambrian to the Quaternary (that is from 570 million years to about 10,000 years ago) are represented. Granitic rocks occupy more than half of the land in Peninsular. This granitic rock mass intrusion coincides with the late Triassic orogenic event during which all the older strata were folded and deformed. Regional metamorphism is widespread and most older rocks show slight to moderate deformation. Faulting is common in all rocks.

2) East Malaysia

Tertiary sedimentary rocks, like sandstone, mudstone, etc. are widely found in East Malaysia. In the Upper Miocene epoch, the Kinabalu Batholith intruded. By the post-tectonic volcanic activity, volcanic rocks, andesite, basalt, etc. erupted in the Semporna Peninsula. Quaternary deposits, consisting of gravel, sand, silt, clay, and coral accumulated along the coast, and are now found in raised terraces and in inland plains too.

(5) Environment

1) Environmental Impact Assessment (EIA)

Guidelines for the Environmental Impact Assessment

The Public Works Department, Malaysia (Roads Branch) has "Guidelines for the Environment Impact Assessment of Highway/Road Projects" on its own terms. The

EIA procedure adopted in Malaysia consists of three major steps. The steps in the EIA procedure are as follows:

a) Preliminary assessment of all prescribed activities,
b) Detailed assessment of those prescribed activities for which significant residual environmental impacts have been predicted in the preliminary assessment,
c) Review of assessment reports.

Review of EIA Reports is carried out internally by the DOE for preliminary assessment reports and by an ad hoc Review Panel for detailed assessment reports. Recommendations arising out of the review are transmitted to the relevant project approving authorities for consideration in making a decision on the project.

2) Tropical Weathering

Under the high temperature and high humidity conditions in tropical regions, chemical weathering is most dominant. Rocks are easily weathered into soils that are rich in oxides and hydroxides of iron and aluminium. The mode and level of weathering is closely related to the occurrence of slope failures.

3) Fauna and Flora

More than 50% of the land in Malaysia is covered by tropical rain forest of very complex structure and with a diversity of animal and plant species. Recent progress of deforestation has had a large impact on forest ecosystems.

(6) Other Environment Disruption

Various kinds of development activities in industry, agriculture, tourism etc. are underway all over the country. It is possible that some of these activities are destroying present environmental conditions; destruction of tropical forest, erosion, siltation, loss of cultivation soil, the combined effect of which may lead to floods and mud flow in downstream district. Careful study is required prior to development activity in environmental regulations.

2.4 Reconnaissance Survey of Six Study Roads

(1) Objective of Study

Field reconnaissance of six federal roads was carried out for about 2 weeks in the Phase I Study in December 2000. The reconnaissance was carried out with the objective to grasp the general conditions of road slopes in the country and to analyse the mechanisms and typical classification of slope failure.

(2) Result of Site Reconnaissance

The Schematic Geological Profile was prepared in sections along each road in Figure 2.4.4 to 2.4.8 of the Main Report containing information on ground elevation, geographical features, vegetation, geology, weathering grade and trace of slope disasters. The results of site reconnaissance are summarised in Table 2.4.1 below.

Table 2.4.1 Summary of Slope Failures along Six Routes

Disaster Type & Symbol		R4		R59		R56		R55		R6		R500	
		no	%	no.	%	no	%	no.	%	no	%	no	%
Collapse	Total	23	44	128	93	12	86	92	80	23	67	32	35
	Surface Failure	17	32	128	93	12	86	92	80	23	67	27	30
	Gully	6	12	0	0	0	0	0	0	0	0	5	5
Rock Fall	Rock Fall	6	12	0	0	2	14	7	6	6	18	1	1
Rock Mass Failure	Wedge Slip	6	12	0	0	0	0	0	0	0	0	0	0
Landslide	Total	11	20	2	1	0	0	10	8	1	3	37	41
	Landslide	11	20	2	1	0	0	10	8	1	3	17	19
	Settlement of Road	0	0	0	0	0	0	0	0	0	0	20	22
Debris Flow	Debris Flow	2	4	1	1	0	0	3	3	2	6	13	14
Embankment Failure	Total	4	8	7	5	0	0	3	3	2	6	2	9
	Embankment Failure	2	4	0	0	0	0	0	0	0	0	1	1
	Surface Failure – below shoulder	2	4	7	5	0	0	3	3	2	6	7	8
	Total	52	100	138	100	14	100	115	100	34	100	91	100

R4 : East-West Highway R59 : Cameron Highlands Road
R56 : Gap-Fraser's Hill R55 : Kuala Kubu B.-Gap- Teranum
R6 : Penang Road R500 (State Road) : Penampang-Tambnan (Sabah)

2.5 Selection of Case Study Route

(1) Six (6) Alternative Routes

As shown in the Chapter 1, six roads were nominated as the reconnaissance roads. Several items were compared and studied, such as natural conditions (geology, topography etc.), anticipated slope failure type, road geometric design standard, slope height, present road management operation, availability of road maintenance record, and socio-economic conditions. Each item of the conditions of the six alternative roads is compared and shown in Table 2.5.3, Main Report.

(2) Requirement for Case Study

The case study was carried out to develop a model road slope disaster management information system to be applied to nationwide federal roads. In this context the case study route was required to satisfy the following conditions:

a) Include All typical slope failure types
b) Existence of landslides
c) Existence of high cut slopes
d) High standard of geometric design
e) Good slope management operation
f) Data availability
g) Socio-economic conditions

(3) Selection of Case Study Route

After careful study, the JICA study team reported the following recommendation to the Steering Committee meeting held on 8th January 2001.

1) The East–West Highway (Federal Route 04) is recommended as the most suitable route for the case study, as it satisfies almost all requirements.

2) The other 5 routes are not regarded as suitable for the model study, due to a lack of most requirements mentioned above.

3) However, if any other road is requested to select for trial testing of the new slope management system, the Penampang-Tambunang-Keningau Road (Sabah) is recommended, because this route has many high slopes and landslides to be managed urgently.

2.6 Current Status of Countermeasure Works

During the reconnaissance survey on the six federal roads, the current status of slope countermeasure was carefully observed. Generally speaking, it was assessed that adequate countermeasure work has been selected and implemented at most of the failed slopes based on technical knowledge and local experience.

However, it was often observed that insufficient or improper slope work has been applied at some slopes, presumably due to a shortage of budget or shortage of technical expertise in some special situations. Our observation and comment on the current countermeasures will be briefly described according to the types of slope failure as below:

(1) Collapse (CL)

At many slopes where collapse has previously occurred, failed debris was already cleared for traffic passage. But sufficient repair work was not immediately implemented at many sites, due to the limitation of budget. Gabion wall, shotcrete works, soil nailing etc. are often observed as effective measures against collapse. It should be noted that these measures are thought to be effective temporarily, but not sufficient to prevent large scale collapse permanently. (Special consideration is recommended to the stability of risky slope of large scale, in accordance with the size and mechanism of failure at each site).

(2) Rock Fall (RF)

Rock fall netting and catch gabion wall were often observed as the slope work applied against rock fall, and were mostly assessed as effective.

(3) Rock Mass Failure (RM)

Rock mass failure in the form of toppling and wedge failure was observed along the six reconnaissance routes. But no countermeasure has actually been implemented due to the high cost of effective measures on steep and high slopes.

(4) Landslide (LS)

Along the reconnaissance routes, several landslide areas were found. But in most cases, countermeasures against landslide were limited to just temporary works such as gabion wall, embankments, etc. (in a few landslide areas, permanent works such as ground anchors have been implemented).

(5) Debris Flow (DF)

Debris flows was recognised at a few locations along the reconnaissance routes. So far no countermeasures have been implemented.

(6) Embankment Failure (EB)

Embankment failures mainly took place in some old embankments that were constructed many years ago. One of the reasons for this is considered to be improper design such as too steep angle and insufficient instalment of drainage facilities. Most of these points have been corrected in recent years.

2.7 Classification and Mechanism of Slope Failure

(1) Classification

Based on the Reconnaissance Survey and other literature study, road slope failure in Malaysia is classified into six (6) types depending on the failure mechanism. These are listed in Table 2.7.1 below. The main features of each type are summarized in Figure 2.7.1.

Table 2.7.1 Classification 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)

(2) Rainfall Data

Rainfall data from the Department of Irrigation and Drainage (DID) and Malaysian Meteorological Service (MMS) were collected and analysed. For the reconnaissance routes it was found that there is a big difference in rainfall between stations along one road. For example, the average annual rainfalls of Jeli (E-W Highway) and Tapah (Cameron Highland Road) are both more than 3,000 mm, while rainfall at other stations along the same roads show values of 1,000 mm or smaller. The probable annual and maximum daily rainfalls were calculated.

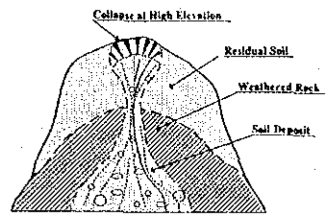
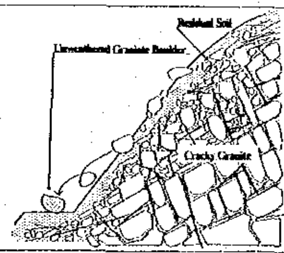
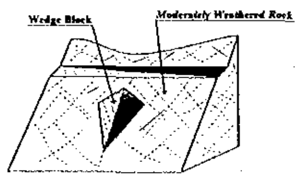
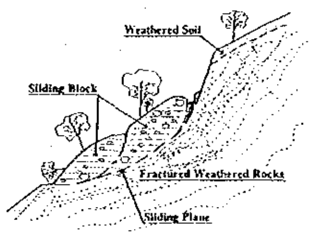
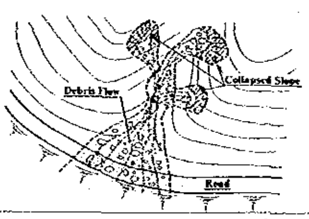
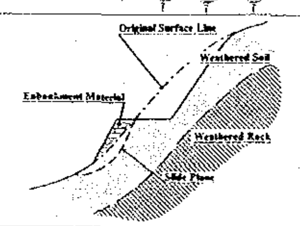
FAILURE TYPE (Inspection Sheet to be applied)	Characteristics	SCHEMATIC ILLUSTRATION
1. Collapse (CL)	- Collapsing materials are residual soils and highly weathered or jointed rocks. - Prone to occur on steep slopes. - Mostly triggered by rainfall infiltrating - Similar to slump failure in some cases. - 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. Embankment Failure (EB)	All type of slope failure in embankment - Slump or collapse of slope, - settlement of road surface - Scouring of toe part	

Figure 2.7.1 Classification of Slope Failure

(3) *Relationship Between Road Disasters and Rainfall*

1) Disaster Record

Records of slope disasters along the reconnaissance routes were collected and analysed, including the date, time, location, fallen volume, restoration cost, etc. Unfortunately, there are few disaster records available. Based on this fact, recommendations are made on the establishment of slope disaster recording system with connection with rainfall data.

2) Relationship between Road Disasters and Rainfall

For the road disasters for which the date could be identified, the disaster volume and rainfall before the road disaster occurred were collated.

Figure 2.7.2 shows the relationship between daily rainfall and weekly rainfall when the slope failure occurred. In the figure, the risk curve is assumed to make sense of the figure, though collected data are too few to position the curve accurately. The risk curve indicates that even if daily rainfall is low, slope disasters can be caused if there has been a lot of cumulative rainfall. On the other hand, even if cumulative rainfall is little, slope disasters can be caused if there is a lot of rainfall in a day. Also it was found that some of the slope failures happened without any identifiable connection with rainfall.

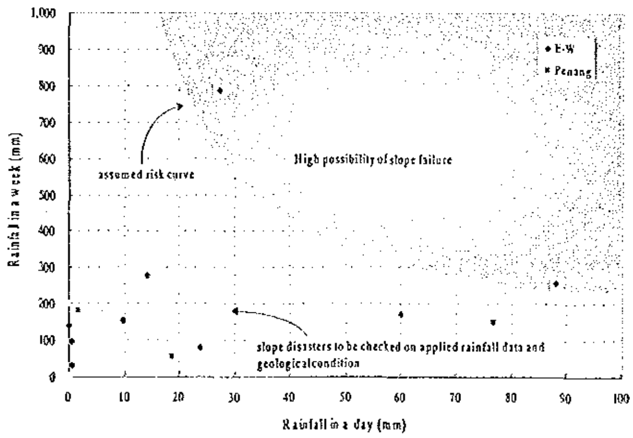


Figure 2.7.2 Relationship between Road Disaster and Rainfall in Malaysia

2.8 Existing Slope Information Systems

This section summarises and reviews the existing systems in Malaysia, outlining their intended purpose, inherent strong and weak points for deployment, and use history. The intent is to leverage past experience to benefit the design and deployment of a new system.

The existing systems are;

(1) Slope Management System (SMS)
(2) Malaysian Engineered Highway Management System (MEHMS)
(3) Slope Priority Ranking System (SPRS)

A brief comparison between these systems is summarised in Table 2.8.1.

Table 2.8.1 Summary of the Existing Slope Information Systems

Module	Function	SMS	MEHMS	SPRS
Slope Information	Slope Inventory	Yes	Yes (but no data entry form)	Yes
	Slope Inspection	Yes	Not designed	Yes, but not professional
	Slope Maintenance	Yes	Not designed	Not designed
	Countermeasure	Not designed	Using CHASM Module	Yes, but quite simple
Rating Analysis	Hazard Rating	Yes	by slope stability analysis, CHASM	Yes, but not professional
	Consequence of Slope Failure	Yes	Not designed	Yes
	Risk Rating	Yes	Factor of Safety by CHASM	Yes
	Economic Analysis	Not designed	Not designed	Yes, but rough cost estimation only
Disaster Support	Emergency Response	Not designed	Not designed	Not designed
GIS Application	Location Map	Yes	Not designed	Not designed
	Thematic Mapping	Yes	Not designed	Not designed
	Spatial Analysis	Not designed	Not designed	Not designed
Administrative Functions	Data management	Yes	Yes	Not designed
	User management	Not designed	Not Available	Not designed

2.9 Method of Slope Risk Rating

(1) Evaluation of Slope Risk

Evaluation of slope risk against possible failure is the basic subject of study in slope disaster management. Slope inspection is most commonly used at the stage of screening and prioritisation of countermeasure implementation plans in the SMS, SPRS, and the current Japanese Slope Management System. Another method, slope stability analysis, is employed in MEHMS. As detailed geotechnical and hydrological data are required for each slope, this technique may be appropriate to be used at the stage of detailed design of countermeasure.

(2) Study of Specification of Slope Inspection

Specifications for the slope inspection method were compared between SMS, SPRS, and the current Japanese system for the establishment of specifications for the proposed new system.

The following items were carefully studied in the design of the new system.

1) Objective
2) Target Road
3) Personnel for Inspection
4) Slope Failure Type
5) Risk Rating Formula
6) Hazard Score factors
7) Hazard Score distribution
8) Consequence Score
9) Economic Analysis
10) Countermeasure Selection and Cost Estimation